Potential value of community-based water monitoring in water resource protection decision-making in a developing country context: South Africa

by

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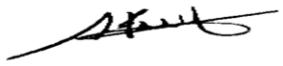
I declare that the above dissertation is my own work and that all the sources I have used or quoted have been referenced in accordance with university requirements and acknowledged under the references.

I further declare that I submitted the dissertation to originality-checking software and that it complies with the accepted requirements for originality.

I further declare that I have not previously submitted this work, or any part of it, for examination at the University of South Africa (UNISA) for another qualification or at any other higher education institution.



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SIGNATURE DATE

DEDICATION

This research is dedicated to all the individuals devoted to making a sustainable difference in the protection of water resources and the environment at large.

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ABSTRACT

Over the past two decades, most developing countries, especially in Africa, have been transitioning towards water sector reform. While new water legislation in many African countries – as in South Africa – has included the environmental protection and the Polluter Pays Principle as priorities, it has given little attention to community involvement. South Africa faces many water-related challenges, the most significant being water quality deterioration, which requires constant monitoring. Water resource monitoring is essential for protecting water resources but presents challenges that constitute research gaps this study aimed to address. Key gaps include: the lack of policy support for community stakeholder participation in water resource monitoring; the exclusion of community data from water resource protection decision-making; poor integration of monitoring programmes and information sharing among different institutions; and uncertainty about the effectiveness of stakeholder engagement in reaching the intended objectives.

As a result of the identified gaps, a main research question was formulated: What is the potential value of community-based water monitoring (CBWM) in water resource protection decision-making in a developing country context such as South Africa?. The main research question was informed by the five sub- questions: 1. What are the benefits, values, pitfalls, and challenges of CBWM programmes? 2. What criteria should be considered in CBWM in developing countries? 3. Based on the opinions of governance structures and the real-life experiences of communities, to what extent do the selected catchments in South Africa, as a developing country, benefit from CBWM? 4. What are the views of governance structures on the extent to which CBWM operates in South African communities? 5. How might a conceptual framework work by enhancing the use of CBWM data in decision making for developing countries?

A case study research design utilising a mixed-methods research approach, incorporating both qualitative and quantitative methods, was followed to answer the research questions. The study integrated a literature review with primary data collection through three case studies. Data were gathered through interviews and a survey questionnaire.

The study's findings indicate that sustainable CBWM programmes promote community involvement in water monitoring while encouraging public ownership and trusteeship of water resources. However, the absence of appropriate guiding policy and CBWM-related challenges have hampered progress and prevented community data from contributing to decision-making. This study demonstrates the importance of a standardised protocol as a baseline for monitoring, managing data, ensuring value for money, and securing funding. The study highlighted the extent of catchments benefiting from CBWM initiatives as an early warning system and emphasised the importance of collaboration between different community

governance structures for effective operation. A conceptual framework was developed for integrating CBWM data into the decision-making process to enhance the use of CBWM data for decision-making and to enhance sustainability and establish consistent information-sharing channels among relevant institutions.

Engaging with the main research question yielded important insights into the role of CBWM data in decision-making. CBWM improves the capacity for monitoring water impacts, enabling more informed decisions through increased data availability. This helps bridge the gap between scientific knowledge and local community knowledge that traditional methods involving only professional scientists have overlooked. The integration of community data in water resource protection fosters a proactive management framework, allowing community members to identify potential water issues early and optimise resource allocation and protection.

A key insight gained is that CBWM participation can guide both data collection and implementation of CBWM initiatives, ultimately promoting sustainable practices. This exploration underscores that CBWM not only enhances data collection, but also supports policy development and stakeholder engagement, thus filling critical gaps identified in both knowledge and practical applications within the field of sustainable water management.

Keywords: Community-based water monitoring, water resource protection, decision-making, conceptual framework, stakeholder views and experiences, monitoring value, community benefits and challenges, conceptual framework, South Africa.

TSHIHUMBULELWA

Kha mahumi mavhili a miṅwaha yo fhiraho, mashango a no khou bvelela, zwihulusa a dzhango ḽa Afurika, a khou shandukela kha tshanduko ya zwa maḓi. Musi milayo miswa kha mashango manzhi a dzhango ḽa Afurika, sa Afurika Tshipembe, yo katela na u tsireledza mupo na tshikafhadzo yawo i vhidzwaho “Polluter Pays Principle”, ya dovha hafhu ya katela zwiṱukuṱuku na u dzhenelela ha vhadzulapo. Afurika Tshipembe ḽi khou livhana na khaedu nnzhi dza maḓi, zwihulusa u kuna hao zwine zwa tea u dzula zwi tshi khou poswa iṱo. U ṱola zwiko zwa maḓi ndi zwa ndeme kha u tsireledza zwiko, fhedzi zwi na khaedu kana magake ane a ṱoḓa tsedzuluso ya zwine ngudo iyi ya khou ṱoḓa u bvisela khagala. Magake aya a ndeme a katela, u shaeya ha thikhedzo ya milayo kana mbekanyamaitele ya vhafaramikovhe vha tshitshavha kha u ṱhogomela zwiko zwa maḓi; u sa dzhielwa nṱha ha mawanwa a tshitshavha musi hu tshi dzhiiwa tsheo; u shaeya ha u ṱanganya mbekanyamushumo dza u ṱhogomela na u ṋekana zwidodombedzwa uya nga u fhambana ha madzangano na u sa shumisana ha vhafaramikovhe kha u swikelela zwipikwa.

Nga nṱhani ha magake o waniwaho, ho bveledzwa mbudziso nthihi khulwane ya ṱhoḓuluso ‘Ndeme khulwane ya community-based water monitoring (CBWM) kha tsheo dza u tsireledza zwiko zwa maḓi kha shango li no khou bvelela sa shango la Afurika Tshipembe?’ Mbudziso khulwane nga ha thoduluso yo tutuwedzwa nga mbudziso thanu ṱhukhu dzine dza vha: 1. Ndi mbuelo, ndeme, khombo na khaedu dzifhio dza mbekanyamushumo dza CBWM? 2. Ndi nḓila dzifhio dzine dza fanela u tevhelwa kha CBWM kha mashango a no khou bvelela? 3. Zwo disendeka kha kuhumbulele kwa zwiko zwa mavhusele, na kuhumbulele kwa tshitshavha, ndi lini hune khuvhanganyo ya maḓi Afurika Tshipembe, sa shango ḽi no khou bvelela ḽa bindula u bva kha CBWM? 4. Ndi mbonalele ifhio uya nga ha zwiko zwa muvhuso zwine CBWM ya khou bveledzisa? 5. CBWM data I nga shumiswa hani kha u dzhiya tsheo kha mashango ane a khou bvelela?

Ngudo ya tsumbo ya tsedzuluso ye ya shumisa tsedzuluso yo ṱanganelaho, yo katela tsedzuluso ya khwaḽithethivi nay a khwanthithethivi ya tevhelwa nga u fhindula mbudziso dza tsedzuluso. Ngudo iyi yo shumisa nḓiḽa ya ṱhoḓuluso yo ṱanganelanaho, yo katela tsedzuluso ya maṅwalwa and mawanwa o kuvhanganyiwaho kha ṱhoḓuluso tharu dza ngudo Mawanwa o wanala nga u ita nyambedzano na vhathu vho tou nangiwaho ha dovha hafhu ha netshedzwa dzinwe mbudziso.

Mawanwa a tsedzuluso a sumbedza uri mbekanyamushumo dza CBWM dzi thusa tshitshavha kha u vha tshipiḓa na kha u lavhelesa kana tsireledzo ya maḓi, na u vha na vhuḓifhinduleli. Sa zwenezwo, u sa vha na milayo na khaedu dza CBWM zwi ita u ri hu sa vhe na mvelaphanḓa. Ngudo iyi I sumbedza ndeme ya u vha na ndaulo I ṱanganedzwaho nga nnyi na nnyi sa mutheo, u ri hu kone u vha na u londola kana u ṱhogomela, u ṱhogomela mawanwa (data), na u kona u

wana ndambedzo ya masheleni. Ngudo yo bvisela khagala u ri CBWM I khou thusa tshitshavha u swika ngafhi ya dovha ya tsivhudza vhuṱhogwa ha u shumisana kha zwitshavha u ya nga u fhambana. Ho bveledzwa nḓila ya u dzhenisa mawanwa ya CBWM musi hu tshi dzhiiwa tsheo na u khwaṱhisa u ṋekana nḓivho nga zwiimiswa uya nga u fhambana.

Kha mbudziso khulwane ya ṱhoḓuluso, zwo bveledza u khwiṋisea kha tshipida tsha u tsireledza zwiko zwa maḓi na u shumisa mawanwa a re hone. Mbuelo idzi dzi thusa u fhungudza magake vhukati ha nḓivho ya saintsi na ya vhadzulapo ya sialala. U ṱanganyisa mawanwa a vhadzulapo kha tsireledzo ya zwiko zwa maḓi zwi ṱuṱuwedza u shuma kana u langula, zwine zwa tendela vhadzulapo u kona u vhona zwi sa khou tshimbilaho zwavhuḓi na u kona u ṋetshedza na u tsireledza maḓi.

Mbuelo dzo wanwaho kha u shumisana na CBWM ndi u kona u sumba nḓila kha u kuvhanganya mawanwa na u sumbedza vhurangaphanḓa, zwine zwa ṱuṱuwedza tshumisano ya tshifhinga tshilapfu. Ṱhoḓulusa iyi I sumbedza vhuṱhogwa ha CBWM kha u ṱandavhudza ṱhoḓuluso na u kuvhanganya mawanwa na u tikedza kha u bveledza mbekanyamaitele na u katela vhafaramikovhe, zwine zwa vala gake vhukati ha nḓivho na nyito.

Maipfi a ndeme: Tsedzuluso ya maḓi nga vhadzulapo, tsireledzo ya zwiko zwa maḓi. muangarane wa u dzhia tsheo, tshipirioni na vhupfiwa ha vhafaramikovhe, vhuṱhogwa ha u ṱola, u bindula na dzikhaudu kha vhadzulapo, ṱhanganyo ya mawanwa, Afurika Tshipembe.

XIVUMBEKO

Eka makume mambirhi ya malembe lama hundzeke, matiko yo tala lama hluvukaka, ngopfungopfu eAfrika, ya vile ya hundzukela eka mpfuxeto wa sekithara ya mati. Loko milawu leyintshwa ya mati ematikweni yo tala ya Afrika – tanihi le Afrika-Dzonga – yi katsa nsirhelelo wa mbango na Nsinya wa Nawu wa Nthyakiso wa Ntshikelelo tanihi swilo leswi rhangisaka emahlweni, wu nyikile nyingiso wutsongo eka ku nghenelela ka vaaki. Afrika-Dzonga ri langutane na mintlhontlho yo tala leyi fambelanaka na mati, leyi nga ya nkoka swinene i ku hohloka ka khwalithi ya mati, leswi lavaka ku vekiwa tihlo nkarhi hinkwawo. Ku vekiwa tihlo ka switirhisiwa swa mati i swa nkoka eka ku sirhelela switirhisiwa swa mati kambe swi tisa mintlhontlho leyi vumbeke swivandla swa ndzavisiso leswi ndzavisiso lowu a wu kongomisiwile ku swi lulamisa. Swivandla swa nkoka swi katsa: ku pfumaleka ka nseketelo wa pholisi eka ku nghenelela ka vakhomaxiave va vaaki eka ku vekiwa tihlo ka switirhisiwa swa mati; ku hlongoriwa ka datha ya vaaki eka ku tekiwa ka swiboho swa nsirhelelo wa switirhisiwa swa mati; ku hlanganisiwa loku nga riki kahle ka minongonoko yo veka tihlo na ku avelana mahungu exikarhi ka swivandla swo hambana; na ku nga tiyiseki mayelana na ku humelela ka ku nghenelela ka vakhomaxiave eku fikeleleni ka swikongomelo leswi kunguhatiweke.

Hikwalaho ka swivandla leswi hlawuriweke, xivutiso lexikulu xa ndzavisiso xi vumbiwile ‘Hi wihi nkoka lowu nga vaka kona wa community-based water monitoring (CBWM) eka ku tekiwa ka swiboho swa nsirhelelo wa switirhisiwa swa mati eka xiyimo xa tiko leri hluvukaka ku fana na Afrika-Dzonga?’. Xivutisonkulu xa ndzavisiso xi tivisiwile hi swivutiso leswitsongo swa ntlhanu: 1. Hi yihi mimpfuno, mimpimanyeto, mintlhamu, na mintlhontlho ya minongonoko ya CBWM? 2. Hi swihi swipimelo leswi faneleke ku tekeriwa enhlokweni eka CBWM ematikweni lama hluvukaka? 3. Hi ku ya hi mavonelo ya swivumbeko swa vulawuri na mintokoto ya xiviri ya miganga, xana swihlovo leswi hlawuriweke eAfrika-Dzonga, tanihi tiko leri hluvukaka, swi vuyeriwa ku fikela kwihi eka CBWM? 4. Hi wahi mavonelo ya swivumbeko swa vulawuri eka mpimo lowu CBWM yi tirhaka ha wona eka miganga ya Afrika-Dzonga? 5. Xana rimba ra miehleketo ri nga tirha njhani hi ku ndlandlamuxa matirhiselo ya datha ya CBWM eka ku teka swiboho eka matiko lama hluvukaka?

Dizayini ya ndzavisiso wa dyondzo ya xiyimo leyi tirhisaka endlelo ra ndzavisiso wa maendlelo yo hlangana, leyi katsaka maendlelo ya xiyimo na ya nhlayo, yi landzeriwile ku hlamula swivutiso swa ndzavisiso. Dyondzo yi hlanganisa nkambisiso wa matsalwa na nhlengeleto wa datha ya masungulo hi ku tirhisa tidyondzo tinharhu ta timhaka. Data yi hlengeletiwile hi ku tirhisa mimbulavurisano na ndzavisiso.

Swikumiwa swa ndzavisiso swi kombisa leswaku minongonoko ya CBWM leyi nga ta tshama nkarhi wo leha yi tlakusa ku nghenelela ka vaaki eka ku vekiwa tihlo ka mati loko yi ri karhi yi hlohlotela vun’wini bya mfumo na vutshembeki bya switirhisiwa swa mati. Hambiswiritano, ku

pfumaleka ka pholisi yo kongomisa leyi faneleke na mintlhontlho leyi fambelanaka na CBWM swi kavanyetile nhluvuko na ku sivela datha ya vaaki ku hoxa xandla eka ku teka swiboho. Dyondzo leyi yi kombisa nkoka wa phurotokholo leyi ringaniseriweke tanihi masungulo yo veka tihlo, ku lawula datha, ku tiyisisa nkoka wa mali, na ku kuma mali. Dyondzo yi kombisile mpimo wa swihlovo leswi vuyeriwaka eka migingiriko ya CBWM tanihi sisiteme ya xitsundzuxo xa le mahlweni naswona yi kandziyisile nkoka wa ntirhisano exikarhi ka swivumbeko swo hambana swa vulawuri bya vaaki ku endlela matirhelo lama humelelaka. Rimba ra miehleketo ri tumbuluxiwile ro hlanganisa datha ya CBWM eka phurosese yo teka swiboho ku ndlandlamuxa matirhiselo ya datha ya CBWM ku teka swiboho na ku ndlandlamuxa ku kondletela na ku simeka tindlela leti nga cincekiki to avelana mahungu exikarhi ka swivandla leswi faneleke.

Ku nghenelela na xivutiso xa ndzavisiso, swi humesile vutivi bya nkoka lebyi ndlandlamuxaka ku twisisa ntirho wa datha ya CBWM eka ku teka swiboho. CBWM yi antswisa vuswikoti byo langutisisa ku khumbeka ka mati, ku endla leswaku ku va na swiboho leswi nga na vutivi byo tala hi ku engetela ku kumeka ka datha. Leswi swi pfuneta ku hlanganisa xivandla exikarhi ka vutivi bya sayense na vutivi bya vaaki va ndhawu lebyi tindlela ta ndhavuko to katsa vativi va sayense va xiphurofexinali ntsena ti honiseke. Ku hlanganisiwa ka datha ya vaaki eka nsirhelelo wa switirhisiwa swa mati swi kurisa rimba ra vulawuri lebyi nga na vuxiyaxiya, ku pfumelela swirho swa vaaki ku kuma timhaka leti nga vaka kona ta mati ka ha ri na nkarhi na ku antswisa avelo na nsirhelelo wa switirhisiwa.

Vutivi bya nkoka lebyi kumiweke hileswaku ku nghenelela ka CBWM ku nga kongomisa havumbirhi bya nhlengeleto wa datha na ku tirhisiwa ka migingiriko ya CBWM, eku heteleleni ku tlakusa maendlelo lama nga ta tshama nkarhi wo leha. Ku lavisisa loku ku kandziyisa leswaku CBWM a yi ndlandlamuxi ntsena nhlengeleto wa datha, kambe yi tlhela yi seketela nhluvukiso wa pholisi na ku nghenelela ka vakhomaxiave, xisweswo yi tata swivandla swa nkoka leswi hlawuriweke eka vutivi na matirhiselo lama tirhaka endzeni ka xiyenge xa vulawuri bya mati lebyi nga heriki.

Marito ya nkoka: Ku vekiwa tihlo ka mati loku simekiweke eka vaaki, nsirhelelo wa switirhisiwa swa mati, ku teka swiboho, rimba ra miehleketo, mavonelo na ntokoto wa vakhomaxiave, not yak u hlawuleka, mabindza na mintlhontlho ya nhlayo, hlanganiso, Afrika-Dzonga.

LIST OF ACRONYMS

AaR	Adopt-a-River
AWARD	Association for Water and Rural Development
Bot-NWP	Botswana National Water Policy
CAES	College of Agriculture and Environmental Studies
CBM	Community-based monitoring
CBWM	Community-based water monitoring
CER	Centre for Environmental Rights
CL	Chlorine
CMA	Catchment management agency
CMF	Catchment management forum
CMS	Catchment Management Strategy
COD	Chemical Oxygen Demand
COGTA	Department of Cooperative Governance and Traditional Affairs
DFFE	Department of Forestry, Fisheries and Environment
DO	Dissolved Oxygen
DPM	Dundee Precious Metals
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
E. coli	*Escherichia coli*
EC	Electrical conductivity
ENSO	El Nino-Southern Oscillation
ESG	Environmental, Social, and Governance
GDP	Gross Domestic Product
GWA	Government of Western Australia
GWP	Global Water Partnership
IUCMA	Inkomati-Usuthu Catchment Management Agency.
IWRM	Integrated water resource management
KNP	Kruger National Park
KZN	KwaZulu-Natal
LIMCOM	Limpopo Watercourse Commission
MCs	Management classes
MDGs	Millennium Development Goals
NGO	Non-governmental organisation
NO_3	Nitrates
NWA	National Water Act
NWP	National Water Policy

NWRS	National Water Resource Strategy
NWRS 2	National Water Resource Strategy 2nd edition
NWRS 3	National Water Resource Strategy 3rd edition
ORASECOM	Orange-Senqu River Commission
pH	The potential of hydrogen
PO_4	Phosphates
POPIA	Protection of Personal Information Act
PPP	Public–private partnership
PSPs	Professional service providers
RDM	Resource Directed Measures
REMP	River Ecosystem Monitoring Programme
RHP	River Health Programme
RQOs	Resource Quality Objectives
SADC	Southern African Development Community
SAEON	South African Environmental Observation Network
SALGA	South African Local Government Agency
SASS	South African Scoring System
SDC	Source Directed Control
SDGs	Sustainable Development Goals
SPSS	Statistical Package for the Social Sciences
SS	Suspended solids
Stats SA	Statistics South Africa
TDS	Total dissolved solids
UN	United Nations
UN–Water	United Nations–Water
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISA	University of South Africa
U.S. EPA	United States Environmental Protection Agency
WDCS	Waste Discharge Charge System
WHO	World Health Organization
WMA	Water management area
WQM	Water Quality Management
WRC	Water Research Commission
WRCS	Water Resource Classification System
WSA	Water Services Act
WULA	Water Use Licensing Authorisation
WWTW	Wastewater treatment works

DEFINITIONS

Capacity building: The process of developing skills and knowledge through formal training and other educational activities (Carlson *et al*., 2017).

Catchment: An area of land where rainfall drains into a watercourse (DWS, 2023d).

Community-based monitoring: A process in which community members (interested and affected parties from government, civil society [public], non-profit organisations [NPOs] and the private sector) collaborate to monitor and respond to issues of common community concern (Conrad & Hilchey, 2011).

Community-based water monitoring: A process in which community members collaborate to monitor and respond to water-related issues of concern (Conrad & Hilchey, 2011).

Conceptual framework: A framework that outlines how governance systems function as institutions to guide the execution of roles and responsibilities (Nepfumbada, 2020).

Construct validity: The extent to which a measurement tool or method accurately measures the theoretical concept it is intended to measure (Lester *et al*., 2020).

Crowdfunding: A form of fan-based crowd sourcing fundraising campaign, where individuals or groups of people voluntarily pledge sums of money to support a project or a programme (Sithole, 2023).

Day-Zero: A level of critical water restrictions or zero flow intercept (Ramulifho *et al*., 2019)

Decision-making: A process of making choices by gathering information, assessing alternative resolutions, and influencing authority in reaching the final verdict (Akhmouch & Clavreul, 2016).

Descriptive statistics: Statistics that summarise a group of data, indicating central tendency (mode, median and mean), dispersion (e.g. range, standard deviation, and the degree of relationship between two variables (Cresswell, 2014).

Ecosystem: A community of biotic (animals, plants, and other organisms) and abiotic (soil and other minerals) factors interacting in their physical environment (DWS, 2023d).

Environment: External factors, conditions, and influences that affect the growth, development, and survival of organisms or a community. This includes climate, physical, chemical, and biological factors, nutrients, and social and cultural conditions (DWS, 2018).

External validity: The extent to which the findings of a study can be generalised to other populations, settings, or contexts beyond the scope of the initial study (Cresswell, 2014).

Inferential statistics: Statistics used for drawing conclusions about a population based on sample data (Welman *et al*., 2005).

Information flow: The channels, systems and pathways through which information is communicated among stakeholders (Goldin *et al*., 2023).

Indigenous knowledge: Knowledge generated through the voluntary involvement of indigenous citizens in scientific research and data collection (Conrad & Hilchey, 2011).

Internal validity: The extent to which a study establishes a causal relationship between independent and dependent variables without bias (Cresswell, 2014).

Legislation: A law or a series of laws providing for the management, maintenance, and restoration of citizenship (Constitution, 1996).

Monitoring parameters: Parameters sampled or monitored for a water quality ecosystem, e.g. physical, chemical or microbial (WHO, 2019).

Policy: A plan of action or statement of ideals proposed by an individual or organisation, including government (Cardno, 2021).

Population: All members of the entire group (UN, 1992).

Public participation: The process of engaging or considering the public's input in decision-making concerning issues affecting their lives or livelihoods. This includes participation in data collection and knowledge generation by offering time, solutions, and social benefits through supporting government policies and frameworks (Khair *et al*., 2020).

Sample: A percentage of participating population (Budiu & Moran, 2021).

Stakeholders: Individuals or groups of people who can affect (have a vested interest in) or are affected by policies or decisions of an organisation in the private or non-profit sectors, government, public, civil societies, and community-based organisations (Akhmouch & Clavreul, 2016).

Stakeholder engagement: A process by which any interested and affected person or group of people maintain sustainable stakeholder relationships (Akhmouch & Clavreul, 2016).

Sustainable development: Meeting the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987).

Vulnerability: Sensitivity to harm and lack of capacity to cope and adapt (UNESCO, 2021).

Water resource protection: Prevention of the pollution of water resources, to maintain an acceptable quality to be used in an ecologically sustainable manner (DWS, 2023d).

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND TO THE STUDY

A country's development depends on establishing a water governance framework that considers both water availability and quality. The international sustainable development goals established in Agenda 21 by the United Nations (UN) at Rio de Janeiro, Brazil, in 1992, facilitated a paradigm shift that led many countries to revise their water legislation (UN, 1992:1–5). The efficient use of local knowledge in implementing water management involves traversing the domains of water management and water governance, where water resources include hydro-social factors, with both people and policies at the centre of water issues (Hezri & Dom, 2017:1–3).

Developing countries face a significant lack of data and information production on water resource protection due to several factors, including fragmented information flow, lack of funding, inadequate policy frameworks, insufficient human capacity and related skills, and lack of standardised methods (Bliss *et al*., 2001:160–165; Johnson *et al*., 2021:458–464). Globally, effective water resource management requires collaboration among experts in the water sector to implement a robust integrated water resource management (IWRM) approach (Global Water Partnership, 2024). The IWRM approach includes environmental management, economic development, and public participation or stakeholder engagement (Hezri & Dom, 2017: i–iv; Dirwai *et al*., 2021:2). When all stakeholders and interested and affected parties – including the community and civil society – are involved in the entire value chain of IWRM, access to information increases at a lower or no cost, as participants are residents with no travelling expenses. Data availability becomes enhanced as community members contribute indigenous knowledge relative to the area and in line with the objective (Conrad & Hilchey, 2011:276–279; Bannatyne *et al*., 2017:366–375). Cost-saving, timesaving, and value for money are the opportunity cost-saving factors that promote economic efficiency, thereby ensuring successful stakeholder engagement (Akhmouch & Clavreul, 2016:8–13; Savitri & Gail, 2016:12–37).

One of the challenges of community participation in water resource management is that local-level stakeholders have limited or no support in strategic or operational information system decision-making, particularly in developing countries (Quin, 2012:1–24). To address this challenge, Mwaka *et al*. (1999:1–27) and Johnson *et al*. (2021:452–566) identified the need to facilitate sector engagement and formulated strategies to broaden access to information and encourage the commitment of community members and non-governmental organisations (NGOs) to improve water resource management. Mwaka *et al*. (1999) focused on rural perspectives, while Johnson *et al*. (2021) examined digital approaches.

Access to information is related to good data management, which includes incorporating available data into decision-making as one way of conducting data management (Government of Western Australia [GWA], 2023:6–50). Data gaps in the availability, use, and quality of water are challenges hampering informed decisions in most developing countries, leading to disasters that could have been avoided had a robust approach been put in place. For example, the catastrophic flood that hit the Philippines in 2012 could have been avoided if flood data had been collected in time (Hezri & Dom, 2017:18). Water resource management is therefore crucial for protecting valuable and vulnerable water resources (Mosello *et al*., 2015:40; Bannatyne *et al*., 2017:366–375).

Water is a scarce commodity essential for livelihood, human health, poverty alleviation, economic growth, and environmental sustainability (Sorooshian, 2024:8), making it a key resource for sustainable development. The Brundtland Report (1987) defines sustainable development as development that meets the needs of the current generation without compromising those of future generations (Brundtland, 1987; Dasgupta, 2021:331). Recognising water's critical role, access to clean and affordable drinking water has been established as a universal human right (Statistics South Africa [Stats SA], 2022b:33–38) to support socio-economic development. Improving livelihoods ranges from food security to human and environmental health, contributing to improved social well-being (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2021). A study by the Association for Water and Rural Development (AWARD) (2018:1) has reported that socio-economic development carried out without depleting natural resources or degrading the environment should be encouraged to ensure sustainable development. However, anthropogenic activities such as urbanisation, mining, and industrial growth result in water scarcity and quality deterioration, which hampers sustainable development, thereby negatively affecting people's livelihoods. These human-related impacts, together with climate change impacts such as floods and droughts, are among the key drivers of water scarcity; therefore, water policies for water resource management need to be strengthened to ensure adequate enforcement, alongside stakeholder involvement and policy change that require optimal governance (Hezri & Dom, 2017: i–ii).

Governments or authorities cannot resolve issues pertaining to water pollution on their own, as these challenges require joint efforts with various stakeholders, including industries, agriculture, municipal water users, and the community at large (Bedawy, 2014:108; Makurira & Mugumo, 2005:172). An effective institutional framework for engaging water resource institutions must involve all levels of governance, from national government to catchment and community levels, especially in developing countries (Bedawy, 2014:108). Notwithstanding the involvement of all stakeholders in the value chain, it is paramount for all people to change attitudes and commit to change (Kativhu *et al*., 2021:21). An operational plan with a clear

mandate is vital, not least in developing countries such as Ethiopia, South Africa, and Nepal, where institutional roles are not clearly articulated. In some parts of the world, decentralisation helps focus on water management at local levels, creating better opportunities for community members to participate in local programmes (Goldin *et al*., 2023:56). For example, similar to the catchment management agency (CMA) concept in South Africa, Malaysia has established an agency to manage rivers at a local level to combat an autocratic government style of management that was impeding IWRM implementation (Hezri & Dom, 2017:18–27). Similarly, in Ethiopia, various monitoring programmes were designed in isolation to meet individual functional data needs, pointing to a need to harmonise monitoring programmes and encourage information sharing among different institutions, including community-based water monitoring (CBWM) programmes (Mosello *et al*., 2015:33–50).

Community-based monitoring (CBM) refers to participation of community members across diverse disciplines ranging from health to education. CBWM is a water-related CBM specialised area dealing with hydrology, water quality and aquatic ecosystem. While all CBWM initiatives are examples of CBM, not all CBM involves water. The literature review chapters, Chapters 2 and 3 focused on the use of CBM in broad, and introduced CBWM usage in Section 3.5.4, which was consistently used in Chapter 4 to Chapter 6. However, the discussion sections in Chapter 5 used CBM in source referenced text and the reference list.

Determining and studying the benefits and pitfalls of CBWM programmes is vital, particularly in terms of determining how selected catchments in South Africa can benefit from CBWM programmes. This study, therefore, assessed the potential value of CBWM initiatives in decision-making processes aimed at protecting water resources. A gap was identified by examining existing literature conducted during the literature review phase to identify limitations and inconsistencies. That gap showed that either limited research has been conducted or outdated guidelines applied on stakeholder engagement in achieving water resource management and protection objectives (Mosello *et al*., 2015:42; Moolman, 2023:147). Consequently, this study sought to promote stakeholder inclusion from the planning stage through to the implementation of water resource protection strategies and initiatives.

1.2 PROBLEM STATEMENT

Several challenges have been reported in terms of CBWM, one of which is the lack of strategic support for the participation of local-level stakeholders in decision-making, a gap that this research tried to fill within the developing country context of South Africa (Quin, 2012:1–24). Carlson and Cohen (2018:168–177) reported that CBWM data are seldom used to inform decision-making in government policy.

The involvement of civil society comes with its own set of challenges, such as mistrust, unclear roles, power (hidden agendas), uneven education levels, language barriers, and gender

preferences. In the absence of policies guiding or standardising monitoring procedures, citizens' role in monitoring is called into question (Gray *et al*., 2001:3–20; Blomquist & Schlager, 2006:106–114; Bannatyne *et al*., 2017:366–375).

As much as it takes time and effort to create a unified vision, community involvement in environmental issues is a long-term investment (Savitri & Gail, 2016:12–37). Conrad and Hilchey (2011:273) identified major gaps in citizen science and CBWM. To address these gaps, they compared possible outcomes of CBM programmes and the utilisation of CBM data in decision-making processes to devise solutions and understand the social, economic, and ecological benefits. Conrad and Hilchey's (2011) recommendations are supported by Johnson *et al*. (2021:452–566), who indicate that not much is known about the use of CBM data into tangible outcomes. The need for water governance to promote social learning is backed up by the need for the integration and transfer of local, scientific, and technological knowledge. Pallo *et al*. (2024:210–211) highlighted the need for considering community social impact in water resource management, as it affects water scarcity and aquatic ecosystem health.

Mosello *et al*. (2015:33–50) highlighted the need to harmonise water monitoring programmes and encourage information sharing among different institutions– another gap this research sought to fill. The verification of the effectiveness of stakeholder engagement in reaching the intended objectives (Akhmouch & Clavreul, 2016:8–13) is another gap identified in the literature. Considering these challenges, the purpose of this study was to holistically investigate the potential value of CBWM in resource protection decision-making in the developing country context of South Africa, using a multiple-case study approach.

1.3 RATIONALE FOR THE RESEARCH

Water resource management and protection demand stronger sector engagement, improved access to information, and greater commitment from external stakeholders and NGOs to enhance water resource management in a rural setting representative of a developing country (Mwaka *et al*., 1999:1–27). While access to information is a key element of good data management, this is not sufficiently happening between CBM organisations and their respective governments (Carlson & Cohen, 2018:168–177). Incorporating data into decision-making is one way of ensuring efficient information sharing (GWA, 2023:50). Mwaka *et al*. (1999:1–27) assert that a CBWM framework must be pitched at the lowest level of management and be realised through the establishment of public involvement, with fully delegated financial and management powers. While the participation of community members in water resource management in the rural settings of South Africa is essential, in developing countries, water resource management presents critical issues associated with dynamics such as mistrust, ambiguous roles, and diverse educational backgrounds. In addition, the complexities associated with limited local-level stakeholder participation and support in CBWM

initiatives pose substantial challenges. Existing literature underscores a notable gap in the integration of CBWM data within water policy frameworks, highlighting the urgent need for information flow and engagement between CBWM programmes and governmental entities. The concept of IWRM in Asia and Africa does not include water resource protection, a shortfall identified as lack of implementation in India (Hezri & Dom, 2017:1–3), and water security issues in Ecuador and Burkina Faso (Sally *et al.,* 2011:375; Ködmön and Szőke, 2025:8977). This study aimed to explore the potential value of CBWM in water resource protection decision-making in South Africa as a developing country.

By investigating the benefits, challenges, and criteria for success within CBWM programmes, the study evaluated how CBWM initiatives can influence the decision-making process and the use of data for the protection of water resources. This was accomplished by examining community experiences and governance structures in the selected three catchments that served as case studies. The study aimed to propose a holistic, stakeholder-oriented, cost-effective, and user-friendly framework designed to improve water protection data informing decision-making processes. This framework supports the call for education and awareness around CBWM initiatives and emphasises the importance of common environmentally sustainable solutions.

Despite the recognised benefits and challenges of CBWM participatory approaches in water monitoring, the existing literature lacks investigations into the tangible value of CBWM in shaping water resource protection decision-making. By addressing this gap, as identified by Conrad and Hilchey (2011:273), the study would enhance academic understanding of the effectiveness of CBWM initiatives and provide a pathway for improving water governance practices in South Africa.

This study pursued CBWM as a fundamental approach to enhancing community involvement and informed decision-making in water governance. The research employed a robust methodological framework, as detailed in Section 1.5, to ensure a systematic exploration of the research questions and study themes. It is hoped that this research will ultimately contribute to sustainable water resource management strategies for this region.

1.4 RESEARCH QUESTIONS

Main research question

What is the potential value of CBWM in water resource protection decision-making in a developing country context such as South Africa?

Sub-research questions:

The overall research question was informed by the following sub-research questions:

1. What are the benefits, values, pitfalls, and challenges of CBWM programmes?
2. What criteria should be considered in CBWM in developing countries?
3. Based on the opinions of governance structures and the real-life experiences of communities, to what extent do the selected catchments in South Africa, as a developing country, benefit from CBWM?
4. What are the views of governance structures on the extent to which CBWM operates in South African communities?
5. How might a conceptual framework work by enhancing the use of CBWM data in decision making for developing countries?

1.5 RESEARCH STRUCTURING AND LAYOUT

The research was structured around six steps, resulting in six chapters (Figure 1.1), designed to address the five sub-research questions. The structuring and layout of this thesis mark the conclusion of this chapter and are presented in detail in Sections 1.5.1–1.5.6.

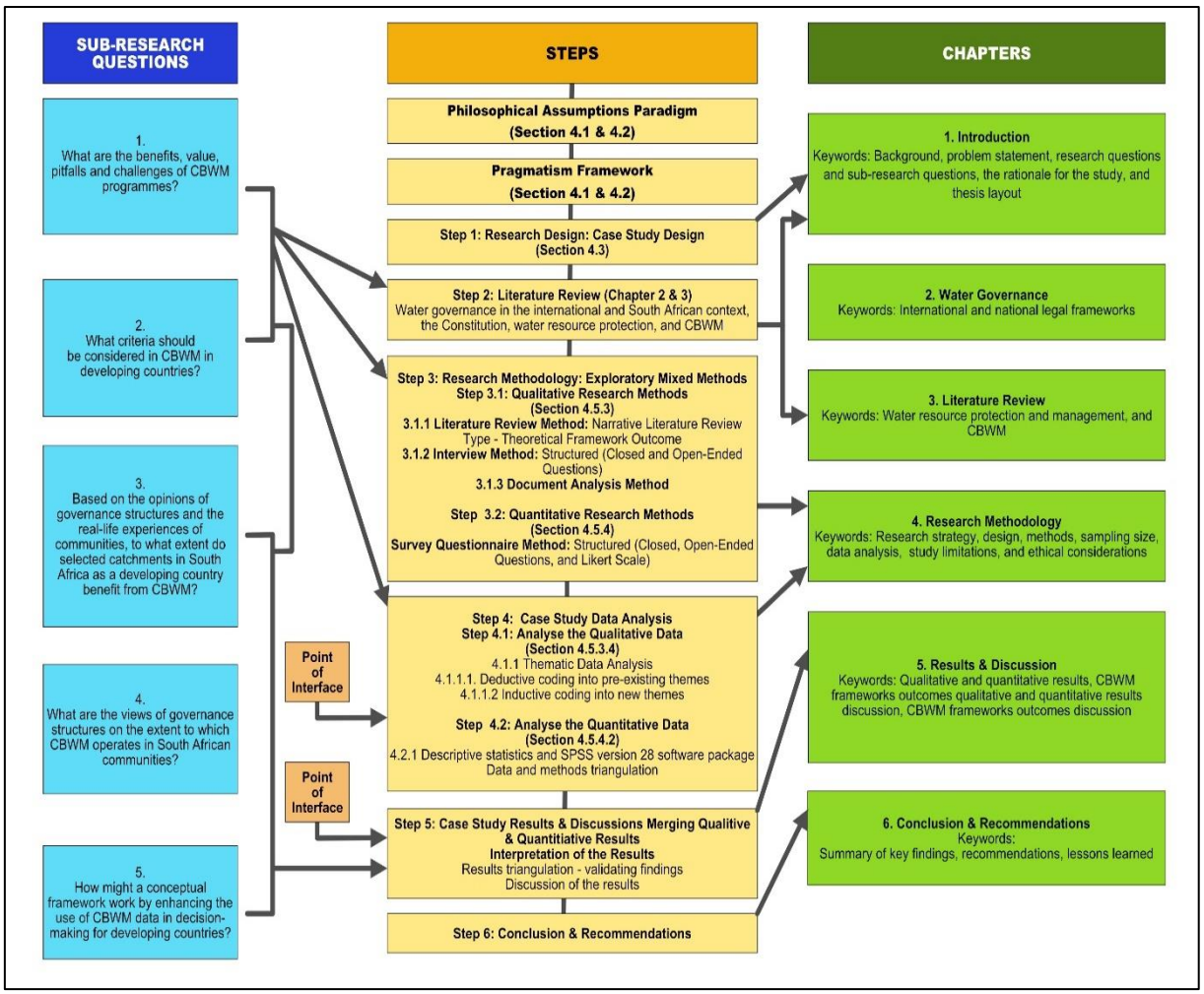


Figure 1.1: Research structure and layout

Source: Adapted from Creswell & Plano Clark (2011), Terrell (2012), and Moolman (2023)

1.5.1 Step 1: Research design

Step 1 of the research focused on designing the research using a case study approach (as discussed in Chapter 4 – Research Methodology) to address research questions concerning the value of CBWM in water resource protection decision-making presented in Chapter 1. The alignment between Step 1 and Chapter 1 ensures that the choice of design is suitable for capturing participants' insights in response to the research questions.

1.5.2 Step 2: Literature review

Step 2 focused on the literature review in Chapters 2 and 3 and contributes to the responses to sub-research questions 1 and 2 regarding the benefits, challenges, and criteria of CBWM programmes. Chapter 2 provides an overview of water governance in the international and South African context, while Chapter 3 presents the literature review as a research method and baseline information for the study, which resulted in the study's theoretical framework detailed in Section 3.6.

1.5.3 Step 3: Research methodological approach

Step 3 of this research, addressed in Chapter 4, delineates the research methodology and the guidelines for the application of qualitative and quantitative methods applied in the three case studies. This includes a discussion of the research design, sampling procedure, data analysis, data storage, and ethical considerations.

1.5.4 Step 4: Case study data analysis

The case study data analysis of both qualitative and quantitative data outlined in Step 4 of this study forms part of Chapter 4. Qualitative and quantitative data were analysed separately, with thematic and descriptive approaches used for qualitative data, and SSPS software and inferential approaches used for quantitative analysis.

1.5.5 Step 5: Case study results and discussion

The interface points between the two research methods discussed in Step 4 were used as an initial point for the fifth step of the study. Step 5 entailed evaluating the case study's findings against sub-research questions 3–5, using data from interviews and survey questionnaires, as presented in Chapter 5. Chapter 5 provides the interpretation and discussion of the results, synthesising the overall research findings and discussion of the data, bringing in discussions from other sources.

1.5.6 Step 6: Conclusion and recommendations

Chapter 6 presents the study's conclusion and recommendations, synthesising key findings and providing recommendations regarding the research question and sub-questions posed in Chapter 1.

1.6 CONCLUSION

Chapter 1 provided an overview of the background, problem statement, research questions and sub-research questions, and rationale for the study. It concluded with the structure and layout of the thesis. The following step, Step 2, comprises two chapters, Chapters 2 and 3, covering water governance (review of the global and South African legal framework) and the literature review (comprehensive review of water resource protection, CBWM, and presentation of the study's theoretical framework), respectively.

CHAPTER 2: WATER GOVERNANCE REVIEW

2.1 INTRODUCTION

Step 2 of the study, the literature review, illustrated in Figure 2.1, is divided into two chapters, Chapters 2 and 3, and is the initial step in addressing sub-research questions 1 and 2, providing a comprehensive review of the existing literature. While Chapter 2, water governance, relates to the legal framework, Chapter 3 comprises a literature review and document analysis related to water resource protection, CBWM, and the study's theoretical framework as an outcome. The reason for breaking the literature review into two chapters was to ensure the study's theoretical framework is highlighted as an output of the literature review content.

This chapter marks the first part of the literature review step, and its purpose is to discuss the legal framework, within a global context, used to guide the management of water resources, with specific reference to water resource protection.

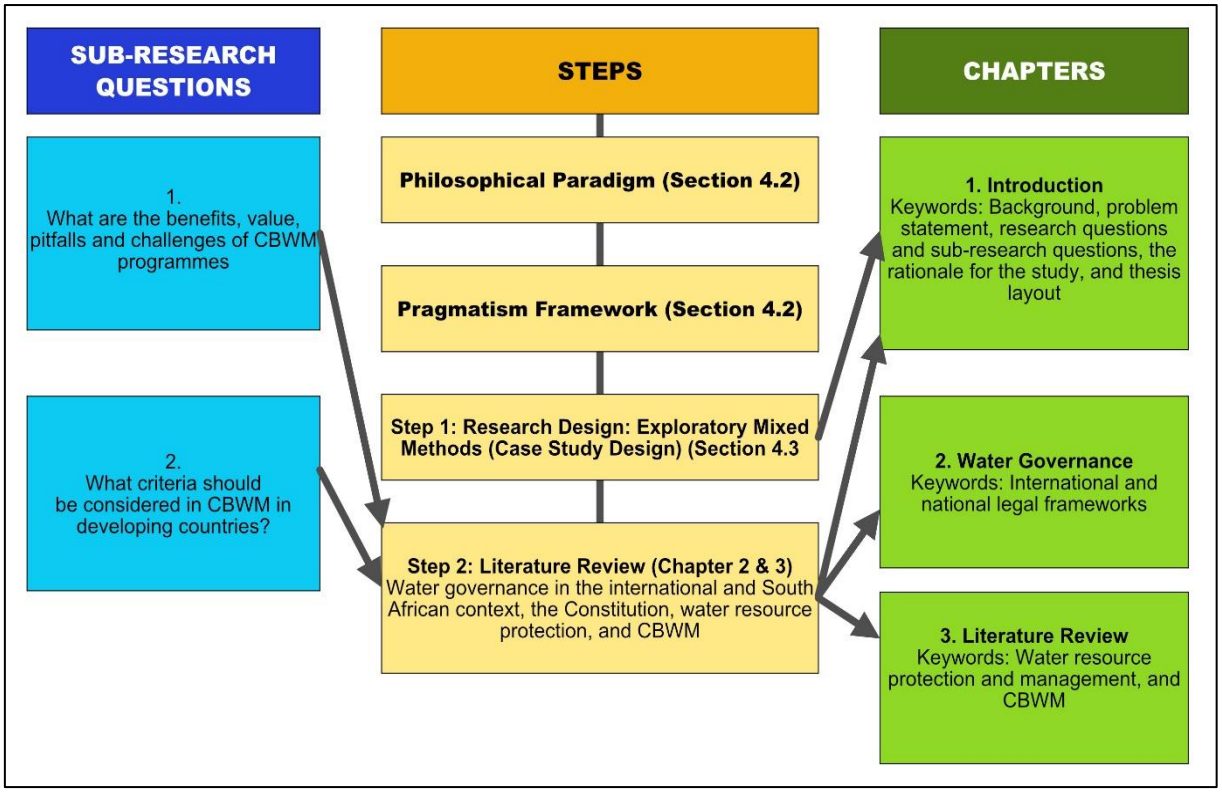


Figure 2.1: Research layout of the literature review in Chapters 2 and 3 (Step 2)

This review encompasses insights from a wide range of studies, exploring key themes in the literature on CBM and CBWM initiatives. Identified themes include best practices in water monitoring and management, the role of collaborative governance in fostering stakeholder participation, assessments of water quality status, and analyses of the legal and institutional frameworks governing water resource management. Water governance includes legal and

institutional frameworks that guide decision-making, policy development, and the implementation of actions in water management across organisations, communities, and society.

While Khair *et al*. (2021:22) emphasises the role of CBWM initiative as instrumental in bridging the gap between communities and government through participation in governance, Lotz-Sisitka *et al*. (2019:17) highlights the importance of the legal and institutional framework for political buy-in, suggesting that community participation is the priority goal for both CBWM and collaborative governance.

A sustainable governance system determines the effectiveness of water, sanitation, and hygiene services (United Nations–Water [UN–Water], 2019:1–2). Collaborative networks between CBM and government partnerships benefit CBM initiatives by enhancing access to monitoring resources and knowledge, and the opportunity to use data in decision-making, as the government provides data quality assurance, funding, and capacity building through increased levels of community interaction with government-appointed experts. The provision of data storage, analysis, and reporting completes the CBM-government partnership (Carlson *et al*., 2017:19).

2.2 LEGAL AND INSTITUTIONAL FRAMEWORK FOR WATER RESOURCE PROTECTION

2.2.1 Overview of the legal framework and governance tools

The legal framework for water resource protection calls for an integrated approach, including socio-economic development and ecological sustainability for all stakeholders contributing to the implementation of integrated water resource management (IWRM), as prescribed by the UN 2030 Agenda for Sustainable Development (Global Water Partnership [GWP], 2024:1). The European Union and African Union are international organisations engaged in water resource management issues on the African continent, playing a vital role in achieving the Sustainable Development Goals (SDGs), which apply to all countries, regardless of financial status (UN, 2015:1; Goldin *et al*., 2023:30–38).

Legislation governing water rights differs according to country, with most African and Asian countries recognising customary water rights attached to land ownership legislation (Goldin *et al*., 2023:30). In most developed countries, water rights are no longer linked to property ownership but are instead treated as user rights (van der Zaag *et al*., 2002:19–32). Over the past two decades, developing African countries such as South Africa, Eswatini, Zimbabwe, and Tanzania have been revising their water laws to adopt a user rights approach (Makurira & Mugumo, 2005:167). However, the water laws in most developed countries such as New Zealand, the Netherlands, and France are advanced. Such countries regard water as a public

good and take into consideration the IWRM approach, focusing on economic growth, the environment, regulatory governance institutions, and public consultation (van der Zaag *et al*., 2002:19–32; Davis & Threlfall, 2006:86–99; Nion 2009:221–230). In addition, New Zealand's sustainable management legislation includes integrated resources such as air, land, water, and the ecosystem (Davis & Threlfall, 2006:86–99). France's Water Policy provides funding for water agencies to involve stakeholders at catchment level in water resource protection (Nion, 2009:221–230).

Most developing countries are still struggling with poverty eradication, and the provision of basic water and sanitation in certain areas remains a challenge. Consequently, their legislation governing water management is not yet sufficiently aligned to address these challenges. Water policies in most developing countries, especially African countries, are centralised and managed at a strategic level, and are limited in terms of incorporating an IWRM approach that encompasses the environment, water quality, economic development, and public participation or stakeholder engagement (Davis & Threlfall, 2006; Makurira & Mugumo, 2005:168). Water resource management in Egypt, for example, faces a struggle between increasing water demands and limited supply caused by low rainfall, high salinity concentrations, and evaporation. Egypt's water policy has had limited success in aligning with the IWRM approach. Efforts to include water quality management in policy have not materialised, as effective pollution control regulations are not yet in place to prevent pollution (Bedawy, 2014:108).

The policy and legislative frameworks of some developing countries in Asia and Africa have managed to integrate IWRM in principle, but not in practice. Malaysia still lacks comprehensive water legislation, and the implementation of its water policy was said to require revision and integration into IWRM (Hezri & Dom, 2017:i–iv). The evidence provided by Pallo *et al*. (2024:212–213) further reinforces the idea that most developing countries like Ecuador have solid water resource management legal framework in place, but implementation is still a challenge. The Ethiopian government continues to struggle with implementing its framework, which is sound in principle, due to a lack of funding, stakeholder coordination, relevant skills, and fragmented water governance (Mosello *et al*., 2015:34–56). Contrary to Mwaka *et al.*'s (1999:1–27) highlight on Tanzania, East Africa, their domestic water use is declared a priority water user, followed by livestock, and then irrigation, the *National Water Act* 36 of 1998 [NWA] stipulates that the South Africa's water legislation grants allocation rights only to the Reserve, defined as the quantity and quality of water required to meet basic human needs and protect aquatic ecosystems. Ködmön and Szőke (2025:8977), like Tanzania, offered a contradictory perspective regarding Burkina Faso–a war zone in West Central Africa–on the country's holistic water management strategy, which treats water as a strategic asset for stability and development, not merely for basic human needs. However, this contrast raises concerns, as the provision should generally form part of the global engagement with civil society at the local

level in developing countries for the monitoring, evaluation, and reporting of the SDG (UN, 2015:12–24; UN Peacebuilding, 2020:1–25).

2.2.1.1 Sustainable Development Goals

The 17 UN SDGs, adopted in the UN General Assembly in 2015, are an international set of goals with associated targets and indicators that UN member states are expected to use to guide their agendas and policy decisions by 2030. The SDGs replaced the Millennium Development Goals (MDGs) in 2015, introducing a broader and more integrated framework that addresses social, economic, and environmental dimensions of development. Designed to promote global collaboration across both developed and developing countries, the SDGs aim to improve livelihoods and secure a sustainable future by balancing the three dimensions of sustainable development: environment, social, and economic (UN, 2015:1–6; Sorooshian, 2024:1–14). The goals are outlined as follows: SDG 1 – poverty alleviation; SDG 2 – hunger eradication; SDG 3 – health and well-being; SDG 4 – quality education; SDG 5 – gender equality; SDG 6 – clean water and sanitation; SDG 7 – affordable and clean energy; SDG 8 – economic growth; SDG 9 – industry, innovation, and infrastructure; SDG 10 – equity; SDG 11 – sustainability; SDG 12 – protecting the planet against pollution; SDG 13 – climate action; SDG 14 – aquatic life; SDG 15 – terrestrial life; SDG 16 – justice for all; and SDG 17 – partnerships. SDGs 6, 13, 14, and 17 are particularly relevant to the water sector, with SDG 6 and SDG 17 specifically highlighted for this study.

SDG 6 focuses on the management of water and sanitation, including the elimination of open defecation, and is driven through targets and indicators used to determine different components and monitor progress. One SDG 6 target relevant to the protection of water resources is target 6.3, which addresses the improvement of water quality, wastewater treatment upgrading, and the implementation of IWRM at all levels.

Implementation of the SDG 6 2030 targets to improve the healthy functioning of water resources from a security and development perspective requires the adoption of SDG 17, which emphasises the need to strengthen the implementation of global partnerships (UN-Water, 2019:1–2). Inadequate partnerships and stakeholder cooperation may constrain the achievement of the SDGs. Compliance with SDG targets requires supportive policies and cooperation from all actors at all levels within member states (Sorooshian, 2024:1–14), including South Africa.

The SDG framework encompasses civil society involvement and local partnerships with community members (Sandler Clark, 2015:1–3) and was thus considered an overarching international framework relevant to this study. The SDGs incorporate human rights considerations and private sector involvement in the poverty alleviation journey (Sandler Clark 2015:1–3), which supports the view that community members should be crucial participants in

achieving the SDGs, as was the case with the MDGs (Haddock & Devereux, 2016:68–74). The SDGs were endorsed by all Heads of State, including South Africa, and currently serve as a reporting framework for monitoring progress towards sustainable development and ensuring accountability among all stakeholders for achieving the goals by 2030 (UN, 2015:5; UN, 2018a:13–19).

2.2.1.2 Constitution of the Republic of South Africa

UNESCO (2021:1–5) emphasises that access to safe drinking water and dignified sanitation is a human right, aligning with Principle 8 of the South African Water Reform Programme (NWA 1998). According to the UN (1992:9–25) and Section 24 of the Constitution of the Republic of South Africa (1996), “everyone has a right to an environment that is not harmful to their health or well-being”. Chapter 3 of the Constitution introduces the concept of “cooperative governance”, which integrates the national, provincial, and local spheres of government to perform their functions in the spirit of governance. Cooperative governance encompasses all organs of state, the private sector, and civil society. Community-based water monitoring initiatives are civil-society-based and promote citizen science.

The effectiveness of the Constitution relies on the National Development Plan (NDP), which is the implementation plan that reflects and operationalises South African constitutional ideals to ensure participatory governance (Department of Water and Sanitation [DWS], 2023d:2).

2.2.1.3 National Development Plan

An NDP outlines a country’s strategic development objectives, articulating its social and economic plans (UN-Water, 2019:5). In the South African context, the NDP presents the country’s vision for 2030, clearly articulating the development objectives of poverty alleviation and equity promotion, while also implementing the National Water Resource Strategy Edition 3 (NWRS 3) (DWS, 2023d:5–8). The South African NDP also prioritises climate change impacts and water shortages, addressing these through environmental sustainability measures including water conservation, demand management, and nature-based solutions (Dasgupta, 2021:438; DWS, 2023d:49–52). However, a gap remains in effective cooperative governance monitoring that incorporates community members into the implementation of both the NWA and the NDP, due to insufficient policy support for CBWM (van Koppen *et al*., 2020:7–9).

2.2.2 White Paper on a National Water Policy for South Africa

The White Paper on a National Water Policy of 1997 (NWP) provides the regulatory framework for the South African government to fulfil its mandate to uphold the legal obligation of linking water availability with the provision of water supply and sanitation services to every citizen. It is governed by Section 27 of the *Constitution* (1996) that stipulates that everyone has the right to have access to water. Water in South Africa is now regarded as a public good (NWA, 1998),

unlike the apartheid regime reign when the old Water Act of 1956 implements the riparian rights system of linking water rights with property rights (van Koppen, 2022:383–396). The apartheid era laws discriminated and deprived black population against the privileged white people. The inequalities of the apartheid laws affected even access to water and service delivery, and its aftermath is linked to poor water quality and inadequate service delivery in some rural areas (Jegede & Shikwambana, 2021:3–11). A trajectory pattern in Burkina Faso, as highlighted by Sally *et al.* (2011:375), indicating the inequalities of the past led to the displacement and evictions of the under privileged, and the impediment of access to water. Redressing the inequalities of the past, without justifying the position of privileged restores trust, minimises conflicts, and supports sustainable water security (Ködmön & Szőke, 2025:8967–8977). The NWP incorporates two pieces of legislation: the NWA, and the Water Services Act 108 of 1997 (WSA). The NWA operationalises this policy and ensures that water resources are used, protected, developed, conserved, managed, and controlled sustainably. The WSA (1997) complements the NWA and provides for the right of access to basic water supply and sanitation services. The NWRS 3 sets out the goals and actions required to implement the NWA and is aligned to the SDGs, as the DWS is obliged to report to the relevant SDGs (DWS, 2023d:6–8).

2.2.2.1 National Water Resource Strategy

The NWRS advocates for the sustainable and equitable use of water and provision of sanitation services for all citizens of South Africa, which is in line with the country's NDP and the SDGs. The NWRS and the National Water and Sanitation Master Plan (DWS, 2018:17) define the functions of different stakeholders such as government institutions, local municipalities, catchment management agencies (CMAs), water users, and community members within the water sector to give effect to the NWA (DWS, 2023d:76).

2.2.2.2 Catchment management agencies

The NWA (1998) made provision for establishing CMAs as implementing agencies to assist DWS in fulfilling its mandate, through collaboration and partnership with all spheres of government, including civil society. The purpose of CMAs is to decentralise water management powers to the local level. The CMAs are local water management structures within water management areas (WMAs) that play an important role in the implementation of the NWRS 3, guided by the Catchment Management Strategy (CMS), which outlines the water resource management principles for each CMA (DWS, 2022a:32–38).

The CMAs collect data and information and report to national DWS offices, which use this information to regulate the objectives of the NWRS 3 and to inform planning, decision-making, and policy development (DWS, 2023d:48–56). Water resource protection, compliance, monitoring, and enforcement activities at the catchment level are more effectively managed

within community boundaries by CMAs. Of the six proposed CMAs to be established, the Inkomati–Usuthu CMA operates within the Limpopo–Olifants WMA where the three case studies for this study were identified.

At the national level, South Africa's legal framework for protecting water resources includes Resource Directed Measures (RDM) and Source Directed Controls (SDC). However, water protection and management at the catchment level is the mandate of the CMAs, facilitated by community involvement, hence the inclusion of the CMA section in this study.

2.2.2.3 Resource Directed Measures

The RDM, a similar concept to that of the American Water Resource Association (Snelder & Biggs, 2007:1225–1237), are stipulated in Chapter 3 of the NWA. Parts 1, 2, and 3 of Chapter 3 of the NWA set out a series of measures to protect water resources, aligned with the NWRS 3 and the CMS. The first stage of protection is described in Part 1 as the "Classification system for the water resources", in which a system to classify the nation's water resources is developed. The system provides guidelines and procedures for classifying water resources into different classes. Part 2 serves as the second stage of the series, which entails the classification of water resources (rivers, wetlands, groundwater, estuaries, and lakes), and then determines the Reserve and the resource quality objectives (RQOs). The inclusion of the RDM, encompassing the Water Resource Classification System (WRCS), Reserve, and the RQOs as detailed below, is considered crucial in this study. They are the planning tools coordinated at a national level, to protect water resources that guides the involvement of local communities in the planning and implementation of measures aimed at the protection of water resources.

(a) Water Resource Classification

The WRCS is stipulated in the NWA (1998) as a set of guidelines and procedures that determine the desired characteristics that place water resources (rivers, estuaries, wetlands, and aquifers) into management classes (MCs). The MC outlines attributes required by the DWS and society, as well as those needed for different water resources. The WRCS prescribes a consultative process (with various stakeholders, including civil society) to classify water resources (classification process) and facilitate a balance between protection and use of the nation's water resources (NWA, 1998).

Water resources are classified into three MCs, ranging from Class 1 (minimally used resources resulting in minimally altered water resources) to Class 3 (heavily used resources resulting in significantly altered water resources).

(b) Reserve Determination

In a sustainable world, the management of water resources is for the benefit of human health and environmental integrity (UNESCO, 2021:1–5), and in the South African context, it is referred to as water for the Reserve (NWA*,* 1998). The need to protect water resources, which is the main purpose of the study was based on the country's mandate to protect the environment and the basic human need, for the benefit of the community. The Reserve is determined for a specific water resource and is defined in the NWA (1998) as the quantity and quality of water of that resource necessary to:

- Satisfy basic human needs by securing a basic water supply, as prescribed under the WSA, for people who are currently or who will in the reasonably near future be relying upon that resource, who will be taking water from that resource, or who will be supplied from that resource (known as the basic human needs Reserve); and
- Protect the aquatic ecosystems to secure ecologically sustainable development and use of the relevant water resource (known as the ecological Reserve).

(c) Resource Quality Objectives

The RQOs are numerical and narrative descriptions of conditions that need to be met to achieve the required MCs, as determined during the resource classification. To ensure that appropriate RQOs are set for each MC, clear water resource quantity and quality goals required to implement the MCs are set. The process stipulates that in determining RQOs, a balance is sought between the need to protect, sustain, and use water resources (NWA 1998).

Following the setting of the RQOs, the implementation of the RDM in the form of compliance monitoring follows. The Reserve, in the form of the ecological water requirements, is monitored for RQOs compliance. Compliance with RQOs is implemented through the application of SDC measures: water quantity, water quality, in-stream and riparian habitat, and aquatic biota. The RQOs are benchmarks for sustainable management of water resources, as monitoring results serve as evidence to stakeholders and the communities on progress towards set goals, hence relevant to this study.

2.2.2.4 Source Directed Controls

The SDC are water resource protection measures focusing on the management of land-use activities such as water abstraction and effluent disposal from different sources such as wastewater treatment works (WWTW), industrial activities, mining operations, and agricultural practices. These land-use activities are associated with human activities and water users. The SDC entail activities around pollution prevention and control of pollution incidents, of which community members as contributors should be a part, making the SDC relevant to this study. The following regulations and enforcement measures give effect to the SDC:

(a) Water Use Licensing Authorisation

All water users require Water Use Licensing Authorisation (WULA) prior to using water for any purposes stated in the NWA (1998), section 21 (a)–(k) as a way of regulating water use. Apart from Schedule 1, which includes water for domestic purposes, gardening, and animal watering, all other water uses must be authorised under a General Authorisation, Existing Lawful Use, or WULA. The authorisation process depends on the amount of water abstracted from a water resource, either surface water or groundwater, and the type, volume, and concentration of wastewater discharged into the water resource. WULA represents a first step in monitoring and managing point sources of pollution, as all water users within the catchment should be known, as well as details on which ones are likely to be potential polluters on account of their land use activities. The cumulative impact of all licensed discharges is used to monitor RQO compliance and to calculate waste discharge charges according to the Waste Discharge Charge System (WDCS) (Reddy & Mgwebi, 2012:6–8).

(b) Polluter Pays Principle

This licensing framework underpins the integrated catchment management concept that emerged from linking the two water resource protection measures, the RDM and the SDC. The Polluter Pays Principle, originally developed through Agenda 21 (UN, 1992:1–5), later informed the development of the SDC. From this, the Hierarchy of Decision-Making emerged, which was further refined through the establishment of the WDCS in 2012. The Polluter Pays Principle serves as the baseline for the WDCS, as the initial concept behind the strategy was intended to operationalise this principle.

(c) Waste Discharge Charge System

Building on the Polluter Pays Principle, the WDCS promotes water quality management in an IWRM manner, integrating ecological-environmental, social, and economic imperatives. According to the Department of Water Affairs (DWA) (2013a:4–5), the WDCS is based on two categories of charges: the legal mandate and acceptable limits. The system uses economic incentives and penalties to reduce pollution. Revenue collected from polluters is intended to mitigate and rehabilitate the cumulative impact for the benefit of downstream users or the aquatic ecosystem. The health of the aquatic ecosystem is measured by the Reserve and according to compliance with the RQO. Whether acceptable or unacceptable, the level of impact on water resources must be taken to stakeholder engagement platforms for agreement before gazetting. The technical processes (classification and RQOs) and stakeholders within the study catchment should determine acceptable standards and social acceptability of waste discharge limits. The WDCS will then be applied based on achieving the RQOs, which implies that the focus will be on catchments where RQOs are compromised or threatened.

Charge calculations consider multiple factors: the type and volume of waste discharged, waste concentration or quality, the likelihood of environmental impact, the nature and extent of such impact, and required monitoring frequency. All registered water users must pay for their discharge load as point sources. These charges also apply in cases where the origin of diffuse sources of pollution cannot be traced. Water users or dischargers are also liable for the opportunity costs of degraded water resources. This opportunity cost represents the lost potential to use water when quality deterioration renders it unacceptable for other purposes.

2.3 SOUTHERN AFRICAN DEVELOPMENT COMMUNITY

The Southern African Development Community (SADC) is an inter-governmental organisation comprising member states made up of representatives of countries situated south of the African continent. It is guided by the Revised Protocol on Shared Watercourse, revised in 2000 (Goldin *et al*., 2023:9), which supports the monitoring of the shared watercourses. This requires cooperative and coordinated participation through public–private partnerships across borders, and a similar principle should apply at the national level. While SADC protocol activities involve cross-border collaboration, responsibilities are initiated by the member states. This section is integral to this study, providing global background and insights into national water resource dynamics that influence South African policy and strategies.

2.4 PUBLIC–PRIVATE PARTNERSHIPS

In a public–private partnership (PPP), the government steers the coordination and focuses on quality assurance, performance monitoring, and corrective actions, while the private sector partner handles the assigned task. In a PPP relationship, private sector players such as industries, mining, and the agricultural sector collaborate with municipal public entities, complementing CBWM efforts to achieve sustainability (Kativhu *et al*., 2021:20). To ensure the success of the partnership, communication and information sharing should be a coordinated effort at all levels (UN-Water, 2019:1–2). For example, according to Thulamela by-laws, the local government in Limpopo supports municipal public engagement that includes community structures (Limpopo Provincial Gazette, 2016:17).

The South African context of public partnership is rooted in the concept of public consultation, as prescribed in sections 3, 140, and 145 of the NWA. These sections make provision for public access to information and for the state’s role as public trustee of the nation’s water resources. Public consultation is a requirement that must be conducted before the execution of any water-related controlled activities, the formation of the CMA as the planning institution for water resources at a local level (Goldin *et al*., 2023:14), the development of the CMS, the formulation of the pricing strategy, and the implementation of water use regulations.

The key objective of the South African National Policy and Strategy was to develop six CMAs countrywide as mitigation measures against climate change impacts and to enhance service delivery to all citizens. To date, the DWS has finalised the establishment of six CMAs: Limpopo–Olifants (North-West and Limpopo provinces), Inkomati–Usuthu (Mpumalanga province), Vaal–Orange (North-West, Gauteng, and Free State provinces), Pongolo–Umzimkhulu (KwaZulu-Natal and Eastern Cape provinces), Mzimvubu–Tsitsikamma (Eastern Cape province), and Breede–Olifants (Western Cape province). While public participation in water resource management provides the activity linked to community participation, the lack of provision for community involvement in water monitoring creates CBWM gaps, necessitating a dedicated CBWM policy.

Sections 8 and 77 of the NWA provide for the establishment of the CMA and the CMS, seeking the cooperation of stakeholders and interested persons. The implementation of the CMA makes provision for a socio-political framework that involves local communities (Ramulifho *et al*., 2019:9). This framework supports climate and water management coordination through good governance principles. Regional cooperation, as demonstrated by the sustainable establishment and implementation of the SADC river basin (Goldin *et al*., 2023:9), reinforces the establishment of the CMA and the CMS (Ramulifho *et al*., 2019:9, UNESCO, 2020:5).

Public partnership is an ongoing collaborative process to assist the public in becoming involved, exchanging information, improving networks, and gaining insight into concepts, as well as jointly participating with government officials and environmental non-governmental organisations (NGOs) in decision-making (Boivin *et al*., 2010:1–4; Marzuki, 2015:30–35; Savitri & Gail, 2016:12–37). This collaborative approach in water management, which entails community involvement in decision-making, is underpinned by Agenda 21, in the Rio Declaration of 1992 on Public Participation (UN, 1994:1–5). Carlson and Cohen (2018:170–173) and the DWS (2017b:1–5) emphasise that public partnership is a key factor that leads to an informed society, resulting in effective integrated water quality management and CBWM. Credible data collected by the public requires standardisation of the public participation and stakeholder engagement framework (Hoedjes, 2014:1–32; Nepfumbada, 2020:11–32).

In some contexts, public participation and stakeholder engagement are considered similar concepts. However, in this thesis, public participation in the water sector is understood to involve the broader public. In contrast, stakeholder engagement refers to different types of institutions and individuals specifically invited to address a specific topic or theme.

2.4.1 Public participation

Parkins and Mitchell (2003:529–530) define public participation as the process of power redistribution to enable previously marginalised individuals or communities to have access to information and resources and to be meaningfully represented in decision-making.

Public participation in the water sector is defined as the information-sharing process that engages individuals or groups of stakeholders within the community in data collection, generation of new knowledge, and decision-making processes concerning issues that affect their livelihoods, through meetings, surveys, interviews, and focus groups (Dundee Precious Metals [DPM], 2014:3–18; United States Environmental Protection Agency [U.S. EPA], 2018:1–7; World Health Organization [WHO], 2019:11). It provides social benefit to community members as they offer their time and diverse perspectives of solutions and support to government policies and frameworks (Starkey *et al*., 2017:801–817). Public participation enhances partnerships between communities and local authorities, while CBM empowers community members to participate in environmental monitoring in compliance with the SDGs (Khair *et al*., 2020:1–2).

Although several studies in a developing country such as Kenya have explored the effectiveness of public participation in improving the agricultural practices in response to climate change (Gudowsky & Bechtold, 2013:1–35; Hoedjes, 2014:1–32), few have examined information sharing and knowledge reconciliation, indicating a significant gap. However, gaps identified during the public participation process included a lack of information sharing, poor communication, limited feedback to the public on results, and challenges in reconciling scientific knowledge with local or public knowledge (Gudowsky & Bechtold, 2013:1–35; Hoedjes, 2014:1–32). For CBWM to succeed, different public participation processes must be applied (Boivin *et al*., 2010:1–4; Conrad & Hilchey, 2011:278; U.S. EPA, 2018:1–7).

In South Africa, CBWM has been identified as a fragmented practice without a defined governance structure (Lotz-Sisitka *et al*., 2019:3–8). According to section 195 of the Constitution, public participation is considered a constitutional right, not a privilege, as it states that the public must be encouraged to participate in policymaking. This right is operationalised through local government such as municipalities supported by the Municipal Structures Act 117 of 1998 and the Municipal Systems Act 32 of 2000. Municipalities are regarded as the level of government closest to communities in South Africa, hence their mandate for service delivery and public participation. While public participation at the municipal level enforces accountability to community members and enhances governance (Rivett *et al*., 2014:15–22), this approach limits civil society's ownership.

Citizen science participation is a community partnership aimed at aligning science and policy, promoting public participation in policy implementation and ensuring a commitment to equity and inclusiveness (Wehn *et al*., 2023:1). At the same time, it contributes to SDG6b, which aims to support local communities in improving water management (UN-Water, 2019:5). Building on this citizen science approach, CBWM is a mechanism of civil society participation involving local, provincial, and national government, together with academic institutions that provide necessary support (Lotz-Sisitka *et al*., 2019:8–16; Kativhu *et al*., 2021:20). One of the

purposes of this study was to align CBWM with relevant national legislation to ensure that national and international agreements, including SDGs, are met.

The lack of CBWM operational procedures in South Africa – including an effective data management system, appropriate funding, a means of verification for participation – as well as a need for CBWM data to feed into the government's data generation system, was confirmed by Lotz-Sisitka *et al*. (2019:19–28). These factors constitute the need for a CBWM regulatory framework.

2.4.2 Stakeholder engagement

Stakeholder engagement has received attention for the past three decades from various application angles (Rodriguez-Campos, 2012). In South Africa, stakeholder engagement is a legal requirement supported by international best practices such as the SDGs (Savitri & Gail, 2016:12–37; DWS, 2022a:32–38). Stakeholder engagement entails building and maintaining sustainable stakeholder relationships and collaboration between individuals, groups, or organisations to source stakeholder expertise that informs the decision-making process (Akhmouch & Clavreul, 2016:8–13). In this study, the term 'stakeholder engagement' includes stakeholder participation, influencing decision-making, and striking a balance between socio-economic, political, and ecological sustainability. It involves organisations in the private or non-profit sectors, government, the public, civil society, and community-based organisations (Parkins & Mitchell, 2003:529–540; DPM, 2014:3–18; Bourne, 2015; French & Morse, 2015:107–131; GWP, 2024:1–2), and is intended to facilitate agreement on key project or programme milestones and decisions before proceeding to the next phase.

The purpose of stakeholder engagement is to capacitate stakeholders to have meaningful participation, expression of community needs, and partnership to enhance decision-making by creating value and confidence, building trust, and managing shared societal challenges into scientific information (Bal *et al*., 2013; DWS, 2022a:32–38). It is also required to provide feedback for policy formulation (Franceys & Gerlach, 2011:61). The success of stakeholder engagement depends on whether stakeholder inputs are valued (Nemutamvuni, 2018:21) and whether stakeholder expectations are met (Bal *et al*., 2013).

South African legislation promoting cooperative governance and PPP stakeholder engagement draws from the international SDGs, as well as from national and local frameworks such as the NDP and the Water Policy (which incorporates the NWA), as outlined by the NWRS Edition 2 (NWRS 2) (Department of Water Affairs [DWA], 2013b:1–13). The SDGs relevant to CBWM include SDG 6.3: the implementation of IWRM at all levels; SDG 6B: supporting and strengthening local communities' participation; and SDG 17: strengthening global partnerships. Linking SDG targets 6.3, 6B, and 17 to the CBWM context calls for alignment with the principles of the NWA and NWRS 3 (DWS, 2023d:7–72). As a member state affiliated

with the SDGs, South Africa – through the DWS – is reporting on SDG 6 targets but does not mention citizen science or CBWM participation initiatives. This points to the need to integrate CBWM into IWRM for it to be sustainable, as the targets emphasise the importance of supporting and strengthening local communities' participation in water and sanitation management.

In contrast, in some developing countries, such as Ethiopia, a lack of consistency in stakeholder engagement results in uncertainty, which may hamper decision-making (Mosello *et al*., 2015:42–55). Conrad and Hilchey (2011:274) describe stakeholder engagement as a form of transformative engagement suitable for CBM, whose advantage is the involvement of communities in specific local issues.

For stakeholder engagement to be effective, CBM recommendations should be distributed beyond the water community to broaden the scope of discussion and maximise community participation (Mosello *et al*., 2015:58; Starkey *et al*., 2017:802). The regulatory and institutional framework governing PPP processes that manages the collaboration between government entities and private sector companies is crucial to deliver public water resource protection. The participation of government and the private sector contribute to effective water governance, which requires coordination among stakeholders such as the community and civil society.

2.5 CONCLUSION

In this study, the legal framework includes international and national laws and frameworks governing and ensuring accountability and enforcement, while institutional governance refers to watershed bodies, government institutions, NGOs, CMAs, and water users responsible for carrying out water governance. Water challenges affecting the supply of safe drinking water quality can be effectively addressed through cooperative governance. Effective water governance requires the commitment and collaboration of organisations, community members, and broader society. A key focus of this study is to evaluate the potential value of CBWM in water resource protection decision-making in South African community context, of which SADC protocol is considered pivotal in understanding regional integration and its governance impact on South Africa.

Chapter 3 provides an in-depth literature review, focusing on CBWM.

CHAPTER 3: LITERATURE REVIEW

3.1 INTRODUCTION

Chapter 3 is the second of this study's literature review chapters, and marks the final part of Step 2, which focuses on CBWM as a strategy for protecting water resources and concludes with the development of the CBWM Theoretical Framework. The study combines both a literature review and document analysis, detailed in Section 3.7, to provide a comprehensive understanding of the concepts. These research methods complement each other to yield more detailed insights.

This chapter provides a detailed review of the existing international and national literature applicable to this study and the theoretical framework guiding the study process. It begins with a discussion of water resource protection at a global and regional scale and examines the factors influencing water resource degradation. It further explores water monitoring and resource management, which govern how water is managed in relation to CBWM to mitigate the consequences of ecosystem degradation, as well as economic and health impacts. The chapter introduces the concept of CBWM to outline the complexity of policies, practices, and societal factors influencing water resource management strategies.

Given the broad scope of components outlined above, this chapter aims to synthesise the existing knowledge surrounding water resource protection to develop a CBWM Theoretical Framework (Figure 3.2 in Section 3.6.2), underpinning effective community water resource management practices.

The study was grounded in the existing body of knowledge provided by the literature review (Snyder, 2019:333–339; Dirwai *et al*., 2021:3), providing a foundation to support sub-research question 1, which solicits the benefits/value and pitfalls/challenges of CBWM programmes, and sub-research question 2, which identifies the criteria that should reflect in CBWM in developing countries.

3.2 WATER RESOURCE PROTECTION

Water resource protection forms an integral part of the sustainable development process. It requires defined governance structures and implementing agencies to ensure enforcement and monitoring (Mwaka *et al*., 1999:1–27; Makurira & Mugumo, 2005:168; UN-Water, 2019:60–67). The decision-making process is improved by ensuring that economic, social, and environmental integration are considered (UN-Water, 2019:51–57; GWP, 2024:1–2). Water resource protection demands an integrated intervention to manage water ecosystems, water quantity, water quality, habitat (instream and riparian ecosystem), and biota. According to Aslam (2013:22–190), water resource protection prevents water contamination, mainly

bacteriological, due to sewage and surface runoff. It is estimated that between 58% and 75% of the water sources in developing countries are susceptible to pollution because of improper wastewater management (Aslam, 2013:22–190).

The integrated water resource management (IWRM) approach provides for the alignment of water availability with different water users, including the environment (UN-Water, 2021). Cooperative governance requires the engagement and participation of government, the private sector, and community stakeholders in monitoring to give effect to IWRM (Starkey *et al*., 2017:801–817). The legislative frameworks supporting such cooperative approaches vary significantly across different regions and countries.

Water legislation in most developing countries in Asia and Africa is silent on water resource protection. In Asia (Malaysia, Indonesia, and India), IWRM implementation needs to be customised to suit local water norms (Hezri & Dom, 2017:1–3). The Tanzanian Water Utilisation Amendment Act No. 10 of 1981 (which only became operational in 1988, seven years later) was passed with the sole intention of regulating water utilisation and water quality through standards regulating effluent and receiving waters. Tanzania had a similar predicament to South Africa where – despite the launch of the NWA – the implementation of some crucial measures is still not fully in place (Mwaka *et al*., 1999:1–27). This explains why CBWM is crucial: it ensures communities are aware of and participate in water resource protection, thereby enabling them to hold government accountable for implementing and enforcing necessary measures.

3.3 WATER MONITORING AND WATER RESOURCE MANAGEMENT

3.3.1 Water monitoring

Water monitoring creates an understanding of water resource protection efforts, which positively impact water resource management (Goldin *et al*., 2023:8). It entails the assessment of water bodies to collect data or information on chemical and microbial parameters, quantity (flow), and environmental factors (habitat and biota). It also involves assessing the current state of water resources against set measures and standards to track performance, that is, whether the water resource is protected from contamination or not (Gomme *et al*., 2010:4–17; GWA, 2023:6–50). Taking responsibility and accountability starts with monitoring (Bliss *et al*., 2001:160–165), which is driven by the management principle that says, “If you cannot measure it, you cannot manage it” (Goldin *et al*., 2023:iii). Community involvement in monitoring may encourage responsibility and hold government accountable.

In support of South Africa’s legal mandate and policy, Chapter 14 of the NWA and Chapter 13 of the NWRS 2 have given the Minister of the DWS a mandate to establish a national

monitoring system to monitor and disseminate information on the quality of water resources (NWA, 1998; DWA, 2013b:91–93).

As with water monitoring governance levels, water monitoring functions can operate at national, provincial (catchment – water management area), and local levels (DWS, 2015:1–27). As much as water resource management is the mandate of the national DWS in South Africa, water quality monitoring is shared among various levels of institutions (e.g. provincial and local municipalities) and organisations in the country (Rivett *et al*., 2014:1; Goldin *et al*., 2023:8). The National water monitoring programmes facilitate the collection of data to report on the status and trends of water quantity and quality in the entire country. Catchment level monitoring programmes give additional information for catchment management purposes. Civil society, together with local government, fulfils the objectives of local monitoring networks, which entail compliance monitoring discharges from agricultural, industrial, mining, and wastewater treatment works (WWTW) (DWS, 2017a:16). However, despite the involvement of industry players and local government, communities are not meaningfully engaged in or benefiting from these monitoring activities.

Among all the other components of water monitoring – such as water quantity, habitat and biota – water quality monitoring is crucial for environmental protection and community education (GWA, 2023:6–50). This is precisely why CBWM has significant potential: it provides a practical mechanism for communities to generate data and information regarding the health and wellbeing of the water resources they depend on, as highlighted in Figure 3.2. Real-time water monitoring is best suited at the community level, as travel costs would not be a factor and mitigation measures for vandalism would be more certain, as the monitors would be residents in that catchment (Bhatt & Patoliya, 2016:44–46). Water quality aspects of data collection are the focus of water resource protection, making water quality management a component of water monitoring.

3.3.2 Water quality management

Water quality management (WQM) is the process of ensuring that the quality of water is safe and suitable for its intended use. It encompasses activities such as monitoring, treatment, regulation, and enforcement to maintain and improve the quality of water in water resources for the benefit of the public and community members. Water quality pollution is among the main concerns for sustainable development, especially in developing countries where a water crisis leads to the use of dirty water and sewage left untreated (Botswana National Water Policy [Bot-NWP], 2012:4–6). This has health implications, as it becomes a breeding ground for waterborne diseases such as cholera and dysentery. Access to water is a human right, but managing it is everyone’s responsibility (Bedawy, 2014:108), which is why communities need to be involved.

The impact of WQM is measured by assessing the country's water quality status and the extent of deterioration that leads to pollution of receiving water bodies (McDowell *et al*., 2018:1–8; Dolan *et al*., 2021:1–3). Several factors exacerbate the deterioration of water quality in developed and developing countries of Africa and Asia, including human activities such as urbanisation, WWTW effluent discharges of untreated and partially treated wastewater, polluted storm water, industrialisation; mining, and agricultural activities (Mwaka *et al*., 1999:1–27; Ndiitwani, 2004:iii–iv,10; Hezri & Dom, 2017:19). The water quality in urban areas of South Africa has been reported to be significantly worse than in rural areas (Kannel *et al*., 2007:93–110). Urban infrastructure developments associated with pollution include settlements, industries, and mines responsible for generating domestic and industrial effluent and stormwater inflows. This points to a need to involve urban communities in the protection and restoration of local water resources.

Poor water quality reduces the assimilative capacity of water resources, requiring more water to dilute them to a state fit for use. The complexity of water quality management requires proper mechanisms such as policies, institutional arrangements, funding, skilled human resources, measures to counteract pollution, and adequate monitoring (Bedawy, 2014:108).

Integrated water quality management should include the management of the riparian ecosystem, as it serves as the community's provision for goods and services in the form of food, medicine, and flood control (Mwaka *et al*., 1999:1–27). The sustainable management of the riparian ecosystem ensures continued benefits for the community and the environment. South African legislation and policies are designed to enable holistic partnerships among government institutions, CMAs, water user associations, local municipalities, water sectors (industrial, mining, and agricultural), and public involvement to manage water in a sustainable manner (Biswas & Tortajada, 2011:5–11). The strategic approach to integrated water quality management in South Africa entails the DWS leading with a national plan, in partnership with state organs, water management institutions, water users, and water sector institutions to improve, facilitate, and coordinate ongoing water monitoring and the dissemination of data and information. Kannel *et al*. (2007:93–110) emphasise the need for developing countries to develop an IWRM water quality monitoring programme and management actions (McDowell *et al*., 2018:1–2). The holistic partnership approach of water monitoring is supported by Tidwell *et al*. (2004:359), who believe that no single sector can solve the region's problems, and no single mitigation, conservation, or financial measure can be sufficient. This is another reason to involve communities in monitoring their local water resources. The proactive approach to water quality management – including flood control measures, groundwater resource monitoring, and cleaner technology options for water provision and wastewater treatment – supports adaptation to the impacts of climate change.

3.3.3 Climate change

Resource-poor countries are vulnerable and likely to be severely impacted by climate change, as their adaptation level is rated low due to a lack of monitoring and financial constraints (Costa *et al*., 2018:1–10). Inadequate access to water and sanitation services and inappropriately structured governance are some challenges limiting climate change ecosystem-based adaptation measures (Levin *et al.*, 2022:1–10). The cause of water scarcity is the combination of influences from climate change, inappropriate water use, and water resource management (Dolan *et al*., 2021:1–10).

Climate change impacts are expected to increase weather patterns to extreme cases of wetter and drier regions (Nepfumbada, 2020:26–27; DWS, 2022b:4). Projected changes in flood and drought risks will affect water availability and quality trends. Drought is likely to cause land degradation and desertification, leading to mortality and socio-economic impact relative to gross domestic product (GDP) (Levin *et al*., 2022:1–10). South Africa has experienced significant flood events, particularly affecting the Eastern Cape and KwaZulu-Natal provinces, which have had severe socioeconomic impacts requiring billions of rands in disaster relief interventions (Mahlalela, 2022:2–3).

The main effects of climate change on water quality are related to hydrology, atmospheric emissions of greenhouse gases, and temperature. Changes in the timing and intensity (duration) of precipitation negatively affect water quality. For example, because of increased rainfall and intense rainstorms, flooding transports contaminants into water bodies. Flooding tends to overload stormwater and wastewater systems, resulting in untreated pollutants directly entering waterways. Global warming is associated with a 1.2°C (2°F) increase in temperature due to the production of heat-trapping carbon dioxide (CO_2), resulting in unbearable conditions of drought, extreme heat, and floods, and threatening food security and livelihoods (Maurya *et al*., 2020:5; DWS, 2022b:4; Levin *et al*., 2022:1–10).

Climate change, through a combination of high-water temperatures and low water flow, is often associated with the spread of vector-borne diseases such as cholera (Ndiitwani 2004:iii–iv; Levin *et al*., 2022:1–10; Sorooshian, 2024:8). It also causes disturbances to aquatic ecosystems and biodiversity, resulting in the decline of certain fish species that communities depend on for their livelihoods (Hosseini *et al*., 2017:3–15; Costa *et al*., 2018).

Sub-Saharan Africa and some parts of Asia are global hotspot regions that are vulnerable to the impacts of climate change (Hezri & Dom, 2017:18; Levin *et al*., 2022:1–10). Adaptation measures that strengthen community resilience to climate change contribute to water security, sustainable development, and SDG compliance (Nepfumbada, 2020:31–32). Effective water resource management is essential amid uncertainties and water scarcity, as these challenges threaten progress towards achieving SDGs (UN, 2015:5; Dolan *et al*., 2021:1–2). To

accomplish the SDGs, climate change should be incorporated into water resource management and planning, and the implementation of adaptation measures at local, transboundary, and SADC levels (Dirwai *et al*., 2021:20; DWS, 2022b:4–18). Vulnerability to climate change and the effects of population growth affect freshwater availability and the global water cycle (UNESCO, 2021:1–2; DWS, 2022b:28–29), resulting in water availability uncertainties, extreme weather patterns, and rainfall variability (Dolan *et al*., 2021:1–2; DWS, 2022b:4). This highlights the importance of educating and involving vulnerable communities in CBWM, particularly those most susceptible to climate change impacts, as they are likely to be the worst affected.

3.3.4 Water availability versus water scarcity

Water security is rated as one of humanity's strategic challenges due to inequities in access to water, climate change, and pollution. Equitable access to water enhances a country's development and livelihood (Nepfumbada, 2020:8–10). The frequency of floods and droughts occurring in the arid sub-Saharan region is linked to climate change and affects water availability and food shortages (Hezri & Dom, 2017:20). Water scarcity and water quality degradation propel the need to change how water systems are managed (UN, 2020:1–34). According to UN-Water (2021), 2.3 billion people live in water-scarce regions, including Northern Africa; Western, Central and Southern Asia; and Southern Africa (South Africa, Namibia, Lesotho, and Botswana), where water scarcity is experienced at the 60th percentile (Bot-NWP, 2012:6).

The UN has placed a strong focus on the value of collaboration among sectors, communities, disciplines, and states to achieve water security and reduce the risk of potential conflicts over water (UN-Water, 2013). The UN Climate Conference COP 26 emphasised nature-based solutions for climate change mitigation and adaptation (Arora & Mishra, 2021:588).

The El Niño-Southern Oscillation (ENSO) and La Niña non-ENSO events are drivers influencing Southern Hemisphere weather patterns and unpredictable climate change (Wang *et al*., 2019:22512–22517). Water distribution in South Africa is aligned to rainfall patterns, with average rainfall ranging from less than 100 mm to more than 1,500 mm per annum and decreasing availability from east to west. High water yield and groundwater recharge areas occur in mountainous catchments and watersheds, which constitute strategic water source areas and need to be included among protected areas of high priority (Moseki, 2017:16–20). Competition for water as a scarce commodity creates conflict among different water users, which requires a sound understanding and synchronisation of social, economic, and ecosystem balance (Mwaka *et al*., 1999:1–27; Sorooshian, 2024:8). Since South Africa is a water-scarce country – ranked as the 30th driest country globally (Stats SA, 2022a:37) – greater attention must be paid to equity and management of the country's water use.

3.3.5 Water use

Water use includes withdrawing water from water resources for various purposes, streamflow-reducing activities (e.g. plantations), waste disposal and wastewater discharges, and recreation (NWA, 1998). Globally, and mostly in arid regions, water use has increased at twice the rate of growth in the population, resulting in water scarcity on every continent. Water demand and climate change are the biggest contributors to water scarcity (Bot-NWP, 2012:6–9; UN-Water, 2021). In 2013, the Global Water Institute predicted that by 2030, approximately 700 million people would be competing for precious and limited water resources, as the available resources' capacity would be much less than the growing demand (UN-Water, 2021). Equitable access to water is essential for everyone, yet different levels of inequality due to spatial and urban-rural inequality and historical imbalances of the past influence water scarcity (Ravnborg, 2016; Cole *et al*., 2018). South Africa has a history of inequality and remains one of the most unequal countries in the world, with a Gini Coefficient of 0.67 regarding wealth distribution, which contributes to unequal access to and use of water within the population (van Koppen, 2022:2).

Globally, agricultural activities are the leading water user, negatively impacting water resources, consuming 72.0%, followed by domestic use for households and services at 16.0%, and then industries at 12.0% (Dolan *et al*., 2021:1–2; UN-Water, 2021). Approximately 74.0% of South Africa's rural population depends on groundwater rather than surface water (Goldin *et al*., 2023:1–4). Over two billion people remain dependent on unsafe water and inadequate sanitation services, leaking untreated sewage into the environment and rendering available water unfit for human consumption (UN-Water, 2019:1–2). Major adjustments are needed between sustainable water use and water resource protection to safeguard water resources against pollution.

The social impact of water is as important as the environmental and economic impacts, as it affects the livelihoods of vulnerable people such as women and children in terms of issues pertaining to their needs (UN-Water, 2019:12–59). Water misuse increases pressure on freshwater and creates the need to regulate water use, control water pollution, and protect and manage water resources (Mwaka *et al*., 1999:1–27; van der Zaag *et al*., 2002:19–32; UN-Water, 2019:1–2).

Different sectors in South Africa, such as the agricultural, mining, industrial and domestic sectors, are competing water users, resulting in regulated flows (Nepfumbada, 2020:2). This is similar to other countries neighbouring South Africa, such as Botswana (Bot-NWP, 2012:6). These water uses may lead to the alteration of water quantity and quality, resulting in resource impacts, pollution, and water becoming unfit for other purposes. To ensure adequate water

quality and water resource management, relevant sector role-players and stakeholders must work together with the government in an integrated manner (DWS, 2017b:1).

3.4 WATER RESOURCE IMPACTS

Water resources are affected by anthropogenic factors emanating from increasing demands of domestic, agricultural, mining, industrial, and power generation water uses that can alter the chemical, biological, and physical characteristics of water, causing water pollution (Flores-Díaz *et al*., 2018:1). According to Yang *et al*. (2024:1–3), pollution from such uses could increase the nutrients (e.g. phosphorus and nitrogen), salts, acids, trace elements, toxins, and temperature in freshwater bodies, resulting in impacts threatening ecosystems, human health, and the economy in the form of food production. Recent research has identified new pollutants in waterways, which contain endocrine-disrupting compounds associated with pharmaceutical products, steroids and hormones, oil, microplastics, and microbeads. The impacts of these new pollutants are yet to be determined, which adds to existing water quality management problems (DWS, 2023b:71). This further emphasises the importance of involving and educating communities. The water quality impacts most likely to affect the livelihoods of all water users, including communities and civil society groups, are as follows:

- **Ecosystem degradation:** This is the deterioration of the living environment through disturbances of biotic and abiotic elements including water, habitat, and biota due to natural and anthropogenic causes (Camara, n.d.). Land-use activities such as agriculture, industries, mining, and domestic activities are the major causes of ecosystem degradation (Ndiitwani, 2004:121–124; Maurya *et al*., 2020:1–12). Poor water quality due to pollution has the potential to degrade water resources. Approximately 40% of water is unfit for human consumption and physical contact. This is, especially concerning given that many South African communities depend on surface water directly from natural resources, endangering fish and amphibian species (Maurya *et al*., 2020:9). Water pollution from agricultural activities and alien invasive plants further hampers essential ecosystem goods and services, threatening community livelihoods. Policymakers are urged to see beyond economic gains to marry nature with social (community) needs, as well as economic and financial decision-making (UN Environment Programme, 2021:1).
- **Economy (food production):** Ecosystem biodiversity threats due to water pollution have led to disturbances in the entire food chain, consequently jeopardising food production and other livelihood benefits (Millennium Ecosystem Assessment, 2005:18–77). Poor water quality also has a direct impact on water availability, as it decreases the assimilative capacity of water resources, thus rendering water unfit for various uses (Maurya *et al*., 2020:9). Poor water quality is a limiting factor in economic growth, as well as in raising treatment costs (Centre for Environmental Rights [CER], 2016:12–80). This highlights the importance of engaging all stakeholders in water management and monitoring efforts. For

example, the European Union was reported to have threatened to stop imports from farmers in Mpumalanga (South Africa) who irrigated their crops with mining-polluted water from the Olifants River (CER, 2016:12–80). Declining irrigation water quality in the Western Cape (South Africa) has become a threat to meeting international standards for export to Europe and the United Kingdom (Cullis *et al*., 2018).

- **Health impacts:** A lack of adequate sanitation services leads to untreated wastewater entering the fresh-water system, as indicated by the presence of *Escherichia coli* (*E. coli*) bacteria, which signals faecal contamination (DPM, 2016:25), thus causing waterborne diseases such as diarrhoea and dysentery (WHO, 2019:70). Since the 1990s, water pollution has worsened in almost all urban rivers of Africa, Asia, and Latin America (UN, 2018b:12), largely due to poor water management (Biswas & Tortajada, 2011:5–11). The deterioration of water quality is expected to escalate further over the coming decades, increasing threats to human health.

Globally, the most prevalent water quality challenge is nutrient loading, which – depending on the region, such as China, the United States of America (USA), and New Zealand – is often associated with WWTW effluent (U.S. EPA, 2018:1–7). Recent nutrient loading in South African water bodies was reported to originate from WWTW and industrial effluent, settlements, stormwater, and agricultural runoff. South Africa has numerous examples of places where water has become undrinkable due to nutrient pollution from WWTW. such as the town of Parys in the Ngwathe Local Municipality, Free State Province, and the town of Carolina in the Albert Luthuli Local Municipality, Mpumalanga Province. These examples emphasise the importance of CBWM (DWS, 2023c:141–323). This nutrient loading causes eutrophication, leading to increased production of toxic algae and aquatic macrophytes, which deteriorates water quality and poses risks to both human and animal health (DWS, 2023b:20–33). The greatest threats from exposure to pollutants are expected to occur in low-income countries, given their higher populations, low economic growth, and poverty associated with the lack of wastewater management systems (Gao & Zhang, 2010:388–391; UN, 2018b:7; U.S. EPA, 2018:1–7). Wastewater capacity in the Free State province has not yet been addressed, and the budget for the eradication of its sub-standard bucket system wastewater management is under review (DWS, 2023c:123–140). The complexities of water quality management demand urgent global attention and action. In line with the principle “Think globally, act locally”, IWRM principles and CBWM participation offer a means of decentralising water resource management and decision-making processes to the catchment level. The impacts outlined above demonstrate that increasing demands from domestic, agricultural, mining, and industrial water use, combined with destructive impacts identified in the CBWM Theoretical Framework (Figure 3.2), compromise both water quality and community well-being.

CBWM is therefore particularly well suited to addressing these water resource impacts, as it offers a practical approach to water resource protection through community involvement.

3.5 COMMUNITY-BASED WATER MONITORING

3.5.1 Introduction

As introduced in Chapter 1, CBWM is a form of CBM, an approach that focuses on empowering local communities to monitor their water resources, rivers, wetlands, estuaries, and aquifers. It provides a vital foundation for effective water monitoring and management, allowing for early detection of issues and targeted interventions. As discussed in Sections 3.3.4 and 3.3.5 above, involving South African communities in CBWM is critical given the country's water scarcity and persistent inequalities in water access.

Internationally, the UN (2020:1–34) emphasises the involvement of community members in environmental issues, encouraging them to participate and build capacity to link the data they produce to decision-making. Here, community refers to a society at a local level with common interests, norms, values, and needs. Participation of community members in water-related decision-making is considered an important strategy for combatting water security issues and encouraging community participation (Graham *et al*., 2016:40; Kim *et al*., 2022:11). The availability of adequate information flow into systems influences decision-making (Lotz-Sisitka *et al*., 2019:17). Pollock and Whitelaw (2005:216–221) and the UN (2020:1–34) define CBWM as a process in which interested and affected parties from government, civil society, NPOs and the private sector collaborate to monitor the local effects and respond to issues of common interest. In contrast, Starkey *et al*. (2017:801–817) define CBM as the participation of members of the public in monitoring projects. Dominguez-Rendon *et al*. (2024:2–16) note that using community-based monitoring data highlights the importance and value of citizen monitoring efforts. Further studies were recommended to prove that CBM efforts can improve the condition of the environment (Johnson *et al*., 2021:452–566). This directly links to the main research question of this study, which is to evaluate the potential value of CBWM in water resource protection decision-making in the South African community context. The primary reason for emphasising CBWM, as articulated by Carlson and Cohen (2018:168–177) and Goldin *et al*. (2019:15–17), is its potential to bridge the relationship between science and society in collectively solving water-related problems through a process that involves communities in assessing freshwater quality and quantity regarding availability for use. The CBWM Theoretical Framework presented in Figure 3.2 provides a useful frame to support this study in understanding the role of CBWM, which encompasses environmental, social, and economic benefits. However, the challenges reflected in the framework could be counter-productive to the benefits and value highlighted.

In South Africa, CBM is used interchangeably with citizen science, Adopt-a-River (AaR), and community science (Carlson & Cohen, 2018:168–177). In this study, Pollock and Whitelaw (2005:216–221) and the UN's (2020:1–34) definition of CBM were adopted. CBM and CBWM were used interchangeably; therefore, the literature presented on CBM also applies to CBWM. The CBM platform is also referred to as participatory monitoring, in which communities collaborate on different platforms with governments, industries, academic institutions, and civil society (Johnson *et al*., 2021:452–566).

Participation in CBM encourages community members and scientists to work together and to bridge the gap towards monitoring and evaluating water quality to support existing departmental programmes (Walker & Strashok, 2010:1–5). Civil society acts as the ears and eyes of the department on the ground, augmenting and validating the scientific knowledge of water management issues, as they may have first-hand information on compliance and monitoring and capacity to do more (Parlee & Łutsël K'é Dene First Nation, 1998:1–37; Gofman, 2010:9–40; Conrad & Hilchey, 2011:273).

Interestingly, in South Africa, CBWM initiatives such as the River Ecosystem Monitoring Programme (REMP) – formerly known as the River Health Programme (RHP) – and AaR programmes began as volunteer responses to water management collaboration between communities and the DWS. Volunteerism is defined as the involvement of individual volunteers or groups without payment, driven by mutual benefits and working towards shared knowledge and decision-making power over the environment around them (Goldin *et al*., 2023:50).

Like citizen science, the AaR programme initially targeted pensioners, youth, school learners, students, catchment forums, water user associations, municipalities, and civil society, focusing on water saving, improving water quality, youth development, and societal capacity on IWRM. The second phase of the AaR programme shifted the focus from volunteerism towards job creation targeting youth, women, and people with disabilities, which created implementation challenges. Unfortunately, due to a lack of confidence in government-led collaboration, the programme emphasises public–private partnerships, advocating community involvement and ownership of the programme (Graham *et al*., 2016:1–40). Community participation on a voluntary basis creates initiatives and promotes the implementation of IWRM (Hezri & Dom, 2017:19).

3.5.2 The role of community-based monitoring

The role of CBM is to monitor community issues of concern by detecting deviations from the desired state, which is a fundamental component in CBWM. This supports the improvement of water quality and public health, facilitates the management of water catchments and watersheds, and contributes to the restoration and rehabilitation of streams through public participation. It also fosters cooperation and synergy to address common water problems in a

culturally acceptable manner (Savitri & Gail, 2016:4–5; Flores-Díaz *et al*., 2018:11; Johnson *et al*., 2021:452–566). Policymaking and the implementation of capacity-building programmes through citizen monitoring and participation (Parlee & Łutsël K'é Dene First Nation, 1998:1–37; Reutebuch *et al*., 2008) are considered crucial, even in developed countries.

Furthermore, CBM aims to involve citizens in water monitoring to assess the status of the water resources (Conrad & Hilchey 2011:273), enhance water quality and public health, manage water catchments, restore and rehabilitate water resources, influence policymaking, and strengthen capacity building efforts (Dominguez-Rendon *et al*., 2024:2–16).

Walker and Strashok (2010:1–5) suggest that integrated water management should shift from regulation to a focus on protecting vulnerable areas. Indigenous and older members of the community are viewed as important sources of traditional and local knowledge, developed through lived experience (UN-Water, 2019:12–49). This positions them to better understand current environmental conditions, which gives them the advantage of being able to contribute to scientific research aimed at shaping the future (Parlee & Łutsël K'é Dene First Nation, 1998:5; Gray *et al*., 2001:6).

According to Pollock and Whitelaw (2005:213) and a recent publication by Dominguez-Rendon *et al*., 2024:2–7), CBM has been confirmed to complement scientific work. The integration of CBM with indigenous data sources helps provide valuable insights and fill monitoring gaps (Starkey *et al*., 2017:802–815).

A CBM programme offers the following benefits to participants, and a plan to guide the implementation is discussed in Section 3.5.3:

- **Increased access to information** at little or no cost, with fewer resource demands (Starkey *et al*., 2017:802–815).
- **Training of local people**, especially within rural areas, is essential (Quin, 2012:1–24), as CBM can contribute to the development of the community and job creation (Graham *et al*., 2016:2–3, Lotz-Sisitka *et al*., 2019:17).
- **Encouragement of local leadership and identification of champions** (Pollock & Whitelaw, 2005:216–221), whether a community representative or a government official familiar with the local ecosystem’s health (Gray *et al*., 2001:14). Community-based leaders should be visionaries who are willing to lead beyond their communities, seek resources, and establish partnerships with external organisations (Gray *et al*., 2001:14). A lack of succession planning to replace existing community leadership threatens citizen-based groups, as strong leadership contributes to programme resilience (Walker & Strashok, 2010:1–5).

- **Promotion of broad public participation** (Pollock & Whitelaw, 2005:216–221) – the decision-makers' and facilitators' role should be clearly mapped from the programme's initiation.
- **Enhancement of ground-truthing of citizens' scientific knowledge** and encouraging well-informed, environmentally conscious, and water-savvy communities (Graham *et al*., 2016:2–3, Starkey *et al*., 2017:802–815).

The role of CBM highlighted above reflects similarities within the South African context, with the commonly shared benefits summarised in Figure 3.2 as environmental and economic investment that enable social benefit through capacity building.

3.5.3 Community-based monitoring plan

Community-based monitoring is not a one-size-fits-all solution with a single set of rules and therefore requires a CBM plan. Currently, no conceptual framework exists that can be used to develop a CBM plan. Flexible policy mandates, in the form of an open and inclusive community-based conceptual framework, need to be developed (Gray *et al*., 2001:6).

A conceptual framework is a nexus of interlinked concepts brought together to create a comprehensive understanding – a framework that includes governance, sustainability, and community participation (Cleland, 2017:64; Goldin *et al*., 2023:44–46). To establish a compatible framework for such a diverse and complex situation, Gray *et al*.'s (2001:12–13) guiding principles may be applied as follows:

- **Inclusiveness:** All Interested and affected participants must be actively engaged in the process.
- **Accessibility:** The process must be tailored to meet the community's diverse needs.
- **Transparency:** Openness, clarity, and communication must be maintained throughout the process to restore and sustain trust between communities and government institutions. Regulatory decision-making systems must include community-based data or input to maintain ongoing community-based contributions (Walker & Strashok, 2010:1–5).
- **Adaptability:** The levels of risk, uncertainty, fear, and complexity faced by communities require flexible approaches that adapt to change and new information.

Buckland-Nicks *et al.* (2017:1–9) indicate that, when designing a CBM programme, quality assurance – including standards, volunteer roles, and goals – forms a solid foundation.

The CBM plan should be unique and community-specific, as communities differ in background (Gray *et al*., 2001:3), values, vision, and interests (Parlee & Łutsël K'é Dene First Nation, 1998:3; Pollock & Whitelaw, 2005:219). These varied community cultural norms and values are essential in strengthening the country's water governance (Walker & Strashok, 2010:1–5).

Tidwell *et al*. (2004:357) emphasise that the development of a CBM plan that is both scientifically sound and socially acceptable requires openness and transparency, as participants' confidence is built on trust, which helps minimise the challenges encountered in CBWM practices and those identified in Figure 3.1, Section 3.5.4, and Figure 3.2.

3.5.4 Community-based water monitoring challenges

The main challenge for CBWM is that the participation of local-level stakeholders receives limited or no support in strategic or operational information system decision-making. This issue is present in both developing and developed countries, with reported cases in Uganda and Sweden, respectively (Quin, 2012:1–24).

Despite the challenges encountered in CBWM, the study aligns with the assertion by Bliss *et al*. (2001:145) and Goldin *et al*. (2019:30) that monitoring will only occur where both the will and the right mindset exist in tandem. Challenges pertaining to CBWM are identified and highlighted in Figure 3.1 and detailed in Sections 3.5.1.4–3.5.4.10.

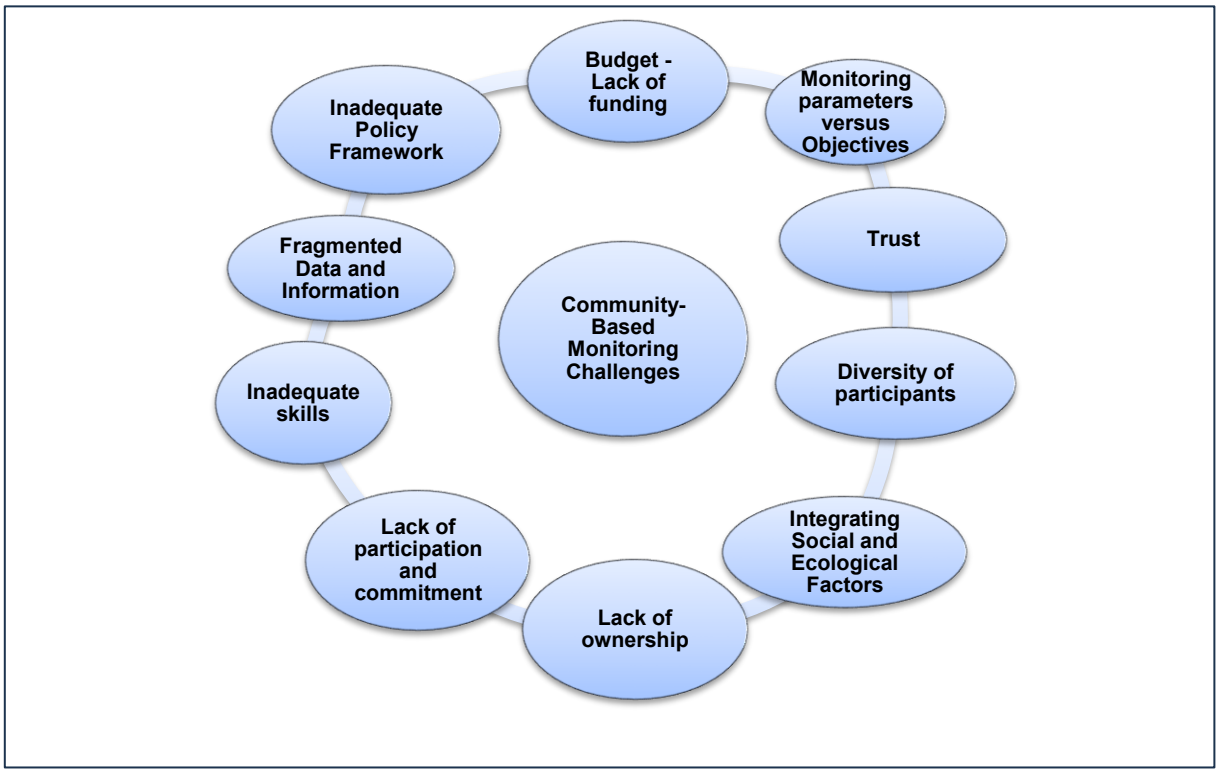


Figure 3.1: Community-based water monitoring challenges

Source: Author's own contribution

3.5.4.1 Budget – Lack of funding

While Johnson *et al*. (2021:452–566) and DWS (2022b:18) emphasised data gaps, unaccountability, and implementation as challenges associated with lack of funding, Graham *et al*. (2016:17) highlights the importance of sustainable financing and a sound business model as key to the success of CBWM programmes, suggesting that a comprehensive understanding requires integrating both perspectives. A funding framework and business model should be

developed and implemented through partnerships between government, non-governmental organisations (NGOs), the public, international bodies, and crowdfunding sources to maintain the sustainability of CBWM.

Smartly incentivised community programmes – through stipends, funding for monitoring tools, skills development, or bursary opportunities, and well-marketed CBWM initiatives – will maintain public interest (Graham *et al*., 2016:21–26). The provision of funds for implementing the Environmental Water Requirements (EWR) component of water resource protection at the catchment level can serve as a means of conflict resolution (Ramulifho *et al*., 2019:9–10). The EWR component facilitates equitable water allocation, prioritising the environment – specifically the water resources in this context – thereby alleviating pressure on communities already burdened by conflict and water scarcity.

Parlee & Łutsël K'é Dene First Nation (1998:2) report that communities must find ways to maximise benefits using minimal resources. For example, monitoring programmes should be aligned with available financial resources to achieve intended goals (Buckland-Nicks *et al*., 2016:5–13). The assistance of citizens or volunteers in data collection can be particularly valuable when government decision-makers face budgetary constraints (Walker & Strashok, 2010:1–5). This presents a challenge in South Africa, where high levels of unemployment, poverty, and inequality persist. Ring-fencing funds allocated for monitoring could help safeguard community interests and promote their continued involvement in water monitoring.

Another important aspect to consider is volunteer remuneration. It has been reported that about one-third of communities in developing countries rely on donor funding (Aslam, 2013:48–82). Donor funding dependency has become a threat to the sustainability of CBWM, as community initiatives reliant on such support are vulnerable to funding depletion (Lotz-Sisitka *et al*., 2022:15–18). Communities in Pakistan are notable examples of self-reliance, where funds are collected from consumers and used to maintain community-based programmes (Aslam, 2013:48–82). Promoting domestic resource mobilisation, such as improving revenue collection and strengthening governance and policy frameworks through enforcing anti-corruption measures to build investment and attract funding, might bring much-needed funding solutions. So far, no viable sustainable solution has been found to address funding challenges. South Africa provides another successful case of a self-reliant regional practice, where a blended financial approach that sourced funds from multiple sources proved effective. The Amanzi Ethu Nobantu Enviro–Champs programme secured funding from the Duzi uMngeni Conservation Trust, in addition to donor funding. The Mpophomeni Enviro–Champs initiative secured sustainable funding from the uMngungundlovu District Municipality, Green Trust, and Expanded Public Works Programme (Lotz-Sisitka *et al*., 2022:6–145).

Volunteers must understand the significance of these initiatives and be motivated by their commitment to their communities. However, Gray *et al*. (2001:9) argue that community groups should be treated with respect and compensated with a living wage that contributes to the well-being of their communities. Community-based ecosystem workers in South Africa still face high rates of poverty and unemployment, often relying on seasonal employment with minimal benefits – despite the important role they play.

3.5.4.2 Inadequate policy framework

Water governance requires the multi-sectoral participation of stakeholders from government, civil society, and the private sector to ensure a holistic approach to IWRM (UNESCO 2021:1–5). The IWRM approach is essential for multi-level governance participation in developing countries in Africa and Asia, as well as in developed countries such as those in Europe (Quin, 2012:1–24; Dirwai *et al*., 2021:3).

The absence of a legal mandate, policy, or specific best practices governing CBWM (Khair *et al*., 2021:2), coupled with fragmented and uncoordinated governance structures and political interferences weakening governance enforcement, creates confusion, weakens the authority of water governance institutions to assign sector responsibilities – ultimately leading to dysfunction and impediments (Quin 2012:1–24; Hezri & Dom, 2017:20; UN, 2020:1–34).

Most water policies assign low priority to stakeholder participation in water resource protection – if it is considered at all. In Tanzania, for example, private sector involvement was not considered (Mwaka *et al*., 1999:1–27), a situation similar to that of South Africa. Unresolved conflicts between different pieces of legislation have led to ownership disputes in community-based projects (Bannatyne *et al*., 2017:366–375).

For community-based monitoring to be effective, Aslam (2013:48–82) emphasises the need for developing a cost-effective and user-friendly framework capable of accommodating various levels of data quality.

A standard conceptual framework that enables CBWM data to be incorporated into the decision-making process remains lacking. This concern is echoed in CBWM across Canadian watersheds, where participants expressed a strong desire to influence government decision-making in water resource management but lacked clarity on how to do so – warranting the need for further research (Buckland-Nicks *et al*., 2016:14–18).

3.5.4.3 Fragmented data and information

There is a perception that community-generated data is unreliable; however, the availability of standardised monitoring protocols and relevant equipment may assist in levelling the playing field (Conrad & Hilchey, 2011:281; Goldin *et al*., 2019:17). The rate of vandalism of monitoring

equipment in South Africa and the lack of technology can be a challenge to community data collection. Community-based monitoring data, when collected with appropriate levels of rigour, are more likely to be considered in water resource protection decision-making (Buckland-Nicks *et al*., 2016:14–18; Goldin *et al*., 2019:15–16). Data with incompatible standards and existing gaps pose challenges that may lead to data rejection (Conrad & Hilchey, 2011:281; Carlson *et al*., 2017:12).

To ensure compatibility and continuity, internal and external data and information flows must be standardised and managed according to three dimensions: information access, exchange, and documentation:

- Information access relates to the fact that data must be easily accessible and retrievable.
- Information exchange involves the dissemination and sharing of data.
- Documentation refers to record keeping and data storage.

Lack of access to water-related data remains a significant barrier to implementing water resource protection strategies (DWS, 2022b:81–95).

Quality assurance from the point of data collection through to dissemination is essential, as "information without quality is useless" (Durugbo *et al*., 2010:365–366). Both the availability and accuracy of data must be maintained and standardised to ensure compatibility and uphold quality assurance (Dominguez-Rendon *et al*., 2024:12–13; Starkey *et al*., 2017:801–817; Johnson *et al*., 2021:461). Durugbo *et al*. (2010:368) further recommend that future research adopt "a dynamic approach for information flow modelling" to cope with changing stakeholder behaviours.

Quin (2012:1–24) notes that having access to local information encourages communities to appreciate local catchment management. The critical roles of CBWM – data collection, entry, storage, and sharing – are often constrained by technical and social limitations (Johnson *et al*., 2021:452–566). The AaR community programme in South Africa emphasises the value of data and information reporting to cater for ecological and social benefits as a measure of success (Graham *et al*., 2016:28).

3.5.4.4 Inadequate skills

Aslam (2013:3) and DWS (2022b:19) confirm that the current education systems, cultural factors, and the lack of dedicated technical officials in developing countries such as Pakistan and South Africa have contributed to challenges in water resource protection. Training community members could significantly enhance awareness and responsiveness.

Integrated levels of community-based water programmes are necessary to shift education and awareness in developing countries to more productive and sustainable levels. Lotz-Sisitka *et*

al. (2019:8) identified the need to develop a science education and literacy model to impart trustworthy and reliable knowledge to CBWM participants. Enhancing science literacy in South Africa's impoverished communities requires active communication channels such as radio telecasts, as radio even reach deep rural areas (Graham *et al*., 2016:33–41).

Empowerment and transfer of knowledge and skills to communities are critical for the sustainability of CBWM programmes. The training framework should focus on various levels of training – basic, technical, and advanced – which will influence career pathways. It should also issue attendance certificates to participants, which act as additional incentives (Graham *et al*., 2016:34–40). Pollock and Whitelaw (2005:223) supported this approach, noting that training manuals and assistance sources are essential for successful community monitoring. Community empowerment is the final step toward achieving sustainable mitigation (Khair *et al*., 2021:1). Education and capacity building in water management also serve as community incentives (Franceys & Gerlach, 2011:61–70).

3.5.4.5 Lack of participation and commitment

The lack of credibility, volunteer interest, and organisational capacity is a primary challenge to CBM success (Conrad & Hilchey, 2011:278). Working with people is complex, as individuals from diverse social and economic backgrounds have different perspectives, motivations, and challenges. Understanding diverse cultural groups – including participants' backgrounds – must be a priority, as a lack of technical understanding might otherwise be misinterpreted as a lack of commitment. While DWS has a social component, its limited capacity, leaves natural scientists responsible for tasks beyond their knowledge or training.

The availability of incentives is likely to improve participation, whereas their absence (i.e. disincentives) may lead to demotivation. Recognition of CBWM participants through various media platforms, publications, and the issuing of certificates is an important form of non-monetary reward (Graham *et al*., 2016:26–27). However, it may benefit the advantaged minority who were the beneficiaries under the previous inequality regime, rather than the majority of people living in poverty.

To maintain sustainability or credibility, CBM teams must partner with other independent, private, and non-governmental groups such as academic institutions (Mwaka *et al*., 1999:1–27; Walker & Strashok 2010:1–5). Increased collaboration with academic institutions improves access to funding, training, and monitoring tools and facilities (Conrad & Hilchey, 2011:278). Most importantly, the availability and willingness of community members are essential enabling conditions for responsible participation (Aslam, 2013:9–20).

3.5.4.6 Lack of ownership

Community groups are encouraged to take ownership of CBM programmes, with full delegated authority throughout the project life cycle – from preparation to implementation, operation, and maintenance. Assuming ownership reduces over-reliance on government and, in return, ensures sustainability (Mwaka *et al*., 1999:1–27). The inclusion of the private sector, communities, the academic sector, and volunteers – without shifting towards paid workers – could restore a sense of participation and ownership in AaR initiatives (Graham *et al*., 2016:19). However, Kativhu *et al*. (2021:20) argue that CBWM ownership does not influence the sustainability of water management projects.

CBWM engagement models range from institution or government-led to community-led initiatives (Buckland-Nicks *et al*., 2013:17). A measure of success in community-based systems is evident when communities themselves report satisfaction and confidence in the system, as demonstrated in Pakistan (Aslam, 2013:9–20).

3.5.4.7 Integrating ecological, social, and economic factors

Achieving ecosystem sustainability involves balancing ecological, social, and economic considerations. From an ecological perspective, maintaining biodiversity and ecosystem services is paramount to ensure long-term resilience and functionality. This includes preserving habitats, managing resources sustainably, and mitigating environmental impacts.

From a social perspective, clear communication and shared goals are essential. Stakeholders often have diverse interests and values, which can lead to conflict if not addressed transparently. Cultural differences further complicate matters, potentially necessitating translation services that incur additional costs (Carlson & Cohen, 2018:168–177). Moreover, CBM programmes face challenges when external researchers fail to adequately share their findings with local communities, thereby undermining trust and collaboration. This lack of accountability can jeopardise the sustainability of CBWM initiatives and erode initial investments (Johnson *et al*., 2021:463).

Economically, sustainability efforts must consider both short-term costs and long-term benefits. While investments in sustainable practices and technologies may initially be costly, they can yield long-term economic returns through improved efficiency, reduced resource consumption, and enhanced resilience to market fluctuations.

Thus, achieving ecosystem sustainability requires navigating complex trade-offs across ecological, social, and economic dimensions, which is not the case in South Africa, as CBWM initiatives depend on treasury for funding. Treasury funding carries the risk of expenditure cuts and cost-containment measures, which stalls progress (Graham *et al*., 2016:24–62). Effective

governance, stakeholder engagement, and integrated planning are critical to striking a balance that ensures lasting environmental health, social equity, and economic prosperity.

3.5.4.8 Diversity of participants

Community participation must be as inclusive as possible, involving older people, women, youth, local groups, and religious leaders (UN, 2020:1–34). The participatory approach should prioritise the involvement of women, who play a pivotal role in water management as primary household water users (Dirwai *et al*., 2021:3). Although women also carry the burden of most household tasks and childcare, CBWM participation should not become an additional burden for them. In South Africa, with its high levels of gender-based violence and criminal acts, women's involvement should be coupled with measures to reduce their burdens and enhance their safety. The more active the participants, the more successful the project is likely to be (Parlee & Łutsël K'é Dene First Nation 1998:8).

However, participant diversity may hinder progress if not managed properly, as it might create conflict and lack of cooperation because of cultural differences (Goldin *et al*., 2023:61–63). Poor communication has been linked to weak community participation, which points to the need to develop clear two-way communication channels between CBWM implementing agents and the public. A clear Memorandum of Agreement (MoA) defining participants' roles and responsibilities, along with the designation of a CBWM communication officer to oversee reporting and coordination of the programme, is crucial. This provides a structured communication framework (Graham *et al*., 2016:32–33).

3.5.4.9 Trust

Trust refers to the belief that one can rely on a partnership and is essential to the successful implementation of CBM and effective information sharing (Goldin *et al*., 2019:26–30). It plays a critical role in social networks and political linkages among volunteers, government, NGOs, researchers, and tribal authorities (Goldin *et al*., 2023:53). A discursive risk management strategy is imperative for clarifying issues, building trust, and encouraging stakeholder participation, especially in South Africa, a country ravaged by the aftermath of racial conflicts and financial inequalities.

Relationships within CBWM may be based on either trust or fear. A change of direction from the original plan can stir emotions (Kim *et al*., 2022:1–2) and participants should be encouraged to step outside their comfort zone. In the South African context, a lack of clearly defined roles and responsibilities for the volunteer group in the AaR programme created confusion and mistrust, ultimately resulting in volunteers going their separate ways and splitting from the paid workers (Graham *et al*., 2016:17).

To maintain trust, the benefits and drawbacks of CBWM must be clearly communicated. Ongoing reporting and feedback to communities on achievements and risks help strengthen community trust and ownership of the process (Khair *et al*., 2021:17).

3.5.4.10 Monitoring parameters versus objectives

The choice of monitoring parameters – including type, scale, and methodology – must align with the study's objectives or process. Standardisation and integration of technical knowledge and CBWM must be balanced, without favouring one over the other (Bliss *et al.,* 2001:160–165; Walker & Strashok, 2010:1–5). Respect should be maintained (Gray *et al*., 2001:7; Carlson *et al*., 2017:15).

An implementation guide gives direction and empowers communities to make decisions. The method of choice must be appropriate to the approach chosen (Kativhu *et al*., 2021:21). According to Walker and Strashok (2010:1–5), an integrated decision-making framework understanding should accommodate both the community's holistic view of healthy aquatic ecosystems, together with the regulatory approaches of decision-makers. For this reason, communities should be involved in developing these frameworks to ensure sustainability and encourage buy-in.

While CBWM focuses on empowering local communities to manage their water resources, collaborative governance highlights the importance of involving all stakeholders – including community members – in the decision-making process.

The global CBWM challenges highlighted above and summarised in Figure 3.2 (CBWM Theoretical Framework), reflect commonalities with the South African context, as both aim to address the failure to recognise community data as valuable, hence the inclusion of this concept in this study.

3.6 THEORETICAL FRAMEWORK REPRESENTATION

3.6.1 Introduction

The study's theoretical framework (see Figure 3.2) was derived from the link between water resource protection and CBWM literature and is supported by the Sustainable Development Goals (SDGs), specifically SDGs 6 and 17.

Although the study's theoretical framework is closely aligned with the SDGs, it is not limited to Goal 6 (clean water and sanitation) and Goal 17 (strengthen global collaboration in the implementation of sustainable development). It also considers Goal 5, which promotes gender equality, due to the critical importance of addressing gender and its impact. SDG 5 is included to provide an overview of the challenges and future commitments related to gender equality and its interconnectedness with SDGs 6 and 7. These goals are to be implemented through

community participation, in collaboration with the principles set out in the Millennium Development Goals (MDGs). One approach to achieving sustainable water management is the decentralisation of governance at the catchment level through stakeholder engagement, including active participation by community members in the management of local water resources.

The theoretical framework developed for this study is composed of three main components. The first component outlines the benefits of sustainable water use by balancing environmental, social, and economic impacts. The second focuses on using water resources to enhance investments that support water security, human health, and livelihoods. The third addresses the challenges encountered during CBWM processes, ranging from lack of budget to inadequate governance.

The CBWM Theoretical Framework (Figure 3.2) encompasses the three pillars of the Environmental, Social, and Governance (ESG) framework. ESG policies are widely recommended to guide organisations in implementing good ethical practices to minimise environmental harm and prevent the exploitation of social wellbeing. With the rise of environmental impacts and social issues, ESG frameworks increasingly serve to assess, manage, and report on non-financial risks and opportunities associated with sectoral activities that are likely to impact the environment (Brock, 2023:1; Camara, n.d.).

3.6.2 Theoretical framework schematic representation

The CBWM Theoretical Framework developed in this study is grounded in SDGs 6 and 17, as well as the national policy engagement prescripts outlined in Chapter 3 of the NWA, which prescribes the protection of water resources. The NWA recognises such protection as essential to ensuring the sustainability of water resources in the interest of all users.

The DWS in South Africa is aligning its water policy and IWRM mandatory functions with the SDGs, particularly as the country is obligated to monitor and report annually on SDG 6 (UN, 2018a:13–19). The alignment between the South African water policy and SDG 6 also helps identify water-related benefits and challenges (DWS, 2022b:68–94).

Sections 77–80 of the NWA outline the need to integrate the management of water resources through the establishment of CMAs. The purpose of establishing these agencies in South Africa is to delegate water resource management to the catchment level and involve local communities within the framework of the National Water Resource Strategy and Catchment Management Strategy – similar to the approach used in establishing the AaR programme. Community-based water monitoring, therefore, embodies the participation of local communities in the management of water resources. This participatory approach is presented in the CBWM Theoretical Framework in Figure 3.2.

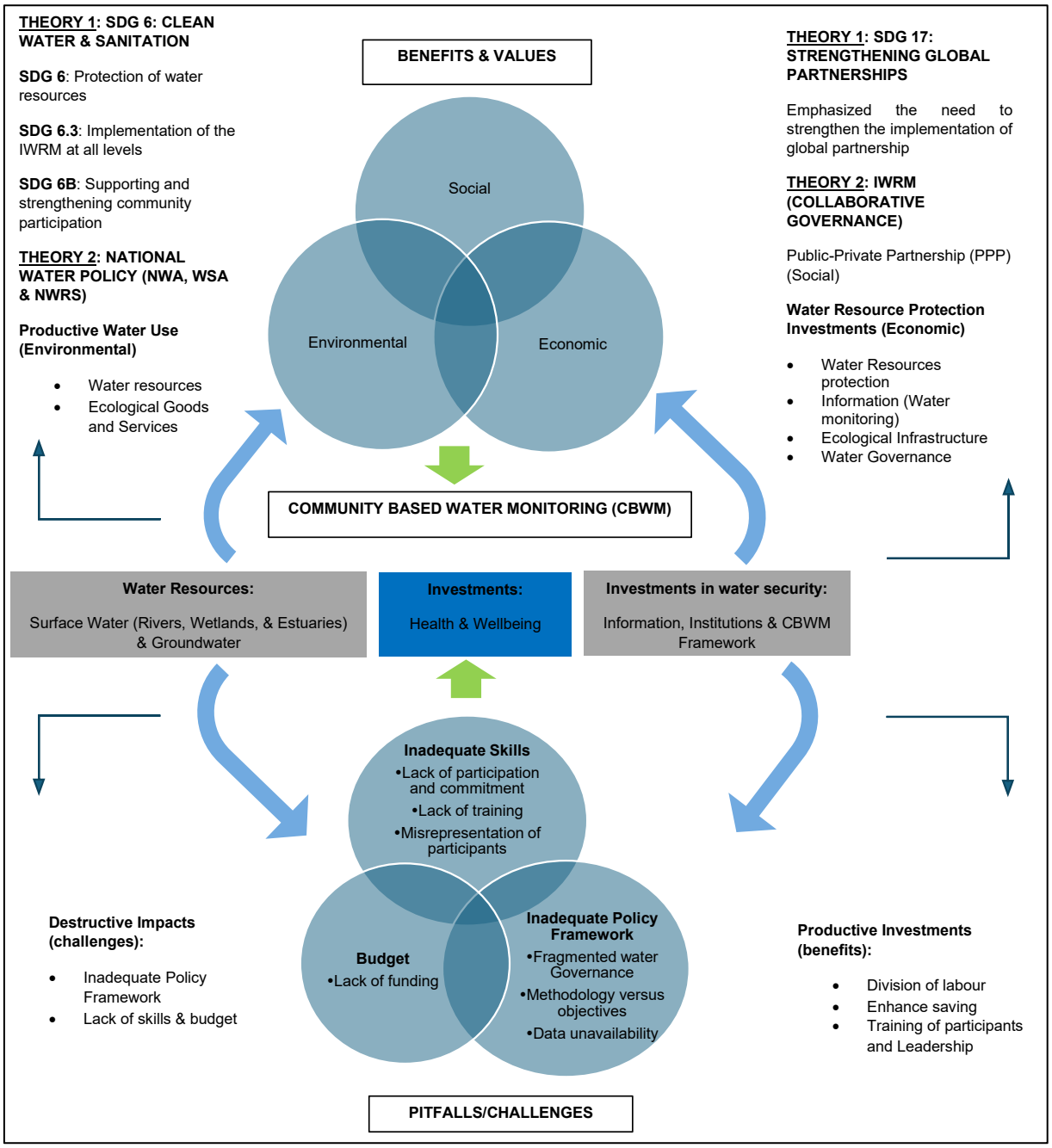


Figure 3.2: CBWM Theoretical Framework for water resource protection decision-making

Source: Adapted from Nepfumbada (2020)

The environmental, social, and economic benefits and values presented as overlapping intersection in Figure 3.2 depict an interconnectedness relationship. A policy supporting water resource protection needs sufficient budget allocation to enable stakeholder participation to achieve ecological improvement, goods and services.

The vicious cycle of the interdependencies of challenges presented as overlapping areas in Figure 3.2 are inadequate skills, policy framework, and budget. Insufficient or lack of budget for stakeholder's training and capacity building results in inadequate skills hindering the generation of data to strengthen and develop CBWM policy.

3.7 DOCUMENT ANALYSIS IN THE CONTEXT OF COMMUNITY-BASED WATER MONITORING

The literature review, summarised in Chapters 2, 3, and 4, (see Research Methodology Section 4.5.3.1 – Literature review and Figure 4.9 – Literature Review Flowchart), and document analysis were included as qualitative research methods in this study, supplementary to the interview and survey questionnaire data collection methods. Notably, only one document (4.8% (n = 1/21)) within the two mixed-methods categories identified document analysis as a stand-alone method; the remainder cited it as a supplementary method and suggested supporting its use.

The document analysis findings, based on 21 studies (Appendix A1) collected via a snowball effect, highlighted that CBWM is an emerging field within the water resource management sector, with few (33.3%, n = 7/21) of the proposed articles published within the past five years. The findings also reflected that most documents (57.1%, n = 12/21) originated from educational journals, followed by health journals (28.6%, n = 6/21), and then policy journals (14.3% (n = 3/21). This distribution supports the view that the CBM concept initially emerged from the educational and health sectors, with CBWM more recently gaining prominence.

The study's participants were asked to recommend materials for further investigation, resulting in a list that included: Thulamela By-Laws, Kruger National Park (KNP) RHP, Green Drop Report, AWARD resource list, RESILIM-O website, online Groot Marico documents, Water Research Commission (WRC) knowledge hub, Water Quality Policy Document (2016/17), and a reference to Prof. Jackie Goldwin. Additionally, survey respondents recommended AaR documents and reports, citizen science water resources monitoring tools, communities of practice for South Africa, Flores-Díaz *et al.*'s (2018:2–10) article on CBM in Response to Local Concerns, the National Water Master Plan–Botswana, strategies for catchment management, WRC dialogue documents on citizen science, and UN's water resource management publications.

Furthermore, the majority (66.7%, n = 14/21) of documents appear in journals focused on South Africa's national public, environmental, and Water Research Commission topics, while others were published in international water policy journals (33.3%, n = 7/21).

A total of 28 documents, comprising 21 primary sources and 7 additional sources that employed document analysis as their data collection method, were reviewed, including multi-country studies featuring South Africa, Botswana, Lesotho, Namibia, and other developing countries, as well as Denmark, New Zealand, the USA, Mexico, Bulgaria, the Republic of Korea, Turkey, and the UK, representing developed countries.

The analysis indicates that most of the recent literature focuses on the South African context, while the diversity of the studies demonstrates interest in both local and global contexts. This suggests that the study topic is dynamic, with recent contributions primarily addressing both national and international perspectives.

3.8 CONCLUSION

This chapter analysed existing literature that informed the development of the primary research question and sub-research questions, to gain new insight. In addition to the information discussed, the literature review was used as one of the qualitative research methods in this study, as expanded in Section 4.5.3. It provided data relevant to sub-research question 1, which investigated the benefits and challenges associated with CBWM programmes, and sub-research question 2, which sought to identify the essential criteria necessary for the successful implementation of CBWM in developing countries.

In addition, this chapter explored water resource protection, monitoring and management, examining anthropogenic impacts and climate change issues globally and in South Africa. Thereafter, CBWM as a form of CBM was explored, describing its evolution globally and regionally. The main findings of this chapter are the development of the CBWM Theoretical Framework that incorporates governance policies such as the SDGs and underscores the interconnectedness of water resource protection measures and active community participation through water monitoring and management to combat water quality deterioration. The cooperative management approach, involving all water users, including CBWM programmes in water monitoring, complements the government's role in water resource protection.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION AND RESEARCH DESIGN

This chapter covers Steps 1, 3, and 4 of the study and describes the research design and methodology. It provides first an overview of the research design (Section 4.1.1), followed by the philosophical assumptions of the research (Section 4.2), after which a description of the case studies and relevant catchment areas is provided (Section 4.3). Thereafter, the sampling strategy is discussed (Section 4.4), followed by an explanation of the application of the exploratory mixed-methods approach (Section 4.5) for exploring the value of CBWM in water resource protection decision-making in South Africa. This is followed by an explanation of the study limitations and trustworthiness of data (Section 4.6) and, finally, a discussion on the ethical considerations for the study (Section 4.7).

The chapter was informed by the literature reviews in Chapters 2 and 3 and seeks responses to sub-research questions 1 and 2, as displayed in Figure 4.1.

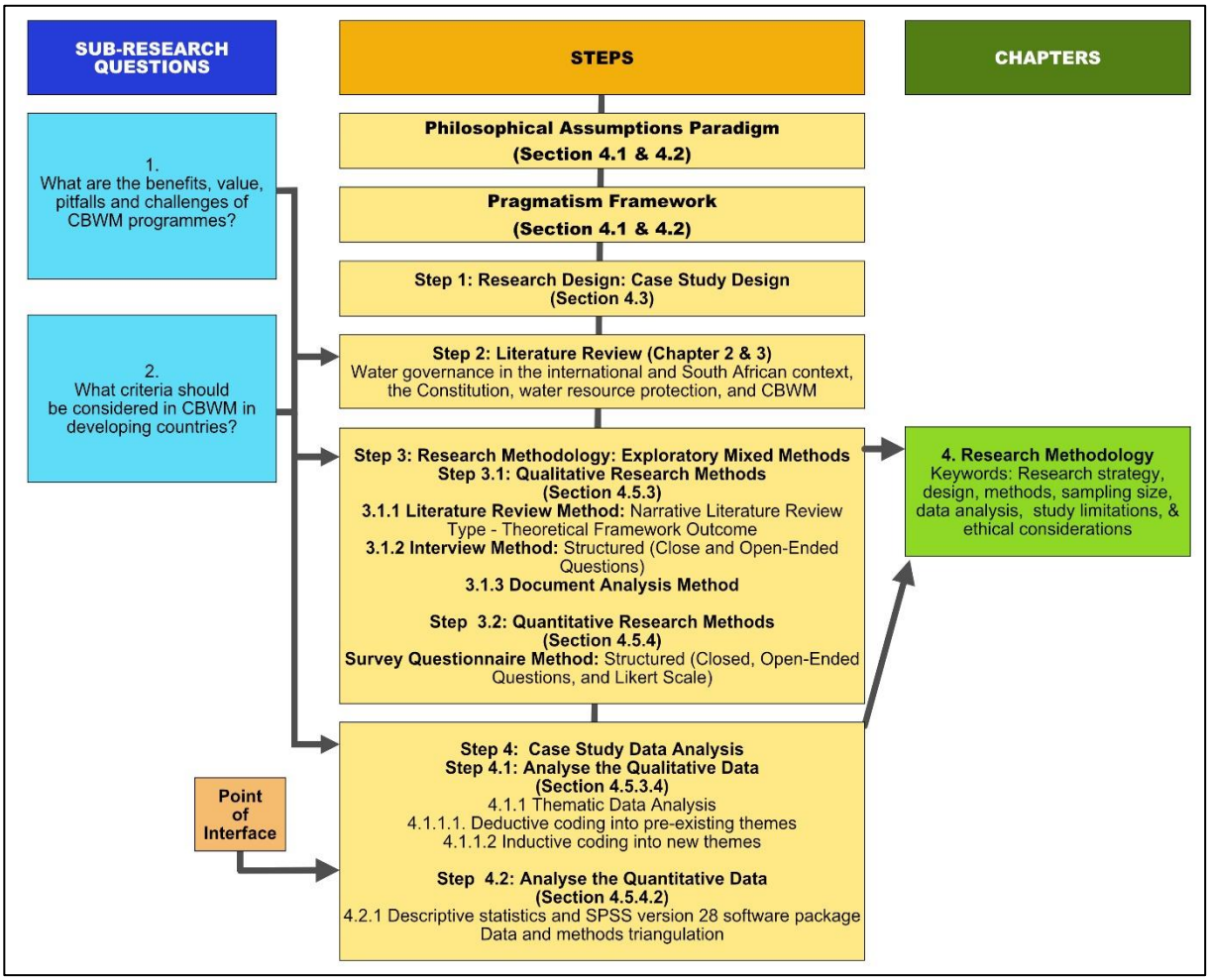


Figure 4.1: Research methodology layout of Chapter 4 (Steps 3 and 4)

As presented in Figure 4.1, this chapter outlines the research design (Step 1), materials used, the methods for data collection (Step 3 – Methodology), and the methods for data analysis

(Step 4), which were adopted to address the research question and sub-questions with the aim of responding to the challenges outlined in the problem statement.

The section that follows provides a brief overview of the research design, which is followed by a detailed discussion relating to the philosophical assumptions, case study research design, sampling strategy, and research methodology and methods. Chapter 4 concludes with the data analysis, study limitations, and ethical considerations.

4.1.1 Research design

Research design provides a framework for seeking answers to research questions (Hu & Chang, 2017:205–207). It offers a rational sequence that connects empirical data (collection and analysis) to a study's research objectives (or questions, as for this exploratory study) and conclusions (Kekeya, 2021:28–31). A case study research design specifically provides an intensive analysis and an in-depth investigation of the study area, whether an organisation or a community, in its real-life context (Schoch, 2020:245; Kekeya, 2021:28–29). According to Schoch (2020:246), a case study research design helps to confine the boundaries of the study area into a unit of analysis and allows for the opportunity to collect different kinds of data such as interviews, document analysis, and surveys within the same study area. Schoch (2020:245) further explains that case study research refers to the intensive study of a small number of cases or a single case (Schoch, 2020:245). This study employed a case study research design, providing a holistic understanding of CBWM in South Africa. Refer to Section 4.3 for further reading about the multiple-case study research design for this study that follows Section 4.2 (Philosophical assumptions of the research) below.

4.2 PHILOSOPHICAL ASSUMPTIONS OF THE RESEARCH

This research explored the real-life experiences of participants in three case studies to evaluate the potential value of CBWM in water resource protection decision-making within the South African context. This is pragmatic research which, according to Creswell (2014:6), makes "real world practice-oriented claims" of knowledge. The suitability of pragmatism as a guiding philosophical research paradigm for this investigation is significant, as it supports case study research design and the application of a mixed-methods research methodology (Creswell, 2014:31–36; Aucamp, 2015:122; Wessels, 2015:7–8). Importantly, it should be kept in-mind is that both pragmatism and case study design allow a researcher to choose suitable methods (Creswell, 2014:11) or a combination of suitable methods to answer research questions.

Qualitative and quantitative research methods were given equal priority, as qualitative data were used to substantiate the quantitative results (Creswell, 2014:51). In this study, the qualitative method included a literature review, interviews, and document analysis. In contrast,

the quantitative method included survey questionnaires that collected quantitative data. The qualitative and quantitative data were collected and analysed separately and independently, and the results were integrated concurrently, as discussed in Chapter 5. Thereafter, the researcher observed the relationships among the three case studies as marginal significance in the form of a *p*-value.

4.3 CASE STUDY RESEARCH DESIGN AND CASE DESCRIPTION

According to Schoch (2020:246), case study research refers to the intensive study of a small number of cases or a single case (Schoch, 2020:245). A multiple-case study research design, consisting of three cases, was chosen to answer the study's research question and sub-questions (see Sections 4.3.1–4.3.3 for a discussion on the study area and cases; Luvuvhu, Selons, and Koffiekraal catchments). As mentioned earlier, Figure 4.1 (see Section 4.1) presents the case study design choice as Step 1.

The rationale for selecting a multiple–case study design was based on the type and extent of land-use activities that impact water resources (i.e. catchments) in WMAs with mega-infrastructure land-use activities such as bulk water supply dams. The bulk water supply dams in the three case study catchments are the Nandoni Dam in the Luvuvhu River catchment, Loskop Dam in the Selons River catchment, and Kromellemboog Dam in the Koffiekraal area in the Groot Marico River catchment. Large water use-related infrastructure such as dams brings water use-related pressures, which need stakeholder interventions (Akhmouch & Clavreul, 2016:7–14).

South African water legislation mandates the development of the CMA for each WMA, for the management of water resources at a local level (DWS, 2022a:8), which opens the opportunity for the involvement of community members in water resource protection.

Part of the research design entailed using a literature review as the basis for the case study design (see Step 2 of Figures 1.1, 2.1 and 4.1), which assisted in answering sub-research questions 1 and 2, generating the questions for the final interview schedule (Appendix A3) and the survey questionnaires (Appendix B2 and B3) – the tools used for collecting data from the cases. The literature review also aided the development of the theoretical framework (Figure 3.2 in Section 3.6.2), which informed the development of CBWM evaluation criteria (see Table 4.1 of Section 4.5.2.6.

4.3.1 Case study and relevant catchment area description

The study focused on the protection of water resources (surface water, groundwater, wetlands, and estuaries) in three catchments within the WMAs, located in three different provinces of South Africa as the scope of the study (Figure 4.2). The country's watershed and catchment boundaries are divided into six WMAs. The three case studies (Figure 4.2) – the Luvuvhu River

catchment (Figure 4.3), Selons River catchment (Figure 4.4), and Koffiekraal area in Groot Marico catchment (Figure 4.5) – are all within the Limpopo–Olifants WMA 1 and [1]proto-CMA.

The three case studies covered in this study are in the Limpopo, Mpumalanga, and North West Provinces, which form part of the SADC countries, including the Limpopo Watercourse Commission (LIMCOM) and the Orange-Senqu River Commission (ORASECOM) shared watercourse systems. The Koffiekraal case study formed part of ORASECOM, as it is part of the Molopo River System that flows into the Orange River Basin. ORASECOM manages water resources shared with Lesotho, Botswana, and Namibia.

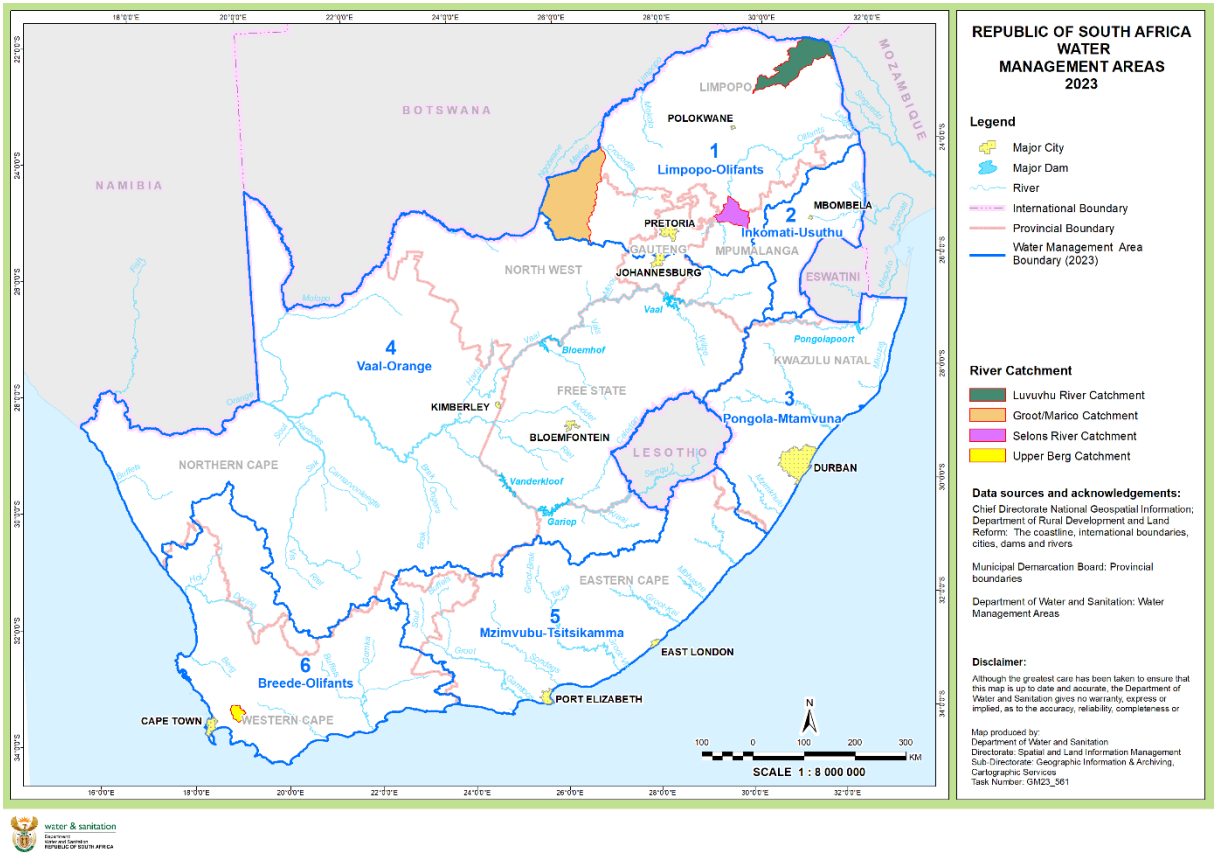


Figure 4.2: Map of the three case studies on the new gazette's (2023) six WMAs boundaries in South Africa

Source: Department of Water and Sanitation (2023)

Within each of the three case studies, institutional and organisational representation considered was case study-specific, but similar groups of participants were sourced from all three areas. The aftermath of the apartheid regime did not spare the institutional arrangement of the people within the designated WMAs, displacing and segregating them to homelands according to their race, ethnicity, culture and language (van Koppen *et al.*, 2021:383–396; van Koppen, 2022:6–18). Languages in homelands served as identity and a means of social discrimination during apartheid, and indigenous languages were stigmatised and suppressed

[1] Proto-CMA: A proposed CMA not yet established.

in favour of the languages of the oppressors and those of dominant groups (Jegede & Shikwambana, 2021:5–6). The perpetuated language inequalities resulted in language barriers, presenting community water monitoring challenges requiring translation, as conducted in this study.

The three case study areas fall in the same proposed homogenous hydro-climatic zones referred to as the Upper Limpopo, Olifants, Inkomati-Usuthu, and Upper Vaal WMA. This is also known as the Highveld Climatic Zone, which is a summer rainfall region with an average temperature range of 10°C in winter to 25°C in summer (DWS, 2022a:26–28). The mean annual rainfall in the Limpopo–Olifants WMA ranges from 200 mm in the north to 1,200 mm in the Soutpansberg mountainous region (DWS, 2022a:14–16).

The Limpopo–Olifants WMA has an estimated population of 15 million people, with 57% living in urban centres such as Polokwane, Pretoria, Johannesburg, and Rustenburg, and 43% residing in rural areas (DWS, 2022a:14–16). Mining is a predominant economic activity in the Limpopo–Olifants WMA, mainly in the Limpopo area, followed by agriculture (mostly in the Olifants area), then ecotourism, power generation, and small-scale manufacturing activities, mainly in Polokwane and Gauteng (DWS, 2022a:14–16).

The Limpopo–Olifants WMA contributes 52% of the South African GDP, which explains the need for water of good quality that is fit for consumption. The area's economic activities can change the composition of water quality in surrounding water resources, leading to water pollution (DWS, 2022a:16).

Water scarcity is a major concern in the Limpopo–Olifants WMA, given the climatic conditions, population size, and land-use activities, which result in water demand exceeding supply. As a supplement, the WMA depends on the Vaal–Orange WMA and the Orange–Senqu Basin water transfer (DWS, 2022a:17–31). Water scarcity is one of the reasons water resources are monitored, with the inclusion of all water users, including community members, as a focus for this study.

4.3.1.1 Luvuvhu River catchment

The geographical location of the Luvuvhu River catchment case study is the Limpopo–Olifants WMA, in the north-western part of South Africa (Figure 4.3). The WMA forms part of the internationally shared Limpopo River Basin area, shared with Botswana, Zimbabwe, and Mozambique. The WMA falls within a semi-arid climate (mostly dry), characterised by generally warm summers with daily temperatures exceeding 40°C, and mild winters. Groundwater has augmented water supply in the area, but the 2015–2016 drought in Limpopo resulted in yield reductions in groundwater aquifers, contributing to extended dry periods (DWS, 2022a:114–115).

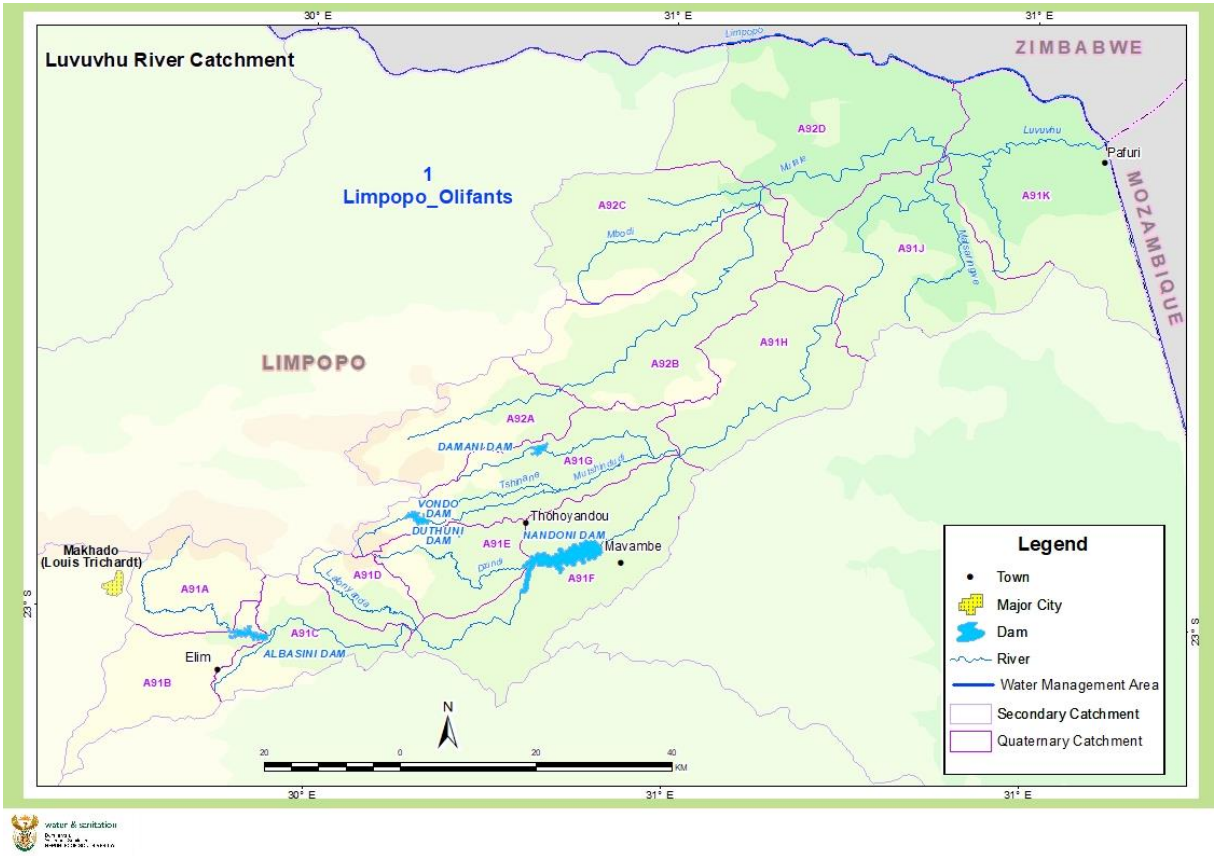


Figure 4.3: Luvuvhu River catchment

Source: DWS Metadata (2021)

The Luvuvhu River catchment forms part of the Limpopo River Basin, which rises from the Soutpansberg Mountains, covering 5,941 km^2, with a mean annual precipitation of 608 mm. The Luvuvhu River catchment, a perennial system, has the Mutshindudi and Mutale rivers as its main tributaries and flows into the Limpopo River, which runs into the KNP (SoR, 2001b:27; SoR, 2014:1–6).

The catchment's population (quaternary catchments A91F and A91E) is approximately 261,059 people, with most of the population living in rural areas under tribal chiefs (Stats, SA 2022a:2–3). The catchment's land-use activities include towns (e.g. Thohoyandou and Giyani), rural settlements, agricultural farming, domestic grazing, sand mining, wildlife grazing, and dryland agriculture on the Highveld. Water supply dams in the catchment include Albasini, Vondo, Damani, Phiphidi, and Nandoni dams, supplying water for domestic and agricultural purposes. Activities within the catchment contribute to water supply demand for the catchment (DWS 2022a:114; DWS, 2023a:287–288).

4.3.1.2 Selons River catchment

The Selons River catchment case study falls within the Olifants River system, part of the Limpopo–Olifants WMA, of which the Selons River is one of the main tributaries feeding into the main Olifants River (Figure 4.4). The Olifants River system forms part of the Bushveld

basin, and it meanders from Johannesburg, through the Loskop Dam to the confluence with the Elands River, into the KNP, then Mozambique. The river system forms part of the international LIMCOM (South Africa and Mozambique) collaboration. As with the Luvuvhu River catchment, groundwater is extensively used for irrigation and domestic purposes. The study area catchment shares a water management boundary with the Inkomati-Pongola WMA (Heath *et al.*, 2010:1–3; DWS, 2023a:276).

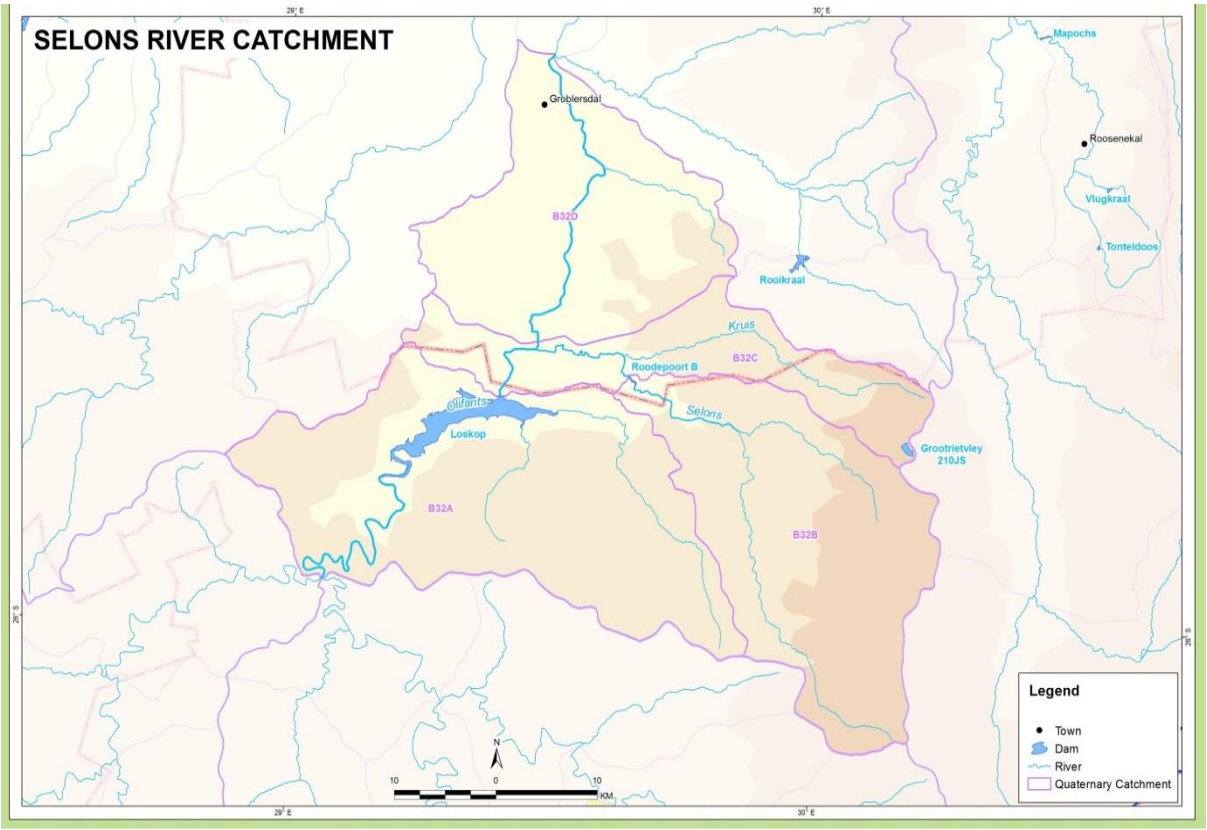


Figure 4.4: Selons River catchment

Source: DWS Metadata (2021)

The population of the Selons River catchment (quaternary catchments B32A and B32D) is mostly rural, with few patches of urban settlements. The area has approximately 6,577 people (Stats SA, 2022a:2–3), with most of the population living on privately owned farms.

The land-use activities supporting the economy in the area are predominantly agriculture, forestry, mining, industrial activities, and tourism. The low-lying areas are mostly dominated by the KNP frontier, an international conservation area. The climate in the Highveld regions is characterised by cooler temperatures ranging from 10 to 18 ^{0}C and summer rainfall ranging from 400 to 1,000 mm per annum. The temperatures in the escarpment are warmer than the Highveld, with readings ranging from 10 to 26 ^{0}C, and the area is drier with rainfall ranging from 400 to 600 mm per annum (SoR, 2001a:26–36; SoR, 2014:6–10; Hlungwani, 2024:20–70).

The fact that the population is low does not mean that the rate of water use and wastewater discharge is low. Tourism attraction centres and the KNP attract many tourists per annum, contributing to high water use demand and pollution loads (SoR, 2001a:26–36; Heath *et al.*, 2010:1–3).

4.3.1.3 Koffiekraal (Groot Marico River catchment)

The Koffiekraal area case study is part of the Groot Marico River catchment in the North West province, situated in a semi-arid region of South Africa (Figure 4.5). As with any other river system in the country, it has been affected by human impacts in the name of development. Koffiekraal is situated in the lower reaches of the Groot Marico River, upstream of the Uitkyk and Phela locations (Tempelhoff *et al*., 2012:24–26).

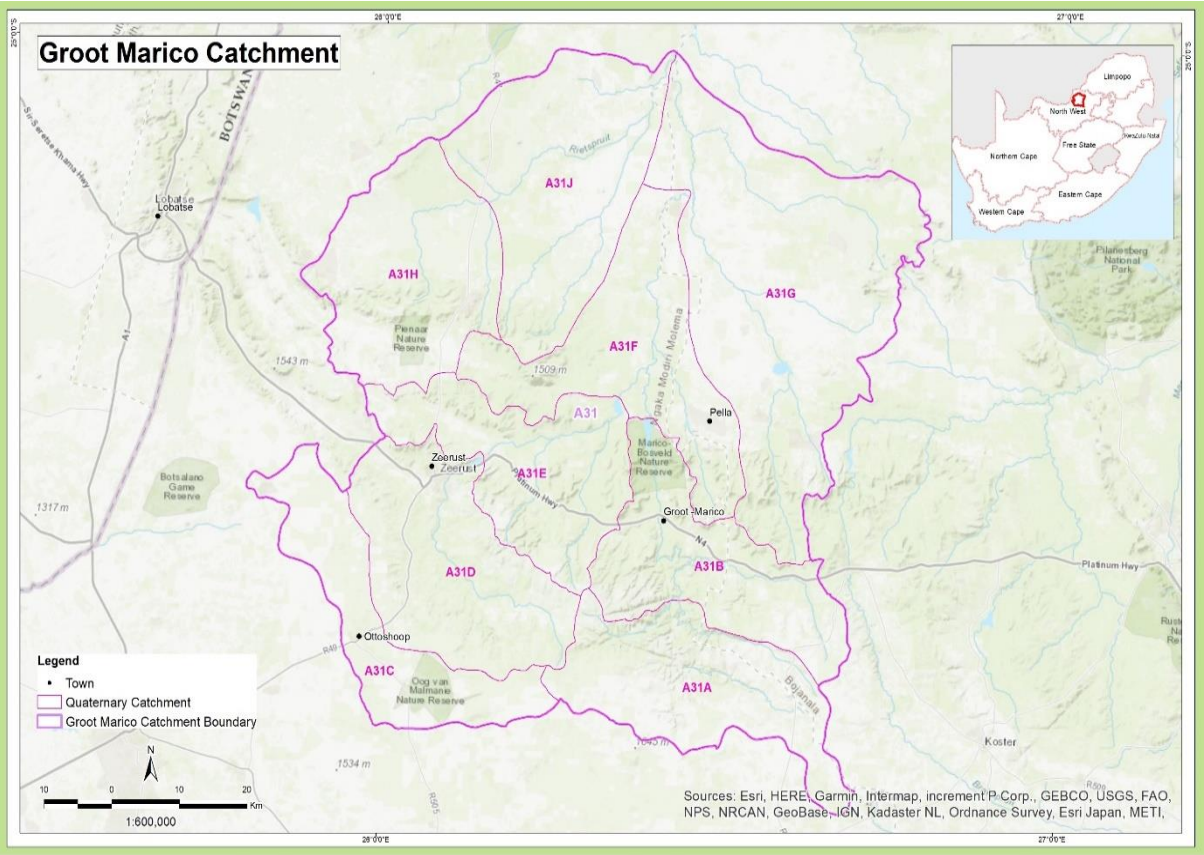


Figure 4.5: Koffiekraal area in Groot Marico catchment

Source: DWS Metadata (2021)

The Crocodile West and Groot Marico rivers are the two major river systems in the south-western part of the Limpopo River basin (Drainage Region A), ultimately draining into the Indian Ocean in Mozambique. The Crocodile (West) and Marico, part of the Limpopo WMA 1, borders Botswana (north-west). The confluence of the two major river systems, the Crocodile West and Marico rivers, is fed by the mountainous dolomitic Molemane and Marico Eyes, and flows into the Limpopo River, on the South Africa/Botswana border. Botswana depends on water from the Groot Marico River (Templehoff *et al*., 2012:24–27). The headwaters of the

Molopo River, a tributary of the Orange River that drains westwards into the Atlantic Ocean, form part of the WMA.

The tertiary drainage regions of the WMA are A10, A21–A24, A31, and A32, and quaternary drainage region D41A. The WMA covers a total catchment area of 47,565 km^2. The Pienaars, Apies, Moretele, Hennops, Jukskei, Magalies, and Elands rivers are the major tributaries of the Crocodile River and together make up the A20 tertiary drainage catchment, with 39 quaternary catchments (DWS, 2023a:323–381).

The Crocodile River contributes to the flow of the Limpopo River Basin, which is shared with Botswana (occupying 14% of Botswana's territory in the eastern part), Zimbabwe, and Mozambique. The river system forms part of an international watershed, involving the ORASECOM (South Africa, Lesotho, and Botswana – occupying 12% of southern Botswana's territory) and LIMCOM (South Africa and Mozambique) (Bot-NWP, 2012:6); DWS, 2023d:14).

The population in the Groot Marico River catchment (quaternary catchments A31A, B, F, and A32D) is approximately 24,060 (Stats SA, 2022a:2–3). The Koffiekraal population is approximately 50,000, mostly from the Hurutshe clan, a Sotho-Tswana-speaking group. Most of the population lives in rural settlements and relies on subsistence farming as a source of food, under the tribal authority of a chief. The rest depend on bushveld farming, which was one of the reasons new mining proposals were rejected to protect the river (Templehoff *et al*., 2012:26).

4.4 SAMPLING STRATEGY

To successfully evaluate how CBWM data informs decision-making, the participation and involvement of all local communities and stakeholders in water resource protection were prioritised. The study population unit of analysis (represented as ***n***, in terms of the individuals or group of participants) comprised participants from different levels of government, including national, provincial, and local levels.

The study also considered participants from government institutions and other water sector organisations, including academic institutions, research organisations, ecological groups, industrial companies, mining companies, non-governmental organisations (NGOs), and representatives from the domestic sector.

Government participants included strategic managers, project managers, scientific managers, control environmentalists, and production scientists involved in policies and strategies, resource quality information systems, environmental reporting, water ecosystems, the REMP, and AaR programme units. Specific government institutions considered in the surveys included the DWS, nature conservation agencies, and municipalities. Other sectors represented were the Water Research Commission (WRC) and NGOs such as the South African Environmental

Observation Network. Domestic sector participants included representatives from the South African Local Government Association (SALGA), the Department of Cooperative Governance and Traditional Affairs (COGTA) and community members.

Non-probability sampling was used, and participants were identified through purposive and snowball sampling (Welman *et al*., 2005:6–8). Purposive sampling involves the intentional selection of a sample for a specific purpose – a non-randomly selected sample or targeted population groups that represent the broader population (Welman *et al*., 2005:6–8; Carlson & Cohen, 2018:171–172). In this study, members involved in CBWM projects, REMP, AaR programmes, or water resource protection were included. Where snowball sampling was used, participants from the sample population acted as informants – experienced and knowledgeable participants – who assisted in identifying other relevant members to include in the sample. Respondents identified through snowball sampling participated through survey questionnaires. A combined approach of purposive and snowball sampling was used to balance potential biases and maximise the sample size until saturation point was reached, as justified by Carlson and Cohen (2018:170–172).

The sample size is defined as the number of individuals selected to participate in the research or study (Budiu & Moran, 2021:1; Kibuacha, 2021:1–5). A sample size needs to represent the study population, which is defined as a measure of confidence intervals. Levels of precision and risk are the determining factors to be considered when identifying a sample size. Hence, representativity can guarantee accuracy and not necessarily a large sample size (Taherdoost, 2017:237–239). The sample size target in this study was set at 12 to 16 participants per case study, who were interviewed to collect data, as supported by Morgan *et al.* (2017:90) and Taherdoost (2017:237–239).

The list of community stakeholders was sourced from the DWS database and served as a sampling frame and size for the population, as it contained all the required units of analysis – such as gender (male, female, and other), age (elders and youth over 18 years), designation, and race (in line with the demographic composition of South Africa). Written consent was obtained from the DWS, Luvuvhu, and Koffiekraal local authorities (Appendix C1). Participants' right to privacy was upheld in accordance with the *Protection of Personal Information Act* 4 of 2013 (*POPIA*).

A pilot case study followed by three case studies identified in South Africa were used to apply multiple techniques, interviews, and survey questionnaires. Participants identified in Appendices F1 and F2 were interviewed and returned questionnaires through case studies, exploring real-life events, situations, experiences, and relations in context (Cleland, 2017:66).

4.4.1 Luvuvhu case study sample size

Qualitative data were through interviews, and quantitative data through survey questionnaires. The participants and respondents for the Luvuvhu catchment case study, presented as sample sizes in Figure 4.6, included DWS officials, the ecological sector, academic institutions, REMP practitioners, AaR programmes (civil society and public members), professional service providers (PSPs), farmers, municipalities, and mining organisations.

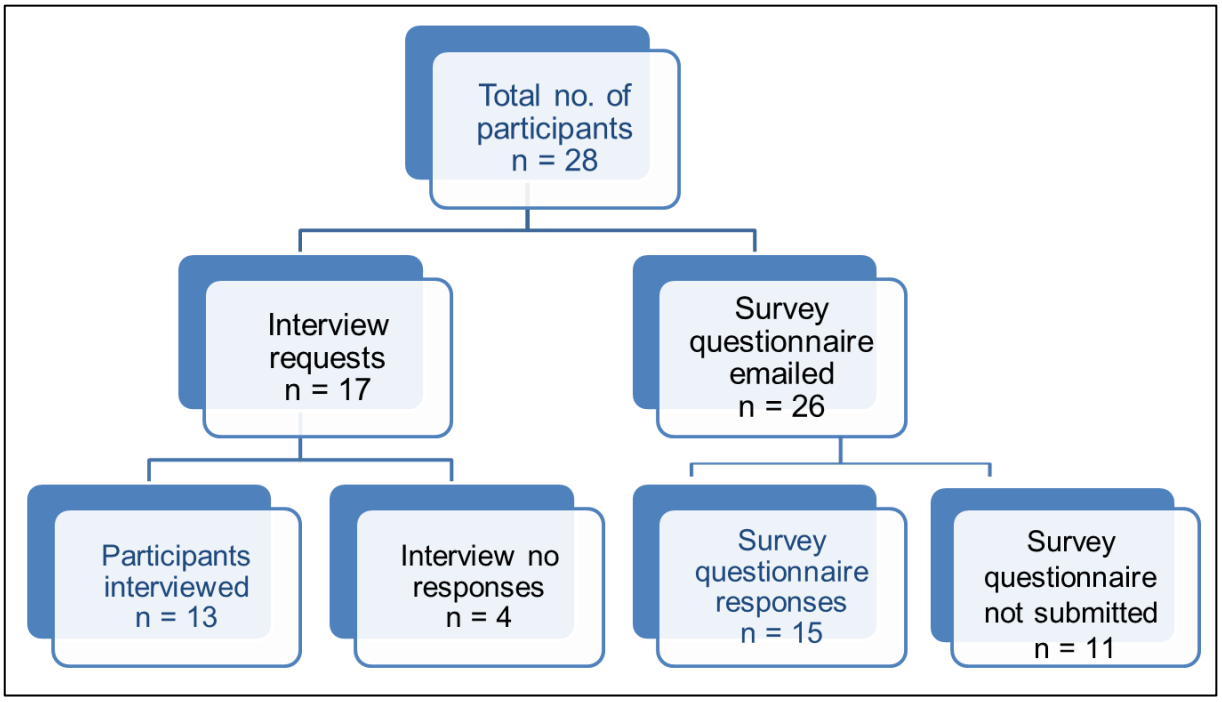


Figure 4.6: Flow diagram of Luvuvhu case study interview and survey questionnaire sample size

Luvuvhu case study requests for participation in the form of consent forms (Appendix A2) were emailed to 17 participants.

Thirteen (n = 13) participants agreed to be interviewed by signing and returning the study consent forms. The interviewed participants included representatives from academic institutions (n = 3), research institutions and PSPs (n = 2), the ecological sector (n = 1), the DWS (n = 1), municipalities (n = 2), civil society (n = 2), farmers (n = 1), and the mining sector (n = 1).

Four (n = 4) participants did not respond to the interview invitation, with one (n = 1), a community member, appearing reluctant to participate, as he kept on postponing to a new date whenever called. Two members (n = 2) from academic institutions showed interest but never committed to an interview date. A retired member of the ecological sector (n = 1) did not respond at all.

In addition, in the Luvuvhu case study, a Google Forms survey questionnaire (Appendix B2**)** website link was emailed to 27 identified participants. Fifteen (n = 15) survey responses were

received from academic institutions ($n = 3$), the ecological sector ($n = 1$), the DWS ($n = 2$), Reserve determination ($n = 2$), REMP ($n = 3$), AaR and civil society ($n = 2$), an international cross-boundary watershed ($n = 1$), and the mining sector ($n = 1$).

Questionnaires were not submitted by 11 ($n = 11$) respondents who received emails with Google Forms questionnaire survey links. These were from academic institutions ($n = 3$), including two students, a lecturer, and a retired lecturer who complained about the network connection in his area of residence, the ecological sector ($n = 4$), the DWS ($n = 1$), PSPs/consulting sector ($n = 1$), mining ($n = 1$), and a community member ($n = 1$).

4.4.2 Selons case study sample size

The sample sizes of the participants and respondents for the Selons River catchment case study are presented in Figure 4.7. They included DWS officials, the ecological sector, academic institutions, REMP practitioners, AaR programmes (public members), PSPs, the construction sector, and CMAs.

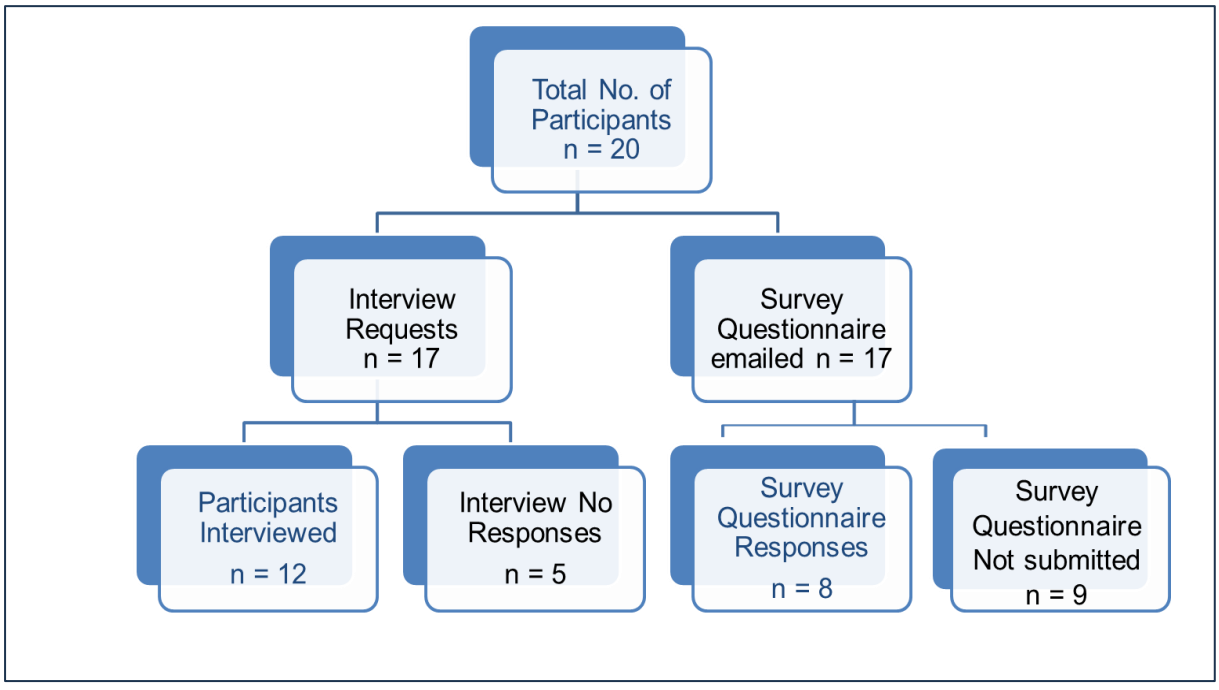


Figure 4.7: Flow diagram of Selons case study interview and survey questionnaire sample size

Of the 17 participants identified in the Selons case study, 12 agreed to be interviewed. The interviewed participants included representatives from the DWS ($n = 2$), REMP ($n = 2$), AaR ($n = 1$), the Inkomati-Usuthu CMA (IUCMA) ($n = 2$), the Association for Water and Rural Development (AWARD) ($n = 2$), research and academic institutions ($n = 1$), construction ($n = 1$), and PSPs ($n = 1$).

Of the five participants (n = 5) who declined the interview invitation, two – one representing the water association ($n = 1$) and the other from a research NGO ($n = 1$) – cited a lack of relevance to the land degradation functions they were performing as the reason for not

participating. Of the two from academic institutions ($n = 2$), one indicated interest in participating but could not commit, and the other did not respond. An IUCMA member who was part of the water quality monitoring department directed the researcher to a doctoral candidate who never responded.

Eight survey questionnaire responses were obtained from institutions – the DWS and REMP ($n = 2$), IUCMA ($n = 2$), CBWM ($n = 1$), PSP ($n = 1$), Water Services Authority ($n = 1$), and the municipal sector ($n = 1$).

Questionnaires were not submitted by nine ($n = 9$) respondents who received emails with Google Forms survey questionnaire links. These were from the IUCMA ($n = 2$), the ecological sector ($n = 1$), an NGO ($n = 1$), PSPs ($n = 2$), a municipality ($n = 1$), and community members ($n = 2$). An additional suggested respondent from an academic institution was not included in the Selons survey, as he had already participated in the Berg River catchment pilot study.

4.4.3 Koffiekraal case study sample size

The sample sizes of the Koffiekraal case study participants and respondents are shown in Figure 4.8. These include DWS officials, academic institutions, REMP practitioners, AaR programmes (public members and CBWM), PSPs, municipalities, mining, energy, and the Botswana and Lesotho International Watershared Commissions.

The Koffiekraal case study was the third to be conducted in this investigation, with 17 participants invited for interviews. Thirteen participants were interviewed ($n = 13$), including representatives from the DWS ($n = 2$), REMP ($n = 2$), PSPs ($n = 2$), a municipality ($n = 1$), CBWM ($n = 1$), international CBWM ($n = 3$), Eskom's energy sector ($n = 1$), and the mining sector ($n = 1$).

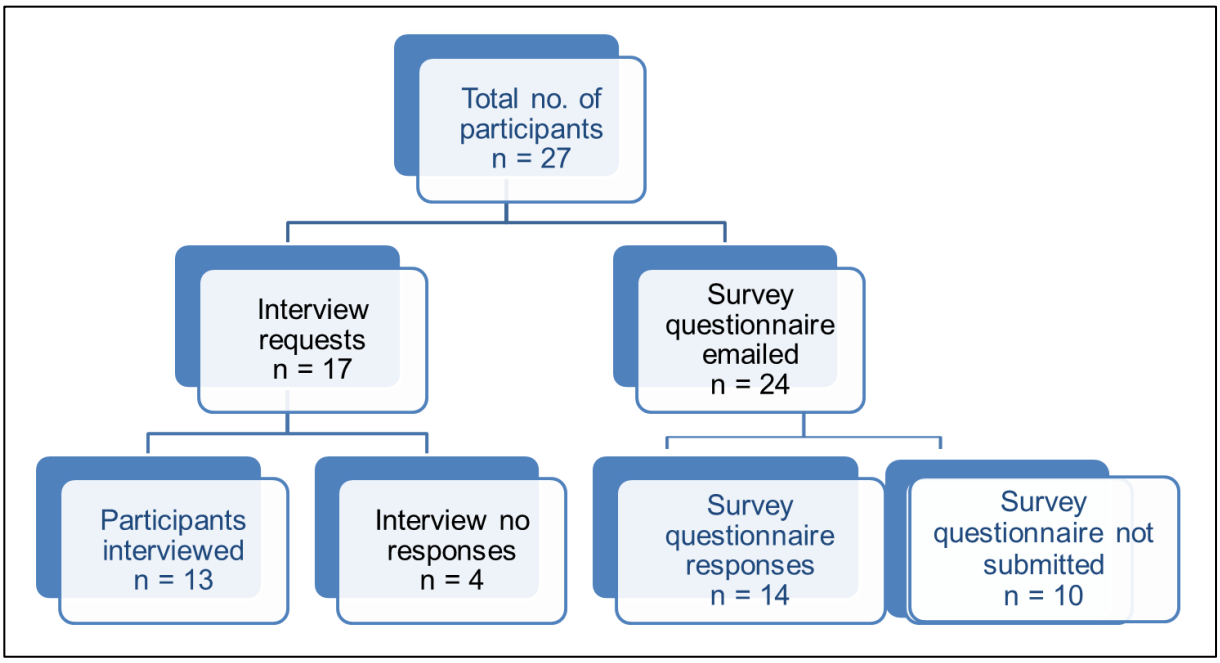


Figure 4.8: Flow diagram of Koffiekraal case study interview and survey questionnaire sample size

Four ($n = 4$) declined to participate in the interview, with a municipal official ($n = 1$) indicating that their office did not approve their participation. A potential international participant cited the irrelevance of the research topic to the institution's functions, and two local CBWM representatives ($n = 2$) cited network challenges and limited technology proficiency.

Fourteen survey questionnaire responses were submitted from the DWS ($n = 3$), CBWM ($n = 1$), PSPs ($n = 3$), an academic institution ($n = 1$), the Lesotho international cross-boundary watershed ($n = 4$), and the Botswana international cross-boundary watershed ($n = 2$).

Questionnaires were not submitted by 10 respondents ($n = 10$). These were from the academic sector ($n = 2$), international cross-boundary watersheds ($n = 2$), community members ($n = 4$), and the DWS ($n = 2$). Additional suggested respondents from the research sector and international cross-boundary watershed were not considered, as they had already participated in the Berg River catchment pilot study and the Koffiekraal case study interviews.

4.5 RESEARCH METHODOLOGY AND METHODS

4.5.1 Introduction to mixed-methods approach

In this study, an exploratory mixed-methods approach was chosen to support the case study research design. This methodology combines multiple forms of data collection methods, including qualitative and quantitative research methods, to obtain data from the selected cases of this study (Tashakkori & Creswell, 2007:112–130; Terrell, 2012:256–276; Hu & Chang, 2017:205–206; McKim, 2017:203–210). The mixed-methods approach was developed from

information adapted from Terrell (2012:256–276), Creswell and Plano Clark (2011:1–6), and Hu and Chang (2017:205–206), as outlined in Figure 4.1. The methodology examines how qualitative data explore meaning, how quantitative data generalise findings, and how the two different data sources complement each other (Creswell, 2014:31–34; Salmons, 2022:24–25). The mixed-methods approach is widely used in social science, where qualitative and quantitative data are collected, analysed, and integrated in a single study.

Qualitative research is a descriptive form of research that displays personal experiences in the data collected (Creswell, 2014:1–5), as demonstrated in this study through interviews, a literature review, and document analysis. The use of qualitative methods for this study is discussed further in Section 4.5.3, with Section 4.5.3.1 providing details of the literature review method, Section 4.5.3.2 providing details of the interview method, and Section 4.5.3.4 presenting a detailed discussion of the document analysis method. The methods employed for the analysis of the qualitative data are provided in Section 4.5.3.4.

Quantitative research is a numerical and inferential form of inquiry, and in this study, it was applied through a survey questionnaire to collect quantitative data (Welman *et al*., 2005:236; Creswell, 2014:4). The quantitative methods used in this study are discussed further in Section 4.5.4, with Section 4.5.4.1 providing a detailed discussion of the use of the survey questionnaire, followed by Section 4.5.4.2, which provides a discussion of the analysis of the quantitative data generated by the survey questionnaire.

4.5.2 Exploratory mixed-methods

Mixed-methods research produces results best used in understanding data management behaviours (Peersman, 2014:1–10; Berman, 2017:10; Hu & Chang, 2017:205–206). The rationale for using mixed research methods in this study was to tap into the advantage of using quantitative measures to confirm data generated from qualitative experiences (Creswell, 2014:32).

To overcome the CBWM challenges highlighted in Section 3.5.4, the study adapted Carlson and Cohen's (2018:173–174) data collection and analysis, which categorised issues of concern into six pre-existing themes as follows:

4.5.2.1 Theme 1: Effectiveness of CBWM programmes

Category 1.1: CBWM partnerships

The effectiveness of CBWM begins with the programme's design, the initiation phase, setting goals, identification of participants, education versus local knowledge, and the level of engagement. The programme's effectiveness depends on the benefits and challenges encountered. The success of CBWM programmes should not be measured only by monitoring and evaluation of the biophysical status of water resources; social behavioural patterns,

cultural values, and norms around community water use should also be considered (Graham *et al*., 2016:46–48).

Category 1.2: Correlation between effective collaborative governance

The core of maintaining effective collaboration in CBWM lies in establishing strong partnerships. Collaborations between government and CBWM networks are said to be effective, as they strengthen local initiatives' capacity.

4.5.2.2 Theme 2: Prevalence of standardised monitoring protocols

How monitoring types (programmes) and parameters are chosen in CBWM initiatives is imperative, as this informs monitoring protocols. Currently, adherence to standardised protocols in CBWM has improved compared to two decades ago.

4.5.2.3 Theme 3: Perceptions of CBWM data uptake in policy and decision-making

This theme aimed to assess whether data inform policy, the extent of governance among national, provincial, and local levels – including civil society – and the reasons for initiating the CBWM programme.

4.5.2.4 Theme 4: CBWM benefits and challenges identified through literature review

The benefits of CBWM are explained in Figure 3.2 and Section 3.5.2, and the challenges are addressed in Figure 3.1 and Section 3.5.4.

4.5.2.5 Theme 5: Type of monitoring parameters chosen, as in the literature review

These are listed and explained as monitoring method/s and the use of a standard monitoring protocol.

4.5.2.6 Theme 6: CBWM governance and community engagement

This was the main theme revolving around the extent of community involvement in CBWM operations.

The CBWM criteria were developed in this study, addressing sub-research question 2 findings and are presented in Table 4.1. Presenting the study's CBWM criteria in Chapter 4 is appropriate, as the six pre-existing themes listed in Table 4.1 serve as a reference for the presentation of the results in Section 5.3.

Table 4.1: List of criteria for evaluating CBWM, incorporated into the study's sub-research questions and pre-existing themes

Sub-research questions	Pre-existing themes
1. What are the benefits, values, pitfalls, and challenges of CBWM programmes?	Theme 4: CBWM benefits and challenges *Sub-theme 4.1*: CBWM benefits and values

Sub-research questions	Pre-existing themes
	Sub-theme 4.2: CBWM challenges
2. What criteria should be considered in CBWM in developing countries?	Theme 5: CBWM criteria *Sub-theme 5.1*: Monitoring parameters *Sub-theme 5.2*: Data management *Sub-theme 5.3*: Funding *Sub-theme 5.4*: Value for money Theme 2: Prevalence of standardised monitoring protocols
3. Based on the opinions of governance structures and the real-life experiences of communities, to what extent do selected catchments in South Africa, as a developing country, benefit from CBWM?	Theme 1: Effectiveness of CBWM programmes *Sub-theme 1.1*: CBWM partnerships *Sub-theme 1.2*: Correlation between effective collaborative governance
4. What are the views of governance structures on the extent to which CBWM operates in South African communities?	Theme 6: CBWM governance and community engagement
5. How might a conceptual framework work by enhancing the use of CBWM data in decision-making for developing countries?	Theme 3: Perceptions of CBWM data uptake in policy and decision-making.

Both qualitative and quantitative data were collected simultaneously, after which the two datasets were analysed separately.

4.5.3 Qualitative research methods

The study's qualitative research focus was on answering the "what", "how", and "in what ways" questions, expressed as "identify, explore, explain, and describe" (Cleland, 2017:61–63). Due to the COVID-19 pandemic, regulations were promulgated in South Africa that restricted physical meetings during the time of data collection for this study. As a result, ethical clearance (Appendix D1) was amended to cancel the planned focus group and change face-to-face interviews to virtual interviews. Virtual interviews were conducted to collect qualitative data in the pilot study and for the three case studies, in compliance with the amended ethical clearance (Appendix D2). In support of what was done in this study, qualitative data were collected as a descriptive form of participants' perceptions of the issues, voice recorded, transcribed in a research report, and presented in coded themes (Welman *et al*., 2005:6–8; Babbie & Mouton, 2007:53–58; van Gog *et al*., 2008; Quin, 2012:1–24; Berman 2017:1–19; Cleland, 2017:65; Kılıçoglu, 2018:949–951). The data collection tools applied in this study's qualitative research are outlined below.

4.5.3.1 Literature review

A literature review is an initial step in the research process, and was performed first in this study, as it helped to build on the findings, collect information on the research question, identify research gaps, and point out the direction for future research (Mwadzingeni *et al.*, 2022:1–4). The conclusions drawn from literature review sources were used to develop the research topic, main research question, sub-research questions, and the generation of the study's theoretical framework (Figure 3.2).

Figure 4.1 shows the study layout, splitting the literature review into Chapters 2 and 3 for ease of reference, as introduced in Sections 2.1 and 3.1. Chapter 2, on water governance, addresses sub-research question 2, while Chapter 3 covers the literature review related to sub-research question 1. The literature review is also incorporated into this chapter as one of the qualitative research methods used in this study.

The study employed the literature review as an additional data collection method (Cardno, 2018:634) used to address sub-research questions 1 and 2, supplementing the interview and survey questionnaire methods. The narrative literature review used in this study to answer sub-research questions 1 and 2 analyses and summarises the literature from previous studies (Berman, 2017:11). This study is supported by Welman *et al*. (2005:37–49) and Berman (2017:19), who note that a literature search on the intended subject area provides a definitive way of formulating research questions through previous researchers.

Google Scholar, Google Search, and Web of Science databases were used for literature review searches. This study identified literature review materials by using key concepts indicated in the "Key Concepts and Terms" page as the inclusion criteria. The literature review, supplemented with the document analysis method (see Section 3.7), helped in developing and refining research instruments such as the interview schedule (Appendix A3) and survey questionnaire (Appendices B2 and B3).

The literature review search results summary, as illustrated in Figure 4.9, highlights that a total of 351 articles in this study's literature review were initially identified, of which 339 articles were finally reviewed. Studies that matched the inclusion criteria were included in the literature review, and the unmatched results were excluded and discarded. The exclusion of unrelated publications strategy is consistent with what is discussed in Pallo *et al*. (2024:208), which stated that publications not related to the research topic were excluded. Out of the 333 eligibles for further screening after the removal of 12 duplicates, an additional 143 articles whose title, abstract, and information did not meet the inclusion criteria were excluded. The literature cited for the entire thesis is based on 190 studies and appears in the reference list, as required by the University of South Africa (UNISA, 2023:20–32). The literature review flowchart (Figure

4.9), featuring 21 additional sources identified in Section 3.7 (Document analysis in the context of CBWM) and the reference list were the outputs of the literature review method.

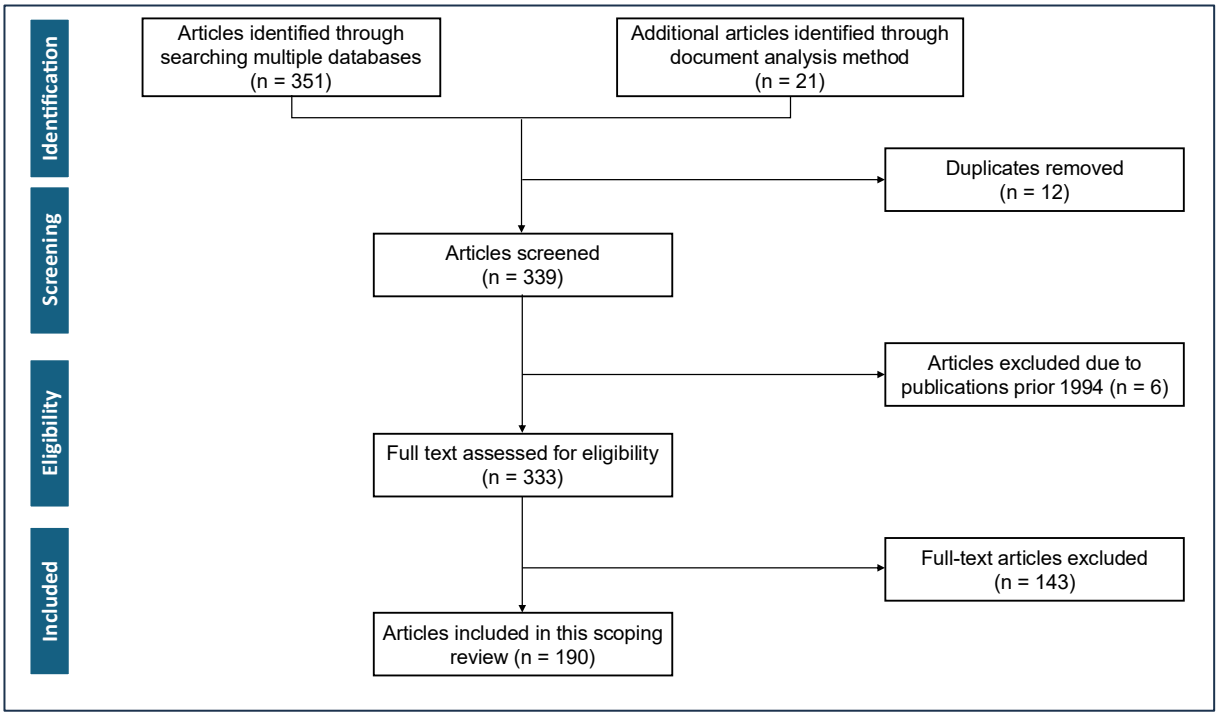


Figure 4.9: Literature review flowchart

Source: Adapted from Kim *et al*. (2022)

To achieve sustainability, integrated water resource management emphasises community involvement in monitoring, managing, and protecting water resources. The findings of sub-research questions 1 and 2 highlight the benefits and challenges of CBWM in Section 3.5.2 and Figure 3.1 in Section 3.5.4, respectively, and the development of the CBWM criteria in Table 4.1 in Section 4.5.2. In addition, the outcomes of the literature review chapter of this study linked various sources in the generation of research tool questions, the development of the research methods, and the theoretical framework (Figure 3.2). The theoretical framework indicates the synergy between three tiers of water resource protection sustainability components: economic, social, and environmental (ecological).

4.5.3.2 Interviews

An interview is a flexible and adaptable method of data collection in an unstructured, semi-structured, or structured manner (Creswell, 2014:32). In this study, an interview schedule was developed by the researcher to inform sub-research questions 1 and 2, based on data generated through the literature review and data collected for sub-research questions 3 to 5. Closed-ended and a few open-ended questions created and formulated for this study are listed in the interview schedule (Appendix A3). This schedule ensures consistent data collection by asking all participants the same questions in the same order. Probing questions were asked

for clarity or further investigation, as indicated by Welman *et al.* (2005:6–8). Interviews were conducted virtually using Microsoft (MS) Teams and telephone calls, following the order prescribed in the interview schedule.

(a) Development of the interview schedule

A draft interview schedule was structured by grouping questions into themes adapted from Carlson *et al*. (2017:4–20) and Vasileiou *et al.* (2018:2–18), with these themes reflected in Section 4.5.2. The process for pre-testing and piloting the draft interview schedule, leading to the revision of the document (Appendix A3), is elaborated upon below.

One of the weaknesses of the interview method is the limitation of in-depth data collection due to language barriers, particularly in case studies conducted in rural villages where participants speak their native languages. However, language and cultural differences were taken into consideration in this study. In the South African context, communities are segregated according to their indigenous languages and cultural practices (Welman *et al*., 2005:253), so each case study has its preferred indigenous language of communication. For example, in the Koffiekraal area in the Groot Marico catchment (North West), Setswana is the indigenous language, and Tshivenda and Xitsonga are spoken in the Luvuvhu catchment (Limpopo). To overcome language barriers, the data collection instruments (interview schedule and consent forms) were translated into the participants' first languages – Setswana, Tshivenda, and Xitsonga (Appendix E). The translated data collection tools and letters from the language practitioners certifying the credibility of the translated materials are made available in Appendix E.

Interviews were conducted with a minimum of 12 research participants per case study (three case studies) to examine whether community-generated data were being integrated into water management planning and decision-making (Buckland-Nicks *et al*., 2016:14–18).

(b) Pre-testing the interview schedule

The interview schedule was pre-tested with an external academic expert and in the Berg River catchment pilot case study, mainly to check for clarity and ambiguity in the interview questions. The purpose of pre-testing was to check the validity of the content, and participants were asked to suggest any criteria not included in the interview schedule. Pre-testing the validity and reliability of the instrument was viewed as necessary, as this would measure the responses to the research questions and address errors identified before the interview application.

The internal validity of the instrument was tested by submitting the interview schedule to UNISA's College of Agriculture and Environmental Studies (CAES) Ethics Committee, as well as to the study supervisor and co-supervisor. The interview schedule was approved by the Ethics Committee without any amendments. An external specialist was sourced to provide an

expert review of the interview schedule. The pre-testing conducted in 2020 with Dr Helen Dallas from the Freshwater Resource Unit, University of Cape Town, resulted in no amendments to the interview schedule, except for her suggestion to include an additional two participants in the study sample.

(c) Interview piloting

The Upper Berg River catchment (Figure 4.10) in the Western Cape was chosen for the pilot case study in this research.

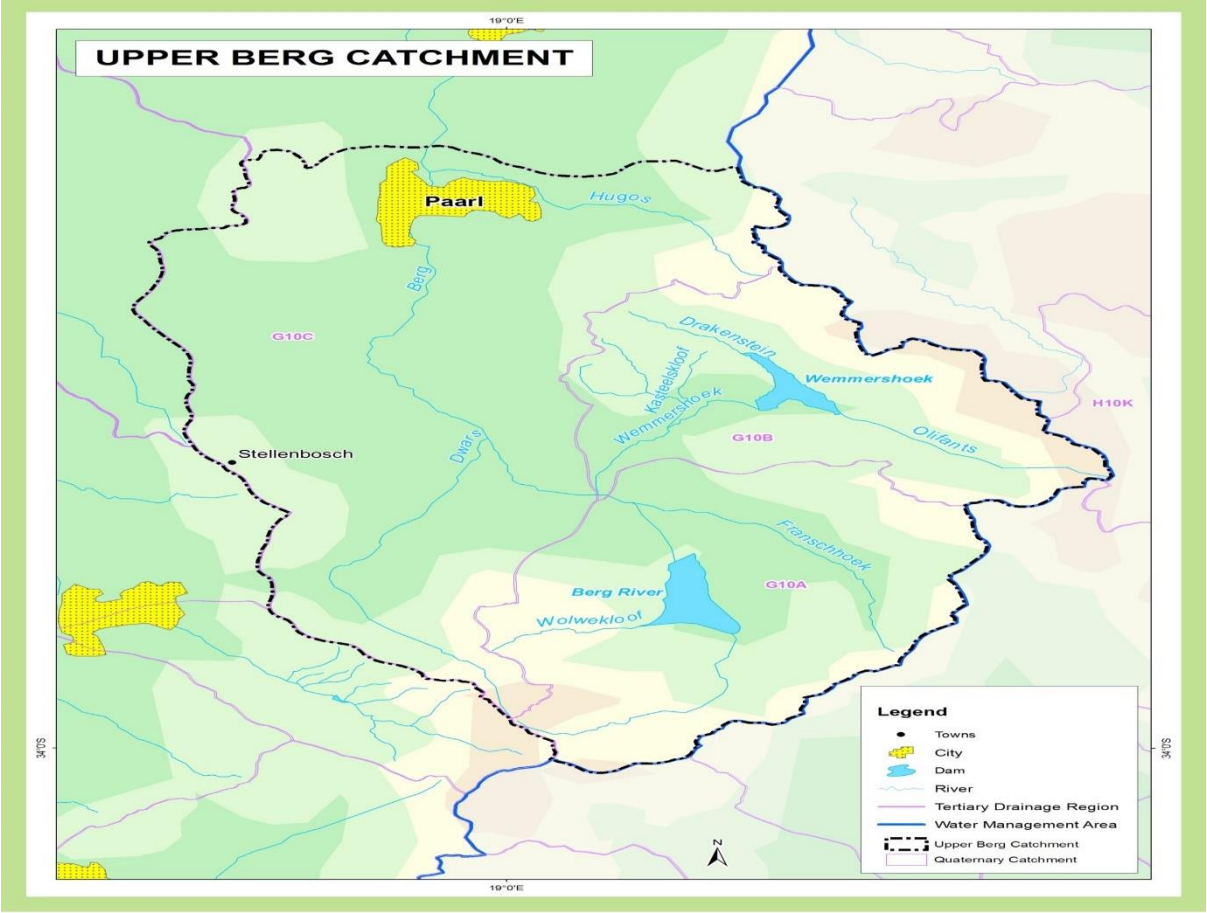


Figure 4.10: Pilot study area in the Upper Berg River catchment
Source: DWS Metadata (2021a)

McBurney (1994:170) suggests piloting as a preliminary data collection step to test the interview tools in place. Questions from the interview schedules were tested with participants from the Upper Berg River catchment pilot study. This was done to test whether the intended meaning and interpretations of questions were clear, and that the allocated time of 15 minutes per interview was sufficient. One of the identified challenges was that a 15-minute interview slot was insufficient, and tools were revised and aligned to increase the precision of the study before being used in other case studies, as supported by Peersman (2014:9).

A sample of 12 participants was purposively selected for the interview piloting process. These participants included PSPs in the water resource management sector, the research sector, local government (municipalities), CMAs, the DWS, the Department of Forestry, Fisheries, and the Environment (DFFE) and the ecological sector (South African National Parks). Forty-two percent (42%, $n = 5/12$) of the interview pilot participants responded to the call to add any criteria of importance that they thought should reflect on the interview schedule. Various open-ended questions were suggested: "What are the skills needed for CBWM?", "What are the benefits of CBWM?", "What are the pitfalls/challenges of CBWM?", "What is the frequency of data collection?", "What method/s do you use?", "What equipment is needed for monitoring?", and "What are the main challenges of monitoring?" Questions related to CBWM were incorporated under question 2 (CBWM) and those related to data collection and monitoring were added to question 3 of the final interview schedule (Appendix A3). The outcomes of the interview piloting led to the improvement of the draft interview schedule, resulting in the final version. The key learning was the effectiveness of snowball sampling, as 75% ($n = 3/12$) of participants suggested additional participants to be included in the study sample.

(d) Development of the final interview schedule

The five sub-research questions derived from the main research question in this study, as indicated in Section 1.3, are as follows:

1. What are the benefits, values, pitfalls, and challenges of CBWM programmes?
2. What criteria should be considered in CBWM in developing countries?
3. Based on the opinions of governance and the real-life experiences of communities, to what extent do selected catchments in South Africa, as a developing country, benefit from CBWM?
4. What are the views of governance structures on the extent to which CBWM operates in South African communities?
5. How might a conceptual framework work by enhancing the use of CBWM data in decision-making for developing countries?

The interview schedule was used to collect data to answer the sub-research questions (Gofman, 2010:9–10; Carlson *et al*., 2017:4–20; Carlson & Cohen, 2018:170). Participants' suggestions given during pre-testing and piloting were taken into consideration, and the draft interview schedule was refined accordingly to produce the final interview schedule. The interview schedule's initial seven sets of questions remained, with additional suggested questions reflected under questions 2 (CBWM) and 3 (monitoring parameters). The structure of the final interview schedule reflects seven sets of questions categorised into the six pre-existing themes identified under Section 4.5.2.

Questions 1 and 2 elicited participants' involvement in water resource management and protection through open-ended questions. These focus on the skills required for their involvement, as well as the benefits and challenges of CBWM, as identified in Section 3.5 of the literature review chapter (CBWM roles, principles, and challenges) and Section 3.6 (theoretical framework; Figure 3.2). These questions were central to understanding the extent and effectiveness of participants' involvement in CBWM, as well as its benefits and challenges (or pitfalls) (Carlson & Cohen, 2018:169–174). They were included specifically to address sub-research question 1 and to validate the information from the literature review.

The CBWM criteria (Table 4.1) were developed from the literature review and were used to inform this research tool, analyse coding, and develop themes. The criteria also guided the generation of interview questions, such as monitoring parameters, data management, and funding in questions 3 to 5.

Within the set of questions, question 6 (value for money criteria) in the draft interview schedule included one question about the value of data produced by CBWM and another about the participants' perception of the value of CBWM data, the latter of which was discarded and did not form part of the final interview schedule.

Question 6 (value for money) in the final schedule posed questions around monitoring continuity, the value of data produced, and the future and sustainability of the CBWM project. These questions were formulated to understand the extent of community benefits from CBWM, as informed by sub-research question 3. Participants' views on governance structures related to the implementation of CBWM, addressing sub-research question 4, were elicited by the first three parts of interview question 7, which covered institutional drivers such as involvement, engagement, and the relationship between CBWM data collection and policy development. The final part of question 7, concerning knowledge of the CBWM framework and the development of one where none existed, was designed to source data for sub-research question 5.

To overcome potential language barriers, the final consent form and interview schedule were translated into Tshivenda, Xitsonga, and Setswana (Appendix E). An advantage was that the researcher, being a Tshivenda speaker, had experience in stakeholder engagement through work with the DWS and in conducting citizen science with civil society in the Tshivenda, Xitsonga, and Setswana communities. Interviews were conducted via MS Teams and telephone calls following the final interview schedule.

(e) Interview administration

An interview invitation, together with an attached consent form (Appendix A2), was emailed to each participant, requesting that they sign the consent form and return it should they accept

the invitation to be interviewed. The signed consent forms were returned along with an indication stating the preferred date and time for the interview. Interview options included:

- Virtually, using MS Teams: The virtual method of administering interviews was used to collect data from purposively selected participants.
- Telephonically: The telephone method of administering interviews was used to collect data when participants indicated challenges with network coverage, lack of data, language barriers, or illiteracy. To avoid potential challenges related to access to data and technology, interview schedules were translated into participants' home languages (Appendix E).

4.5.3.3 Document analysis

Document analysis is a data collection method that involves investigating, assessing, analysing, and evaluating eligible documents to answer research questions and review data and information (Bretschneider *et al*., 2017:1–5). It is commonly used in social and health policy analysis studies (Kayesa & Shung-King, 2022:1–2; Kim *et al*., 2022:3). Document analysis entails the researcher examining documents and determining whether they are relevant and appropriate (Cardno, 2018:625–627; Kim *et al*., 2022:1). The number of documents reviewed may be informed by the sampling strategy (Aucamp, 2015:153), as reports taken from the public domain can be reviewed.

The document analysis method applied in this study (Appendix A1) included policies, strategies, and position papers identified as having information that fell within the scope of the study and supported sub-research question 5. Documents and articles were screened based on title, author(s), and keywords, with eligible articles sourced from Google Scholar, the Water Research Commission (WRC), and South African DWS databases. The document inclusion criteria were peer-reviewed journals and conference proceedings. The study identified 21 documents for inclusion in the review through snowball sampling based on interviews and survey questionnaires, all of which met the inclusion criteria of being complete and published after 1994. The analysis covered the number and types of documents assessed – quality assessments, data extraction processes, and key insights gained in addressing document sourcing challenges. Documents were reviewed to identify existing CBWM conceptual frameworks and to ascertain the need to develop one. For documents in the public domain, the DWS granted consent to conduct this research.

In this study, the term 'document analysis' was used to describe the processes of document identification and selection, data extraction, and analysis. The number of documents analysed was informed by and narrowed down to the documents listed by the interview participants and the survey questionnaire respondents in all three case studies. Data and information generated were supplementary to the interviews and questionnaire survey data, as the document analysis

method is still regarded as insufficiently robust to be a reliable standalone data collection tool (Quin, 2012:1–24; Cardno, 2018:266; Kayesa & Shung-King, 2022:3).

4.5.3.4 Qualitative Data Analysis

A qualitative data analysis method was selected to align with the intended research questions (Guetterman, 2019:11–15). The advantage of using both deductive and inductive thematic data analysis approaches in this study's qualitative data collection is the production of quality data, as affirmed by Dawadi (2020:63) and Lester *et al*. (2020:94–95).

Qualitative data analysis is the process of analysing qualitative data generated from interviews and document analysis, in the form of content, thematic, and narrative analysis. Thematic data analysis is a systematic comparative method that serves as a starting point for qualitative data analysis (Lester *et al*., 2020:94–98) and involves grouping datasets into categories and themes (Dawadi, 2020:62–63). In this study, narrative data were deductively coded into six pre-existing themes identified from the literature review and presented in Table 4.1, while data generated from the interviews were inductively coded into new themes that emerged from the study's data analysis presented in Section 5.3.

Data from the document analysis relevant to the study's main and sub-research questions were analysed descriptively and presented by type of document analysed. Document references and information – including document name and year of publication – were noted, as supported by Vasileiou *et al*. (2018:1–2).

4.5.4 Quantitative research methods

A questionnaire was designed to allow participants to indicate the strength of their opinions and supports the application of a quantitative research method, as advised by Welman *et al*. (2005:156–157) and Babbie and Mouton (2007:49). In this study, the perceptions of various respondents' – including water resource managers, the RHP, the REMP, AaR programme coordinators, and community members – were explored to rate the criteria influencing the success of CBWM, as well as the perceived need for and importance of a CBWM framework.

A representative sample size in a survey questionnaire is one of the most important features of quantitative research (Sauro & Lewis, 2012:274; Morgan *et al*., 2017:90). The number of participants required in quantitative research varies, typically ranging from 20 to 40, though it may be more or fewer depending on the context. Statistical reliability depends on the population size, success rate, and confidence level – that is, collecting sufficient data to produce reliable results with an acceptable margin of error (Bidiu & Moran, 2021:1–4). Triangulation was used to enhance the reliability of the study's findings. In this study, survey questionnaire links were sent to 17–26 participants in each case study, with an expected

response rate of 12 participants per case study. The quantitative research method applied in this study is outlined below.

4.5.4.1 Survey questionnaires

The survey questionnaire developed by the researcher for this study was used to collect quantitative data. Although closed-ended questions limit the participant to pre-determined alternatives, approximately 87.0% of the survey questionnaire comprised closed-ended questions. The advantage of this approach is that the data collected are direct and easier to code and analyse (McBurney, 1994:170). Survey questionnaires in this study were administered in two different modes: a Google Forms survey questionnaire link that allowed for real-time data collection, and – where network issues and technologically challenged participants were identified – an electronic survey questionnaire form (Appendix B3) sent via email. The survey links for data collection were distributed to participants by email, with a request that they be returned upon completion within a specific period. Follow-up emails were sent and phone calls made to non-responders as reminders – the purpose was to ascertain the reason for failing to respond and to assist in collecting data from respondents should they be willing to take part.

(a) Development of the questionnaire

The Google Forms survey questionnaire (Appendix B3) and draft survey questionnaire were designed by the researcher, drawing primarily on information from Chapters 2 and 3. The instrument was developed using a procedure recommended by Gofman (2010:9–10), Carlson *et al*. (2017:4–20), and Carlson and Cohen (2018:168–177), which includes a literature review as a baseline research tool.

In this study, a combination of nominal “Yes/No” options, multiple choice questions (questions 3–6), and five-point Likert-scale items (questions 9 and 15) was used to develop a draft survey questionnaire. The Likert scales ranged from 1 (“of no importance”) to 5 (“of extreme importance”), and from 1 (“Strongly Disagree”) to 5 (“Strongly Agree”) (McBurney, 1994:197). The advantage of the Likert scale is that it effectively captures attitudes towards an object or statement (Welman *et al*., 2005:156–157), which was valuable in this study for assessing perceptions of CBWM success.

The survey questionnaire was completed in the respondents’ own space and timeframe, which offered comfort and benefited the study by increasing the response rate (Welman *et al*., 2005:153).

(b) Pre-testing the questionnaire

A draft research questionnaire was pre-tested by internal and external experts reviewing the tool and its application in the Berg River catchment, primarily to check the appropriateness,

validity, and reliability of the sampling methods and clarity of the questions. Pre-testing also aimed to gather participants' feedback on the content validity, with participants encouraged to suggest any criteria not included in the questionnaire.

The internal validity of the instrument was tested by submitting the questionnaire to UNISA's CAES Ethics Committee and through internal review by the supervisor. The Ethics Committee approved the questionnaire without any amendments. The supervisor's amendments were to questions 2, 9, and 15. The suggestion for question 2 was to include "Unsure" rather than having a binary "Yes" or "No" as an answer, and for questions 9 and 15, to replace two of the five-point Likert-scale middle ratings from "Of moderate importance" to "Undecided", and from "Neutral" to something along the lines of "Unable to judge", respectively. All the changes suggested were implemented and factored into the revision of the questionnaire, except for "Unable to judge", which was substituted with "Don't know" after an additional literature search regarding questionnaire development.

An expert review by an external specialist, Prof. Tally Palmer from Rhodes University, was sourced in 2020. She suggested the inclusion of "Other" as an option under the gender indication of "Male versus Female" in question 2 and the deletion of question 6 regarding racial categories of participants, as it was deemed irrelevant. These inputs were considered, and the questionnaire was modified, as detailed below in Section 4.5.4 – (d): Development of the final questionnaire.

(c) Questionnaire piloting

Survey questionnaire piloting is performed as a preliminary data collection stage to test the questionnaire (McBurney, 1994:170), as was the case in this study. The survey questionnaire was piloted with respondents from the Upper Berg River catchment to test whether the intended meaning and interpretations of questions were clear. As supported by Peersman (2014:1–6), identified challenges were noted, and tools were revised and aligned to increase the study's accuracy before using them in other case studies.

A quantitative sample of 12 respondents was selected for the questionnaire piloting process through snowball suggestions. These respondents included lecturers, the research sector, the DWS, the DFFE, NGOs, and civil society. Eight survey questionnaires were completed and returned, while four were never returned. The key lesson learned from questionnaire administration was to be patient and consistently remind participants to complete and return the questionnaire; however, even this could not recover the remaining four outstanding responses.

Changes in the final survey questionnaire (Appendix B3) included adding two questions under question 14: framework funding and CBWM hosting institution. The key lesson from the internal

and external expert review and piloting, which tested the instrument's validity, was that the survey questions and variables needed to be redefined and adjusted, as supported by Quin (2012:1–24). The questionnaire pre-testing findings improved the research tool and assisted in revising the questionnaire for data collection.

(d) Development of the final questionnaire

Following the external expert review, pre-testing, and piloting processes, the final questionnaire was revised to incorporate participants' comments and suggestions. Besides changes made after the pre-testing process, further inputs received from the internal supervisor and co-supervisor were also considered in the questionnaire's improvement and finalisation. The initial survey questionnaire's 17 questions were reduced to 16 due to the deletion of question 6 (race), which was considered irrelevant to the sub-research questions.

The revised, final survey questionnaire comprised 16 questions:

- Questions 1–6: Respondent background and demographics
  - Question 1: Respondent's involvement in water resource management
  - Questions 2–6 (Box 1 – see Figure 4.11): Respondent's demographic status, level of involvement, gender, age, and educational qualifications
- Questions 7–8: CBWM roles and membership
- Question 9: Level of importance of CBWM criteria (monitoring parameters, data management, funding, value for money, and guiding principles) identified under Section 4.5.4.1, responding to sub-research question 2. Respondents were asked to evaluate 19 variables by rating their level of agreement on a five-point Likert-scale
- Questions 10–11: Benefits/values and pitfalls/challenges encountered in CBWM, in response to sub-research question 1, as shown in Sections 3.5.2 and 3.5.4 and Figure 3.2 (theoretical framework) of the literature review chapter
- Question 12: Respondents' views on catchments benefiting from CBWM, in response to sub-research question 3
- Question 13: Respondent's views on governance structures for CBWM implementation, aligned to respond to sub-research question 4
- Questions 14–15: Knowledge of any existing CBWM framework, development of the framework, and the level of agreement on five rating variables regarding the CBWM framework, addressing sub-research question 5. These questions utilised a five-point Likert-scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

The final survey questionnaire (Appendix B3) was developed to suit online administration of quantitative data collection methods.

Box 1. Survey Questions concerning CBWM Demographic data

Q1. Are you involved OR where you involved in any water management OR Water Resource Protection?

1. Yes	
2. No	
Unsure	

Q2. If yes, what aspect/s are you involved with?_____

Q3. How are you involved (Please indicate with a cross X):

Scientist / Environmental officer	
Managers (National Provincial & Local Government)	
Water Sector (Domestic e.g. SALGA & COGTA, Agriculture, Ecological/Environmental & Research)	
Community-Based Water Monitoring (CBWM) (RHP / REMP / AaR programme)	
Community members	
Other (please specify):	

Q4. Please indicate your gender (Please indicate with a cross X):

Male	
Female	
Other (please specify):	

Q5. Please indicate your age group (in years) (Please indicate with a cross X):

18-21	
22-30	
31-45	
46-60	
60 and over	

Q6. Please indicate (with a cross X) your highest level of education / qualification:

No formal education	
Primary school	
Secondary school/Matric	
National diploma/certificate	
Undergraduate degree	
Postgraduate degree	
Postgraduate degree (please specify e.g. Honours, Masters or Doctorate):	

Figure 4.11: Survey questionnaire

(e) Survey questionnaire administration

The Google Forms survey questionnaire link for each case study was distributed to participants by email, requesting that they be returned on completion within one month. The Google Forms questionnaire survey website link for the Luvuvhu River catchment, Selons River catchment, and Koffiekraal area in the Groot Marico River catchment case studies included a consent form (Appendix B1) and a questionnaire embedded together in one questionnaire survey (Appendix B3).

Respondents were sourced using snowball sampling (Carlson & Cohen, 2018:170–172), whereby interview participants identified additional participants they deemed essential to

include in the research sample for each case study. Participants were contacted telephonically as a follow-up when the response rate for the submitted responses was low. This was an additional effort to increase research participation and reduce measurement bias (Peersman, 2014:1–6).

4.5.4.2 Quantitative data analysis

In this study, quantitative data analysis involved analysing quantitative data to address the research questions stipulated in Section 1.4. Descriptive statistical analysis was used as the quantitative research method, which was applied to the survey questionnaire data (Guetterman, 2019:11). The survey questionnaire data were recorded in Excel spreadsheets, and then summary statistics involving calculating the mean values and percentages of the dataset were conducted.

The five-point Likert-scale rating (1 – Of no importance, 2 – Of little importance, 3 – Undecided, 4 – Of moderate importance, 5 – Of great importance) was used, the scale used to measure participants' opinions on the level of significance in the CBWM criteria. In addition, another five-point Likert-scale (1 – Strongly disagree, 2 – Disagree, 3 – Don't know, 4 – Agree, 5 – Strongly agree) was used to measure participants' views on the level of agreement regarding the CBWM framework.

Inferential approach and Statistical Package for the Social Sciences (SPSS) version 28 software were used for survey questionnaire statistical analysis, complementing the descriptive statistical analysis used in the qualitative data analysis, at a "point of interface" (Figure 4.1). Inferential statistics and SPSS were used to calculate the probability and frequency of responses, and chi-square tests (χ^2) were conducted to test whether the relationships between the case studies were statistically significant. SPSS was used to display the Pearson correlation coefficients and *p*-values associated with each statistical test, with a significance threshold set at 0.05 (5%). *P*-values less than 0.05 (p-value < 0.05) were considered statistically significant, whereas those greater than 0.05 (p-value > 0.05) were deemed statistically non-significant. The *p*-value describes the probability of observing the results and increases the level of confidence that the data are genuine.

4.6 STUDY LIMITATIONS AND TRUSTWORTHINESS OF DATA

4.6.1 Limitations

The case studies were limited to three (see Section 4.3 for the rationale behind their selection) to represent different scales and types of CBWM programmes and to ensure the practicality of the research. The fourth case study was the pilot study, which was not included in the results and discussion chapter (Chapter 5), as its findings led to the revision of the sampling tools.

In-person interviews and focus groups were the data collection methods for this study and were approved by the Ethical Clearance Committee in 2019. In 2020, the ethical clearance was amended by changing in-person interviews to virtual interviews and cancelling the focus group method (Appendix D2), according to UNISA COVID-19 guidelines (UNISA, 2020:1–3).

The CBWM initiative should be based on scientific research involving the public, considering their different levels of expertise and involvement. The divergences in knowledge and experiences may affect the accuracy of the responses, as the content might require an in-depth understanding of water resource management, water resource protection, and the CBWM programme, as recommended by Carlson and Cohen (2018:172).

The study could be criticised for having an unrepresentative sample, given that participants were not randomly selected. However, the sample size of 12 participants ($n = 12$) per case study was sufficient to accommodate purposively selected individuals. The dataset was further extended through snowball sampling by including additional survey questionnaire respondents. The study achieved data saturation among participants with in-depth knowledge of CBWM and water resource protection. The risk of over-generalisation was reduced, as most eligible participants were accessed.

The application of chi-square tests in Chapter 5 is the assumption of case independence, suggesting that each case study is independent of others, making results valid. The shared administrative and ecological contexts among the three case studies violated the assumption, as such, the test may produce biased results as the case studies may not be truly independent.

Keywords used as search terms for the literature review assessment may have been restrictive, as different authors might have used different terminology, potentially leading to the exclusion of relevant literature. Moreover, the exclusion criteria – namely, incomplete articles and those published before 1994 – may also have been restrictive, as earlier publications could contain critical information relevant to this study.

Document analysis is a cost-effective, manageable research method for investigating the nature of a document. It rarely requires ethical clearance, unless confidential information is involved. Limitations include the unavailability of relevant documents to review, potential bias in document selection, and the absence of standard guidelines for data analysis (Cardno, 2018:625–627).

4.6.2 Validity

Validity is the extent to which a test or instrument measures what it is intended to measure – the quality of data that has legal standing (Thatcher, 2010:125; Lester *et al*., 2020:102; van Gog *et al*., 2008; Nha, 2021:1). Incorrect research and statistical procedures, poor samples, and inaccurate data skew validity (Welman *et al*., 2005:105–127; Nha, 2021:1–4). Therefore,

to ensure validity in this study, content-related, statistical, and internal types of validity were examined to ensure the reliability and trustworthiness of the research methods, tools, data collection, data, and data analysis (van Gog *et al*., 2008:769–770).

The use of a mixed-methods research design ensured the collection and analysis of qualitative and quantitative data from various sources, allowing these to complement each other, reduce biasness, and enhance data generalisability. This approach allowed for a better understanding of the research problem and increased the validity of the findings and data interpretation (McKim, 2017:203–210). However, the risks that typically accompany the application of a mixed-methods research design include the difficulty of analysing samples from different research methods, merging various datasets, or dealing with contradicting results. The use of closed-ended and open-ended questions in this study was intended to manage data-transformation and data-validation variants in the survey questionnaire.

Triangulation of qualitative and quantitative data collection methods increased validity (Pelto, 2017:242–243), and the use of document analysis to supplement interview and questionnaire methods added rigour to the study (Cardno, 2018:626). Additionally, the use of SPSS software to analyse quantitative data was believed to increase rigour.

Pre-testing and piloting of interview and survey questionnaire research tools with research supervisors and water management experts took place to ensure they were unambiguous and understandable. These research tools were pre-tested in the Upper Berg River catchment pilot study to ensure content validity, as supported by Ramli *et al*. (2017:14–15).

The use of thematic data analysis to analyse qualitative (interview) data in this study has been proven to be valid (Dawadi, 2020:62–63) due to its transparency and flexibility. Flexibility in this study was demonstrated by the researcher's ability to adapt data collection methods in response to amendments approved by the CAES Ethics Committee without compromising the credibility and reliability of the study findings. Both deductive and inductive thematic data analysis were performed to maximise the overall depth of the analysis.

Participant confidentiality and data protection are important ethical considerations. To protect their identities, interview participants (P1) and questionnaire respondents (R1) were allocated numbers. Concerns regarding the assurance of participants' data confidentiality protection are clearly explained in the questionnaire and interview consent forms (Appendices A and B).

In this study, participants within the water resource protection and CBWM community were purposively selected. As much as the study lacked independent evaluators to prove that participants had no affiliations to the CBWM initiatives, experts review pre-testing the interview schedule and the questionnaire promote validity and rigor of the study. The limitation of the small sample size discussed in Section 4.6.1 could have posed a risk to the validity of the study

(Vasileiou *et al*., 2018:14–18). However, the study acknowledged that the small sample was appropriate.

The description of the data collection process (Section 4.4), data analysis (Sections 4.4.3 and 4.4.4), and methodology limitations (Section 4.6.1) met the credibility, dependability, and confirmability criteria, as supported by Lester *et al*. (2020:102).

Three categories of validity – internal, external, and construct validity – were used to assess the study's validity. The study satisfied internal validity requirements, which ensured consistency in qualitative data collection through the interview method's sampling technique, where interview schedule tools were used consistently for all participants as quality control measures implemented to ensure standardisation.

4.6.3 Reliability

Reliability refers to research indicators and findings that are consistent, stable, repeatable, and credible in their application (Twycross & Shields, 2004; Welman *et al*., 2005:145–147; Nha, 2021:1–4). Repeatability refers to the extent to which a study yields the same results when administered on different occasions but under the same conditions (van Gog *et al.*, 2008). The reliability of data collection and analysis is supported by the use of valid and reliable data collection instruments (Ramli *et al*., 2017:24), and requires standard operating procedures based on national standards, quality assurance, and control (GWA, 2023:6–30).

Standardisation and consistency in how data are collected, analysed, and interpreted help to minimise error and improve accuracy. According to Kimberlin and Winterstein (2008:2277), reliability is measured using coefficients ranging from 0.00 to 1.00, with higher coefficients indicating greater reliability.

Reliability and validity are key indicators of data quality. High-quality data can be trusted and compared to reference condition data (i.e. data collected in the past), provided they were obtained in the same way under comparable conditions (GWA, 2023:25–50). Poor quality data, by contrast, are often considered less useful.

The interview and questionnaire instruments used in this study were appropriate for answering the sub-research questions (Ramli *et al*., 2017:24), as reflected in the results presented in Chapter 5. Comparable participants were selected from each case study to ensure consistency. Coding was used to analyse qualitative data, thus establishing data reliability (Nha, 2021:1–4).

4.7 ETHICAL CONSIDERATIONS

Given the involvement of human participants, the minor potential risk of inconvenience classified this study as a low-risk application, meaning it posed no harm beyond everyday

norms (as outlined in the UNISA-CAES Standard Operating Procedure on Research Ethics Risk Assessment, detailed in Appendices D1 and D2). Nonetheless, the research methodology ensured the safety and protection of participants' social and ethical well-being by securing ethical clearance from the Ethics Committee of the CAES at UNISA, along with authorisation from the relevant community leaders. Ethical approval was granted by CAES, and research approval letters were obtained from the Koffiekraal and Luvuvhu case study communities, which fall under the authority of traditional leaders (Appendix C).

The initial research ethical clearance approval letter, issued on 29 November 2019 (Appendix D1), authorised one-on-one site visits, interviews, and focus groups. An amended approval was issued on 10 July 2020 (Appendix D2), recommending that the research be conducted in line with UNISA's COVID-19 position statement and South Africa's COVID-19 regulations, which limited social gatherings and encouraged social distancing. The amendment also approved changes to the study methods and procedures, including the removal of focus groups and the use of virtual data collection via MS Teams and telephonic interviews.

Participants were informed of their right to participate through the administration of the informed consent forms (Appendices A2 and B1), drafted in compliance with *POPIA* (2013) legislation. The forms outline the purpose and duration of the research, the implications of participating, risks involved, protection from unethical activities, participants' right to privacy, benefits, and the intention to share the research findings and publications. These informed consent forms were distributed to all participants to be signed and returned prior to conducting interviews or collecting survey questionnaires. Any identifying information obtained in surveys was kept confidential, as the participants were identified by numbers rather than names (e.g. Participant 1), and such information would only be disclosed with the participant's permission or if required by law. During the interviews, interaction among participants was avoided, and engagement between participants and the researcher was based on mutual respect and trust.

The informed consent forms and interview schedules used for the Koffiekraal and Luvuvhu River catchment case studies were translated into Setswana, Tshivenda, and Xitsonga to accommodate participants from rural communities, where some individuals might have difficulty expressing themselves in English (see Appendix E).

The following chapter discusses the research findings from the primary data collected in this study.

CHAPTER 5: RESULTS AND DISCUSSIONS

5.1 INTRODUCTION

Chapter 5 (Step 5 in Figures 1.1 and 5.1) provides an overview of the study's results obtained from the interviews and survey questionnaires, along with a discussion of the study findings in the context of the literature. This chapter presents the results and the discussion of the three case studies in response to sub-research questions 3, 4, and 5, and confirms sub-research questions 1 and 2 (initially addressed in Step 2 – the literature review in Chapters 2 and 3), as depicted in Figure 5.1.

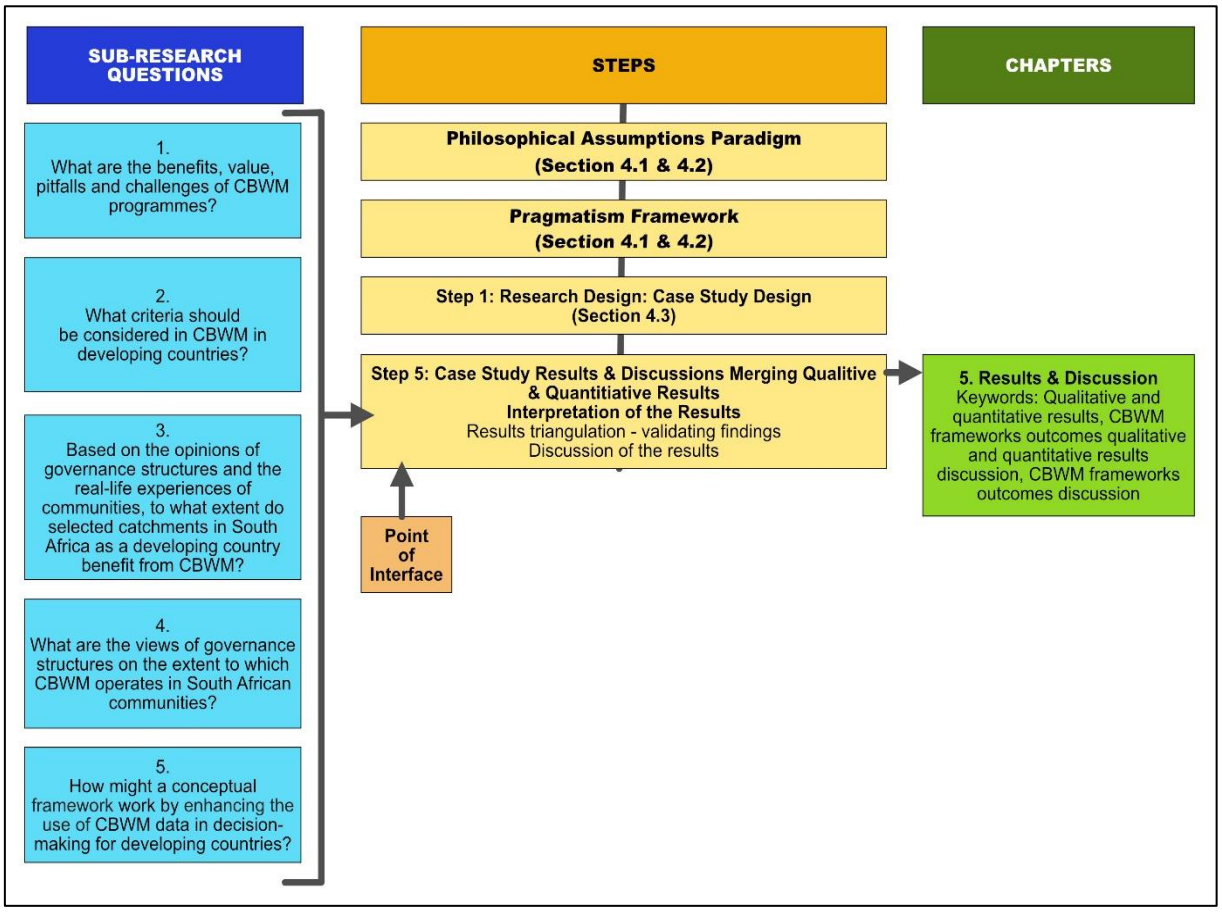


Figure 5.1: Case study analysis, results presentation, and discussion of Chapter 5 (Step 5)

5.2 DEMOGRAPHIC RESULTS

The demographic characteristics of the respondents who participated in this study serve as an introduction to the study's results and were presented in terms of the level of involvement, gender, age, and level of education (see Chapter 4, Section 4.5.4.1(d), Figure 4.11). Although not presented as part of the interview and survey questionnaire results in Section 5.3, the demographic data were collected as part of the study, responding to survey questionnaire questions presented in Figure 4.11. The data do not address any of the study's sub- research questions; therefore, the results are not presented in figures. Quantitatively, the study's

findings indicate that most respondents (78.0%) are not involved in community-based water monitoring (CBWM), compared to only 22.0% who are participating in CBWM initiatives. Gender representation was female-dominated at 60.0%, followed by males at 38.0%, and other at 2.0%. Most respondents, at 66.0%, represented the 31–45 years age group, compared to approximately 9.0% in the youth age group (18–30 years), with elders (46–60 years) at around 25.0%. Participants' education level indicated that the majority (over 75.0%) had obtained postgraduate degrees, followed by undergraduate and certificate/diploma qualifications. The qualitative responses from the study revealed that among those involved in CBWM, scientists (53.3%), managers (33.4%), and CBWM programme coordinators (13.3%) comprise the main participant categories.

The discussion on the relevance of these demographic variables in this study revolves around the measure of the rate of recruitment and participation in CBWM initiatives. The fact that most respondents indicated that they were not involved compromises the sustainability of such programmes. Among the few who confirmed their involvement, the majority were professional scientists at managerial level, reflecting the level of scientific knowledge and suggesting that these scientists are possibly coordinators of CBWM programmes. Scientific water monitoring is more likely to increase with advanced academic qualifications. On a positive note, most respondents were of working age, followed by youth, and then older people, indicating a promising recruitment potential as more youth become involved. A surprising trend was that of gender representation, with women's involvement being dominant, which goes against societal norms, including those in South Africa, that perceive men to be more dominant and suited for positions of influence, even in water management (Gofman, 2012:33–34; van Koppen, 2022:6–18).

5.3 INTERVIEW AND SURVEY QUESTIONNAIRE RESULTS

The interview and survey questionnaire results obtained from participants of the three case studies (Luvuvhu, Selons River, and Koffiekraal) are presented according to the sub-research questions listed in Section 1.4 and are linked to the pre-existing themes outlined in Table 4.1 of Section 4.5.2.6. These sub-research questions and themes were developed through analysis of the literature review, which highlighted key insights and gaps. The qualitative (interview) and quantitative (questionnaire) case study results and discussions are structured around the sub-research questions, aligned with the pre-defined themes in Table 4.1, as well as any newly identified emerging themes.

The results obtained from the qualitative interviews and quantitative questionnaire responses provide data to explore the potential value of CBWM in water resource protection decision-making within South Africa. The survey questionnaire findings complement the results of the interviews. The statistical analysis of the survey data was conducted using SPSS version 28

to create cross-tabulations that compare the three case studies, with an indication of a *p*-value per variable. The combined presentation of the qualitative and quantitative findings brings new insights, with the quantitative data expanding on the qualitative results (Berman, 2017:7–11).

5.3.1 Benefits and challenges of CBWM programmes

5.3.1.1 Introduction

In addressing the study's sub-research question 1, the interview participants were asked for their views on Theme 4 – benefits (see sub-theme 4.1 of Table 4.1 in Section 4.5.2.6) and challenges (see sub-theme 4.2 of Table 4.1 in Section 4.5.2.6) of CBWM programmes. The qualitative interview data obtained from interviewees of the three case studies are presented in Appendices G1–G3 and findings in Figures 5.2 and 5.3 below. Analysing the data obtained in the interviews about the benefits and challenges of CBWM resulted in emerging key themes (Themes B and C), as presented in Table 5.1. This provides a framework for understanding the opportunities and challenges related to community water management.

Table 5.1: Emerging themes about CBWM benefits and challenges

CBWM benefits: Emerging themes (Theme B)	**CBWM Challenges: Emerging themes (Theme C)**
Theme B1: Community empowerment and participation	Theme C1: Community engagement and collaboration efforts
Theme B2: Education and awareness	Theme C2: Financial constraints
Theme B3: Sustainable water resource management	Theme C3: Expertise and capacity (education and awareness)
Theme B4: Monitoring and implementation	Theme C4: Governance and enforcement
	Theme C5: Data and technology
	Theme C6: Operational and safety concerns

In the quantitative component, questions 10 and 11 of the survey questionnaire were designed to elicit respondents' insights regarding the benefits and values (see Figure 5.4 below) and challenges (Figure 5.5 below) associated with CBWM. The case study findings presented in Figures 5.2–5.5 and Appendices G1–G3 confirm the benefits and challenges of CBWM identified in the literature review, as outlined in Chapter 3 (Figure 3.1).

5.3.1.2 Results: Benefits and challenges of CBWM programmes

Findings from the interviews on CBWM benefits are presented in Figure 5.2, highlighted as four themes, Themes B1–B4, tabulated in Table 5.1.

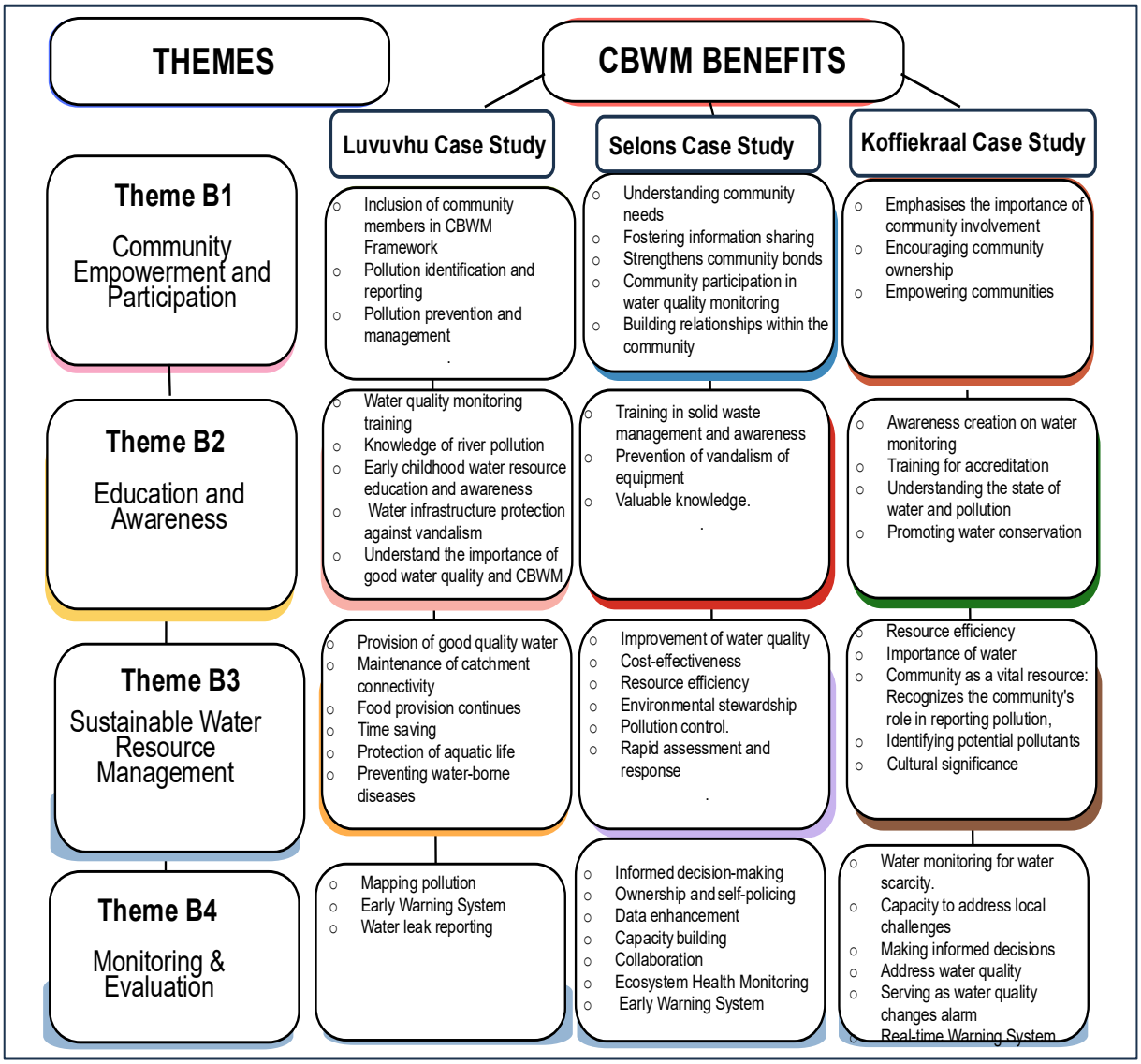


Figure 5.2: Interview findings on CBWM benefits

The findings regarding the benefits of CBWM revealed a common theme among all the case studies in Theme B1 – the crucial need for community involvement in pollution identification and prevention through partnerships and ownership. The differences emphasised comprise an inclusive approach to integrating communities into the CBWM framework, demonstrated in the Luvuvhu case study, and the understanding of community needs as a social concept, evident in the Selons case study. Theme B2, education and awareness, emphasised community education and awareness and the imparting of valuable knowledge to community members through water resource management training in all the case studies, except for the addition of an early childhood learning advantage raised by the Luvuvhu participants. Sustainable water resource management, Theme B3, made provision for the maintenance of good water quality through cost-effective and timesaving usage of CBWM in the management of water resources for all the case studies. The differences were highlighted by the Luvuvhu participants, with the addition of the prevention of waterborne diseases to protect community health. Water monitoring for assurance of supply and ecosystem health, real-time early warning systems,

and water leak reporting were common benefits among all the case studies in Theme B4. Community ownership and self-policing were additional attributes raised by the Selons case study, whereas water monitoring to address water challenges and prevent water scarcity that allows the community to make informed decisions were recorded for Koffiekraal participants as crucial benefits.

Water conservation and protection are vital to prevent waterborne diseases, and community members should collaborate through an early warning system to quickly respond to water-related emergencies, without their financial status being a barrier. This approach could work for the catchments and the surrounding communities to maintain a healthy and sustainable water ecosystem.

CBWM challenges (Themes C1, C2, C3, C4, C5, and C6 recorded in Table 5.1), derived from the interviews in Appendices G1–G3, are interpreted in Figure 5.3 as six themes.

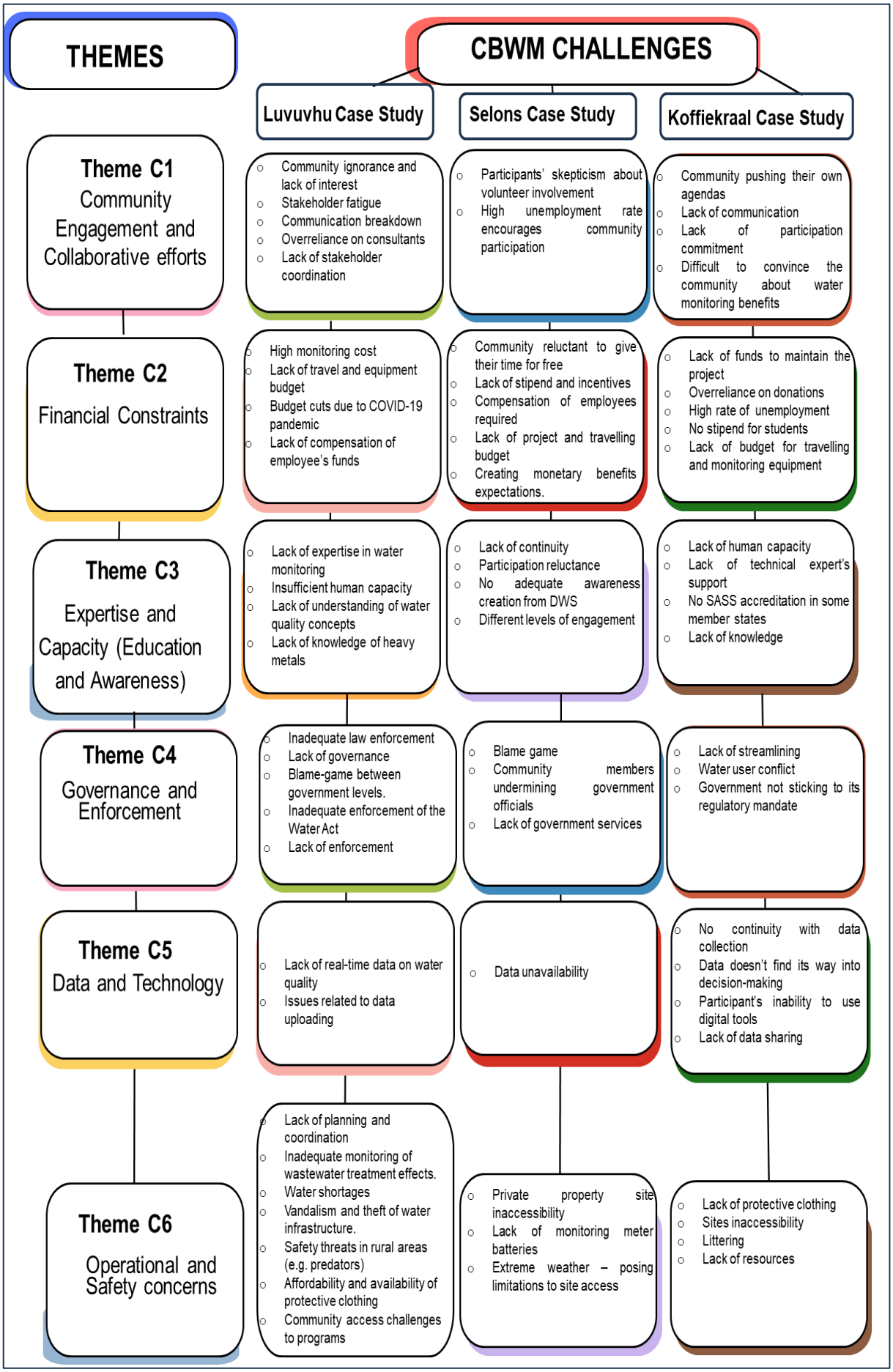


Figure 5.3: Interview findings on CBWM challenges

The findings regarding CBWM challenges suggest common issues reflected in all three case studies, as well as in all six themes that need to be addressed to ensure the successful implementation and effectiveness of CBWM programmes. Theme C1, community engagement and collaborative efforts, identified communication breakdown among monitoring institutions, lack of interest from the community, and ignorance as common challenges. Theme C2, financial constraints, revealed budgetary constraints for monitoring equipment, travelling, project management, and compensation of employees (including stipends and incentives) as common to all the case studies.

A lack of human capacity with relevant expertise was a challenge emphasised by the Luvuvhu and Koffiekraal case studies concerning Theme C3, expertise and capacity. In contrast, Selons participants blamed the government for not creating adequate awareness and for allowing researchers to conduct studies for their own benefit, at the expense of the community. This contributed to the community's reluctance to engage in water monitoring participation, resulting in a lack of continuity.

The "blame game", in which government blames communities, and vice versa, was mentioned in the Luvuvhu and Selons case studies, but the focus was on the lack of law enforcement from government's side, which aligned closely with the governance and enforcement issues addressed in Theme C4. Although Koffiekraal participants did not raise the "blame game" concern, they emphasised government's lack of executing its regulatory mandate. The differences identified in Theme C4 came from Selons participants. This presented a new challenge, implying that community members sometimes undermine orders from junior government personnel, resulting in unlawful activities such as illegal dumping and land-use activities encroaching into surface water flood lines.

The lack of real-time data and data collection continuity were common challenges evident in all the case studies, under the Theme C5, data and technology. Data uploading and the use of digital tools were challenges only noted in the Luvuvhu and Koffiekraal case studies, with the challenge of data sharing being a concern for the Koffiekraal case study only. Theme C6, regarding operational and safety concerns, highlighted community access to CBWM programmes and monitoring sites, and a lack of protective clothing and monitoring equipment as challenges of common concern in all the case studies. Koffiekraal noted littering as an additional concern, while Selons highlighted extreme weather patterns resulting in inaccessibility to the monitoring sites, and Luvuvhu identified water predators such as crocodiles and hippopotamus posing a danger to communities.

The interview findings for the Luvuvhu catchment underscore the importance of government accountability in addressing participants' concerns across multiple dimensions. Social concerns included lack of knowledge among historically disadvantaged community members,

vandalism and theft of infrastructure, data uploading issues, and safety concerns regarding killings, robberies, and wild animals in rural areas. Financial challenges centred on the unsustainable act of overreliance on PSPs. Ecological issues encompassed poor water monitoring governance and lack of implementation of the legislation.

A lack of understanding of the concepts “u naka ha madi a zwi ambi u kuna ha madi”, a Tshivenda saying meaning “water looking clean does not necessarily mean it is safe or of good quality”, raised health concerns. Monitoring challenges identified as extreme weather conditions and monitoring site access issues were said to hamper CBWM progress in the Selons River catchment, resulting in a lack of maintenance. Complex social issues such as the unemployment rate, scepticism towards volunteer programmes, and resistance to authority were also identified as challenges. The new challenges brought by Koffiekraal case study interview participants demonstrated the need for a data-driven approach that sustainably prioritises community empowerment and government accountability.

The findings of the survey regarding CBWM benefits for the three case studies shown in Figure 5.4 confirmed all the benefits to be crucial in all the case studies, with the exception of Selons participants whose views on information accessibility at lower cost differed from those of the other case studies, scoring less than 60.0%.

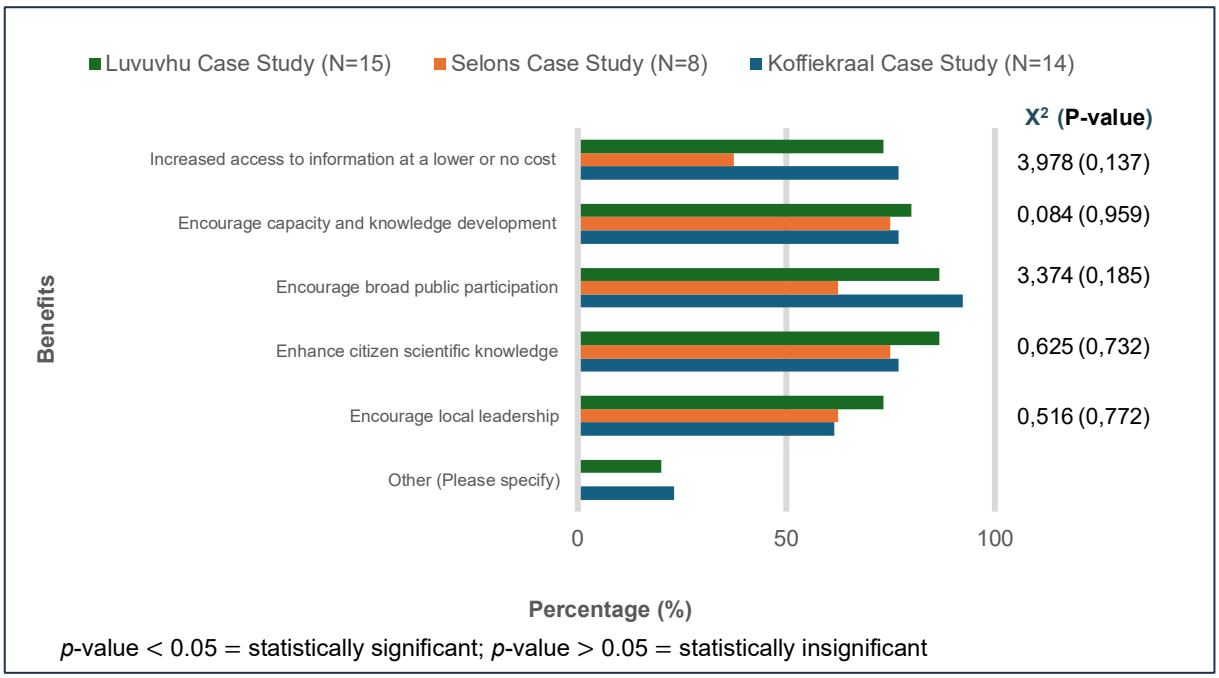


Figure 5.4: Survey findings on CBWM benefits

The feedback from the survey participants on the benefits of CBWM programmes resulted in a *p*-value greater than 0.05, suggesting no significant differences among the three case studies, as illustrated in Figure 5.4.

The Luvuvhu case study findings on the benefits of CBWM revealed the order of importance as encouraging public participation and scientific knowledge enhancement at 86.7% for both, followed by capacity and knowledge development at 80.0%, and both access to information at low cost and local leadership and ownership encouragement at 73.3%. The Selons case study findings highlighted the order of importance as both capacity and knowledge development and scientific knowledge enhancement at 75.0%, followed by both encouraging public participation and local leadership and ownership encouragement at 62.5%, and access to information at low cost at 37.5%. The Koffiekraal case study findings highlighted the order of importance as encouraging public participation at 92.3%, followed by scientific knowledge enhancement, capacity and knowledge development, and access to information at low cost, all at 76.9%, and local leadership and ownership encouragement at 61.5%.

The challenges faced in CBWM programmes, as shown in Figure 5.5, showed the similarities between the three case studies, which shared the same sentiment that issues such as lack of budget and participation and commitment were the most significant challenges.

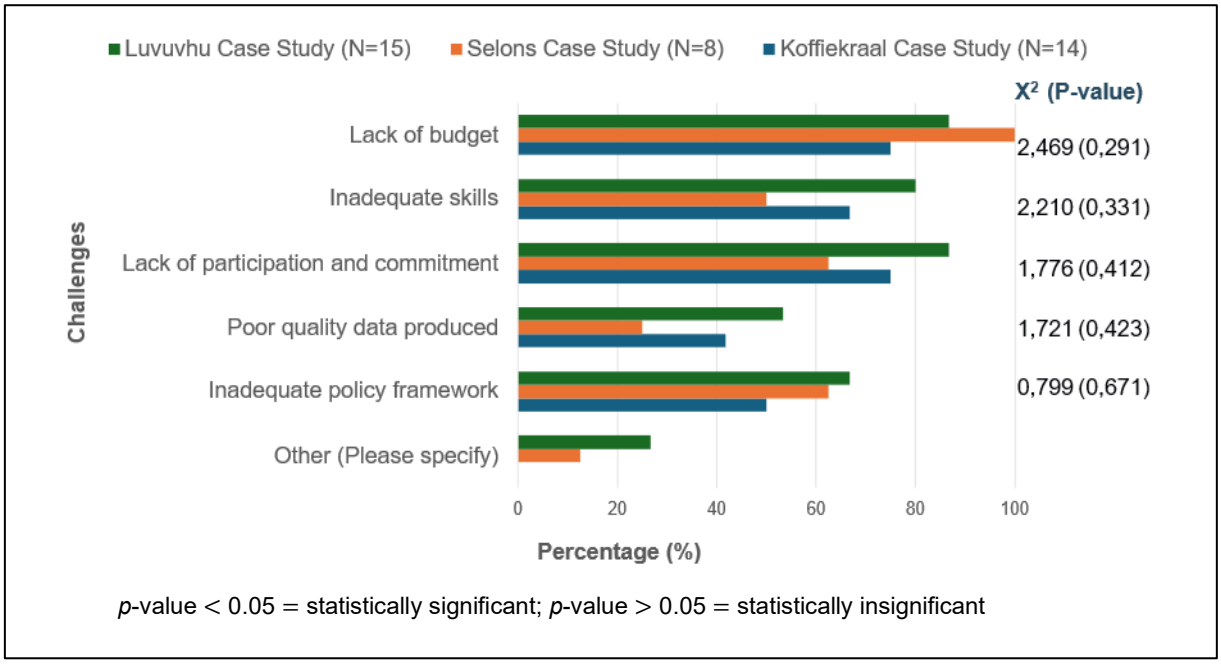


Figure 5.5: Survey questionnaire findings on CBWM challenges

The findings regarding the challenges of CBWM for the Luvuvhu case study revealed the order of priority as both lack of budget and lack of participation and commitment at 86.7%, followed by inadequate skills at 80.0%, inadequate policy framework at 66.7%, and poor quality data produced at 53.3%. The Selons case study highlighted the order of priority as lack of budget at 100.0%, followed by both lack of participation and commitment and inadequate policy framework at 62.5%, inadequate skills at 50.0%, and poor quality data produced at 25.0%. The Koffiekraal case study findings revealed the order of priority as both lack of budget and lack of

participation and commitment equally at 75.0%, followed by inadequate skills at 66.7%, inadequate policy framework at 50.0%, and poor quality data produced at 41.7%.

The findings showed a *p*-value of more than 0.05 ($p > 0.05$), indicating statistically insignificant differences among the three case studies. In contrast, the poor quality data produced did not seem to matter in the Koffiekraal and Selons case studies, which might imply that the respondents did not see this variable as being influential compared to Luvuvhu. At the same time, concern regarding inadequate skills in the Selons case study showed an equal split, with half of the respondents supporting and half opposing.

5.3.1.3 Discussion on the benefits and challenges of CBWM programmes

Sub-research question 1 explored the benefits and challenges of CBWM programmes in the three case studies concerning Theme 4 of Table 4.1 in Section 4.5.2.6. In discussion, the qualitative and quantitative results confirmed the benefits and challenges highlighted in the literature review as common. For example, the case study findings on the benefits emphasised the importance of promoting engaged communities that prioritised communication among stakeholders, as acknowledged by Moolman *et al*. (2022:12). Moreover, the findings showed that knowledge sharing, leadership, and ownership development were integral components of sustainable development and effective CBWM participation, as highlighted by Moolman *et al*. (2022:12). Encouraging local leadership, which rated highly in this study, might bring a sense of CBWM ownership, one of the factors leading to CBWM sustainability. However, Kativhu *et al*. (2021:20) argued that there was no relationship between CBM, sense of ownership, and sustainability of water management; this is a gap that calls for further research. Access to information at low cost was rated the least beneficial, despite the lack of budget, which was rated the biggest challenge in CBWM operation.

The findings for the three case studies on CBWM challenges underscored the necessity for comprehensive strategies that address budgeting, participation and commitment, community training, policy development, and encourage commitment to enhancing the effectiveness of CBWM initiatives. Goldin *et al*. (2019:15–16) rated the collection of reliable and valid data as important for community participation. Generating credible data through CBWM is a key tool for involving the community in water-related decision-making (Flores-Díaz *et al*., 2018:10). Nonetheless, poor quality data produced by community members was rated as the least significant concern in these study findings, which is supported by Goldin *et al*. (2023:50), who confirm that data collected by volunteers is no less reliable than data collected by scientists. Moreover, CBWM produces rapid data that can be used to identify and address local problems. To achieve this, participants only require basic literacy skills and data quality assurance to enhance data credibility (Flores-Díaz *et al*., 2018:4–11).

All stakeholders have a role to play in sharing information to support effective community engagement (Rivett *et al*., 2014:13). Scepticism towards volunteers' contributions was emphasised in this study as a trust issue and was regarded as one of the critical issues related to information sharing among stakeholders (Goldin *et al*., 2019:26–30). That being said, community-based approaches are encouraged to form part of the decision-making process (Moolman *et al*., 2023:119).

5.3.2 Criteria that should be considered in CBWM in developing countries

To respond to the study's sub-research question 2 regarding the criteria to be considered in the development of CBWM programmes in developing countries (see Themes 5 and 2 in Table 4.1, Section 4.5.2.6), several criteria were examined. These included the types of monitoring programmes (presented as type of monitoring under the monitoring parameters theme in question 3 of Appendix A3 and question 9 in Appendix B2), prevalence of standardised monitoring protocols (Theme 2), monitoring parameters (sub-theme 5.1), data management (sub-theme 5.2), funding (sub-theme 5.3), and value for money (sub-theme 5.4), all of which were solicited from Table 4.1.

The responses from the interviews relating to CBWM criteria (see question 3 of the final interview schedule – Appendix A3) across the three case studies are captured in Appendices H1–H3, and the findings are presented in Figures 5.6 and 5.7. In this qualitative data analysis, the number of participants per case study was represented as a percentage of the total sample for each type of monitoring conducted out of the four stipulated types – a form of descriptive analysis typically associated with quantitative data analysis. However, in this study, these descriptively analysed data are explained by indicating the rarity or significance of occurrence, which qualifies them as qualitative data analysis (see Section 4.5.3.4 for qualitative data analysis). This approach demonstrates the advantage of using mixed methods.

The survey questionnaire findings to question 9 (see Appendix B2) are illustrated in Figures 5.8–5.12 (see Section 4.5.4.2 on quantitative data analysis).

5.3.2.1 CBWM criteria results

In relation to the type of monitoring (question 3 in Appendix A3 and question 9 in Appendix B2), which represent monitoring programmes, the qualitative interview results presented in Figure 5.6 show that water quality was the most frequently monitored parameter by Koffiekraal at 76.9% and Luvuvhu at 54.0%, followed by REMP (Luvuvhu [23.0%] and Koffiekraal [7.7%]), and then river cleaning campaigns (Luvuvhu [23.0%], Selons [8.0%], and Koffiekraal [7.7%]). However, the Selons case study followed a different pattern, highlighting the REMP monitoring type as the most monitored, at 50.0%, followed by water quality at 42.0%, and then river cleaning campaigns at 8.0%. Water quantity monitoring was only recorded in the Koffiekraal

case study (7.7%). Surface water resources were indicated as the most monitored programmes when compared to groundwater resource monitoring.

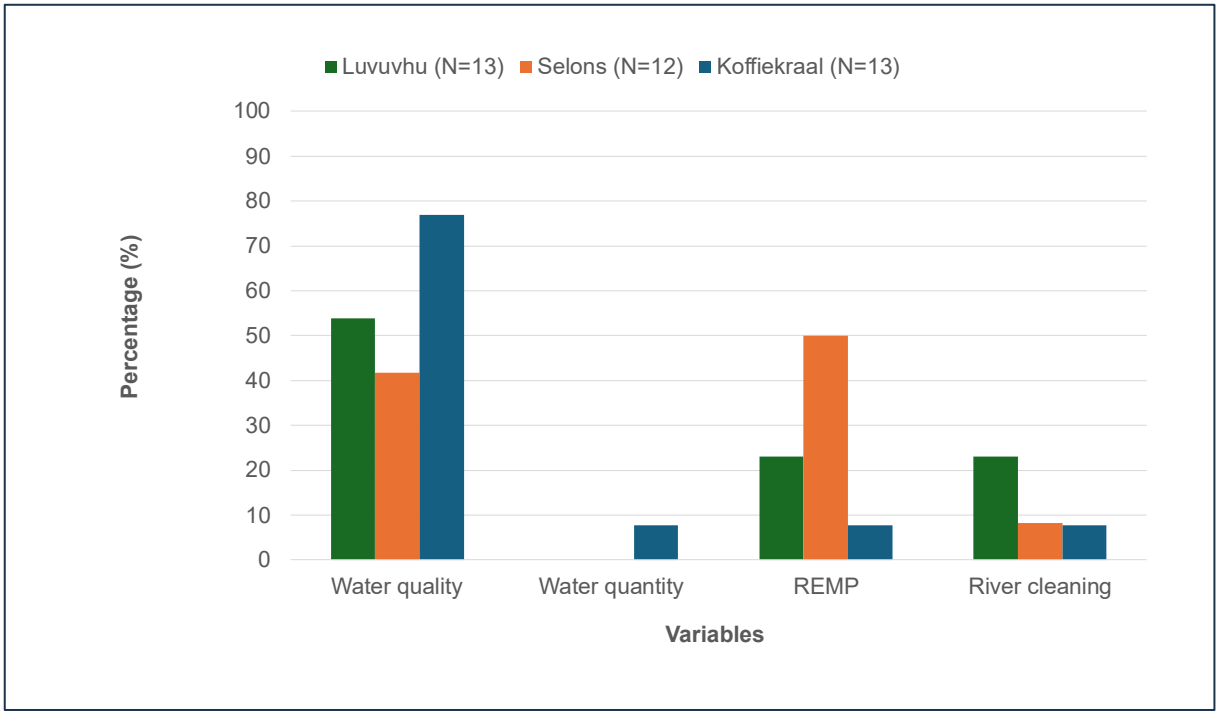


Figure 5.6: Interview findings on types of monitoring programmes

The study's sub-research question 2 was addressed through interviews with participants, who were asked for their insights on Theme 2 – the prevalence of standardising monitoring protocols (see Table 4.1 in Section 4.5.2.6). The qualitative interview data obtained from the three case studies are presented in Appendices H1–H3, with the findings illustrated in Figure 5.7 below. The findings demonstrated that most participants in all three case studies indicated following a standardised monitoring protocol (Luvuvhu at 76.9%, Selons at 58.3%, and Koffiekraal at 76.9%), followed by community priorities (Luvuvhu at 23.1% and Koffiekraal at 15.4%), and then the availability of monitoring equipment at 7.7% in the Koffiekraal case study. By contrast, the Selons case study participants indicated the availability of monitoring equipment as their second choice at 33.3%, while community priorities ranked lower at 8.3%. The disparity in percentages points to a significant preference among participants regarding the standardisation of monitoring protocols as a common practice in choosing monitoring parameters.

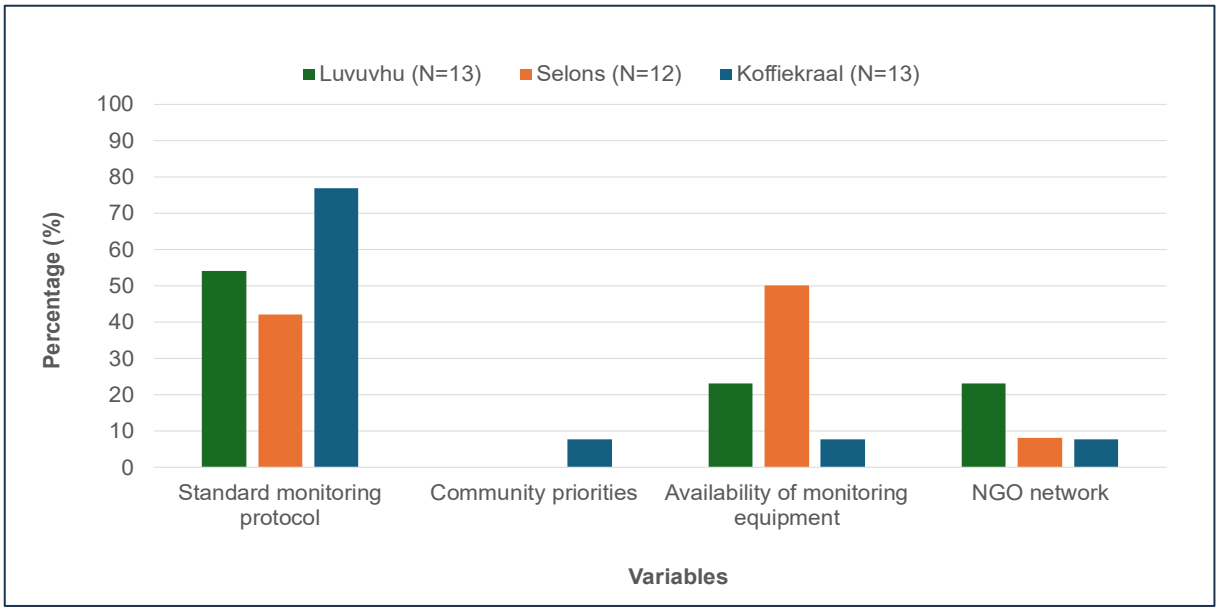


Figure 5.7: Interview findings on the prevalence of standardised monitoring protocols

Question 9 of the survey questionnaire (Appendix B2) was designed to ask respondents to share their perceptions regarding the criteria to be considered in CBWM, as they pertained to their specific case studies. Respondents were instructed to select an appropriate rating from a provided five-point Likert-scale (1 – Of no importance, 2 – Of little importance, 3 – Undecided, 4 – Of moderate importance, 5 – Of great importance). This scale measured participants' opinions on the level of significance in the CBWM criteria set as *Monitoring Parameters* (with type of monitoring and methods, and prevalence of standardised monitoring protocols embedded), *Data Management*, *Funding*, and *Value for Money* variables (Figure 5.8). The variables for rating monitoring parameters include the type of monitoring, monitoring parameters, standardised monitoring protocols, community priorities, and the capacity of monitoring equipment and other resources. The variables for rating data management include data storage, access to data, funding of data collection, and the relationship between CBWM data collection and policy development. The variables regarding funding include options such as unpaid volunteers as the best, participants must get a stipend, and participants must get paid. Variables for rating value for money include addressing reasons for starting the CBWM programme, maintaining CBWM continuity, and establishing long-term datasets.

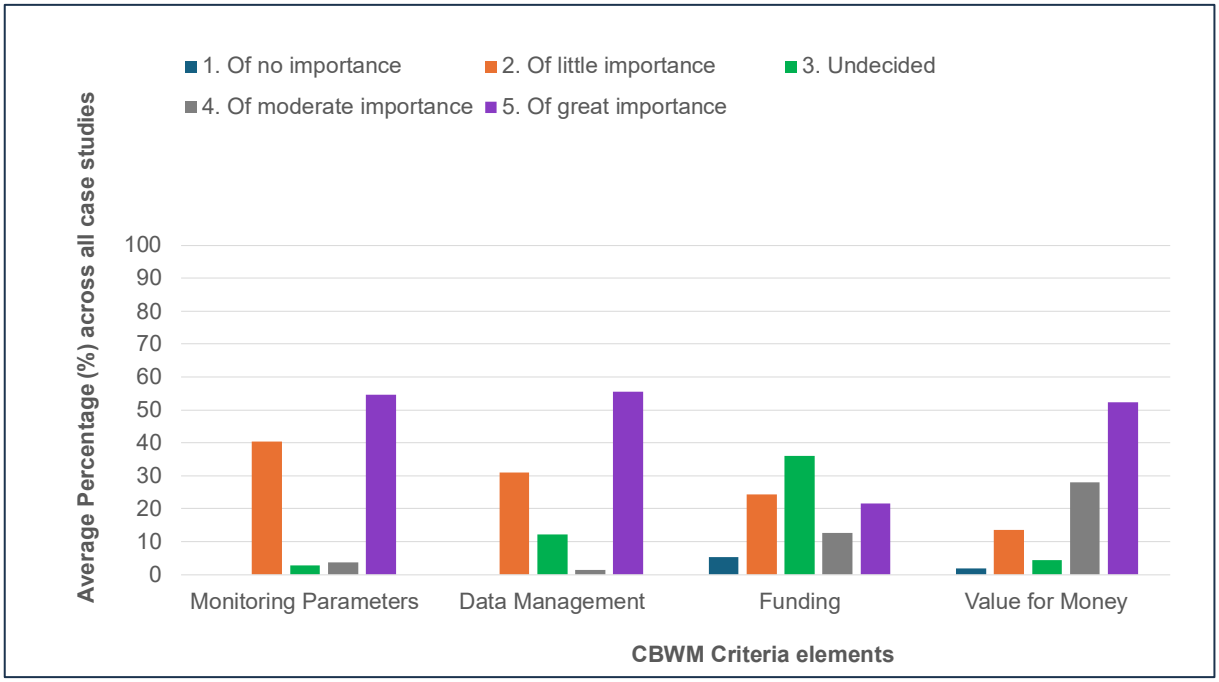
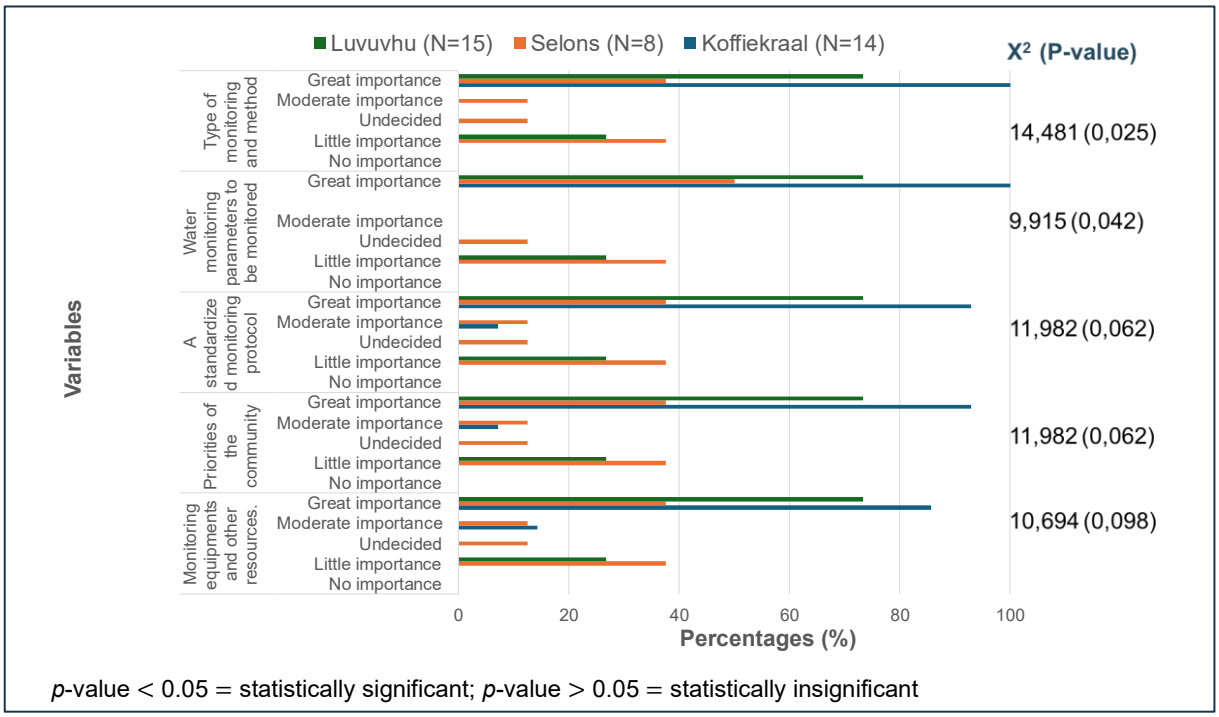


Figure 5.8: Average survey findings on CBWM criteria

Given unequal sample sizes (Luvuvhu n=15, Selons n=8, Koffiekraal n=14), data in Figure 5.8 represents average percentages calculated from the three case studies using equal weighting of each case, regardless of sample size. As indicated in Figure 5.8, over 50.0% of the respondents stated that monitoring parameters, data management, and value for money were of great importance, indicating that these were priority criteria elements to be maintained in CBWM initiatives, ahead funding. The individual criteria element findings of the survey questionnaire indicated in Figure 5.8 are further explained in Figures 5.9–5.12.



p-value < 0.05 = statistically significant; *p*-value > 0.05 = statistically insignificant

Figure 5.9: Survey findings on monitoring parameters

All the monitoring parameter variables in Figure 5.9 are reflected as of great importance – over 70% for both the Luvuvhu and Koffiekraal case studies. The Selons case study shows relatively similar results for variables of little and of great importance, which might suggest participants' preferences rather than theoretical considerations.

The *p*-values for the three monitoring parameter variables regarding standardised monitoring protocols, community priorities, and monitoring equipment are greater than 0.05 ($p > 0.05$), indicating statistical insignificance. This suggests that there are no statistically significant differences among the three case studies regarding those variables. The monitoring type, method, and parameter variables show *p*-values of less than 0.05, suggesting significant differences among the case studies. The significance of these criteria was confirmed by 100.0% of Koffiekraal survey questionnaire participants, who rated these variables as being of great importance, compared to over 85.0% for the other two variables. These findings complement the interview data in Figures 5.6 and 5.7, which indicate that Koffiekraal participants felt strongly about conducting all four types of monitoring, in addition to adhering to all four standardised monitoring protocol variables.

The survey questionnaire findings on data management, presented in Figure 5.10, indicate a strong correspondence, with a high percentage (over 70.0%) of "Great Importance" ratings in both the Luvuvhu and Koffiekraal case studies across all data management variables. The two case studies showed an inverse pattern compared to the Selons case study, which indicated a smaller proportion rating variables as of great importance (50.0%) across all data management variables, with the relationship between CBM data and policy development being rated as of little importance for inclusion as part of the criteria.

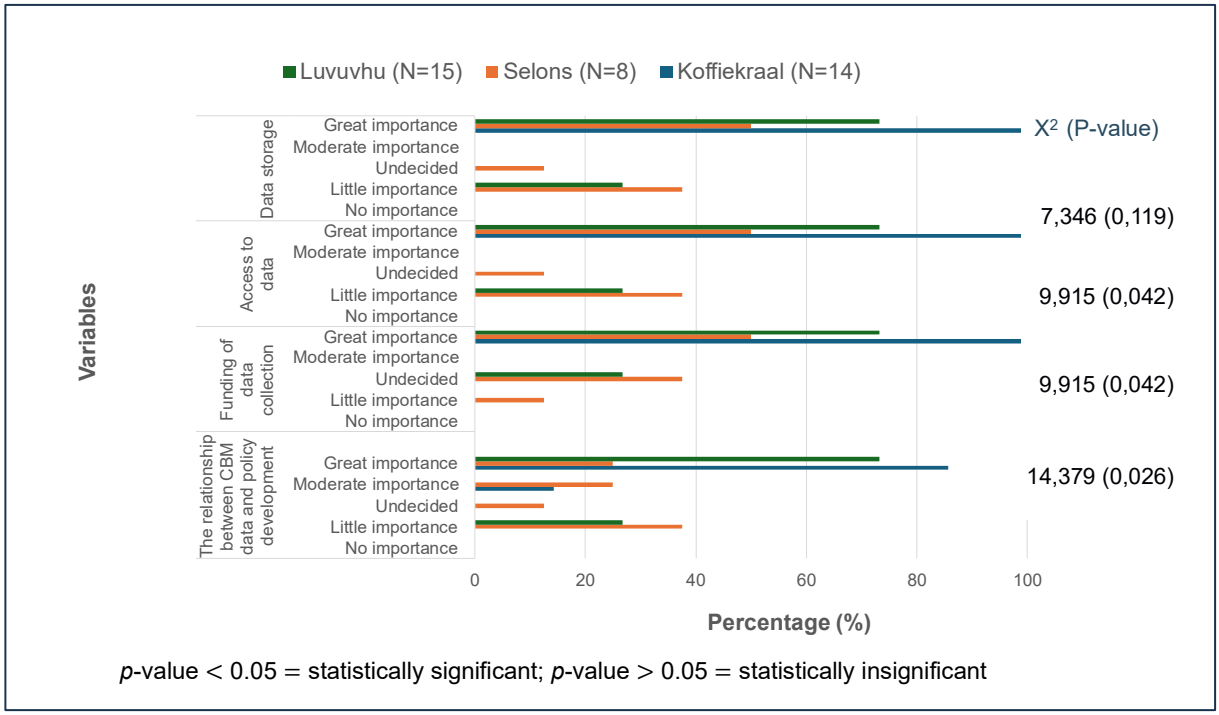


Figure 5.10: Survey findings on data management

The *p*-values for all the data management variables are less than 0.05 ($p < 0.05$), showing significant statistical differences for everything but the data storage variable. This suggests that there are significant differences among the three case studies in all the data management variables except for data storage. However, the increase in data management challenges indicated by the interview findings warranted an integrated database and data management matrix. The cost associated with data storage and data structure concerning NGOs' design were specific concerns raised in the Selons case study. Participants identified the need for a budget to support data storage solutions such as cloud services and suggested the use of flyers for public data sharing. Two interview participants in the Selons case study, P11 and P12 (Appendix H2), notably, expressed support for data management improvement, with a preference for academic publications disseminating information to the community. This view was echoed by participant P9, who suggested "A diverse perspective of data management should include cross-border data sharing, involving Mozambique".

In all three case studies, the findings regarding the importance of funding are reflected in Figure 5.11.

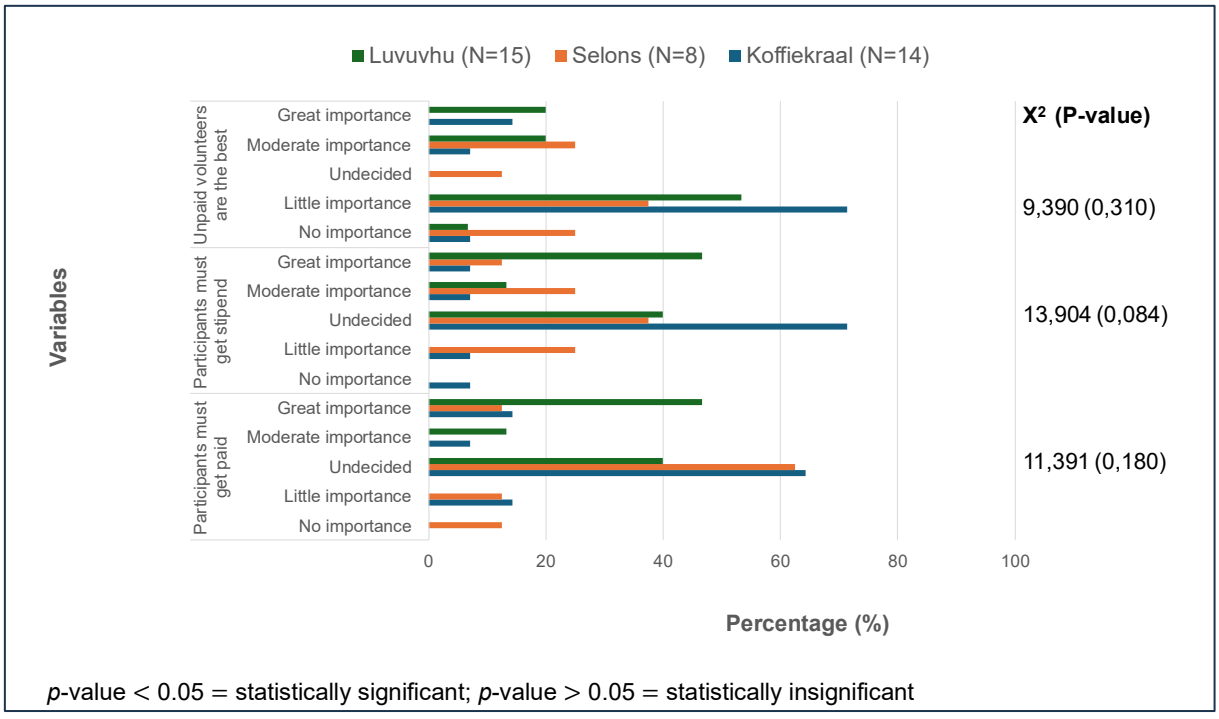


Figure 5.11: Survey findings on funding

These findings indicate that most respondents in all the three case studies – with over 55.0% in both the Luvuvhu and Koffiekraal case studies – view the participation of unpaid volunteers in the CBWM programme as of little importance. Additionally, notable uncertainty surrounds financial compensation for participants in the CBWM programme. Specifically, more than 60.0% of respondents in both the Selons and Koffiekraal case studies were undecided on whether CBWM participants should be paid for their involvement, with over 70.0% of

Koffiekraal case study participants being unsure that they should receive a stipend. The *p*-value for all the funding variables is greater than 0.05 ($p > 0.05$), indicating that the statistical differences are insignificant. This suggests no meaningful differences exist among the three case studies in relation to the variables assessed.

The findings regarding value for money are illustrated in Figure 5.12.

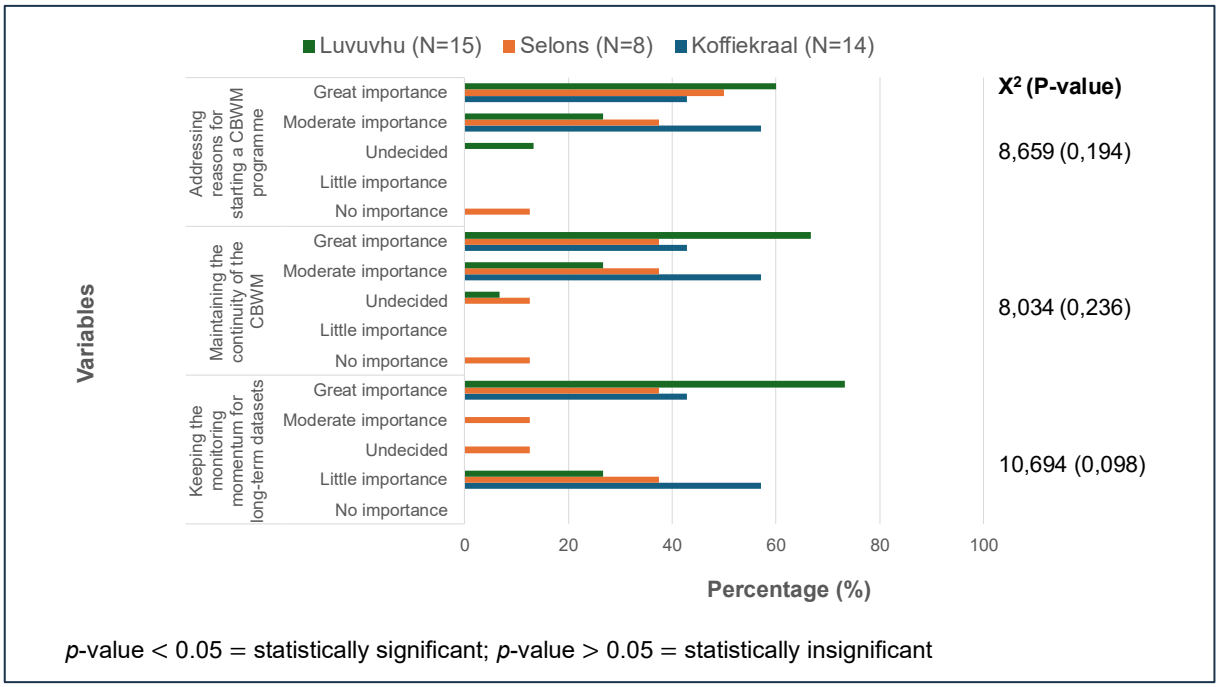


Figure 5.12: Survey findings on value for money

Across all three case studies, the three rating variables demonstrating value for money were deemed of great importance, with more than 50.0% of respondents on average sharing this view. Approximately 40.5% of respondents in all the case studies perceived these variables to be of moderate importance, except for the statement concerning the maintenance of long-term datasets, which received the same percentage but was categorised under little importance instead. The *p*-value for all the value for money variables is greater than 0.05 ($p > 0.05$), indicating that the statistical differences are insignificant. This suggests that there are no differences among the three case studies regarding the variables evaluated.

5.3.2.2 Discussion on CBWM criteria

Although the statistical significance of the differences between the three case studies was minimal, monitoring parameters were considered necessary, with data management following closely. The failures of CBWM initiatives were attributed to the application of a blanket approach without standardisation for consistency. For a sustainable CBWM project, a recommendation was made to avoid a one-size-fits-all approach and instead adopt a customised strategy that applies site-specific but standard approaches (Kativhu *et al.*, 2021:20–21). A lack of standardised methods leads to data inaccuracy and poor-quality control

(Pollock & Whitelaw, 2005:213; Kativhu *et al*., 2021:20). Biophysical monitoring of the water resources discussed above is not the only measure of the success of CBWM programmes. Socio-economic changes, alterations in behavioural patterns, and cultural values and norms around community water use should also be considered (Graham *et al*., 2016:46–48).

The qualitative findings revealed the role of unpaid volunteer participation and compensation for participation in the CBWM programme as less significant. The quantitative findings regarding the importance of funding for data collection indicated a lack of consensus among the respondents regarding the significance of volunteer participation and the need for financial incentives in the context of the CBWM programme. Supporting these findings, a literature review of the participants' lack of consensus revealed two parallel perspectives about CBWM funding. As suggested by Graham *et al*. (2016:34–40), one view proposed that attendance certificates for all participants be provided as additional incentives for the community, which could be more valuable to students in the community than monetary incentives. Furthermore, education and capacity building on water management served as an incentive (Franceys & Gerlach, 2011:61–70).

In contrast, a citizen science workshop conducted in Limpopo in 2019, in the same study area, concluded that challenges – such as a lack of data sharing emerging in community-based initiatives – were linked to the unavailability of monetary incentives (Goldin *et al*., 2019:22). Some participants were of the opinion that to alleviate the financial burden, public–private partnerships should provide funding for CBWM projects (Kativhu *et al*., 2021:21). The risk of CBWM activities being dependent on voluntary community members without payment or stipends proved to result in failure or a lack of continuity. Makurira and Mugumo's (2005:170–171) experience with CBWM regarding financial support versus voluntary participation was that without financial support, community activities were doomed to fail. At least payment for subsistence and travelling expenses was considered appropriate CBWM compensation in developing countries (Makurira & Mugumo, 2005:172).

The participants' lack of consensus on funding may imply that stakeholders need to explore the roles and motivations of volunteers further and the potential impact that financial compensation could have on participation in CBWM initiatives. It could also reflect a broader attitude towards volunteerism and compensation in CBWM programmes, highlighting a need for further research on how best to support and motivate participants in such initiatives.

Addressing the reasons for establishing a CBWM programme, maintaining the continuity of an established programme, and sustaining monitoring momentum were variables used in this study as indicators of value for money. The quantitative survey findings across all case studies showed that respondents perceived value for money as highly important in water resource protection. Regarding value for money, the knowledge generated by CBWM is invaluable and

requires a multi-sector collaboration between local and technical expertise, academics, and scientists to ensure sustainability (Flores-Díaz *et al*., 2018:11).

The variables were strongly linked to CBWM ownership, and most participants confirmed that the reasons for establishing a CBWM initiative have been met, although a lack of implementation poses a challenge to sustaining monitoring. CBWM programmes serve as a means of generating water resource knowledge, enhancing the understanding of water dynamics, and informing users' decisions (Flores-Díaz *et al*., 2018:1).

Monitoring of water quality and aquatic microinvertebrates using the South African Scoring System (SASS) version 5 (MiniSASS) emerged as the most prevalent activities in this study, whereas litter cleaning campaigns were the least common. These tools have proven effective in assessing water pollution and the ecological health of riverine systems (Ndiitwani, 2004:124).

In addition, key water quality parameters highlighted by participants included pH (potential of hydrogen), total dissolved solids, *Escherichia coli (E. coli),* and, to a lesser extent, chlorine. While chlorine was among the least frequently mentioned, it remains a critical parameter in chemical testing for compliance with drinking water standards (DPM, 2016:25). In this study, the need to include *E. coli* bacteria as an indicator of health hazards in CBWM monitoring was raised by Luvuvhu case study participants. Although *E. coli* is typically harmless when found in the intestines of healthy humans and animals, its presence in water indicates faecal contamination from warm-blooded animals, which can introduce harmful bacteria associated with waterborne diseases.

Regarding pre-existing the Theme 2, which focuses on the prevalence of a standardised monitoring protocol, the study's findings show that most participants in all three case studies used a standard monitoring protocol (Figure 5.7) and rated it as highly important (Figure 5.9). This is supported by Goldin *et al*. (2019:17), who encouraged volunteers in the Limpopo River basin to adhere to a standardised protocol for efficient data collection and sharing.

This emphasis contrasts with a literature review by Conrad and Daoust in 2008 (Carlson & Cohen, 2018:173), which found that 73.0% of CBM respondents in Canada did not use standardised protocols to collect data. However, a follow-up study by Carlson and Cohen (2018:173) in the same province found that 75.0% of respondents had adopted standard monitoring protocols. This shift suggests that, at a minimum, standardised monitoring protocols have become more common over the past two decades in developed countries and are now being effectively adopted in the developing country context of South Africa.

5.3.3 Community's experiences on the extent to which catchments benefit from CBWM

Sub-research question 3 aimed to assess the extent to which catchments benefit from CBWM. Interview question 6 asked participants to explain 'the value of data produced in CBWM initiatives', which was clarified to them as referring to the benefits of CBWM at the catchment level. Survey question 12 asked respondents, 'Based on the opinions of governance and the real-life experiences of the community, do catchments benefit from CBWM?'

The response findings from the participants of the three cases are summarised in Table 5.2 below and indicate a *p*-value of greater than 0.05, suggesting that the statistical differences in perceptions of catchment-level benefits from CBWM are insignificant – meaning there were no differences across the three case studies. Notably, over 85.0% of respondents in all the three case studies agreed that catchments benefit from CBWM initiatives, with the promotion of ownership and an early warning system highlighted in Figure 5.13 and 5.14, respectively.

Table 5.2: Catchments benefiting from CBWM

		Case Study			Total	X^2 (*p*-value)
		Luvuvhu N (%)	Selons N (%)	Koffiekraal N (%)		
Do catchments benefit from CBWM?	Yes	14 (93.3%)	7 (87.5%)	12 (92.3%)	33 (91.7%)	.243[a] (.885)
	No	1 (6.7%)	1 (12.5%)	1 (7.7%)	3 (8.3%)	

5.3.3.1 Catchments benefiting from CBWM results

Responses from the interview conducted with participants in the three case studies are summarised in Appendix I1 and the four emerging themes (Themes E1–E4) are presented in Figure 5.13.

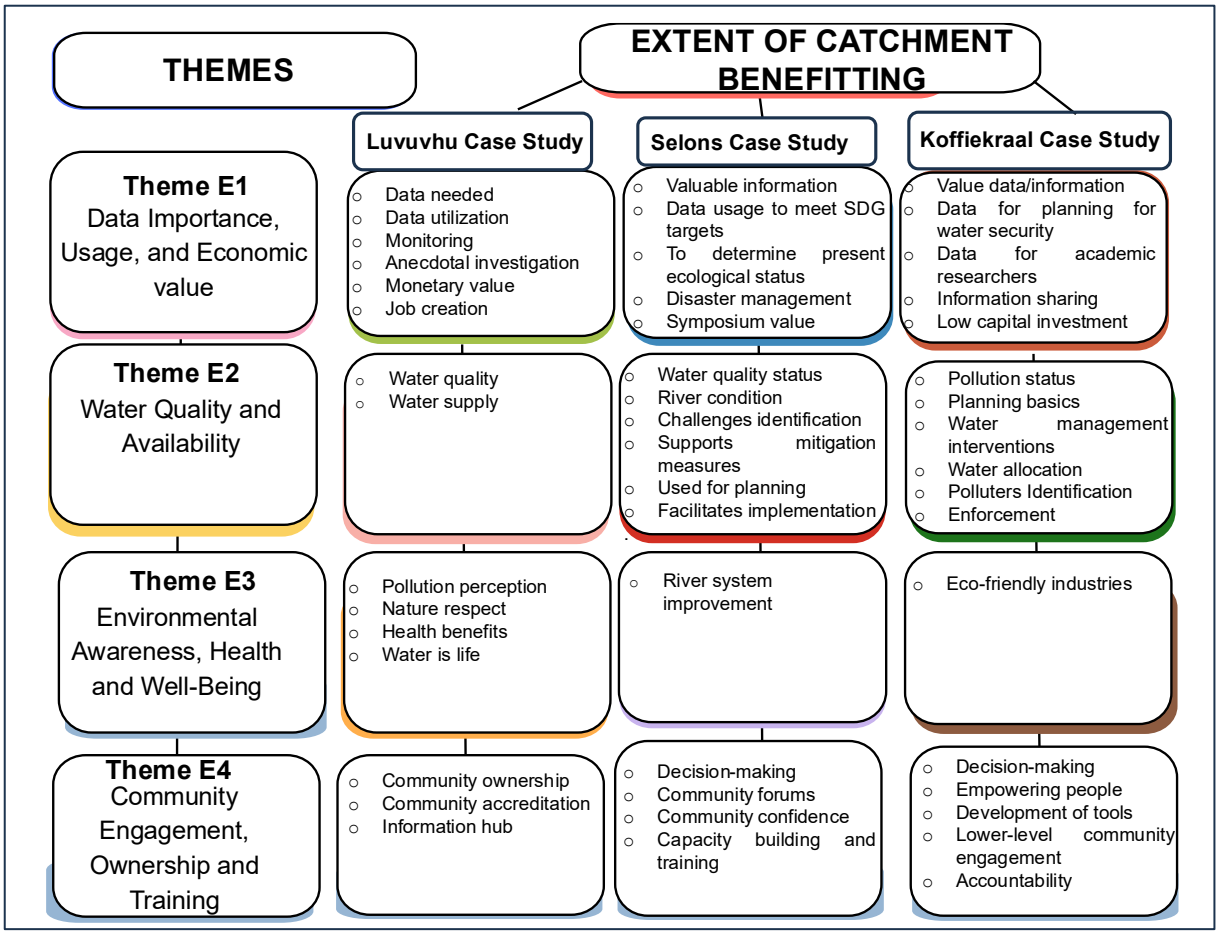


Figure 5.13: Interview findings on the extent to which catchments benefit from CBWM

Data usage to produce valuable information for determining present ecological status, compliance with the Sustainable Development Goals (SDGs), and monetary value in terms of long-term investment were the common codes identified under Theme E1 – data importance, usage and economic value – in all the case studies. The only notable difference in Theme E1 emerged in the Luvuvhu study, where participants highlighted the use of data for anecdotal information. This requires further investigation.

Theme E2 assessed water availability and quality as key catchment benefits, both of which featured strongly in all three case studies. Water quality was described in terms of water quality status, pollution status, or overall river condition, while water supply was viewed as a planning tool for water allocation and management. Koffiekraal participants additionally identified polluters and enforcement as priority catchment benefits under this theme.

Theme E3 – environmental awareness, health, and community well-being – revealed no commonalities across the three case studies. Participants in the Luvuvhu case study emphasised community perceptions of pollution as a key driver of understanding and respecting the notion that “water is life”. In the Selons case study, participants viewed improvement of the river system as a benefit.

Theme E4 – community engagement, ownership, and training – highlighted a range of catchment benefits, including community ownership of CBWM initiatives and the ability to hold municipalities accountable. Common benefits across all three case studies included the need for decision-making data, proper training for community members through forums involving members at all levels, and community ownership of CBWM programmes. Participants in the Luvuvhu case study were the only ones to emphasise the value of community members receiving accreditation for their skills and expertise and acting as local information hubs. In contrast, participants in the Koffiekraal case study stressed the value of communities having opportunities to hold relevant institutions, such as municipalities, accountable for protecting water resources.

The results of question 12 of the survey questionnaire (Appendix B2) are summarised in Appendix I2 and illustrated in Figure 5.14, with a blank space in the Selons case study, indicating no catchment benefit for Theme E3.

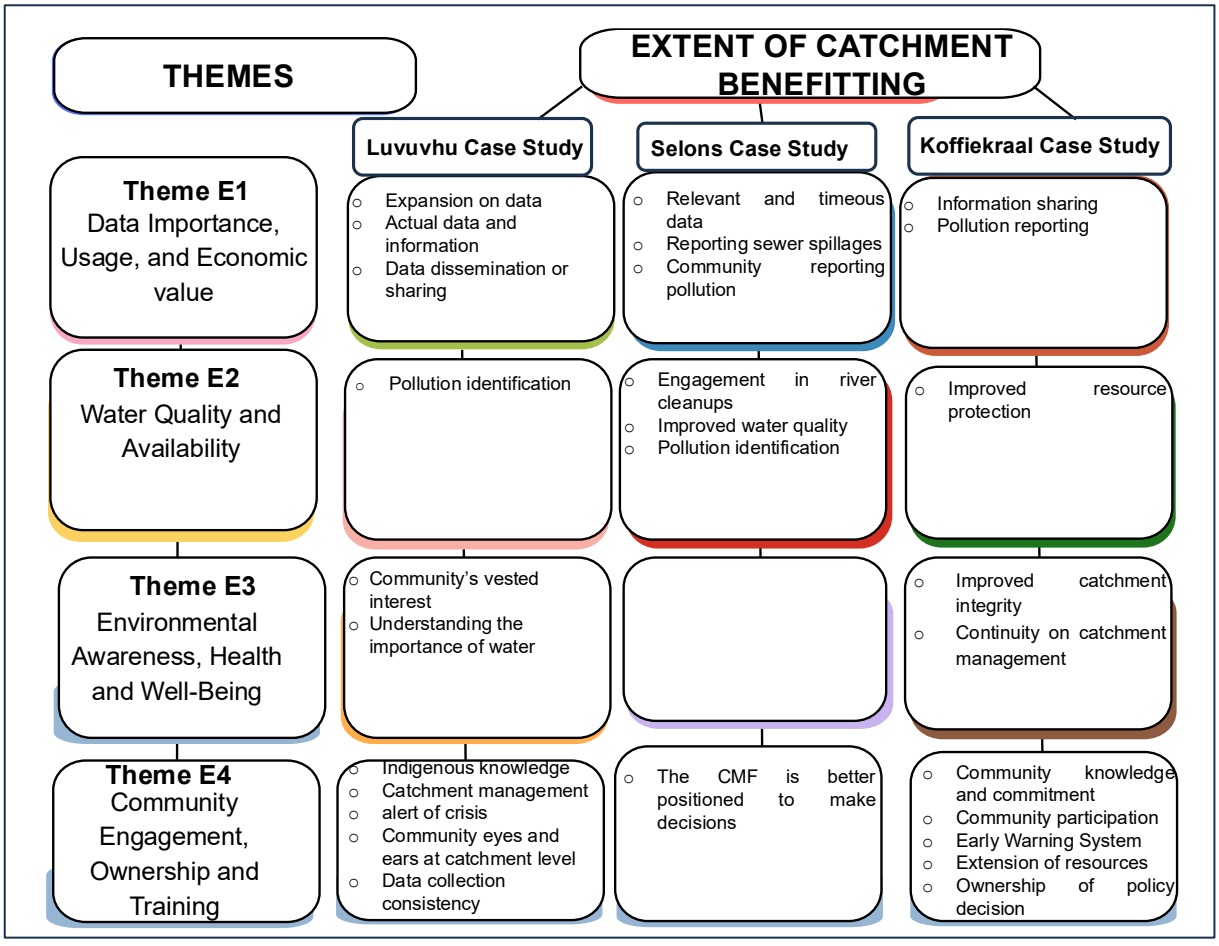


Figure 5.14: Survey findings on the extent to which catchments benefit from CBWM

The survey questionnaire findings are presented in the same format used for the interview findings.

The key highlights of the Luvuvhu case study quantitative results include a better understanding of the water resources (Theme E3), integration of science and Indigenous

knowledge, improved consistency in ecological monitoring (Theme E4), and land-use identification (Theme E2). While CBWM may produce substandard data, it helps identify and address issues within the catchment and serves as eyes and ears on the ground (an early warning system). The findings emphasise that community-generated data is invaluable (Theme E1) for effective catchment-level water resource management, as it contributes to data collection and compensates for under-capacitated government entities.

The quantitative findings of the Selons case study identify community benefits, such as training provided to communities (Theme E4) to engage in practical pollution mitigation activities, including river cleanups and incidental spill responses (Theme E2). Unlike the other case studies, participants in the Selons case study did not associate CBWM with benefits under Theme E3. Rather, they viewed CBWM initiatives as contributing relevant and timely data to water quality improvement (Theme E1), compared to traditional government monitoring programmes. Regular monitoring equips communities with skills to advocate for their right to access good quality water, enables timely management interventions, and provides evidence to address water disputes and conflicts.

The quantitative findings from the Koffiekraal case study outline community benefits such as local ownership and buy-in (Theme E4), improved catchment integrity (Theme E3), increased knowledge and commitment, capacity building, public participation, decision-making empowerment, information sharing, citizen science advocacy, and the development of a reporting mechanism (Theme E1). As in the Luvuvhu and Selons case studies, the provision of community involvement as an early warning system in water resource management was also emphasised in the Koffiekraal case study. In addition, Koffiekraal participants uniquely highlighted community ownership of policy decisions. Informed and engaged communities are empowered to influence policy decisions to improve their water resources (Theme E2) – a benefit not identified in the other two case studies.

5.3.3.2 The extent to which catchments benefit from CBWM

As noted before, sub-research question 3 explored the extent to which communities benefit from CBWM programmes. The qualitative and quantitative findings confirmed that CBWM initiatives offer certain benefits to communities.

The interview results indicated that the effectiveness of CBWM programmes, in terms of community benefits and sustainability, remains questionable due to inadequate resourcing for implementation. Kativhu *et al.* (2021:20) view CBWM in the rural water sector as a solution that promotes water sustainability. Community ownership, partnerships between local networks and government (in the form of community forums), and empowerment were among the significant benefits identified, as supported by Carlson and Cohen (2018:173–174).

Quantitative study findings across the three case studies showed that almost all the respondents agreed that communities benefit from CBWM initiatives. However, volunteer involvement in community monitoring may pose a challenge, as the data they collect could be scrutinised for lacking quality assurance and robustness (Buckland-Nicks *et al*., 2016:14–18). Nevertheless, the findings of this study suggest that community-generated data do factor in indigenous knowledge into science (Moolman *et al*., 2022:5–7), and can contribute to early pollution identification, dispute resolution, and training for community decision-makers. However, this aligns with the argument made in Pallo *et al*. (2024:213), which suggests that science informs decision-making, as it fosters collaboration amongst scientists, government, and community members and solidify scientific evidence and indigenous knowledge.

In 2012, the mining prospectus CBWM meetings were held at Koffiekraal, where the chairperson of the Lehurutse traditional chieftaincies – a participant in this study's Koffiekraal case study – helped the community successfully oppose a mining proposal that had potential to pollute water in the Groot Marico River and jeopardise the rural lifestyle (Tempelhoff *et al*., 2012:26).

The data gathered in the quantitative survey supports the qualitative insights, highlighting job creation, low per capita investment, compensation for understaffed government entities, and early warning systems as invaluable community contributions that can benefit catchments. This is supported by the Government of Western Australia (2023:6–50), who noted that early local information can trigger emergency responses.

5.3.4 Views of governance structures on the extent to which CBWM operates

Sub-research question 4 aimed to explore the views of governance structures on the extent of CBWM operations in the three case study areas. The first two sub-questions of interview question 7 (Appendix A3) sought participants' insights into the reasons for, and types of, institutions and stakeholders that should be involved in CBWM initiatives. Survey question 13 (Appendix B2) probed the views of governance structures on CBWM operations. The interview and survey results were assessed to address sub-research question 4, and the results are presented in five themes generated as Themes O1–O5.

5.3.4.1 Governance perspectives from interview findings on CBWM operations

Interview findings on governance views regarding CBWM operations are summarised in Appendix J1 and illustrated in Figure 5.15.

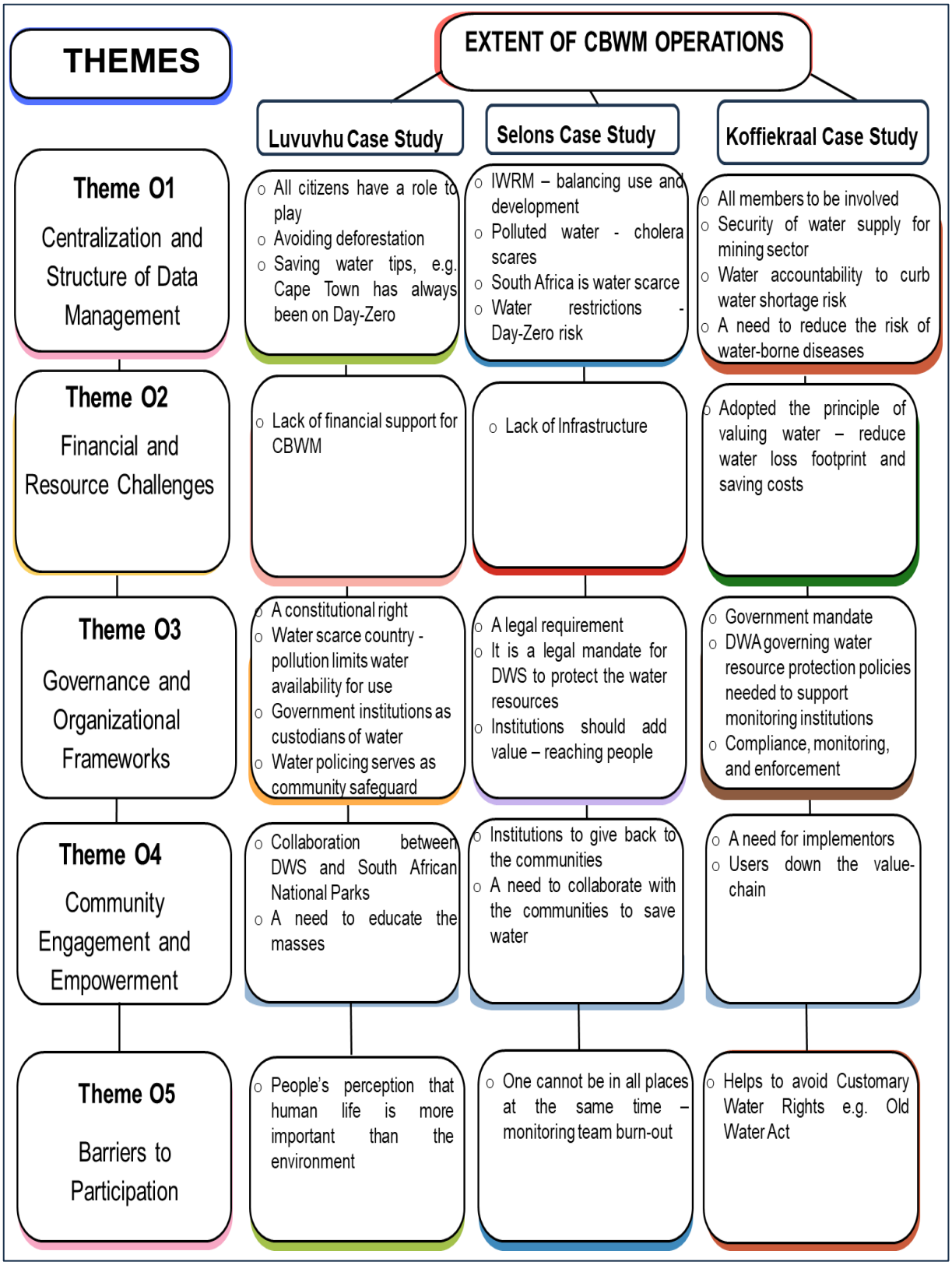


Figure 5.15: Interview findings on governance views regarding CBWM operations

Participants in the Luvuvhu and Koffiekraal case studies emphasised that water management is everyone's responsibility, particularly since many people live downstream (Theme O1). The findings of the Selons and Koffiekraal case studies further emphasised that institutions managing water resources are essential for implementing mitigation measures against

waterborne diseases. Additionally, the importance of valuing water to minimise loss and reduce costs was emphasised, along with a need to promote practical water-saving tips. This includes effective implementation of national water restrictions, responses to the country's call to reduce water loss, and efforts to avoid risks of water scarcity, such as those that led to Cape Town's "Day-Zero" in April 2018.

A lack of financial support and infrastructure for CBWM operations was highlighted by participants in both the Luvuvhu and Selons case studies as a key financial challenge (Theme O2). In contrast, Koffiekraal participants viewed Theme O2 as a wake-up call to reduce water loss to save costs. Governance and organisational frameworks (Theme O3) were identified in all three case studies as the mandate and responsibility of the DWS, through implementation of the NWA. Other key issues raised included community engagement and empowerment (Theme O4), with encouragement for the collaboration of different institutions from all sectors to take part in the implementation of CBWM activities, coupled with education of broader communities.

Additional barriers to CBWM operations (Theme O5) included community perceptions, as raised by participants in the Luvuvhu case study, participant burn-out, as identified in the Selons case study, and a need for effective an updated water rights frameworks, as indicated by participants in the Koffiekraal case study.

The list of stakeholders identified as essential for enabling CBWM operations across the three case studies included international bodies; government entities such as municipalities, water boards, the DWS, COGTA, DFFE, the Department of Mineral Resources and Energy, the Department of Agriculture, Rural Development, and Land Reform; SALGA; academic institutions; NGOs; local traditional authorities (community leaders, traditional leaders, religious organisations, and community forums); sector representatives (from the mining, industrial, agricultural, and academic sectors); and civil society groups. Some participants also advocated for youth and school learners to be educated in water management programmes from an early age. Moreover, responsible stakeholders should be trained as auditors to support compliance and enforcement efforts. A bottom-up approach was emphasised to ensure community needs are factored into water management strategies.

Sustainable practices were stressed in the Luvuvhu case study – such as encouraging the planting of more trees than are felled – to conserve water. Budget constraints were also identified as a significant challenge, shining a spotlight on the need for targeted financial support, public education, and awareness of water protection as a means to promote sustainability. The findings suggest that increased stakeholder involvement leads to greater impact. For example, Luvuvhu case study participants identified the Zion Christian Church as an important institution to involve in CBWM efforts.

Key motivations for institutional engagement in the Selons case study included adding value by serving communities – not merely enforcing regulations. Institutions such as Legalametsi and the Association for Water and Rural Development (AWARD) were recognised for their roles in water monitoring and compliance, indicating a collaborative effort in the Selons River system. The Selons case study also suggested that the private sector, particularly industry, should be monitoring their manufacturing product life cycle and waste and wastewater disposal practices. The involvement of international stakeholders, such as Mozambique, was highlighted as a crucial aspect of transboundary water resource management. The findings also noted that organisations such as the South African Weather Service require stronger representation in water management forums.

The findings further emphasised South Africa's ongoing water scarcity, the recurrence of water restrictions, and the threat of "Day-Zero" scenarios, which call for urgent preventive action. Community collaboration is vital in mitigating risks and facilitating information-sharing around water shortages and health threats such as cholera, often linked with polluted water resources. This study underscores the importance of moving beyond a top-down approach towards a holistic model that advocates for the involvement of stakeholders from grassroots community members to national policymakers.

Survey findings on governance perspectives regarding CBWM operations are summarised in Appendix J2 and illustrated in Figure 5.16, with blank spaces indicating no perceived imperative to improve CBWM operations.

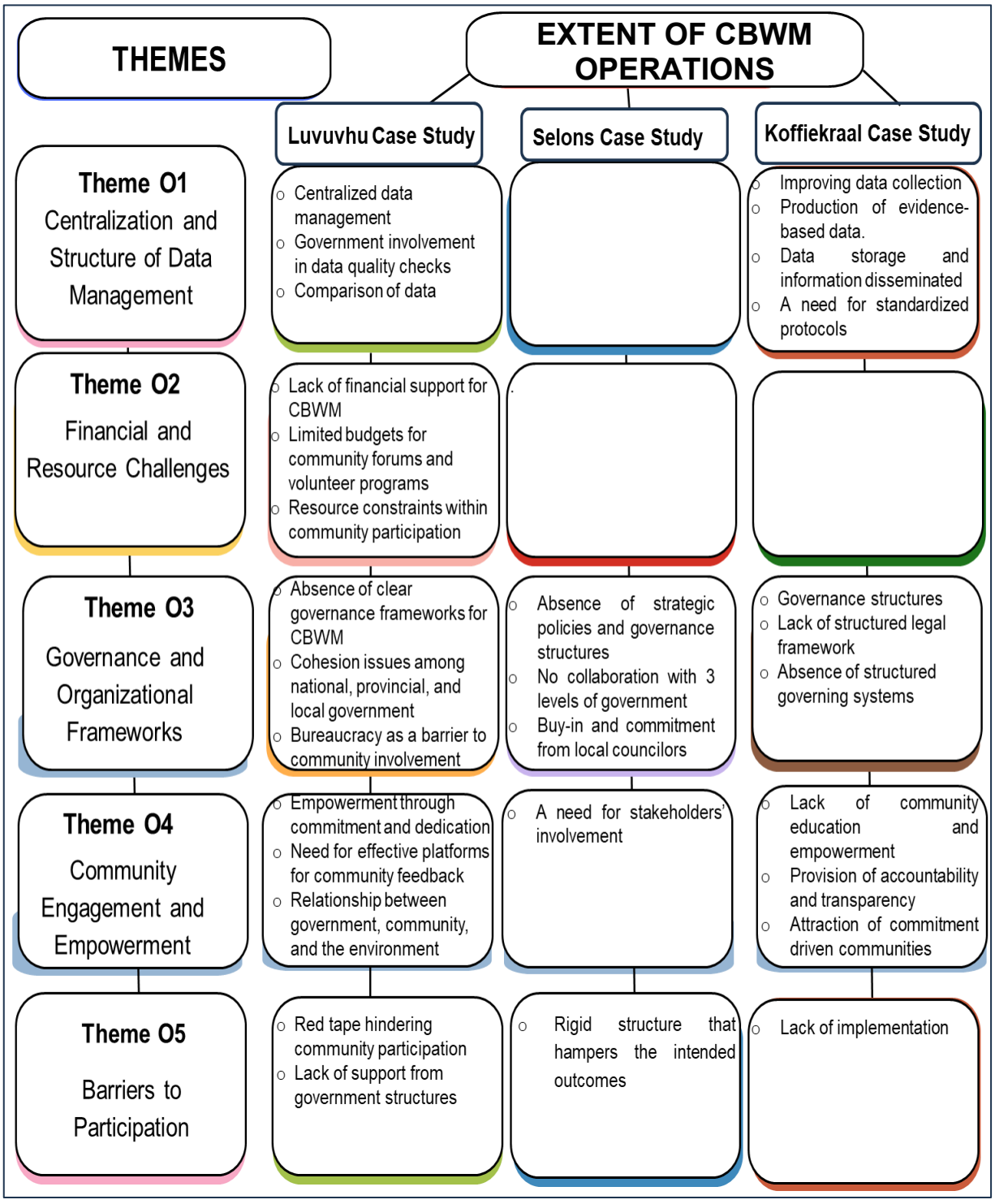


Figure 5.16: Survey findings on governance perspectives regarding CBWM operations

The Luvuvhu case study findings on CBWM operations identified several challenges (Themes O2, O3, and O5) and opportunities (Themes O1 and O4). CBWM opportunities are identified as the creation of a platform for communities to express their views (Theme O1), empowerment, and community involvement (Theme O4). The challenges include hurdles in the form of excessive bureaucracy (Theme O3) that can diminish community enthusiasm, and the absence of governance frameworks to guide and monitor CBWM activities. Lack of

cohesion leading to ineffective collaboration (Theme O5), insufficient financial support (Theme O2), and challenges with the establishment of the CMA were identified as obstacles to CBWM operations. A key finding was the need for a government centralised database with quality checks conducted by scientists to ensure reliability.

The Selons case study findings did not identify Themes O1 and O2 as imperative in improving CBWM operations compared to the Luvuvhu and Koffiekraal case studies, but participants outlined a need for community collaboration, involvement of local councillors, and multi-level engagement with three spheres of government. Alignment with the existing regulatory framework (if available) and tailored institutional arrangements are suggested governance-related improvement areas (Themes O3 and O4). In summary, Theme O5 attributed rigid government structures to hampering the successful implementation of CBWM initiatives.

Participants in the Selons and Koffiekraal case studies revealed critical deficiencies, including inadequate implementation (Theme O5) of the available fragmented CBWM operations guidelines. As with the Luvuvhu findings, critical shortcomings include data gaps (Theme O1), education and training deficiencies (Theme O4), technical limitations, and the lack of a supportive legal framework (Theme O3).

5.3.4.2 Discussion

Sub-research question 4 explored the views of governance structures on the extent of CBWM operations. Participants in the qualitative study pointed out the importance of DWS and DFFE playing a custodian, leadership, and regulatory role in water management. This includes the operation of CBWM initiatives, a constitutional obligation according to the NWA (1998). Du Toit (2015:9) confirmed the importance of governance in CBWM operations by underlining the need for effective structures and committed participants. The issue of water scarcity that led to Day-Zero in most of the catchments in South Africa served as a wake-up call to participants who emphasised that “we are all affected, and we need to act”. They noted that collaboration between regulatory and institutional structures and all water users is crucial for the protection of water resources through the effective operation of CBWM initiatives. The structures that represent all water users identified by participants include water sector institutions such as local municipalities, as well as the industrial, mining, agricultural, and academic sectors, together with community leaders and members. The need to prioritise and encourage the participation of vulnerable groups, such as the elderly, women, youth, and people with disabilities, in the operations of CBWM initiatives was raised by DPM (2014:4–12). Notably, the participatory approach should emphasise women’s contribution, as they play a pivotal role in water management, being the primary users within households (Dirwai *et al*., 2021:3).

Therefore, the participation of community structures (leaders and members) in CBWM plays an important role in effectively managing and protecting water resources. In support of the

roles of different stakeholders in CBWM operations, Goldin *et al*. (2023:8) emphasise collaboration among institutions such as the SADC River Basin organisations (Orange-Senqu River Commission [ORASECOM] and Limpopo Watercourse Commission [LIMCOM]), national government, district and local municipalities, unions, and tribal authorities/traditional leadership in community water monitoring.

CBWM operations opportunities identified by the qualitative study findings range from enhanced collaboration to the creation of communication platforms, as well as training and empowerment. On the other hand, shortcomings such as a lack of governance structures, data gaps, education and training deficiencies, bureaucracy that can limit participation and lack of CBWM governance and legal framework to standardise CBWM operations were identified. In support of the findings in Figures 5.15 and 5.16, Moolman *et al*. (2022:5–12) attributed uncertainties in decision-making to a lack of resources such as water infrastructure, budget, time, data, and information. The lack of community capacity for CBWM participation was related to a lack of expertise, which is one of the challenges faced in developing countries (Makurira & Mugumo, 2005:171–172). A wide range of stakeholders within a community might pose another challenge regarding the level of capacity building needed to accommodate the entire target group (Makurira & Mugumo, 2005:171–172).

5.3.5 The efficacy of the conceptual framework in enhancing the use of CBWM data in decision making process

The study's sub-research question 5 explored the usefulness of the existing CBWM conceptual framework, with the aim of developing a framework suitable for enhancing the use of CBWM data in water resource protection decision-making. This sub-question focused on pre-existing Theme 3 – Perceptions of CBWM data uptake into the development of policy and decision-making (see Table 4.1 of Section 4.5.2.6). Theme 3 aimed to identify whether data produced by CBWM informs policymaking. The last three sub-questions of interview question 7 (see Appendix A3) explored the relationship between CBWM data collection and policy development; knowledge of the existing CBWM framework; and the criteria for either the existing framework or the development of a new one. Similarly, questions 14 and 15 of the survey questionnaire (see Appendix B2) sought participants' insights on linking CBWM data to policy development, identifying any existing relevant frameworks, and developing a suitable CBWM conceptual framework. Responses from case study participants from both interviews and surveys are presented in Figures 5.17 and 5.18, respectively. These responses informed the development of the CBWM categories presented in Figures 5.19–5.21, which built up to a CBWM Conceptual Framework, as presented in Figure 5.22.

5.3.5.1 Effectiveness of the conceptual framework in promoting the use of CBWM data in decision-making

Despite the lack of framework awareness, all interview (Figure 5.17) and survey participants expressed strong support for the need for a conceptual framework that facilitates the use of CBWM data in decision-making and contributed to its development, with a few participants suggesting transitioning to a bottom-up conceptual framework (Appendix H1 and H2).

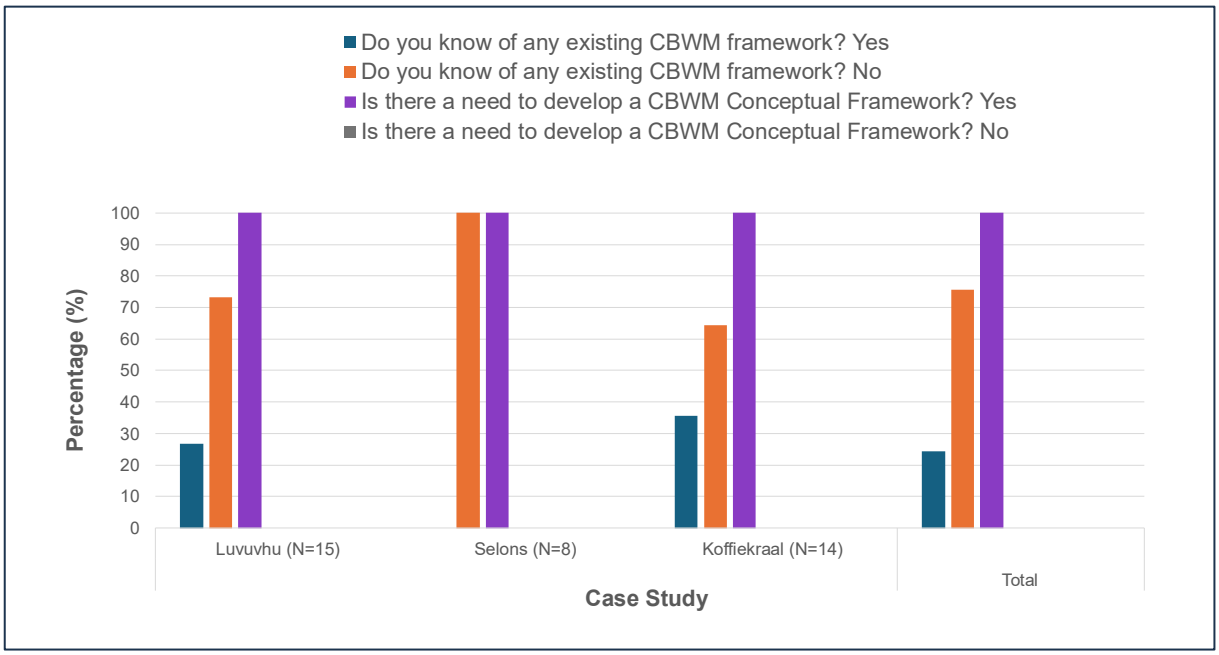


Figure 5.17: Interview findings depicting knowledge of existing CBWM frameworks

Despite a low number of interview participants (40%) in all the case studies being aware of existing CBWM frameworks (Figure 5.17), all participants in all the case studies agreed that there is a need for the development of a conceptual framework relevant to the implementation of CBWM initiatives.

Question 15 of the survey questionnaire (Appendix B2) was designed to probe respondents to share their views on their level of agreement regarding CBWM framework statements for their specific case study. Respondents were asked to select an appropriate rating from a five-point Likert scale (1 – Strongly disagree, 2 – Disagree, 3 – Don't know, 4 – Agree, 5 – Strongly agree). This scale measured participants' views on the level of agreement with the following statements: "There is a *need for a CBWM programme in each WMA or catchment*"; "*I am likely to recommend the inclusion of CBWM in water resource protection policies*"; "*I am likely to recommend the integration of CBWM in water resource protection governance structures*"; "*There is a need for a conceptual framework to enhance the use of CBWM data for water resource protection decision-making*"; and "*I am likely to recommend the development of a conceptual framework that clearly indicates information flow from data collection to decision-making*" (Figure 5.18).

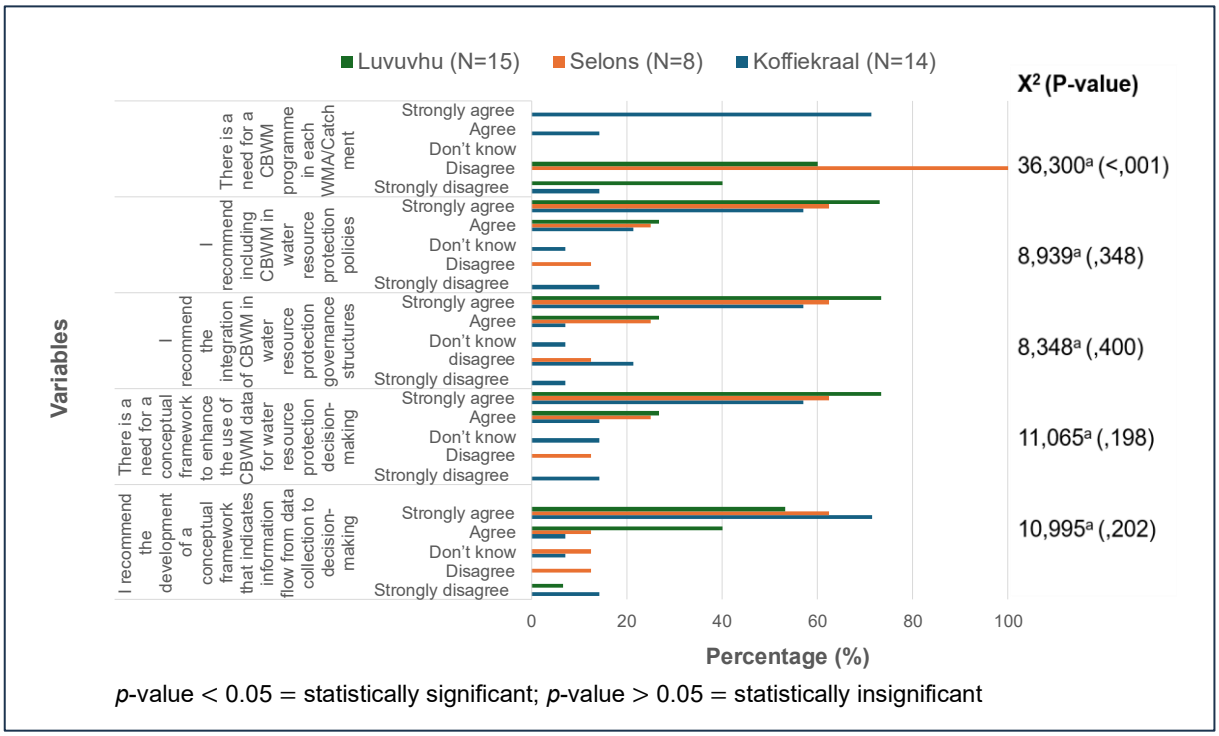


Figure 5.18: Survey findings on recommendation for a conceptual framework

The findings of the survey about a CBWM framework are illustrated in Figure 5.18 (see Likert scale survey question 15 of Appendix B2). In support of the interview findings presented in Figure 5.17, most participants (Luvuvhu at 53.3%, Selons at 62.5%, and Koffiekraal at 71.4%) reported that they strongly agreed with the development of a conceptual framework, with a *p*-value of 0.202, which is more than 0.05, indicating that the statistical differences regarding the development of a conceptual framework are insignificant, meaning there are no differences across the three case studies.

However, it is important to note that most respondents (over 57.0%) in all the case studies strongly agreed with the following three statements: "*I am likely to recommend the inclusion of CBWM in water resource protection policies", "I am likely to recommend the integration of CBWM in water resource protection governance structures",* and *"There is a need for a conceptual framework to enhance the use of CBWM data for water resource protection decision-making*", as presented in Figure 5.18. The findings show no significant differences among the case studies, with a *p*-value of more than 0.05 for all. In contrast, the statement *"The need for a CBWM programme per WMA or catchment"* shows a *p*-value of 0.001, which is less than 0.05, indicating significant differences among the case studies.

5.3.5.2 Discussion

The study's sub-research question 5 investigated the availability and usefulness of the existing CBWM conceptual framework and developed a series of CBWM conceptual framework categories proposed to enhance the use of CBWM data in water resource protection decision-making. The CBWM Conceptual Framework developed for this study was intended to guide

and support the use of CBWM data in water resource protection decision-making. Graham *et al*. (2016:10–11) confirmed the importance of data collection in the development of conceptual frameworks. In addition, Flores-Díaz *et al*. (2018:1–2) affirmed that CBWM data contributes to water resource management decision-making.

The participants and respondents in each case study listed the criteria informing the development of this study's CBWM conceptual framework categories. The fact that over three-quarters of participants indicated they were unaware of any existing CBWM conceptual framework suggests the need to develop one. The CBWM criteria listed by the participants emphasised the inclusion of groundwater components complementing the determination and implementation of the Reserve for priority water resources (Ndiitwani, 2004:124), linking the SDGs and the operationalisation of the conceptual framework.

Participants in the qualitative study strongly affirmed the need for a CBWM conceptual framework and suggested a bottom-up approach starting with civil society. These results are further supported by Moolman *et al*. (2023:2), who state that a multi-dimensional approach is recommended, instead of the top-down approach norm, for the effectiveness of policy implementation. In support of this approach, Flores-Díaz *et al*. (2018:11) and Moolman (2023:208) recommended stakeholder involvement in decision-making at the lowest level and that monitoring designed by the community itself sustains CBWM and maintains ownership of the programme. Building upon the work of Sally *et al.* (2011:375–380) regarding a need to balance PPP and downward accountability towards the implementing stakeholders in Burkina Faso, this study developed a CBWM Conceptual Framework emphasising the value of both top-down and bottom-up approaches.

The Koffiekraal community and the neighbouring residents in the Groot Marico River catchment once presented a united front, irrespective of their racial and cultural differences, against the mining proposals in the water management area (WMA) and protected the river and its aquatic environment by denying mining prospecting. They maintained their dignity and took ownership of the community initiative with ease as the meetings were conducted in their Sotho-Tswana language (Tempelhoff *et al*., 2012:28–29). The diversity of ethnicities and marginalised communities was often overlooked, mainly due to the loss of use of their indigenous language (Swift, 2019:1; Nyamande, 2024:1). The use of a common language has improved dialogue among community participants and enhanced collaboration and skills (du Toit, 2015:10; van Koppen, 2022:6–18).

The proposed conceptual framework allows for a bottom-up approach, recognising all the water users and community needs, and advocates for more community-level implementers than national-level decision-makers. Unlike Graham *et al*.'s (2016:10) top-down approach, the AaR governance framework, where implementation efforts were channelled through DWS

national and provincial coordinators, seems to disregard local community members. According to the Public Service Act (2008), the public must be encouraged to participate in policymaking in South Africa. Citizens can participate at a local level in development planning matters. This approach allows for the identification of CBWM champions to conduct reporting of information among the governance levels. In Zimbabwe, the decentralisation of water-related functions into the hands of communities is implemented through what are referred to as catchment councils (Makurira & Mugumo 2005:169), an equivalent to legal reforms in South Africa that transfer local authority to the CMAs, which has proved to be effective.

Respondents in the quantitative study confirmed a need for a conceptual framework, as affirmed by the qualitative study findings. Quantitative respondents highlighted criteria proposed to inform the development of a CBWM conceptual framework, including providing an integrated database, considering indigenous knowledge, standardisation, data collection and sharing, regulatory support, groundwater supply, communication frameworks, data quality assurance, governance, funding, education, and empowerment. Often, the groundwater component of the water resources is not included in water resource management planning, and the same applies to water resource protection. This study's results for sub-research question 2 regarding monitoring criteria demonstrate that the most conducted type of water monitoring was water quality, followed by the SASS, then litter picking campaigns, occurring in surface water bodies. The emphasis on groundwater supply in the qualitative study's framework criteria was supported by Bot-NWP (2012:10–12), which conducted a study on South Africa's and Botswana's transboundary shared watercourses, as groundwater is a major source of water in the WMA due to water scarcity. Botswana's policy principles and the country's consideration of the revised *SADC Protocol on Shared Watercourses* revolved around equity, efficiency, and sustainability, since the country is dependent on international shared and transboundary waters. Hence, the involvement of Botswana and Lesotho participants/respondents in this study was justified by their engagement through ORASECOM. The development and implementation of the CBWM framework provide data valuable for closing knowledge gaps, empowering community members, and finding solutions to water-related issues in the catchment (Goldin *et al*., 2019:30–32).

A small fraction of both qualitative and quantitative participants confirmed the existence of CBWM conceptual frameworks but emphasised the lack of implementation. Most implementation efforts were expected to be at the local and provincial level. The unavailability of enabling policies and strategies hampers the implementation of the framework (Hezri & Dom, 2017:19). In contrast, Pallo *et al*. (2024:211-212) indicates that the availability of data and insights informs water management strategies and policy formulation, which confirms the value of cycle of integration. Unpaid local community members were disregarded compared to government-paid participants. The development of the CBWM Conceptual Framework was

designed to address the discrepancies of CBWM data in the decision-making processes of South African water resources. It aimed to address the disregard of volunteers (Graham *et al*., 2016:10), to create community capacity building through monitoring, and to source funds to execute monitoring, purchase monitoring equipment and personal protective equipment, and budget for incentives and compensation of participants.

The community participation framework plays a vital role in enhancing the use of community data in decision-making. This corresponds with Quin's (2012:1–14) observation of conceptual models in both developing (Uganda) and developed (Sweden) countries playing a role in the implementation of rural water supply and information flow directives.

Since the inception of the NWA in South Africa, several frameworks to guide the management of water resources have been developed, but they do not link the participation of CBWM in water resource protection. In response, this study developed a CBWM framework reflecting governance, financial, and training categories as outcomes. These categories are supported by the statement that when making decisions about water resources, participants need to consider critical aspects such as social, environmental, and economic values (AWARD, 2018:1). The implementation of CBWM affects financial, technical, social, and governance institutions (Kativhu *et al*., 2021:20–21). Lack of human capacity, financial constraints, and poor coordination among stakeholders are reasons for the non-development of CBM (Makurira & Mugumo, 2005:172). While each of these frameworks attempts to build on one another, they follow a similar logic, where conceptual frameworks are classified into three categories elaborated on in Section 5.3.5.3.

5.3.5.3 Development of the CBWM Conceptual Framework

The data collected in this study to address sub-research question 5 contributed to the development of the CBWM Conceptual Framework. In the absence of a defined CBWM conceptual framework that facilitates the incorporation of data collected by community members into the decision-making process, the insights gained from interviews and survey questionnaires conducted across the three case studies serve as the basis for developing three distinct categories within the CBWM Conceptual Framework: governance, financial, and training. These categories are represented in Figures 5.19–5.21.

(a) Governance category

It is evident from the findings of the three case studies that three levels of governance should be considered in the proposed CBWM governance category (Figure 5.19): the national, provincial, and local levels. The international watershed committees oversee transboundary issues of concern. The local level has a two-pronged approach: the urban and rural setup, with

urban areas coordinated by the municipalities through by-laws, and rural communities by tribal authorities or leaders in the form of Chief's rules.

At the provincial level, public participation at a catchment level takes place through the CMA and catchment management forums (CMFs). This is the level at which identification and consideration of community needs by government institutions supporting CBWM volunteers occurs. The purpose of this level is to support community members in enforcing and implementing water legislation, as well as monitoring and evaluating CBWM.

Figure 5.19: CBWM governance category

At the national level, as a member state within a transboundary watershed, this entity serves as a liaison for the SDGs and international watershed committees. In this study, ORASECOM and LIMCOM members participated in the interviews and responded to the survey questionnaire for the Koffiekraal and Selons case studies. The main proposal emphasises the national DWS as a key player in coordinating various institutions involved in water resource protection. It highlights the importance of developing a data management strategy to address CBWM data and to establish a security framework to safeguard water infrastructure from vandalism.

Governance refers to the framework that directs institutions and systems to achieve their objectives. It is also a mechanism through which key stakeholders influence decision-making while building trust by ensuring the accountable and sustainable use of resources. In the governance category, the first level of alignment is policy development (Cardno, 2018:625), followed by community members serving as primary implementers responsible for reporting. Community members report what they see on the ground, with the collaboration of the provincial and CMA levels as the primary coordinators and DWS as a primary custodian of CBWM programmes. The emphasis was on the buy-in from political leadership (Nemutamvuni, 2018:107), traditional authorities and municipal by-laws, identification of community needs, and collaboration of community members with other water sector entities (local municipalities and the ecological, mining, construction, and agricultural sectors), including unpaid volunteers, as supported by Graham *et al*. (2016:10–11) in their AaR programme. With DWS as a leading player coordinating CBWM at a national level, the development of a CBWM data management strategy incorporating a national database with open access to other entities, and the development of a CBWM security framework to safeguard water resource infrastructure against vandalism were highlighted as critical. In terms of the governance category in the South African context, a legal framework must be implemented to support and govern the established structures, such as local municipality by-laws and the CMS to govern the CMA (Kativhu *et al*., 2021:20–21). Ramulifho *et al*. (2019:7–9) concluded that the establishment and implementation of the CMA and CMS in the Luvuvhu River catchment will reduce river water abstraction, restore biodiversity, and improve the provision of goods and services to poverty-stricken communities in the catchment (DWS 2022a:32–38).

(b) Financial category

Different issues require different approaches, and so does CBWM funding. The implementation of the CBWM financial category (Figure 5.20) should outline the benchmark for "*What*" resources are needed, the frequency for "*When*" assessments should occur, the budget provision for "*How*" funds will be allocated, and the rationale behind the intervention, monitoring, and evaluation – "*Why*".

The CBWM financial category emphasises the importance of addressing the "*What*" through assessing available resources, such as human capacity, training needs, and monitoring equipment, before seeking funding.

Monitoring frequency is said to influence the budget required for such efforts, which relates to the timeframe for "*When"* monitoring activities will take place.

The budget provision for CBWM compensation of employees and equipment addresses "*How*" funding should be obtained. Specific fundraising projects should be identified to support the implementation of CBWM programmes, including purchasing monitoring equipment and

personal protective equipment, recruitment of paid participants, and providing incentives for unpaid volunteers.

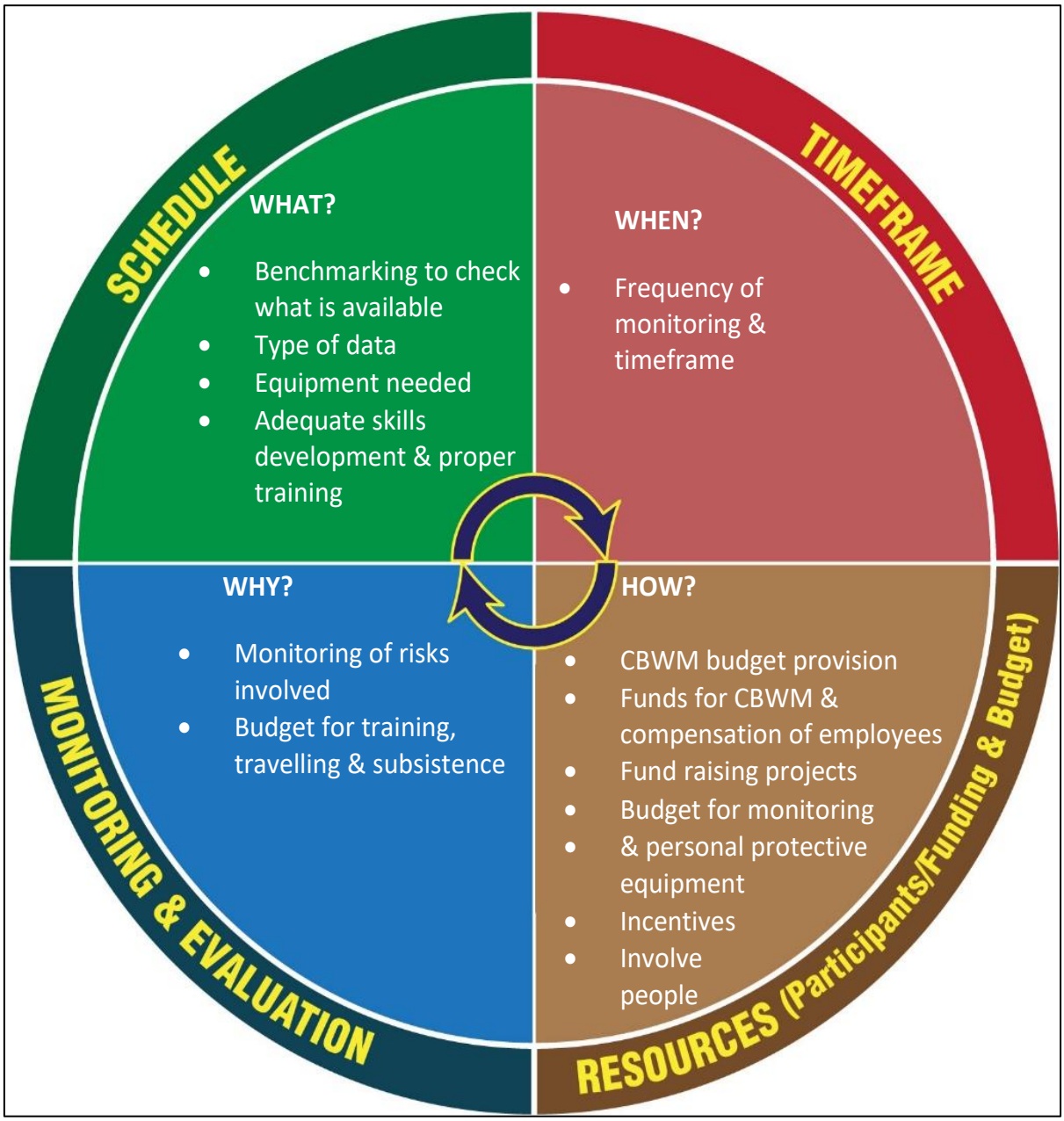


Figure 5.20: CBWM financial category

Monitoring and evaluating the implementation of the CBWM process responds to the "*Why*" question related to meeting the reason for starting a programme or maintaining monitoring continuity. It should involve CBWM risk management and the provision of mitigation measures to ensure the budget secured for monitoring, training, and travelling is spent as intended.

The financial category underlines that policy should have value-based intent, as it determines the availability of resources and a need for the initiative to apply at global, national, and local levels (Cardno, 2018:624). CBWM programmes can be a means of water resources knowledge generation, enhancing the understanding of water dynamics and informing users'

decisions, which is invaluable (Flores-Díaz *et al*., 2018:1). Community members should decide on how to resource and fund CBWM initiatives, what tools to apply when, which measures to mitigate (why), and who to influence concerning decision-making.

(c) Training category

The proposed CBWM training category (Figure 5.21) is divided into four categories: basic, technical, scientific, and transboundary skills.

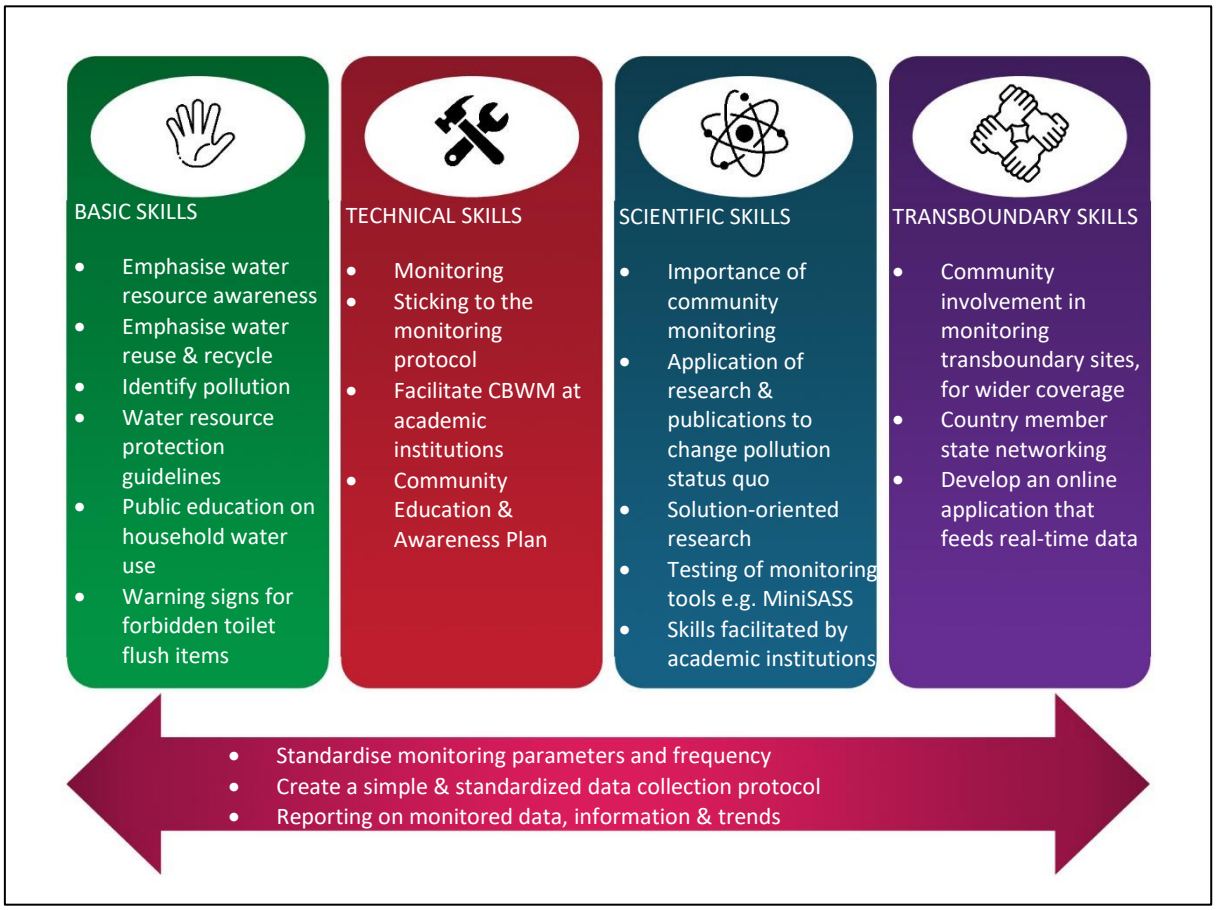


Figure 5.21: CBWM training category

The key factors for basic skills in CBWM encompass promoting awareness and respect for water resources, encouraging water reuse and recycling, identifying sources of pollution, and providing basic guidelines for water resource protection. In addition, the public should be educated about household water use.

Key technical skills in CBWM include effective monitoring practices, adhering to the correct monitoring protocols, facilitating CBWM initiatives at higher educational institutions, and developing a comprehensive community education and awareness plan.

Essential scientific skills in CBWM emphasise the importance of community monitoring, the application of research and publications to address pollution issues, solution-oriented research, testing monitoring tools like MiniSASS, and skills development facilitated by higher

education institutions. In the same way community initiatives in KwaZulu-Natal (KZN) province trained community members to use MiniSASS tools to monitor the uMngeni and Umsunduzi rivers. This approach was considered a success for water quality monitoring and interventions in the area (Sithole, 2023:9).

Transboundary skills focus on community involvement in monitoring transboundary water sites for broader coverage, enhancing member-state networking, and developing an online application for real-time data sharing.

Cross-cutting factors involve reaching consensus on monitoring parameters and frequency, creating a standardised monitoring protocol, and comprehensively reporting data, information, and trends. Incentives for communities are critical. These incentives need not necessarily be financial but can include rendering continuous services to people. Policy development should be integrated, including tariffs and budgets for community initiatives, training, and operations.

Policy needs to be reviewed periodically to align with the current business case of the organisation (Cardno, 2018:637), considering the availability of relevant skilled personnel. The lack of skilled community participation that was highlighted by the study's participants could have been the reason their conceptual framework criteria led to the development of the third category – training. Learning is a process that takes time and involves interaction and relationships with people. Therefore, a conducive environment is encouraged for effective results. Community training is no different (du Toit, 2015:10). A CBWM participant does not necessarily need to have a formal science education. An understanding of the importance and value of water, monitoring, and data management should be the baseline (Goldin *et al*., 2019:26–30). In Mexico, members of community programmes with basic literacy skills (basic reading, writing, and arithmetic) were trained to monitor chemical and bacterial water quality aspects in their river systems, with success (Flores-Díaz *et al*., 2018:3). Willingness to learn, engage, and share data and information with other stakeholders in water resource issues should qualify a participant to be a CBWM member (Goldin *et al*., 2019:30). Many researchers assume that informal training leads to success; however, recent evidence by Ködmön and Szőke (2025:8976) challenges this assumption, suggesting that formal training of professionals in IWRM strategies will effectively solve water scarcity, pollution, and water-borne diseases impacts and vulnerabilities caused by poor governance in developing countries. The Mpophomeni Enviro Champs community initiatives in KZN province paid off when they successfully established a community of practice within the area to address sewage manhole leaking and illegal solid waste dumping to save the river (Sithole, 2023:98–106).

The need for a CBWM framework, confirmed in this study, was addressed through the development of a CBWM conceptual framework, presented as a study outcome in Figure 5.22.

It is a framework that integrates governance, financial, and training categories presented in Figures 5.19–5.21.

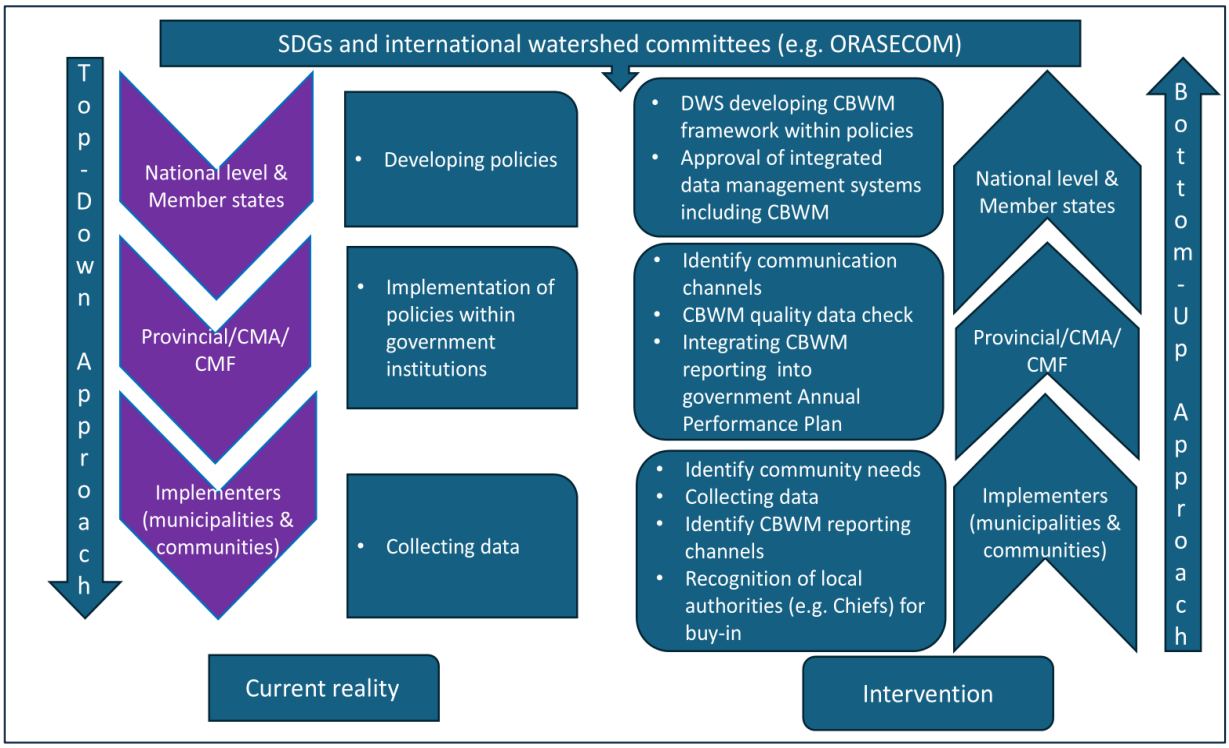


Figure 5.22: CBWM Conceptual Framework

The CBWM Conceptual Framework was derived from the interview and survey results, reflecting participants' views on how the framework should function and what it should include. Community members are expected to identify their needs, together with relevant role players in the catchment, with the emphasis on liaising with local authorities for buy-in of the community initiatives. It was revealed that there are more policymakers than operational task teams, a reversed organisational pyramid that presents implementation challenges. A common working pyramid has few policymakers at the top and an operational task team forming the larger base. Policy implementation occurs at the provincial level, as outlined in the Conceptual Framework in Figure 5.22, which emphasises the importance of considering the community's needs. In terms of governance structuring, DWS's leading role in the management of CBWM data, with the collaboration of other water entities, was strongly supported by participants in the development of the CBWM database and data management strategy.

5.4 CONCLUSION

The results show that building a sense of community ownership and enforcing a standardised monitoring protocol in water resource protection could lead to CBWM sustainability. Addressing the budget and community members' training and the development of CBWM frameworks inclusive of governance serves as relevant support for community data production.

The evidence suggests that community members need to be trained in water resource monitoring to ensure that they produce quality data that contributes to water resource protection.

The analysis indicates that the benefit of data availability from CBWM initiatives could be invaluable, serving as an early warning system that triggers the need for immediate response.

Although the government has a key role in water-related issues, as mandated by the NWA (1998), the findings confirm that its entities alone cannot do everything, hence the lack of implementation. There is a need to create potential for partnership and collaboration with all water users in relevant water sectors, including vulnerable individuals such as women and youth.

The data confirm a need for the development of the CBWM Conceptual Framework, as the existing water resource protection and management policies did not support the CBWM data informing decision-making processes. In conclusion, this study developed the CBWM Conceptual Framework presented in Figure 5.22, which supports a bottom-up approach and informs policy, and will require an action plan for implementation.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This study explored the potential value of CBWM in water resource protection decision-making in a developing country context such as South Africa. Chapter 6 briefly presents conclusions regarding the rationale for CBWM programmes in South Africa, followed by final conclusions and the recommendations of the study, based on the findings from the literature review (Chapters 2 and 3), and the results and discussions in Chapter 5. Chapter 6 consists of the following sections: 6.1.1 Conclusions on the rationale for CBWM programmes in South Africa; 6.2 Key findings of the study (with 6.2.1–6.2.5 summarising findings to sub-research questions 1–5); 6.3 Recommendations for implementation of the CBWM Conceptual Framework (6.3.1 Governance category, 6.3.2 Financial category, 6.3.3 Training category, and 6.3.4 CBWM Conceptual Framework); 6.4 Recommendations for future research; 6.5 Lessons learned; and 6.6 Final conclusion and wisdom gained in exploring the potential value of CBWM in water resource protection decision-making in South Africa.

6.1.1 Conclusions regarding the rationale for CBWM programmes in South Africa

CBWM programmes in South Africa were initiated to address increasing pressures and the unsustainable use of water resources. The global momentum of the SDGs has put pressure on reporting against the country's targets due by 2030, creating a knock-on effect on the country's performance relative to its water legislation, the NWA. The NWA provides a framework for government and its institutions, such as CMAs, to manage and protect water resources, but it does not explicitly consider the involvement of CBWM initiatives. Without technical, financial, and political (governance) support for CBWM programmes, even the best legislation will prove difficult to implement, as research findings in South Africa's context have demonstrated. Moreover, population growth and increased commercial activities will intensify water demand pressures, creating potential for further water challenges and highlighting the need for greater stakeholder collaboration in integrating water resource monitoring data into decision-making for water resource protection. Hence the need for this study, which is elaborated on in the key findings below.

6.2 KEY FINDINGS AND CONCLUSIONS ON RESEARCH QUESTIONS

Among the motivations to undertake CBWM were the community's concerns about good-quality water provision, the government's mandate for water resource protection, and a need for robust water governance through the collection of scientific and local data – factors that drove the rapid initiation of this study. The research question and sub-research questions were formulated to address areas recommended by Conrad and Hilchey (2011:273) and Johnson *et al*. (2021:452–566), who advocated further investigation into the social, economic, and

ecological benefits of community science and the translation of CBWM data into valuable outcomes. This section summarises the findings related to the main research question of the study introduced in Section 1.4, as follows:

What is the potential value of CBWM in water resource protection decision-making in a developing country context such as South Africa?

Five sub-research questions were designed to guide the response to the main research question:

1. What are the benefits, values, pitfalls, and challenges of CBWM programmes?
2. What criteria should be considered in CBWM in developing countries?
3. Based on the opinions of governance structures and the real-life experiences of communities, to what extent do selected catchments in South Africa, as a developing country, benefit from CBWM?
4. What are the views of governance structures on the extent to which CBWM operates in South African communities?
5. How might a conceptual framework work by enhancing the use of CBWM data in decision-making for developing countries?

Conclusions on the five sub-research questions are provided in Sections 6.2.1–6.2.5.

6.2.1 Sub-research question 1: What are the benefits, values, pitfalls, and challenges of CBWM programmes?

The literature review in Chapter 3, Sections 3.5.2 and 3.5.4, summarises the benefits and challenges of CBWM programmes. The benefits included increased access to information at little or no cost, lower resource demands, training of local people, encouragement of local leadership and identification of champions, promotion of broad public participation, and enhancement of ground-truthing of citizens' scientific knowledge. The key challenges included the lack of funding, inadequate policy framework, fragmented data and information, inadequate skills, lack of participation and commitment, lack of ownership, insufficient integration between social and ecological factors, participants' diversity, lack of trust, and misalignment between monitoring parameters and the project objectives.

The mixed-methods study findings of the benefits, values, pitfalls, and challenges of CBWM programmes in Chapter 5, therefore, concluded and confirmed that CBWM data collection effectively supplements and augments governmental water resource monitoring at minimal cost. Communities gain invaluable data and information about their local water resources and monitoring training. Partnerships between CBWM programmes and government entities create

data pathways, facilitate the sharing of resources and expertise, and in return, improve water stewardship. Effective training of community members also equips them to assume ownership of CBWM initiatives and to serve as an early warning system for water-quality incidents.

Strong collaboration between CBWM programmes and other water sectors – ecological, industrial, mining, and agricultural – and stakeholders such as non-governmental organisations (NGOs) and community networks is essential for developing a sustainable CBWM. However, compensation and operation funding support must be secured, as lack of funding remains the top challenge in CBWM.

However, the DWS, as custodian of South Africa's water resources, retains the statutory mandate for monitoring and protection of water resources. To an extent, community members will always rely on the government for certain regulatory functions, such as resolving water conflicts and regulating pollution emanating from communities, which cannot be delegated to community members. While that was identified as a challenge, it reflects the current reality. CBWM programmes must be managed for the right reasons, rather than for publicity or political gain.

6.2.2 Sub-research question 2: What criteria should be considered in CBWM in developing countries?

Chapter 4 (Methodology), Section 4.5.2.6, Table 4.1 defines the criteria for CBWM as Themes 2 and 5, addressed through the literature review. The study's findings of the criteria to be considered in CBWM presented in Chapter 5, Section 5.3.2, are summarised below.

This sub-research question was designed to fill a gap in harmonising water-monitoring programmes and encouraging information sharing among different institutions. The study's findings – reflecting an increasing use of standardised monitoring protocols by CBWM, without undermining community needs and priorities – are positive and support the reliability and trustworthiness of data (Carlson & Cohen, 2018:173). In addition to the importance of regular data and information sharing in establishing stakeholder's trust, Sally *et al.* (2011:380) highlights the importance of conflicts minimisation. To this effect, the perceptions of the study's participants and respondents regarding the criteria to be considered in CBWM in developing countries indicated that standardised monitoring protocols are likely to link data to decision-making. This may be because local management of the water resources sits within the catchments, under the jurisdiction of each CMA, with specific needs and water concerns – hence the need for proper implementation of standardisation to ensure quality assurance.

In addition, this sub-research question also offers insight into expanding standardised monitoring protocols to include the type of monitoring programmes and parameters, data

management, funding provision, and quality data that displays value for money as a significant part of the criteria.

The finding regarding water quality monitoring parameters indicates that *Escherichia coli (E. coli)* and chlorine should be prioritised as chemical parameters to meet community drinking water standards and criteria, for users drawing directly from the resource, as they directly affect community health.

6.2.3 Sub-research question 3: Based on the opinions of governance and the real-life experiences of communities, to what extent does selected catchments in South Africa as a developing country benefit from CBWM?

The study's findings, presented in Chapter 5, Section 5.3.3, support the notion of the effectiveness of CBWM programmes, identified as Theme 1 in Table 4.1 of Section 4.5.2.6. The findings offer insight and demonstrate that partnerships with both CBWM networks and the government strengthen the capacity of community initiatives, thereby closing the gap identified by Akhmouch and Clavreul (2016:8–13), who highlighted the need for verification of the effectiveness of stakeholder engagement.

Conversely, a small percentage of respondents reported involvement by local chiefs – a traditional authority in rural areas – which may be associated with the failure of CBWM initiatives in those contexts. This echoes the African Tshivenda proverb, which says, "khosi ndi khosi nga vhalanda", meaning "a chief is a chief because of the people under his or her chieftaincy". In conclusion, the extent to which selected catchments in South Africa, as a developing country, benefit from CBWM appears to be significant, as most of the participants in all the case studies agreed that catchments do benefit from CBWM. Regarding the extent of the benefits, the findings suggested that CBWM can enhance the importance, usage, and economic value of data, identify the state of water availability and pollution (serving as an early warning system), foster environmental awareness, health, and well-being, and improve community engagement, ownership, and training.

6.2.4 Sub-research question 4: What are the views of governance structures on the extent to which CBWM operates in the South African context communities?

The findings presented in Chapter 5, Section 5.3.4, which were identified as pre-existing Theme 6 in Table 4.1 of Section 4.5.2.6, are evidence of perceptions of governance structures regarding the extent of CBWM operations. In conclusion, the findings emphasised the need for a defined CBWM governance structure to oversee critical water shortages, and to prevent a Day-Zero, no-water scenario; this indicates that a lack of governance structure supporting CBWM initiatives could still constrain implementation. The ongoing issue of limited funding that

affects CBWM operations, as shown across the emerging themes, Theme O2, impacts policy development, training, and capacity building, and directly affects CBWM operations.

6.2.5 Sub-research question 5: How might a conceptual framework work by enhancing the use of CBWM data in decision-making for developing countries?

Sub-research question 5 solicited participants' insights, as presented in Chapter 5, Section 5.3.5. Perceptions of technical water resources managers, policymakers, and community members regarding the inclusion of CBWM data in decision-making processes suggested that a significant amount of data generated by CBWM initiatives may not have been considered in water resource protection decision-making. Such data gaps can undermine the value of CBWM participation in general, and particularly in water resource protection. These findings led to the development of the CBWM Conceptual Framework in this study, integrating governance, finance, and training.

To fill the identified gaps – namely the lack of policy and strategic support for local-level stakeholder participation in decision-making, reflected as Theme 3 in Table 4.1 of Section 4.5.2.6, this study developed a CBWM conceptual framework. It concludes that in South Africa, existing fragmented institutional frameworks are not adequately suited to catchment-level water resource management issues. The developed CBWM Conceptual Framework adopts a bottom-up approach that prioritises the needs of community members and ensures their representation in decision-making.

6.3 RECOMMENDATIONS FOR THE IMPLEMENTATION OF THE CBWM CONCEPTUAL FRAMEWORK

Recommendations concerning CBWM operations include the need for governance structures, practical implementation, standardised monitoring protocols, and alignment with CBWM principles. Three conceptual framework categories were developed – governance, financial, and training – and their specific recommendations are elaborated below.

6.3.1 Governance category

Notably, SDG 6B and South Africa's national authority support community participation in water resource management (Limpopo Provincial Gazette, 2016:50), but policy governing collaborative partnerships between government and CBWM networks is lacking. Governance encompasses social, cultural, and economic services linked to water resources that support local communities and livelihoods. The absence of a CBWM governance structure was identified in the literature review as a key gap this study must address. The governance category (Figure 5.19) should follow a bottom-up approach, prioritising community needs first, and include representatives from the following levels:

- Local level
  - Community members/traditional authorities (rural areas)
  - Municipalities (urban areas)
- Provincial level
  - Provincial government
  - CMAs
- National level
  - DWS
- International watershed committees (member states, e.g. South Africa)
  - ORASECOM

To ensure effective implementation, relevant representatives from each level should be recruited to participate.

6.3.2 Financial category

The government, through the DWS, has a leading role in CBWM initiatives and should allocate budget to the programme's regulation, monitoring, and evaluation. The financial category (Figure 5.20) findings highlight that the government cannot fund everything alone; thus, collaboration and partnerships with private and other water sector stakeholders (industry, mining, and agriculture) are essential contributors to CBWM funding. Budgets (how much) should be secured for monitoring equipment and operations, aligned with the type of monitoring programme (what), its purpose (why), and the monitoring frequency (when).

6.3.3 Training category

The training category (Figure 5.21) findings indicate a lack of relevant capacity and the need for standard guidance on CBWM across communication channels and reporting levels. These results align with Moolman *et al*. (2023:114), who emphasised that community members need to be trained to adapt to the implementation of dynamic policy systems. While the scientific and technical content of water resources is important, CBWM is not content-based and cannot be delivered as a once-off training. CBWM is not a one-off, content-based exercise; it requires continuous learning guided by policy to ensure standardisation and consistency. Training must respond to community needs, be robust and open to professional support, and promote sustainability. This approach should accommodate long-term training and capacity building to develop the necessary skills, competencies, and attitudes. Cooperative governance, supporting a bottom-up approach, must ensure representation of South Africa's demographic diversity (race, gender, age, education levels) in water resource protection decision-making, in line with the democratic "Batho Pele" ("People First") principle.

6.3.4 CBWM Conceptual Framework

The CBWM Conceptual Framework (Figure 5.22) maps the current reality of CBWM in South Africa alongside the proposed interventions from this study. It identifies existing gaps, required resources, and implementation barriers for CBWM initiatives. The framework contrasts the current state with desired outcomes and recommends the development of an action plan to give effect to its components.

6.4 RECOMMENDATIONS FOR FUTURE RESEARCH

The interview and survey questionnaire designed and used in this study did not cater for the potential of CBWM programmes to generate employment in rural areas. Future efforts could explore CBWM as a tool for employment creation in rural areas, building on this study's findings. Unemployment in South Africa is very high, and rural communities are no exception (Gray *et al*., 2001:9). This supports the study's findings that job creation encourages water resource protection, as high unemployment is linked to disruptions in CBWM initiatives.

The study also identified a gap in linking community demographic status with CBWM sustainability, suggesting further research is needed in this area. Investigating how best to connect scientific and community knowledge with artificial intelligence presents a promising avenue. Finally, there is potential to examine cleaner technology options to improve CBWM sustainability.

6.5 STUDY LIMITATIONS AND LESSONS LEARNED

The research limitations were discussed in Section 4.6.1, which included the use of three case studies instead of four, as changes prevented the pilot case study from being part of the study's' case studies; amendments to the data collection methods due to the COVID-19 pandemic – substituting in-person interviews with virtual ones and cancelling the focus groups, participants' different levels of expertise affecting the accuracy of the responses, purposive selection of participants resulting in a small sample size, differences in terminology use potentially leading to the exclusion of relevant literature, and the lack of standardised data analysis for document analysis method of data collection.

The lessons learned from the practical application of interviews and survey questionnaires across three case studies – conducted to ascertain the value of CBWM in water resource protection decision-making in the South African context – are summarised below:

- The pilot study in this research identified challenges and tested the feasibility of the data collection methods, which required adjustments and resulted in the revision of the sampling methods. The fact that the pilot study required extra effort, time, and funding, only to learn that its findings could not form part of the study's results and discussion chapter, Chapter 5, was a setback. However, that did not take away the lessons learned

in detecting and minimising the errors in advance, reducing study risks and building research confidence.

- The COVID-19 outbreak was a wake-up call, emphasising the importance of being flexible during unforeseen circumstances – a lesson to always have a plan and be prepared to remain resilient.
- Regardless of the sample size, purposive selection of participants applied in this study yielded meaningful, in-depth insights, as participants with relevant experience to the research questions were intentionally selected.
- Although diversity in the use of terminology can be a limitation in research, variations in terminology facilitated the redefining of existing terms into the development of new ideas, expanding the relevance of the research.
- The lack of standardised data analysis for document analysis limited the opportunity to compare findings with other research, which might lead to inconsistencies and open the door to criticism of the study's findings. However, this experience afforded the study an opportunity to tailor its own analysis methods suitable for answering and supporting the research questions.
- The practice of patience in questionnaire administration was emphasised, including the need to frequently remind respondents to complete and submit their questionnaires.
- Network interruptions prevented some participants from joining virtual interviews; for example, telephone interviews replaced MS Teams interviews for several participants in the Luvuvhu case study.
- Expert and professional participants often preferred to undertake CBWM activities without a stipend, unlike participants in rural areas, where unemployment rates are highest.

6.6 FINAL REMARKS

This study provided critical insights into the potential value of CBWM in water resource protection decision-making. A literature review, interviews, and surveys demonstrated that CBWM data collection, analysis, and management enhance monitoring frequency and reduce response timelines. These improvements bridge knowledge gaps and create information-flow pathways into decision-making that support sustainable water resource management and protection.

The wisdom gained affirms that integrating CBWM into scientific monitoring enhances community confidence, informs policy formulation, and promotes community ownership. This work contributes to academic discourse by offering a conceptual framework that clarifies the

value and limitations of CBWM in water resource protection decision-making in the Limpopo-Olifants WMA, within the context of a developing country such as South Africa.

Investing time and effort into understanding and developing a CBWM conceptual framework leads to improved sustainability, enhanced resource management, and a more resilient, water-wise future. It fills a vital gap in the literature and lays the groundwork for future research and implementations to advance community-based water monitoring.

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APPENDICES

APPENDIX A1: DOCUMENT ANALYSIS SEARCH

(Adapted from Kayesa and Shung-King, 2021)

Author(s) and Year of Publication	Country of study	Aim of study	Data collection methods	Focus of study	Findings reflecting availability of existing CBWM conceptual framework (Yes/No)	Referenced (Yes/No)
1. Provincial Gazette (PG). 2016. Thulamela Municipality Spatial Planning and Land-use Management (SPLUMA) By-Laws	South Africa	This By-law binds every user of land and applies to all land within the jurisdiction of the Municipality, including land owned by the state, including all essential elements like provisions applicable to all properties relating to storm water.	Policy formulation	Provision of servitudes for the installation of water supply pipes, waterborne sewage and the management of stormwater channels and pipes.	No. Touched base on Community Participation Information to be established in rural areas.	Yes
2. Rivett *et al.,* 2014 (WRC Projects – TT 583/13)	South Africa	To investigate the possibility of incentivising community engagement to improve drinking water supplies in South Africa.	Literature review	roles and responsibilities of local and district municipalities	No. Assessment of the success of incentivizing communities. It is envisaged that the roles incentives play in engaging with the public and what incentives are relevant in the service delivery sector.	Yes

Author(s) and Year of Publication	Country of study	Aim of study	Data collection methods	Focus of study	Findings reflecting availability of existing CBWM conceptual framework (Yes/No)	Referenced (Yes/No)
3. WRC. 2000. The Kruger National Park (KNP) Rivers Research Programme WRC Report No. TT 130/00 ISBN 1 86845 622 6	South Africa	Understanding of water quality and quantity of water in the KNP Rivers	Surveys and document reviews.	Monitoring the water quality conditions of the river system Policy Implementation	No. Approaches to water quality management in South Africa focused on achieving discharge standards and on monitoring river health. little has been done to develop predictive capabilities for integrated water quality management in river systems (including estuaries).	No
4. Green Drop Progress Assessment Report, 2023	South Africa	Incentive-based regulation programme that provides incentive or penalty certificates to good performing or flawed WWTW	Cumulative Risk Rating	Water Quality Policy Implementation	No. The Document is an innovative and uniquely South Africa response to challenges in the water sector, giving Status of WWTW.	Yes
5. Graham *et al.,* 2016. A revised AaR programme:	South Africa	Review and redesign of the 2008 AaR programme Stakeholder input on the institutional and financial frameworks with a focus on an implementation strategy. WRC Project No. K8/1109	Stakeholder workshops and Focus Groups	Re-vision of the institutional/governance framework, developing a funding framework and potential business case towards developing a revised and sustainable AaR Programme.	Yes. Revised institutional framework and business model for the AaR Programme, in addition, recommendations for the implementation of the AaR Programme.	Yes

Author(s) and Year of Publication	Country of study	Aim of study	Data collection methods	Focus of study	Findings reflecting availability of existing CBWM conceptual framework (Yes/No)	Referenced (Yes/No)
6. Burger M. 2021. Partners for People and Platform (Tripple-P), AaR programme	South Africa	Sustainability of Citizen-science monitoring programme	Case studies: Amanze Ethu Nobuntu	Sustainability in the business context of the citizen science monitoring programme	No. Answering the call to test sustainability and training community members to be environmental champions (Enviro-Champs)	No
7. Van Koppen *et al.,* 2020. IWMI	South Africa	Working Paper: Guidelines for Community-led Multiple Use Water Services: Evidence from Rural South Africa.	Focus Group meetings and Construction of water infrastructure by Forum members (getting stipend)	*Operationalising community-led Multiple use water Services (MUS) in South Africa*	No. The project envisaged local communities as the drivers of decision-making on institutional and small-scale technological improvements in self-supply or public water infrastructure	Yes
8. The Association for Water and Rural Development (AWARD). 2018. RESILIM O project	South Africa	Decision-making for land and natural resource-use	Crossroads: A game of decisions and consequences	The game provides a tool for learning about trade-offs and benefits from nature (financial and non-monetary benefits and market and non-market values of nature and ecosystem services).	No. Empowering participants to assess different options and make informed decisions	Yes

Author(s) and Year of Publication	Country of study	Aim of study	Data collection methods	Focus of study	Findings reflecting availability of existing CBWM conceptual framework (Yes/No)	Referenced (Yes/No)
9. Du Toit, D. 2015 Stakeholder Engagement. Process Design for Social learning and Transformation in RESILIM-O. AWARD	South Africa	Stakeholder Engagement	Focus groups and meeting sessions	Stakeholder Engagement approach requires policy documents, governance structure in place, and access to information and committed participants	No. The use of common language in the Olifants River System improved dialogue among catchment/ community participants, collaboration and skills.	Yes
10. Goldin, J *et al.,* 2019. Report on 3rd multi-sector, Citizen-Science workshop in the Hout River catchment part of the Sand River Basin in Limpopo, South Africa.	The ESGUSA project is a Danish-funded research project led by the University of Copenhagen in Denmark, the University of the Western Cape in South Africa, DWS and IWMI-South Africa (International Water Management Institute) – South Africa.	The aim is to involve volunteers in the collection of reliable and valid data.	Focus Group	To address the knowledge gaps of aquifer systems, and interactions with rivers, wetlands, terrestrial systems and the management of potential adverse impacts of climate change and increasing population, with the involvement of the local community through Citizen Science; supporting SDGs: "Clean Water and Sanitation".	No. Enhancing Sustainable Groundwater Use in SA. Establishment of Citizen-Science, Polokwane, South Africa (ESGUSA).	Yes

Author(s) and Year of Publication	Country of study	Aim of study	Data collection methods	Focus of study	Findings reflecting availability of existing CBWM conceptual framework (Yes/No)	Referenced (Yes/No)
11. Goldin, J *et al.* 2023.	South Africa	Citizens were trained on the use of cost effective and appropriate technology to obtain data on groundwater and rainfall	Groundwater monitoring – Standardised monitoring protocol	How do volunteers feel about the work they are doing in a Catchment – any sense of pride or belonging?	No. It was ascertained that data collected by the volunteers is no less reliable than data collected by scientists.	Yes
12. Templehoff *et al.,* 2012. Groot Marico documents online	South Africa	The River as an Artefact: Interpreting the Groot Marico River Catchment and its People in the 21st Century	Focus groups and community meetings	Assessment of the prospectus and mining proposal in the Groot Marico River Catchment by the community members	No. The community cultivated the sense of dignity, irrespective of their racial and cultural differences, they stood united against mining proposals and protected the river and its aquatic environment.	Yes
13. Graham *et al.,* 2016. A revised AaR programme: Stakeholder input on the institutional and financial frameworks	South Africa	AaR programme Implementation Strategy. (WRC) Project No. K8/1109	Focus group meeting, Literature and Document reviews.	Revising of the AaR document	No. Revised AaR document	Yes

Author(s) and Year of Publication	Country of study	Aim of study	Data collection methods	Focus of study	Findings reflecting availability of existing CBWM conceptual framework (Yes/No)	Referenced (Yes/No)
14. DWS, 2017b. Water Quality Policy Document	Water Quality Management Policies and Strategies for South Africa	The aim was to provide the DWS with possible organisational options and recommendations that will strengthen the WQM function	Water Resource Management methodologies	Water Quality Management Policies and Strategies to improve the effectiveness and efficiency of the WQM function	No. Establish formal structures that will be aimed at improving decision making, performance, and information sharing. Consolidate WQM capacity to an integrated approach to the implementation of water quality policies and strategies	Yes
15. Swift J. 2019. Prof. (Prof. Goldwin Smith) studies forgotten communities through literature	United States of America (USA), Cornell University	A study of forgotten communities	Literature review Creative Writing	Communities losing identity	No. The mix of ethnicities and marginalised communities that were forgotten due to loss of use of their own language.	Yes

Author(s) and Year of Publication	Country of study	Aim of study	Data collection methods	Focus of study	Findings reflecting availability of existing CBWM conceptual framework (Yes/No)	Referenced (Yes/No)
16. Flores-Díaz et al. 2018	Mexico	Community-Based Monitoring in Response to Local Concerns: Creating Usable Knowledge for Water Management in Rural Land. *Water*. 2018; 10(5):542. https://doi.org/10.3390/w10050542	Water Quality Monitoring, Water Quality Index (WQI)	This study (1) analyses water knowledge generated by a community-based water monitoring (CBWM) network within a world heritage site; (2) discusses the extent to which monitoring responds to community concerns about water; and (3) indicate challenges in the generation of local usable knowledge.	No. Demonstrates of how CBWM schemes can be a means of generating knowledge of water resources, enhancing the understanding of water dynamics and inform users' decisions.	Yes
17. Botswana National Water Policy (Bot-NWP). 2012. Ministry of Minerals, Energy and Water Resources. Government Paper No…of 2011.	Republic of Botswana.	To upgrade and extend water and wastewater services throughout the country.	Policy Development	To develop a Policy for water and wastewater services, with Community Based Natural Resources Management Policy (2007) as sub-principle.	No. Recognising the importance of the environment to securing this sustainable growth	Yes
18. McDowell *et al.,* 2018. Catchment Management Strategies	New Zealand	A strategy for optimising catchment management actions to stressor–response relationships in freshwaters. Ecosphere 9(10): e02482. 10.1002/ecs2.2482	Identification of Stressor-Response curve	Development of the management actions	No. Development of the management strategy aligned to the objectives to eradicate impacts. No mention of the community members' involvement.	Yes

Author(s) and Year of Publication	Country of study	Aim of study	Data collection methods	Focus of study	Findings reflecting availability of existing CBWM conceptual framework (Yes/No)	Referenced (Yes/No)
19. Limpopo - Olifants CMA Business Case. 2022	South Africa	Business Case for the Establishment of the Limpopo–Olifants Catchment Management Agency	Document analysis	South Africa water legislation mandated the development of CMA for the management of water resources at catchment level.	No. Limpopo–Olifants is one of the six established CMAs in South Africa	Yes
20. United Nations (UN). 2020.	UN Publication. New York	Community Engagements Guidelines on peace building and sustainable peace.	Policy formulation - Working Groups Engagement with local civil society actors	UN Guidelines on Peacebuilding and sustaining peace.	No. Involvement of community members in environmental issues, encouraging them to participate and get capacitated, with the aim of linking the data they produce into decision-making.	Yes
21. UN. 2023.	UN Publication. New York	*The Sustainable Development Goals (SDG) Report*. 2023 Special Edition	Policy formulation	A call for global community to reemphasise the implementation of SDGs action plans.	No. The world's recent catastrophes related to climate change and COVID-19 pandemic hampered progress towards implementation of the SDG objectives.	Yes
Review Documents from the study's Reference List						
1. Kayesa, NK and Shung-King, N. 2021. Division, University of Cape Town,	South Africa	The role of document analysis in health policy analysis studies in low and middle-income countries.	Qualitative systematic review. *Health Policy Open 2*.	School of Public Health and Family Medicine, Health Policy and Systems	No. Challenges in accessing documents contributed to methodological difficulties.	Yes

Author(s) and Year of Publication	Country of study	Aim of study	Data collection methods	Focus of study	Findings reflecting availability of existing CBWM conceptual framework (Yes/No)	Referenced (Yes/No)
2. Dundee Precious Metals (DPM). 2014.	Bulgaria.	Krumovgrad gold mine project Stakeholder Engagement Plan. To understand the stakeholder engagement requirements of Bulgarian legislation.	A combination of Document analysis, meetings, focus groups & workshops.	To develop a Strategic Engagement Plan involving and capacitate community members on the life cycle (project planning, design, operation and closure) of the proposed mine.	No. Monitoring and review improve effectiveness and stakeholder buy-in.	Yes
3. Bretschneider *et al.,* 2017.	USA	Teacher Research. SAGE Research Methods Cases Part 2.	Document Analysis as a Qualitative Research Data Collection Method for Teacher Research	The use of Document analysis as part of qualitative research method	No. Research-based analysis document reviews in educational settings.	Yes
4. Kılıçoglu, A. 2018. *The Qualitative Report*	Turkey	Qualitative Research for Educational Science Researchers: A Review of An Introduction to Qualitative Research.	Document Analysis, observation or interview.	Qualitative Research Techniques	No. Development of the reference book on qualitative research for educational science researchers.	Yes
5. Kim *et al*., 2022	Republic of Korea	A scoping review of qualitative geographic information systems in studies addressing health issues	Document Analysis	This scoping review gathers evidence from 38 articles to illuminate when and how QGIS is used to address health issues	No. Qualitative Geographic Information Systems (QGIS) encourage participation from people and communities in health-decision making.	Yes
6. Cardno, C. 2018.	New Zealand	Policy Document Analysis A Practical Educational Leadership Tool and a Qualitative Research Method. *Educational Administration: Theory and Practice.*	Policy Document Analysis	Policy Document Analysis as a method to examining the nature of policy document	No. Policy Document Analysis is valuable in research settings	Yes

Author(s) and Year of Publication	Country of study	Aim of study	Data collection methods	Focus of study	Findings reflecting availability of existing CBWM conceptual framework (Yes/No)	Referenced (Yes/No)
7. Cleland JA. 2017	UK	The qualitative orientation in medical education research. *Centre for Healthcare Education Research and Innovation, Institute of Education for Medical and Dental Sciences*	Interviews and Document Review	Qualitative research and the role of the researcher in the qualitative process.	No. Qualitative research addresses the "how" and "why" research questions	Yes

APPENDIX A2: INTERVIEW CONSENT FORM

A: LETTER OF INTRODUCTION AND INFORMED CONSENT FORM FOR AN INTERVIEW

Potential value of Community-Based Water Monitoring in Water Resources protection decision-making in a developing country context: South Africa.

Research Conducted by: Mrs Tovhowani Nyamande
0828054449
Research Leader: Prof. Jan-Albert Wessels
0972524847

Dear Prospective participant,

You are invited to participate in an interview (virtual MS Teams and/or telephonic) conducted by **Mrs. Nyamande TB** under the supervision of **Prof. Jan-Albert Wessels**, an Associate professor in the Department of Environmental Science towards a **PhD degree** at the University of South Africa.

The interview has been designed to study **the extent of community involvement in water resource protection, and to check if water monitoring data and information collected contribute to decision making**. **You were selected to participate in this survey because you are a representative in a water sector responsible with water monitoring and or management. Please note exclusion to participate in this interview [you will not be eligible to participate in the interview if you are under 18 years].** By participating in the interview, you agree that the information you provide may be used for research purposes, including dissemination through peer-reviewed publications and conference proceedings.

It is anticipated that the information we gain from this interview **will help us to value the community contribution to water resource protection science.** You are, however, under no obligation to participate in the interview and you can withdraw from the study prior to the interview schedule. The interview is developed to be anonymous, meaning that we will have no way of connecting the information that you provide to you personally. Any identifying information that is obtained in connection with this interview will remain confidential as the participant will be identified as numbers (e.g. Participant 1) and will be disclosed only with your permission or as required by law. Even though confidentiality cannot be guaranteed in a focus group setting, provision is made that the names of the participants will not be recorded during sessions. If you choose to participate in this interview, it will take no more than **15 minutes** of your time. You will not benefit from your participation as an individual; however, it is envisioned that the findings of this study **will benefit the whole community by improving the quality of the water resources and stakeholder engagement.** We do not foresee that you will experience

any negative consequences by completing the interview, hence the minimal charges associated with virtual MS Team interview compared to telephonic one.

The researcher(s) undertake to keep any information provided herein confidential, not to let it out of our possession and to report on the findings from the perspective of the participating group and not from the perspective of an individual.

Electronic information will be stored on a password protected computer and an external storage device by the researcher for a period of five years in a safe place for future research or academic purposes. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. Electronic information will be permanently deleted using relevant software functionality should the information need to be destroyed.

You will not be reimbursed or receive any incentives for your participation in the interview.

The research was reviewed and approved by the **College of Agriculture and Environmental Sciences (CAES) UNISA** Ethics Review Committee. The primary researcher, **Mrs Tovhowani Nyamande**, can be contacted during office hours at **012 336 7521 (Tel) & NyamandeT@dwa.gov.za (e-mail).** The study leader, **Prof. Jan-Albert Wessels**, can be contacted during office hours at **011 471 2804 (Tel) & wesselsj@unisa.ac.za**. Should you have any questions regarding the ethical aspects of the study, you can contact the chairperson of the **CAES UNISA** Ethics Research Committee (**Ethical Clearance Reference No: 2019/CAES_HREC/182)**. Alternatively, you can report any serious unethical behaviour at the University's Toll-Free Hotline 0800 86 96 93.

You are deciding to participate on the interview by signing the consent form. You are free to withdraw from the study at any time prior to participation.
Please sign the form to indicate that:

- You have read and understand the information provided above.
- You give your consent to participate in the study.

_____ _____

Participant's signature **Date**

APPENDIX A3: FINAL INTERVIEW SCHEDULE

To collect relevant information for this case study, a semi-structured **Interview questions** [2] meant to address mostly open-ended questions will be used.

Greetings and welcome. Tell me about yourself – Who are you and where are you based?

Q= Question

Q1 Are you involved in any water management OR Water Resource Protection?
If yes, how are you involved?

Q2 Community-Based Water Monitoring (CBWM) (RHP / REMP / AaR programme)

- Are you involved in a CBWM project?
- What is the name of the project?
- What are the main goals of the project?
- Who are the participants?
- Who initiated the project?
- Which skills (educational qualification/s and practical training) are needed for CBWM application?
- What are the benefits of CBWM?
- What are the Pitfalls/ challenges of CBWM

Q3 Monitoring and Monitoring Parameters

- How many are the monitoring sites, locations and how were they selected?
- What type of monitoring do you do?
- How many times per year do you do monitoring (Frequency on data collection)?
- What method/s do you use?
- What monitoring equipment/s do you need (basic monitoring tools)?
- What are the main challenges of monitoring?
- How were your monitoring parameters chosen (mark your answer from the table below)?

How were your monitoring parameters chosen	Mark your answer (X)
1) a standardised monitoring protocol,	
2) priorities of the community living adjacent to the water resource being monitored,	
3) availability of monitoring equipment and other resources,	
4) did you follow a water monitoring protocol, as directed by a government agency, NGO network, Indigenous community, or other organisations.	

[2] The Interview questions were derived from Carlson and Cohen (2018: 173–174)'s themes and Golfman (2010:15-32)'s community monitoring basics, together with other relevant sources illustrated in Section 1.3, **Figure 2.1** and **2.2**, and **Table 2.1**.

Q4 Data Management

4.1 How do you manage your data?

1. Manage own data	
2. Government Institution manages	
3. Non-Government Institution manages	
Other (please specify):	

4.2 Where is it housed, stored or archived?

1. On hard copies	
2. Individual computers	
3. On a National Database	
Other (please specify):	

4.3 How do you share data in the long-term?

1. Upon individual request	
2. Giving access to central database	
3. Do not share data	
Other (please specify):	

4.4 How is data collection funded?

1. Not funded	
2. Government funding	
3. Non-Government Organisation funding	
Other (please specify):	

4.5 What challenges do you face in effectively managing data?

1. No challenges	
2. No proper storage facilities	
3. Storage is done in silos	
4. No control over the management of data	
Other (please specify):	

4.6 What institutional data management support or services do you require?

1. None	
2. Data capturer	
3. Computers to store data	
4. An access to a national database	
Other (please specify):	

Q5 Funding (Volunteers versus paid staff and participants)

1.1 How did you address funding issue in your project?

1. Unpaid volunteers	
2. Fundraising	
3. Secured Government funding (stipend)	
4. Non-Government Organisation funding (paid participants)	
Other (please specify):	

Q6 Value for Money

- Are the reasons for starting a CBWM programme being addressed?
- Is the established CBWM maintaining continuity of monitoring, in terms of generating a long-term dataset?
- What is the value of data produced by CBWM?
- What advice would you give to others who would like to develop a similar project?
- What future do you see for this project?

Q7 Institutional Drivers (i.e. strategies, policies, guidelines, processes, technologies, and services).

- Why should institutions engage in water resource protection?
- Which stakeholders should be involved in the institutional water resource protection?
- What is the relationship between CBWM data collection and policy development?
- Do you know of any existing CBWM framework?

  If **yes**, please indicate criteria which reflect that framework.

  If **no**, how can a conceptual framework be used as data management support in enhancing the use of CBWM data for decision making in water resource protection.

Any participant you would like to suggest I add in the sample or interviews?

Any document you would like to suggest for further investigations?

THANK YOU FOR YOUR PARTICIPATION

APPENDIX B1: SURVEY QUESTIONNAIRE CONSENT FORM

A: LETTER OF INTRODUCTION AND INFORMED CONSENT FORM FOR A QUESTIONNAIRE SURVEY)

Potential value of Community-Based Water Monitoring in Water Resources protection decision-making in a developing country context: South Africa.

Research Conducted by: Mrs Tovhowani Nyamande
0828054449
Research Leader: Prof. Jan-Albert Wessels
0972524847

Dear Prospective participant,

You are invited to participate in a questionnaire survey conducted by **Mrs Nyamande TB** under the supervision of **Prof. Jan-Albert Wessels**, an Associate professor in the Department of Environmental Science towards a **PhD degree** at the University of South Africa.

The survey you have received has been designed to study **the extent of community involvement in water resource protection, and to check if water monitoring data and information collected contribute to decision making**. **You were selected to participate in this survey because you are a representative of a water sector responsible with water monitoring and or management. Please note exclusion to participate in this survey [you will not be eligible to complete the survey if you are younger than 18 years].** By completing this survey, you agree that the information you provide may be used for research purposes, including dissemination through peer-reviewed publications and conference proceedings.

It is anticipated that the information we gain from this survey **will help us to value the community contribution to water resource protection science.** You are, however, under no obligation to complete the survey and you can withdraw from the study prior to submitting the survey. The survey is developed to be anonymous, meaning that we will have no way of connecting the information that you provide to you personally. Any identifying information that is obtained in connection with this survey will remain confidential as the participant will be identified as numbers (e.g. Participant 1) and will be disclosed only with your permission or as required by law. Even though confidentiality cannot be guaranteed in a focus group setting, provision is made that the names of the participants will not be recorded during sessions. If you choose to participate in this survey it will take up no more than **15 minutes** of your time. You will not benefit from your participation as an individual; however, it is envisioned that the findings of this study **will benefit the whole community by improving the quality**

of the water resources and stakeholder engagement. We do not foresee that you will experience any negative consequences by completing the survey.

The researcher(s) undertake to keep any information provided herein confidential, not to let it out of our possession and to report on the findings from the perspective of the participating group and not from the perspective of an individual.

Electronic information will be stored on a password protected computer and an external storage device by the researcher for a period of five years in a safe place for future research or academic purposes. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. Electronic information will be permanently deleted by relevant software functionality should the information need to be destroyed.

You will not be reimbursed or receive any incentives for your participation in the survey.

The research was reviewed and approved by the **College of Agriculture and Environmental Sciences (CAES) Unisa** Ethics Review Committee. The primary researcher, **Mrs Tovhowani Nyamande**, can be contacted during office hours at **012 336 7521 (Tel) & NyamandeT@dwa.gov.za / 67097219@mylife.unisa.ac.za (e-mail).** The study leader, **Prof. Jan-Albert Wessels**, can be contacted during office hours at **011 471 2804 (Tel) & wesselsj@unisa.ac.za**. Should you have any questions regarding the ethical aspects of the study, you can contact the chairperson of the **CAES Unisa** Ethics Research Committee (**Ethical Clearance Reference No: 2019/CAES_HREC/182)**. Alternatively, you can report any serious unethical behaviour at the University's Toll-Free Hotline 0800 86 96 93.

You are deciding whether to participate by continuing to the next page. You are free to withdraw from the study at any time prior to sending back the questionnaire.

Please sign the form to indicate that:

- You have read and understand the information provided above.
- You give your consent to participate in the study.

_____ _____

Participant's signature **Date**

APPENDIX B2: FINAL ELECTRONIC SURVEY QUESTIONNAIRE

TOPIC: Potential value of Community-Based Water Monitoring in Water Resource Protection decision-making in a developing country context: South Africa.

Please answer the following Survey Questionnaire questions[3] and return as soon as possible to NyamandeT@dwa.gov.za. I would appreciate your return of the questionnaire even if you do not wish to participate on the research.

Q=Question

Q1. Are you involved OR where you involved in any water management OR Water Resource Protection?

1. 1. Yes	
2. 2. No	
3. Unsure	

Q2. If yes, what aspect/s are you involved with?_____

Q3. How are you involved (Please indicate with a cross X):

1. Scientist / Environmental officer	
2. Managers (National Provincial & Local Government)	
3. Water Sector (Domestic e.g. SALGA & COGTA, Agriculture, Ecological/Environmental & Research)	
4. Community-Based Water Monitoring (CBWM) (RHP / REMP / AaR programme)	
5. Community members	
Other (please specify):	

Q4. Please indicate your gender (Please indicate with a cross X):

1. Male	
2. Female	
3. Other (please specify):	

Q5. Please indicate your age group (in years) (Please indicate with a cross X):

1. 18-21	
2. 22-30	
3. 31-45	
4. 46-60	
5. 60 and over	

Q6. Please indicate (with a cross X) your highest level of education / qualification:

1. No formal education	
2. Primary school	
3. Secondary school/Matric	
2. National diploma/certificate	
3. Undergraduate degree	

[3] The Survey Questionnaire questions were derived from Carlson and Cohen (2018: 173–174)'s themes and Golfman (2010:15-32)'s community monitoring basics, together with other relevant sources illustrated in Section 1.3, **Figure 2.1** and **2.2**, and **Table 2.1** of the Thesis.

4. Postgraduate degree	
Postgraduate degree (please specify e.g. Honours, Masters or Doctorate):	

Q7. Are you OR where you a Community-Based Water Monitoring (CBWM)[4] Member?

1. Yes	
2. No	

Q8. If yes, what is the name of CBWM group?_____

*If you are OR were a CBWM Project member, please answer the importance scale in **question 9** below, and then continue with the remainder of the questionnaire. If you **are NOT** OR **were NEVER** a CBWM Project member, **please skip question 9**.*

Q9. For a CBWM to be a success the following criteria[5] in Likert-scale rating has been taken into consideration, please indicate how *important* the following aspects are to you, by rating (with a cross X) the level of importance on the listed aspects:

	IMPORTANCE RATING				
	Of no importance	Of little importance	Undecided	Of moderate importance	Of great importance
Monitoring Parameters[6]					
Type of monitoring and method	1	2	3	4	5
Water monitoring parameters to be monitored	1	2	3	4	5
Following a standardised monitoring protocol, as directed by a government agency, NGO network, Indigenous community, or other organisations.	1	2	3	4	5
Priorities of the community living adjacent to the water resource being monitored	1	2	3	4	5
Capacity of monitoring equipment and other resources.	1	2	3	4	5
Data Management					
Data storage	1	2	3	4	5
Access to data	1	2	3	4	5
Funding of data collection	1	2	3	4	5
The relationship between CBM data collected and policy development?	1	2	3	4	5
Funding					
Unpaid Volunteers is the best	1	2	3	4	5
Participants must get stipend	1	2	3	4	5
Participants must get paid	1	2	3	4	5
Value for Money					
Addressing reasons for starting a CBWM program	1	2	3	4	5
Maintaining the continuity of the established CBWM	1	2	3	4	5

[4] CBWM: A process in which community members collaborate to monitor and respond to water related issues of concern
[5] See Table 2.1: CBWM Criteria
[6] Monitoring parameters: parameters sampled or monitored for water quality ecosystem e.g., physical, chemical or microbial.

	IMPORTANCE RATING				
	Of no importance	Of little importance	Undecided	Of moderate importance	Of great importance
Keeping the monitoring momentum across time to establish long-term datasets	1	2	3	4	5
Guiding Principles					
Inclusiveness - All Interested, and Affected Participants involved in the process must be actively engaged with.	1	2	3	4	5
Accessibility – The process must be tailored to suite the community's diverse needs.	1	2	3	4	5
Transparency – Openness, clarity and communication must be maintained throughout the process.	1	2	3	4	5
Adaptability –The number of risks, uncertainties, fear and complexity the communities face requires approaches that are flexible and able to adapt to change of direction and new information.	1	2	3	4	5

Q10. Please indicate the benefits / value of CBWM programmes (Please mark with a cross (x) all the applicable options):

1. Increased access to information at a lower or no cost	
2. Encourage capacity and knowledge development	
3. Encourage broad public participation	
4. Enhance citizen's scientific knowledge	
5. Encourage local leadership	
Other (please specify):	

……
……
……

Q11. Please indicate the pitfalls / challenges of CBWM programmes (Please mark with a cross (x) all the applicable options):

1. Lack of budget	
5. Inadequate skills	
6. Lack of participation and commitment	
7. Poor quality data produced	
8. Inadequate policy framework	
Other (please specify):	

……
……
……

Q12. Based on the opinions of governance and the real-life experiences of the community, does Catchments benefit from CBWM?

1. Yes	
2. No	

If yes, how?_____

……
……
……

Q13. What are your views of governance structures [7]on the extent to which CBWM operates?

……
……
……

Q14. Do you know of any existing CBWM framework?

1. Yes	
2. No	

If **yes**, please indicate criteria which reflect in that framework.

……
……
……

If **no**, how can a conceptual framework be used as data management support in enhancing the use of CBWM data for decision making in water resource protection.

……
……
……

How should the framework be supported and funded?

……
……

Who or which institution should best host CBWM, and why?

……
……

Q15. Please indicate (mark with a cross (x)) your level of agreement with the following CBWM framework in Likert-scale rating statements:

	Strongly disagree	Disagree	Don' t know	Agree	Strongly agree
There is a need for CBWM programme in each Water Management Area or Catchment	1	2	3	4	5
I am likely to recommend the inclusion of CBWM in water resource protection policies	1	2	3	4	5
I am likely to recommend the integration of CBWM in water resource protection governance structures	1	2	3	4	5
There is a need for conceptual framework to enhance the use of CBWM data for water resource protection decision making	1	2	3	4	5
I am likely to recommend the development of the conceptual framework, that clearly indicate information flow from data collection to decision making	1	2	3	4	5

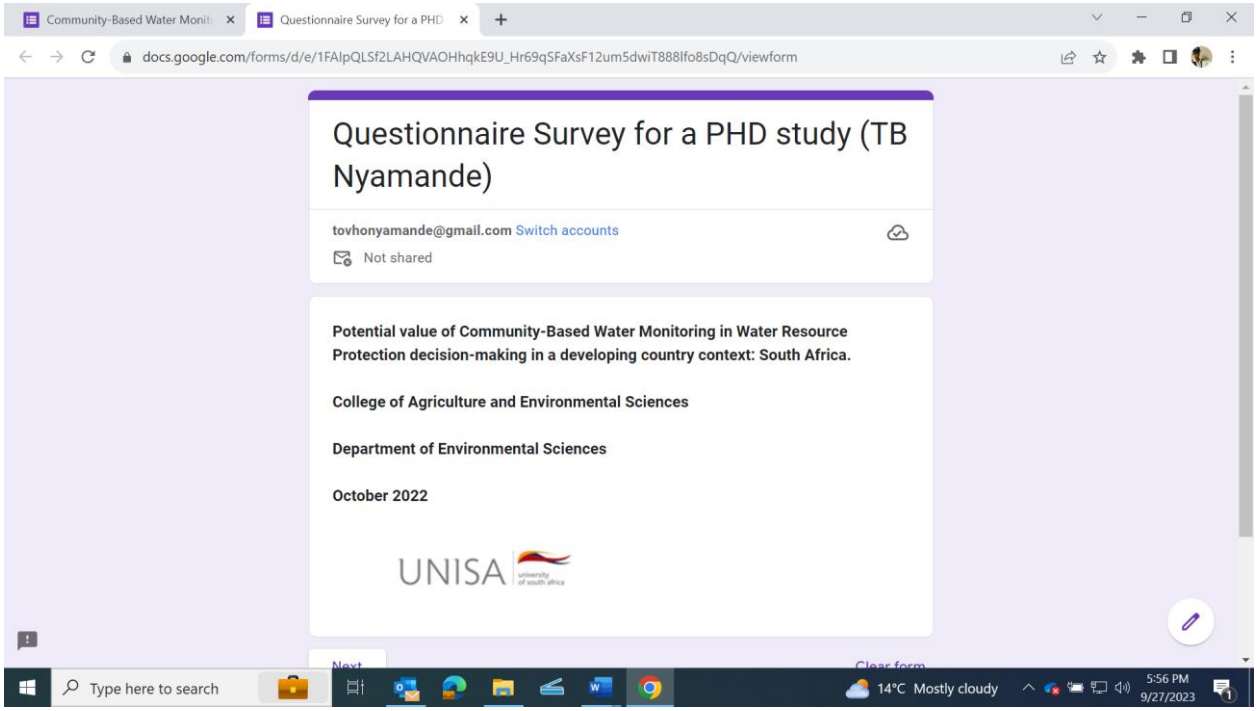
Any participant you would like to suggest I add in the sample or questionnaire?

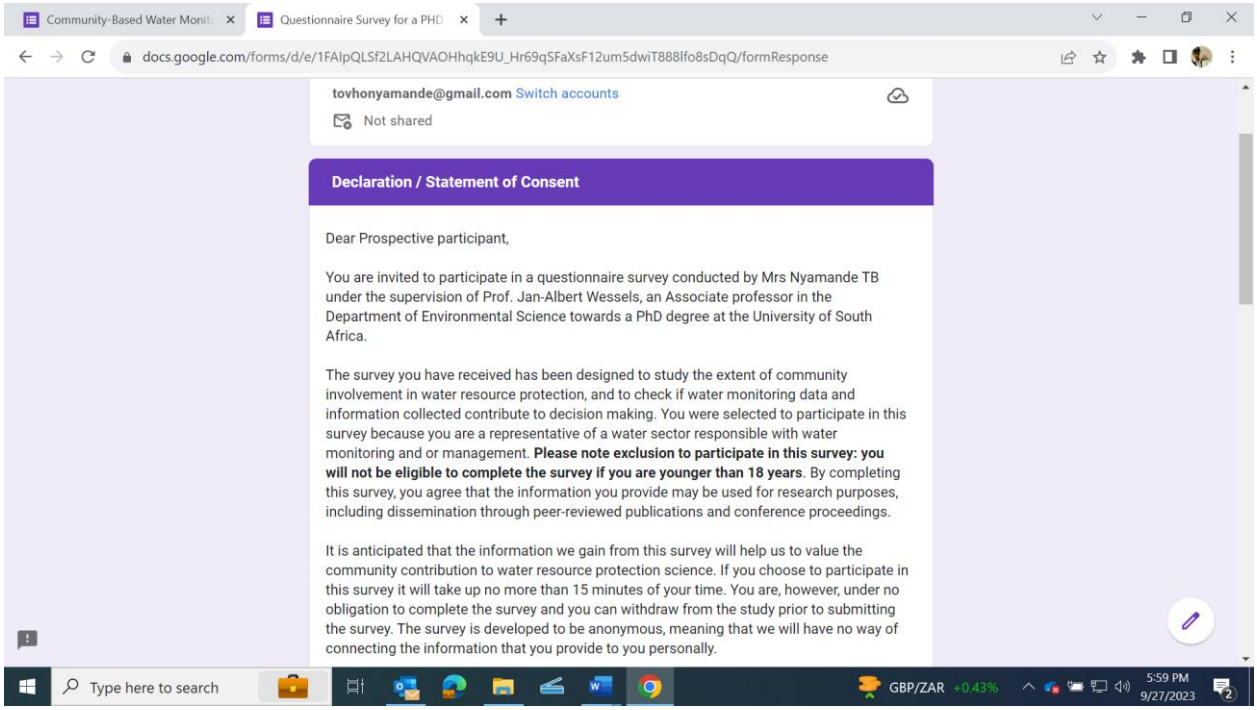
Any document you would like to suggest for further investigations?

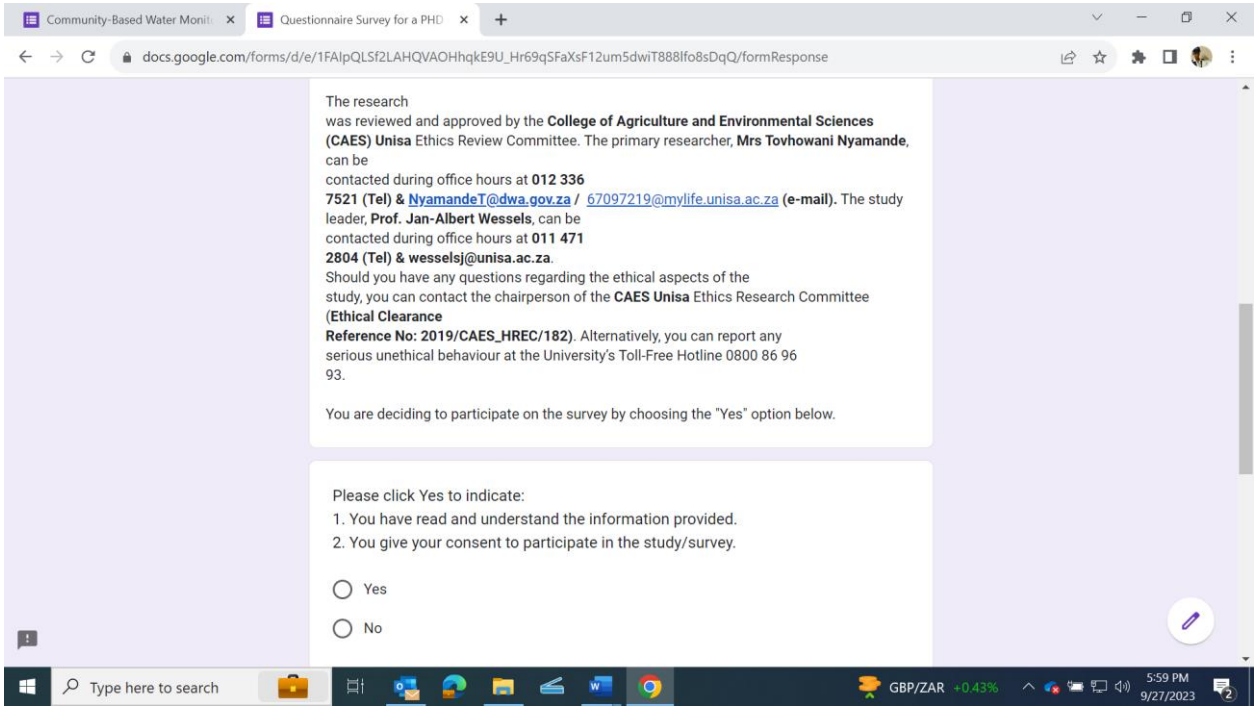
THANK YOU FOR YOUR PARTICIPATION

[7] Governance structure: Also referred to as governance framework – the structure of the governance of the organization or institution.

APPENDIX B3: FINAL GOOGLE FORMS SURVEY QUESTIONNAIRE






Community-Based Water Monit
Questionnaire Survey for a PHD
docs.google.com/forms/d/e/1FAIpQLSf2LAHQVAOHhqkE9U_Hr69qSFaXsF12um5dwiT888lfo8sDqQ/formResponse
The research
was reviewed and approved by the College of Agriculture and Environmental Sciences (CAES) Unisa Ethics Review Committee. The primary researcher, Mrs Tovhowani Nyamande, can be
contacted during office hours at 012 336
7521 (Tel) & NyamandeT@dwa.gov.za / 67097219@mylife.unisa.ac.za (e-mail). The study leader, Prof. Jan-Albert Wessels, can be
contacted during office hours at 011 471
2804 (Tel) & wesselsj@unisa.ac.za.
Should you have any questions regarding the ethical aspects of the
study, you can contact the chairperson of the CAES Unisa Ethics Research Committee (Ethical Clearance
Reference No: 2019/CAES_HREC/182). Alternatively, you can report any
serious unethical behaviour at the University's Toll-Free Hotline 0800 86 96
93.
You are deciding to participate on the survey by choosing the "Yes" option below.
Please click Yes to indicate:
1. You have read and understand the information provided.
2. You give your consent to participate in the study/survey.
Yes
No
Type here to search
GBP/ZAR +0.43%
5:59 PM
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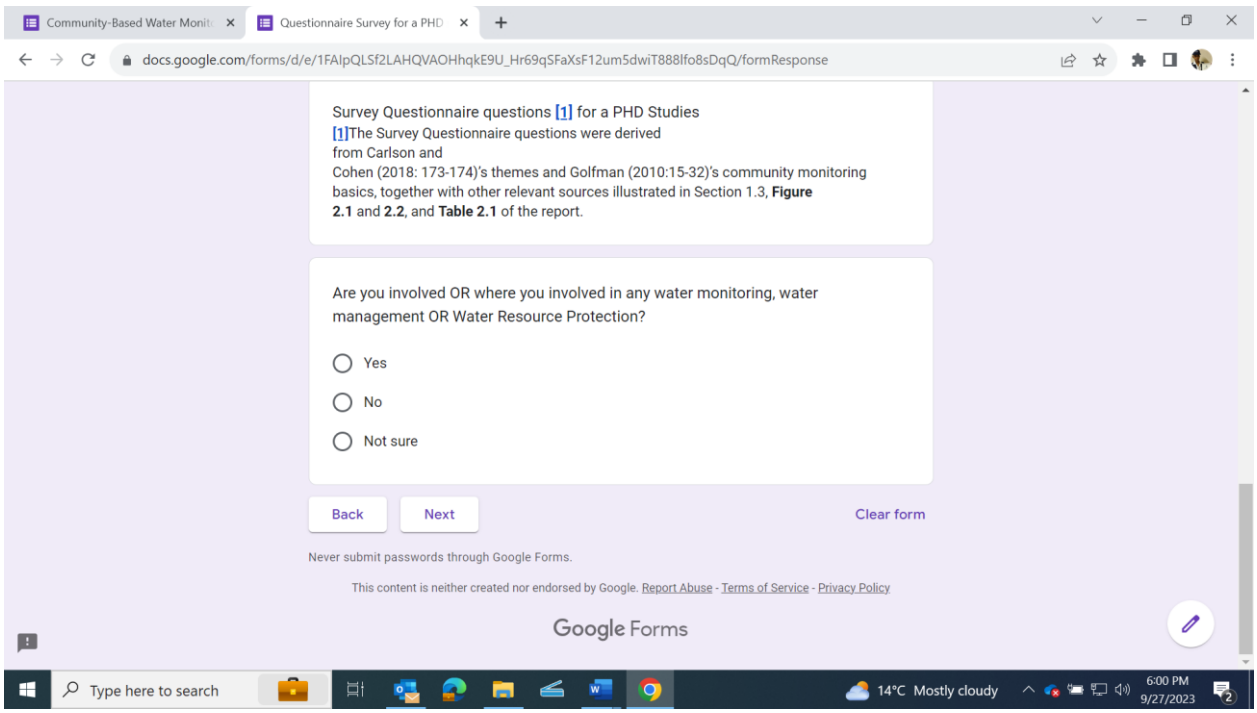
Community-Based Water Monit
Questionnaire Survey for a PHD
docs.google.com/forms/d/e/1FAIpQLSf2LAHQVAOHhqkE9U_Hr69qSFaXsF12um5dwiT888lfo8sDqQ/formResponse
Survey Questionnaire questions [1] for a PHD Studies
[1]The Survey Questionnaire questions were derived
from Carlson and
Cohen (2018: 173-174)'s themes and Golfman (2010:15-32)'s community monitoring basics, together with other relevant sources illustrated in Section 1.3, Figure 2.1 and 2.2, and Table 2.1 of the report.
Are you involved OR where you involved in any water monitoring, water management OR Water Resource Protection?
Yes
No
Not sure
Back
Next
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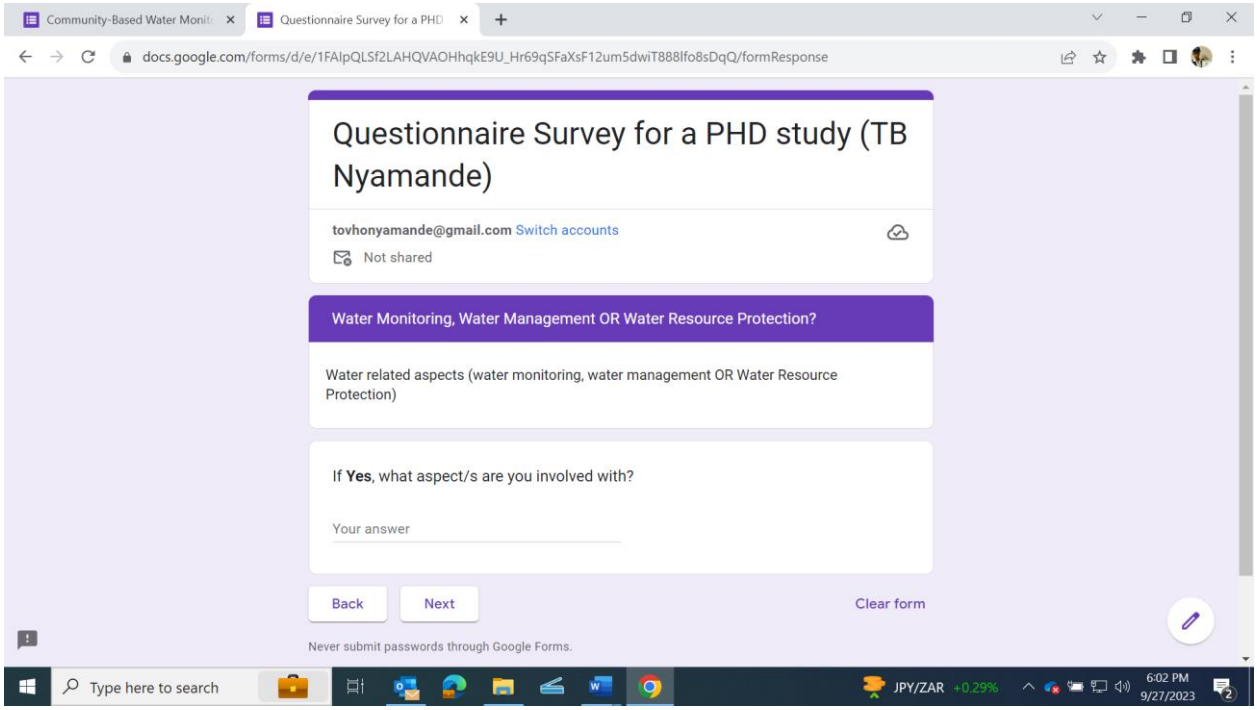
Community-Based Water Monit
Questionnaire Survey for a PHD
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Questionnaire Survey for a PHD study (TB Nyamande)
tovhonyamande@gmail.com Switch accounts
Not shared
Water Monitoring, Water Management OR Water Resource Protection?
Water related aspects (water monitoring, water management OR Water Resource Protection)
If Yes, what aspect/s are you involved with?
Your answer
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JPY/ZAR +0.29%
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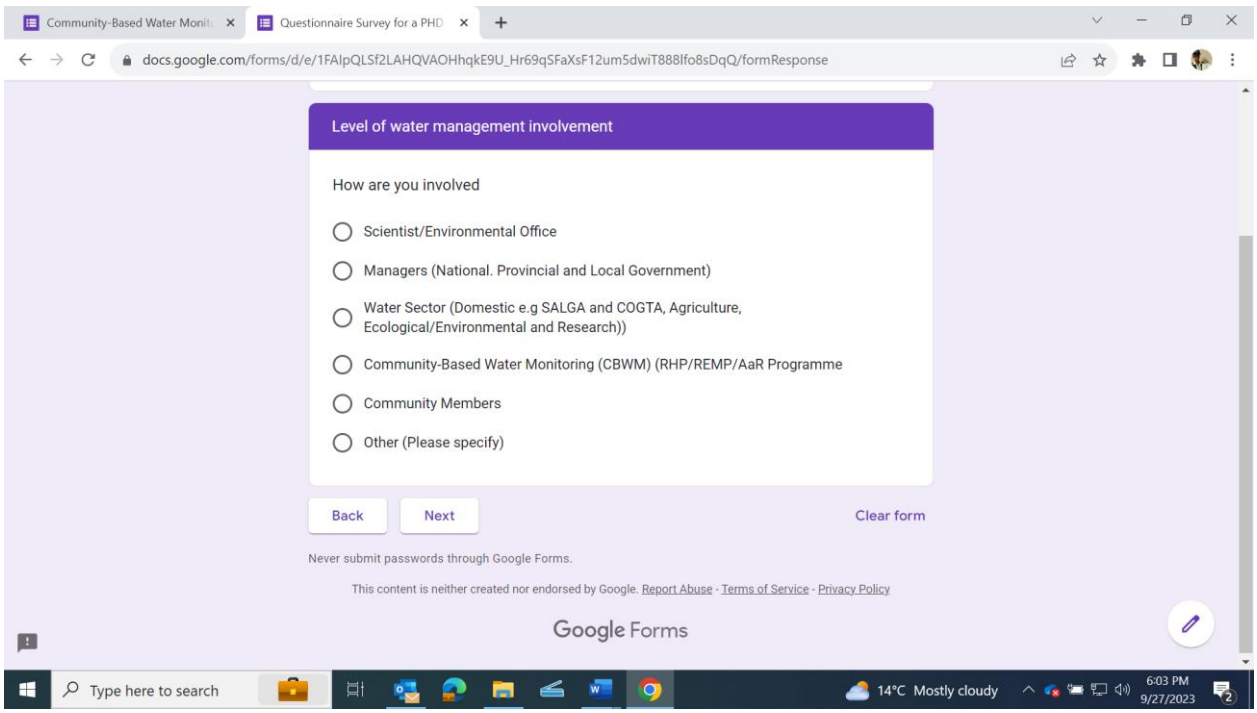
Community-Based Water Monit
Questionnaire Survey for a PHD
docs.google.com/forms/d/e/1FAIpQLSf2LAHQVAOHhqkE9U_Hr69qSFaXsF12um5dwiT888lfo8sDqQ/formResponse
Level of water management involvement
How are you involved
Scientist/Environmental Office
Managers (National. Provincial and Local Government)
Water Sector (Domestic e.g SALGA and COGTA, Agriculture, Ecological/Environmental and Research))
Community-Based Water Monitoring (CBWM) (RHP/REMP/AaR Programme
Community Members
Other (Please specify)
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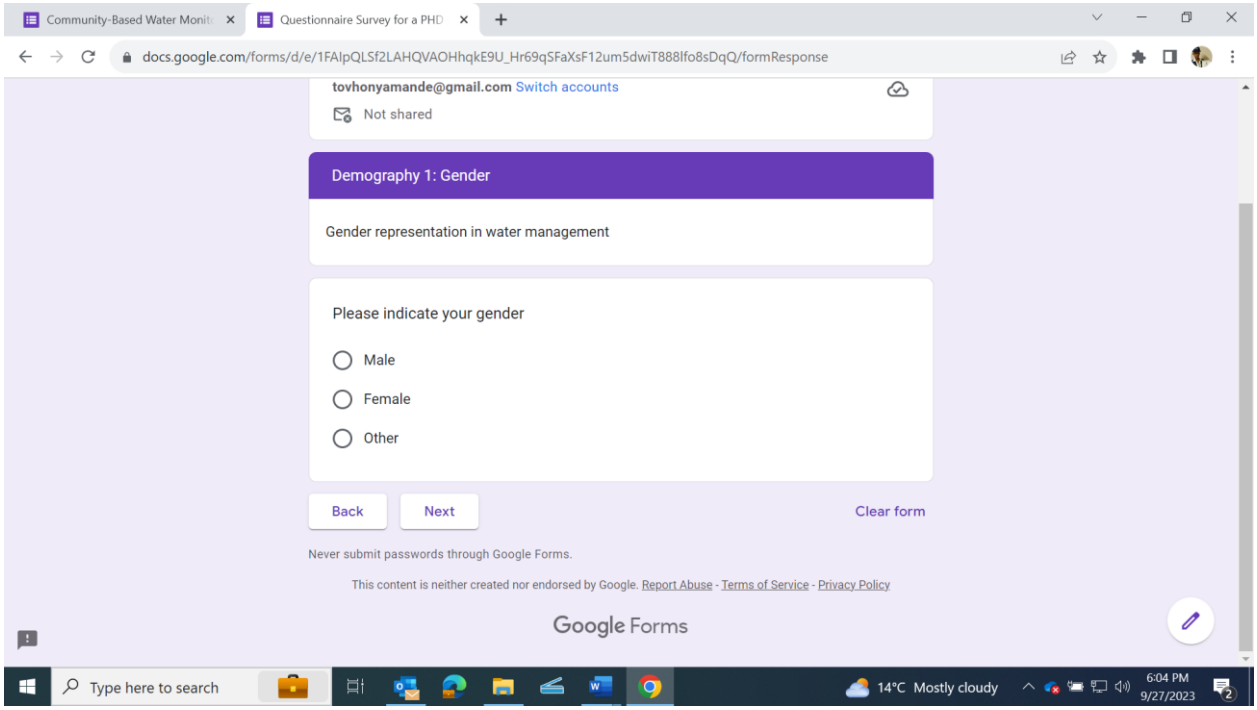
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Questionnaire Survey for a PHD
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tovhonyamande@gmail.com Switch accounts
Not shared
Demography 1: Gender
Gender representation in water management
Please indicate your gender
Male
Female
Other
Back
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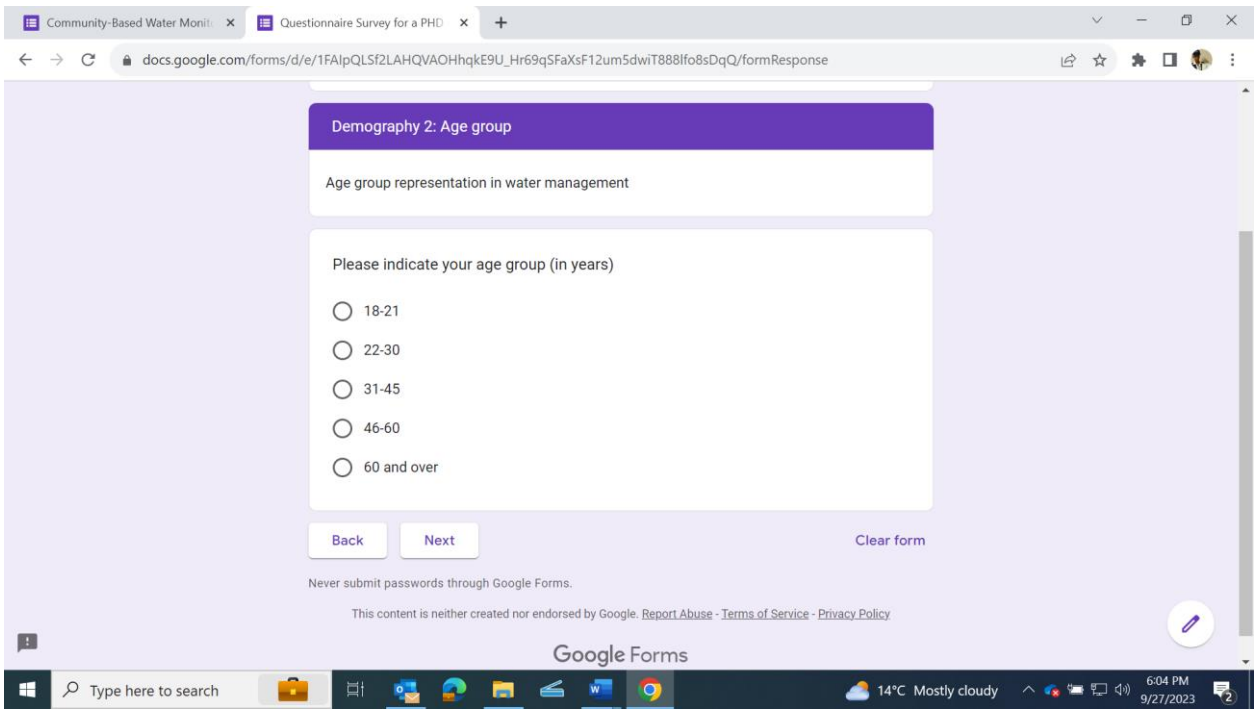
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docs.google.com/forms/d/e/1FAIpQLSf2LAHQVAOHhqkE9U_Hr69qSFaXsF12um5dwiT888lfo8sDqQ/formResponse
Demography 2: Age group
Age group representation in water management
Please indicate your age group (in years)
18-21
22-30
31-45
46-60
60 and over
Back
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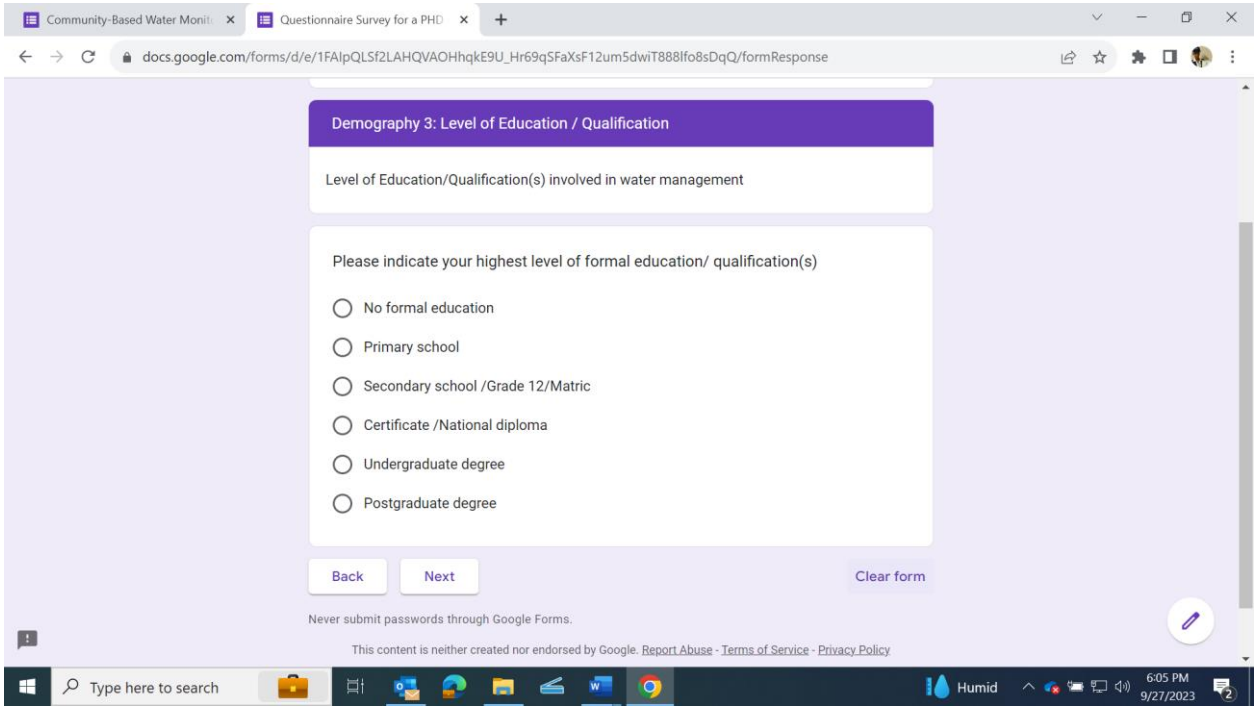
Community-Based Water Monit
Questionnaire Survey for a PHD
docs.google.com/forms/d/e/1FAIpQLSf2LAHQVAOHhqkE9U_Hr69qSFaXsF12um5dwiT888lfo8sDqQ/formResponse
Demography 3: Level of Education / Qualification
Level of Education/Qualification(s) involved in water management
Please indicate your highest level of formal education/ qualification(s)
No formal education
Primary school
Secondary school /Grade 12/Matric
Certificate /National diploma
Undergraduate degree
Postgraduate degree
Back
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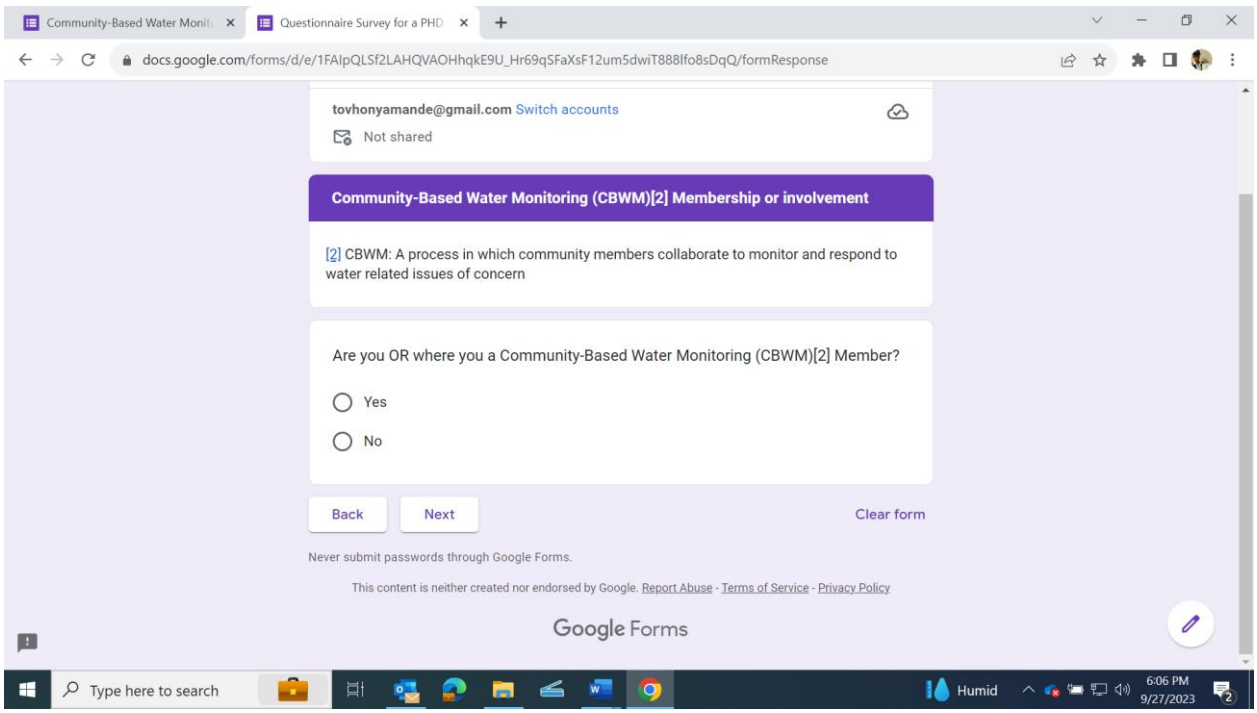
Community-Based Water Monit
Questionnaire Survey for a PHD
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tovhonyamande@gmail.com Switch accounts
Not shared
Community-Based Water Monitoring (CBWM)[2] Membership or involvement
[2] CBWM: A process in which community members collaborate to monitor and respond to water related issues of concern
Are you OR where you a Community-Based Water Monitoring (CBWM)[2] Member?
Yes
No
Back
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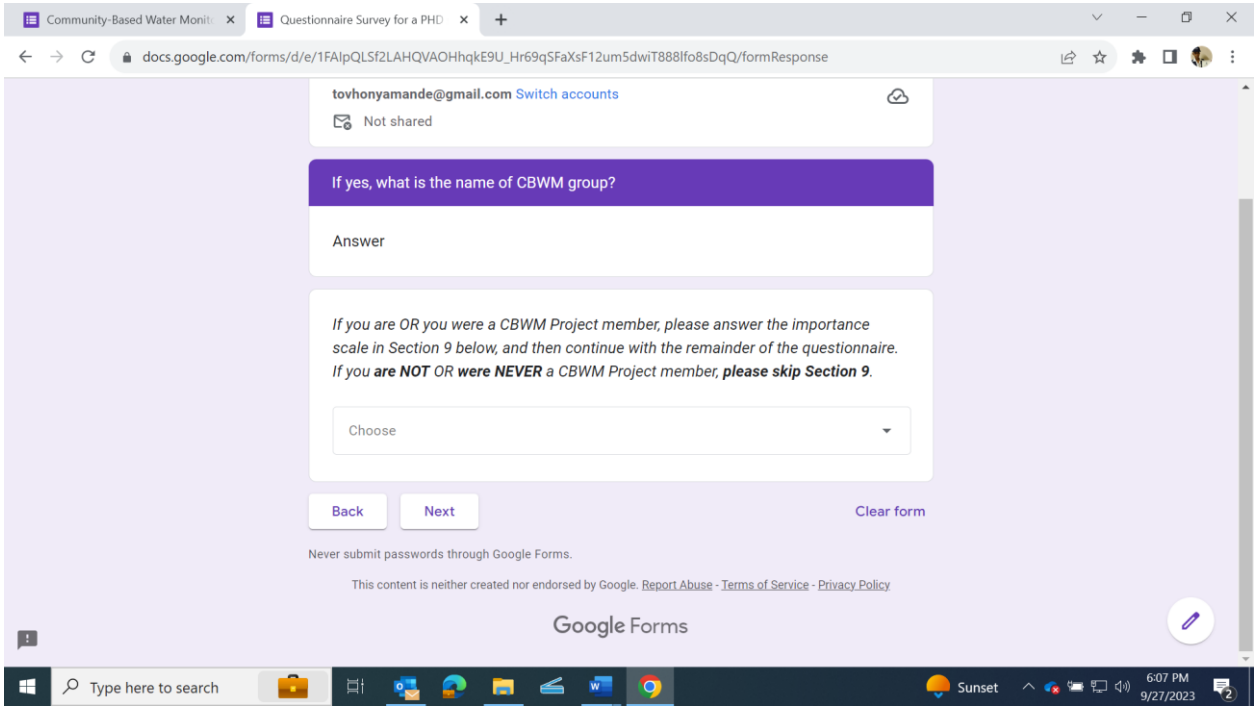
Community-Based Water Monit
Questionnaire Survey for a PHD
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tovhonyamande@gmail.com Switch accounts
Not shared
If yes, what is the name of CBWM group?
Answer
If you are OR you were a CBWM Project member, please answer the importance scale in Section 9 below, and then continue with the remainder of the questionnaire. If you are NOT OR were NEVER a CBWM Project member, please skip Section 9.
Choose
Back
Next
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Sunset
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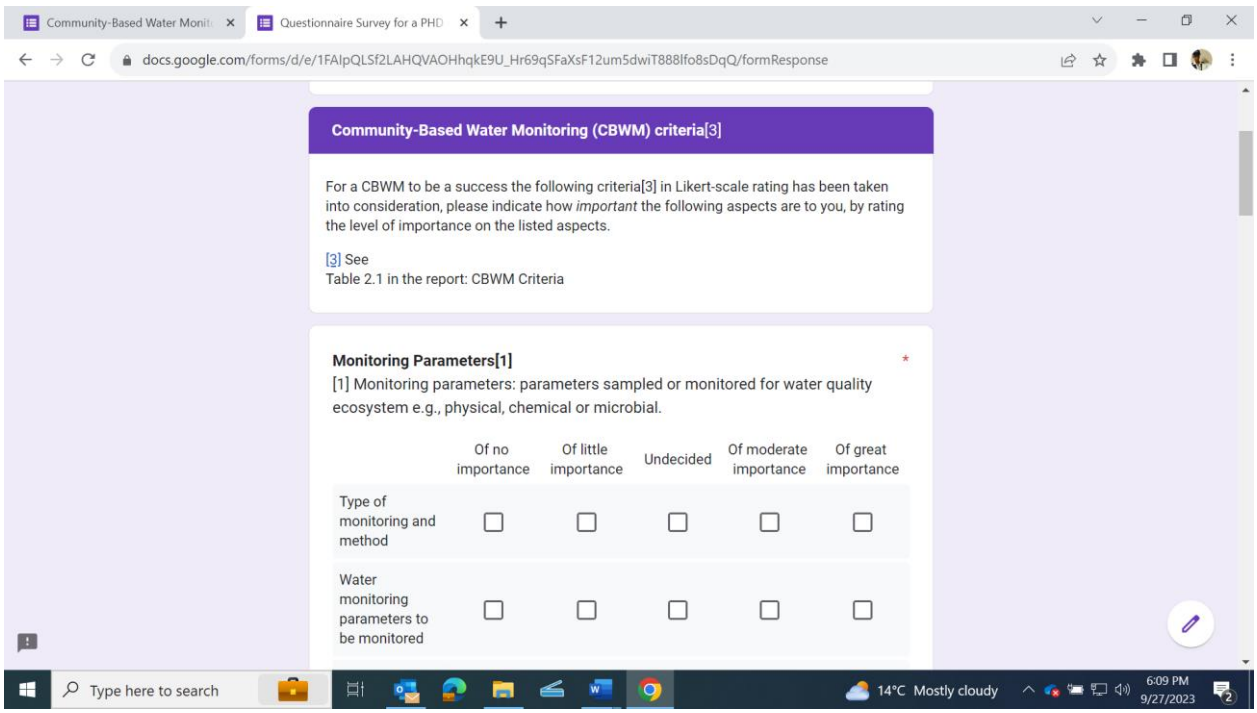
Community-Based Water Monit
Questionnaire Survey for a PHD
docs.google.com/forms/d/e/1FAIpQLSf2LAHQVAOHhqkE9U_Hr69qSFaXsF12um5dwiT888lfo8sDqQ/formResponse
Community-Based Water Monitoring (CBWM) criteria[3]
For a CBWM to be a success the following criteria[3] in Likert-scale rating has been taken into consideration, please indicate how important the following aspects are to you, by rating the level of importance on the listed aspects.
[3] See
Table 2.1 in the report: CBWM Criteria
Monitoring Parameters[1] *
[1] Monitoring parameters: parameters sampled or monitored for water quality ecosystem e.g., physical, chemical or microbial.
Of no importance
Of little importance
Undecided
Of moderate importance
Of great importance
Type of monitoring and method
Water monitoring parameters to be monitored
Type here to search
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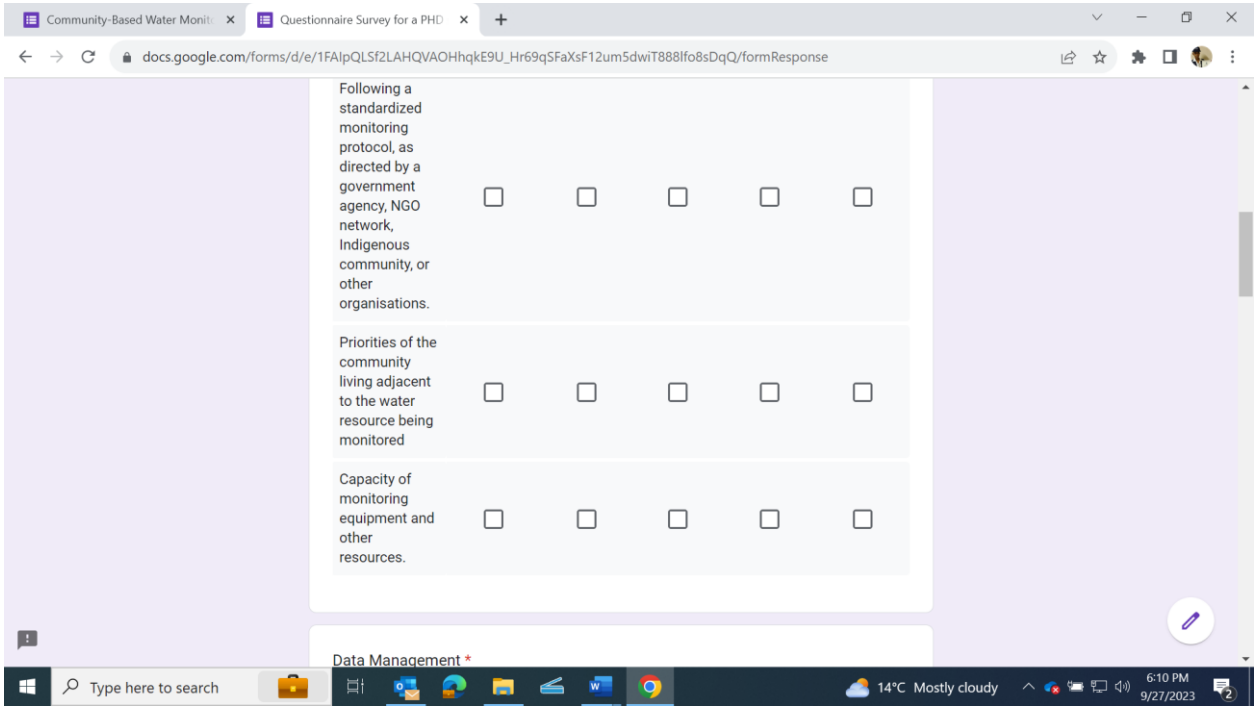
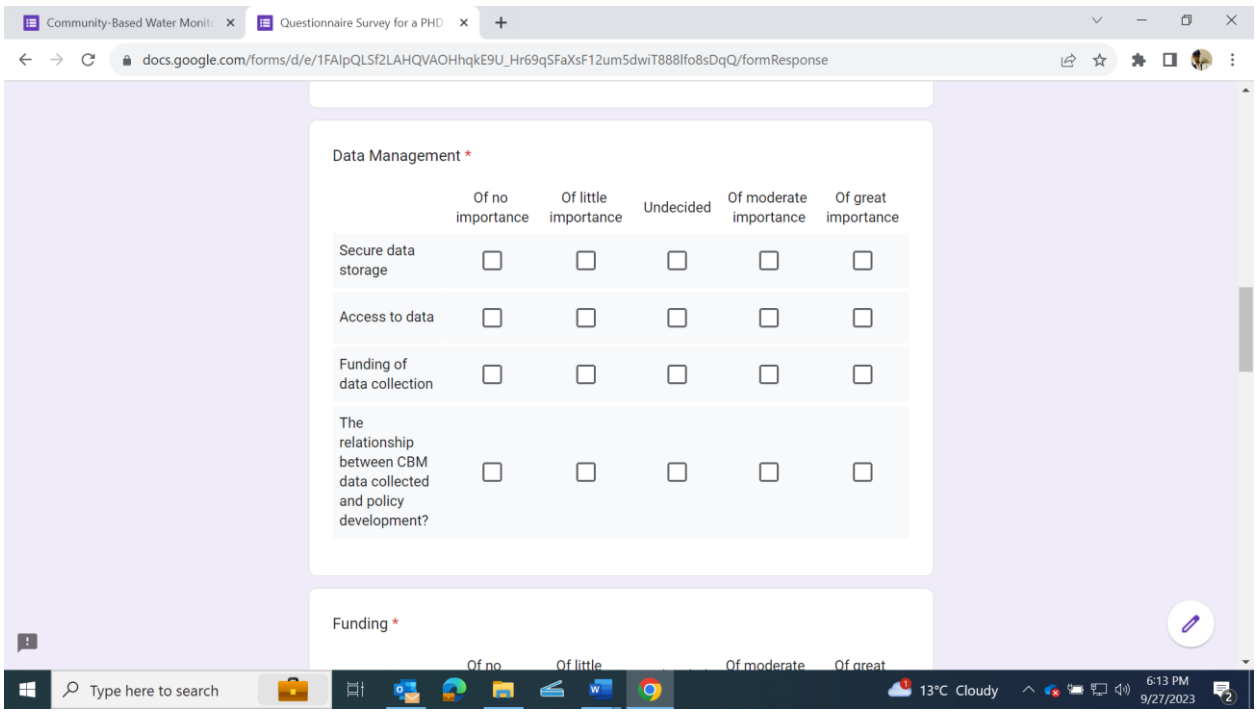


Following a standardized monitoring protocol, as directed by a government agency, NGO network, Indigenous community, or other organisations.	☐	☐	☐	☐	☐
Priorities of the community living adjacent to the water resource being monitored	☐	☐	☐	☐	☐
Capacity of monitoring equipment and other resources.	☐	☐	☐	☐	☐

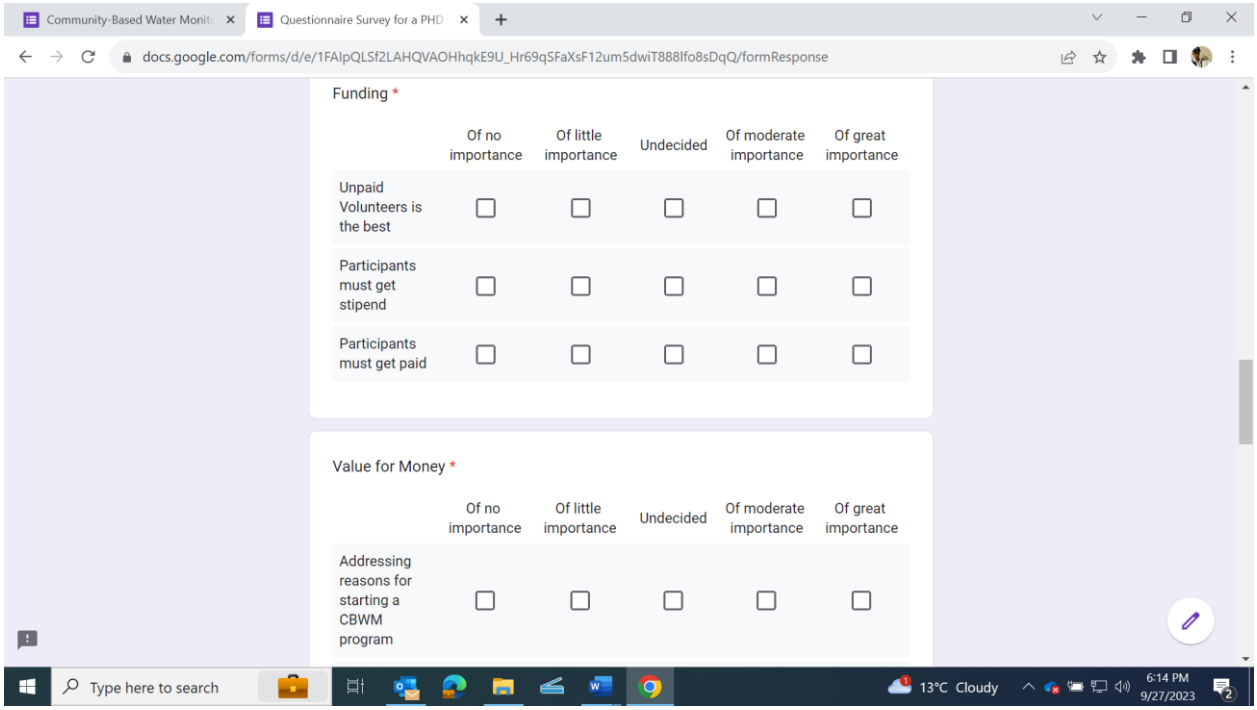
Data Management *



Data Management *

	Of no importance	Of little importance	Undecided	Of moderate importance	Of great importance
Secure data storage	☐	☐	☐	☐	☐
Access to data	☐	☐	☐	☐	☐
Funding of data collection	☐	☐	☐	☐	☐
The relationship between CBM data collected and policy development?	☐	☐	☐	☐	☐

Funding *


Community-Based Water Monit
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docs.google.com/forms/d/e/1FAIpQLSf2LAHQVAOHhqkE9U_Hr69qSFaXsF12um5dwiT888lfo8sDqQ/formResponse
Funding *
Of no importance
Of little importance
Undecided
Of moderate importance
Of great importance
Unpaid Volunteers is the best
Participants must get stipend
Participants must get paid
Value for Money *
Of no importance
Of little importance
Undecided
Of moderate importance
Of great importance
Addressing reasons for starting a CBWM program
Type here to search
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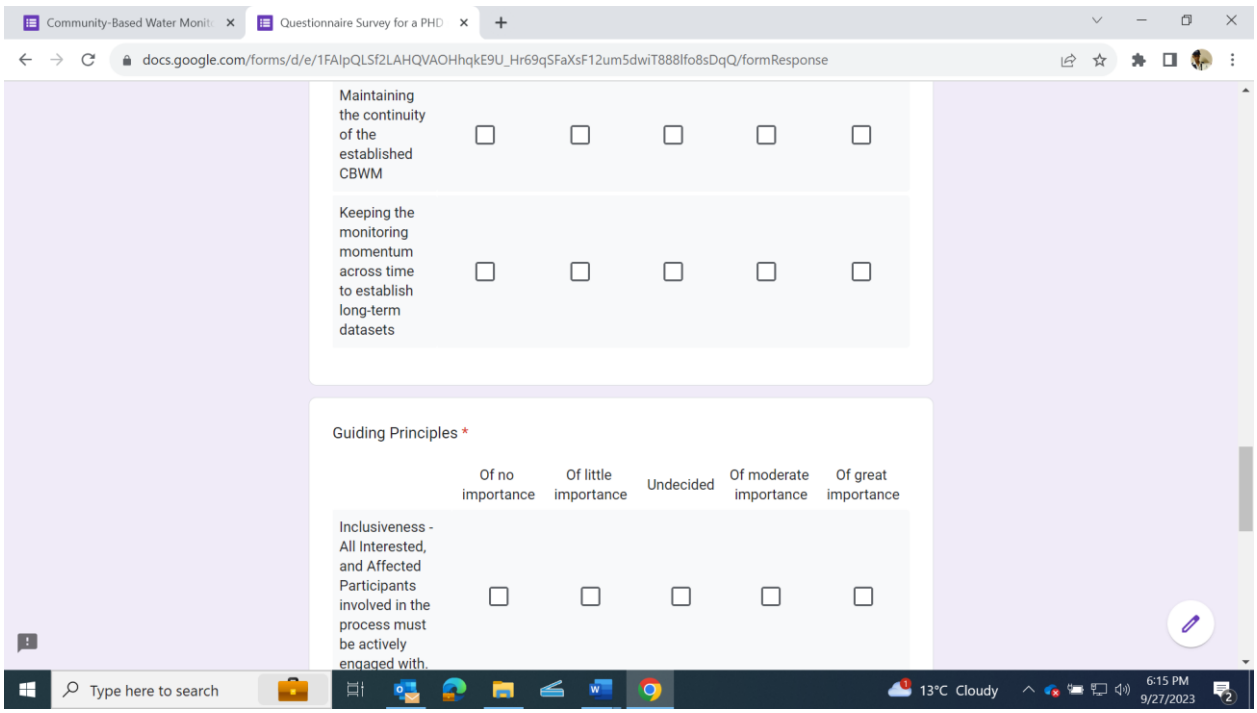
9/27/2023


Community-Based Water Monit
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Maintaining the continuity of the established CBWM
Keeping the monitoring momentum across time to establish long-term datasets
Guiding Principles *
Of no importance
Of little importance
Undecided
Of moderate importance
Of great importance
Inclusiveness - All Interested, and Affected Participants involved in the process must be actively engaged with.
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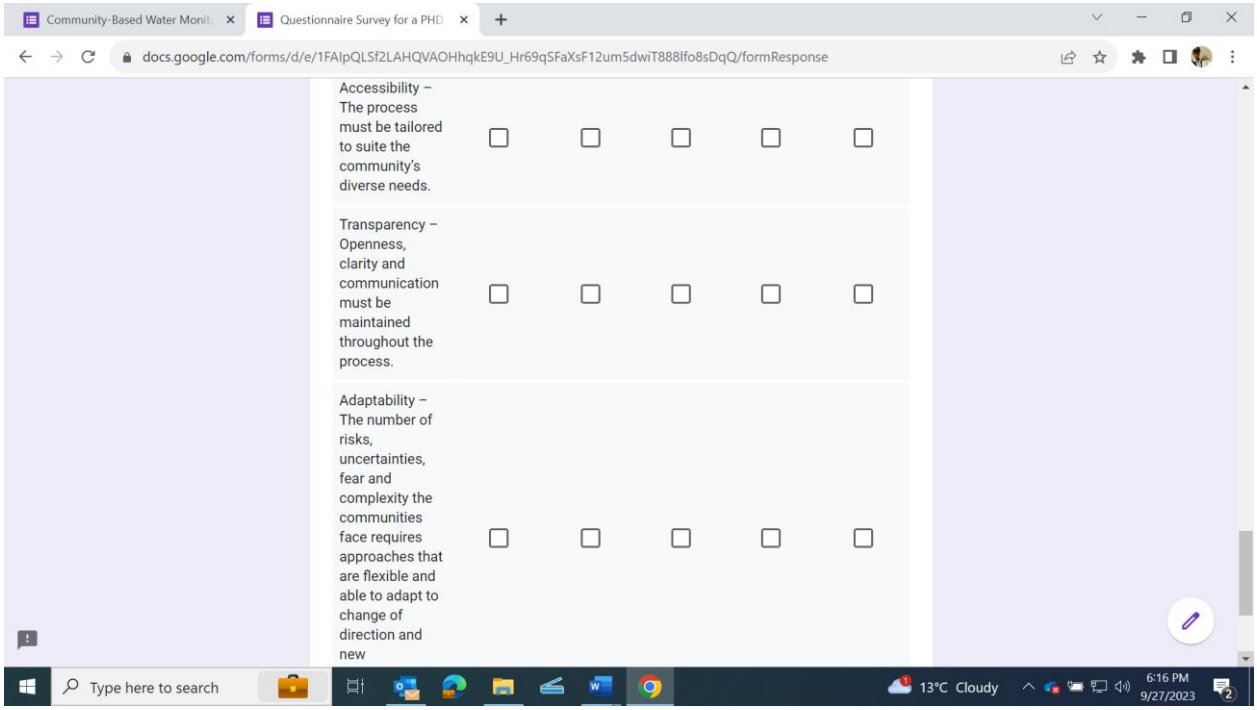
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Accessibility – The process must be tailored to suite the community's diverse needs.
Transparency – Openness, clarity and communication must be maintained throughout the process.
Adaptability – The number of risks, uncertainties, fear and complexity the communities face requires approaches that are flexible and able to adapt to change of direction and new
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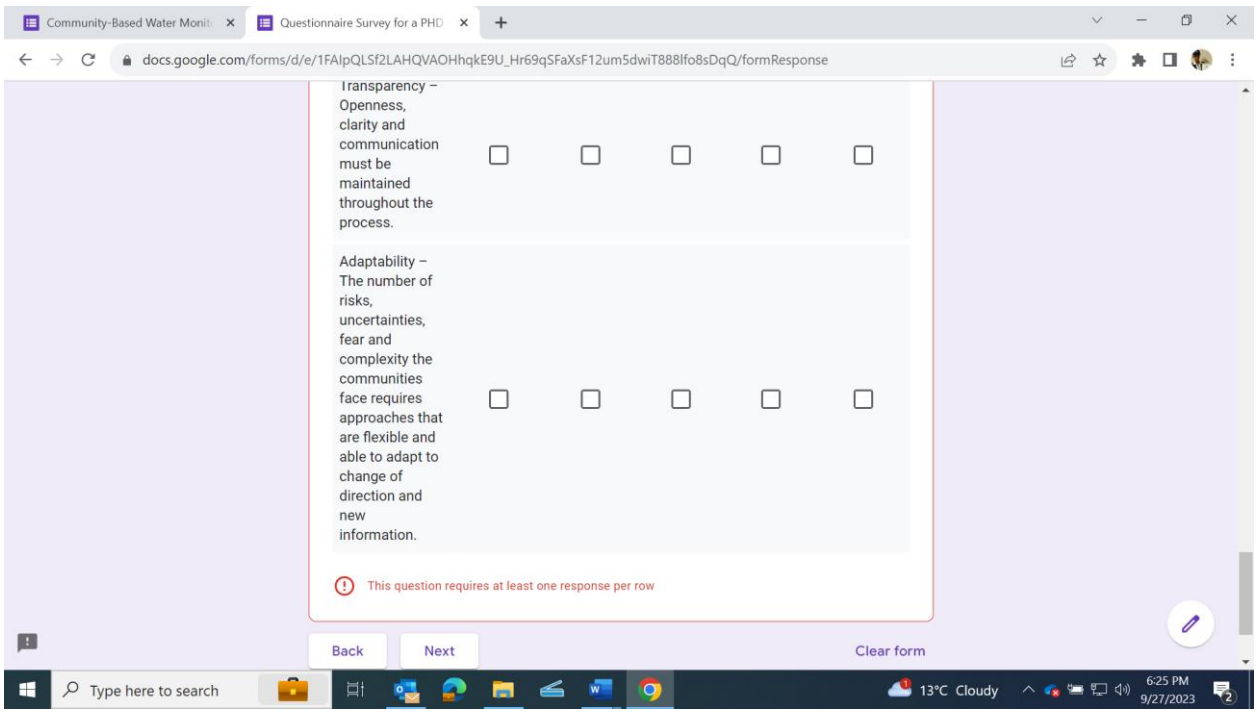
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Questionnaire Survey for a PHD
docs.google.com/forms/d/e/1FAIpQLSf2LAHQVAOHhqkE9U_Hr69qSFaXsF12um5dwiT888lfo8sDqQ/formResponse
Transparency – Openness, clarity and communication must be maintained throughout the process.
Adaptability – The number of risks, uncertainties, fear and complexity the communities face requires approaches that are flexible and able to adapt to change of direction and new information.
This question requires at least one response per row
Back
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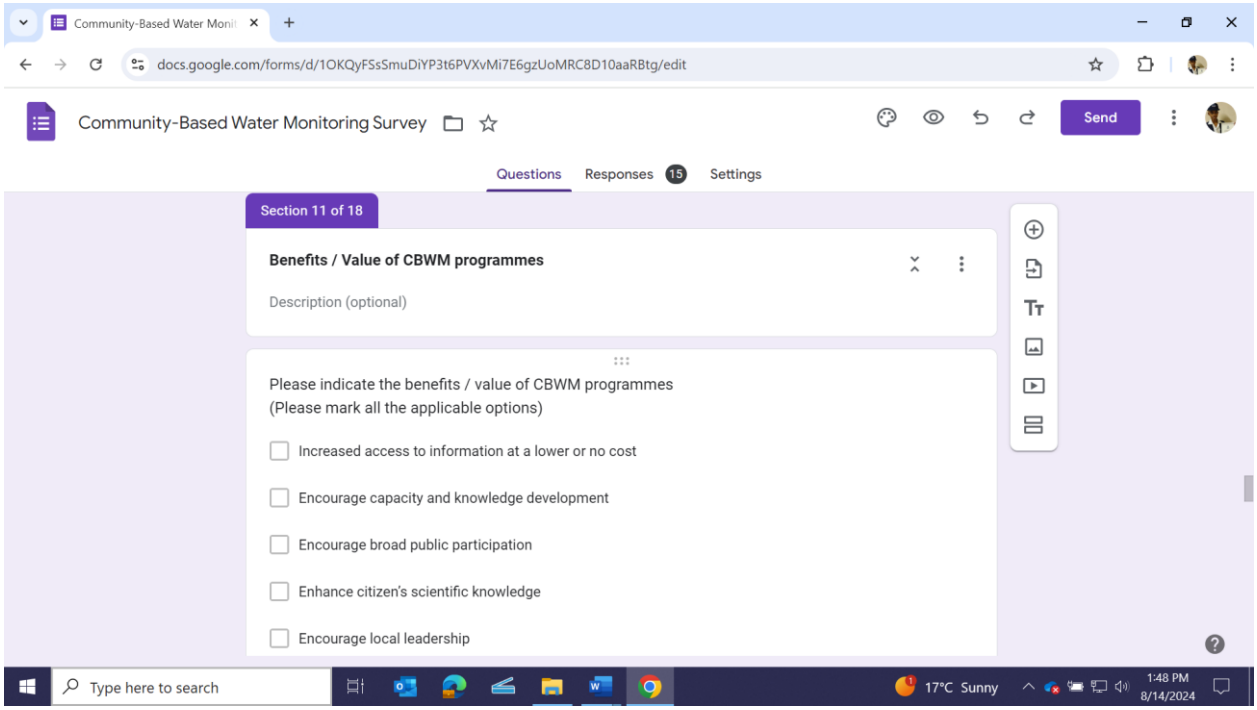
13°C Cloudy
6:25 PM
9/27/2023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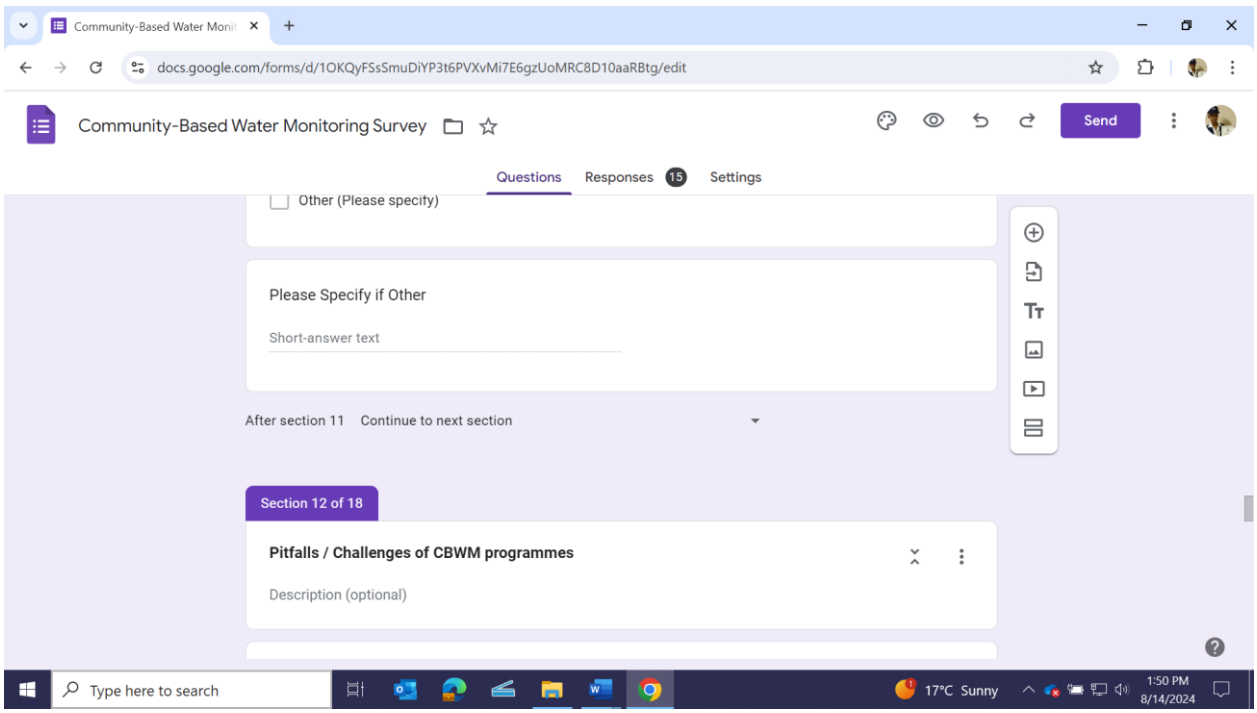
Community-Based Water Monitoring Survey
Send
Questions
Responses 15
Settings
Section 11 of 18
Benefits / Value of CBWM programmes
Description (optional)
Please indicate the benefits / value of CBWM programmes
(Please mark all the applicable options)
Increased access to information at a lower or no cost
Encourage capacity and knowledge development
Encourage broad public participation
Enhance citizen's scientific knowledge
Encourage local leadership
Type here to search
17°C Sunny
1:48 PM
8/14/2024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Community-Based Water Monitoring Survey
Send
Questions
Responses 15
Settings
Other (Please specify)
Please Specify if Other
Short-answer text
After section 11
Continue to next section
Section 12 of 18
Pitfalls / Challenges of CBWM programmes
Description (optional)
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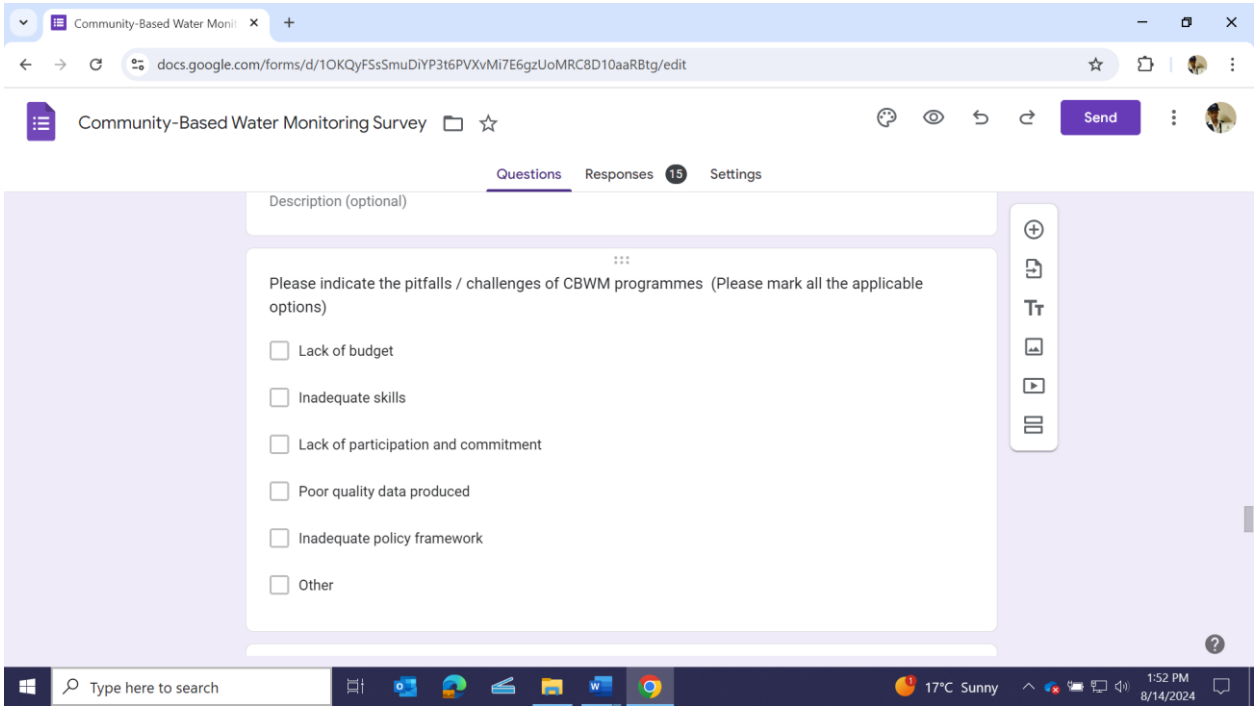
8/14/2024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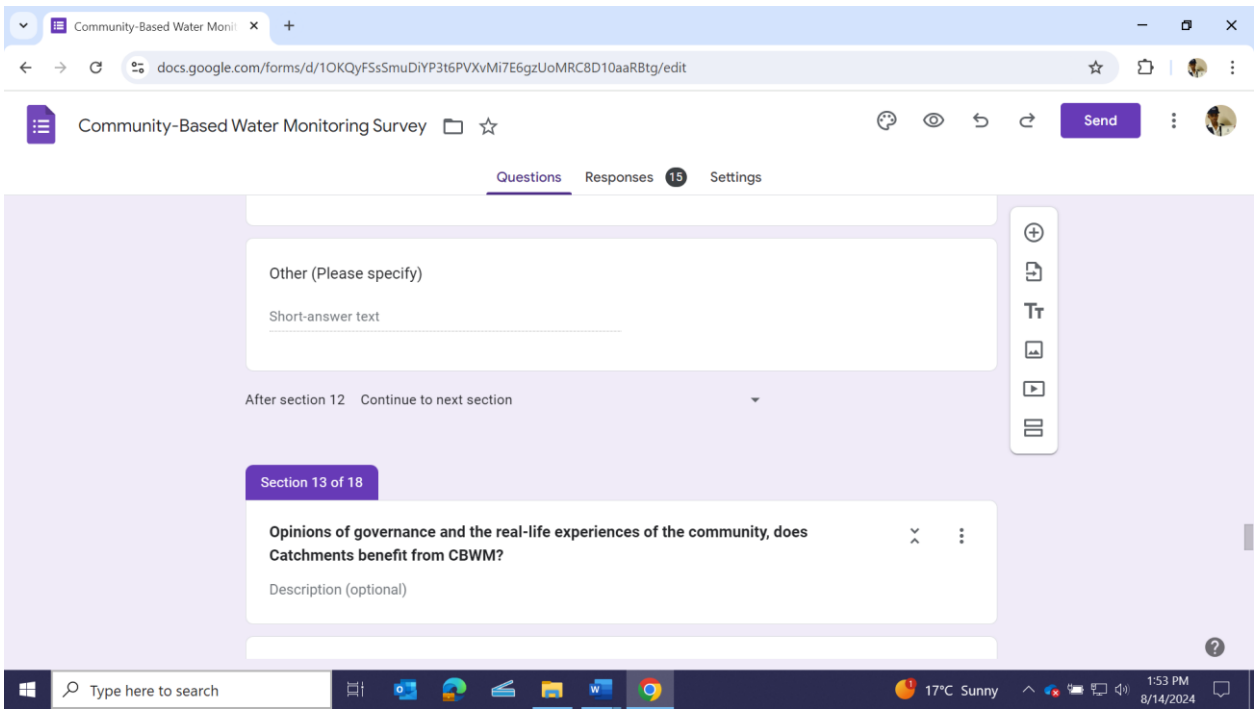
Community-Based Water Monitoring Survey
Send
Questions
Responses 15
Settings
Description (optional)
Please indicate the pitfalls / challenges of CBWM programmes (Please mark all the applicable options)
Lack of budget
Inadequate skills
Lack of participation and commitment
Poor quality data produced
Inadequate policy framework
Other
Type here to search
17°C Sunny
1:52 PM
8/14/2024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Community-Based Water Monitoring Survey
Send
Questions
Responses 15
Settings
Other (Please specify)
Short-answer text
After section 12 Continue to next section
Section 13 of 18
Opinions of governance and the real-life experiences of the community, does Catchments benefit from CBWM?
Description (optional)
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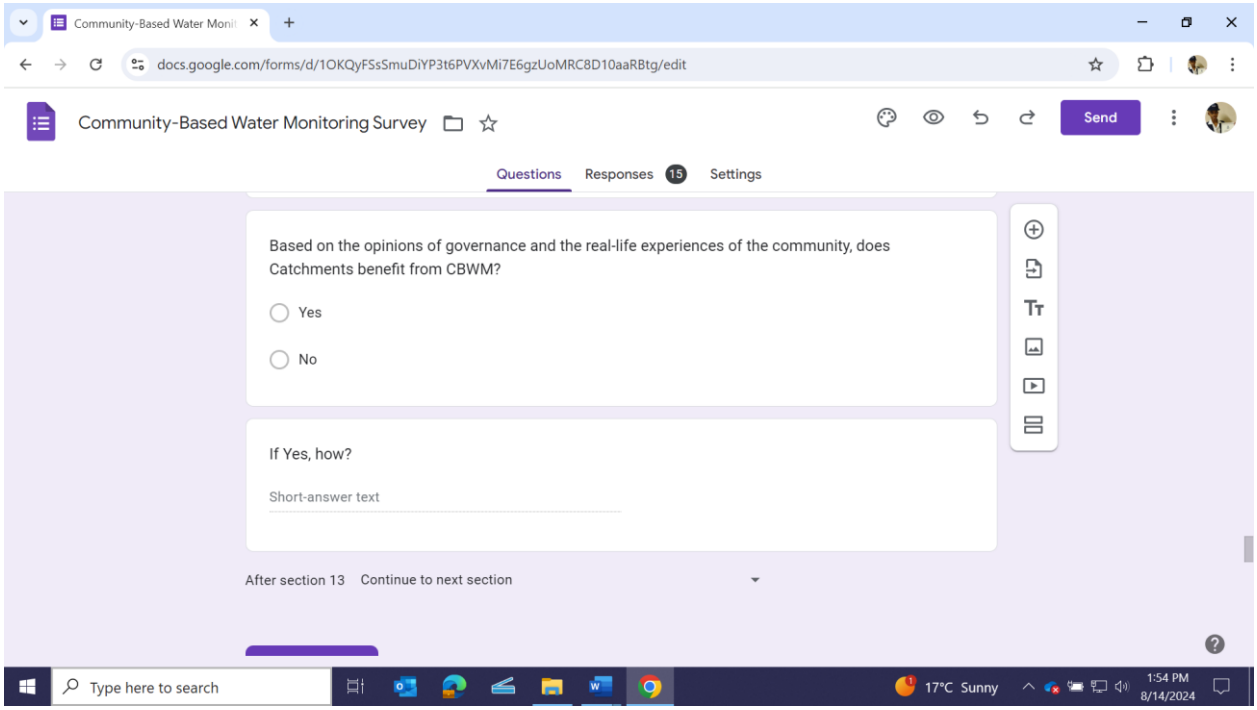
8/14/2024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Community-Based Water Monitoring Survey
Send
Questions
Responses 15
Settings
Based on the opinions of governance and the real-life experiences of the community, does Catchments benefit from CBWM?
Yes
No
If Yes, how?
Short-answer text
After section 13 Continue to next section
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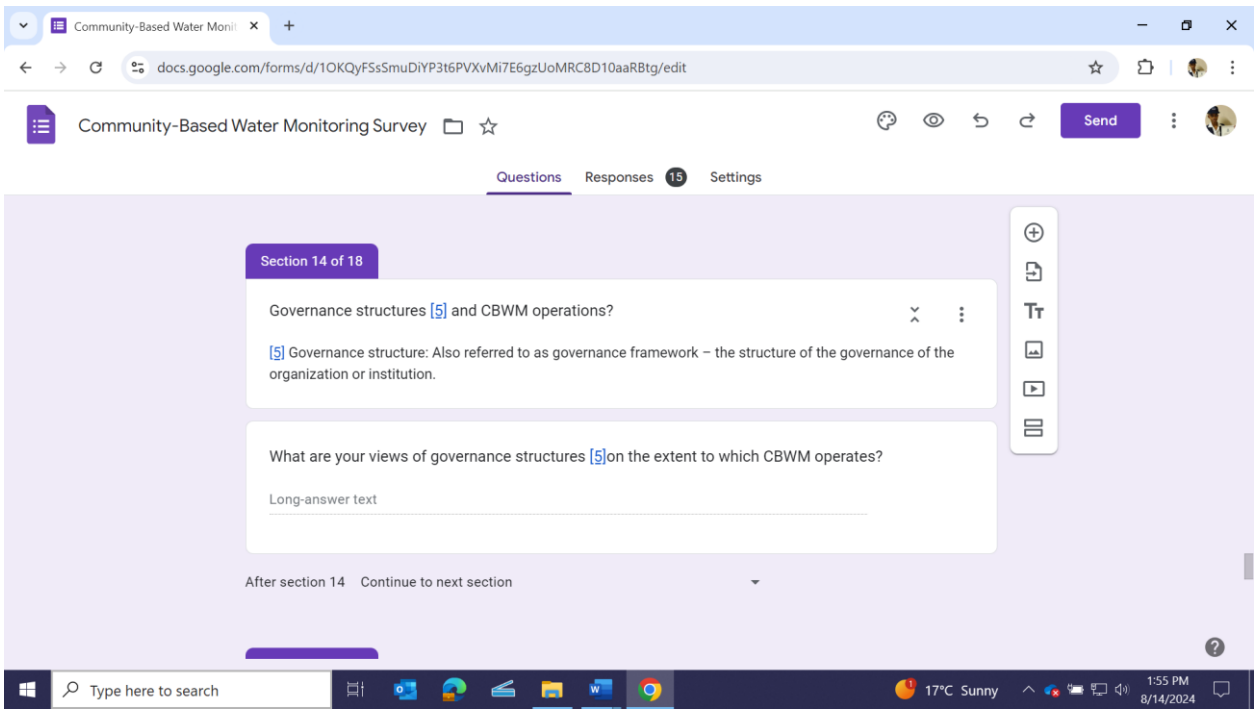
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Community-Based Water Monitoring Survey
Send
Questions
Responses 15
Settings
Section 14 of 18
Governance structures [5] and CBWM operations?
[5] Governance structure: Also referred to as governance framework – the structure of the governance of the organization or institution.
What are your views of governance structures [5]on the extent to which CBWM operates?
Long-answer text
After section 14 Continue to next section
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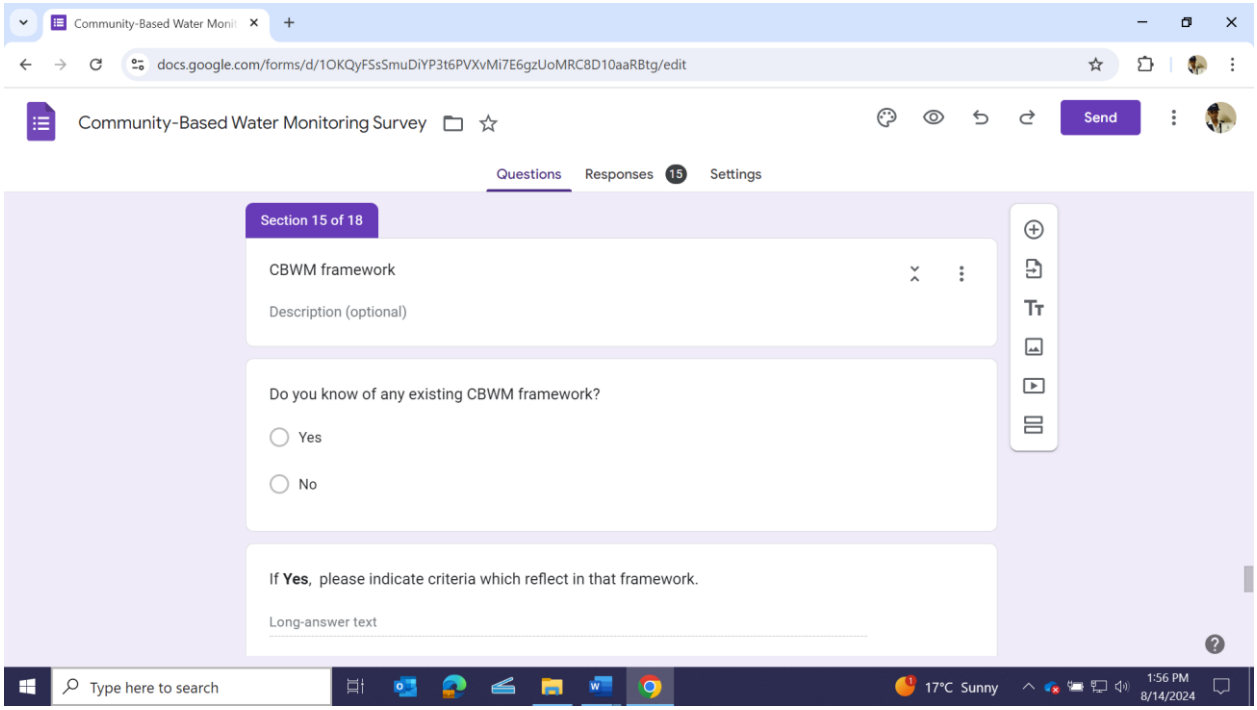
17°C Sunny
1:55 PM
8/14/2024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Community-Based Water Monitoring Survey
Send
Questions
Responses 15
Settings
Section 15 of 18
CBWM framework
Description (optional)
Do you know of any existing CBWM framework?
Yes
No
If Yes, please indicate criteria which reflect in that framework.
Long-answer text
Type here to search
17°C Sunny
1:56 PM
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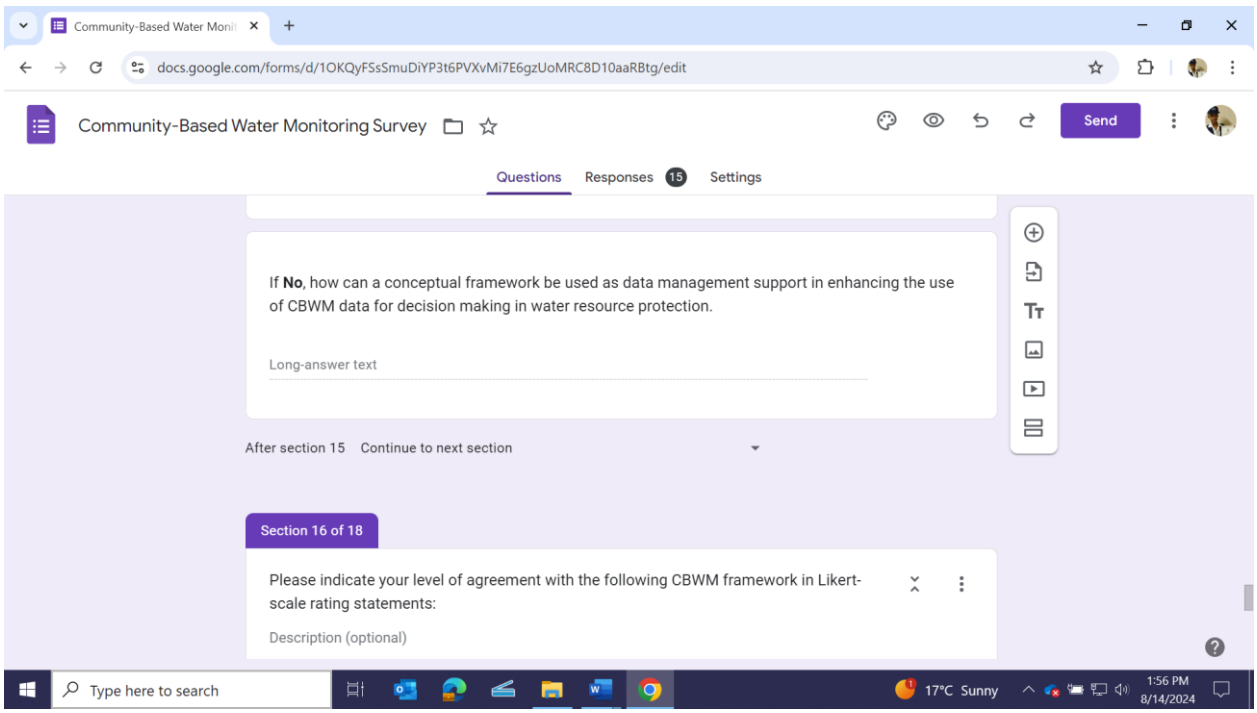
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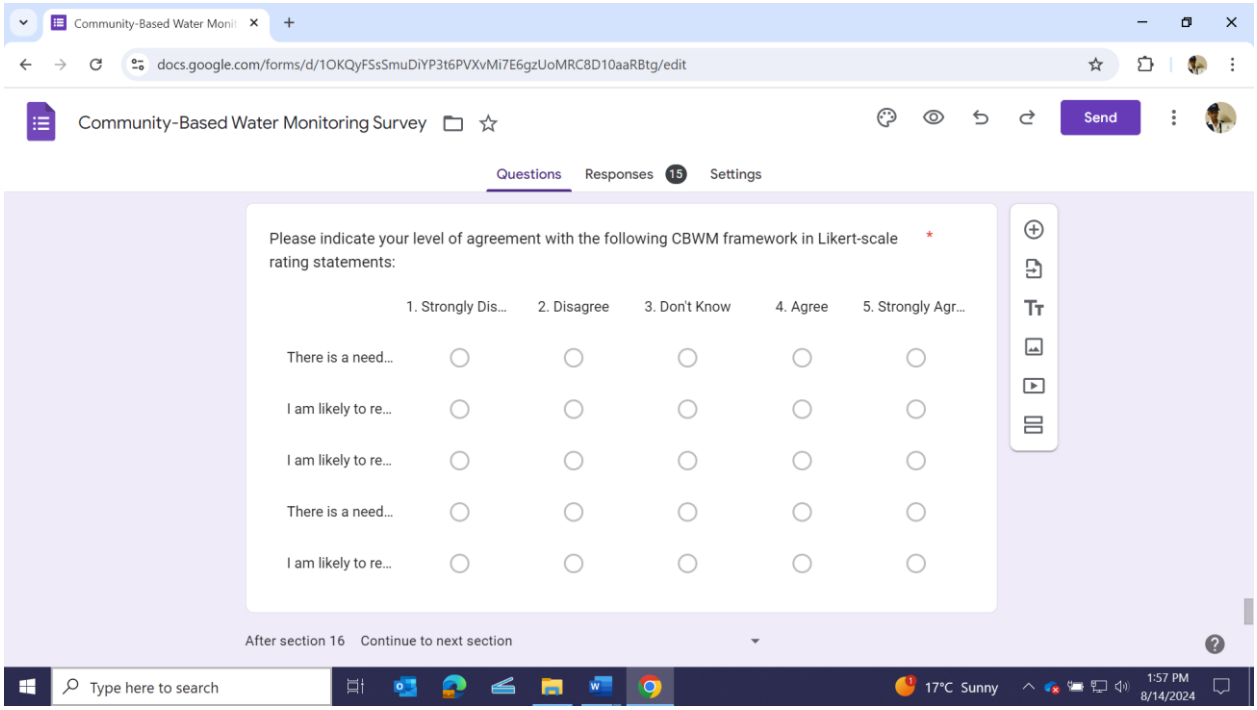
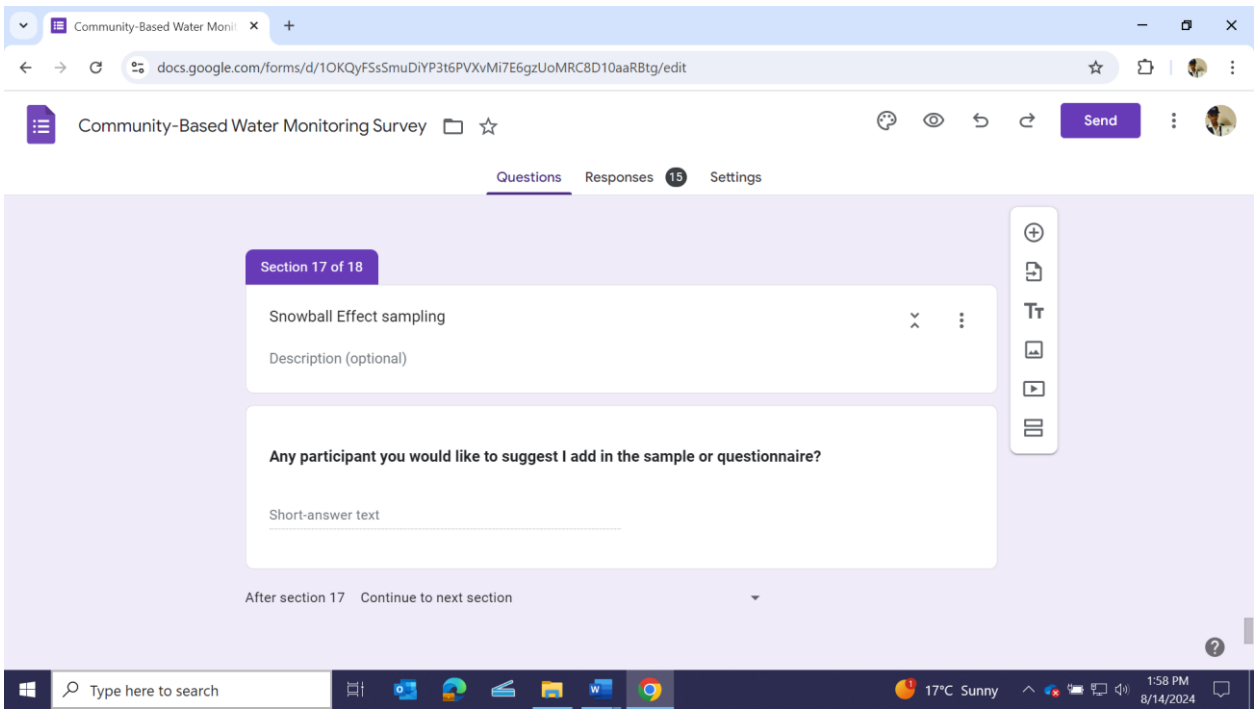
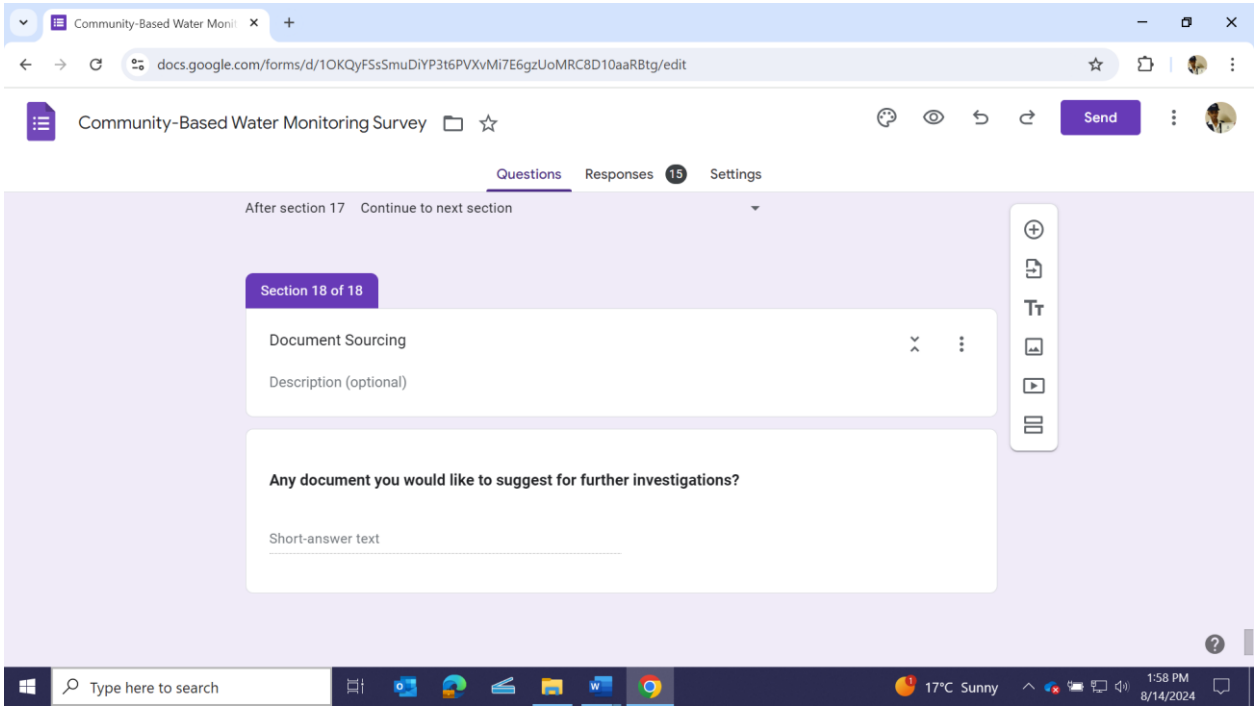
docs.google.com/forms/d/1OKQyFSsSmuDiYP3t6PVXvMi7E6gzUoMRC8D10aaRBtg/edit
Community-Based Water Monitoring Survey
Send
Questions
Responses 15
Settings
If No, how can a conceptual framework be used as data management support in enhancing the use of CBWM data for decision making in water resource protection.
Long-answer text
After section 15 Continue to next section
Section 16 of 18
Please indicate your level of agreement with the following CBWM framework in Likert-scale rating statements:
Description (optional)
Type here to search
17°C Sunny
1:56 PM
8/14/2024


Community-Based Water Monit
docs.google.com/forms/d/1OKQyFSsSmuDiYP3t6PVXvMi7E6gzUoMRC8D10aaRBtg/edit
Community-Based Water Monitoring Survey
Send
Questions
Responses 15
Settings
Please indicate your level of agreement with the following CBWM framework in Likert-scale rating statements:
*
1. Strongly Dis...
2. Disagree
3. Don't Know
4. Agree
5. Strongly Agr...
There is a need...
I am likely to re...
I am likely to re...
There is a need...
I am likely to re...
After section 16
Continue to next section
Type here to search
17°C Sunny
1:57 PM
8/14/2024


Community-Based Water Monit
docs.google.com/forms/d/1OKQyFSsSmuDiYP3t6PVXvMi7E6gzUoMRC8D10aaRBtg/edit
Community-Based Water Monitoring Survey
Send
Questions
Responses 15
Settings
Section 17 of 18
Snowball Effect sampling
Description (optional)
Any participant you would like to suggest I add in the sample or questionnaire?
Short-answer text
After section 17
Continue to next section
Type here to search
17°C Sunny
1:58 PM
8/14/2024



THANK YOU FOR YOUR PARTICIPATION

APPENDIX C: DWS AND COMMUNITY – RESEARCH APPROVAL LETTERS

C1: DWS - Research Approval Letter

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Private Bag X313, Pretoria 0001 /Sedibeng Building, 185 Schoeman Street, Pretoria
Tel: 012 336 7500 / Fax: 012 323 4470 or 012 326 2715

Eng: Mirriam Moagi **Tel**: 012 336 7447 **Fax**: 086650 6241 **Email**: MoagiM@dws.gov.za
Ref: Approval to conduct research

Ms TB Nyamande
Department of Water and Sanitation

Dear Ms Nyamande

APPROVAL TO CONDUCT RESEARCH IN THE DEPARTMENT OF WATER AND SANITATION IN FULFILLMENT OF POSTGRADUATE STUDIES

Your request to conduct research in the Department of Water and Sanitation dated 26 June 2019 refers.

The Department supports and approves your request to conduct research in the Department. You are, however, requested that upon completion of the research, prior to publication of your findings, you submit a draft copy to the office of the Acting Director-General of the Department of Water and Sanitation for concurrence and future use by this Department.

I wish you all the best with your studies.

Yours sincerely

C Greve
CHIEF DIRECTOR: HUMAN RESOURCES
DATE:2019-8-30

C2: Bahurutshe Boo Mokgatlha Traditional (Koffiekraal Community) - Research Approval Letter

BAHURUTSHE TRADITIONAL BOO MOKGATLHA ADMINISTRATION

FROM: GOO MOKGATLHA
MADIKWE
NORTH WEST
2848
15 / 01 / 2020

BAHURUTSHE BOO MOKGATLHA
Traditional Council
2020 -01- 15
P.O. Mokgatlha
NORTH WEST PROVINCE

ENQ: MRS S MAPALETSEBE (SECRETORY)

REF: UNIVERSITY REQUESTS PERMISSION FOR ITS STUDENT TO CONDUCT PhD RESEARCH PROJECT IN OUR AREA.

TO: THE UNIVERSITY OF SOUTH AFRICA
CITY OF TSHWANE
SOUTH AFRICA

TO: PROFESSOR JAN – ALBERT WESSELS

You are hereby informed that your student Mrs. Nyamande Tovhowani Brenda is welcomed to conduct her research project in and around our area. This came after the council was informed by your request and resolved that you are permitted to conduct the research. And the council requests that after the completion of your research; inform us about your findings (the state of water in our area)

On behalf of our community we thank university for being involved in rural development in the past here in our area on the following project: Field Management, Community Tourism, Water Management and Beats Making. We really benefited.

We hope our relationship will never end.

Yours faithfully

Peter Phefo (Traditional Leader)

C3: Mphaphuli Development Trust - Research Approval Letter

Office G-13, Sabina Plaza, 93 Mphephu Drive, Thohoyandou, 0950
Tel: 082 410 0028, Cell: 083 410 1477 or 081 442 3851
admin@mphaphuli.com, mchuthbert@mphaphuli.com

Mrs. Nyamande T.B

University of South Africa

Preller Street, Muckleneuk, Pretoria, 0003

Dear Madam

RE: PERMISSION TO CONDUCT PHD RESEARCH AT LUVUVHU RIVER CATCHMENT, AROUND NANDONI DAM

The above matter refers,

The Mphaphuli Development Trust, a developmental arm of both the Mphaphuli Royal Council and the Mphaphuli Traditional Council now permit you to conduct the study as requested. Please do note that other stakeholders might be affected or interested in your research, whose approval may not be covered by this letter; please consider approaching them separately too.

We hope you find this to be in order. Should you require any other information, please do not hesitate to contact us anytime.

Yours sincerely,

Mphafudi J.P.A

Chairman: Mphaphuli Development Trust

1

APPENDIX D1: ETHICS APPROVAL LETTER – INITIAL APPROVAL

UNISA university of south africa

UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 29/11/2019

NHREC Registration # : REC-170616-051
REC Reference # : 2019/CAES_HREC/182
Name : Ms TB Nyamande
Student #: 67097219

Dear Ms Nyamande

Decision: Ethics Approval from 01/12/2019 to completion

Researcher(s): Ms TB Nyamande
NyamadeT@dwa.go.za

Supervisor (s): Prof JA Wessels
wessej@unisa.ac.za; 011-471-2084

Dr I Aucamp
ilse@equispectives.co.za; 082-828-0668

Working title of research:

Potential value of community-based water monitoring in water resource protection decision-making in a developing country context: South Africa

Qualification: PhD Environmental Science

Thank you for the application for research ethics clearance by the Unisa-CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is granted until the completion of the project, **subject to submission of yearly progress reports and the relevant permission letter. Failure to submit the progress report will lead to withdrawal of the ethics clearance until the report has been submitted.**

Due date for progress report: 30 November 2020

Please note the points below for further action:

1. The researcher indicates in section 3.1 of the ethics application form that permission has been obtained, but no permission letter was attached to the application. The researcher must submit the permission letter as part of the application.

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

2. The researcher did not complete section 4.3 in the ethics application form, which should reflect the aims and objectives of the research. This must be included and the form resubmitted to the committee for record purposes.
3. How was the sample size calculated or arrived at? Has the researcher investigated whether the targeted community-based water monitoring organisations have a membership list? Could the researcher not establish the total population via these lists and then calculate the sample size from that, which would negate the need for snowball sampling?
4. The researcher did not identify the type of documents that will be reviewed, or what they will be reviewed for.
5. The questionnaire asks for the participants' names and other information that identify them. What measures will the researcher put in place to ensure the anonymity of these participants?
6. The researcher indicates that the questionnaires and other documents will be translated before distribution. She is cautioned that all translations should be done by a certified translator.
7. The researcher will include community members in the research. Therefore permission should also be obtained from the relevant community leaders and submitted to the committee.
8. The data analysis section needs to be strengthened, especially regarding the analysis of the quantitative data. The researcher can address this aspect in the first progress report that will be due in one year's time, and need not do so now.
9. The researcher indicates in section 2.5 of the research proposal that she will use SPSS version 2.2 for analysis. However, that is an old version of SPSS, and the researcher is advised to use a newer version such as SPSS version 25.

*The **low risk application** was **reviewed** by the UNISA-CAES Health Research Ethics Committee on 28 November 2019 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.

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4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
7. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:
*The reference number **2019/CAES_HREC/182** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Prof MA Antwi
Chair of UNISA-CAES Health REC
E-mail: antwima@unisa.ac.za
Tel: (011) 670-9391

Prof MJ Linington
Executive Dean : CAES
E-mail: lininmj@unisa.ac.za
Tel: (011) 471-3806

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
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APPENDIX D2: ETHICS APPROVAL LETTER – AMENDMENT APPROVAL

UNISA university of south africa

UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 10/07/2020

NHREC Registration # : REC-170616-051
REC Reference # : 2019/CAES_HREC/182
Name : Ms TB Nyamande
Student #: 67097219

Dear Ms Nyamande

Decision: Approval of Amendment

Researcher(s): Ms TB Nyamande
NyamadeT@dwa.go.za

Supervisor (s): Prof JA Wessels
wessej@unisa.ac.za; 011-471-2084

Dr I Aucamp
ilse@equispectives.co.za; 082-828-0668

Working title of research:

Potential value of community-based water monitoring in water resource protection decision-making in a developing country context: South Africa

Qualification: PhD Environmental Science

Thank you for the application for approval of an amendment to your project to the Unisa-CAES Health Research Ethics Committee. The following amendment is approved:

- The addition of virtual data collection using Microsoft Teams and telephonic interviews.

The researcher is cautioned that consent must be verbally obtained and recorded at the start of each virtual interaction, and that participants must be informed of all stipulations in the Unisa consent form before the interview may commence.

Furthermore, the clarifications required in the original feedback letter as stipulated below must still be addressed in the progress report due in November 2020:

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PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

Due date for progress report: 30 November 2020

Please note the points below for further action:

1. The researcher indicates in section 3.1 of the ethics application form that permission has been obtained, but no permission letter was attached to the application. The researcher must submit the permission letter as part of the application.
2. The researcher did not complete section 4.3 in the ethics application form, which should reflect the aims and objectives of the research. This must be included and the form resubmitted to the committee for record purposes.
3. How was the sample size calculated or arrived at? Has the researcher investigated whether the targeted community-based water monitoring organisations have a membership list? Could the researcher not establish the total population via these lists and then calculate the sample size from that, which would negate the need for snowball sampling?
4. The researcher did not identify the type of documents that will be reviewed, or what they will be reviewed for.
5. The questionnaire asks for the participants' names and other information that identify them. What measures will the researcher put in place to ensure the anonymity of these participants?
6. The researcher indicates that the questionnaires and other documents will be translated before distribution. She is cautioned that all translations should be done by a certified translator.
7. The researcher will include community members in the research. Therefore permission should also be obtained from the relevant community leaders and submitted to the committee.
8. The data analysis section needs to be strengthened, especially regarding the analysis of the quantitative data. The researcher can address this aspect in the first progress report that will be due in one year's time, and need not do so now.
9. The researcher indicates in section 2.5 of the research proposal that she will use SPSS version 2.2 for analysis. However, that is an old version of SPSS, and the researcher is advised to use a newer version such as SPSS version 25.

*The **low risk application** was **reviewed** by the UNISA-CAES Health Research Ethics Committee on 28 November 2019 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.

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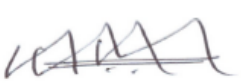
www.unisa.ac.za

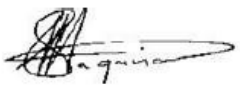
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
8. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **2019/CAES_HREC/182** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,





Prof MA Antwi
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Prof SR Magano
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APPENDIX E: TRANSLATION OF CONSENT FORMS, INTERVIEW SCHEDULE AND QUESTIONNAIRE; TRANSLATION CREDIBILITY CERTIFYING LETTER FROM LANGUAGE PRACTITIONERS

E1: Consent form translated into Setswana

MAMETLELELO A: LEKWALO LA KITSISO LE FOROMO YA TUMELELO E E NANG LE TSHEDIMOSETSO YA POTSOLOTSO

Mosola o o ka nnang teng wa Tlhokomelo ya Metsi e e Theilweng mo Morafeng mo tseong ya ditshwetso tsa Tshireletso ya Metswedithuso ya Metsi mo nageng e e tlhabologang: Aforikaborwa.

Patlisiso e e Tshwerweng ke: Mme Tovhowani Nyamande
0828054449
Moeteledipele wa Patlisiso: Mop. Jan-Albert Wessels
0972524847

Go mongwe yo a ka nnnang motsayakarolo,

O lalediwa go tsaya karolo mo potsolotsong (virtual MS Teams le/kgotsa ka founu) e e tshwerweng ke **Mme Nyamande TB** ka fa tlase ga tlhokomelo ya ga **Prof. Jan-Albert Wessels**, an Associate professor mo lefapheng la Saense ya Tikologo e e isang kwa go nneng le **dikerii ya PhD** kwa University of South Africa.

Potsolotso e diretswe go ithuta ka **selekanyo sa seabe sa setšhaba mo tshireletsong ya motswedithuso wa metsi, le go tlhola gore a tshedimosetso ya go tlhokomela metsi le tshedimosetso e e kgobokantsweng di na le karolo e di e fang mo tseong ya ditshwetso. O kgethilwe go tsaya karolo mo patlisisong e ka gore o moemedi wa lephateng la metsi le le nang le maikarabelo a tlhokomelo le kgotsa taolo ya metsi. Tsweetswee ela tlhoko ba ba ka se akarediwng mo potsolotsong e [ga o na go tshwanelega go tsaya karolo fa o le dingwaga tse di ka fa tlase ga 18].** Ka go tsaya karolo mo potsolotsong o dumela gore tshedimosetso e o e fang e ka dirisediwa mabaka a patlisiso, go akaretsa ka go fetisiwa ka diphasalatso tse di sekasekilweng ke balekane-ka-kemo le dikwalo tsa se se diragalang mo khonferenseng.

Go solofelwa gore tshedimosetso e re nnang le yone go tswa mo potsolotsong eno e **tlaa re thusa go tsaya tshwaelo ya morafe mo saenseng ya tshireletso ya motswedithuso wa metsi e le botlhokwa.** E fa go le jalo, ga o tlamege go tsaya karolo mo potsolotsong le gone o ka ikgogela kwa morago go tswa mo thutopatlisisong pele ga lenaane la potsolotso. Potsolotso e diretswe gore e nne ya botlhokaina mo go rayang gore ga re na go nna le tsela epe ya go golaganya tshedimosetso e o e fang le wena ka sebele. Tshedimosetso epe e e amogelwang tebang le potsolotso e e tlaa nna ya khupamarama ka gore motsayakarolo o tlaa kaiwa ka dipalo (jaaka Motsayakarolo 1) mme e tlaa senolwa fela ka tetla ya gago kgotsa jaaka go lopiwa ke molao. Le fa khupamarama e ka se tlhomamisediwe mo seemong se go botsolotswang batho fa ba botsolotswa ba le mmogo mo setlhopheng, go tlaa tsewa matsapa a gore

E2: Interview schedule translated into Setswana

Karolotlaleletso C: **Lenaane la Potsolotso**

Gore go kgobokanngwe tshedimosetso e e maleba ya sekao sa thutopatlisiso (case study) e, **potsolotso** e e rulagantsweng e na le thulaganyo ka bontlhanngwe e tlaa itebaganya le dipotso tsa bokhutlo jo bo sa tswalelwang le dipotso tsa bokhutlo jo bo tswaletsweng e tlaa dirisiwa. Dipotso tsa potsolotso di kwadilwe ka mo go latelang:

Mametlelelo C: Lenaane la Potsolotso

ELA TLHOKO: Dipotso tsa potsolotso di tserwe mo go Carlson et al (2017) le Gofman (2010).

Madume le gone o amogetswe. Mpolelele ka ga gago – Gore o mang le gore o nna kwa kae?

P= Potso

P1 **A o na le seabe KGOTSA a o ne o na le seabe mo taolong epe ya metsi KGOTSA Tshireletso ya Metswedi ya Metsi?**
Fa e le ee, o na le seabe KGOTSA o nnile le seabe jang?

P2 **Lenaane la Community-Based Water Monitoring (CBWM) (RHP / REMP / AaR programme)**

- A o na le seabe mo porojekeng ya CBWM?
- Leina la porojeke eo ke mang?
- Ke eng maikaelelomagolo a porojeke?
- Batsayakarolo ke bomang?
- Ke mang yo o simolotseng porojeke?

P3 **Mafelo a Tlhokomelo & Melelwane**

- Mafelo a tlhokomelo a kae ka palo?
- Mafelo a tlhokomelo a tlhophilwe jang?
- O dirisa mofuta ofe wa tlhokomelo le gone ke tsela efe e o e dirisang?
- Melelwane ya gago ya tlhokomelo e tlhophilwe jang? (tshwaya karabo ya gago mo lenaneong le le fa tlase)?

Melelwane ya gago ya tlhokomelo e tlhophilwe jang	Tshwaya karabo ya gago (X)
1) tsamaiso ya tlhokomelo ya tlhomamo,	
2) ditlapele tsa morafe o o tshelang go bapa le motswedi wa metsi o o tlhokometsweng,	
3) ka ntlha ya go nna teng ga mothamo jaaka didiriswa tsa tlhokomelo le metswedithuso e mengwe.	
4) a o ne wa latela tsamaiso ya tlhokomelo ya metsi, jaaka go kaetswe ke setheo sa puso, dikgolagano tsa NGO, morafe wa setso, kgotsa mekgatlho e mengwe	

P4 Tlhokomelo ya Datha

4.1 O laola/tsamaisa datha jang?

1. Ke laola/tsamaisa datha ya me	
2. Setho sa puso ke sone se laolang/tsamaisang	
3. Setheo se e seng sa Puso ke sone se laolang/tsamaisang	
Se sengwe (tsweetswee totobatsa):	

4.2 E beilwe, bolokilwe kgotsa akhaefilwe kae?

1. Mo dikhoping tse di tshwaregang	
2. Mo dikhomphiutheng tsa motho ka esi	
3. Mo Dathabeising ya Bosetšhaba	
Se sengwe (tsweetswee totobatsa):	

4.3 O abelana jang datha mo lobakeng lo loleele?

1. Fa motho a e kopa	
2. Go fa phitlhelelo go dathabeisi ya legare	
3. Ga ke abelane datha	
Se sengwe (tsweetswee totobatsa):	

4.4 Kgobokanyo ya datha e duelelwa jang?

1. Ga e fiwe matlole	
2. E fiwa matlole ke puso	
3. E fiwa matlole ke Mokgatlho o e seng wa Puso	
Se sengwe (tsweetswee totobatsa):	

4.5 Ke dikgwetlho dife kgotsa dikganedi tse o kopanang le tsone tse di go itsang gore o laole (tsamaise) datha ka kaetlego?

1. Ga go na dikgwetlho	
2. Ga go na ditlamelo tse di maleba tsa polokelo	
3. Poloko e dirwa ka ditlhophana ntle le kgolagano epe le ba bangwe	
4. Ga go na taolo epe ya tsamaiso ya datha	
Se sengwe (tsweetswee totobatsa):	

4.6 Ke tshegetso kgotsa ditirelo dife tsa tsamaiso ya datha ya setheo tse o di tlhokang?

1. Ga go dipe	
2. Mokgobokanyo wa datha	
3. Dikhomphiutha tse di bolokelang datha	
4. Go kgona go fitlhelela dathabeisi ya Bosetšhaba	
Se sengwe (tsweetswee totobatsa):	

P5 Matlole (Baithaopi kgatlhanong le badirammogo ba ba duelwang le batsayakarolo)

5.1 O ne wa itebaganya jang le morero wa matlole mo porojekeng ya gago?

1. Baithaopi ba ba sa duelweng	
2. Baithaopi ba ba duelwang (dikatso)	
3. Matlole a puso a a tlhomamisitsweng (dikatso)	
4. Matlole a a abiwang ke Mokgatlho o e seng wa Puso (jaaka go Kgobokanya madi)	
Se sengwe (tsweetswee totobatsa):	

P6 Boleng jwa Madi

- A mabaka a go simolola lenaane la CBWM a arabilwe?
- A CBWM e e tlhomilweng e tshegetsa tsweletso ya tlhokomelo, tebang le go tlhagisa dathasete ya pakatelele?
- Boleng (kakanyo ya gago) jwa datha e e dirilweng ke CBWM ke eng?
- Ke eng se o akanyang gore ke phitlhelelo ya konokono ya porojeke?
- Ke kgakololo efe e o ka e fang ba bangwe ba ba ka batlang go dira porojeke e e tshwanang?
- Ke isago efe e o e bonelang porojeke e?

P7 Dilo tse di Laolang Setheo (ke gore, maano, dipholisi, ditirego, dithekenoloji, le ditirelo).

- Goreng ditheo di tshwanetse go inaakanya le tshireletso ya metswedi ya metsi?
- Ke banaleseabe bafe ba ba tshwanetseng go akarediwa mo tshireletsong ya metswedi ya metsi ya setheo?
- Ke tsalano efe e e leng teng fa gare ga kgobokanyo ya datha ya CBWM le tlhabololo ya pholisi?
- A o itse ka letlhomeso lepe la CBWM le le leng teng?

  Fa e le ee, tsweetswee kaya maemo a a kayang letlhomeso leo.

  Fa e le nnyaa, letlhomeso la kgopolo le ka dirisiwa jang jaaka tshegetso ya tsamaiso ya datha mo go nonotsheng tiriso ya datha ya CBWM ya go tsaya ditshwetso mo tshireletsong ya metswedi ya metsi.

A go na le dintlha dipe tse o batlang gore di akarediwe mo potsolotsong e, tse di neng di seyo mo dipotsong tse di fa godimo?

A go na le motsayakarolo ope yo o ka ratang gore ke mo akaretse mo sampoleng kgotsa mo dipotsolotsong?

A go na le tokomane epe e o batlang go e atlanegisa gore e dirisediwe ditlhotlhomiso tsa go ya kwa pele?

RE GO LEBOGELA GO TSAYA KAROLO GA GAGO

E3: Translation credibility certifying letter from the Setswana language practitioner

DR PULA SOLOMON "BASIE" KHUNOU
Box 19134 Pretoria West, 0117
Mobile: +27 73 203 4576; **Tel:** +27 12 382 4430 (O);
Email 1: khunoups@tut.ac.za; Email 2: khunoups@gmail.com;
Accredited Member of the South African Translators Institute (Membership No.: 1000778)

19th November 2020

To whom it may Concern,

RE: CERTIFYING THE CREDIBILITY OF THE TRANSLATED MATERIAL

This is to declare that I, Pula Solomon Khunou, academic, editor and accredited professional translator of the South Africa Translators' Institute (Membership No.: 1000778), have translated the two files namely an *"Annexure A: Letter Of Introduction And Informed Consent Form For An Interview"* and an *"Updated Interview Schedule June 2020"* into Setswana (RSA) for the researcher Mrs Tovhowani Nyamande. I also by this letter certify the credibility of the quality of the translation into Setswana as spoken in the Republic of South Africa.

Dr Pula Solomon "Basie" Khunou
PhD; PGCHE; APTrans (SATI)

UNASHAMEDLYETHICAL

E4: Consent form translated into Tshivenda

TSHIPIDA TSHA A: VHURIFHI HA ŢHALUSO NA FOMO YA THENDELANO YA NYAMBEDZANO

Vhuţhogwa ha u ţoliwa ha maḓi nga vhadzulapo malugana na maga a tsireledzo ya madi, kha shango ḽine ḽa kha ḓi tou bvelela, sa ḽa Africa Tshipembe.

Tsedzuluso yo itwa nga: Vho-Tovhowani Nyamande
0828054449
Mulanuli wa Tsedzuluso: Vho-Prof. Jan-Albert Wessels
0972524847

Kha Muvhudziswa o nangiwaho,

Vha khou rambiwa kha u dzhenelela kha nyambedzano (ine ya do itiwa nga vidio - virtual MS Teams kana nga foini/founu) I no do itiwa nga **vho-Nyamande TB**, vha nga fhasi ha mulanguli **vho-Prof. Jan-Albert Wessels**, vhane vha vha muthusa Professor kha Muhasho wa Science ya zwa u gudela Mupo. nyambedzano ndi tshipida tsha pfunzo ya **PhD degree** (vhudokotela ha pfunzo) kha University ya **Africa Tshipembe**.

nyambedzano yo dzudzanyelwa u ita ngudo nga ha ndeme ya u dzhenelela ha vhadzulapo kha u ţhogomela maḓi, u ţola mawanwa a maḓi na vhuţanzi ho kuvhanganyiwaho u thusa nga u dzhia tsheo. **Vhone vho nangiwa u do dzhenelela kha mutevhe ngauri vhavha vha muimeleli wa miṅwe ya mihasho ya u ţola na u londola maḓi. Kha vha ţhogomele uri: vhana vha minwaha ya fhasi ha fumi malo (18) a vho ngo tendelwa u dzhenelela.** Nga u dzhenelela kha dzi nyambedzano, vhone vha khou tenda uri vhuţanzi vhune vha do vhufha vhu do shumiswa kha research, manwalwa na kha mitangano.

Zwo lavhelelea uri vhuţanzi vhu no do wanala kha hei nyambedzano, vhu do **thusa kha u sumbedza vhuţhogwa ha u shela mulenzhe ha vhadzulapo kha ngudo ya u ţhogomela maḓi**. A vha khou kombetshedzea u dzhenelela kha nyambedzano, na hone vha a tendelwa u litsha vha saathu u thoma u na dzimbudziso. nyambedzano yo bveledzwa nga ndila ine hu si vhe na a no divha uri munwe o fhindula mini, zwine zwa amba uri a huna ano do lunzhedza uri vhone vho fha vhuţanzi vhufhio. Vhuţanzi vhuṅwe na vhuṅwe vhu no sumba vhune kha heyi nyambedzano, vhu do vha zwa tshidzumbe sa izwi muvhudziswa a tshi do fhiwa nomboro mbidzwa (sa tsumbo, muvhudziswa 1), nahone dzina lawe li do ambiwa arali ene mune o ṋea thendelo kana zwo tendelwa nga mulayo. Naho zwa tshidzumbe zwi si nga do konadzea kha dzulo, madzina a vhathu hanga do ṅwaliwa fhasi. Arali vha nanga u dzhenelela kha hei nyambedzano a zwi nga vha dzhieli tshifhinga tshi no fhira mithethe ya 15. A vha nga vhuelwi nga u dzhenelela kha heyi nyambedzano, fhedzi, mvelele dzayo dzi do **vhuedza tshidzulapo nga u khwinisa**

u kunakiswa ha madi na u dzhenelela ha vhadzulapo. A hu khou lavheleliwa masiandaitwa a si a vhudi kha u dzhenelela kha nyambedzano hedzi, fhedzi hu nga vha na mbadelo thukhu thukhu kha data ya musi hu khou shumiswa virtual MS Team, ri tshi vhambedza na u shumisa founu.

Vha languli vha nyambedzano vho ḓi gana u dzumbetshedza vhuṱanzi vhu no ḓo ṋewa, a vha nga vhu phaḓaladzi sa vhuṱanzi ha muthu e eṱhe, vhu ḓo vhewa sa vhupfiwa ha vhathu vhoṱhe.

Vhuṱanzi ho vhulungwaho kha computer na kha zwinwe zwi rathisi zwa thekeniki, vhu do tsireledzwa nga nomboro ya tshiphiri nga muvhudzisi. Zwi do vhulungwa lwa minwaha mitanu, zwi tshi itelwa tsedzuluso dza tshifhinga tshidaho kana zwa tshikolo. Ane a do shumisa mawanwa ayo o vhulungwaho, u do tea u wana thendelo I bvaho kha komiti ya tsedzuluso ya vhuḓifari "Research Ethics Review Committee". Mawanwa o vhulungwaho kha computer a do thuthwa tshothe zwezwo.

A vha nga do badeliwa / holeliwa kha u di wana vho dzenelela kha nyambedzano iyi.

Nyambedzano heyi yo tendeliwa nga vha **College of Agriculture and Environmental Sciences (CAES) UNISA** Ethics Review Committee. Musedzulusi, **vho-Tovhowani Nyamande**, vha wanala nga tshifhinga tsha mushumo kha **012 336 7521 (nomboro ya luṱingo) &** NyamandeT@dwa.gov.za **(e-mail)**. Mulanguli **vho-Prof. Jan-Albert Wessels**, vha wanala nga tshifhinga tsha mushumo kha **011 471 2804 (nomboro ya luṱingo) & wesselsj@unisa.ac.za**. Arali vha na mbudziso nga ha vhudifari ha ngudo heyi, vha nga kwama mudzulatshidulo wa komiti ya tsedzuluso ya vhuḓifari I no pfi **CAES UNISA** Ethics Research Committee. Kana, vha vhiga zwi sa khou tshimbila zwavhudi kha lutingo lwa malhala lwa Univesithi - 0800 86 96 93.

Arali vha saina afho fhasi vha khou tenda uri vha khou ṱoda u dzhenelela kha nyambedzano iyi. Fhedzi arali vha pfa vha si tsha zwi takalela, vha a tendelwa u bva kha ngudo iyi tshifhinga tshiṅwe na tshiṅwe.

Kha vha saine fomo iyi u sumbedza uri:

- Vho vhala vha dovha vha pfesesa zwidodombedzwa zwo newaho afho ntha.
- Vha khou tenda u dzhenelela kha ngudo iyi.

Tsaino ya Muvhudziswa **Ḓuvha**

E5: Interview schedule translated into Tshivenda

Tshipida tsha C: Tsumba mushumo ya Nyambedzano

NB: Dzi mbudziso dza nyambedzano dzo ṅwalwa ho sedziwa maṅwalwa a vho-Carlson et al (2017) na vho-Gofman (2010).

Dzindumeliso! Kha vha pfe vho ṱanganedzwa. Vhone ndi vhone vhonnyi – Dzina ḽavho ndi nnyi nahone vha shumela ngafhi?

M= Mbudziso

M1 Vha shuma na zwa u langula maḓi KANA u a londola?
Arali phindulo I Ee, vhone mushumo wavho u wa mini?

M 2 Community-Based Water Monitoring (CBWM – U ṱoliwa ha maḓi nga vhadzulapo) (RHP / REMP / AaR programme)

- Vhone vha na mukovhe naa kha thandela ya u ṱoliwa ha maḓi nga vhadzulapo?
- Dzina ḽa thandela ndi ḽi fhio?
- Zwipikwa zwa thandela ndi zwifhio?
- Vhathu vho dzhenelelaho ndi vhafhio?
- Thandela yo thomiwa nga nnyi / vho nnyi?

M 3 Mielo ya u ṱola maḓi

- Ndi kha zwipiḓa zwingana kha mulambo, hune maḓi a do ṱoliwa hone?
- Hu ḓo vha hu khou ṱoliwa mini, nahone hu shumiswa maitele-ḓe?
- Mielo ya u ṱola maḓi yo nangiwa / tiwa hani kana ho sedziwa mini (kha vha nange phindulo afho fhasi nga u tou swaya tshidanga)?

Mielo ya u ṱola maḓi	U swaya kha phindulo (X)
1) maitele a u ṱola maḓi a fanaho hoṱhe	
2) zwa vhuṱhogwa kha muvhundu wo dzulelanaho na afho hu no khou ṱoliwa maḓi hone	
3) u vha hone ha mitshini ya u ṱola na mbalo ya vhaṱoli vha maḓi	
4) no tevhedza maga one a maitele a u ṱola maḓi uya nga ha muvhuso, dzinwe thandela, kana pfano ya vhadzulapo?	

M 4 U londola mawanwa a u ṱola maḓi

4.1 Vha londola hani mawaṅwa a u ṱoliwa ha maḓi?

1. Vha tou londola vhone vhane	
2. Zwiimiswa zwa muvhuso ndi zwone zwi no londola	
3. Zwiimiswa zwo ḓiimisaho nga zwoṱhe ndi zwone zwi no londola	
Zwiṅwe-vho (kha vha ṱanḓavhudze):	

4.2 Mawaṅwa a u ṱoliwa ha maḓi a vheiwa kana u vhulungiwa ngafhi?

1. Kha mabammbiri	
2. Kha dzi computer dza vhane vhadzo	
3. Kha Database ya muṱanganelano	
Zwiṅwe-vho (kha vha ṱanḓavhudze):	

4.3 Vha kovhekana hani na vhaṅwe mawanwa a u ṱoliwa ha maḓi, nahone vha vhulunga hani mawanwa eneo lwa tshifhinga tshilapfu?

1. Arali muthu o a humbela	
2. Muthu u fhiwa thendelo ya u dzhena kha database	
3. A vha kovhekani mawanwa	
Zwiṅwe-vho (kha vha ṱanḓavhudze):	

4.4 Thandela dza mawanwa a maḓi dzi badelwa hani?

1. A dzi badelwi	
2. Dzi badelwa nga muvhuso	
3. Dzi badelwa nga zwinwe zwi imiswa	
Zwiṅwe-vho (kha vha ṱanḓavhudze):	

4.5 Dzithaidzo kana vhuleme vhune vha ṱangana naho kha zwa u vhulunga maḓi zwavhudi ndi mini?

1. A huna vhuleme	
2. A huna dzi mbulungelo dza vhudi dza u vhulunga mawanwa	
3. Muṅwe na muṅwe u vhulunga mawanwa awe	
4. A huna vhulanguli kha u vhulunga mawanwa	
Zwiṅwe-vho (kha vha ṱanḓavhudze):	

4.6 Thuso ine vha ṱoda malugana na zwiimiswa zwa u vhulunga mawanwa kana tshumelo ndi ifhio?

1. A huna	
2. Muthu wa u ṅwala mawanwa	
3. Dzi Computer dza u vhulunga mawanwa	
4. U swikelela Database ya muṱanganelano	
Zwiṅwe-vho (kha vha ṱanḓavhudze):	

M5 Dzimbadelo (Vho tou funaho u thusa vha sa badelwi kana u shuma u tshi hola)

5.1 How did you address funding issue in your project?

1. Vho tou funaho u thusa vha sa badelwi / holi	
2. U engedza tshikwama	
3. Tshikwama tsha muvhuso (muholo)	
4. Tshikwama tsha zwiṅwe zwiimiswa (u shuma u tshi hola)	
Zwiṅwe-vho (kha vha ṱanḓavhudze):	

M 5 **Tshikwama** (Vho tou funaho u thusa vha sa badelwi Kana vhashumi vha no khou badelwa)

- Ḽi fhungo ḽa vhane vha khou thusa vha sa badelwi na avho vha no badelwa vho ḽi tandulula hani kha heyi thandela?
- Khaedu dze vha ṱangana nadzo ndi dzi fhio, nahone vho dzi tandulula hani?
- Hu na tshikwama tsho vhetshelwaho iyi thandela ya u ṱoliwa ha maḓi nga vhadzulapo? Arali zwo ralo, tshikwama tsho eḓana, nahone tshelede I dzula I hone naa?
- Zwo dzhia tshifhinga tshingafhani u wana tshikwama itsho, nahone khaedu dzo livhanaho na zwezwo ndi dzi fhio – arali dzi hone?

M 6 **Ndeme ya Tshelede**

- Ndeme ya u thoma thandela (ya tshifhinga tshilapfu) ya u ṱoliwa ha maḓi nga vhadzulapo, yo swikelea naa?
- Uhu u ṱoliwa ha maḓi nga vhadzulapo ho thomiwaho, hu khou u ṱuṱuwedza mvelaphaṋḓa siani ḽa u ṱoliwa ha maḓi na u bveledza mawanwa lwa tshifhinga tshilapfu?
- Ndeme ya mawanwa a u ṱoliwa ha maḓi nga vhadzulapo ndi ifhio?
- Kha inwi, ndeme ya mawanwa a u ṱoliwa ha maḓi nga vhadzulapo ndi ifhio?
- Inwi ni humbula u nga mvelelo khulwane ya iyi thandela ndi ifhio?
- Ngeletshedzo ine vha nga ṋea vhaṅwe vhane vha khou toḓa u thoma thandela ino fana na heneyi ndi ifhio?
- Iyi thandela vha I vhonela vhumatshelo ḓe?

M 7 **Mavhusele a mihasho** (i.e. maine, dzipholisi, mashumisele, zwatekiniki na tshumelo).

- Ndi ngani mihasho I tshi tea u ṱanganelana kha u londola maḓi?
- Ndi mirafho ifhio ine ya tea u vha miraḓo kha mihasho ya ndondola madi?
- Vhushaka vhukati ha u ṱoliwa ha maḓi nga vhadzulapo na u bveledza dzi pholisi ndi vhufhio?
- Vha a ḓivha nga ha inwe tsumba nḓila ya u ṱoliwa ha maḓi nga vhadzulapo vho?

  Arali zwo ralo, kha vha sumbedze nḓila yo shumiswaho u ḓa na tsumba nḓila ya maitele eneo.

  Arali zwi songo ralo, tsumba nḓila ya maitele I nga shumiswa hani u tikedza u langula mawanwa nga vhadzulapo, uri mawanwa eneo a shumiswa-vho hu tshi dzhiwa tsheo nga ha u londola maḓi.

Tshiṅwe tshipiḓa tshi no tea u dzhenisiwa kha u ṱoliwa ha maḓi nga vhadzulapo ndi tshifhio, tshine tsha vha tshi songo ambiwa afho nṱha?

Muṅwe ane vha nga tama a tshi dzhenisiwa kha hezwi zwa dzimbudziso ndi nnyi?

Hu na maṅwe maṅwalwa ane vha nga tama a tshi sedzuluswa naa?

NDO LIVHUWA U DZHENELELA HAVHO

E6: Translation credibility certifying letter from the Tshivenda language practitioner

Mr Ndindeleni Nyamande
2040 Ext 139, ANNLIN
PRETORIA , 0182
E-mail address:
nyamanj@unisa.ac.za
21 October 2019

To whom it may Concern,

RE: CERTIFYING THE CREDIBILITY OF THE TRANSLATED INTERVIEW GUIDE AND CONSENT FORM

This is to certify that I, **Ndindeleni Joshua Nyamande 6908065858084**, am a qualified Language Practitioner with an Honours Degree in translation obtained at the University of South Africa (UNISA). I also am an academic and a professional translator working with the Department of African Languages at UNISA, translating documents from English to Tshivenda and vice versa. I have translated the two documents (**Informed consent letter for interview** and **interview guide**), to Tshivenda to the best of my ability.

Kind Regards

UNISA university of south africa

Mr Ndindeleni Joshua Nyamande

Administrative Coordinator

Department of Psychology

Tel: 012 429 2088

E-mail: nyamanj@unisa.ac.za / manddpsych@unisa.ac.za

E7: Consent form translated into Xitsonga

XIENGETELWA A: PAPILA RA MANGHENELO NA FOMO YA NTWANANO YA NKAMBELOVUTIVI

Nkoka wa vuswikoti byo Langutisa Mati ya Muganga eku endleni swiboho swo sirhelela Tindhawu Laha Mati ma Kumekaka Kona eka vundzeni bya mhaka bya tiko leri hluvukaka: Afrika Dzonga.

Ndzavisiso wu Fambisiwile hi: Man Tovhowani Nyamande
0828054449
Murhangeri wa Ndzavisiso: Prof. Jan-Albert Wessels
0972524847

Eka Munhu loyi a hlawuriweke,

U rhambiwa ku nghenelela eka nkambelovutivi (Ntlawa wo Tirhiseka wa MS na/ kumbe riqingho) lowu fambisiwaka hi **Man. Nyamande TB** ehansi ka vulawuri bya **Prof. Jan-Albert Wessels**, phurofesa ya xinakulobye eka Ndzawulo ya Sayense ya swa Mbangu eka **PhD degree** eYunivhesithi ya Afrika Dzonga.

Nkambelovutivi wu endleriwile ku dyondza **sayizi yo nghenela ka muganga eka nsirhelelo wa ndhawu laha mati ma kumekaka kona, no kamba loko switiviwa swo languta mati na mahungu lama hlengeletiweke ya hoxa xandla eka ku endliwa swiboho. U hlawuriwile ku nghenelela eka nkambelo hikuva u muyimeri eka sekithara ya mati laha u nga na vutihlamuleri byo languta mati na kumbe vulawuri. Hi kombela u tekela enhlokweni ku suka ku nghenelela eka nkambelovutivi lowu [u nge pfumeleriwi ku nghenelela eka nkambelovutivi loko u ri ehansi ka malembe ma 18].** Ku va u nghenelela eka nkambelovutivi lowu, u pfumela leswaku mahungu lama u ma nyikaka ma nga tirhisiwa hi xikongomelo xa ndzavisiso, ku katsa ku hangalasa hi le ka vuhangalasi byo hleriwa hi ntangha ya wena na migingiriko ya minhlengeletano.

Swi languteriwile leswaku mahungu lama hi ma kumaka ku suka eka nkambelovutivi lowu **ma ta hi pfuna ku vona nkoka wo nghenelela ka muganga eka sayense ya nsirhelelo wa ndhawu laha mati ma kumekaka kona**. Hambiswiritano, a wu le hansi ka xiboho xo nghenelela eka nkambelovutivi naswona u nga huma eka dyondzo ku sunguleni ka xedulu ya nkambelovutivi. Nkambelovutivi wu sunguleriwa ku va wu nga tiveki, leswi vulaka leswaku hi nge vi na ndlela yo va hi hlanganisa mahungu lama u hi nyikaka eka wena n'wini. Mahungu man'wana na man'wana lama tiviwaka lama kumekaka ya hlangana na nkambelovutivi lowu ya ta va ya xihundla tanihiloko munhu loyi a ngheneleke a ta tiviwa hi tinomboro (xik. Munhu wo sungula) naswona u ta humeseriwa erivaleni ntsena hi ku kuma mpfumelelo eka wena kumbe loko swi laveka hi nawu. Hambileswi xihundla xi nge tshembisiwi eka ku setiwa ka ntlawa lowu landzelerisaka, mbulavulo wa endliwa leswaku mavito ya vanhu lava ngheneleke ya nga rhekhodiwi hi nkarhi wa minhlangano. Loko u hlawula ku nghenelela eka nkambelovutivi lowu wu nge teki ku tlula **15 wa timinete** ta nkarhi wa wena. U nge vuyeriwi eka ku nghenelela ka wena tanihi munhu un'we,

hambileswi, swi anakanyiwile leswaku swikumiwa swa dyondzo leyi **swi ta vuyerisa muganga hinkwawo hi ku antswisa xiyimo xa tindhawu laha mati ma kumekaka kona no nghenelela ka mukhumbeki**. A hi languteri leswaku u ta hlangana na switandzhaku swin'wana na swin'wana swo ka swi nga ri kahle hi ku va u heta nkambelovutivi, hikokwalaho tichaji ta le hansi ti fambelanaka na nkambelovutivi wa Ntlawa wo Tirhiseka wa MS loko ku fananisiwa na ya riqingho.

Valavisisi va tirhana no tshama na mahungu man'wana na man'wana lama nyikiweke ya ri xihundla, ku va ya nga humeli ehandle ka vulawuri bya hina no vika swikumiwa ku suka eka vonelo ra ntlawa lowu nghenelekе ku nga ri eka vonelo ra munhu un'we.

Mahungu ya swa gezi ya ta hlayisiwa eka khomphyuta leyi sirheleriweke hi rito ra xihundla leri faneleke ku tirhisiwa ku kuma mpfumelelo wo amukeriwa endhawini yo karhi na nchumu wo hlayisa wa le handle hi mulavisisi ku ringana nkarhi wa ntlhanu wa malembe endhawini yo hlayiseka ku endlela ndzavisiso wa nkarhi lowu taka kumbe swikongomelo swa tidyondzo. Ku tirhisiwa ka nkarhi lowu taka ka switiviwa leswi hlayisiweke ku ta va nhlokomhaka eka Nxopaxopo wa Matikhomelo ya Ndzavisiso lowu yaka emahlweni na mpfumelelo loko swi fanerile. Mahungu ya swa gezi ya ta susiwa hi laha ku nga heriki hi ku tirhisiwa ka xiphemu xa khomphyuta lexi faneleke loko mahungu lama lavekaka ya fanele ku herisiwa.

U nge rihisiwi kumbe ku kuma minsusumeto yin'wana ku va u nghenelela eka nkambelovutivi.

Ndzavisiso wu xopaxopiwile no amukeriwa hi kholichi ya Vurimi na Tisayense ta swa Mbangu (CAES) UNISA Ntlawa wa Nxopaxopo wa Matikhomelo. Mulavisisi wo Sungula, **Man Tovhowani Nyamande**, a nga fowuneriwa hi nkarhi wa tiawara ta le ofisi eka **012 336 7521 (Thel) na** NyamandeT@dwa.gov.za **(imeyili)**. Murhangeri wa dyondzo, **Prof. Jan-Albert Wessels**, a nga fowuneriwa hi nkarhi wa tiawara ta le ofisi eka **011 471 2804 (Thel) na wesselsj@unisa.ac.za**. Loko u ri na swivutiso swin'wana mayelana na swiphemu swa matikhomelo swa dyondzo, u nga ti hlanganisa na mutshamaxitulu wa **CAES UNISA** Ntlawa wa Ndzavisiso wa Matikhomelo. Hi ndlela yin'wana, u nga vika mahanyelo man'wana na man'wana yo ka ya nga tolovelekanga eka riqingho ra mahala ra yunivhesithi 0800 86 96 93.

U endla xiboho xo nghenelela eka nkambelovutivi hi ku sayina fomo ya ntwanano. U tshunxekile ku va u huma eka dyondzo nkarhi wun'wana na wun'wana ka ha ri na nkarhi eka ku nghenelela.
Please sign the form to indicate that: Kombela u sayina fomo ku kombisa leswaku:

- U hlayile no twisisa mahungu lama nyikiweke laha henhla.
- U nyika mpfumelelo wa wena ku nghenelela eka dyondzo.

_____ _____

Nsayino wa munhu loyi a nghenelekе **Siku**

E8: Interview schedule translated into Xitsonga

Xiengetelwa C: **Xedulu ya Nkambelovutivi**

Ku kota ku teka mahungu lama nga fanela eka ndzavisiso lowu, **nkambelovutivi** lowu nongonoko wa swivutiso wu nga landzeleriki nawu lowu nga ta tivisa ku hlanganisiwa ka swivutiso swo pfumela ku va munhu a hlamula hi vuenti na swivutiso swo pimela munhu ku va a hlamula hi vuenti wu ta tirhisiwa. Swivutiso swa nkambelovutivi swi mpfampfarhutiwile hi ndlela leyi landzelaka:

Xiengetelwa C: Xedulu ya Nkambelovutivi

NB: Swivutiso swa nkambelovutivi swi huma eka Carlson et al (2017) ma Gofman (2010).

Ku pfuxela no amukeriwa. Ndzi byele hi mayelana na wena – Xana hi wena mani naswona u kumeka kwihi?

X= Xivutiso

X1 **Xana u na KUMBE u ve na xiave eka vulawuri byin'wana na byin'wana bya mati kumbe Nsirhelelo wa Ndhawu Laha Mati ma Kumekaka Kona?**
Loko ku ri ina, u ve na xiave xiave hi ndlela yihi?

X2 **Ku Langutisa Mati ya Muganga (CBWM) (RHP/REMP/ nongonoko wa AaR)**

- Xana u na xiave eka purojeke ya CBWM?
- Xana vito ra purojeke i yini?
- Xana swikongomelo nkulu swa purojeke i yini?
- Xana vanhu lava nga nghenelela i va mani?
- Xana i mani a nga sungula purojeke?

X3 **Tindhawu to Langutisiwa na Tipharamitara**

- Xana i tindhawu tingani to langutisiwa?
- Xana tindhawu to langutisiwa ti hlawuriwile hi ndlela yihi?
- Xana i muxaka wihi wo langutisa naswona ku tirhisiwa maendlelo wahi?
- Xana tipharamitara ta wena to langutisa ti hlawuriwile hi ndlela yihi? (fungha nhlamulo ya wena etafuleni la hansi)?

Xana tipharamitara ta wena to langutisiwa ti hlawuriwile hi ndlela yihi	Fungha nhlamulo ya wena (X)
1) Nawu wo langutisa lowu ringanisiweke,	
2) Swirhangana swa muganga lowu tshamaka kusuhi na ndhawu leyi langutisiweke laha mati ma kumekaka kona	
3) Hikokwalaho ka vukona bya ntalo tanihi switirho swo languta hiswona na switirhisiwa swin'wana.	
4) Xana u landzelerile nawu wo langutisa mati, tanihiloko swi kombisiwile hi nhlangano wa mfumo, netiweke ya NGO, muganga wa ntumbuluko, kumbe mihlangano yin'wana	

X4 Vulawuri bya Switiviwa

4.1.1 Xana u lawula njhani switiviwa swa wena?

1. Lawula switiviwa swa wena	
2. Vulawuri bya Vandla ra Mfumo	
3. Vulawuri bya Vandla ro ka ri nga ri ra Mfumo	
Swin'wana (kombela u hlamusela):	

4.2 Xana swi vekiwa, hlayisiwa kumbe ku rhekhodiwa kwihi?

1. Eka ti phepha ro kandziyisiwa ra switiviwa leri nga le ka khomphyuta	
2. Khomphyuta hi yin'weyin'we	
3. Eka databezi ya Rixaka	
Swin'wana (kombela u hlamusela):	

4.3 Xana u ava njhani switiviwa eka nkarhi wo leha?

1. Loko munhu a kombela	
2. Ku nyika mpfumelelo eka databezi nkulu	
3. A wu avi switiviwa	
Swin'wana (kombela u hlamusela):	

4.4 Xana nhlengeleto wa switiviwa wu seketeriwa hi ndlela yihi hi timali?

1. A wu seketeriwi hi swa timali	
2. Yi seketeriwa hi swa timali hi Mfumo	
3. Nseketelo hi timali ta Nhlangano wo ka wu nga ri wa Mfumo	
Swin'wana (kombela u hlamusela):	

4.5 Xana i mintlhontlho kumbe swirhalanganyi swihi u hlanganaka na swona eka ku lawula switiviwa swa wena hi ku hetiseka?

1. Ku hava mintlhontlho	
2. Ku hava switirhisiwa swa kahle swo veka eka swona	
3. Vuhlayiselo byi endliwa hi vunyingi	
4. U hava vulawuri ehenhla ka vulawuri bya switiviwa	
Swin'wana (kombela u hlamusela):	

4.6 Xana hi wihi nseketelo wa vulawuri bya switiviwa swa vandla kumbe vukorhokeli lebyi u byi lavaka?

1. Ku hava	
2. Ku rhekhoda switiviwa	
3. tikhomphyuta to veka switiviwa	
4. Mpfumelelo eka databezi ya Rixaka	
Swin'wana (kombela u hlamusela):	

X5 Nseketelo wa Timali (Vanhu vo tinyiketela ku kanetana na vatirhi lava hakeriwaka na vanhu lava nga nghenelela)

5.1 Xana u xi tivise hi ndlela yihi xiphiqo xa nseketelo wa mali eka purojeke ya wena?

1. Vanhu vo tinyiketela vo ka va nga hakeriwanga	
2. Vanhu vo ti nyiketela lava hakeriwaka (mali ya le hansi)	
3. Nseketelo wa mali ya Mfumo lowu hlayisekeke (mali ya le hansi)	
4. Nhlangano wa Nseketelo wa timali wo ka wu nga ri wa mfumo (Xik.Ntlakuso wa nkwama)	
Swin'wana (kombela u hlamusela):	

X6 Nkoka wa Mali

- Xana swivangelo swo sungula nongonoko wa CBWM swi tivisiwile ke?
- Xana CBWM leyi simekiweke yi le ku hlayiseni ku yisiwa emahlweni ko langutisa, hi kuya hi ku endla sete ya switiva nkarhi wo leha?
- Xana hi wihi nkoka (vonelo ra wena) wa switiviwa leswi tumbuluxiweke hi CBWM?
- Xana u ehleketa leswaku mfikelelo nkulu wa purojeke hi wihi?
- Xana u nga nyika xitsundzuxo xihi eka van'wana lava nga tsakelaka ku kurisa purojeke leyi fanaka?
- Xana u vona vumundzuku bya njhani hi purojeke leyi?

X7 Vafambisi va Vandla (xik. matshalatshala, tipholisi, swiletelo, maendlelo, tithekinoloji, na vukorhokeli).

- Xana mavandla hikokwalaho ka yini ma fanele ku nghenelela eka nsirhelelo wa ndhawu laha mati ma kumekaka kona?
- Xana i vakhumbeki vahi va faneleke ku nghenelela eka nsirhelelo wa vandla ra ndhawu laha mati ma kumekaka kona?
- Xana hi byihi vuxaka lebyi nga kona exikarhi ka nhlengeletano wa switiviwa swa CBWM na nhluvukiso wa pholisi?
- Xana u tiva rimba rin'wana na rin'wana leri nga kona ra CBWM?

Loko ku ri **Ina,** kombela u kombisa xihlawulekisi lexi tekelaka nhlokweni rimba relero.

Loko ku ri **E-e**, xana rimba ra miehleketo ri nga tirhisiwa hi ndlela yihi tanihi nseketelo wa vulawuri bya switiviwa eku antswiseni ku tirhisiwa ka switiviwa swa CBWM eku endleni ka swiboho eka nsirhelelo wa ndhawu laha mati ma kumekaka kona.

Swihlawulekisi/ swiphemu swin'wana na swin'wana leswi u tsakelaka ku swi engetela eka nkambelovutivi lowu, leswi nga anakanyiwangiki eka swivutiso leswi laha henhla?

Xana ku na munhu un'wana loyi u tsakeleka leswaku ndzi nga n'wi katsa eka sampulu kumbe nkambelovutivi?

Dokhumente yin'wana na yin'wana leyi u tsakelaka ku yi pimanyeta ku va yi lavisisiwa ku ya emahlweni?

INKOMU KU VA U NGHENELERILE

E9: Translation credibility certifying letter from the Xitsonga language practitioner

2020/11/18

To whom it may concern.

RE: CERTIFYING THE CREDIBILITY OF THE TRANSLATED MATERIAL

I Nkateko faith Shikwambana 9108050471087, I am a qualified Language Practitioner with a B-Tech in Language Practice. I translated the two documents (**Informed consent letter for interview** and **Updated interview schedule June 2020**), Into Xitsonga and I have translated them to the best of my ability.

N.F Shikwambana
0790404806
Nkatekofaith87@gmail.com

APPENDIX F1: STUDY POPULATION SAMPLING FRAME OUTLINE INDICATING SUB-RESEARCH QUESTIONS AND RESEARCH METHODS

Topic	Potential value of CBWM in Water Resource Protection decision-making in a developing country context: South Africa.				
Main research question	What is the potential value of CBWM in water resource protection decision-making in a developing country context?				
Research Methods	**Sub-research questions 1**	**Sub-research questions 2**	**Sub-research questions 3**	**Sub-research questions 4**	**Sub-research questions 5**
Literature Review	X	X			
Document Analysis	X	X			
Qualitative Research (Interview Questions)					
Interview Q1					
Interview Q2	X				
Interview Q3		X			
Interview Q4					
Interview Q5					
Interview Q6			X		
Interview Q7				X	X
Quantitative Research (Questionnaire Questions)					
Questionnaire Q1					
Questionnaire Q2					

Topic	Potential value of CBWM in Water Resource Protection decision-making in a developing country context: South Africa.				
Main research question	What is the potential value of CBWM in water resource protection decision-making in a developing country context?				
Research Methods	**Sub-research questions 1**	**Sub-research questions 2**	**Sub-research questions 3**	**Sub-research questions 4**	**Sub-research questions 5**
Questionnaire Q3					
Questionnaire Q4					
Questionnaire Q5					
Questionnaire Q6					
Questionnaire Q7					
Questionnaire Q8					
Questionnaire Q9		X			
Questionnaire Q10	X				
Questionnaire Q11					
Questionnaire Q12			X		
Questionnaire Q13				X	
Questionnaire Q14					X
Questionnaire Q15					X

APPENDIX F2: STUDY POPULATION SAMPLING FRAME OUTLINE INDICATING SUB-RESEARCH QUESTIONS, POPULATION TARGET, RESEARCH METHODS AND SAMPLE SIZE

<table>
<tr><td>Topic</td><td colspan="5">Potential value of CBWM in Water Resource Protection decision-making in a developing country context: South Africa.</td></tr>
<tr><td>Main research question</td><td colspan="5">What is the potential value of CBWM in water resource protection decision-making in a developing country context?</td></tr>
<tr><td>Rationale behind sample size</td><td colspan="5">Participants were purposively chosen for analysis, only participants interested in and involved in CBWM and or water resource management were chosen.</td></tr>
<tr><td>Sub-research questions</td><td>Population Target</td><td>Where</td><td>Who</td><td>Research Method</td><td>Sample size (No. of participants/respondents per case study)</td></tr>
<tr><td rowspan="3">Sub-research questions 1: What are the benefits and pitfalls of CBWM programmes?
Sub-research questions 2: What Criteria / elements should be reflected / considered in CBWM in developing countries?
Sub-research questions 3: Based on the opinions of governance and the real-life experiences of the community, to what extent does selected catchments in South Africa as a developing country benefit from CBWM?
Sub-research questions 4: What are the views of governance structures on the extent to which CBWM operates and what are the real-life experiences of</td><td>• REMP</td><td rowspan="3">1. Luvuvhu case study in Limpopo province

2. Selons case study in Mpumalanga (MP) province

3. Koffiekraal case study in Groot-Marico Catchment, Northwest (NW) province</td><td>• REMP Senior managers
• REMP coordinators
• REMP Champions
• REMP technicians
• REMP Performance reporting officials</td><td rowspan="3">Qualitative (Interviews)

Quantitative (Survey Questionnaires (15 Questions)</td><td>Case Study 1: 13
Case Study 2: 12
Case Study 3: 13</td></tr>
<tr><td>• AaR Project</td><td>• National AaR Senior managers
• National AaR coordinators
• AaR Champions
• AaR managers
• REMP Performance reporting officials</td><td>Case Study 1: 15
Case Study 2: 8
Case Study 3: 14</td></tr>
<tr><td>• Community</td><td>• Research sector (WRC)
• NGO (SAEON)
• Domestic sector (SALGA, COGTA)
• Community members (elderly-senior citizen),
• adults (women & men)</td><td></td></tr>
</table>

Topic	Potential value of CBWM in Water Resource Protection decision-making in a developing country context: South Africa.				
Main research question	What is the potential value of CBWM in water resource protection decision-making in a developing country context?				
Rationale behind sample size	Participants were purposively chosen for analysis, only participants interested in and involved in CBWM and or water resource management were chosen.				
Sub-research questions	Population Target	Where	Who	Research Method	Sample size (No. of participants/respondents per case study)
communities in the South African context? **Sub-research questions 5**: How does the existing framework look like if any / how a conceptual framework might work in enhancing the use of CBWM data for decision making in a developing country context?			• Youth (over 18years).	Qualitative (Document analysis)	
	Government: • National DWS • Provincial DWS • Local (Municipalities) • Nature conservation		• Senior Managers • Middle Managers • Scientific Managers • Production Scientists • Control Environmental Officers • Municipal Managers		
	Documents:	List of documents	N/A		21 documents
Total					**64 participants**

APPENDIX G1: INTERVIEW LIST OF CBWM PROGRAMME BENEFITS AND VALUES AND PITFALLS/CHALLENGES AT LUVUVHU CASE STUDY

CBWM BENEFITS AND VALUES	CBWM PITFALLS/CHALLENGES
• Knowledge of river pollution to community members • River cleaning training • Pollution prevention • No incentives, clean water • Provision of good quality water - use of water to produce your own products (vegetable and fruits) to meet international export requirements • Mapping pollution • Inform / educate • Publish information for academic needs • Environmental benefits • CBWM Framework to be developed – inclusive of everyone • Maintenance of Luvuvhu Catchment connectivity until Kruger National Park (KNP) • Research benefit – education of the communities • Food provision continues – reliable community protein supply from fish • Community identifying water related issues, and report to the Department of Water and Sanitation or local municipality • Community would look further into water over abstraction matter and stop pollution • School children encouraged to start learning about water systems and the importance of water resources at an early age • Early Warning System for collaboration with KNP and neighbouring communities, especially at night • Constituency for Conservation and development Opportunities e.g.	• Community member's ignorance and showing no interest in water management • High cost of monitoring • Lack of budget for travelling and monitoring tools • Historic disadvantaged individuals do not have the means and knowledge of water monitoring • Lack of knowledge for pollutants, especially heavy metals • People are familiar with biological pollutants – as is closer to home – they care about waterborne diseases • Inadequate law enforcement • Lack water monitoring governance (national, provincial, local government) – a blame game - National government is the custodian of water - but neglecting work to local municipalities, who do not have enough capacity to deal with water challenges • Overreliance on PSPs, which is not sustainable and holistic (not involving all the areas of impacts to be covered) and as a result defeating the purpose of community involvement • Lack of real-time data • Involvement of different people working together and not duplicating efforts. • Stakeholder fatigue – communication breakdown leading to monitoring in places that other role players would be, same place, same time • Inadequate enforcement of the National Water Act • Lack of enforcement from the institutions of authority discourages the communities, as

CBWM BENEFITS AND VALUES	CBWM PITFALLS/CHALLENGES
collaboration with other institutions like DFFE • Getting water, as is the source of life • Time saving as the communities grow their own vegetables • Ensuring the safety of the community by training them to monitor water quality in their rivers and springs e.g. Lepelle Water assesses three springs and Ngwenani CBWM Programme assesses four • South Africa is a water scarce country, so there is a need to preserve water • Training in maintenance and fixing of broken pipes and vandalised water infrastructure • Understand the importance of good water quality • Understanding of the scarcity and impacts of the resource • Understanding that data generated from MiniSASS is important, as it indicates how good or bad the water is even if it doesn't tell what the real problem is • The data is useless if DWS don't look at those results and do something with it - there is a need for implementation • Community awareness -The community cannot report further if they send the results to the governing body, and nothing is done • Communities must also become involved, regardless of their financial status • Effective management of the programme - other than chasing around politicians doing nothing • South Africa is a water scare country, so purified water augments the water resource • Prevent pollution and protect aquatic life • Preventing waterborne diseases	they see that after monitoring nothing happens • Lack of implementation of legislation on the authorities – lack of follow-up on issues brought forward by community members, • No significant improvement of water situation • Lack of human capacity • Lack of relevant expertise • The COVID-19 pandemic left the park with challenges such as budget cut, which was strenuous and still is • Lack of planning and coordination of people for the programme roll-out • Lack of patience - understanding one another and working together • Lack of understanding of the concepts “U naka ha madi a zwi ambi u kuna ha madi” If the water looks clean, does not necessarily mean the quality is good. There is a need for translating the programme into mother tongue as that is the only way the programme will be effective • Lack of compensation funds – people need to be funded – There is a need for transport for supervisors to do monitoring and evaluation of projects in different areas. • Inadequate support from the national authorities on local authorities e.g. Mavhola chief ministry at Ngwenani CBWM (Luvuvhu case study) supports the programme • Vandalism and theft of water infrastructure (pipes, valves and monitoring meters and machines) by community members • Difficulties in community members to get access to the program • Conducting CBWM Programme for the right reasons, not to get their picture on the front page of the paper • Shortage of water in the community

CBWM BENEFITS AND VALUES	CBWM PITFALLS/CHALLENGES
• Awareness of the importance of the system	• Monitoring water quality at different process stages, to see the effect of wastewater treatment • Affordability for protective clothing like gloves, boots in need • Safety in the rural areas –- There is a need for security against robbery, killings and river predators like crocodiles and hippopotamus • Uploading data

APPENDIX G2: INTERVIEW LIST OF CBWM PROGRAMME BENEFITS/VALUES AND PITFALLS/CHALLENGES AT SELONS CASE STUDY

CBWM BENEFITS/VALUES	CBWM PITFALLS/CHALLENGES
• Improved water quality • Improved water resource aesthetic conditions • Educational training on solid waste and alert on vandalism of boreholes and transformers • Stipend / allowance • Information sharing with the communities. • To understand the needs of the community members, that is about them • To rectify misunderstanding • Saving on travelling - community members are based on-site or close to the monitoring site • It is a win for the environment - understand the need for environmental protection • It creates awareness - imparting skills and knowledge • Affords the opportunity for community members to interact with the environment • Stop pollution at source • Respecting the water resources • Rapid technique to indicate the state of Rivers • Minimise fruitless expenditure • Relationships for decision-support • Self-policing vs ownership of the resources • Data supplementing government databases • Custodianship - catchment member relations • Individual capacity building on groundwater monitoring skills • Subsistence farming • DWS liaison and regional collaboration	• Lack of continuity – participants losing interest along the way • Financial challenges • Private Property access denial – difficulty in accessing privately owned land • Blame game: Communities blaming Government for the issues bothering them • Community members undermining Government officials, especially officials below the management level e.g. Malelane black-owned farmers refusing to comply with the Buffer Zone/Floodline, giving the reason that they use the land for survival • Community members gave-in their time for nothing – if there is no stipend • Lack of stipend: compensation is required, as most members are not employed • Dumping continues after clean-ups, as the government fails to service the area • Lack of budget to start the project, travelling, and water conservation and demand management • The current state of socio-economic impact in South Africa – challenge to get volunteers without payment • Participants expecting incentives • Participants might be sceptical about getting involved in volunteer programmes • Extreme weather – posing limitations to site access • High unemployment rate linked to disruptions - job creation will encourage water resources protection • Creating expectations like monetary benefits, other than you can sustain will destroy the initiative's spontaneous continuity

CBWM BENEFITS/VALUES	CBWM PITFALLS/CHALLENGES
• Social networking group to share information • Healthy vegetation, habitat (fauna and flora) around the mine • Municipality monthly water savings • Recycled water • Cost savings • Get new data • Early Warning System - Community members are frequent water users with local ecological knowledge and always on the ground	• Monitoring meter batteries dying off on communities • Participation reluctance on community members • Data and information not readily available • No adequate awareness from DWS side • The level of engagement between government and community members might be different (e.g. Government expectations vs community expectations or researchers doing studies for their own benefits, without the intention of community benefits)

APPENDIX G3: INTERVIEW LIST OF CBWM PROGRAMME BENEFITS/VALUES AND PITFALLS/CHALLENGES AT KOFFIEKRAAL CASE STUDY

CBWM BENEFITS/VALUES	CBWM PITFALLS/CHALLENGES
• Water monitoring is important as water is scarce • Polluting reporting on water use activities • Community serving as informer of any potential pollutants • Cleaning the river • Awareness creation on water monitoring is important • Community being part of water resources, as they are affected • Community member's proximity to the water resources – they are the first to know about ecosystem changes • Community involvement decentralises power and encourages ownership • Communities use rivers for their spiritual beliefs, e.g. baptism and traditional rituals • Training for specialist accreditation • Understand the state of water in the area • Understand water quality sources of pollution • It helps save government unavailable resources - CBWM assist DWS on doing some monitoring schedule rounds • Understand the river's behaviour and interconnection with water supply instream dams • Community members serve as an alarm for water quality changes • Understanding of community members' contribution to the environment • Empowering communities to value their contributions • To empower communities to understand the value of the end-product • Empowering communities with better business negotiation skills	• Lack of funds to maintain the project • No budget to support student's fees • No continuity with data collection • Getting people to be committed • Relying on donations to an extent that no donations, no activities • Data doesn't find its way into decision-making • People pushing their own agendas • High rate of unemployment in South Africa forces communities to always think about incentives • Lack of streamlining – more people participating at once • Lack of protective clothing • Sites inaccessibility • Littering • Lack of communication • Difficult to get participation • Participant's lack of understanding of the content • No stipend results in the risk of not being sure of the sustainability of the voluntary processes • To convince the community that it is to their benefit to monitor water resources • Lack of human capacity • Lack of close support from technical experts • Participant's inability to use digital tools • Lack of resources: • Budget – no funds for travelling logistics • Budget for monitoring tools • Human resources – one participant was SASS accredited, since it has expired, no one in the country (government) is accredited

CBWM BENEFITS/VALUES	CBWM PITFALLS/CHALLENGES
• To save water – by avoiding irrigating between 12:00-15:00 • Having enough provision for irrigation water • Training to report leaking pipes • Monitoring helps to understand “you cannot manage what you cannot measure”	• Water user conflict – when community members themselves pollute the water resources • Lack of knowledge • Lack of data sharing • Government as a regulating entity should not be involved in the nitty-gritties of business • The community members are always at risk of exploitation, in the name of community empowerment • Community members fighting • Not selling crops - rotting crops • Water restrictions affect seasonal crops • Flooding of crops • Surface water quality changes as it flows, not easy to identify pollution • Getting a way to empower communities to collect data as evidence to use in court during prosecution • Potential polluters never get to get prosecuted

APPENDIX H1: THE LUVUVHU CASE STUDY INTERVIEW SUMMARY RESULTS INDICATING CBWM CRITERIA

CBWM Criteria	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
Partnerships: Government-0.0%													
Local Stewardship/ CBWM Networks-53.8%			✓	✓		✓	✓	✓	✓	✓			
Both Government & CBWM Networks-38.5%		✓			✓						✓	✓	✓
Involvement of Local Chiefs-7.7%	✓	x	x	x	x	x	x	x	x	x	x	x	x
Types and methods of Monitoring/Programmes: River cleaning-23.1%	x	x	x	x	x	x	✓	✓	✓	x	x	x	x
Water Quality (WQ)-53.8%	x	✓	✓	✓	✓	✓	x	x	x	x	✓	✓	x
REMP(SASS/Mini)-23.1%	✓	x	x	x	x	x	x	x	x	✓	x	x	✓
Water Quantity -0.0%	x	x	x	x	x	x	x	x	x	x	x	x	x
Monitoring Parameters:				✓	✓	✓						✓	
WQ Parameters													
pH				✓	✓	✓						✓	
EC					✓	✓							
Temp				✓	✓	✓							
DO				✓									
TDS/ Clarity tube												✓	
E. coli swab													
CL, NO_3, PO_4, SS, COD													
Standard Monitoring Protocol-76.9.0%	✓	✓	✓	✓	✓	✓	x	x	x	✓	✓	✓	✓
Community Priorities-23.1%							✓	✓	✓				
Availability of monitoring equipment-0.0%													
NGO network- 0.0%													
Data Management: Access to database-38.5%	✓	✓	x	x University system	x	✓ KNP	x	x	x	✓	✓	x	x
Data management support needed?-61.5%	X	x	✓	x	x	✓	✓	✓	✓	✓	x	✓	✓
Funding: Unpaid Volunteers-53.8%	✓				✓	✓	✓	✓	✓	✓			
Paid participants- 46.2%		✓	✓	✓		x					✓	✓	✓
Value for Money: Reasons for CBWM addressed?-61.5%	✓	✓	x	x	x	x ✓	✓	✓	x	✓	✓	✓	✓
Unsure-7.7%													
Reasons not addresses-30.7%													

CBWM Criteria	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
CBWM continuity/ sustainability-38.5% No continuity-61.5%	✓	x	x	x	x	x	✓	✓	x	✓	✓	x	x
Guiding Principles & Institutional Drivers: Relationship between CBWM & Policy development (46.2%)	x	x	x	x	x	✓	x	✓	x	✓	✓	✓	✓
Knowledge of existing Framework need (84.6% No, 7.7% Yes, 7.7% no implementation)	x	x	x	x	x	x	x	x	x	✓x	x	✓	x
Conceptual framework need (100.0%)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bottom-Up conceptual framework-7.7%	x	x	x	x	x	x	x	x	x	x	x	✓	x

✓ = Yes, X=No, x ✓= Not sure, ✓x = No implementation

APPENDIX H2: THE SELONS RIVER CASE STUDY INTERVIEW SUMMARY RESULTS INDICATING CBWM CRITERIA

CBWM Criteria	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Partnerships: Government-0.0%												
Local Stewardship/ CBWM Networks-41.7%								✓	✓	✓	✓	✓
Both Government & CBWM Networks-58.3%	✓	✓	✓	✓	✓	✓	✓	x	x	x	x	x
Involvement of Local Chiefs-0.0%	x	x	x	x	x	x	x	x	x	x	x	x
Types and methods of Monitoring/Programmes:	✓	x	x	x	x	x	x	x	x	x	x	x
River cleaning-8.3%												
Water Quality (WQ)-41.7%	x	x	✓	x	x	x	✓	x	✓	✓	✓	x
REMP(SASS/Mini)-50.0%	x	✓	x	✓	✓	✓	x	✓	x	x	x	✓
Water Quantity -0%	x	x	x	x	x	x	x	x	x	x	x	x
Monitoring Parameters:												
WQ Parameters										✓		
pH												
EC												
Temp												
DO												
TDS/ Clarity tube			✓	✓	✓			✓				
E. coli swab			✓	✓	✓							
CL, NO_3, PO_4, SS, COD												
Standard monitoring protocol-58.3%	x	✓	x	✓	x	✓	✓	x	x	✓	✓	✓
Community priorities-8.3%									✓	x	x	
Availability of monitoring equipment-33.3%	✓		✓		✓			✓	x	x	x	
NGO network-0.0%												
Data Management: Access to database-33.3%	x	x	x	x	x	✓	✓	x	✓	x	✓	x
Data management support needed?-66.7%	✓	✓	✓	✓	✓	x	x	✓	✓	✓	x	x
Funding: Unpaid Volunteers-16.7%	x	x	✓	x	✓	x	x	x	x	x	x	x
Paid participants-83.3%	✓	✓	x	✓	x	✓	✓	✓	✓	✓	✓	✓
Value for Money: Reasons for CBWM addressed? Yes-58.3%, No-33.3, No implementation-8.3%	✓	✓	x	✓x	✓	✓	✓	x	✓	✓	x	x
CBWM continuity/ sustainability- 58.3%	x	x✓	x	x	✓	✓	✓	x✓	✓	✓	✓	✓

CBWM Criteria	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Guiding Principles & Institutional Drivers: Relationship between CBWM & Policy development-33.3%	x	x	x	x	✓	x	✓	x	✓	x	x	✓
Knowledge of existing Framework, No-75.0%, Not sure-8,3%, yes-16.7%	x	x	x	x	✓	x	✓	x ✓	x	x	x	x
CBWM Framework need-100.0%	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Inputs into the development of conceptual framework-100.0%	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bottom-Up conceptual framework-25.0%	x	x	✓	✓	x	x	✓	x	x	x	x	x

✓ = Yes, X=No, x ✓= Not sure, ✓x = No implementation

Data management support – All needed access to central database

APPENDIX H3: THE KOFFIEKRAAL CASE STUDY INTERVIEW SUMMARY RESULTS INDICATING CBWM CRITERIA

CBWM Criteria	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
Partnerships: Government-0%									-				
Local Stewardship/ CBWM Networks-15.4%							✓	✓					
Both Government & CBWM Networks-61.5%, no response-7.7%		✓	✓	✓	✓	✓	x		-	✓	x	✓	✓
Involvement of Local Chiefs-15.4%	✓	x	x	x	x	x	x	x	x	x	✓	x	x
Monitoring Parameters: Types and methods of Monitoring/Programmes: River cleaning-7.7%	x	x	x	x	x	✓	x	x	x	x	x	x	x
Water Quality (WQ)-76.9%	x	✓	✓	x	✓	x	✓	✓	✓	✓	✓	✓	✓
REMP(SASS/Mini)-7.7%	x	x	x	✓	x	x	x	x	x	x	x	x	x
Water Quantity -7.7%	✓	x	x	x	x	x	x	x	x	x	x	x	x
Monitoring Parameters:					✓	✓				✓			
WQ Parameters													
PH					✓								
EC													
Temp													
DO			✓										
TDS/ Clarity tube		✓	✓				✓			✓	✓		
E. coli swab						✓					✓		
CL, NO3, PO4, SS, COD			✓		✓					✓			
Standard Monitoring Protocol-76.9%	x	✓	✓	✓	✓	✓	x	✓	✓	✓	x	✓	✓
Community Priorities-15.4%							✓				✓		
Availability of monitoring equipment-7.7%	✓												
NGO Network- 0.0%													
Data Management: Access to database-23.1%	x	x	x	✓	x	x	x	x	✓	x	✓	x	x
Data management support needed?-92.3%	✓	✓	✓	✓	✓	✓	✓	✓	x	✓	✓	✓	✓
Funding: Unpaid Volunteers-7.7%	✓	x	x	x	x	x		x	x	x	x	x	x
Paid participants-92.3%	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Value for Money: Reasons for CBWM addressed? Yes-53.8%,	x	✓	✓	x	x	x	✓	x	✓	✓	✓	✓	x

CBWM Criteria	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
No-46.2%, No implementation-0.0%													
CBWM continuity/ sustainability: Yes-61.5%	x	✓	x✓	✓	✓	x	✓	x	✓	✓	✓	✓	✓x
Guiding Principles & Institutional Drivers: Relationship between CBWM & Policy development: Yes-30.8%, No-46.2%, Not Sure-7.6%, no implementation-15.4%	x	✓x	x	x	✓x	✓	✓	x	✓	x	x	✓	x✓
Knowledge of existing Framework, No-100.0%	x	x	x	x	x	x	x	x	x	x	x	x	x
CBWM Framework need-100.0%	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bottom-Up conceptual framework-0.0%	x	x	x	x	x	x	x	x	x	x	x	x	x

✓ = Yes, X=No, x ✓= Not sure, ✓x = No implementation

Data management support – All needed access to central database

APPENDIX I1: INTERVIEW FINDINGS OF VALUE OF CBWM DEPICTING CATCHMENT BENEFITING FROM CBWM

CATCHMENT BENEFITS FROM CBWM: LUVUVHU CASE STUDY	CATCHMENT BENEFITS FROM CBWM: SELONS CASE STUDY	CATCHMENT BENEFITS FROM CBWM: KOFFIEKRAAL CASE STUDY
• Data needed for decision-making • Highly needed information • Without data, no information – no good quality water for drinking • Data is being utilised effectively • Continuation of monitoring and interpretation of data • Solving pollution perceptions – how people value their resources • Monetary value • Improvement of health and wellbeing • Ownership of their resources • Overall qualitative and technical • Anecdotal data - data investigation • Respect of nature • Knowledge that water is life • Information hub • Never know if is useful • Data supply - to University of Venda, Environ company, DWS • State of water resources • Pollution awareness - Identify organic pollution –	• Improvement of the river system • Valuable information – for DWS • Value is great – symposium • We cannot meet SDG targets without community involvement • To determine present ecological status • To check the quality of water • It indicates the river condition • Water quality status • Decision-making • Disaster (floods & droughts) Management • Communities to be heard in the CMF • It brings sense of confidence • Capacity building to the community • Foundational training for communities to communicate • To identify challenges • Gives lead to the right mitigation measures • Used for planning • Facilitates implementation	• Value is based on the translation of data to information • Indication of pollution status • Needed proper training • Decision-making • Empowering people • Development of tools • Engagement of communities at lower levels • Data and information production • It gives planning basics • Water resource management interventions • Water conservation and demand management initiatives • Data for planning for water security • For academic researchers • Water allocation • Water management • Identify polluters • Enforcement: beneficiaries – core business, good water quality • Low capital investment

CATCHMENT BENEFITS FROM CBWM: LUVUVHU CASE STUDY	CATCHMENT BENEFITS FROM CBWM: SELONS CASE STUDY	CATCHMENT BENEFITS FROM CBWM: KOFFIEKRAAL CASE STUDY
MiniSASS and waterborne diseases • Job creation • Water availability – treated water • Community accreditation		• Eco-friendly as a company • Information sharing • Accountability - holding government & municipalities accountable

APPENDIX I2: SURVEY QUESTIONNAIRE FINDINGS OF VALUE OF CBWM DEPICTING CATCHMENT BENEFITTING FROM CBWM

CATCHMENT BENEFITING FROM CBWM: LUVUVHU CASE STUDY	CATCHMENT BENEFITING FROM CBWM: SELONS CASE STUDY	CATCHMENT BENEFITING FROM CBWM: KOFFIEKRAAL CASE STUDY
• Expansion on data collection - more stakeholders collecting much needed data as most offices are understaffed. • Wealth of knowledge developed or improved • Indigenous knowledge • Catchment management • alert of crisis • Actual data and information • Community's vested interest in water source protection • Understanding the importance of water - avoid cutting down trees and discharging sewage into the water resources • They are the eyes and ears at catchment level daily • Data collection consistency • Bringing indigenous knowledge into scientific data • Pollution identification • Though the CBWM produces poor quality data at least one can be able to	• Relevant and timeous data. • Engagement in river cleanups • Reporting sewer spillages • Improved water quality • Community reporting pollution to relevant authorities • Pollution identification to implement effective management actions • Data provides evidence to address water disputes or conflicts • The CMF is better positioned to make decisions in terms of water allocation licenses and catchment management	• Community knowledge and commitment • Community participation -citizen science gets communities from all levels (young to elders) • Early Warning System - detect water alteration in time • Extension of resources that are severely lacking from the regulator • Local ownership and buy-in, promotes water stewardship and local actions • Communities becoming decision makers - changing ways of doing things • Information sharing from different stakeholders. • Ownership of policy decisions • Improved catchment integrity • Improved resource protection • Pollution reporting to DWS • Continuity on catchment management • It enhances community capacity building

CATCHMENT BENEFITING FROM CBWM: LUVUVHU CASE STUDY	CATCHMENT BENEFITING FROM CBWM: SELONS CASE STUDY	CATCHMENT BENEFITING FROM CBWM: KOFFIEKRAAL CASE STUDY
see the problem within the catchment • Data dissemination or sharing		

APPENDIX J1: INTERVIEW FINDINGS ON GOVERNANCE VIEWS ON CBWM OPERATIONS

LUVUVHU CASE STUDY	SELONS CASE STUDY	KOFFIEKRAAL CASE STUDY
• It is constitutional and a must to do • Water is life and South Africa is a water scarce country - pollution limits water availability for use • Departmental institutions such as DWS and DFFE are the custodians of water, and should be acting as “big brother”, enforcing laws, leading and guiding other sectors • Water policing serves as community safeguard, as pollution affects poor communities living downstream • NWA stipulated it – the protection of water resources, the Reserve allocation – which is non-negotiable • People’s perception is that the human life is more important than the environment - the quality and functioning of the resources - service to the wealth, health and well-being of people. • All citizens have a role to play • Collaboration between DWS & South African National Parks	• It is a legal requirement • A need to involve people and CMF • It is a legal mandate for DWS to protect the water resources • Institutions should add value – reaching people • In return, institutions need to give back to the communities first – you cannot expect people without water to adopt a river • For the development, a balance water availability of good quality • IWRM – balancing the use and development • One cannot be in all places at the same time e.g. “Legalametsi” is monitoring for RQOs compliance in Mpumalanga and AWARD is policing the implementation of the Reserve • Breaking News about polluted water and cholera scares • Lack of infrastructure • It is crucial in South Africa as we normally have water restrictions now and Day-Zero is approaching • South Africa is a scarce water country - we are	• It is their responsibility, they must take charge • It is their mandate to implement the NWA, especially in the case of DWS • To support fitness for use aspect • We all live downstream, therefore everybody should be involved in the business • Compliance monitoring – no monitoring, no management • Institutions must regulate the work, facilitate the process • Policies are needed to support the institutions • DWA is governing water resource protection – should continue giving good governance • Security of water supply is crucial for mining companies • Water shortage is a major risk – water accountability • Adopted the principle of valuing water – reduce water loss footprint and saving costs • Water is life for: Development, socio-economic issues • A need to reduce the risk of waterborne diseases

LUVUVHU CASE STUDY	SELONS CASE STUDY	KOFFIEKRAAL CASE STUDY
• Cutting trees is easy, but growing a tree takes a lifetime • Budget- is the main thing • Saving water tips, e.g. Cape Town has always been on Day-Zero • A need to educate the masses - the more the marrier, we need more people to protect water	faced with water-shedding risk • A need to collaborate with the communities to prolong Day-Zero implementation • To share information	• A need for implementors • Users down the value-chain • Helps to avoid Customary Water Rights e.g. Old Water Act

APPENDIX J2: SURVEY QUESTIONNAIRE FINDINGS ON GOVERNANCE VIEWS ON CBWM OPERATIONS

LUVUVHU CASE STUDY	SELONS CASE STUDY	KOFFIEKRAAL CASE STUDY
• Data should be centralised in government • Data quality check be conducted by scientists • The government structure does not provide financial support to CBWM • It allows for comparable data • Red tape and bureaucracy discourage community participation • There is no cohesion between national, provincial and local government. • No clear governance framework guiding CBWM activities • Community empowerment takes commitment and dedication more than education • Government relationship with community and societal involvement on the environment • Government structures don't support CBWM • A good platform for community to raise their views • Limited resources - lack of budget to support CMFs and volunteers on AaR programme	• No strategic policies supporting CBWM • Rigid structure that hampers the intended outcomes • CBWMs should collaborate with all 3 levels of government structures • Buy-in and commitment from local councillors must be encouraged • A need for the governance structures • A need for a regulatory framework • A need for stakeholders' involvement	• Lack of community education and empowerment • Governance structures are imperative to provide guidance and to ensure sustainability of efforts to manage catchments • Legal frameworks and policies should support local institutions • This will enforce commitment and continuity of the programme aimed at empowering local communities • Improving data collection to support decision makers with evidence-based data • Lack of structured framework – for data collection, training frameworks, quality assurance, and • Data storage, information disseminated and provision of decision-making platform • Provides accountability, integrity, diversity, and transparency • No structured governing systems – results in haphazard planning

LUVUVHU CASE STUDY	SELONS CASE STUDY	KOFFIEKRAAL CASE STUDY
		• A need for standardised protocols • Attraction of commitment driven communities • Inadequate if not lack of implementation