INFRASTRUCTURE PERFORMANCE, WATER GOVERNANCE AND CLIMATE CHANGE IMPACTS ON WATER RESOURCE MANAGEMENT FOR SMALLHOLDER FARMERS IN THE WESTERN CAPE, SOUTH AFRICA

Report to the

WATER RESEARCH COMMISSION

by

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EXECUTIVE SUMMARY

Background

Water security is a persistent challenge for South Africa's agricultural sector, with smallholder farmers facing disproportionate impacts due to limited access to resources and systemic inequities in water governance and infrastructure. Climate change, manifesting through extreme weather events such as droughts, has intensified these challenges by reducing water availability and increasing competition for resources. Ageing, inadequate water infrastructure, and governance inefficiencies have further hindered smallholder farmers' access to reliable water supplies. This project sought to evaluate the intersection of climate change, water governance, and infrastructure performance, specifically focusing on smallholder farmers in historical towns in the Western Cape, South Africa.

Aims

The project aimed to:

1. Review the status of water availability and water governance systems in historical towns in the Western Cape, South Africa.
2. Assess the impacts of climate change and drought on water resources as experienced by smallholder farmers and water institutions.
3. Evaluate the performance of agricultural water infrastructure supplying smallholder farmers in historical towns in the Western Cape, South Africa.
4. Analyse water governance and institutional arrangements for smallholder farmers using selected Organization for Economic Cooperation and Development (OECD) principles of good water governance.
5. Develop climate-resilient pathways for water resource management and agricultural production for smallholder farmers.

Methodology

The project employed a mixed-methods approach, combining literature reviews, observations, interviews, focus group discussions and workshops with smallholder farmers and institutional stakeholders in the agricultural water sector. Data were collected on water availability, infrastructure performance, and governance challenges. The study used the Three Horizons framework to explore critical challenges and potential pathways for sustainable water management and agricultural productivity.

Results

Climate change has significantly disrupted water resource availability in the Western Cape, South Africa, leading to a series of cascading impacts on agricultural practices, particularly for smallholder farmers. The increased frequency and intensity of droughts, veld fires, and stronger-than-usual winds worsens water scarcity and creates additional environmental stresses. High rainfall variability and elevated evaporation rates undermine the province's reliance on surface water resources, leaving groundwater and small-scale storage systems, such as JoJo tanks, as critical alternatives. However, these systems are often insufficient to meet water demands during prolonged dry spells, further intensifying water insecurity for smallholder farmers. This challenge is particularly acute for farmers with limited financial resources who want to invest in supplementary water storage or alternative irrigation solutions.

The ageing and deteriorating state of water infrastructure presents a significant barrier to effective agricultural water use in South Africa. This deterioration is due to insufficient investment in maintenance and modernisation, alongside limited technical expertise to address these deficiencies. Although newer infrastructure in the Western Cape has alleviated some challenges, regular maintenance and upgrades are essential to sustain functionality. While cost-effective, the widespread use of gravity-fed irrigation systems is often constrained by the lack of land ownership, holding smallholder farmers back from increasing investment.

The inability to adequately monitor and enforce water usage regulations increases disparities, often favouring commercial farmers over smallholder counterparts. Structural inequalities — rooted in historical socio-economic disparities — compound these issues, limiting smallholder farmers' ability to participate in water governance processes. The lack of inclusive decision-making frameworks and a shortage of financial and human resources for smallholder farmer support further entrenches these challenges.

Despite these obstacles, smallholder farmers have demonstrated remarkable resilience by adopting self-organisation strategies, water conservation techniques, and climate-adaptive practices. These include crop diversification, conservation agriculture, and organic farming. Such practices help mitigate the immediate impacts of water scarcity and enhance the long-term sustainability of farming operations. However, these initiatives often operate in silos, lacking the support and scalability necessary to make a broader impact.

Emerging innovations, such as farmer cooperatives and the introduction of more efficient irrigation and farming methods, offer a pathway to improved agricultural productivity and water management. Cooperatives provide a platform for resource pooling, shared infrastructure, and collective bargaining power, enabling farmers to access markets, finance, and technology more effectively. Advanced farming techniques, including precision agriculture and drip irrigation, have the potential to optimise water use and reduce losses. However, scaling these innovations requires targeted investments in capacity building, access to technology, and financial support through subsidies or grants.

Conclusions

There is a complex interplay of challenges smallholder farmers face, including inadequate water infrastructure, restricted access to water, lack of secure land tenure and insufficient funding. While local initiatives and government support show potential, significant gaps remain in addressing systemic inequities and promoting resilience to climate change. This calls for an integrated approach that combines top-down policy interventions with bottom-up community-driven initiatives

Proposed policy changes

- Strengthen water governance by streamlining policies and building capacity in CMAs and WUAs while promoting inclusivity and partnerships with NGOs and the private sector.
- Invest in modernising agricultural water infrastructure, establish a maintenance fund, and incentivise water-efficient technologies like drip irrigation and rainwater harvesting.
- Promote climate-resilient farming through expanded programmes for crop diversification, drought-resistant seeds, seed banks, and contingency plans for droughts.
- Enhance farmer participation and equity by revising water-use policies, establishing local water management councils, and supporting gender-sensitive approaches and innovative financing models.
- Foster collaboration and innovation through multi-stakeholder initiatives, farmer cooperatives, private sector investment, and a dual approach combining top-down policies with community-driven solutions.

Recommendations

The following are the final recommendations from the project:

- Streamlining water governance policies is necessary to reduce bureaucratic delays and enhance transparency through centralised digital water-use licensing systems.
- Allocate targeted funding for modernising smallholder farmer irrigation systems, reservoirs, and distribution networks.
- Expand programmes that disseminate climate-smart agricultural practices such as crop diversification and conservation agriculture.
- Establish local area catchment councils to ensure farmers participate in water resource management and decision-making.
- Promote multi-stakeholder initiatives to mobilise resources and scale successful pilot projects.
- Combine top-down policy frameworks with community-driven initiatives to create scalable and locally relevant solutions.

Recommendations for future research

From the findings of the project, it is recommended that future research should:

- Explore the use of advanced technologies like remote sensing, GIS, and smart irrigation to enhance water efficiency and resource allocation.
- Investigate the integration of traditional practices and local knowledge into water governance and climate adaptation strategies.
- Assess how CMAs and WUAs can ensure equitable water access, transparency, inclusivity, and accountability.
- Integrate peace engineering principles, such as conflict-sensitive design and participatory approaches, to reduce tensions in water management.
- Study innovative financial models like microfinance, blended financing, and public-private partnerships to support smallholder farmers and infrastructure maintenance.

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Ms T Matlhoahela, Western Cape Department of Agriculture passed on during the course of the project. Ms. Matlhoahela connected the farmers with the research team and accompanied them during their fieldwork. May her soul rest in peace.

FARMERS FROM THE FOLLOWING TOWNS:

Goedverwacht, Moorreesburg, Porterville, Swellendam, Bredasdorp, Caledon, Elim, Genadendal, Napier, Suurbraak, Buffeljagsrivier, Tesselaarsdal, Villiersdorp, Greyton, Barrydale.

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1. INTRODUCTION

1.1 Rationale of the research

Water resources are critical for enhancing agricultural production and livelihoods for communities. Globally, including in many developing countries, climate change and water security are regarded as some of the most challenging issues of this era (World Economic Forum (WEF), 2020). Most climate extreme events are water-related, including floods, tsunamis, cyclones, unexpected precipitations, and droughts. Reliance on infrastructural, structural and engineering solutions alone in solving most natural resource problems, while neglecting the importance of good governance, does not yield sufficient results in the management of climate change and water insecurity issues. Solving climate change and water security challenges requires more than technical or infrastructure solutions. To address the issues of climate change and water security concurrently, the link between water and climate is increasingly becoming very essential (World Water Assessment Programme (WWAP), 2020). Traditionally, the development of water infrastructure was regarded as the most useful intervention in addressing the challenges of water scarcity (Tortajada, 2016). The availability and performance of water infrastructure are fundamental to improving the resilience of vulnerable individuals such as smallholder farmers during climate change extreme events such as drought. However, for infrastructure to be resilient, it is necessary to include it in the governance framework (Tortajada, 2016). Resilience can be defined as the capability of water infrastructure to absorb natural and man-made interruptions while maintaining functionality. The development of infrastructure in isolation from water governance can yield limited value (Tortajada, 2016). A lot of water infrastructure has been constructed without taking into consideration the variability of climate change. In the face of uncertainty due to climate change, climate-resilient pathways should consider mechanisms that include water infrastructure, good water governance and functional institutions. Even though infrastructure is very crucial for conveying water, it is required to be closely related to water governance including institutions (formal and informal), policies, regulations, management practices, laws and participation models to ensure the efficient management of water resources and water-related services (Molden et.al., 2014). Various scholars have indicated that the development of water infrastructure alone cannot achieve water security (Inocencio et al., 2007; Faures and Santini, 2008; Zeitoun, 2011). Water infrastructure and governance are strongly linked, and the management of water infrastructure is rooted in a very complex institutional system that consists of several stakeholders (Bruijn & Herder, 2009). To ensure water security the development of infrastructure should go concurrently with policy and institutional arrangements (Cook & Bakker, 2012). An infrastructure that is well-designed and managed is dependent on strong institutional governance and the sustainability of good governance is reliant upon reliable water infrastructure (Biggs et al., 2013).

Coping with water security challenges not only raises the question of “what to do?” but also “who does what?”, “why?”, “at which level of government?” and “how?”. Various water practitioners, scholars and policymakers agree that improving governance is a vehicle towards addressing a lot of water insecurity challenges (Araral & Wang, 2013; Neto et al., 2018; Ozerol et al., 2018). It has been emphasised that a water crisis is not only about too much or not sufficient water, but many times it is because of a governance crisis where the institutions failed to strengthen resilience and adapt to the dynamic of conditions such as climate variability (Organisation for Economic Co-operation and Development (OECD), 2015). Poor governance is considered one of the main factors contributing to the mismanagement of global problems of climate change and water security, leading to inadequate access to water and resources for mitigation and adaptation (WWAP, 2020). According to (Otto et al., 2018), climate change has been estimated to increase the likelihood of the occurrence of drought; therefore, it is important to include climate change as an important factor in water governance (Jack et al., 2016; Schiermeier, 2018). Madani (2014) and Madani et al. (2016) pointed out that governance challenges are the root causes of water scarcity rather than the technical and engineering issues. Rogers & Hall (2003) highlighted that bad governance may increase social and political risks and institutional failure, reducing the capacity to deal with water-related challenges. Conducting a water governance assessment is critical to identify and bridge water governance challenges at any level. The Multilevel Governance Framework under the motto “Mind the Gaps, Bridge the Gaps” has been developed by the OECD based on 12 OECD principles of good water governance to identify and bridge governance gaps in water policies (Akhmouch and Correia, 2016). The OECD’s framework applies in all countries at any level of government regardless of the institutional settings (OECD, 2011) and groups the water governance gaps into seven categories (policy, accountability, funding, information, capacity, objective and administrative).

Water scarcity is becoming a serious challenge in most arid and semi-arid countries, such as South Africa (SA) (Kahil et al., 2015). Rainfall patterns are distributed unevenly in South Africa (Zwane, 2019). In addition, South Africa has high levels of evaporation, which is characterized by low rainfall of about 465 mm per annum compared to the world's average of 860 mm per annum. Only 10% of the country receives above 750mm, of which 50% is used for agricultural production (Zwane, 2019; Department of Water and Sanitation (DWS), 2018; Pitman, 2011;). The decreasing water availability has become a major factor hindering agricultural production in South Africa (Zwane, 2019), especially in smallholder farming, where farmers lack access to agricultural water (Sadiki and Ncube, 2020). Water is considered one of the key limiting factors hindering smallholder food production despite various water sector reforms such as the National Water Act No 36 of 1998 and the Water Allocation Reforms (Department of Water Affairs (DWAF), 2008) that aimed to correct injustices of the past in terms of access to water for production.

The recent 2015-2018 drought in South Africa affected water resources and farming, leading to disaster declarations in several municipalities nationwide. Smallholder farmers were the worst affected (Maltou and Bahta, 2019). In the Western Cape Province in the Overberg District, within which Genadendal is situated, water resources were identified as a critical concern requiring urgent attention (Birch et al., 2017; Ncube, 2020; Fanadzo et al., 2021). The district is vulnerable to both food and water insecurity in the face of drought and climate change. External stakeholders and municipal officials have stated that water resources will decrease because of the increased frequency of drought, rainfall variability, and temperature increase (Birch et al., 2017), compounded by deteriorating infrastructure and system losses. We saw recently how Clover moved its Lichtenburg production facility to KwaZulu-Natal due to poor service delivery, including water and power (Sowetan Live, 8 June 2021). Investments in maintaining water infrastructures are needed to prevent water loss as well as maximize water storage. There is, therefore, a need to have a holistic approach to solving water challenges to assist smallholder farmers in increasing resilience during drought periods. The determinants of agriculture water access by smallholder farmers in West Coast and Overberg Districts are poorly understood, hence the need to further explore them by assessing the performance of agricultural water infrastructure and water governance (including institutions) as well as determine the impact of drought and climate change on smallholder farming.

Recent studies (Ncube, 2020) indicate complex issues around water allocation and water resource management in the Western Cape, especially in historic towns such as Genadendal and Elim in Overberg District and Goedverwacht on the West Coast. Smallholder farmers in these towns reported challenges such as water loss due to degrading water infrastructure, and some had no access to agricultural water due to irrigation channels being closed off by other farmers. The 2015-2018 drought severely impacted the farmers in areas surrounding Goedverwacht. There seemed to be dysfunctional institutional arrangements, and water governance was complex, making it unclear who was responsible for the management of water resources in the areas. The roles of the church, municipalities, and water resource management institutions were not clearly defined. The result was a lack of access to agricultural water by smallholder farmers in the commonage, surrounding rural farms and church-owned land. There were conflicts between smallholders in the commonage and those whose farms were outside the towns. In addition to the lack of access to water, there was a clear deterioration of water infrastructure, and nobody seemed to take responsibility. This research followed up on the Water Research Commission Project (WRC Project, 2716) entitled *'Smallholder farmer drought coping and adaptation strategies in Limpopo and Western Cape provinces*. The main objective was to understand further the relationship between water allocation, infrastructure management, and institutional arrangements in the two towns and surrounding rural areas and how this impacts farmers in the face of climate change and drought.

Several recent studies have been carried out with a focus on the Western Cape water sector (Pienaar et al., 2017; Pegram and Baleta, 2014; Botai et al., 2017; Sorensen, 2017). Previous studies in the Western Cape (Noemdoe et al., 2006; Saruchera, 2008; Zwane, 2019; Ncube, 2018; Ncube, 2020; Fanadzo, 2021) focused mainly on how smallholder farmers can adapt during drought periods and paid little attention to the performance and impacts of agricultural water infrastructure and the underlying water governance and institutional issues affecting access to water. The performance of water infrastructure can be assessed in terms of availability, capacity, continuity and condition. Condition is defined as the status of the water supply system in terms of serviceability, while continuity refers to the stability of water delivery from the source to the water point

(Rietveld, Haarhoff and Jagals, 2009). Capacity is defined as the adequacy of storage, transport and distribution to supply water in the community, and availability refers to the adequacy of the sources of quantity and quality of water obtained from it (Rietveld, Haarhoff and Jagals, 2009). The research, therefore, aims to inform policymakers, decision-makers and policy implementers in developing appropriate water management strategies to ensure adequate and reliable agricultural water supply to enhance farm production and improve the livelihoods of smallholder farmers, especially in the face of drought and climate change. Several studies have looked at drought and climate change impacts and the resilience of South African smallholder farmers to water shortages (Magombeyi and Taigbenu, 2008; Mpandeli et al.; 2015; Manderson et al., 2016; Ubisi et al., 2017). Building resilient farming systems for smallholder farmers in South Africa is very critical as most smallholder farmers are experiencing a lot of pressure to manage water use as a result of water scarcity due to climate change, among other factors (Kativhu, Mwale and Zuwarimwe, 2020). However, many of these studies did not focus on integrating water availability, water governance and institutions, and water infrastructure. Previous studies on smallholder irrigation schemes found that the interplay of socio-economic, institutional and resource-based attributes greatly influenced farmer participation in collective management of schemes (Muchara et al., 2014), and identified the need to understand further the institutional dynamics in which smallholder farmers operate.

1.2 Objectives of the research

The research had five key objectives, each accompanied by specific actions. The first objective focused on initial site characterisation and defining the scope of the study. This involved a desktop review of literature and data, building on insights from the Water Research Commission Project 2716, entitled *Smallholder farmer drought coping and adaptation strategies in Limpopo and Western Cape Provinces.* The review included analysing water supply systems, agricultural systems, and stakeholder networks in South Africa. Water governance systems and policies were also analysed alongside initial stakeholder mapping. The second objective aimed to assess the impacts of climate change and drought on water resources, as understood by smallholder farmers and water institutions. This was achieved through interviews with water institutions such as the municipalities, Breede-Olifants Catchment Management Agency (BOCMA), Worldwide Water Fund (WWF), the Western Cape Department of Agriculture (WCDoA) and smallholder farmer cooperatives, and smallholder farmers in historical towns in the Western Cape Province (Goedverwacht, Moorreesburg, Porterville, Swellendam, Bredasdorp, Caledon, Elim, Genadendal, Napier, Suurbraak, Buffeljagsrivier, Tesselaarsdal, Villiersdorp, Barrydale and Greytown). The third objective assessed the performance of agricultural water infrastructure using water delivery indicators such as adequacy, dependability, equity, and efficiency. Visual assessments through transect walks were used to evaluate infrastructure conditions and irrigation water requirements. The fourth objective explored the performance of water governance and institutional arrangements using selected Organization for Economic Cooperation and Development (OECD) water governance indicators. Data was collected through semi-structured interviews and focus group discussions with smallholder farmers to evaluate governance structures, institutional capacities, and adaptive responses to drought. Finally, the fifth objective developed climate-resilient pathways for water resource management and agricultural production. This was achieved through participatory visioning, scenario development, and stakeholder collaboration using the Three Horizons Framework to propose infrastructure management strategies, transformative actions, and policy recommendations for building resilience in the agricultural water sector.

2. CURRENT KNOWLEDGE ON THE STATUS OF WATER AVAILABILITY, WATER GOVERNANCE SYSTEMS AND INFRASTRUCTURE PERFORMANCE FOR SMALLHOLDER FARMERS IN SOUTH AFRICA

2.1 Introduction

Water resources are critical for enhancing agricultural production and livelihoods for communities. Climate change and water security are regarded as some of the most challenging issues of this era (World Economic Forum (WEF), 2020). Most climate extreme events are water-related, including floods, droughts, etc. The recent 2015-2018 drought in South Africa affected water resources and farming, leading to disaster declarations in several municipalities nationwide. Smallholder farmers were the worst affected (Maltou and Bahta, 2019). All provinces were affected, including the Western Cape, where water resources were identified as a critical concern requiring urgent attention (Birch et al., 2017; Ncube, 2020; Fanadzo et al., 2021). External stakeholders and municipal officials stated that water resources would decrease due to the increased frequency of drought, rainfall variability and temperature increase (Birch et al., 2017), compounded by deteriorating infrastructure and system losses. Issues such as Clover moving its Lichtenburg production facility to KwaZulu-Natal due to poor service delivery, including water and power (Sowetan Live, 8 June 2021), indicate the importance of water. Investments in maintaining water infrastructure are needed to prevent water loss and maximise water storage. There is a need to have a holistic approach to solving water challenges to assist smallholder farmers in increasing resilience during drought periods. The determinants of agricultural water access by smallholder farmers in the West Coast and Overberg Districts were poorly understood in recent studies (Ncube, 2020; Fanadzo et al., 2021; Pili and Ncube, 2022), hence the need to further explore them by assessing the performance of agricultural water infrastructure, and water governance (including institutions) as well as determine the impact of drought and climate change on smallholder farming.

Recent studies (Ncube, 2020; Fanadzo et al.; 2021. Pili and Ncube, 2022) indicate complex issues around water allocation and water resource management in the Western Cape, especially in historic towns such as Genadendal and Elim in Overberg District and Goedverwacht in West Coast. Smallholder farmers in these towns reported challenges such as water loss due to degrading water infrastructure. Some had no access to agricultural water due to irrigation channels being closed off by other farmers. The 2015-

2018 drought severely impacted the farmers in areas surrounding Goedverwacht. There seemed to be dysfunctional institutional arrangements, and complex water governance made it unclear who was responsible for managing water resources in the areas. The roles of the church, municipalities, and water resource management institutions were not clearly defined. The result was a lack of access to agricultural water by smallholder farmers in the commonage, surrounding rural farms and church-owned land. There were conflicts between smallholders in the commonage and those whose farms were outside the towns. In addition to the lack of access to water, there was an evident deterioration of water infrastructure, and nobody seemed to take responsibility.

2.2 Defining smallholder farmers

Smallholder farmers occupy a considerable part of the global farmland, varying from 62% to 85% in Africa and Asia, respectively (Food and Agriculture Organization of the United Nations (FAO), 2014). However, there is no universally accepted definition of a smallholder farmer (Morton, 2007). Nagayets (2005) defined smallholder farmers as those farmers who cultivate on small pieces of land (usually less than 10ha, frequently less than 2ha). These farmers typically rely on family labour, and farming is regarded as their primary source of income generation and food security. In addition, most smallholder farmers, especially those in developing countries, are characterised by low levels of education, low income, restricted land areas, poor access to credits, markets and technical assistance, and persistent dependence on external support. These characteristics reduced their capacity to adapt to climate change (Morton, 2007; Harvey et al., 2014). Also, in many regions, smallholder farmers are situated on marginal lands (for example, areas with poor soils, steep hillside slopes or susceptible to water scarcity or flooding), and this enables them to be highly vulnerable to extreme weather events impacts that can lead to flooding, droughts, or any other problems (Vignola et al., 2015). Furthermore, in developing countries, many smallholder farmers are in remote areas characterised by low-quality infrastructure, which further hinders their ability to access disaster relief, financial assistance, technical assistance, government support or markets (Harvey et al., 2014).

Stewart et al. (2014) mentioned that smallholder farmers are characterised by at least two of the following characteristics: (1) Farm size is limited in comparison to other farms in the sector, (2) Mainly relying on labour from the family, (3) Limited resources in terms of land, technological and technical support, and/or capital for investment and maintenance and (4) Subsistence farming or mixed farming (subsistence farming and market-oriented farming). Stewart et al. (2014) further emphasised that the land required to be classified as a smallholder farmer depends on the crop type and location, with considerable variation within a particular country due to agro-climatic conditions. In South Africa, especially in rural areas, smallholder farming is a significant source of household income and livelihood. However, these smallholder farmers experience many challenges, including limited access to input, poor infrastructure and market access, soil infertility and poor literacy (Mkuhlani et al., 2020). Smallholder farmers in South Africa are also characterised as less-resourced, less educated, and less developed (Thamaga-Chitja and Morojele, 2014). Thomas et al. (2007) highlighted climate variability as one of the main considerable challenges threatening the livelihoods of smallholder farmers. More recently, the South African Department of Agriculture defined smallholder farmers as those who produce for household consumption and markets (South African Department of Agriculture, 2015). Their farming businesses are the family's income source but are not usually the primary source of income. Various non-farm activities also exist as a source of income to sustain the family. This study adopted this definition of smallholder farmer by the South African Department of Agriculture.

2.3 Water resource governance in South Africa

2.3.1 Water resource governance before 1994

The Dutch East Indian Company and Jan van Riebeeck arrived in South Africa in 1652. They introduced a system of private land ownership. They made many changes in the Cape, which included taking up the land from which the indigenous found themselves with limited access to land and water resources. The indigenous people found it increasingly difficult to sustain themselves in a land where access to limited water resources was necessary for survival (Guelke and Shell 1992). The indigenous people were forced to work for the Dutch East Company. The Dutch rule ended in 1805 when the British government took over and started expanding the process of water, land, and institutional reform. The British introduced two new significant developments: the permanent land tenure system and the formalisation of the riparian principle. The government placed primary focus and importance on irrigation and agriculture, which led to the passing of the Irrigation Act of 1912 (Funke et al. 2007).

In 1948, the National Party came into power and introduced the apartheid government, which promoted increasing water resource projects to stimulate the country's economic development. The government also initiated several Acts that increased its control over water resources, such as the Water Act of 1956 (Funke et al. 2007). The National Land Act resulted in 80% of the black population occupying less than 20% of the land. The 1956 Water Act entrenched riparian rights, leading to further water access inequalities across races (Kidd, 2011, Msibi and Dlamini, 2011). There was a clear distinction between private and public water. Private water was defined as all the water flowing naturally on any land, naturally drains, or flows on one or more original grants but was not for common use for irrigation. Public water was defined as the water that flowed or was found or derived from the bed of a public stream, whether visible or not (Vos, 1978; Kidd, 2011).

2.3.2 Water resource governance after 1994

White paper on water policy

The review of water laws started in 1995 with a public booklet meant to stimulate debate on water rights and to solicit comments incorporated into a set of principles by a Water law Review Panel (Seetal and Quibel, 2005). The cabinet approved the principles in 1996. The 1997 White Paper followed the principles of a National Water Policy for South Africa, which described the framework for water management in South Africa. The main objectives of the document were not just to promote equity in access to and benefit from the nation’s water resources for all South Africans but to make sure that the needs and challenges of South Africa in the 21st century could be addressed. The White Paper was developed over two years of hard work and wide consultation, and the product was a very summarised product of the water law review process, outlining the direction of the development of water law and water management systems for South Africa. Some of the key proposals which were to guide water management in South Africa were:

- Water as a national resource
- Water as a right
- Obligations to South Africa’s neighbours
- System of allocation, abolishing the riparian system and implementing phased water allocation
- Water charges that promoted equitable access to water for basic human needs, with provision made for some or all water charges waived

- Water resource protection through an all-sector water use, conservation and protection policy and regulations

The Water Services Act (1997)

The 1994 White Paper on Water Supply and Sanitation laid the foundations for a new Water Services Bill regulating water supply and sanitation services. The Water Services Act, 1997 (Act 108 of 1997) also gives legal force to the Reconstruction and Development Plan (RDP) mandate. It is the governing legislation for water services and sanitation and provides for:

- the rights of access to basic water supply and basic sanitation
- the setting of national standards and norms and standards for tariffs
- water services development plans
- a regulatory framework for water services institutions and water service intermediaries
- the establishment and disestablishment of water boards and water service committees and their powers and duties
- the monitoring of water services and intervention by the Minister or by the relevant Province
- financial assistance to water services institutions
- certain general powers of the Minister
- the gathering of information in a national information system and the distribution of that information

National Water Act (1998)

The National Water Act (NWA) of 1998 provides for fundamental reform of the law relating to water resources, repeals certain laws, and provides for matters connected therewith. The NWA also focused on redressing the issues of past racial and gender discrimination, promoting equitable access to water, and facilitating social and economic development. The purpose of the 1998 Water Act is to ensure that the nation's water resources are protected, used, developed, conserved, managed, and controlled in ways which take into account amongst other factors:

- meeting the basic human needs of present and future generations.
- promoting equitable access to water.
- redressing the results of past racial and gender discrimination.
- promoting the efficient, sustainable, and beneficial use of water in the public interest.
- facilitating social and economic development.
- providing for growing demand for water use.

- protecting aquatic and associated ecosystems and their biological diversity.
- reducing and preventing pollution and degradation of water resources.
- meeting international obligations.
- promoting dam safety.
- managing floods and droughts

The National Water Resource Strategy (2004, 2013, 2023)

The National Water Resource Strategy (2008, revised 2013, and the latest in 2023) is the document that operationalises the National Water Act (NWA) of 1998. The document set out priorities articulated in the National Development Plan, which are the key drivers to make the change and shape the strategy. The priorities include the economy and development, economic infrastructure, inclusive rural economy, and education and innovation. The economy and development priority focuses on creating job opportunities. The economic infrastructure priority ensures that people have access to clean, potable water and sufficient water for agricultural and industrial use. It also aims to support historically disadvantaged individual farmers. The inclusive rural economy priority aims to activate rural economies through improved infrastructure and service delivery. South Africa aims to develop food, energy and water markets and initiate water management agreements with neighbouring countries. The water sector has established institutional and transboundary arrangements for water management. Lastly, the educational and innovation priority aims to educate and raise awareness about water management, protection, use, conservation, and the creation and development of strategies to improve skills and productivity in the water sector (NWRS, 2013).

The second National Water Resource Strategy (NWRS2, 2013) identified outstanding commitments not addressed by NWRS1. The NWRS2 aims to protect, use, develop, conserve, manage and control scarce water resources towards achieving the NDP. The NWRS2 aimed to ensure that water serves as an enabler for inclusive economic and social development. There are seven strategic themes in the NWRS2, with proposed execution methods, including institutional arrangements, monitoring and information management, financing for the water sector, and research and innovation. The NWRS 2013 put in place five allocation priorities. The priority is the reserve, the second is meeting international water requirements in terms of agreement with riparian countries, and the third priority is the allocation of water for poverty eradication, improving the livelihoods of the poor and marginalised and contributing to gender and racial equity.

The fourth priority is for national economic purposes, and the fifth priority is to ensure general economic purposes (NWRS, 2013). The strategy was previously reviewed every five years.

The third National Water Resources Strategy (2023) focuses on equitable and sustainable water access and use. The role of the Department of Water and Sanitation is to support the strategy through three overarching goals:

- That water must be protected, used, developed, conserved, managed and controlled sustainably and equitably.
- That water and sanitation must support development and the elimination of poverty and inequality.
- That water and sanitation must contribute to the economy and job creation.

Water Allocation Reforms

The Water Allocation Reform Strategy of 2008 built on the foundational principles outlined in earlier documents, such as the 2005 draft Position Paper, to advance equitable access to water resources in South Africa. The strategy stresses the critical role of water allocation in addressing historical inequalities, eradicating poverty, and promoting sustainable economic growth (DWAF, 2008). It prioritises initiatives that support race and gender transformation and the development of viable water-using enterprises, particularly those led by previously disadvantaged individuals and communities. Central to the strategy is the promotion of water use authorisations that includes ensuring that water allocation processes are transparent, inclusive, and responsive to the needs of all stakeholders, particularly marginalised groups (Blacks and women). The strategy of WAR set out approaches or processes that were critical for the achievement of the WAR objectives (DWS, 2014):

- Take steps to meet the water needs of Historical Disadvantaged Individuals and the poor
- Ensure participation by these groups in water resource management
- Promote the sustainable use of water resources
- Promote the beneficial and efficient use of water in the public interest
- Support of government programmes aimed at poverty eradication, job creation, economic development, and rural development

There were several strategic mechanisms and approaches by which the WAR should achieve the set targets. However, the WAR process is very complex and requires collaboration between institutions and, more importantly, public involvement.

Water Roadmap and National Water and Sanitation Master Plan

In 2015, South Africa launched the Water Research, Development, and Innovation (RDI) Roadmap (2015-2025). The Water RDI focuses on implementing national policy, strategy, and planning in water resources management, including the NDP and the National Water Resource Strategy. More recently, South Africa also launched the National Water and Sanitation Master Plan (NWSMP, 2019), which was developed concurrently with the new legislation and strategies. The master plan outlines a series of actions that need to be implemented by the entire water sector to achieve the government's goals and objectives. The plan is based on five key objectives that define a 'new normal' for water and sanitation management in South Africa. (These are: 1) a resilient and fit-for-use water supply, 2) universal water and sanitation provision, 3) equitable sharing and allocation of water resources, 4) effective infrastructure management, operation and maintenance and 5) reduction in future water demand (NWSMP, 2019).

National Water Amendment Bill

In 2023, the Department of Water and Sanitation Minister published the National Water Amendment Bill. The bill seeks to amend certain definitions, ensure equitable water allocation, optimize water use in support of the guiding principles of the National Water Act, and prohibit undesirable consequences of private water trading, among others. The bill also provides for periodic reviews of the national reserve, the national strategy, water use classification determinations, and water resource quality objectives.

2.4 Roles of water management institutions in South Africa

2.4.1 Department of Water and Sanitation

In South Africa, water resources are primarily managed at the national level by the Department of Water and Sanitation (DWS) as prescribed in the National Water Act of 36 of 1998 and Water Service Act 108 of 1997. The DWS is the custodian of water resources and has a legislative mandate to ensure that water resources are used sustainably, protected, developed, managed, and controlled (DWS, 2016). The DWS is the leader and regulator of the water and sanitation sector and is responsible for ensuring equitable access to water resources in the country (Elias, 2015). The government holds full ownership of water resources in South Africa, and the DWS manages the authorisation of water use rights (Enqvist and Ziervogel, 2019).

The DWS is responsible for developing national water policy, strategy, and legislation, including coordinating, overseeing, supporting, and managing the maintenance of bulk water infrastructure (Weston and Goga, 2016). However, DWS's development and maintenance of water infrastructure are mainly at the national level. While the provision of sanitation services remains that of local government, the DWS carries an institutional responsibility to regulate, support, and supervise basic sanitation (DWS, 2016). The main strategic objectives of DWS are to:

- Protect water resources from any form of abuse and pollution
- Ensure that water is used sustainably
- Ensure equitable and reliable water provision
- Generate and make provisions to access information to inform decision-making for water management.

The DWS has the executive role of monitoring the local government's performance concerning water and sanitation provision (DWS, 2016). Through the accountable minister, the Water Service Act of 1997 (Act 108 of 1997) requires the DWS to support the local government's capacity to effectively provide water and sanitation services. The Water Service Act (WSA) 1997 further places the responsibility for managing the National Water Resource Information System (NWRIS) on the DWS. The DWS has acknowledged this as being contained in their strategic objectives. Managing water resource information is fundamental for informing decision-making in water resource management (WRM).

2.4.2 The role of catchment management agencies

The NWA endorses adopting integrated water resources management (IWRM) to manage the country's water resources (Stuart-Hill and Meissner, 2018). This concept calls for the consideration of societal, cultural, economic, and environmental issues in WRM, including the participation of local communities (Stuart-Hill and Meissner, 2018). The implementation of IWRM was envisaged to happen with the establishment of Catchment Management Agencies (CMAs). CMAs are public water resource management institutions founded in terms of the National Water Act of 1998, with the primary purpose of managing the country's water resources at the catchment level (Saruchera, 2008). CMAs are established by or under the powers of the accountable Minister to perform regional water management functions. In areas with no CMAs, the Water and Sanitation Department assumes such functions through their provincial offices (Rodin, et al. 2016).

The CMAs are established and expected to operate in water management areas (WMA) that do not fall within the management parameters of the provincial and local governments (Elias 2015). Formerly, South Africa was divided into 19 WMA (Elias, 2015). One CMA was planned per WMA. However, the number was later reduced to nine CMAs by the Minister of Water and Sanitation (Meissner et al. 2016), and currently, there are six CMAs. CMAs are established to perform management functions in WMA (Meissner et al., 2016). South Africa had only two CMAs that were fully operational and functional: the Inkomati-Usuthu Catchment Management Agency (IUCMA) and the Breede-Gouritz Catchment Management Agency (BGCMA) (Munnik, 2020). However, as of June 2024, the other four CMAs were launched.

The DWS sees the establishment of CMAs as a way of decentralising WRM for inclusive stakeholder participation (DWS, 2017). The purpose of establishing CMAs, as stated in the National Water Act, "is to delegate water resource management to the regional or catchment level and to involve local communities, within the framework of the national water resource strategy". Through establishing a CMA, the responsibilities of the DWS are reduced to that of policy formulation, regulation, and oversight (Pegram and Mazibuko, 2003). The CMA ensures that water resources are protected at the catchment level, used, developed, controlled, and managed to work with local communities and other interested parties in their jurisdiction to manage water resources (Khorommbi, 2019). Once the CMA is established and functional, it becomes the custodian and the leader of water resources at the regional level. The National Water Act set out the following functions for CMA once established:

- Advise relevant stakeholders about protecting, using, and managing water resources in the catchment area.
- Establish a catchment management strategy.
- Manage all activities of water users and water management entities in the catchment.
- Manage the implementation of the development plan of water services and

- Encourage community participation in water management,

Catchment management agencies inherit the functions of the DWS at the regional scale (Munnik, 2020). The DWS delegates the management powers of WRM to the catchment level, which inherently becomes the responsibility of the CMA (Munnik, 2020). In the context of transformation and restitution, the CMA ensures equitable access to water resources for all, including the participation of marginalised communities (Pegram and Mazibuko, 2003). This is done to redress the historical injustice of water segregation (Stuart-Hill and Meissner, 2018).

2.4.3 Water user associations

Water User Associations (WUA) are water management institutions established in the National Water Act 36 of 1998. The NWA defines WUA as a "cooperative association of individual water users who wish to undertake water-related activities for their mutual benefit" (Chapter 8). WUAs are made up of associations of individual water users who collectively undertake water-related activities on behalf of their members. Unlike CMAs, the WUA operate at a limited local level (NWA, 1998). The water-related activities undertaken by WUA may include farm irrigation, fishing, recreation and/or water for domestic uses (Saruchera, 2008). Past irrigation boards founded in terms of the Water Act of 1956, representing commercial farmers are required to transform into WUA as per the NWA (Elias, 2015). The transformation of irrigation boards into inclusive WUAs is still an ongoing process, with some being formally transformed into WUAs, with new governance structures that include representation from historically disadvantaged groups, small-scale farmers, and local communities. However, there is slower implementation, with delays in establishing fully functional and representative WUAs in some areas. According to Kotzé (2023) the delays have been due to several factors such as bureaucratic hurdles, resource constraints, and resistance from some established stakeholders (for example, established large-scale commercial farmers). The establishment of WUA recognises non-commercial water users, predominately disadvantaged local communities, as equal stakeholders in decision-making regarding water resources in their respective jurisdictions (Kemerink et al., 2013). A WUA is responsible for facilitating water users' participation in water resource management at the local level (Kemerink et al., 2013).

The fundamental role of WUAs is supervising water use and allocations to their members and managing water supply (Faysse, 2004). Although WUAs are water management institutions, their core function is not water resource management (RSA,1998). They are formed to represent the needs of local water users who are members of the association. Nonetheless, WUAs can perform water management functions when delegated such responsibility by other water institutions such as DWS or CMA (Faysse, 2004). This includes providing water support services to the local community and water service institutions (RSA, 1998). However, these are ancillary functions and can be undertaken by WUA when it does not prevent or limit the establishment from performing its primary functions (RSA, 1998). WUAs may accept the responsibility of providing support services when they can perform such functions (Pegram and Mazibuko, 2003). As set out in the NWA, the primary functions of WUAs are dependent on their constitutions (RSA, 1998). This implies that the principal responsibility of WUA may vary depending on the members' interests. WUAs have the right to choose their functions for the benefit of individual water users. The intended functions of a WUA establishment should appear in the proposal and its constitution (RSA, 1998). Further, the association's role should fulfil the requirements of the NWA. The Act mandates WUAs to align their functions with the national water resource strategy. Schedule 5 of the NWA sets out the possible primary functions for WUAs to perform in their jurisdictions, which are to:

- Prevent and protect water resources from unlawful use, wastage, and pollution
- Oversee and regulate water resource allocation and use
- Evaluate water use and keep records of water levels
- Build, acquire, manage, and maintain waterworks

However, the functions mentioned above are optional; it does not limit WUAs from proposing other functions in their application to the Minister that they may deem suitable and needed by local users who are members of the associations. As redress and participation are concerns in water allocation, the establishment of WUAs is seen as a vehicle for creating an environment for local people to be part of water governance (Saruchera, 2008) because water resources are then managed at the local level by local users to address their needs. With this bottom-up approach to governance, a WUA empowers local water users and influences water policies for local needs (Kemerink et al., 2013). WUA are legal institutions in South Africa in terms of the NWA. The powers to establish and dissolve WUA reside with the Minister of DWS. The minister, the highest decision-maker, has the authority to approve the establishment of WUAs based on a proposal or as part of a government initiative under the requirements of NWA.

2.4.4 Water Boards

Water boards are service providers of bulk water (Ruiters and Matji, 2015). The WSA (1997) makes provision for the establishment of water boards to provide water services to water service institutions in their service areas. The principal role of water boards is to provide bulk drinking water and water treatment services to water service authorities (DWS, 2016). Water boards are responsible for ensuring sufficient and reliable water resource distribution to their customers. They are also responsible for supporting the implementation of efficient water use to manage water demands (RSA, 1997). A water board is permitted in terms of the WSA to perform other secondary activities in a situation where 1) it does not restrict the organisation from executing its primary role, 2) it complies with the board policy, and 3) it does not constitute a financial loss for the institution. The secondary activities may include but are not limited to providing support to water service institutions, distributing water directly to consumers, and undertaking water conservation and catchment management activities on behalf of responsible authorities (RSA, 1997).

2.4.5 Municipalities

Municipalities are water service authorities and must ensure the provision and access to potable water and sanitation services in their respective areas of service (du Plessis, 2013). The WSA (1997) states that “everyone has the right of access to basic water supply and basic sanitation” (Chapter 1:3). The water services authorities (municipalities) have the responsibility to ensure that this right is fulfilled (Algotsson et al., 2009). This implies that municipalities (water service authorities) are accountable for community access to water services and basic sanitation (Makhari, 2016). It is important to note that every municipality in South Africa is recognised as a water service authority (du Plessis, 2013). While the right to access water may be limited, municipalities cannot block access to water services unreasonably (RSA, 1997). In terms of WSA (1997), discontinuity of water services should be done fairly; users must be informed prior and should not occur in the instance of non-payment where the affected consumer can justifiably provide proof to the municipality that they cannot afford to pay for essential services (RSA, 1997).

There are three categories of municipalities in South Africa: Metropolitan municipalities (category A), which are found in the country’s eight biggest cities; areas that fall outside the metropolitan areas are divided into Local municipalities (category B); and lastly, Districts municipalities (Category C) which are made of more than one municipality (du Plessis, 2013). Municipalities are local spheres of government tasked with the constitutional responsibility of providing sustainable services to communities (RSA, 1996: section 152(1). Concerning water service delivery, the WSA (1997) affirm that “Every water services authority has a duty to all consumers or potential consumers in its area of jurisdiction to progressively ensure efficient, affordable, economic and sustainable access to water services” [Chapter 3: 11(1)].

Municipalities work directly with consumers at the local level, creating an environment for stakeholder participation in service delivery between communities and the government (Haigh et al., 2010). Municipalities must construct, operate, and maintain local water infrastructure and wastewater works in their areas of jurisdiction (Masindi and Dunker, 2016). Where applicable, municipalities appoint water service providers to fulfil the water distribution and sanitation service role, including operating and maintaining wastewater treatment plants (Pegram and Mazibuko, 2003). Further, Municipalities have an institutional responsibility to manage water resources by preventing water wastage by implementing water conservation measures and demand management plans (du Plessis, 2013). As set out by the WSA, the role of municipalities in water management, subject to their jurisdiction, is to ensure water availability and equitable supply, fairly regulate water allocation, monitor compliance, and conserve water resources.

2.5 Status of water resources in South Africa

2.5.1 Groundwater resources

Groundwater is a crucial component of water supply in South Africa, supplementing surface water to meet the needs of the country's growing economy, agricultural sector, and urban and rural populations. Groundwater is a reliable, safe drinking water source in rural areas and many towns in South Africa. Groundwater is also used to irrigate thousands of hectares of valuable arable land around the country and to support large numbers of livestock and game (DWA, 2010). However, climatic factors affect groundwater availability, including rainfall, drought, and floods. Availability may also be affected by over-abstraction.

Approximately 11% of South Africa's population relies on groundwater as their water source. The Utilisable Groundwater Exploitation Potential in South Africa is estimated at 10 343 million cubic meters per year (7 500 million cubic meters in a drought year), allowing for factors such as physical constraints on extraction, portability, and a maximum allowable drawdown. About 1900 million cubic meters, or 9% of the water provided in the country, comes from the total groundwater abstraction recorded in the registers. The primary uses of groundwater are for agriculture (66%), domestic water supply (13%), mining (15%), industry, and aquaculture (6%) (DWA, 2010; Middleton and Bailey, 2009). Given the country's propensity for drought, groundwater is particularly beneficial in many areas. However, groundwater availability varies from location to location across South Africa, and some regions of the country have no groundwater.

Groundwater exploitation is an option for smaller towns and agriculture and larger cities such as Cape Town and Nelson Mandela Bay Municipality (DWA, 2010). However, there is a need for license requirements for commercial and small areas to guarantee that groundwater is not overexploited. Over-abstraction of groundwater can lead to the formation of sinkholes. In South Africa, groundwater resources can also be replenished by artificial recharge. Surplus surface water is transferred underground to be stored in an aquifer for later abstraction and use, for example, in Atlantis in the Western Cape. High groundwater recharge areas are sub-quaternary catchments where groundwater recharge is at least three times more than the primary catchments (Nel et al.,2011). These recharge areas are vital to sustaining river flows, especially during dry times. Underground water storage is more effective than surface storage as the source is less susceptible to evaporation and pollution.

2.5.2 Surface water resources

Seventy-seven per cent of South Africa’s water supplies are derived from surface water resources, 9% from groundwater resources and 14% from recycled return flows (Green Cape, 2017). Furthermore, runoff, which accounts for 50% of the water in South Africa’s River systems, is produced by just 8% of the country's land area. The country has about 320 major dams, with approximately 32,412 million cubic metres of water storage capacity and more than two-thirds of the average annual runoff (Muller et al., 2009). According to the 2016 dam database, there are now more than 5000 registered dams in the country, distributed throughout the nine provinces, including privately owned and Department of Water and Sanitation-operated structures. The biggest is Gariep Dam, which can store over 5340 million cubic metres of water and covers an area of more than 352 square kilometres. According to Section 120 of the National Water Act, the owners of any dam that poses a safety concern (i.e. one with a wall height greater than 5 meters or one with a storage capacity greater than 50 000 m3) are required to register the dam (RSA, 1998).

The demand for water resources is high, but various factors significantly impact the availability of water. Even though South Africa's dams can store substantial volumes of water, the dam levels gradually decrease over time due to high average evaporation rates. One of the significant influences on the availability of surface water in South Africa is climate change and climate variability. The country's catchments are receiving less rainfall, with the Western and Northern desert regions receiving the least rain. Due to the high degree of annual flow variability, which is characterised by floods and droughts, it is necessary to make provisions for water storage facilities to maximise water availability. There are 223 rivers in South Africa, and 25% of these are threatened by different types of pollution, with 32% seriously endangered (WWF-SA2016).

Seven of South Africa’s nine provinces rely on inter-basin transfers, providing more than half of their water requirements (Muller et al., 2009). These transfers are required to provide additional water to urban areas that are far from significant watercourses. An example is the Lesotho Highlands Water project, which sells water to South Africa through the transfer of water from Lesotho to the Vaal River basin. This project is significant for the Gauteng province and surrounding areas as they are far from the river basin.

2.6 Agricultural water uses and infrastructure

Irrigation is a significant use of water in South Africa. Sprinklers, flood and moving systems constitute more than 60% of irrigation systems, yet these are the most inefficient in conserving water (Figure 2.1).

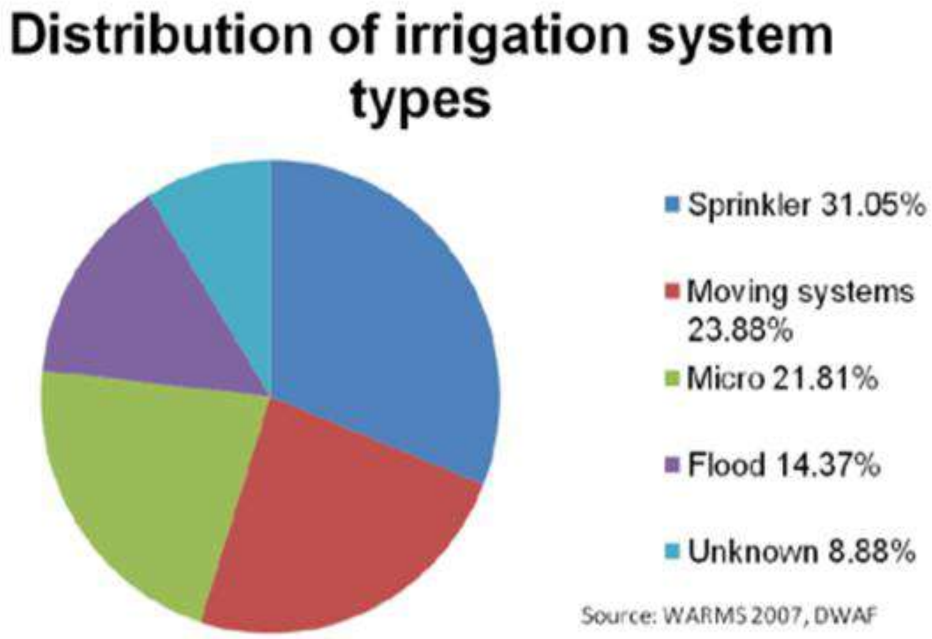

Figure 2.1 Distribution of irrigation system types in South Africa (DWAF,2007)

Agriculture uses more than 60% of freshwater resources (Figure 2.2), mainly for irrigation. Large amounts of field crop cultivation are found in the Free State, the Northwest, and Mpumalanga, as well as in the Western Cape's winter rainfall zone, with Gauteng having the least (DWA,2004).

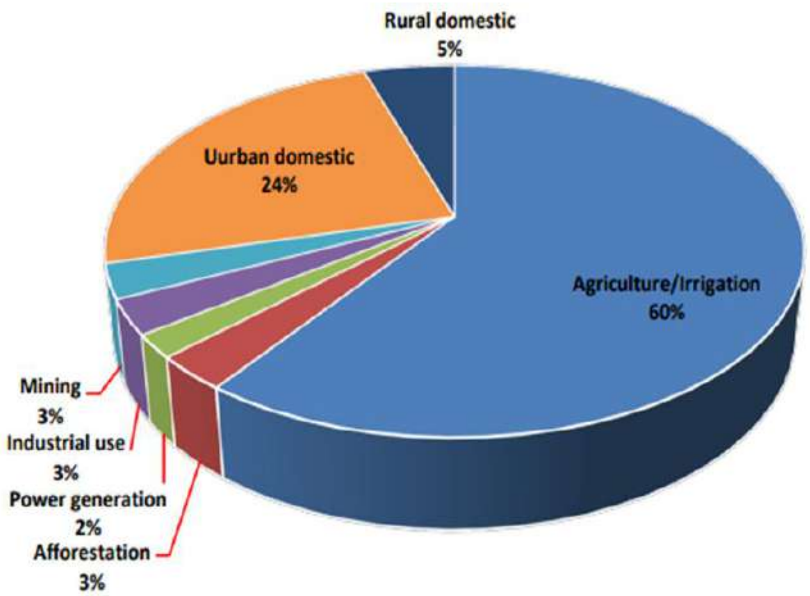

Figure 2.2 Water use by major economic sectors in South Africa (DWA,2004)

Water infrastructure is ageing and typically cannot support greater capacity to provide the quantity of water that is in such high demand in South Africa. Water leaks and sewage effluent spills into freshwater bodies are caused by inadequate water infrastructure (WWF-SA, 2016). Municipalities in South Africa continue to struggle to fulfil the high demand for water due to the deteriorating water infrastructure, fast urbanisation, and rising population. Additionally, the towns frequently lack qualified staff and appropriate operating procedures to address spills and deliver quality water services promptly (Mothetha et al., 2013).

Although there is no condition assessment on a national level to address the issues of ageing agricultural infrastructure, certain studies on a small scale do indicate the consequences of poorly maintained infrastructure. According to Donnenfeld et al. (2018), losses in South Africa are significantly higher than in other water-stressed countries across the globe. The immense pressure placed on the existing and rundown water infrastructure leads to pipeline bursts and water leaks, often resulting in clean water losses and sewage spillages (Babel et al., 2010). The illegal connection to water infrastructure also causes water losses in South Africa. If inexperienced personnel connect illegally to the water distribution system, leakages might increase. Water networks are designed according to population and activities, and once the water networks are overloaded, failing infrastructure arises, which leads to uncontrolled leaks. South Africa’s water challenges are amplified when water service providers, such as the municipalities, do not manage water losses in time (DWAF, 2004).

2.7 Mechanisms of access to agricultural water in South Africa

Water use in South Africa is subject to authorisation by DWS in terms of the NWA. According to section 151(1) of NWA, any unauthorised water use is an offence. Authorisation of water use in South Africa may be granted in four categories, namely, in terms of Schedule 1 of NWA, Existing Lawful Use (ELU), General Authorisation (GA) and by a water use license to applicants [Department of Water Affairs and Forestry (DWAF, 2007)].

2.7.1 The Water Use License process

Any person who wishes to undertake a water use defined under Section 21 of the NWA, which does not fall under Section 22, “permissible water use,” requires a license as set out in Section 40 of the NWA. Licensing is required for water use with medium and high-risk impacts (DWAF, 2007). Section 21 of the NWA defines non-waste disposal water use and waste disposal-related water uses that require authorisation by a responsible authority:

Non-waste disposal water use activities

- Taking water from the water source
- Storing water
- Impeding or diverting the flow of water in a watercourse
- Engaging in a stream flow reduction activity
- Engaging in a controlled activity
- Using water for recreational purposes

Waste disposal water use activities

- Discharging waste or water-containing waste into a water resource through a pipe, canal, sewer, or another conduit.
- Disposing of waste in a manner that may detrimentally impact a water resource.
- Disposing in any manner of water which contains waste from, or which has been heated in any industrial or power generation process.
- Altering the bed, banks, course, or characteristics of a watercourse.
- Removing, discharging, or disposing of water found underground for the
- continuation of an activity or for the safety of persons.

2.7.2 Application for the water use license

Application for water use authorisation or licensing is done through the DWS regional offices. In terms of the NWA, applicants may be required to pay an application fee to the responsible authority. The DWS will assess the application and decide to either grant or refuse water rights. The application process takes the following steps:

Pre-application stage

This is the initial stage of the application process, during which consultation between the applicant and the DWS takes place. The applicant must consult the DWS regional offices about the intent to apply for water authorisation. The consultation process should be initiated before applying for a water use license (DWAF, 2007). The applicant is responsible for informing and providing DWS with detailed information about the nature and the extent of the proposed water use activity (DWAF, 2007). The DWS is responsible for regulating, administering, advising, and supporting the applicant to make an application for a water use license (DWAF, 2007). The DWS decides on the kind of authorisation that is required based on the proposed water use and the risks associated. A risk assessment report is required for water use activity that involves wastewater discharge. Upon necessary consideration, the DWS will, therefore, advise the applicant on the information required to support the proposed application. Public consultation reports and specialist studies generally form part of the application process.

Gathering of information

At this stage, the applicant gathers information to compile a technical report to support the application. A technical report gives detailed information on “what” and “who” is affected by the proposed water use and what management strategies and monitoring plans are placed to prevent adverse impacts (DWAF, 2007). The process of information gathering may start with public consultation. This involves the identification and involvement of interested and affected parties (IPs and APs). Depending on the type of engagement, stakeholders, settings, and context, a public consultation process may vary. It can be face-to-face dialogues in a public gathering or the submission of written public comments through an address. In a case where a person is unable to participate because of literacy or disability, alternative communication channels should be considered to accommodate that individual or group of people (DWS, 2017).

The purpose of public consultation is to inform the public about the application for water use authorisation and obtain comments (RSA, 1998). It gives IPs and APs a platform to raise their concerns and objections or make inputs in favour of the application. In terms of Section 41(4) of the NWA, a public notice should be made to inform Interested and affected parties about the project, and that objections can be made against the application within 60 days of the notice. Further, a communication channel should be established where written comments can be submitted. The NWA (1998) states that public notice must be advertised on a newspaper or other media platforms. The end goal is to ensure that the notice reaches IAs and APs to make them aware of the proposed water use and that they can comment on it. Alternatively, a visible advertisement board in a public place with a written notice to inform IP and APs is proposed (DWS, 2017). It is required that the written notice be visible and placed in areas that are accessible to IP and APs (DWS, 2017). The DWS has amended Section 21(1)(k) and 41(6) of the National Water Act, 1998 (Act 36 of 1998) to make regulations and procedures for water use license applications dated 2017. Guidelines on conducting public consultation processes are made.

The public consultation report is an integral part of the technical report to enable the responsible authority to make informed decisions regarding the application (DWAF, 2007). The second part of information gathering is impact assessment. The applicant must conduct a detailed impact assessment to determine water resources and users that will be affected by the proposed water use activity (DWS, 2017). The magnitude of the impacts on water resources and users should also be determined (DWAF, 2007). After identifying the impacts, the applicant must develop an impact management strategy and monitoring plan to motivate their application to be considered (DWAF, 2007). The public consultation and impact assessment reports are merged into a technical report to support the authorisation of water use activity. While the NWA is not specific about the independence and impartiality of the specialists conducting the technical report, the applicant must remain truthful throughout the application process. Providing misleading information to influence the decision of the application is an offence (DWS, 2017). This includes removing or providing incorrect information to influence the result of the application (DWS, 2017).

Application

During this stage, the applicant applies to DWS regional offices. The DWS has developed an electronic system for water use applications. The application is made on prescribed application forms provided by the DWS. The application should be accompanied by the technical report supporting the application, including other documents that might be required by DWS deemed necessary to motivate the authorisation of water use (DWAF, 2007).

Review and decision-making

The DWS is responsible for reviewing, assessing, and deciding on the application for water use authorisation. Upon receiving the application and supporting documents, DWS will screen the technical report to determine whether to either accept or reject it. DWS is explicit that if the technical report is rejected, the application process will not continue. However, in cases where a technical report is accepted, the application will go for review and finalization. A decision on the application should be made within 144 days (DWS, 2017). The designated authority is responsible for informing the applicant and other affected parties about the outcome of the application. Where the applicant or affected parties are unsatisfied, they may appeal the decision to the minister of the responsible department within 30 days of receiving the outcome (DWS, 2017).

2.7.3 Existing lawful use

Any lawful water use that was exercised at any time in two years before the commencement of the NWA (1998) is recognised as existing lawful water use in terms of section 31(1) of the NWA. This means that a water use that took place legally for two years before the NWA (1998) may continue as an existing lawful use until a water license replaces it. Such water use must have taken place under applicable law before the commencement of the NWA (RSA, 1998). However, there should be proof to determine the legal and practical existence of water use before the NWA (Kapangaziwiri et al., 2016). This suggests that a responsible authority must verify and validate the continuation of existing lawful use (Kapangaziwiri et al., 2016).

The qualifying period for water uses to be considered as an existing lawful use is two years before the NWA (1998) came into effect (RSA, 1998). This implies that any water use that has taken place outside the two years before NWA is not considered an existing lawful use. Continuation of existing lawful use needs registration from a responsible authority. Such water users need to identify themselves to the responsible authority by registering their water use activity (DWAF, 2007). This enables the responsible authority to verify and validate the existing lawful use.

While a person may be allowed to continue an existing lawful water use without a water license, the NWA (1998) states that a responsible authority regulating the water sector may request that anyone operating under an existing lawful use authorization apply for a water license. In case a license is granted, the existing lawful use, including its conditions, will automatically be replaced by a water license. However, if a license is not awarded, the existing lawful use is no longer permitted (RSA, 1998). Therefore, the user may not continue water use under existing lawful use.

2.7.4 Verification and validation

Claims of entitlement to continue an existing lawful water use are subject to a verification and validation process (van Koppen and Schreiner, 2014). The responsible authority may undertake an investigation to verify the legality of the water used under any law before the commencement of the NWA. The authority may also initiate a process to assess the validity of the water use in question during the qualifying period before NWA

(RSA, 1998). The purpose is to determine the authenticity and accuracy of the existing lawful water use (Kapangaziwiri et al., 2016). According to NWA (1998), any person claiming an existing lawful water use may be required by the responsible authority to apply for authorisation verification through a notice. Failure to apply for verification after being served with a notice will automatically terminate the entitlement to continue existing lawful water uses. It is important to note that verification and validation of water use are aimed at determining the lawfulness of existing lawful uses and assessing the legality of water uses post-1998. This implies that water uses that took place after the establishment of the NWA may also be subjected to a verification and validation process if deemed suitable by the responsible authority.

2.7.5 Schedule 1

Schedule one of the NWA deals with permissible water uses. It permits a person to take water from any water resources for domestic use at home and for recreational purposes without needing a license (RSA, 1998). However, it does not permit a person to take water for commercial reasons. In terms of Schedule One, a person is entitled to take water from any water resource during an emergency for consumption or firefighting (RSA, 1998). A person is permitted to capture and use runoff water from a roof. It further entitles a person to discharge wastewater or runoff water through a service provider that is authorised to manage, purify, or dispose of wastewater (DWAF, 2007). Schedule, one permits water uses that are generally low-impact activities and use low-water volumes. It entitles a person to take water that is aligned with domestic uses such as gardening, livestock watering, and consumption. Schedule one authorisation aimed at water uses at a smaller scale (van Koppen and Schreiner, 2014).

2.7.6 General authorisation

A government department responsible for water governance may permit water use without a license under general authorisation subject to limitations and conditions (DWS, 2016). The general authorisation of water use enables a person to use water without the requirement of applying for a water license in terms of the NWA (van Koppen and Schreiner, 2014). The process requires a public consultation before a general authorisation of water use can be gazetted. The responsible authority must invite public comments from interest groups through a written notice. Interested individuals or groups are offered an opportunity to comment on a proposal for general authorization.

Appropriate comments received within specified time limits as per the public notice must be considered in decision-making in terms of the NWA.

A general authorisation of water use may be limited to the geographical area, specific water resource, users, and/or specific timeframe (RSA, 1998). DWS (2016) notice 509 states that a general authorisation of water use is valid for 20 years unless amended or extended. Water use under general authorisation requires registration with the responsible authority (van Koppen and Schreiner, 2014). However, water registration is not a license but a process in which water users notify the authorities about water use (DWAF, 2007). A person exercising water use under a general authorisation is required to undertake a risk assessment and provide mitigation measures (DWS, 2016). Water users are expected to comply with the conditions and limitations contained in the government notice of general authorisation of water use. The DWS is responsible for assisting disadvantaged persons who wish to exercise water use under the general authorisation to comply with the requirements and limitations (DWS, 2016).

2.8 Factors affecting the availability of agricultural water in South Africa

2.8.1 Climate-related factors

Climate change and climate variability

According to an FAO assessment in 2007, roughly 11% of Africa's arable land is predicted to be lost in rural regions due to changing climatic conditions, leading to food insecurity and increasing malnutrition. The sensitivity of agricultural productivity to climatic variability will rise with changes in the timing, frequency, and severity of rainfall events (Aliber and Hart, 2009). These anticipated changes raise concerns about the negative effects of climatic variability on crop production. This is true for South Africa and most African countries, whose agricultural production primarily depends on rainfall (Barrios et al., 2008). The availability of agricultural water is affected by the imbalance between evapotranspiration and rainfall due to the projected changes in temperature and rainfall in South Africa, according to global climate models (GCM) (Kiker, 2000). Like this, Easterling et al. (2007) argued that agriculture is climate-sensitive and that a 1°C rise in temperature may change rainfall patterns, making crops more susceptible to drought stress or flooding in some areas. Therefore, the demand for agricultural water will increase in areas that are getting drier.

Drought

Droughts have long-lasting effects on various industries, including agriculture, tourism, energy generation, and public water supply, with the latter frequently being the most severely impacted (Dilley et al., 2005). Drought in South Africa is a big challenge that puts the agricultural sector under pressure to produce food for the country. South Africa is recognized as a drought-prone country (Baudoin et al., 2017; Jordaan et al., 2017a) that has experienced several “severe” drought events (as occurred in the early 1980s and 1990s, the period 2014–16 (Baudoin et al., 2017), and the recent ongoing drought since 2018 (Mahlalela et al., 2020). The Nelson Mandela Bay Metropolitan Municipality in the Eastern Cape is experiencing an intense drought affecting local farmers and the entire water supply system in the surrounding areas.

2.8.2 Water quality

The quality of the water in South Africa's water sources is a major issue. The country’s freshwater resources are plagued by various forms of pollution, which has been identified as a major contributing factor affecting water quality and water stress (Ochieng et al., 2010). Every day around the country, municipal pollution, industrial effluents, acid, sewage, and agricultural runoff contaminate and pollute water (Rand Water, 2019b). Municipal pollution due to informal settlements built close to watercourses causes the contamination of irrigation supplies. As a result, retailers (particularly in export markets) have threatened to cancel fruit imports from regions where pollution is higher than their local standards for food production. When the water in the South African rivers is contaminated and later seeps into smaller tributaries utilized for human activities, this causes serious issues. This is how diseases often occur in rural areas and their primary cause. We will have serious concerns when water is no longer safe to use daily.

Fertilizers are applied to many farmlands in South Africa to increase the potential of the soil for crop development and meet the country's rising food demand. Properly using fertilizers can have a favourable effect on the soil and increase crop production. However, when runoff erodes soils rich in nitrates and phosphates, drains into surface and groundwater bodies, and causes sedimentation and eutrophication, it can harm the ecosystem and water quality (WWF-SA, 2016). Nutrient-rich soils may degrade and end up in freshwater bodies due to the usage of pesticides and fertilizers on farmlands and heavy irrigation techniques. Such soils would subsequently settle in freshwater bodies, encouraging the development of plants and the build-up of algae (Rand Water, 2019). Water quality in South Africa is seriously threatened by the build-up of fertilizers in water bodies. The proliferation of plants and algae in surface water bodies impacts ecosystems like wetlands and kills aquatic life and the environment (Griffin, 2017).

2.8.3 Population growth

South Africa has an estimated population of 58.8 million people (StatsSA,2019). However, the census results are still underway to confirm this estimation. The average South African population growth rate is 1.8 per cent per annum. Due to the country's growing population, water supply plans must now be more cautious. An estimated 13 million people lack access to clean water, yet the water used by agriculture and mining industries accounts for over half of the country's water. However, the balance of this water used by these industries contributes to boosting the economy and food production. Generally, the average water consumption in South Africa is 237 litres/person/day (l/c/d), which is higher than the world average of about 173 l/c/d (Ngobeni & Breitenbach, 2021). This suggests that to meet the existing conditions of each decade (approximately 8 million increases in population), about 1900 million cubic metres of additional water would be required each decade to balance the demand.

Population growth is high in urban areas because people are moving from rural areas in search of better opportunities to urban areas. South Africa's urban areas expand by 2.7% annually to accommodate the increasing population numbers in these areas (Department of Human Settlements, 2004). The informal settlements receive minimal attention, and some do not have access to water resources. Most agricultural activities in South Africa are located near urban areas, meaning that when the migration rate increases, the water demand also increases, putting additional pressure on agricultural water resources.

2.9 Challenges of water governance and institutional arrangements

Opportunities for improving water governance can be explored through identifying the challenges of water governance and institutional arrangements. This is crucial in creating bases that enable the achievement of principles of good water governance and, consequently, water security. There are numerous principles of good water governance. The Global Water Partnership's (GWP) twelve principles for good water governance are Participative, Open, Transparent, Coherent, Accountable, Effective, Equitable, Efficient, Communicative, Ethical, Integrative and Sustainable. Jacobson et al. (2013) argued that transparency, accountability, and participation are the main principles of assessing water governance. In their study, Klümper et al. (2017) considered these principles important for ensuring water security in the agricultural sector. Woodhouse and Muller (2017) asserted transparency, accountability, and trust across all spatial scales (i.e. the nation, region, community, and household) as fundamental elements of good water governance.

Other scholars have highlighted adaptability and resilience, particularly to climate-driven changes to the hydrological cycle, as important components of good water governance (Akamani 2016; Honkonen 2017). This is particularly important given the climate extreme events such as droughts and floods that are facing most countries around the globe. Sound water governance principles can also include socio-political issues and dynamics such as power relations (Bakker and Morinville, 2013). Judeh et al. (2017) added that addressing good water governance involves legal, financial, organisational, socio-economic, and political issues. To enhance good water governance, the OECD Water Governance Initiative (WGI) has developed a set of 12 principles of good water governance (Figure 2.3). These principles are regarded as the most comprehensive, and they are based on three main dimensions (effectiveness, efficiency, and trust and engagement).

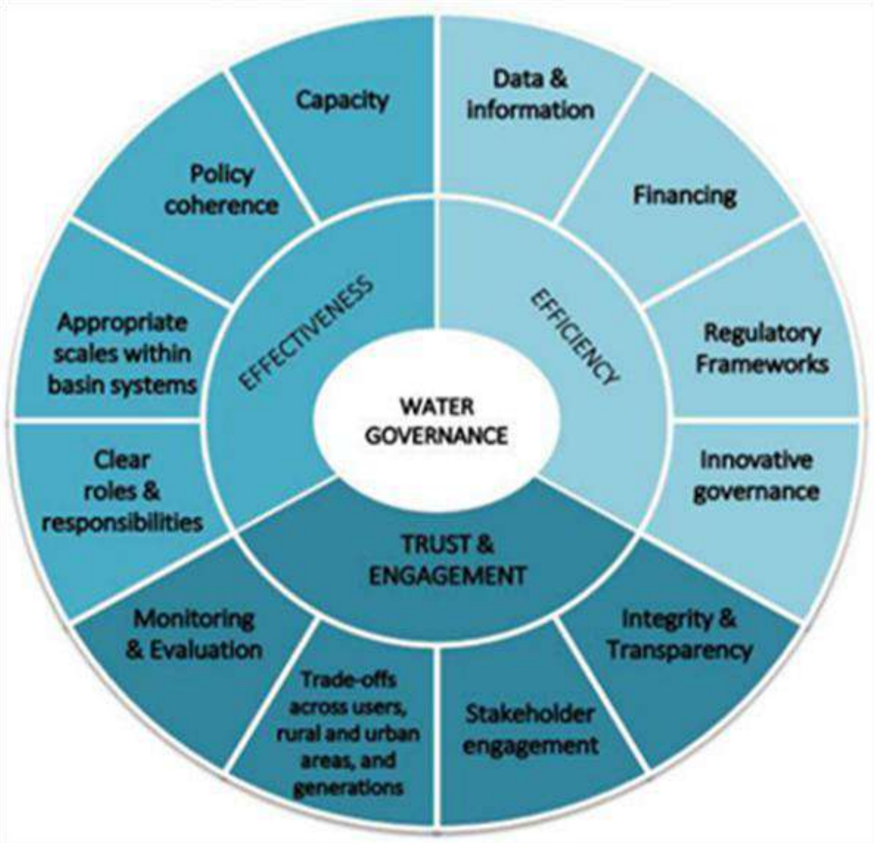

Figure 2.3 OECD principles on water governance (OECD, 2015):

Various approaches or frameworks are used to identify water governance and institutional arrangements challenges to improve the performance of water governance systems to ensure water security. However, since good or effective governance is associated with political issues, it is very challenging to select a suitable framework (Kaufmann et al., 2011). De Stefano et al. (2014) stated that even though water governance comprises technical aspects, it is considered more political than technical. Despite the availability of various water governance frameworks, a comprehensive Multi-level Governance Framework (Figure 2.4), which is based on 12 OECD principles of good water governance (see Figure 2.9.1) was formulated by the OECD under the motto “Mind the gaps, bridge the gaps” (Akhmouch & Correia, 2016). This framework can be used to identify and bridge gaps in water policy to solve water governance challenges and manage water resources. The framework applies at any level of government in all countries, regardless of the institutional settings (OECD, 2011). It categorises the water governance challenges into the seven groups (policy, accountability, funding, information, capacity, objective, and administration).

Figure 2.4 Multi-level governance gaps OECD (2011)

Various water governance challenges in South Africa hinder farmers from attaining water security for agricultural production. These governance challenges include policy incoherence, lack of accountability, insufficient capacity, and lack of funding, which are discussed in the following sections.

2.9.1 Policy incoherence

The policies of various institutions that are supposed to support smallholder farmers have been reported not to be in alignment (Ncube, 2018). The South African National Water Act (NWA) of 1998 is the primary legal instrument related to water governance in South Africa. It emphasised redressing imbalances of the past to ensure water access for all South Africans, including highly disadvantaged individuals (HDIs) such as smallholder farmers who were deprived of accessing water during the apartheid government. Despite its recognition as a comprehensive water law globally, challenges continue concerning water reallocation to smallholder farmers. Managing water in an integrated manner was also one of the aims of the South African NWA. However, various scholars have indicated that integration between land and water institutions has proven to be very challenging (Funke and Jacobs, 2011; Denby, 2013; Mehta et al., 2014). Denby et al. (2016) also indicated that intersecting goals and mandates govern land and water resources in South Africa. Still, unfortunately, they are being managed by different institutions, government policies, and funding schemes. This was also supported by other scholars who pointed out that the land and water reforms in South Africa have followed different paths and are implemented differently (Funke and Jacobs, 2011;

Movik, 2012; Woodhouse, 2012). As a result, this has contributed to the delay in water allocation to smallholder farmers (Msibi and Dlamini, 2011). The slow progress of land and water reforms also reflects water governance challenges that led to inequalities in water access for smallholder farmers (Sadiki and Ncube, 2020). At an institutional level, land and water allocation transfers are supposed to be connected. However, despite the interconnected nature of land and water resources, smallholder farmers in South Africa find it challenging to acquire land for agriculture (Funke and Jacobs, 2011). Lack of access to land also complicates the water allocation process (Sadiki and Ncube, 2020). This is mainly because water access is linked to the ownership of land.

2.9.2 Lack of accountability

In water governance, a lack of accountability occurs when ensuring transparency about water-related management activities, which is very challenging. This is mainly a result of inadequate user commitment and a lack of concern, awareness, and participation. Ensuring that users are directly involved in water resources management enables institutions and users to be accountable for their actions. It enhances them to take part in correcting the challenges of water management (Muchara et al., 2016). Participation is central to successfully managing common pool resources such as irrigation water. In agriculture, when farmers do not participate in decision-making, it is very difficult for decision-makers to make them accountable if they violate new rules because they can claim they were unaware of the new rules (Phakathi et al., 2021).

As previously indicated, water resources in South Africa are managed through the National Water Act (NWA) of 1998 which mainly focuses on making sure that water resources are allocated equitably and sustainably through licensing. The NWA has created the Catchment Management Agencies (CMA) and the Water User Associations (WUAs) as two user-driven water resource management institutions. These decentralised institutions were set up to promote participation and equal representation in water resources management (Faysse, 2004). Unfortunately, since the end of the apartheid, the participation of users such as smallholder farmers in water governance institutions (e.g. CMAs and WUAs) to enable equitable access to water for productive uses has not changed significantly (Schreiner, 2012; Brown, 2014). In their study, Sharaunga and Mudhara (2018) stated that poor participation in water resources management is one of the water governance challenges facing smallholder farmers in

South Africa. Other scholars also pointed out that even though smallholder farmers in South Africa have been incorporated into the WUA to enhance their participation, the research found that most of these farmers are not benefiting from their inclusion in the WUA (Msibi and Dlamini, 2011; Ncube, 2018; Schreiner and van Koppen, 2020). Due to a lack of participation, most smallholder farmers in South Africa, especially at the farm level, do not know formal water legislation such as the NWA (Dlangalala and Mudhara, 2020). For instance, Mehta et al. (2014) found that smallholder farmers in the Inkomati Catchment Management Area lacked knowledge of the NWA.

Power dynamics within the society can also determine the exclusion of users from the planning and management relating to water access (Brown, 2013). Uneven power relations are apparent in South Africa. Marginalised individuals, such as smallholder farmers, are usually excluded from participating and accessing water through formal systems. Denby (2013) highlighted that in South Africa most smallholder farmers cannot voice or participate in formal governance structures, mainly due to large imbalances in power and knowledge. Additionally, Kemerink et al. (2011) reported that smallholder farmers are usually inhibited from participating and challenging their unequal access to water for productive uses and asserting their rights due to various reasons linked to structural, racial, and gender inequalities.

2.9.3 Insufficient capacity

Adequate capacity in terms of human resources plays a very important role in ensuring that water is governed effectively. In South Africa, water allocation is associated with insufficient human resource capacity within institutions that are supposed to support smallholder farmers with the water application process (Sadiki and Ncube, 2020). This is one of the water governance challenges limiting water access for smallholder farmers. As a result of insufficient capacity for human resources, users are still utilising water unlawfully without being prosecuted (Wessels et al., 2019). Additionally, Fanadzo and Ncube (2018) have highlighted inadequate capacity as one of the challenges contributing to the incapability of smallholder farmers to manage water resources in South Africa. The lack of skills and empowerment to manage water resources has also been reported to limit the accessibility of water for smallholder farmers (Thamaga-Chitja and Morojele, 2014).

2.9.4 Lack of funding

Funding is a critical aspect required in the governance of water resources. Water governance challenges, such as insufficient funding to undertake water management activities like operation and maintenance of agricultural water infrastructure, can lead to water insecurity. Compared to land, a static natural resource, water is very challenging to access since it is dynamic and fluid. To fully utilise water for productive uses, sufficient funding for investing in water storage, conveyance infrastructure, and pumps is needed (Faysse, 2004). Various studies have found that inadequate financial capital needed to improve irrigation infrastructure is still a challenge exposing South African smallholder farmers to water insecurity (Faysse, 2004; Denby et al., 2016; Chikozho et al., 2020; Phakathi et al., 2021). For instance, in the Olifants Water Management Area, smallholder farmers in the Arabie Scheme could not utilise all of their water rights due to insufficient funding to develop adequate water infrastructure (Kamara et al., 2002). The reallocation of water resources in South Africa was promoted by compulsory licensing, the central pillar of Water Allocation Reform (WAR) (DWAF, 2013). However, a lack of financial resources from the government has been reported to be hindering water institutions from allocating water to farmers (Movik and de Jong, 2011; Msibi and Dlamini, 2011; Sadiki and Ncube, 2020).

2.10 Impacts on smallholder farmers

Smallholder farming in South Africa is essential in alleviating poverty, especially in rural areas where most people depend on agriculture (Sinyolo et al., 2014). Due to governance and institutional arrangements that fail to govern water resources equitably and effectively, smallholder farmers in South Africa are still experiencing water insecurity challenges (Denby, 2013; Chikozho et al., 2020; Phakathi et al., 2021).

Smallholder farmers' lack of access to water for productive use can lead to reduced agricultural output and income. This hurts the household welfare of smallholder farmers. Inadequate access to agricultural water can also prevent farmers from farming a variety of crops. Water insecurity can also limit smallholder farmers from adopting new technologies to increase their farm production and improve the quality of life in rural areas. Considering these negative impacts implies that solving water governance challenges is critical for controlling and regulating water use to ensure water security for smallholder farmers in South Africa.

2.11 Conclusions

Water insecurity is a continuing challenge facing the agricultural sector in South Africa, especially smallholder farmers. The review highlighted various factors affecting water resource availability, including climate change, water quality, population growth, water governance and institutional arrangements. Water resources for agriculture include groundwater resources and surface water resources. However, the variability of climate change leading to extreme climate events such as drought can influence water quantity and quality and consequently lead to water insecurity challenges. The literature also showed that surface water resources are unreliable due to rainfall variability across the country. High evaporation rates also compound the unavailability of adequate surface water due to extreme temperatures. The evaporation rate is usually greater than the rate at which rainfall is received.

It was also evident from the literature that the performance of agricultural water infrastructure is deteriorating. This is mainly because most of the infrastructure is very old and characterised by leakages and as a result, failing to meet water demand for the rising population. Additionally, illegal connections also contribute to water losses. Inadequate technical staff and suitable operating procedures have been indicated as other factors contributing to the deterioration of the performance of water infrastructure. The literature also stated that the condition assessment procedures to address the challenges of ageing water infrastructure and maintain them are also lacking.

Good water governance and effective institutional arrangements are crucial in ensuring water access. In South Africa, some mechanisms are required to access water for agricultural use. These mechanisms include the water use license application process, existing lawful use, verification, validation, and general authorisation. However, the literature has revealed various challenges relating to water governance and institutional arrangements obstructing farmers from accessing water for agricultural uses. These challenges include incoherence to policy, lack of accountability, insufficient capacity, and inadequate funding.

Water management institutions such as CMAs and WUAs were developed to promote users' participation in the management of water resources. However, literature reveals that the participation of farmers is lacking due to factors such as those linked to users' commitment, racial, structural and gender inequalities, and this led to a lack of accountability and transparency in water-related decision activities. The policies of institutions that are supposed to support farmers in accessing water are not usually coherent. Other governance challenges were inadequate human resources to assist farmers with water use license applications and to empower farmers to manage water resources. In addition, farmers also lack sufficient funding to operate and manage agricultural water infrastructure. Funding is also required to develop adequate water infrastructure to enhance water security. Strategies to improve the performance of water governance, institutions and infrastructure are recommended to strengthen water security status for smallholder farmers at a local level, especially during extreme climate events such as drought.

3. CLIMATE CHANGE AND DROUGHT IMPACTS ON WATER RESOURCES

3.1 Introduction

The chapter addresses the project's second objective, which sought to assess the impacts of climate change and drought on water resources as experienced, framed, and understood by smallholder farmers and water institutions responsible for managing agricultural water. This section is based on comprehensive interviews conducted with key informants, including representatives from water institutions (see section 1.2, Chapter 1) and community-based organisations. Additionally, it captures the experiences and perceptions of smallholder farmers regarding how climate change and recurring drought have affected water availability and accessibility in these historical towns. The findings highlight the tangible challenges farmers face in securing water for agricultural activities, the adaptive measures employed by institutions, and the broader implications for water governance and livelihoods.

3.2 Site description

3.2.1 *Overberg District*

The data for this study was collected at 15 sites on the West Coast (Goedverwacht, Moorreesburg and Porterville) and Overberg District (Swellendam, Bredasdorp, Caledon, Elim, Genadendal, Napier, Suurbraak, Buffeljagsrivier, Tesselaarsdal, Villiersdorp, Barrydale and Greytown) (see figure 3.1).

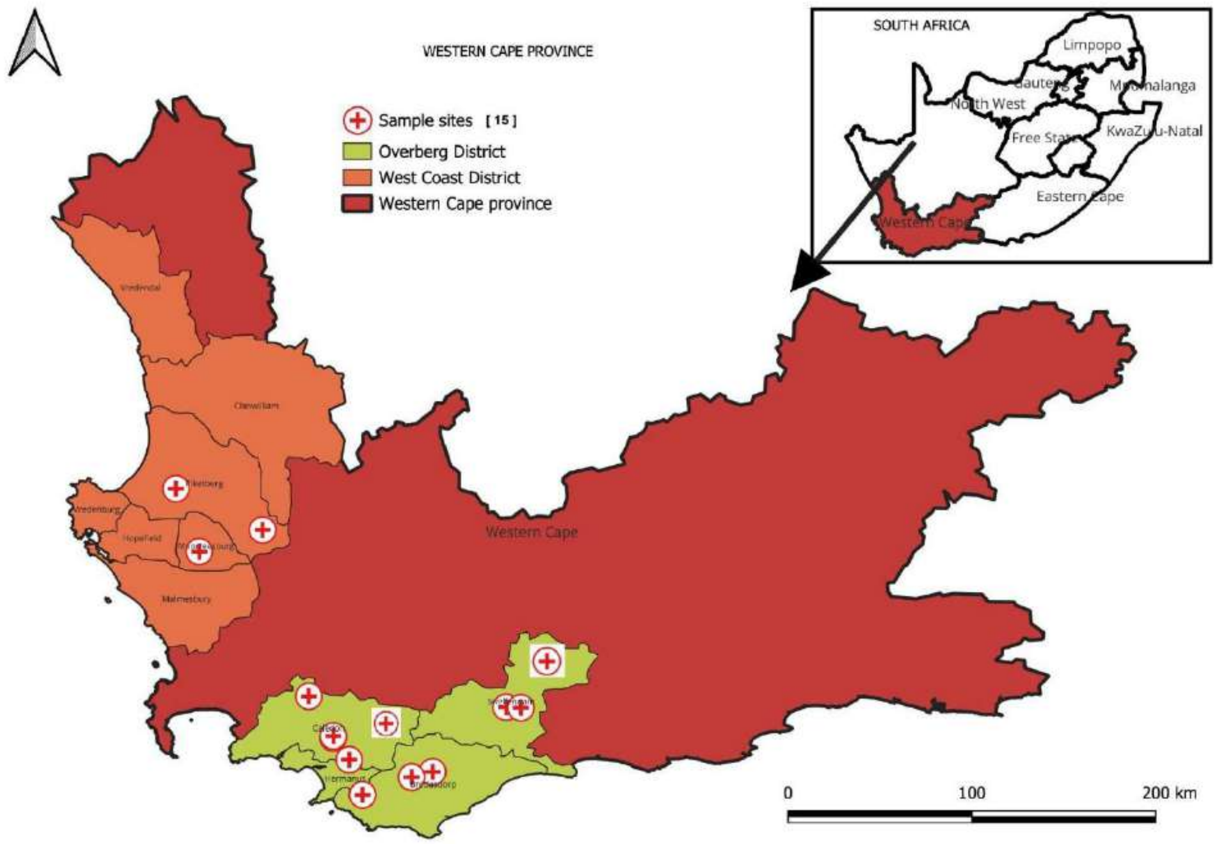

Figure 3.1 Map of the study sites in Overberg and West Coast Districts Overberg District

The Overberg District Municipality (ODM) comprises four local municipalities, i.e., Overstrand, Cape Agulhas, Swellendam, and Theewaterskloof. Towns covered in the Overberg local municipalities for individual interviews and focused group discussions are Swellendam, Bredasdorp, Caledon, Elim, Genadendal, Napier, Barrydale, Suurbraak, Buffeljagsrivier, Tesselaarsdal, Villiersdorp, Barrydale and Greytown. These sites are described in detail in the following sections.

Genadendal

Genadendal is located about 120 km east of Cape Town. It is a small historical town and Africa's oldest Moravian mission station (Roos, 2002). It is in the foothills of the Riviersonderend Mountains within the BOCMA area and Breede River Valley/Basin close to the Theewaterskloof Dam.

Genadendal has a population of 5,663 and 1,593 households. Most (45%) of these households are mainly headed by females. In terms of education, most of the people only have secondary education (43.5%) with only very few matriculating (15.5%) and attaining higher education (7%). About half (49.3%) of the population are non-working dependents aged 15 or above the age of 64. Most households earn below R76 400 per year. The community is dependent on the surrounding fruit farms for seasonal work opportunities.

The town has a Mediterranean climate with an average Mean Annual Precipitation of approximately 700 mm and an average Mean Annual Evaporation of 1,400 mm. It receives most of its rainfall during the winter season. Community members in this town rely on surface water from local rivers and mountain streams.

Agricultural development comprises commercial farmers and smallholder farmers. Presently, smallholder farming is practised on the floor of the valley of the Sonderend River. A series of community allotment gardens for crops and vegetable production is divided by tree avenues, wire fences, and quince hedgerows to enable livestock to graze freely in the open areas. The community shares the traditional canal irrigation system to irrigate their gardens. The irrigation system consists of open water furrows extending over the Sonderend River's valley floor on the southern slopes of the Riviersonderend Mountains (Swart et al., 2009).

Bredasdorp

Bredasdorp is a town located in the Southern part of the Overberg region about 160km South-East of Cape Town. Bredasdorp is an urban-type settlement located at the centre of Cape Agulhas Municipality. It is the largest town in the Municipal Area with a population of 15,524 people and is considered the economic service hub of the surrounding areas. The main economic activities in Bredasdorp are agriculture, manufacturing, tourism, and retail services. Bredasdorp is also home to several government institutions including the head offices of Cape Agulhas Municipality and the Overberg District Municipality. The town was founded following the establishment of the Dutch Reformed Church in 1838 on the Langefontein farm. The town has grown over the years to 4,525 households with an average household size of 3 members per household (Stats SA, 2011).

Bredasdorp is composed of 80% formal dwellings and other informal settlement types. As reported by the 2011 census report, over 30% of households were headed by females (Stats SA, 2011). Most of the population, 38% had some secondary education, 25% attained Matric, and 12% had post-matric education. In addition, most people had access to drinking water, electricity, and weekly waste removal. Like many towns in South Africa, poverty is an issue in Bredasdorp with over 8% of the households lacking income (Stats SA, 2011).

Bredasdorp has a Mediterranean climate experienced throughout the Western Cape Province. Agriculture in Bredasdorp includes grain, wheat, canola, and indigenous fynbos cultivation. Livestock farming includes cattle, pigs, and sheep farming. The farming system is composed of both commercial and smallholder farmers. Water resources in Bredasdorp include the Klein Sanddrift Dam and Vleikloof Dam. In addition, the municipality relies on several boreholes to supply water in the community as well as the Uitvlught spring water resource (Cape Agulhas Municipality, 2020).

Swellendam

Swellendam is considered among the oldest towns in South Africa with a population of 17,537 people and 5,172 households (Stats SA, 2011). Swellendam is an urban type-settlement in the Western Cape province located in the N2, about 220 km from Cape Town. The administration and economic functions of the Swellendam Municipality are fulfilled in Swellendam town. The municipality considers the development of Swellendam town to be vital to the economic and political sustainability of the municipal area. The municipality declares the infrastructure development of Swellendam to be limited by physical and natural features. Agriculture in Swellendam plays an important role in the town's economic development.

The expansion of informal settlements also creates pressure on service delivery. According to the 2011 census report, over 30% of households in Swellendam are headed by females. About 11% of the households had no income with a dependency ratio of over 50%. In terms of education, 5% of the population had no formal education, with most people reporting having obtained some secondary education. Swellendam is dominated by the coloured (66%), White 19%, and Black 15% population.

The town shares a Mediterranean climate experienced in the Western Cape. Agricultural practices include wheat, canola, goats, sheep, and cattle farming. The community relies on the municipality's water supply in terms of water resources. Other water resources include the Koornlands River, which runs through the town. Agriculture and tourism mainly dominate the economy of Swellendam. Swellendam is next to three Nature

Reserves: the Bontebok National Park, Marloth Nature Reserve, and De Hoop Nature Reserve.

Caledon

Caledon is a town in the Theewaterskloof Local Municipality. Caledon is situated about 100 km east of Cape Town on the foothills of Little Swartberg, adjacent to the N2 National Road. It is an urban type of settlement comprised of formal and small informal dwellings. Generally, Informal dwellings are characterised by challenges in accessing basic services (e.g., water, sanitation, and electricity) and issues of crime. The informal settlement in Caledon is unique as it is found very close to the formal dwelling. The houses are built of corrugated iron like many informal dwellings in the country.

According to the 2011 census report, Caledon has a total population of 13,020 people and 3,544 households, and females headed 30% of the households with an average size of 3.5 family members. Most people are coloured Afrikaans speaking, followed by whites and blacks (IsiXhosa and Sesotho speaking).

The economy in Caledon includes a combination of a few industries and retailers in the central business area. Agriculture in Caledon is characterised by organised commercial farmers and small vegetable and chicken backyard farmers. The town is surrounded by commercial wheat, barley, canola, and onion farmlands. Water resources in Caledon that farmers rely on include the Baths River that passes through the town. Smallholder farmers rely on municipal water schemes for irrigation. Some smallholder farmers have water tanks for rainwater harvesting. Due to land access challenges, smallholder farmers organise themselves to lease small pieces of land in schools and other local properties.

Elim

Elim is a farm town located in the southern part of the Overberg region. This is the oldest town in the Agulhas Plain, established in 1824 by German missionaries as the Moravian station (Stats SA, 2011). It is a community with a small population of about 1400 people and 490 households, 37% of which are headed by females (Stats SA, 2011). Like many rural South African towns, Elim is challenged by a high unemployment rate (Alao et al., 2017). The Stats SA (2011) Census reports a dependency ratio of 51% in Elim. There are very few economic activities in Elim except farming (Alao et al. 2017).

There are two major geological formations in Elim: The Table Mountain sandstone and Bokkeveld ranges (Van der Hoven, 2001). The town is surrounded by gentle rising slopes from the eroded Bokkeveld range (Van der Hoven, 2001). Unlike the erodible Bokkeveld range, Table Mountain is made up of sandstone layers showing a high resistance to erosion. The common soils found in Elim are shale soil and brown-red soil formed by the breakdown of silcrete and ferric rete rock (Van der Hoven, 2001). Elim is rich in fynbos vegetation. Large areas of the town are covered with indigenous fynbos (Mehl, 2019). Van der Hoven (2001) identified four classes of fynbos that are endemic to the area: asteraceous fynbos, acid sand proteoid fynbos, renosterveld, and wetlands. Elim fynbos vegetation is endangered by overgrazing, agricultural activities, and invasion by alien invasive species (Thring & Weitz, 2006). Historically, the floral diversity in the region is the key source of medicinal plants indigenous people use to treat health conditions (Thring & Weitz, 2006). Also, harvesting fynbos for exports played a significant role in the creation of employment in the past (Van der Hoven, 2001).

Elim also shares a Mediterranean climate experienced throughout the Western Cape. The mean annual rainfall in Elim is approximately 250mm. Primary water sources include the Nuwejaars River, which starts east of Elim and flows about 25km easterly to drain into the Soetendalsvlei Lake (Van der Hoven, 2001; Mehl, 2019). Sources of Nuwejaars River include Pietersiekloof River, Koue River, and Jan Swarkskraal River (Mehl, 2019). The waters of the Nuwejaars River peak in winter and are reduced in summer (Van der Hoven, 2001). This is because the Agulhas Plain experiences wet winters and dry summers. The community receives domestic water from a spring-fed reservoir (Van der Hoven, 2001). The Stats SA census report in 2011 showed that 98% of the inhabitants in Elim receive their water from the municipal water scheme, with only 2% reporting having boreholes.

In Elim, agriculture is the main source of income and livelihood (Alao et al., 2017). The land ownership in Elim is under the Moravian Church. The church owns about 6500 hectares of land (Fortaine, 2013). Van der Hoven (2001) reported that half of Elim's land had already been used for crop plantation by the year 1996. Agricultural activities taking place in and around the area include livestock farming and crops like wheat and canola (Mehl, 2019). Vegetable gardening, fynbos, and protea plantations are some common farming activities in the Agulhas Plain.

Tesselaarsdal

Tesselaarsdal is a rural village located approximately 22 km southeast of Caledon under Theewaterskloof Municipality. The community in Tesselaarsdal is mostly involved in agricultural activities (Theewaterskloof Municipality, 2019)**.** Generally, agriculture is the main economic activity, and it includes commercial and rain-dependent small-scale farmers. Common farming activities are flowers, piggery, and backyard vegetables.

Access to service delivery in Tesselaarsdal is a challenge due to its remote location (Theewaterskloof Municipality, 2019). The roads are gravelled, and there is no public transport system. Smallholder farmers can sell their produce locally since there are no reliable transport networks to reach formal markets. Tesselaarsdal has the potential for tourism development, which can stimulate economic activities and employment in the area (Theewaterskloof Municipality, 2019). The source of tourism development in Tesselaarsdal comes from its species of high biodiversity value, Lowland Renosterveld and rare fynbos (Theewaterskloof Municipality, 2019).

The water resources include the fountains located high up in the mountains and the Klein River and Hartebeeste River that run through Tesselaarsdal. These are important water resources in the community. The community also has access to the municipality water scheme. There is no breakdown regarding the demographic profile of the Tesselaarsdal population. Its population is grouped as that of rural areas and was not found in the 2011 census data. In Theewaterskloof Municipality (2019), 1500 people lived within Tesselaarsdal and in the surrounding regions in 2009, and the population is projected to grow to 1800 by 2028.

Suurbraak

Suurbraak is a very small settlement in the Overberg region with a population of 2,252 people, and 570 households. It was founded by the London Missionary Society in 1812 as a mission station to serve the Khoikhoi community. Suurbraak falls under the Swellendam Local Municipality. This rural town has potential tourism potential because of its landscape and heritage assets. In addition, small-scale farming has the potential to contribute to rural development. The town and the surrounding area are currently subjected to a land reform process. This process will determine residents' land ownership rights.

According to the 2011 census report, the average household size in Suurbraak is four members per household. Over 30% of households are headed by females with a dependency ratio of over 50%. Regarding education level, most (40%) attained secondary education, 19% had Matric, and 3% achieved post-matric education. Most of the households reported an average household income of R32,200 per year. Suurbraak is a dominant-coloured community accounting for 93% of the total population.

Buffeljagsrivier

Buffeljagsrivier is a small farming community in the Overberg region with a total population of 1,439 and 355 households. Buffeljagsrivier is also under the service of Swellendam Local Municipality. The settlement is east of Swellendam town and south of the N2. Buffeljagsrivier is comprised of a combination of a relatively high concentration of agriculture industries.

Barrydale

Barrydale is a small town in the scenic Tradouw Valley at the foot of the Langeberg Mountains. As of the 2022 national census, Barrydale has a population of approximately 4,000 to 5,000 residents. The town is part of the Swellendam Local Municipality and is known for its picturesque landscape, attracting tourists, and its agricultural activities, which are central to the local economy.

Agriculture in Barrydale relies heavily on water resources, which are sourced primarily from local rivers, boreholes, and small dams (Ncube and Lagardian, 2018). However, the town, like much of the Western Cape, faces significant challenges related to water availability, exacerbated by irregular rainfall patterns and prolonged droughts. The agricultural water infrastructure in Barrydale includes irrigation systems, which are often outdated and require maintenance or upgrading (Ncube, 2018). Water management practices are crucial, particularly during the dry summer when water demand peaks and supply diminishes.

Barrydale is home to several smallholder farmers who play a vital role in the town’s agricultural sector. These farmers typically cultivate various crops, including vegetables, fruits, and some livestock, on small plots of land. However, smallholder farmers in Barrydale face numerous challenges, including limited access to reliable water sources, funding constraints, and the impacts of climate change (Fanadzo et al., 2021). Despite these difficulties, they are integral to local food security and contribute to the socio-economic fabric of the community. Many smallholder farmers are increasingly adopting sustainable practices and exploring cooperative models to improve their resilience and productivity.

Napier

Napier is a picturesque town in the Overberg region of the Western Cape, South Africa. Nestled between rolling hills and farmlands, it is known for its serene rural character and vibrant agricultural activities. The town experiences a Mediterranean climate, with warm, dry summers and cool, wet winters, making it suitable for diverse farming practices. Napier's landscape is characterised by fertile soils, making it an ideal location for both commercial and smallholder farming. Smallholder farming in Napier is critical to the local economy and community livelihood. Farmers often cultivate crops such as wheat, barley, canola, and a variety of fruits and vegetables, leveraging the fertile land and seasonal rains. Livestock farming, including sheep and cattle, is also prevalent, contributing to wool, meat, and dairy production. These small-scale farmers frequently employ traditional farming techniques, complemented by modern methods like conservation agriculture and crop rotation to maintain soil health. Challenges include water scarcity during prolonged droughts, limited access to advanced farming technologies, and market barriers. Despite these hurdles, smallholder farmers in Napier contribute significantly to food security and community development, often supplying local markets and engaging in cooperative initiatives to enhance productivity and sustainability (Theewaterskloof Municipality, 2019)

Villiersdorp

Villiersdorp, located in the Overberg region of the Western Cape, South Africa, is a picturesque town known for its agricultural heritage and scenic surroundings. Nestled in a valley surrounded by mountains, Villiersdorp benefits from a temperate Mediterranean climate, with warm, dry summers and cool, wet winters. This climate, combined with its proximity to water sources such as the Theewaterskloof Dam — one of the largest reservoirs in the Western Cape — makes the area well-suited for agriculture.

Smallholder farming plays a significant role in Villiersdorp's local economy and community. The area is renowned for its fruit farming, particularly apples, pears, and plums, which thrive in the fertile soils and favourable climate. Many emerging farmers cultivate vineyards, contributing to the Western Cape's renowned wine industry. Some farmers diversify by growing vegetables, such as carrots and onions, and practising livestock farming, including sheep and cattle. Access to irrigation water from the Theewaterskloof Dam is a key enabler of agricultural productivity in Villiersdorp. However, smallholder farmers often face challenges such as rising input costs, fluctuating market access, and occasional water scarcity during periods of drought. Despite these challenges, initiatives such as agricultural cooperatives and government support programs have been established to help smallholders improve their productivity and sustainability. Villiersdorp's smallholder farmers often employ innovative practices, such as drip irrigation and organic farming, to optimise water use and enhance soil health

Greytown

Greytown is a historical town in the Western Cape province of South Africa, nestled at the foot of the Riviersonderend Mountains. With a relatively small population (2940), the town has a close-knit community characterized by a blend of residents and individuals who have moved to the area for its tranquil environment and scenic beauty. The geography of Greytown features rolling hills, fertile valleys, and a climate suitable for various agricultural activities, making it conducive for smallholder farming. The town's agricultural sector is dominated by small-scale farming operations that focus on crops such as vegetables, fruits, and grains and limited livestock farming. Traditional water management systems support these farming practices, although access to reliable water resources has become increasingly challenging due to the impacts of climate change and periodic droughts.

3.2.2 West Coast District

The West Coast District (WCD) is north of Cape Town. The WCD has five local municipalities. These are the local municipalities of Saldanha Bay, Bergrivier, Swartland, Cederberg, and Matzikama. Only two towns, Goedverwacht and Porterville under Bergrivier municipality, were considered for focused group discussions and individual farmer interviews as the lists of smallholder farmers to interview were provided by the Western Cape Department of Agriculture. In addition, key informant interviews were done in Moorreesburg, under the Swartland District. Descriptions of study sites in WCD are detailed in the following sections.

Goedverwacht

Goedverwacht is a small community located 25 km west of Piketberg in Bergriver Local Municipality which is under the West Coast District Municipality in the Western Cape Province. Goedverwacht is estimated to have about 650 built houses with 1700 inhabitants (during the week) which increases to 3000 people on weekends and holidays when people return from their employment outside of the Goedverwacht. Afrikaans and Isixhosa are the most spoken languages in Goedverwacht, with most of the Coloured, African, and White people.

The land in Goedverwacht is privately owned by the Moravian Church of South Africa, not the municipality, as is the case in most historical communities across the country. This of course, makes the institutional arrangements and governance in the community complex and unique. Due to insufficient opportunities in the community, people resort to going out of Goedverwacht to find better job opportunities. According to a study by Ncube (2020), Goedverwacht depends on the Platkfool or Riet River for its water supply, with wells, fountains, and a dam as water storage facilities. Water is diverted through two weirs to the community for domestic and agricultural use. The residents in the Goedverwacht only own the houses and not the land.

Goedverwacht is known as the region's fruit and vegetable basket. The area has the potential for farming, but most of the land is currently not cultivated. Some community members are involved in fruit and vegetable farming and keeping livestock. The community has a farmers' association that promotes and supports local farmers.

Even though there are such establishments (farming organisations) to support the growth of farming activities in the community, residents who occupy the farming lands are reluctant to invest in better agricultural systems, such as irrigation systems, as they do not have water rights. Farmers only sell their produce to the community and the visitors. They do not have access to markets outside their village.

Porterville

Porterville is a town in the West Coast District under Bergrivier Local Municipality in the Western Cape. The town is located at the foot of the Olifants River Mountains, 27 km southeast of Piketberg and 155 km northeast of Cape Town. The 2011 census reported that Porterville had a population of 7,057 people and 1949 households with an average household size of 3.5 (Stats SA, 2011). The Bergrivier Local Municipality (2019) predicts an increase in the population of Porterville to 9650 by 2028. Most people in Porterville were coloured, followed by whites and a few Africans and Indians/Asians (Stats SA, 2011). The language spoken in Porterville is mostly Afrikaans with a small English-speaking population.

The climate conditions in Porterville are dry, hot summers and cold, rainy winters. Porterville has two streams running through the town into the Berg River. Despite being the major water resource of Porterville, the Berg River is facing the challenge of pollution from littering (Bergrivier Local Municipality, 2019). This comprises the water quality in the river. Smallholder farmers do not have much access to reliable water resources. They mostly rely on rainwater, smallholder livestock farmers transport water from alternative sources through their motor vehicles into the farming areas.

Agriculture is the economic backbone of Porterville, followed by tourism and reaction (Bergrivier Local Municipality, 2019). Common tourist attractions are the Groot Winter Hoek Mountains for hiking trails and the Winter Hoek Nature Reserve area. Wheat is among the high-value cash crops farmed in Portville. Smallholders are practising with livestock, mainly pig farming.

Moorreesburg

Moorreesburg, in the West Coast area of the Western Cape, South Africa, is located 105 km north of Cape Town on the N7, in the middle of the wheat and canola fields. Most of the land has been devoted to large-scale wheat cultivation, earning it the nickname "South Africa's breadbasket," with its manufacturing of wine and olives growing in importance. According to the 2022 census, the town has a population of 13,736: Male Population, 6,515 (47.4%); Female Population, 7,221 (52.6%). The towns of Moorreesburg and Koringberg are supplied with drinkable water by the Moorreesburg system. Water from the Misverstand dam is extracted and processed at the Withoogte WWTW, which is located outside of Moorreesburg. Water is supplied to Moorreesburg and Koringberg's supply reservoirs and reticulation systems networks via bulk distribution networks.

3.3 Research design and data collection

A qualitative approach was used to attain the second objective of the research. Compared to quantitative analyses, qualitative research offers a comprehensive understanding of the concepts under investigation (Tewksbury, 2009). This research used a qualitative approach to capture in-depth perceptions of smallholder farmers and key informants regarding climate change and drought impacts on water resources.

The Sustainable Livelihoods Framework (Scoones, 1998; Department for International Development [DFID], 2000) was used as the guiding framework for developing data collection instruments. The aim was to capture climate change impacts and drought on the Western Cape Province's water resources and its effects on smallholder farmer livelihoods. It also analysed how institutions and smallholder farmers mitigate the effects of climate change and drought for livelihood protection. Two qualitative questionnaires for key informant interviews and smallholder farmers were developed to collect data.

Meetings to present the project were held with the WCDoA Officers at the Bredasdorp, Caledon, and Moorreesburg Offices from 11-14 April 2023. The project's objectives were explained in the meetings, the smallholder farmer questionnaire was discussed, and research sites were jointly selected. The key informant interviews (n=21) involved the municipality (n=1), BOCMA (n=2), Worldwide Water Fund (n=1), the Western Cape Department of Agriculture (n=10) and smallholder farmer cooperatives (n=6). Smallholder farmer interviews (n=119) were held in historical towns in the West Coast and Overberg District Municipalities.

The interviews were conducted within each participant's environment and at a convenient time. The research team explained the research details to the participants and informed them to feel free to withdraw from participating at any time they felt uncomfortable. The research team assured the anonymity of the participants, and that information obtained would only be used for this research. The researchers also asked permission from the participants to record the interviews. The interviews took about 45 minutes, which was explained at the beginning of each interview. The interviews were mainly done in English but translated to Afrikaans or IsiXhosa by an interpreter for farmers who did not understand English.

3.4 Data analysis

The data regarding the impacts of climate change and drought on water resources gathered from key informants and smallholder farmer interviews underwent coding to safeguard the anonymity of project participants. Pseudocodes were generated based on interview locations, and researchers were referred to as facilitators (see Chapter 5, section 5.2, Table 5.2.1). The raw data and recordings were then disseminated to all facilitators for transcription.

For data analysis, Atlas. ti was employed. In utilising Atlas. ti, the initial qualitative step involved coding, wherein category codes were generated. During this phase, researchers listed emerging ideas and identified frequently used keywords by the participants as indicators of significant themes. The last stage comprised focused coding, where researchers refined, merged, or subdivided coding categories identified in the first step. Emphasis was placed on recurring ideas and broader themes connecting the codes.

3.5 Results and discussion

3.5.1 Impact of climate change

Environmental Impacts

A common view among the participants was that climate change led to some natural disasters, mostly drought and sometimes wildfires and strong winds in the study area, which impacted the environment and smallholder farmers. For example, one informant stated that:

> *"Drought has caused the water table to go down, and it is difficult to drill boreholes. Low dam water level has led to lack of sufficient water for irrigation."* (KBreOD6)

This has negatively affected smallholder farmers, as demonstrated by the narratives below:

> *"The timing of rainfall has changed especially for grain farmers. Barrydale was the only area that was mostly affected by drought and the farmers in that area have qualified for drought relief assistance. The pasture was affected, and animals needed supplement feeds."* (KCalOD4)

> *"There was a reduction in crop production, finance was affected, and livelihoods were affected."* (KMorWD6)

> *"Livestock farmers sold their stock and vegetable farmers stopped farming. Many pig farmers ended up selling their stock and the vegetable farmers closed."* (KMorWD7)

A minority of the key informants posited that although the drought was not bad, the timing of planting and harvesting was affected. However, participants were unanimous that drought caused by climate change led to a shortage of water resources throughout the municipality, and restrictions were imposed across all sectors including domestic usage.

The results above demonstrate that climate change led to a shortage of water for agriculture, reduced agricultural production and some farmers abandoned farming. Similar results were obtained by Ziervogel et al.'s (2014) study of climate change adaptations in South Africa, Makate et al.’s (2019) study on smallholder farmers in Southern Africa and Thinda et al.’s (2021) research on the effects of climate change on agricultural productivity in South Africa. Having determined the effects of climate and as a by-product of drought on the farmers, it is important to analyse water availability, especially for irrigation purposes.

Water Availability

Narratives from the participants revealed several water sources for irrigation such as dams and boreholes. These water sources are important for climate change adaptation by smallholder farmers as they are important during the dry seasons. Several participants indicated that there were dams for the water supply:

> *"There is a big dam in Strandveld located between Bredasdorp and Elim which was built by the previous owner, a pump to extract water from the river to the dam, pipes to transport water from the dam by gravity to the fields and solar panels to pump water."* (KCalOD5)

> *"Strandveld area has a dam with a capacity of 190 000m^3 and farmers have 28.35m^3 per hour of water rights usage from the river. Farmers are registered for water allocation of 245 000m^3 per annum from the BOCMA."* (KBreOD3)

In Overberg, participants revealed that water was available, but there was a pumping challenge due to high electricity bills. Thus, there is no limit; "the amount of water used is determined by the irrigation activities and the farmers' affordability to purchase water" (KMorWD7). In summer, water is a challenge. Water quality from the dam was also a challenge, but the problem was resolved. Load shedding was another challenge; farmers were forced to pump water at night. A solar panel was installed, but the solar power was not enough, and the installation was not done properly.

In Porterville, smallholder farmers revealed that they were too many and boreholes were not enough for them. Farmers wished to have more boreholes, solar panels, and submersible pumps in this area. In contrast, farmers who use water from dams were comparatively better in the Overberg District, and their water infrastructure was enough, provided they could afford the electricity bills. Thus, suggestions were to improve water flow and increase water storage facilities.

However, as much as there were suggestions for applications for Jojo tanks from BOCMA, other participants urged negotiation for water fees with the municipality, where a smallholder farmer uses a lot of water and is unable to pay. Nevertheless, for some key informants, municipal water fees remain a limiting factor in storing more water because the more water a smallholder farmer uses, the higher the bill they pay. Therefore, farmers found having a bigger storage facility unnecessary even though water is not enough.

There was a unanimous agreement among the smallholder farmers that climate change is caused by human beings through activities such as industrial activities, although there were differences in how the effects were pronounced in the two districts. There was also unanimity that drought causes suffering among livestock, although in Porterville, during the drought, smallholder farmers contended that they had spent a lot of money on supplementary feeding for their livestock. Participants from Genadendal agreed that sometimes there is a water shortage in summer, but in winter, there is enough water. Some farmers maintained that they had never heard about day zero, which occurred in Cape Town during the 2015 – 2018 drought period. During the 2015 – 2018 drought in the Western Cape, there was enough water for example in Goedverwacht and Elim, and they were not affected by that drought. Potterville and Barrydale farmers reported that in 2019, they suffered because there was a shortage of water, and the dam in Barrydale was closed and only opened in the morning and the evening for about 50 minutes.

Most farmers felt that the rainfall had decreased, and the temperatures increased. There are more hotter days as one farmer puts it:

> *"I have observed the change in river water level, and every year it is getting hotter and hotter. I once predicted that the river would decrease over time and changes are starting to be visible." (SGeoWD1)*

This was also supported by another farmer:

> *"When it is in summer the water is very hot, and everyone will be having a problem with water, but we go and talk with other farmers upstream so that they can also give us a chance to use water in our farms."* (STesOD45)

A minority of the farmers felt that although they experienced some water shortages during the 2015–2018 drought, the actual challenge in Goedverwacht was water management. In contrast to the current findings, several studies have postulated a convergence between drought and major socio-economic and environmental effects, especially on communities with few resources and those already vulnerable. For example, Mpandeli et al. (2015) argue that it is more than just a natural danger and physical event. Drought has caused vegetation loss, health problems for humans and animals, and water shortages, leading to poverty and a lack of food in South Africa (Lottering and Mafongoya, 2021). It also negatively impacts agricultural output. Drought has indirectly worsened the environment, raised food shortages, and lowered human well-being (Bahta and Myeki, 2022).

To some extent, the findings are consistent with the data obtained by Ubisi et al. (2017), showing that the effects of drought on smallholder farmers in South Africa have been severe, including the deterioration of grazing grounds, the loss of crops, the exhaustion of agricultural resources, and the poverty of farmers, especially the most vulnerable ones. The differences between the current results and the diversity of findings between the sites may be primarily due to climate differences. For example, Goedverwacht is situated in a valley and receives water from the surrounding mountains that feed into their river; therefore, there is a high availability of water that mitigates drought. However, Porterville is situated in the mountain shadows, and there seem to be no major rivers around the area. Similarly, Swellendam, Bredasdorp, Caledon, Elim, Genadendal, Napier, Suurbraak, Buffeljagsrivier, Tesselaarsdal, Villiersdorp, and Barrydale each experience varying water availability influenced by their unique geographic and climatic contexts. Towns like Villiersdorp, situated near significant water sources, often benefit from better irrigation opportunities, while areas such as Barrydale and Napier, with less consistent water supply, face more pronounced challenges during drought.

Water scarcity

Smallholder farmers indicated that water scarcity was more of a management problem. They stressed that poor planning and inadequate infrastructure, rather than the physical availability of water, often worsened the issue. Additionally, ineffective policies and lack of coordination among water management stakeholders further intensified the challenges faced by the farming communities. This is demonstrated by the narratives below:

"There is a lot of water in Goedverwacht, but there are not enough tanks to store water" (SbreOD20)

"The closest source of water is a windmill which is connected directly to the tanks. However, the windmill is broken." (SGenOD34)

"Because the windmill is broken, you cannot fill Jojo tanks when there is no water." (SPorWD15)

"I wish I stored water in the tanks which are located at higher levels and use the tank water for irrigation when there is drought." (SSweOD72)

"I got my tanks because I had been requesting tanks to catch rainwater from my roof, but without the contract you get nothing." (STessOD80)

The findings reveal that water scarcity among smallholder farmers is primarily a management and infrastructure challenge rather than a lack of physical water availability. Farmers highlighted issues such as insufficient storage capacity and a lack of water tanks to harvest and store rainwater in areas like Goedverwacht despite the abundance of water. Broken infrastructure, such as non-functional windmills, further hampers access to available water resources, as seen in Porterville and Genadendal. These challenges are compounded by limited access to irrigation systems and bureaucratic barriers, such as requiring contracts to obtain essential water storage equipment. Smallholder farmers are still at the “tail-end” of policy development, and frequently, farmers are not properly consulted when creating policies.

Additionally, farmers who implement novel concepts like in-field water harvesting are not provided with any incentives. The advantages of implementing enhanced water harvesting, which has included greater yield or improved food production, have not been the subject of research. Conflicts and disputes among farming households are examples of unexpected consequences of climate adaptation policy (Jat et al., 2014). However, given that the concepts ingrained in policies encourage the movement of the agricultural sector towards improved livelihoods, agricultural policy has a huge potential to increase family production.

Conflicts

Concerns were expressed about water conflicts that militated against mitigation against climate change and drought. Over half of those interviewed reported that there were conflicts over the irrigation schedule. Throughout the interviews, it also emerged that division among the farmers made it challenging to manage water resources. There were intra-group conflicts, for example, between upstream and downstream farmers, as aptly put by two participants:

> *"There is no problem here upstream but those farmers downstream face water problems because of farmers upstream who block the water to flow downstream."* (SGoeWD12)

> *"The farmers upstream sometimes use a lot of water, and the downstream farmers do not get water on time."* (STessOD87)

Shoko (2022) argues that to handle the mutual dependence among farmers, a strong social framework is required. This will allow disputes to be avoided wherever feasible and dealt with when they do arise. Although a scheme is technically completely functioning, inadequate conflict management typically has a detrimental impact on its general efficiency and, in extreme situations, may result in the entire cessation of irrigation activities. It has been established in previous studies that interpersonal disputes can develop within a social structure, such as a smallholder irrigation system. There are conflicts between people over procedural or how-to issues. Such a conflict typically results from a dispute based on selfishness or personal reasons rather than a difference in thoughts or beliefs. Role deviants are people in a group who choose to disregard the rules and are despised by their peers since the conflicts they generate do not advance the interests of the group.

There were also inter-group conflicts, especially between the Khoisan descendants and the Moravian Church. From the interviews, it appeared that the conflict was historical and tied to the land and appeared difficult to resolve. For example, the church is said to be the owner of the land through purchasing and the farmers, who regard themselves as first-generation inhabitants, are squatters. Since the farmers are squatters and do not have contracts, the church always threatens to repossess the land and there are always tensions. One participant farmer argued that:

> *"The farmers must do their work, and the church must do their work. When two parties are focusing on their things, the rest of us will help the community that is less fortunate and does not have the means to survive with this farming produce. However, this church has been taken to court in Elim so many times, but nothing happens because the CEO of the church tells everybody that they cannot find help anywhere because he has government connections."* (SGoeWD8)

The above views were shared by other participants:

> *"The Moravian church is supposed to do the maintenance, but they just get the money and use it for their benefits, and they are so difficult to work with."* (SGoeWD9)

> *"The municipality is supposed to help us, but the church is difficult. The church is just taking the money from us and not helping us, and they use the money for their uses. The church just takes the money and does not render its services, and it is a big challenge."* (SGoeWD6)

The findings highlight notable tensions between the church and local stakeholders, with participants alleging that the church prioritises its interests over the community's needs. This sentiment is compounded by claims of the church leveraging political connections to avoid accountability, which has eroded trust. Additionally, the church's perceived failure to fulfil its water maintenance responsibilities and collaborate effectively with the municipality results in challenges in addressing community development and support for vulnerable populations. The finding dovetails with Shoko's (2019) argument that water rights must be created that are documented, tradeable, enforced, independent from land, and backed by processes that can address disputes, third-party effects, and water quality concerns.

3.5.2 Adaptation to climate change and drought

Self-reliance

A recurrent theme was a sense amongst interviewees that they need to be self-reliant to overcome the effects of climate change by maintaining their water infrastructure. One participant stated*:*

> *"I do my maintenance if they are pipes at my farm, if outsides we as farmers operating around are all capable of doing our maintenance" (SNapOD59),* and another

commented, *"No maintenance is being done because there are no leaks, but if it breaks, I will fix it myself" (STessOD87)*.

In one case, the participant observed that farmers fix their infrastructure even if nobody is specifically employed for maintenance (SSuuOD77). Commenting on self-reliance, one of the interviewees said:

> *"We fix the broken pipes immediately when we spot leakages because we need water, we cannot let the water go to waste. We need to sustain ourselves by the money they generate from their farming produce, cannot waste our water."* (SGrey98)

The results demonstrate that smallholder farmers can cope with climate change effects on their own devices by reinvesting income generated from their plots into their water infrastructure. Although various studies referred to above demonstrate the need for government support for smallholder farmers in mitigating the effects of climate change and drought, the cognitive abilities of the farmers should be considered a starting point in any programme designed to lessen the impact of climate change.

Modern farming methods

Key informants reiterated that they assist smallholder farmers to move from traditional to modern farming methods, by bringing new cultivars that are adaptive to drought. They also encourage farmers to practise conservation agricultural methods such as mulching, this also helps to prevent soil erosion. However, "there are challenges with the migration from traditional to modern farming methods because farmers are not sure whether they will get the same yields when departing from their traditional farming techniques" (KOnline13).

Issues related to drought-resistant crops were particularly prominent in the interview data. For example, one key informant (KOnline16) indicated that:

> *"Crop farmers should use water sparingly or save water as well as reduce the number of crops to be planted but farmers can tell you that we cannot plant less. Use water when necessary and use grey water."*

Another participant supported this:

> *"We encouraged farmers to plant drought-tolerant crops that use less water as well as changing planting and harvesting time. We also tried to convince farmers that climate-related disasters are real."* (KBreOD3)

In Goedverwacht, participants conserved water through organic farming practices. They explained how they crafted pipes from organic materials and planted numerous trees along riverbanks to absorb excess water. Additionally, they practised minimal tillage to preserve the integrity of the subsoil and maintain its structure.

> *"We plant trees along the riverbanks because they help to manage water by soaking up the excess during floods." (SGoedOD45)*

> *"We do not plough deep because we want the subsoil to stay intact and keep the nutrients where they are needed." (SGoedOD67)*

The participants suggested sustainable agricultural practices by integrating organic farming methods that prioritise soil and water conservation. Their innovative use of organic materials to construct water management infrastructure reflects a resourceful approach to enhancing water retention in the soil. Planting trees along riverbanks mitigates flooding and contributes to ecosystem health and biodiversity. Minimal tillage practices show a clear understanding of preserving soil structure and fertility, ensuring long-term productivity. These practices point to environmental stewardship, showcasing how localised, farmer-driven solutions can address water management challenges while promoting climate change resilience. The findings reveal the pressing need for farmers to adopt modern farming methods. In similar studies, Ruwanza et al. (2022) suggest similar techniques, such as rain harvesting, irrigation technology and drilling of boreholes, as coping strategies for climate change. According to a related study by Turpie and Visser (2013), the primary methods smallholder farmers employed to adjust to climate change were shifting planting and harvesting dates. According to Acquaah (2011), who also acknowledges the current study, small-scale farmers in Morogoro, Tanzania, usually favour shifting planting dates as well as crop varieties as adaptation tactics. Hammer et al. (2002) contend that these results are only partially accurate because variable changes should represent genetic diversity. This is in line with findings by Singh et al. (2014) on peanuts for cotton across West Africa.

Water conservation

Several key informants commented that there are numerous water conservation techniques that they teach smallholder farmers to mitigate the effects of climate change. More than half of the informants agreed that the Western Cape Department of Agriculture encourages farmers to conserve water. Several water conservation techniques were suggested. For example*, "using shade netting and storing water during rainfall for fruits and livestock" (KOnline21)*, "*downscaling production, using water retention methods, irrigating late in the evening, practising irrigation scheduling and water conservation methods" (KGrey15).* Some informants suggested introducing a drip system for irrigation to save water and suggested sunrise and sunset irrigation schedules to minimise chances of water loss through evaporation and practise mulching to minimise water usage through other irrigation techniques. Other informants felt that there was a need to follow up and "check if the smallholder farmers practise those water conservation techniques" (KI5). There were also calls for more research on water sources, conserving wetland water wastages, and investigating the water table and water quality near farmers' operations. The informants argued that this would assist when the municipality helps drill boreholes for the smallholder farmers.

It is implied that some of the smallholder farmers in the study area, employ irrigation systems and are thus familiar with the water scheduling practices that are frequently followed. Because they know that water is scarce in the area, these farmers are more likely to embrace and follow water conservation practices. It is important to note that consistent with these findings, scholars such as Moswetsi et al. (2017) advised that techniques like supplemental irrigation and rainwater gathering technology be given precedence in attempts to solve the dryland water challenges.

Research

The overwhelming majority of the key informants expressed a desire for research and collaboration to assist farmers in coping with climate change and drought. One informant stated:

> *"We need to pass knowledge or strategies to cope and adapt to drought to agricultural advisors so that they can disseminate the knowledge to other farmers. The results obtained by the researchers should be made aware to the agricultural advisors so that improvements can be made. Do not just collect data from us, we need to know the*

> *results so that we can assist farmers and improve where we are getting wrong. It is very important to discuss the results together with agricultural advisors to help farmers."* (KOnlie20)

This was supported by another informant:

> *"More research should be done on water conservation methods and efficient pump systems. Engineering should come up with wind turbines and biogas on the farm to reduce the high dependency on Eskom."* (KMorWD9)

Services for agricultural extension play a special role in sharing knowledge, networking, and acceptance of innovation. The results support the conclusions of Nyangena and Juma (2014), who discovered higher adoption frequency by farmers because of enhanced awareness and knowledge influenced by extension advisers.

A small number of those interviewed suggested research and development of technology to mitigate climate change effects. For example, one farmer said, "*More research should be carried out on developing new technology focusing on agriculture and self-financing strategies for farmers"* (SBufOD7). Another added, *"Research should be carried out on the technology, rainfall patterns, and temperature variation and present the results back to the farmers"* (STessOD69) It is important to design technology that is both user-friendly as well as suitable for both men and women. Perez et al.'s (2015) study, which indicated that rural communities continue to depend on human labour over technology and insufficient guidance for a wide range of farming tasks, supports this conclusion.

Assistance

When asked about actual assistance to farmers, most participants were of the view that there was some assistance of different kinds available to farmers from the government. One informant indicated that they assist emerging farmers to become sustainable:

> *"We assist farmers with the funding application process. If we cannot assist farmers, we can direct them to responsible organisations. I am not sure if the Breede-Gouritz Catchment Management Agency is involved."* (KMorWD8)

Other informants widely supported this. For example, one commented that they "*inform farmers about climate-related disasters as well as do road shows and keep farmers informed about what is happening*" (KBreOD2). Another reported that they *"supply* *farmers with production inputs (seeds, feeds and medicine), fuel and Jojo tanks"* (KCalOD5)

However, half of the smallholder farmers argued that support was minimal. One informant argued, *"The Department of Agriculture only install the water infrastructure, but farmers are supposed to maintain the infrastructure which is why we are paying water use fees"* (SPorWD60). Another informant added, "*As for dams not much support, there was nothing done for us in this regard"* (SNapOD34). One commented that:

> *"We are not managing their water. The farmers have their council to manage their water. Local municipality is not supposed to manage water, farmers are supposed to manage water for themselves. Farmers do not have funds to manage water and municipalities sometimes assist but it is not their responsibility."* (KGreOD3)

Overall, most informants felt that the Department of Agriculture should encourage farmers to have insurance so that they can get funds when disasters come and provide financial management training to farmers as well as firefighting training. Recently, considerable evidence has accumulated to show several challenges to smallholder farmer adaptation in South Africa. For example, Ubisi et al., (2017) found that there is a lack of climate information dissemination support services and a high rate of illiteracy. Since they are likely incapable of comprehending and reading (for example, weather forecasts), smallholder farmers' views of climate change might also hinder their ability to keep up with events in their immediate surroundings. The financial security of smallholder farmers is in danger due to poor adaptation techniques since they struggle to adjust (Makate et al., 2019). So that they can adapt to climatic challenges, farmers require support mechanisms that can spread knowledge about climate change while keeping them informed.

3.5.3 Climate change adaptation challenges

Water Rights

According to Bourblanc and Blanchon (2019), landowners with water rights have (or should have) access to nearby bodies of water. Landowners with riparian rights have access to and use flowing water sources, such as rivers and streams. However, as the narratives below suggest, water rights are problematic because the government is the licence holder.

> *"There is no water use license for grain farmers and natural dams. Livestock just drinks water in natural dams. As for fynbos farmers who are practising irrigation farming in the Strandveld area, the water use license is not [in] the name of the farmers because the farm is for the government, and it has been leased for 30 years."* (KMorWD8)

This is so because:

> *"Water rights are not in the names of farmers because farmers do not own the land. There are no water rights without land rights."* (SGoeWD3)

Most participants agreed with the statement that water rights are not in the names of farmers, but the government and this has affected the former, as one key informant put it:

> *"When there are no water rights and no water tanks, farmers lose crops and livestock. There is no agriculture without water. Food security is impacted, and this leads to food insecurity."* (KBreOD2)

In addition to a lack of licenses, farmers using boreholes pay a yearly fee. Those farmers who are using water from Theewaterskloof pay for using water through the farmers' association. Since they do not own the water, some pipelines for transporting water are unknown, and some farmers use water freely.

The results indicate inequalities in water access which are also tilted in favour of commercial farmers who have water use rights as opposed to subsistence and smallholder farmers who wish to have those rights. In addition, most black smallholder farmers only got the opportunity to participate in farmer activities around the year 2008. Thus, given these findings and previous ones, Ncube (2018) argues that given water rights will continue the land even after the black recipients have left farming. Therefore, one might ultimately claim that the water supply still benefits the white commercial producer. Since the bulk of the farmers of formerly marginalised farmers lack access to land and water, they are often uninterested in making significant choices, refusing on the part of some parties to help with justice and equity (Fanadzo and Ncube, 2018). It is becoming clearer from studies in South Africa that water rights are crucial, and that the management of progressively constrained water resources is severely hampered by the absence of efficient water rights systems (Kidane et al., 2019). This is because vague property rights typically constrain the value that individuals attribute to resources (Okorie et al., 2019). Water usage decisions are severely hampered by the high transaction costs resulting from poorly defined water rights. This suggests that individuals will be ready to pay higher rates for water consumption since the cost of transactions will decrease if water rights are well specified. This makes it feasible to analyse various water rights policy choices using contingent valuation approaches.

Insufficient resources

A minority of participants reported that insufficient resources are another challenge in climate change adaptation. There were some arguments that there was never enough for livestock, crops, and vegetables because the number of animals and fruit production is always increasing on limited plots of land. In addition, medication and fodder for livestock were inadequate. Packages for disaster relief were also regarded as insufficient, and farmers experienced drought differently. Funds were also seen as insufficient to support every farmer. Lastly, farmers wished to get support from key institutions.

Data from several studies suggest that because they lack resources, most smallholder farmers in South Africa cannot pay for expensive fertilisers (Odhiambo and Magandini, 2008; Ruwanza et al., 2022). The use of mineral fertiliser is dangerous for some reasons. Farmers worry that their crop revenue is not high enough in any given year to pay their fertiliser expenditures because yields and output prices might vary greatly yearly. A study by Odhiambo and Magandini (2008) showed that 75% of farmers cannot afford the required quantities of fertilisers due to limited funds. Similar findings were reached by Matlou et al. (2021) on the fact that having a little surplus of revenue as a smallholder farmer restricts the adoption of various climate change adaptation measures. Thus, it is difficult for small-scale farmers to apply adaptation techniques based on their agricultural revenue since income without knowledge will not help them adapt more effectively. The possibilities for adaptation available to smallholder farmers depend on their understanding of climate change. The study's findings show that understanding the unpredictability of climate change is crucial for successfully adjusting to crop variety or diversification. There is a strong likelihood that small-scale farmers who are cognisant of climate change would combine adaptive tactics. Farmers adopting adaptation strategies is a crucial prerequisite.

Resistance to change

Concerns were expressed about smallholder farmers' resistance to change. Two divergent and often conflicting discourses emerged on why the smallholder farmers resisted change. On the one hand, two key informants said:

> *"Farmers normally do not want to listen because they want to continue their age-old practices. They are relatively slow to change their ways of doing things, especially older farmers, but younger farmers can listen better and are willing to change."* (KCalOD4)

> *"Farmers were not willing to accept the advice from the agricultural advisor to sell a portion of their livestock or to reduce the area of crops, and that resulted in more damage to their produce and the death of their livestock."* (KMorWD10)

On the other hand, one key informant argued that technology is expanding, and farmers are not able to cope with new technology:

> *"The BOCMA has introduced an online system for farmers to apply for water use licenses and remove the manual application. It is very difficult for farmers to use the online system application. Online application systems should go hand in hand with the manual application system."* (KOnline19)

It is impossible to overstate the importance of education in overcoming resistance to change to ensure the agricultural sustainability of Enyibe, Ermelo, South Africa. Numerous additional research studies (Kadafur et al., 2020) have revealed that educated families are more receptive to knowledge and capable of adopting new technology, which complements this conclusion.

Inadequate infrastructure

A common view among interviewees was that climate change and disaster mitigation are difficult because of the lack of adequate water infrastructure. The comments below illustrate this:

> *"Since I have a farm at my house, I have a pool that I can use to extinguish the fire. There is no fire hydrant on the road that can be used by the fire brigade to connect and extinguish the fire. That is why it is difficult to overcome fire in this area, the last time when big fire happened, we got help from the municipality by sending three helicopters."* (SBarOD95)

> *"We do not measure the amount of water we just use water. There are no water meters. The system is too old, and the water meters are broken because it is now about 50 years since the system was established"* (SGoedW3)

> *"I have got now three tanks (2 plastic tanks and 1 asbestos tank) with a total storage capacity of 10 000 litres; however, the other 2500 lire tank is broken."* (STessOD73)

> *"Because the windmill is not working and now everyone gets water transported from the other farmer."* (SPorWD19)

> *"We use an electric pump, but the electricity is always off. The electricity is always off because the church did not pay the money that was supposed to be paid to Eskom."* (SGoeWD4)

The findings highlight significant challenges related to inadequate water infrastructure that hinder climate change adaptation and disaster mitigation among smallholder farming communities. Taken together, these findings indicate the lack of water infrastructure that may come in handy in mitigating the effects of climate change. However, there seems to be poor water infrastructure that affects climate change adaptability. The results are similar to Mugejo and Ncube's (2022) findings in Genadendal, Western Cape, which showed poor performance of irrigation water infrastructure due to inadequate maintenance. However, as Sharaunga and Mudhara (2016) argue, conflicts including a failure to follow irrigation laws may result from the canal's inability to transport enough water. Therefore, via canal cleaning and repair, the physical issues that obstruct water delivery ought to be addressed as soon as possible.

Lack of training

A few participants were particularly critical of the lack of training for climate change mitigation: One participant noted, *"There was no training received, but the farmers would like to have such, a lot of young people are passionate about farming"* (SGoeWD14). Another reported*: "I am not aware of any organisation providing any training. Maybe no one knows about us"* (SCalOD34). One interviewee commented, "*There is no organisation availing themselves to train the farmers. For the past 23 years, there have not been any people who come with such an offer" (SbreOD40)*

The findings indicate that as the effects of climate change rise, so do the adoption and usage of measures for coping with climate change. Some who have received training in agriculture will use climate change adaptation measures. Adopting techniques for coping with climate change is significantly associated with access to agricultural training. Popoola et al. (2020) posit that training programmes on the widespread use of mobile alongside smartphones to access agricultural information through user-friendly social media platforms that are actively used by those who work in agriculture might be put into place. Numerous studies have shown that smallholder farmers in various African nations have adopted mobile/smartphone technology, which has substantially influenced their agricultural operations.

3.6 Conclusions

This chapter examined climate change impacts and drought on water resources in historical towns in Overberg and West Coast districts. The results in this report were obtained from interviews and surveys on the impacts of climate change and drought on water resources as experienced by smallholder farmers and institutions. Results suggested that climate change led to some natural disasters, mostly drought and sometimes wildfires and stronger than usual winds. Results reveal several climate adaptation challenges for farmers, such as lack of resources, resistance to change, intra-group and inter-group conflicts, and inadequate infrastructure. However, results also reveal various options are available to farmers, such as adopting modern farming methods and technology and possibly getting support from government agencies.

4. PERFORMANCE OF AGRICULTURAL WATER INFRASTRUCTURES THAT SUPPLY SMALLHOLDER FARMERS IN THE OVERBERG AND WEST COAST DISTRICTS

4.1 Introduction

This chapter addresses the project’s third objective: to assess the performance of agricultural water infrastructure supplying water to smallholder farmers. The previous chapter highlighted several climate adaptation challenges that smallholder farmers face, including the lack of resources, resistance to change, intra-group and inter-group conflicts, and inadequate infrastructure. These challenges significantly impact farmers' ability to adapt to climate change and manage water resources effectively.

The chapter specifically evaluates the functioning, efficiency, and sustainability of the water infrastructures crucial for agricultural activities in these communities. Smallholder farmers rely heavily on these infrastructures to ensure reliable water access for irrigation, livestock, and other farming needs. The chapter identifies gaps by assessing the performance of these systems and their adequacy and determining how well they meet the demands of farming operations. Key performance indicators, such as water availability, infrastructure reliability, maintenance practices, and the responsiveness of water management systems, are examined. This assessment explores the efficiency of existing irrigation systems and water storage solutions. It also considers how these systems contribute to climate resilience and their role in mitigating water scarcity during periods of drought.

4.2 Data collection

The chapter focused on Section A and Section C of the questionnaire (see Appendix B). The research team was assisted in identifying and selecting respondents (smallholder farmers) by the Agricultural Extension Officers from the WCDoA. The extension officers work closely with the participants (smallholder farmers) in the project sites. After the initial identification and selection of the participants, the research team then applied the snowball sampling technique, which included referrals from participants to other possible participants. The questionnaire included questions relating to household demographics such as age, gender, size of household and education level. Questions relating to infrastructure included water infrastructure used to transport water, water storage facilities, water leakages, age of water infrastructure and maintenance of water infrastructure, and ways of pumping water from sources.

The questionnaire was administered face-to-face to 119 smallholder farmers in the West Coast (Goedverwacht and Porterville) and Overberg District (Swellendam, Barrydale, Bredasdorp, Caledon, Genadendal, Napier, Suurbraak, Buffeljagsrivier, Tesselaarsdal, Villiersdorp, Greytown). English was the main language used to conduct the interviews. In cases where respondents only understood Afrikaans, interpreters (extension officers or smallholder farmers) assisted the research team. In other instances, some participants were comfortable with interviews conducted in IsiXhosa. In such cases, one team member who was fluent in isiXhosa administered the questionnaire to those farmers.

The research team conducted transect walks around the communities with the assistance of extension officers and smallholder farmers. During transect walks, the research team undertook visual inspections of smallholder farmer water infrastructure within the study sites. The visual assessment aimed to record the availability and conditions of water infrastructure in these sites. The research team captured pictures of the conditions of the water infrastructure for photo records. The photo records included water storage infrastructure, particularly tanks and earth dams for smallholder farmers who were involved in livestock and crop farming.

4.3 Farmer characteristics

Farmer characteristics were captured to understand the age distribution, gender, household size and level of education of the interviewed farmers. This data would help in later understanding whether these characteristics were related to the production levels of the farms. Figure 4.1 shows the age distribution of the interviewed smallholder farmers in the study area.

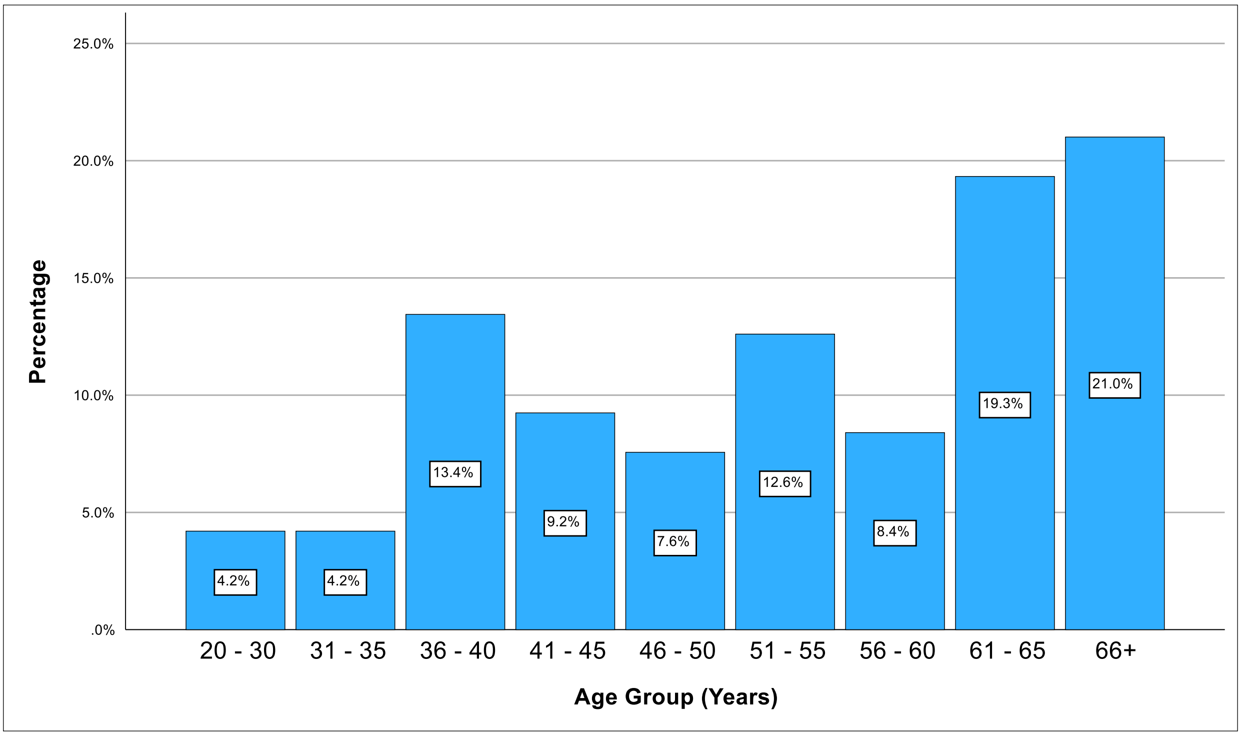

Figure 4.1 Age of the participating smallholder farmers (N=119)

The mode age (21%) of the interviewed farmers was of pensionable age (66+ years), while 19.3% were aged 61-65 years and between 41-45 years, 9.2% were aged between 36-30 years, or between 51-55 years and 56-60 years. A few farmers were aged between 46-50 years (7.6%), 31-35 years (4.2%) and 20-30 years (4.2%). The data demonstrates that farming is mainly an activity done by people who are 51 years old and above, although there is a considerable number of young farmers aged 36-45 years.

About 70% of the interviewed farmers were male (70%), and the minority were women (30%).

The data reveals that smallholder farming and access to land and water might be relatively gender biased in favour of men. This may also be a result of male-dominant households, with women playing a supporting role, although this is in contrast with population statistics, where most households were found to be female-headed in the 2011 census.

Figure 4.2 shows household size across the sites in Swellendam, Barrydale, Bredasdorp, Caledon, Genadendal, Napier, Suurbraak, Buffeljagsrivier, Tesselaarsdal, Villiersdorp, Greytown, Goedverwacht and Porterville.

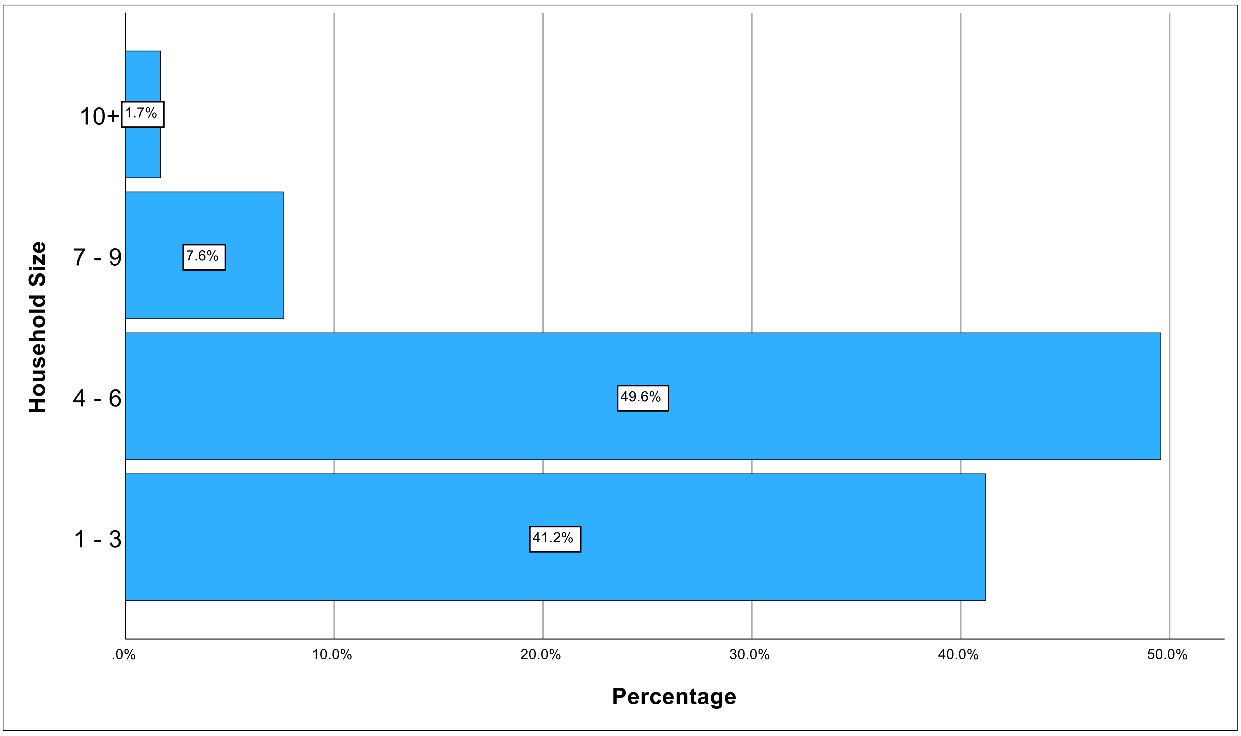

Figure 4.2 Household size for participating smallholder (N=119)

This figure is quite revealing in several ways. First, it shows household size is relatively low among participant farmers (six or less). For example, 41.2% had one to three household sizes, and 49.6% had four to six. The figure shows that 7.6% had a household size of seven to nine, and 1.7% had ten plus. One can infer that since most farmers are either pensioners or approaching pensionable age, their children are most likely to be based in urban areas. These results could be an indicator of negative implications for the availability of farm labour.

Figure 4.3 presents an overview of the level of education of the participants. Sixty-three per cent of the participants had secondary education, 22.7% had primary education, 11% had tertiary education, 1.7% had no formal education, and 8% were unsure. Those with postgraduate degrees were leaders of their respective cooperatives or farmer groups.

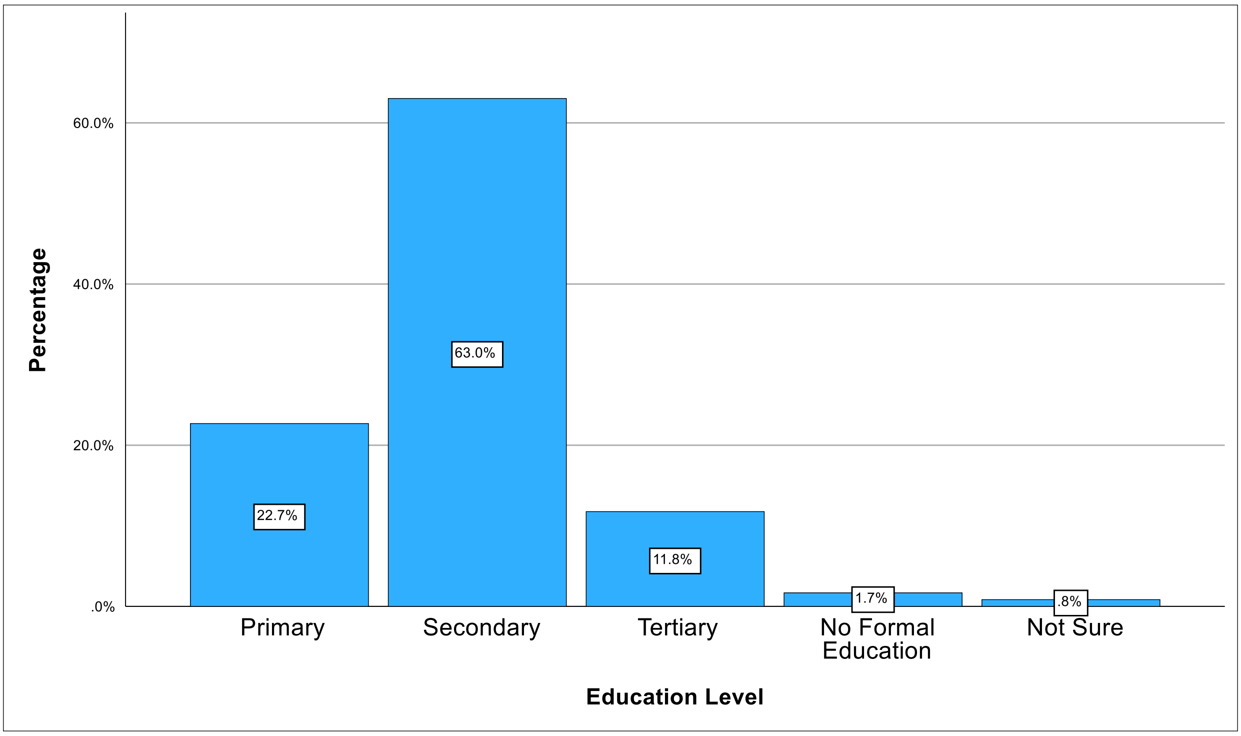

Figure 4.3 Household size for participating smallholder farmers (N=119)

4.4 Farming – land ownership, land size, types of crops

Figure 4.4 shows the summary statistics for land ownership across Swellendam, Barrydale, Bredasdorp, Caledon, Genadendal, Napier, Suurbraak, Buffeljagsrivier, Tesselaarsdal, Villiersdorp, Greytown, Goedverwacht and Porterville.

Twenty percent of the respondents were renting land, and a similar percentage were allocated the land to them by the Western Cape Provincial Government. However, 15.1% used borrowed land, 18.5% inherited the land, 9.2% bought it, and 15% had varied forms of land ownership such as leasing, trusteeship, and informal land.

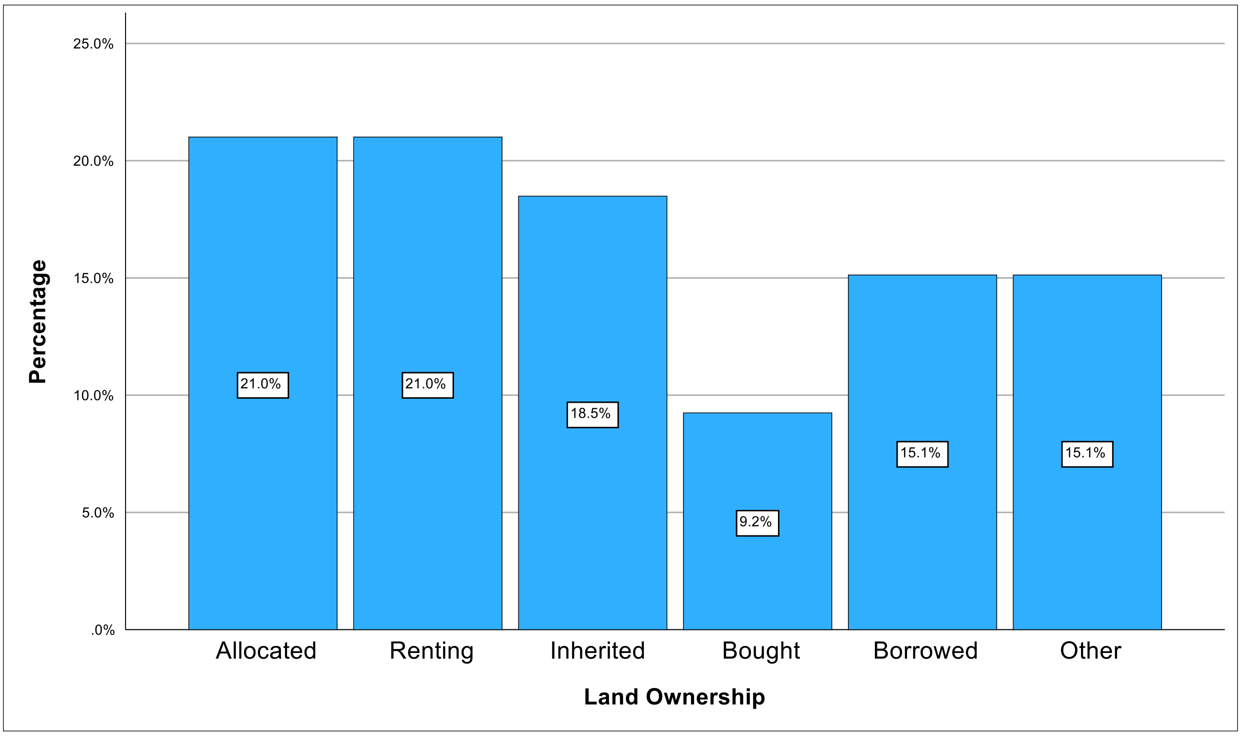

Figure 4.4 Type of smallholder land ownership (N=119)

There are indications from Figure 4.4 that most farmers lack title deeds, which usually militates against obtaining private loans, which often require land as collateral. This may lead to a significant lack of farm water infrastructure investments. Negotiating power for water connections in Bredasdorp was problematic for farmers on informal land.

Figure 4.5 shows the distribution of farm sizes in Swellendam, Barrydale, Bredasdorp, Caledon, Genadendal, Napier, Suurbraak, Buffeljagsrivier, Tesselaarsdal, Villiersdorp, Goedverwacht and Porterville. Many farmers have farm sizes of 10 hectares or less, with 38.7% having 1-10 hectares and 37% having less than 1 hectare. A few farmers had 11-20 hectares (4.2%), and 21-30 hectares (5.9%), whilst some had 30+ hectares (9.2%). Some farmers (5%) were not sure of the size of their farms.

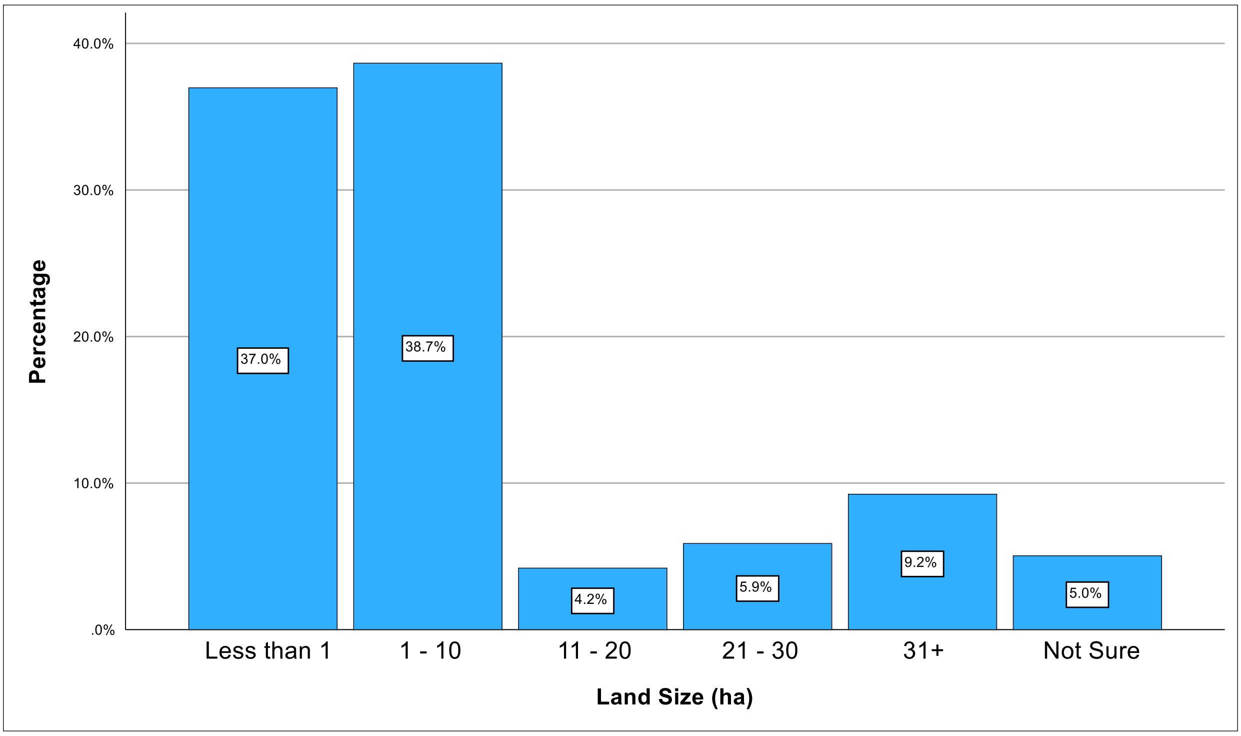

Figure 4.5 Smallholder farm sizes (N=119)

Farm size depended on the farming type; pig farmers had a plot of less than one hectare. Those with 30+ hectares either did mixed farming, with cattle (they need grazing areas) or emerging fruit farmers with up to 300 hectares. Figure 4.6 shows the types of farming practised by the smallholder farmers in the study sites.

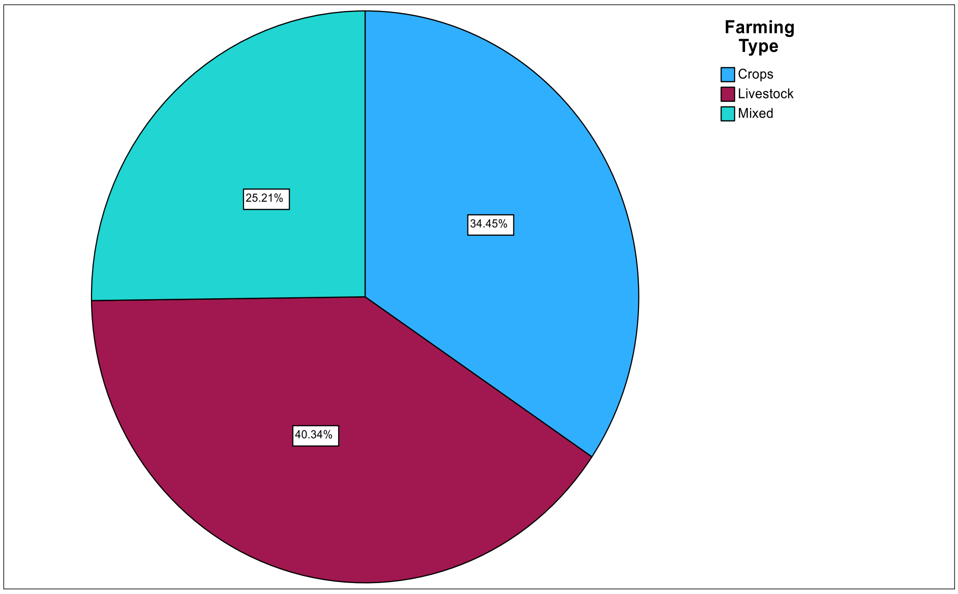

Figure 4.6 Type of farming (N=119)

A large proportion of the respondents were livestock farmers (40.34%). The type of livestock kept by the farmers were pigs, sheep, and cattle. Some farmers (34.45%) were in crop production, for example, vegetables (spinach, onions, cabbage, carrots, beetroot, beans, potatoes, and sweet potato) and fruits (pears, apples, oranges and nartjies). However, some practised mixed crop and livestock farming (25.21%).

4.5 Types of Water Infrastructure

Water infrastructure availability varied from site to site, as did water pumping and storage methods.

4.5.1 Infrastructure types

Figure 4.7 shows the types of infrastructure used by the interviewed farmers. Pipes were used by 63.87% of the farmers as infrastructure to transport water from the sources to their farms, while 7.56% used lined canals, 3.36% used unlined canals, and 1.68% used boreholes.

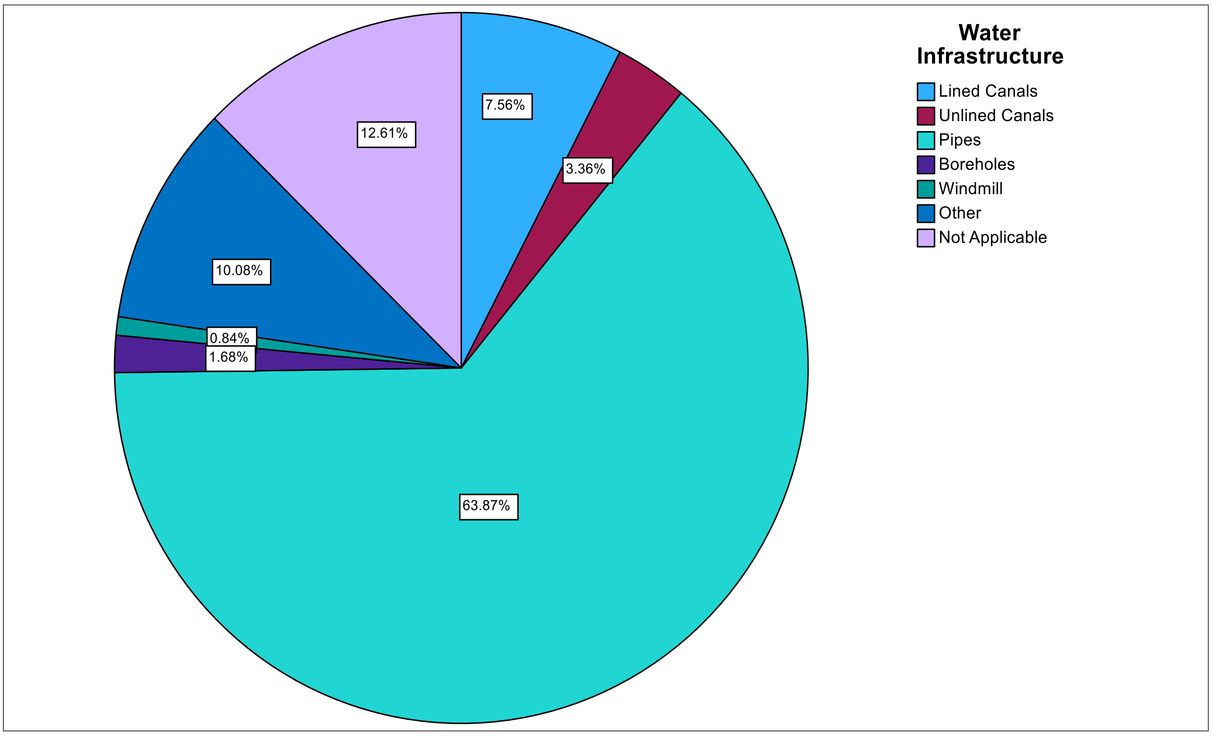

Figure 4.7 Types of infrastructure used by farmers (N=119)

Some farmers (12.61%) used other methods to transport water. These included using buckets to ferry water to pigsties in Bredasdorp. In Swellendam and Potterville, some farmers fetched water somewhere, filled tanks in bakkies, transported it to their farms, and transferred it into JoJo tanks on their farm sites. A couple of reasons were provided for doing this. In Potterville, the windmill that provided water to the farms broke down in 2021, and they had to fetch water from a neighbouring commercial farmer's dam. In Swellendam, some farmers had small dams that dried mid-season and had to rely on municipal water from the town. The results demonstrate the differentiated nature of farmers' access to water infrastructure. Although many farmers had access to functional water infrastructure, a substantial minority lacked access and support and had to use alternatives to keep their farms afloat.

4.5.2 Age of infrastructure

A considerable number of farm water infrastructure was new (1-5 years), accounting for 48% of the respondents (Figure 4.9). A sizable number of infrastructures were old, aged 20+ years (24%). Others ranged from 6-10 years (11%), 11-15 years (4%), and 16-20 years (4%). However, the most striking finding was a less significant figure of farmers who were not sure (9%) of the age of their water infrastructure.

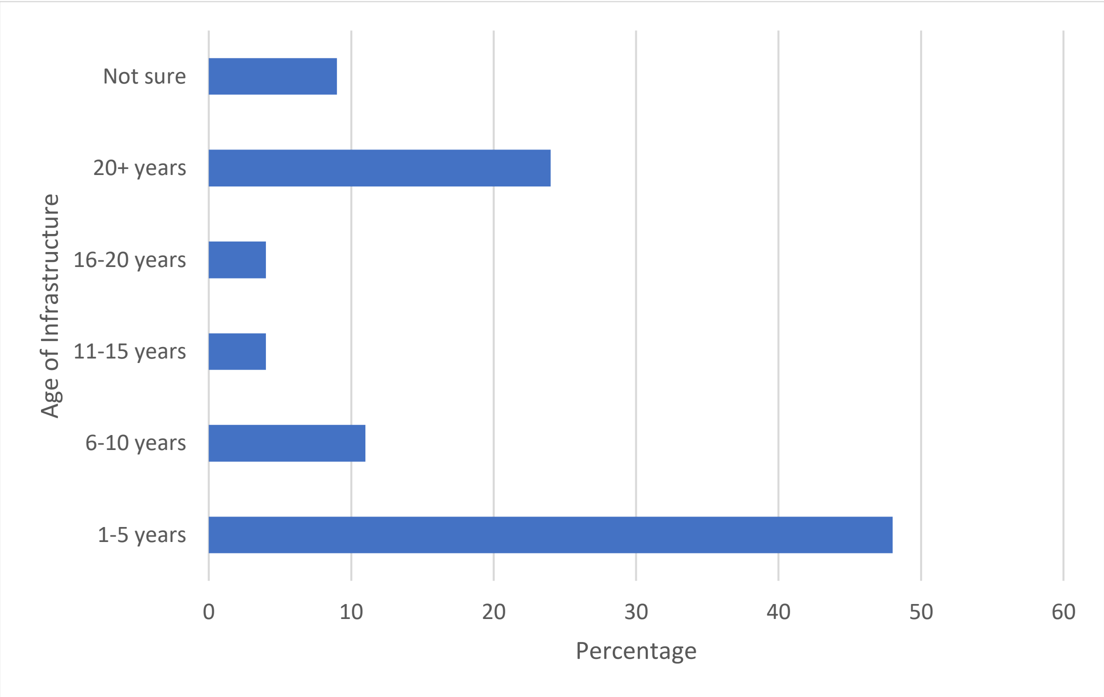

Figure 4.8 Age of water infrastructure (for smallholder farmers with infrastructure) (N=80)

It is important to note that the total number of farmers who had some water infrastructure at their farms was 80. The findings from this study are surprisingly different from several studies in South Africa, which showed ageing water infrastructure among smallholder farmers (Baiyegunhi et al., 2019; Halimani et al., 2019; Mazibuko et al., 2019; Slayi et al., 2023). This shows that there is growth and improvement in funding for agriculture in the Western Cape.

4.5.3 Pumping methods

It can be seen from the data in Figure 4.9 that most farmers used gravity (27.7%) to pump water to their farms.

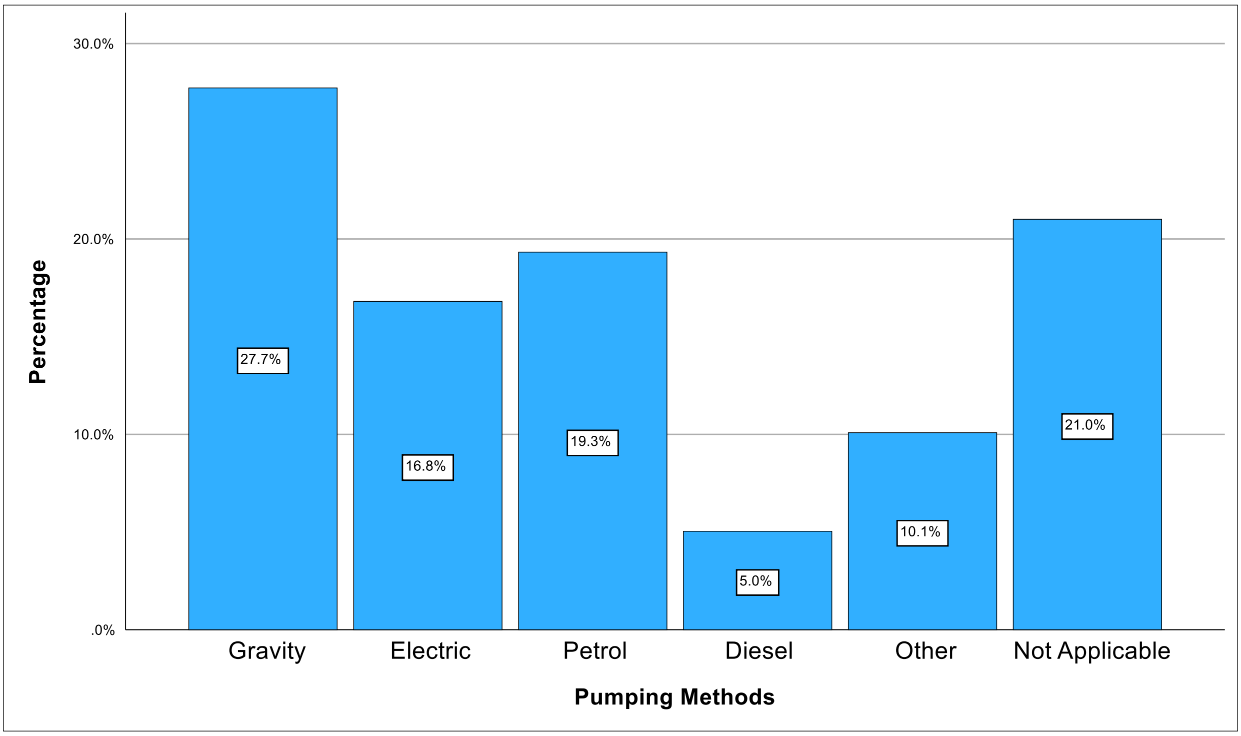

Figure 4.9 Water pumping methods to smallholding (N=80)

In Goedverwacht, farmers drew water from rivers flowing from the mountain, so they just used gravity pipes. The 'other' methods to pump water to farm sites included windmills and tanks in bakkies. The graph further illustrates that 16.8% of the farmers use electric pumps, 19.3% use petrol pumps, and 5% use diesel pumps. Perhaps the most striking observation from these findings is the alternative pumping methods (10.1%) used, especially the physical water ferrying to farms. This is significant as it shows a lack of infrastructure for pumping water in several farms. This likely dents their productivity and ability to cope with droughts and climate change. The results are similar to those of Serote et al. (2021) and Pili and Ncube (2022), who found that only a minority of smallholder farmers in Limpopo Province and Western Cape pumped water to their farms, respectively.

4.5.4 Water storage facilities

Figure 4.10 shows smallholder farmers' water storage methods across the sites.

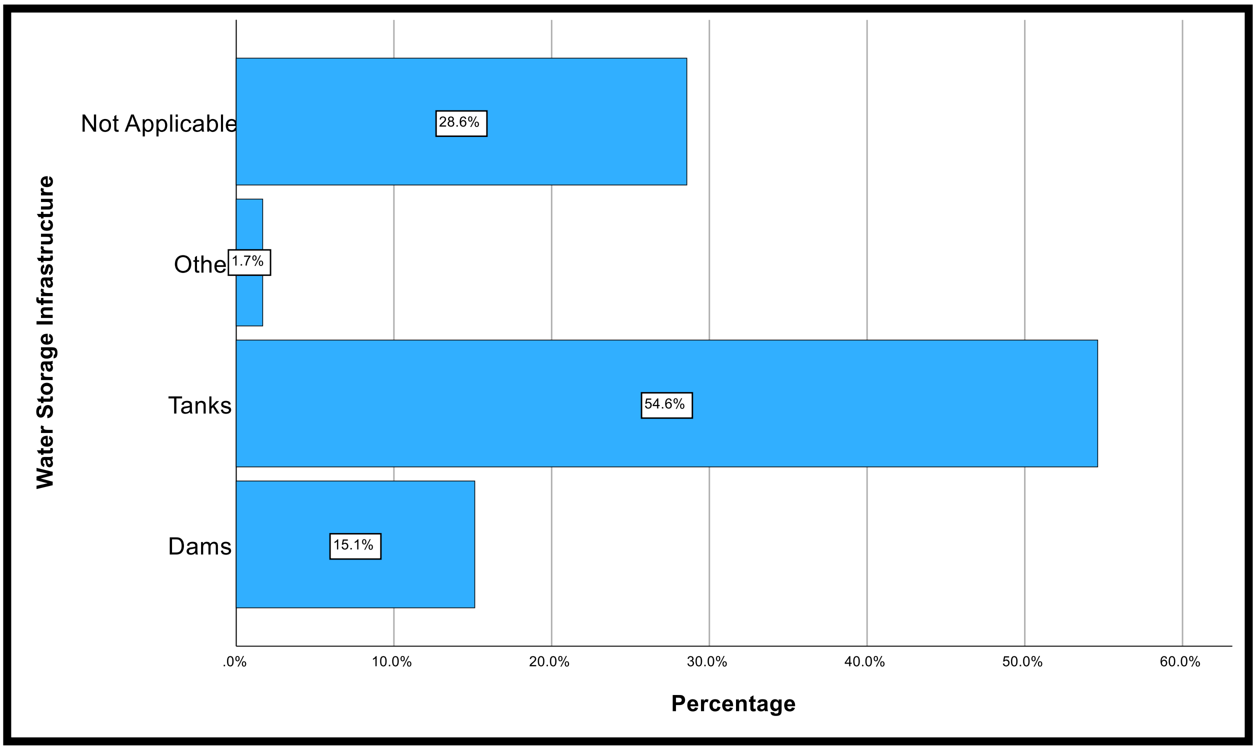

Figure 4.10 Water storage facilities on smallholding plots (N=119)

Many farmers (54.6%) use storage tanks for water storage for farming activities. A minority (15.1%) have small dams which supply water to their farms (Figure 4.11). Dams range from 1000 m^3 to 35, 000 m^3. However, only 66 farmers had water storage facilities, as some pumped water directly from flowing rivers to the farms.

Figure 4.11 A small on-farm rainwater harvesting dam in Swellendam

Tanks ranged from 1000 litre JoJo tanks for sheep farmers in Potterville up to 20,000 litres in Caledon (Figure 4.12).

Figure 4.12 Storage tanks on a smallholder farming plot in Swellendam

It appears that tanks are widely used as water storage facilities by smallholder farmers in South Africa, as exemplified by studies by Pili and Ncube (2022) in Overberg and West Coast Districts in the Western Cape, Nkonki-Mandleni et al. (2019) in Free State, and Mthembu et al. (2022) in Northern Drakensberg.

4.5.5 Adequacy of the water infrastructure

The interview data show that 90% of the participants reported that their water infrastructure does not store and supply enough water. This was exemplified by the narratives below:

> *"Stored and supplied water is not enough at all."* (SBreOD31)

> *"It only supplies my farm with 75 per cent of the water I need. More storage would be desirable."* (SCalOD31)

> *"We would appreciate more tanks to have additional storage capacity."* (SGenOD33)

> *"More storage would assist during to store water to survive during the dry seasons when there is a water shortage."* (SNapOD54)

There were several reasons cited why the water infrastructure was inadequate:

> *"The cost of pumping 2 to 3 times a week is too much due to water storage limitations; if I had sufficient storage, I would only pump once a week or in 2 weeks and save a lot of money."* (STessOD85)

> *"The reeds then grow inside the dam and damage the pump because there is no dam maintenance. The roots of the reeds also damage the pump. The reeds also take water from the dam, but water is not a problem because water is always available. The reeds just need to be removed from the dam."* (SBufOD64)

Sometimes the seasonality and rainfall patterns affected adequacy even if the storage facilities were present. For example, one farmer (SSuuOD90) argued that when there is drought, they cannot control the duration the same and that means they need a very big storage capacity. Another farmer argued: "During the rainy seasons, water is enough. However, in the summer we experience water shortage because we do not have enough storage" (SGreOD45)

However, a substantial number of farmers, particularly in Bredasdorp and Napier, wished to have water storage infrastructure and irrigation systems. Currently, they are using buckets to fetch water from the tap for their livestock. Some farmers in Tesselaarsdal and Goedverwacht did not store water as they had perennially flowing rivers and were pumping water directly from these streams.

The results show a lack of adequacy of water infrastructure among smallholder farmers. The results are like Mugejo and Ncube's (2022) findings on water insecurity among smallholder farmers due to inadequate water infrastructure in South Africa. The findings are also like Dirwai et al.'s (2019) findings in KwaZulu-Natal. These authors found that water governance is at the core of a lack of adequate water infrastructure. Similarly, Muchara et al. (2014) found that local water management and institutional policies were responsible for inadequate infrastructure.

4.6 Water Infrastructure Assessment

A closer assessment of water infrastructure revealed similar results from other provinces across South Africa, although farmers in the study area had relatively new infrastructure.

4.6.1 Maintenance frequency

Figure 4.13 shows the results of the frequency of maintenance for smallholder farmers with water infrastructure in Swellendam, Barrydale, Bredasdorp, Caledon, Genadendal, Napier, Suurbraak, Buffeljagsrivier, Tesselaarsdal, Villiersdorp, Greyton, Goedverwacht and Porterville.

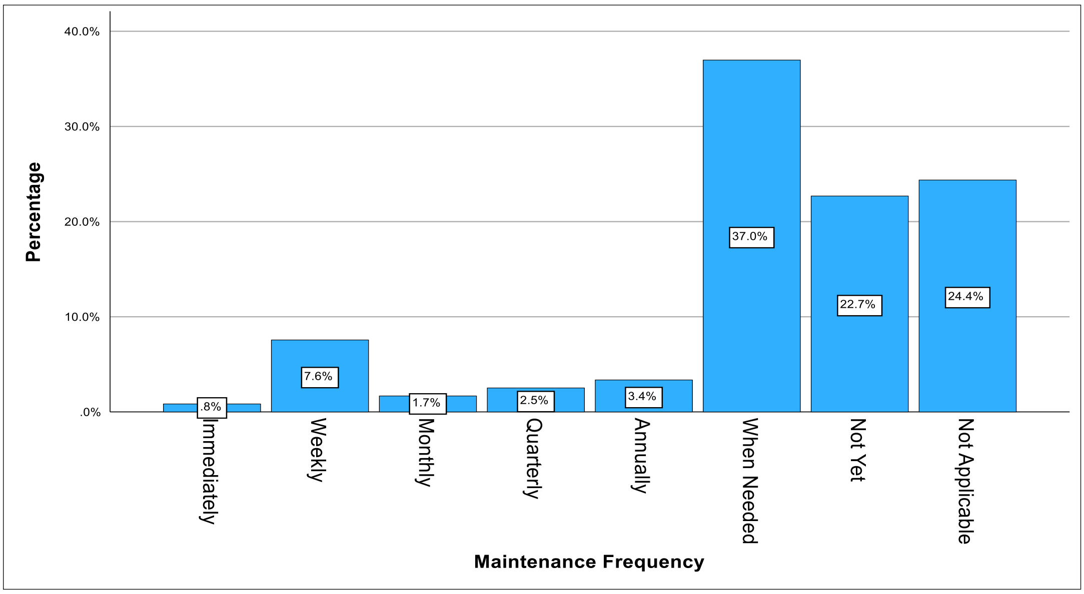

Figure 4.13 Frequency of maintenance for smallholder farmers with water infrastructure (N=80)

The graph shows a significant number of farmers (37%) who either performed maintenance when needed or had not yet maintained their infrastructure (22.7%). There is a positive correlation between the new water infrastructure and them not yet being maintained. Fewer farmers carried out maintenance weekly (7.6%), monthly (1.7%), quarterly (2.5%), and annually (3.4%).

The results demonstrate that most of the water infrastructure is not maintained. The results are similar to the findings by Mwamakamba et al. (2017), who argue that lack of funding and information leads to low maintenance of water infrastructure by African smallholder farmers. However, the reasons for the low maintenance in this study differ from those of Sharaunga and Mudhara (2018), who contend that land tenure affects the drive to maintain water infrastructure. Those farmers with larger block farms are more likely to maintain their water infrastructure compared to those with insecure land tenure.

4.6.2 Measuring devices

Very few farmers have measuring devices, such as a water meter (12.61%), while most do not (69.75%), as shown in Figure 4.14. This might be an issue of licensing, as most farmers use water from flowing rivers and dams and are not licensed. Therefore, they have less awareness or propensity to conserve water.

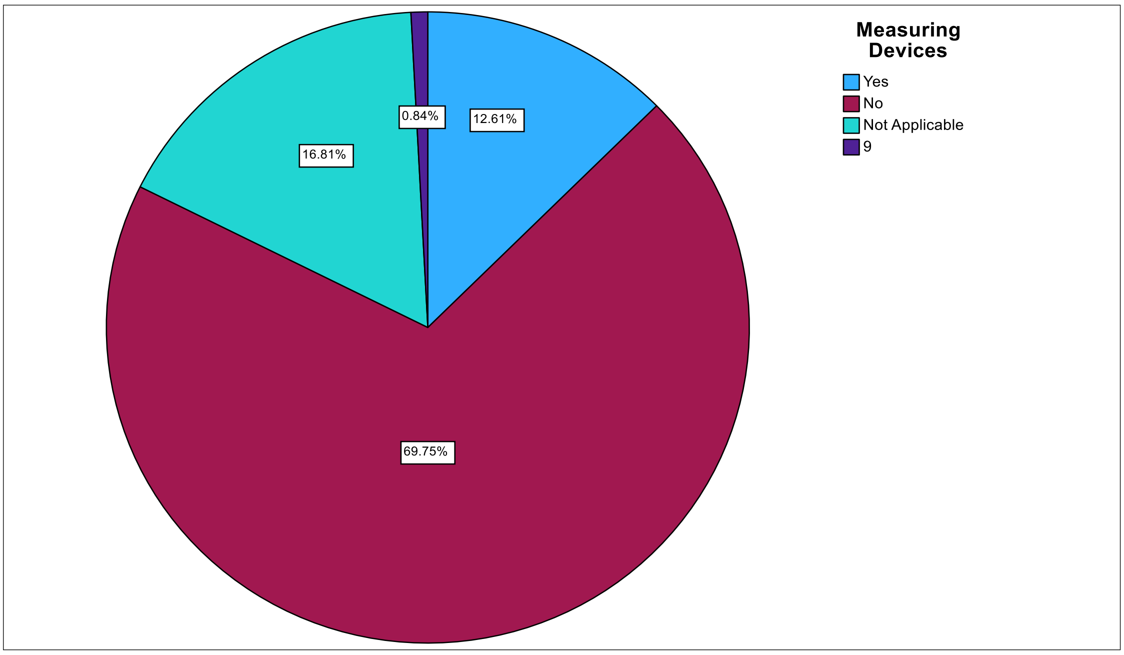

Figure 4.14 Measuring devices for smallholder farmers with water (N=80)

Measuring devices enable farmers to calculate use, although some farmers reiterated that they calculate water use through the time it takes for their tanks to run dry after filling them up. Some farmers reported that they measure the water in the dams through physical inspections. The findings are similar to Muchara et al. (2016), which revealed that smallholder farmers in the Mooi River Irrigation Scheme, KwaZulu-Natal, applied less water to their potato crop when compared to the irrigation crop water requirements due to lack of measuring devices along the canals. Bjornlund et al. (2020) also found a lack of smart moisture monitoring tools among smallholder farmers in Southern Africa.

4.6.3 Leakages

What stands out in Figure 4.15 is the general pattern of non-leakage of water from the infrastructure (64.71%) compared to leakages (17.65%). This probably shows that for those who have relatively new water infrastructure, no leakages have been experienced yet.

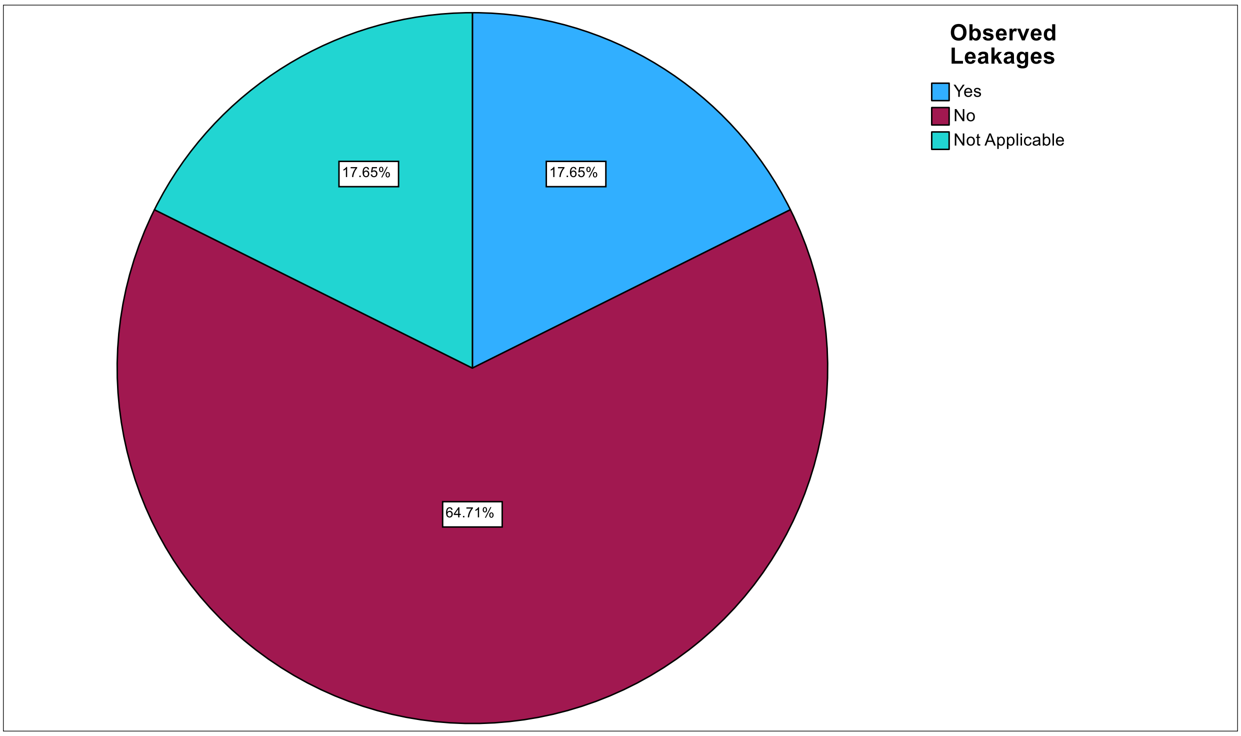

Figure 4.15 Water Leakages in water infrastructure for smallholder farmers (N=80)

A study by Mkuhlani et al. (2020) also found limited water leakages among pensioners with a sense of adventure due to deteriorating irrigation infrastructure. However, this contrasts with Muchara et al. (2020) findings, which revealed leakages among canals in the Mooi River Irrigation scheme, KwaZulu-Natal. These findings are supported by studies by Mpandeli and Maponya (2014) in Limpopo Province, where some water was wasted through leakage because farmers continued to use the concrete furrow irrigation method.

4.6.4 Responsibility for maintenance

As most water infrastructure was new, the participants argued that minimal maintenance was needed as the pipes and tanks were in good condition. However, although most farmers self-serviced their own, some, especially using municipal water, regarded this as the municipality's duty. As some participants reiterated:

> *"Municipality is responsible for dam maintenance. Pump and tanks are maintained by us."* (SGenOD34)
>
> *"The dam was never maintained; the municipality never maintained the pump."* (SGreOD63)
>
> *"The municipality is supposed to maintain the dam and pump. I am responsible for maintaining the water tank and the irrigation system."* (SSweOD65)

In some cases, the farmers hired other people to perform any maintenance-related activities as one farmer reported: "*There is a skilled individual within the group but if the problem is big then we hire people who have more knowledge."* (STessOD89)

The results reveal that the participants lacked awareness of the maintenance of water infrastructure, as they regarded maintenance as repairs. Agholor and Nkosi (2020) argued that most smallholder irrigation projects require significant farmer participation and robust human capital to efficiently maintain the irrigation system and save water throughout South Africa. This is also like arguments by Mugejo et al. (2022) that farm water infrastructure maintenance practices are influenced by the expense of building and maintaining water infrastructure. Many farmers lack the personnel needed to remove the substantial amounts of soil required by certain water techniques in use.

4.7 Conclusions

The chapter assessed the performance of agricultural water infrastructures that supply smallholder farmers. The findings showed the differentiated nature of access to water infrastructure for farmers, with most using pipes to transport water to their farms. The most prominent finding from this study is that due to the Western Cape terrain, most farmers use gravity to pump water to their farms from perennially flowing streams. This study has found that smallholder farmers in the Western Cape generally store water in

JoJo tanks at their farming plots. The research has also shown that due to the relatively new water infrastructure, there are minimal leakages and maintenance.

The evidence from this study suggests the need for improved information on the advantages of water infrastructure maintenance and the fact that infrastructure for water storage needs to be maintained. Overall, the findings strengthen the idea that collaborative governance is required to build an accurate understanding of local water usage and resources for water saving.

The next chapter examines water governance and institutional arrangements by assessing water governance indicators, including transparency, accountability, participation, funding, information, and capacity.

5. PERFORMANCE OF WATER GOVERNANCE AND INSTITUTIONAL ARRANGEMENTS FOR SMALLHOLDER FARMERS

5.1 Introduction

This chapter stems from the project’s fourth objective, centred on evaluating water governance performance and institutional arrangements that impact smallholder farmers. Effective water governance may ensure sustainable and equitable access to water resources, especially for smallholder farmers who are often most vulnerable to climate variability and water scarcity. The study employed a framework based on the Organisation for Economic Co-operation and Development (OECD) water governance indicators to analyse key governance dimensions, including transparency, social networks, accountability, participation, funding, information, and capacity.

These indicators – discussed in Chapter 2 of this report – provide a structured approach to assessing how governance systems function in practice, identifying strengths and weaknesses in the institutional and policy environment that supports smallholder farmers. Transparency, for instance, involves examining the clarity and openness of decision-making processes, while social networks explore the strength and inclusivity of community interactions that facilitate knowledge sharing and collaboration. Accountability measures the mechanisms in place to ensure that water management authorities and institutions act responsibly, and participation evaluates the extent to which smallholder farmers have a voice in water-related decisions that affect them. Funding, information accessibility, and capacity further highlight the resources, data, and skills available to support effective water governance.

To gather comprehensive insights, data was collected using a combination of qualitative methods, including key informant interviews, one-on-one interviews, and focus group discussions with smallholder farmers. These methods provided a detailed understanding of how governance structures and institutional arrangements operate locally and directly impact farming activities.

5.2 Data Collection and Analysis

To achieve the fourth objective, the research team targeted key informants comprised of extension officers affiliated with the WCDoA, Swellendam municipality, BOCMA, WWF, and smallholder farmer cooperatives. For the study's scope, participants who were identified as farmers fell under the classification of smallholder farmers within the Overberg and West Coast Districts, as defined under section 2.2 in Chapter 2.

Face-to-face and online interviews were conducted with key informants and smallholder farmers to assess water governance systems in their area using a semi-structured survey questionnaire. A recording device was used to streamline the interview process, contributing to interviews lasting 45 minutes. Before each interview, participants were asked to sign a consent form, ensuring the confidentiality of their details and granting permission for the recording and photography during the interview. The interviews spanned more than one year and were conducted by the research team in these two districts.

The research team conducted focus group discussions in the Overberg and West Coast districts. Seven different sites were chosen, with five in the Overberg district (Swellendam, Caledon, Elim, Bredasdorp, and Genadendal) and two in the West Coast district (Goedverwacht and Porterville). Extension workers from the WCDoA working in the districts were crucial in facilitating the focus group discussions, particularly in mobilising smallholder farmers and arranging suitable venues. A total of 51 participants took part in the focus group discussions.

Following Smith’s (1972) recommendation to consider participants' comfort, venue accessibility, and minimal distractions, the team ensured each site had ample seating, allowing participants a clear view of each other and the facilitators. The team also ensured there were refreshments for the participants during the FGDs. A focus group guide, developed by the research team included a series of questions and prompts for facilitators to use during the FGD. Recording and photo-capturing devices were utilised during the sessions. Before each focus group discussion, participants were presented with a consent form explaining the purpose of the interview and the use of devices such as recordings. They were assured of anonymity in all the collected information. The fully informed consent of research participant(s) is one of the basic ethical considerations that researchers must adhere to.

Participants were encouraged to express their views in their language of choice. Although most participants were comfortable using English during the discussions, even though it was not their home language, the team encountered cases where participants preferred communicating in their mother tongue (IsiXhosa and Afrikaans). The team accommodated this diversity by having a facilitator who understood IsiXhosa and utilising an extension officer for translation in cases where participants spoke and understood Afrikaans. During the focus group discussions, facilitators took turns asking questions, allowing each participant to respond. Participants were also encouraged to comment on each other's responses if the session was not chaotic. It is important to note that participant selection for the focus group discussions was done in collaboration with extension officers to ensure information was obtained from the identified group. The group sizes during the focus group discussions adhered to the recommendation of having six or more participants, as scholars have suggested this to be conducive to obtaining quality information.

Table 5.1 Participant Characteristics

Study Sites	Sampling Population	Participant Codes	Interview Participants	Focus Group Discussion Participants
Bredasdorp	Key Informants	KBreOD	3	
	Smallholder Farmers	SBreOD	6	5
Buffeljagsrivier	Smallholder Farmers	SBufOD	1	
Caledon	Key Informants	KCalOD	2	
	Smallholder Farmers	SCalOD	9	7
Elim	Smallholder Farmers	FGDElimOD		5
Genadendal	Smallholder Farmers	SGenOD	26	5
	Key Informants	KGenOD	1	
Goedverwacht	Smallholder Farmers	SGoeWD	14	12
Moorreesburg	Key Informants	KMorWD	5	
Napier	Smallholder Farmers	SNapOD	11	
Porterville	Smallholder Farmers	SPorWD	5	6
Suurbraak	Smallholder Farmers	SSuuOD	1	
Swellendam	Smallholder Farmers	SSweOD	11	5
	Key Informants		2	
Tesselaarsdal	Smallholder Farmers	STesOD	10	6
Villiersdorp	Smallholder Farmers	SVilOD	2	
Greyton	Smallholder farmers	SGreOD	3	
	Key Informants	KGreOD	3	
Barrydale	Smallholder farmers	SBarOD	9	
	Key Informants	KBarOD	2	
Online	Key Informants	KOnline	3	
Total			**140**	**51**
Total Interviews and FGD				**191**

The total number of participants was 191, spread over 15 study sites, as shown in Table 5.1. The number included 21 key informants and 119 smallholder farmers who participated in one-on-one interviews, and 51 were engaged in focus group discussions.

The data regarding water governance and institutional arrangements gathered from key informants, smallholder farmer interviews, and focus group discussions underwent coding to safeguard the anonymity of project participants. Pseudocodes were generated based on interview locations, and researchers were referred to as facilitators. The raw survey data and recordings were then disseminated to all facilitators for transcription. For data analysis, Atlas. ti was, and Microsoft Excel was used. In utilising Atlas ti, the initial qualitative step involved coding, wherein category codes were generated. Lastly, researchers documented emerging concepts, developed relationship diagrams to visualise connections, and pinpointed frequently mentioned keywords from participants as markers of key themes.

5.3 Transparency in water governance for smallholder farmers

5.3.1 Community Engagement

Key informants regarded transparency as engaging and communicating with the smallholder farmer community. (Figure 5.1) For example, KBreOD3 argued,

> *"We work together in finding solutions for farmers. Research helps us to understand the problem before finding solutions, before applying the research results to local conditions."*

KCalOD5 also added,

> *"We do continuous training and awareness programmes and also provide more Jojo tanks to store water for the dry season."*

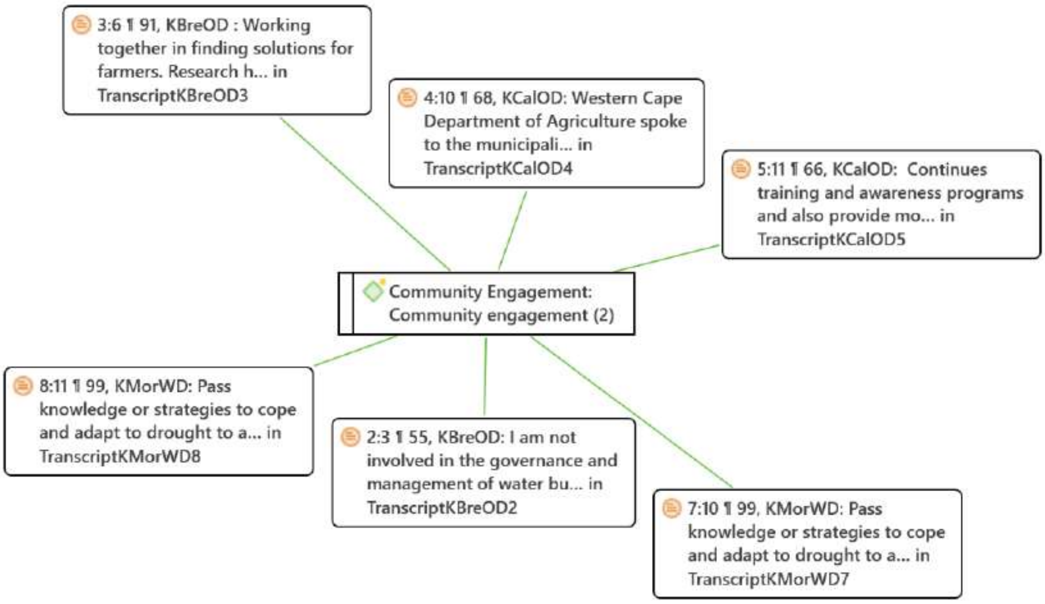

Figure 5.1 Summary of key informant narratives for community engagement

In addition, extension officers also communicate transparently with their peers in government to find lasting solutions to the farmers' water challenges. According to KCalOD4:

> *"Western Cape Department of Agriculture spoke to the municipality about farmers' water rights. We are still negotiating with the municipality, and the municipality is also facing funding challenges. We also communicate with the Department of Water and Sanitation."*

KMorWD8 also urged researchers to pass climate change knowledge or adaptation strategies to agricultural advisors so that they can disseminate the knowledge to other farmers:

> *"The results obtained by the researchers should be made aware to the agricultural advisors so that improvements can be made. Do not just collect data from us, we need to know the results so that we can assist farmers and improve where we are getting wrong. It is very important to discuss the results together with agricultural advisors to help farmers."*

The results demonstrate the importance of transparency in sharing knowledge and engagement of smallholder farmers in water governance. Previous research has shown that government organisations have a role to play in enhancing the leadership and competence of smallholder farmers (Jayasiri et al., 2023). However, expanding the smallholder farmers' capacity is complex and might call for a wide variety of resources, particularly people resources (Kruk et al., 2021). Establishing reliable connections with smallholder farmers and having effective communication is essential (Fallon et al., 2021). Furthermore, bridging communication gaps between and within government agencies at all hierarchical levels is imperative. To sustain positive contact between smallholder farmers and government agencies, it is crucial to recognise extension services (Mugejo & Ncube, 2022). Leclert et al. (2019) investigated transparency and accountability in water governance in South Africa, stressing the importance of public access to information, stakeholder engagement, and decision-making processes. Their research highlights the need for transparent institutional mechanisms that enable smallholder farmers and other stakeholders to participate in water management and monitoring activities. Patel et al. (2018) also examined transparency and corruption risks in the allocation of water resources to smallholder farmers in South Africa. They found that opaque decision-making processes, lack of oversight, and institutional weaknesses contribute to corruption and inequitable access to water among farmers.

5.3.2 Social networks among smallholder farmers

Collaboration

A recurrent theme in the focus group discussions was a sense amongst participants of collaborative activities. Commonly repeated phrases related to collaboration were merged into two subthemes: problem-solving and community support (Figure 5.2).

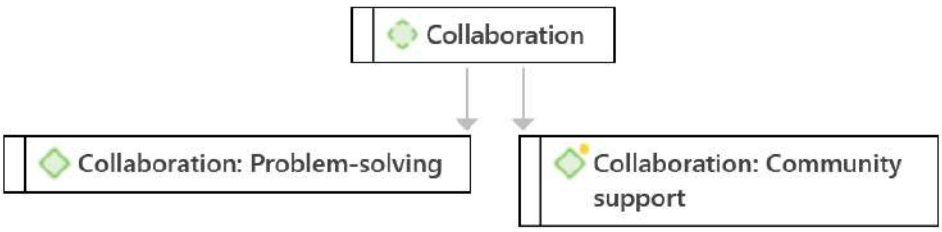

Figure 5.2 Conceptual Map of Findings for Collaboration Theme

In addition, quantitative data showed that to a larger extent, there was less social networking among smallholder farmers. In Figure 5.3, 65% of the participants practised their farming individually, whilst 35% were in group farming. This shows that collaboration among smallholder farmers was, to some extent, low.

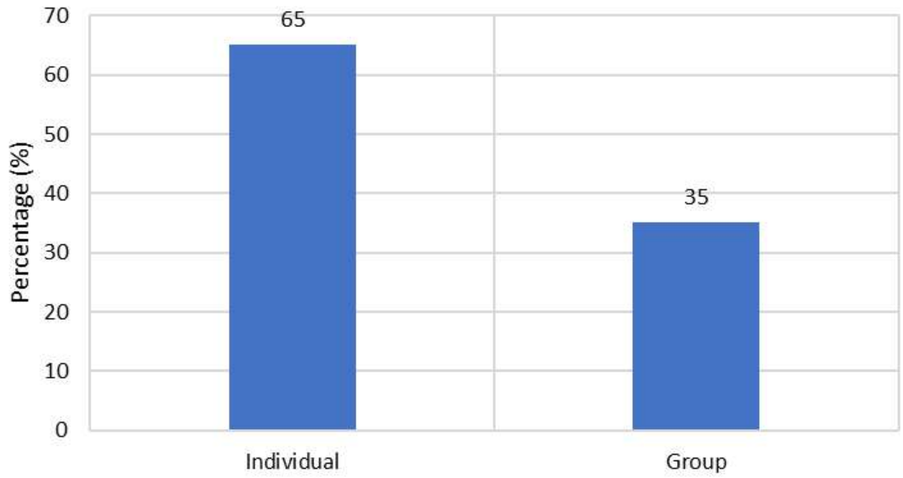

Figure 5.3 Individual and Group Farming Practice among smallholder farmers (N=119)

Problem-solving

Although some participants acknowledged endemic intra-group conflicts among the smallholder farmers, they also alluded to their willingness to collaborate with their peers in sharing water (Figure 5.4). For example, one participant said:

> *"There have been many conflicts in the past. Nowadays it is getting a little bit better because there are fewer users. But I had this brilliant plan to make the irrigation system and that everyone who is farming in Elim must get water from this pump."* (FGDElimOD2)

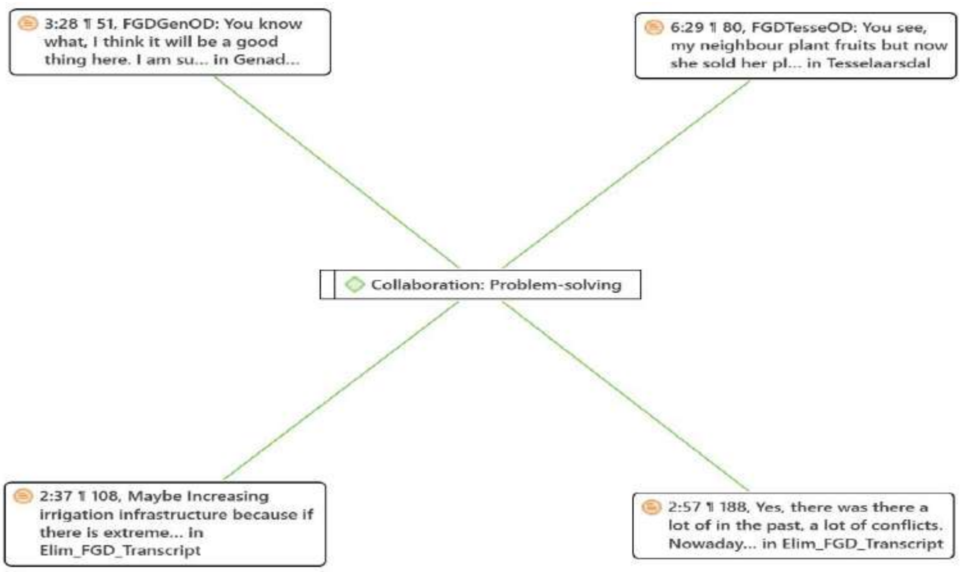

Figure 5.4 Summary of FGD narratives for problem-solving among smallholder

Another participant, FGDGenOD1, referred to the mutual selling of farm produce resulting from increased water availability:

> *"I think it will be a good thing here. I am sure if I sink a borehole here (in the community) it will solve a lot of problems. I think if all farms get boreholes and tanks that will help us. Not everybody farms big, we have smaller gardens."*

FGDTesseOD3 also expressed the desire for increased collaboration to solve water challenges:

"You see, my neighbour planted fruits, but now she sold her plot. I could install a pump and pump water into her dam, and it is for free."

The results reveal a complex dynamic of both conflict and cooperation among smallholder farmers regarding water use and management. While participants acknowledged a history of intra-group conflicts over water resources, a growing willingness exists to collaborate and find collective solutions to water-related challenges. Examples such as a participant's proposal to develop a communal irrigation system in Elim and the mutual selling of farm produce resulting from improved water access in Genadendal highlight a shift towards cooperative efforts. Additionally, the desire to share resources, such as offering free water to a neighbour's dam, demonstrates a strong sense of community and the potential for shared solutions to enhance water security.

Community Support

Some participants felt that the smallholder farmers had supported each other as a community, while a few considered that the Western Cape Department of Agriculture Extension Advisors supported the community to the best of their abilities (Figure 5.5).

This was evident in the narratives below:

"We established our community as an independent entity without direct involvement with the municipality. Our primary source of assistance comes from the Community Work Programme (CWP). CWP aids us by facilitating the hiring of workers for our community. It operates similarly to the Public Works Programme (PWP) and focuses specifically on supporting agricultural practices within the community. Individuals in need of assistance with their gardens can avail themselves of CWP services, which involve hiring and compensating workers for their work." (FGDGenOD3)

"If there is a water shortage and if I have water then they can come and fill up their tanks. I have a dam." (FGDTesseOD4)

"We have plots next to each other. I and my mother can help each other but not everyone. Some want to plant their crops, but they cannot because they do not have a place to do it." (FGDTesseOD5)

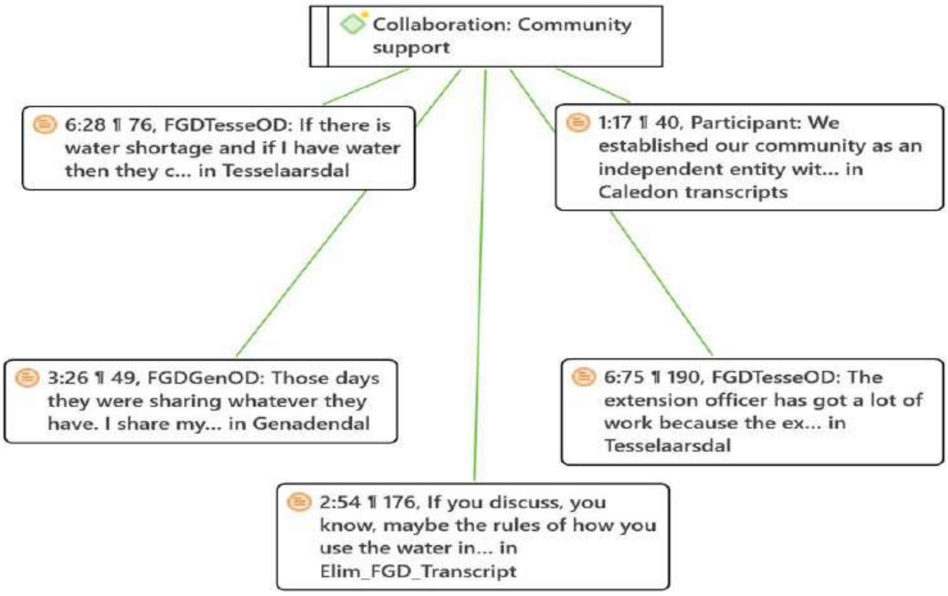

Figure 5.5 Summary of one-on-one interview narratives for community support for smallholder farmers in Overberg and West Coast Districts

However, FGDTesseOD6 indicated the Extension Adviser's support for smallholder farmers' collaborative endeavours.

> *“The extension officer has got a lot of work because she does not only work for Tesselaarsdal but other areas like Grabouw, Swellendam, and Greyton. She has got a lot of work. And I think maybe she must have a person in Tesselaarsdal or Botrivier to help her, then she can sit maybe once a week or once a month and discuss these problems.”*

The results above show that social networks play a crucial role in smallholder farmers' agricultural practices and livelihoods in the Western Cape; a similar finding was reported by Fanadzo et al. (2021). Comparison of the findings with those of other studies confirms that these networks often encompass various forms of social interactions, including kinship ties, community associations, and informal alliances, which facilitate the exchange of information, resources, and support among farmers. Research has highlighted the significance of social networks in enhancing access to market information, agricultural technologies, credit, and labour (Beaman et al., 2012; Conley & Udry, 2010). For instance, Beaman et al. (2012) conducted a study in Tanzania, demonstrating that farmers with extensive social networks were more likely to adopt new agricultural technologies compared to those with limited social connections. Similarly, Conley and Udry (2010) found that social networks significantly influenced farmers' decisions regarding adopting modern farming practices and utilising agricultural inputs. Furthermore, social networks serve as mechanisms for risk-sharing and resilience-building among smallholder farmers, particularly in the face of environmental shocks and economic uncertainties (Fafchamps & Minten, 2012). Through informal insurance arrangements and mutual assistance, farmers within social networks can mitigate the adverse impacts of climate change, crop failures and fluctuations in market prices.

Accountability in water governance

According to the OECD (2011), accountability is the ability of citizens and residents to scrutinise public institutions and the government and hold them to account. In this study, participants were questioned about the existence of water management and allocation organisations and water management training. The assumption was that the area would need to have these water institutions first for smallholder farmers to exercise oversight and get training to discharge this mandate effectively. Their responses are shown in Figures 5.6 and 5.7.

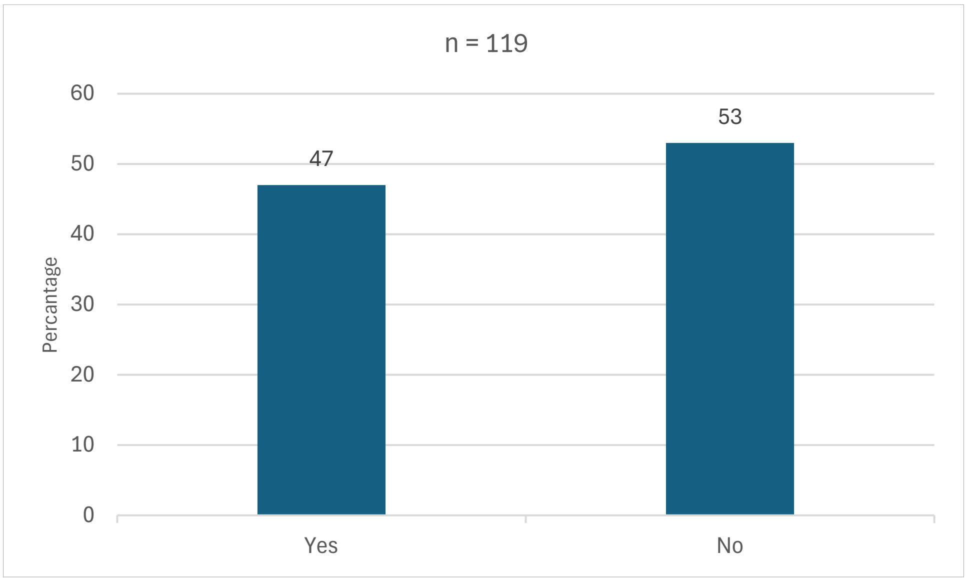

Figure 5.6 Existence of water management and allocation organisations (N=119)

As illustrated in Figure 5.6, about 53% of the participants had no knowledge of water management and allocation organisations in their area, whilst 47% acknowledged their presence.

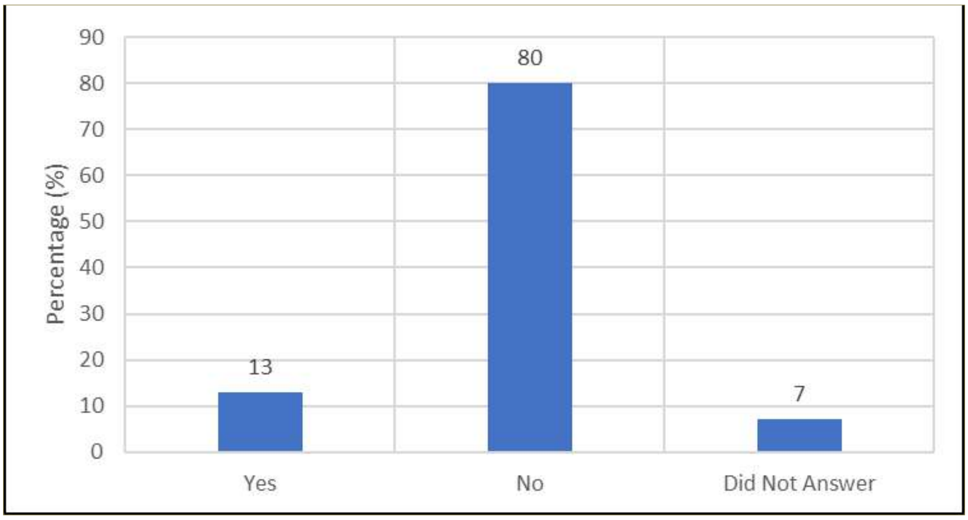

Figure 5.7 Water management training received by smallholder farmers (N=119)

Figure 5.7 shows that 80% of the participants had no water management training, and 13% received the training, although 7% could not answer. The statistics revealed a lack of accountability since most participants lacked knowledge of water management and allocation organisations and had not received water management training. We argue that smallholder farmers hold functional water institutions to account if they have training to manage water resources and have access to these institutions. Accountability is a critical aspect of smallholder farmer water governance in Africa, ensuring transparency, fairness, and effectiveness in managing and distributing water resources.

Several studies have examined the role of accountability mechanisms in enhancing water governance among smallholder farmers in the region. For example, Meinzen-Dick et al. (2019) highlighted the importance of participatory approaches and institutional arrangements that promote accountability in water management. They argue that involving farmers in decision-making processes and establishing clear roles and responsibilities can strengthen accountability and improve the sustainability of water governance initiatives. Furthermore, Boakye-Yiadom et al. (2018) highlight the significance of accountability mechanisms in community-based irrigation schemes in Ghana. Their research underscores the need for transparent decision-making processes, regular monitoring, and feedback mechanisms to hold stakeholders accountable for their actions and ensure equitable access to water resources among smallholder farmers. Moreover, Mukhtarov and Shah (2016) examine the role of social accountability mechanisms, such as community-based monitoring and grievance redress, in enhancing rural water governance. They suggest that empowering local communities to hold water authorities accountable can lead to more responsive and inclusive decision-making processes, ultimately benefiting smallholder farmers.

5.3.3 Smallholder farmer participation in water governance

Community Involvement

According to Jayasiri et al. (2023), sustainable management methods depend on farmers actively participating in decision-making, including resource mobilisation related to efficient water management. In this study, interviews and focus group discussions with smallholder farmers on participation yielded data to suggest some level of community involvement in water governance. This became the theme. Three sub-themes also emerged from the analysis. These were cooperation, local government, and self-reliance (see Figure 5.8).

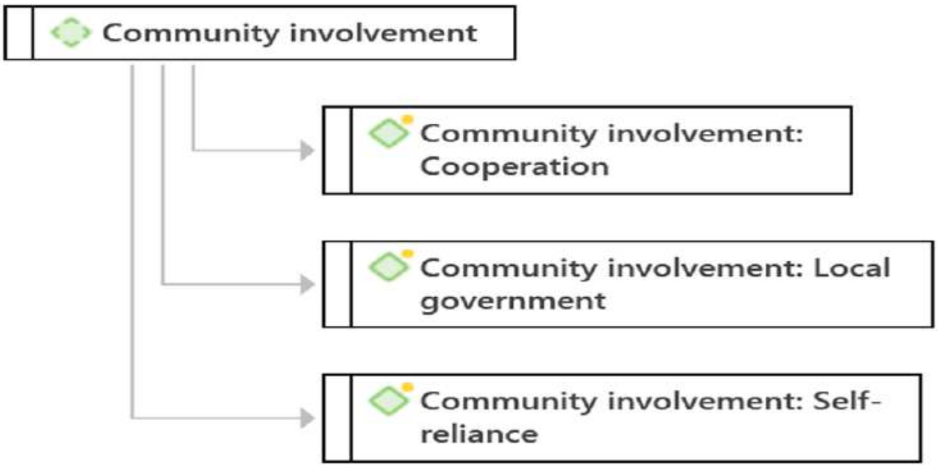

Figure 5.8 Conceptual map of findings for Community Involvement Theme

Cooperation

A common view among interviewees was that community involvement begins with local-level cooperation (Figure 5.9). There were peer interactions that encouraged community cooperation. For example, according to SCalOD11,

"There is a skilled individual within the group, but if the problem is big, then we hire people who have more knowledge."

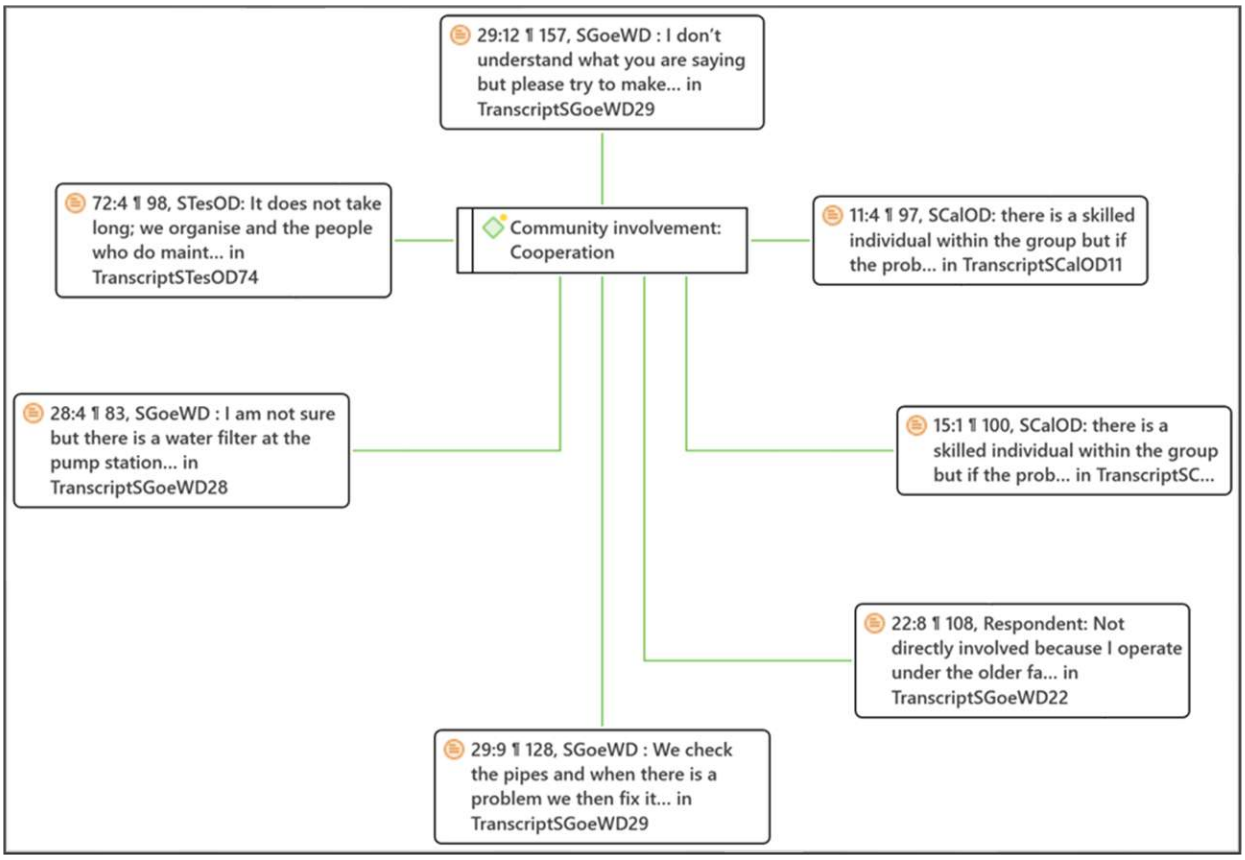

Figure 5.9 Summary of one-on-one interview narratives for cooperation among smallholder farmers in Overberg and West Coast Districts

This was also supported by SGoeWD28,

> *"I am not sure but there is a water filter at the pump station that they need to clean themselves."* Another participant, SGoeWD29 commented, *"We check the pipes and when there is a problem, we then fix it ourselves. There are a lot of farmers who are also using the water."* In addition, STesOD74 also added, *"It does not take long; we organise and the people who do maintenance come according to the agreed schedule."*

Farmers also worked together to provide solutions to climate change-induced water challenges, as pointed out by SGoeWD29:

> *"In summer it is very hot, and everyone will have a problem with water, but we go and talk with other farmers upstream so that they can also give us a chance to use water in our farms."*

However, for a small number of participants, a significant part of the challenges in water management stemmed from the residents themselves, particularly in the town of Goedverwacht. As one participant put it:

> *"Despite being vocal about the issues, they often do not actively participate in providing solutions or offering input when water systems are being constructed. The root of the problem lies in the lack of unity and proactive initiatives among the people."* (FGDGenWD12)

This was supported by another participant:

> *"My perspective is that if the community can come together, devise initiatives, and take responsibility for the maintenance and management of water and infrastructure, we can address these issues without solely relying on external assistance. In the past, a farming community forum was established by smallholder farmers to discuss water management issues. Unfortunately, it disbanded, and the reasons for its dissolution are unknown to me."* (FGDGenWD6)

The results show the dual nature of community involvement in water management, with examples of both strong cooperation and notable challenges. Many participants stressed the importance of local-level collaboration, citing instances of peer interactions and shared responsibilities, such as organising maintenance schedules, cleaning water filters, and negotiating water use with upstream farmers during times of scarcity. These cooperative efforts demonstrate the potential of community-driven solutions to address climate-induced water challenges effectively. However, the findings also reveal underlying disunity and passive participation issues, particularly in Goedverwacht, where some residents are perceived as vocal about problems but less engaged in implementing solutions. Disbanding a previously established farming community forum exemplifies the difficulties in sustaining collective initiatives. This dichotomy suggests that while local collaboration is a strong foundation for addressing water challenges, there should be greater unity, proactive engagement, and consistent community structures to ensure long-term success.

Local Government

Smallholder farmers sometimes reported that the municipalities collaborated with the local communities in water provision (Figure 5.10). Thus, in as much as they provided support to the smallholder farmers, the farmers themselves were willing participants

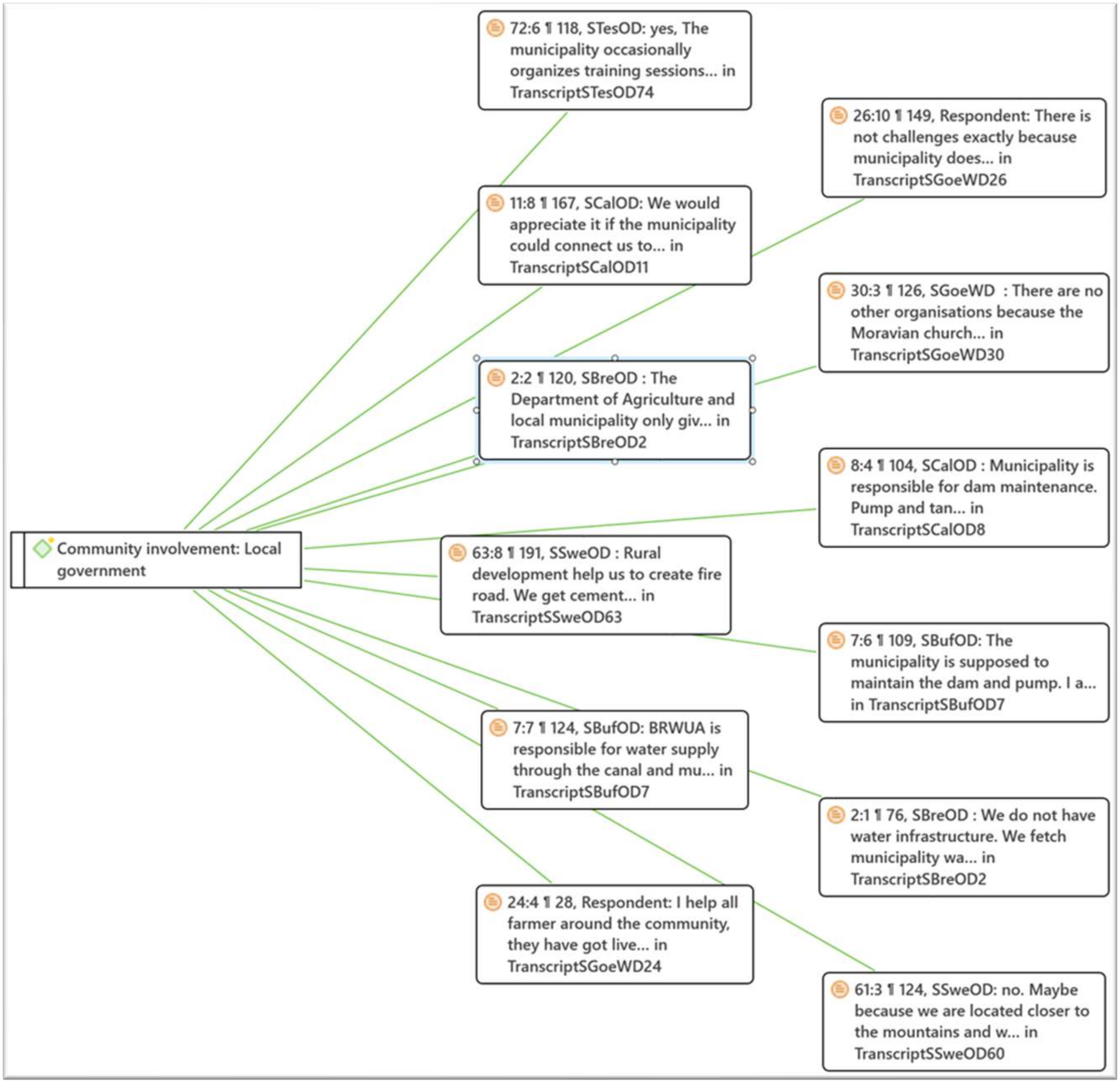

Figure 5.10 Summary of one-on-one interview narratives for local government support to smallholder farmers in Overberg and West Coast Districts

One participant, SBufOD7, reiterated that: *"The municipality is supposed to maintain the dam and pump. I am responsible for maintaining the water tank and the irrigation system."* This view was supported by other participants like SCalOD8, who said:

> *"The municipality is responsible for dam maintenance. The pump and tanks are maintained by us"*, and STesOD74: *"The municipality occasionally organises training sessions for us as farmers, bringing us together at the town hall. This is typically when we are included in water-related programmes."*

The results highlight a collaborative relationship between municipalities and smallholder farmers in water provision and management, where responsibilities are shared to varying extents. Municipalities play a key role in maintaining critical infrastructure, such as dams and pumps, while farmers take on responsibilities for localised systems, including water tanks and irrigation. This partnership shows a relatively mutual commitment to ensuring water availability for agricultural use. Municipalities occasionally support farmers through capacity-building initiatives, such as training sessions and water-related programs, fostering knowledge sharing and engagement. These interactions suggest a functional, though occasionally limited, collaboration that relies on active participation from both parties to address water management challenges effectively. However, the findings also imply that consistent communication and a clear delineation of responsibilities are essential for this partnership to be fully sustainable.

Self-Reliance

There were some negative comments about community involvement and some participants reported that they were self-reliant (Figure 5.11).

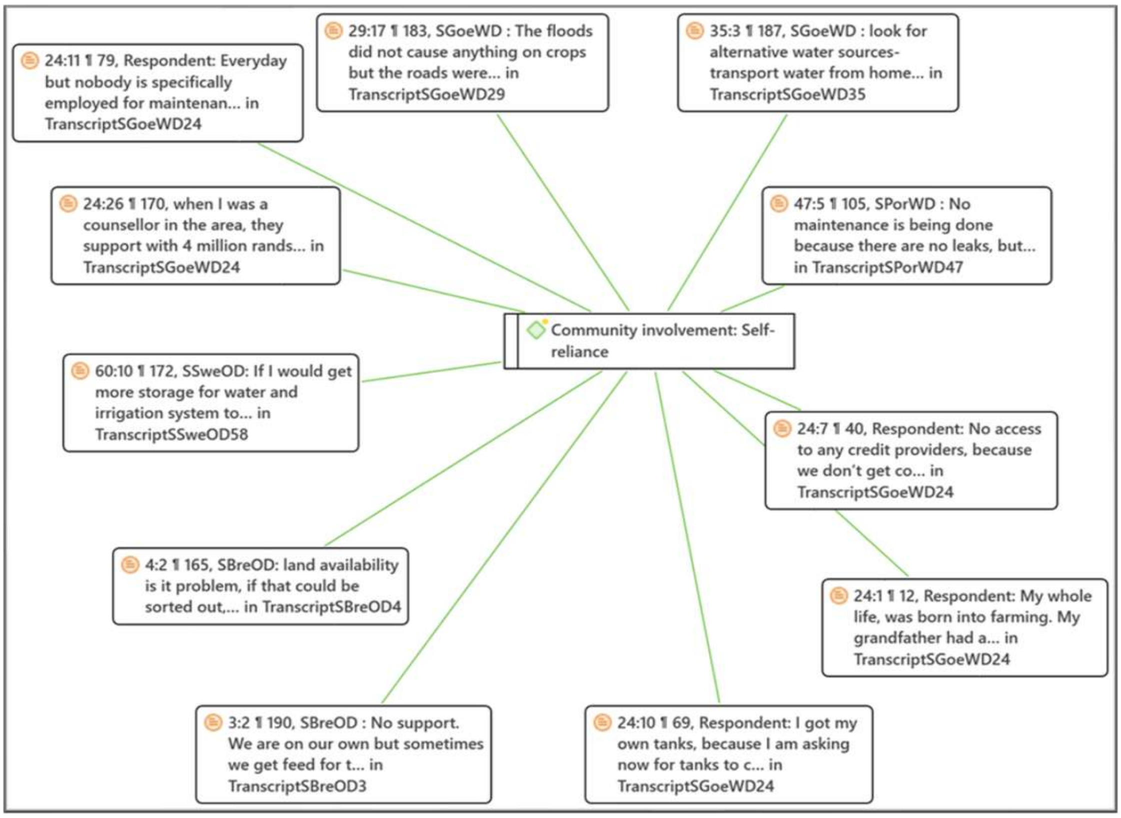

Figure 5.11 Summary of one-on-one interview narratives on self-reliance by smallholder farmers in Overberg and West Coast Districts

For example, one participant, SGoeWD24, stated that:

"I plant stuff at home and have no access to any credit providers because we do not get contacts from the church, and they must give contracts to the farmer. I do not know what the church people have told you, but as I know we do not get help. I am taking the roof water now and putting filters so that I can help people from the community with water."

Another participant, SBreOD3, agreed with the above assertion:

"We are on our own but sometimes we get feed for the pigs from the Department of Agriculture." SGoeWD24 maintained that: *"I got my tanks because without the contract you get nothing. Nobody is specifically employed for maintenance, farmers fix their infrastructure, so if my pipe leaks, I fix it."*

Consistent with the literature, this research found various challenges and the need for enhanced smallholder farmer participation in water governance. For instance, Moyo et al. (2019) conducted a study in Zimbabwe, highlighting the importance of inclusive and participatory approaches in water governance to enhance smallholder farmer engagement. They argue that involving farmers in decision-making processes through mechanisms such as farmer associations and water user committees can lead to more effective and sustainable water management practices. Similarly, Tafesse et al. (2017) examined smallholder farmer participation in water governance in Ethiopia and the role of social capital and institutional arrangements in facilitating engagement. Their research suggests that strong social networks and trust among farmers, combined with supportive institutional frameworks, can enhance participation and promote collective action for water management. Furthermore, Moyo and Mvumi (2018) explored the challenges and opportunities for smallholder farmer participation in water governance in South Africa. They found that issues such as power dynamics, unequal access to resources, and limited capacity among farmers can hinder meaningful participation. However, they also identified potential strategies for overcoming these challenges, including capacity-building initiatives, policy reforms, and strengthening local institutions. Taken together, findings from this study and previous studies reveal the importance of smallholder farmer participation in water governance through inclusive and empowering approaches that address contextual challenges and leverage local knowledge and resources.

5.3.4 Funding for smallholder farmer water infrastructure

Responses on funding for smallholder farmer water infrastructure in Western Cape, South Africa, underscored the importance of adequate financial resources and supportive policies to address the water-related challenges faced by farmers in the province.

Financial Constraints

A common view among the participants was that financial constraints hamper funding for smallholder infrastructure. As illustrated in Figure 5.12, 'financial constraints' was a commonly repeated phrase and became the theme. Subthemes under this theme were financial constraints, infrastructure maintenance and government assistance.

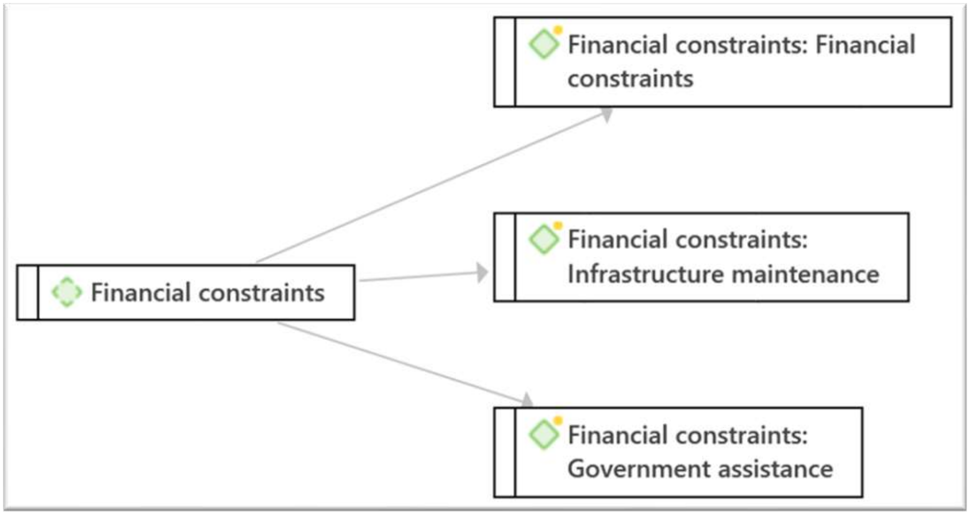

Figure 5.12 Conceptual map of findings for Financial Constraints Theme

The views on financial constraints mainly concerned losses and the ability to repair broken water infrastructure due to lack of funding (Figure 5.13).

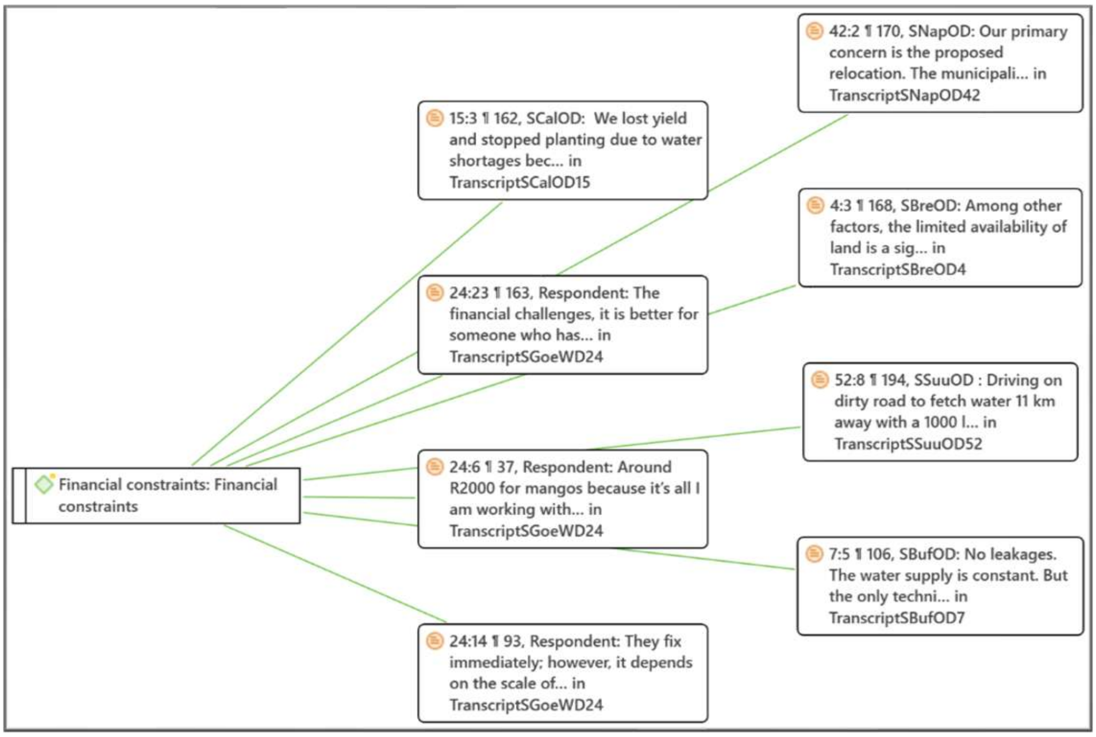

Figure 5.13 Summary of one-on-one interview narratives for financial constraints among smallholder farmers in Overberg and West Coast Districts

According to SCalOD15, *"We lost yield and stopped planting due to water shortages because we could not afford to hire a water truck."*

SGoeWD24 added:

> *"I had leakage in my kitchen from a tap to the incoming water, it was a small thing but the fittings for that cost R400 and I had to fix two of them. That tells you how expensive it is to fix my irrigation infrastructure. It is better for someone who has savings so they can fix their farming facilities."*

Another participant, SSuuOD52 also commented, "*Driving on a dirty road to fetch water 11 km away with 1000 litres in the car can damage the vehicle. Fuel is very expensive."*

Another participant was particularly critical of the municipality's plan to relocate them without requisite support for water infrastructure:

> *"The municipality intends to move us to a distant location, far from the stream where we currently fetch water. Unfortunately, they have no plans to provide us with water resources at the new site. In our current location, we have the convenience of accessing water through buckets. We are unsure how to manage this situation if we are relocated. Unfortunately, we lack transportation for such a move."* (SNapOD42)

Another participant, SBreOD4 linked the lack of funding for water infrastructure to the availability of land:

"Among other factors, the limited availability of land is a significant obstacle preventing us from seizing farming opportunities. Based on the advice I received during a training course I attended; our first step should be securing land through the municipality. This is essential for the Department of Agriculture to assist. Additionally, it would enable us to establish a cooperative that can foster our growth and provide guidance on business finances. Therefore, it seems that the municipality is the entity impeding the progress of our farming efforts in this area."

The results illustrate the significant financial constraints faced by smallholder farmers, which hinder their ability to maintain and repair water infrastructure, sustain agricultural activities, and adapt to changing circumstances. Farmers lamented the prohibitive costs of essential repairs, such as fixing irrigation systems or household leaks, which are unaffordable without substantial savings. The lack of resources extends to challenges like expensive fuel for transporting water over long distances and potential vehicle damage due to poor roads. Criticism of municipal policies, such as plans to relocate farmers without adequate support for water infrastructure, is an indication of a disconnect between municipal decisions and farmers' needs.

Infrastructure Maintenance

A recurrent theme in the focus group discussions was a sense amongst interviewees that financial constraints hampered water infrastructure maintenance (Figure 5.14).

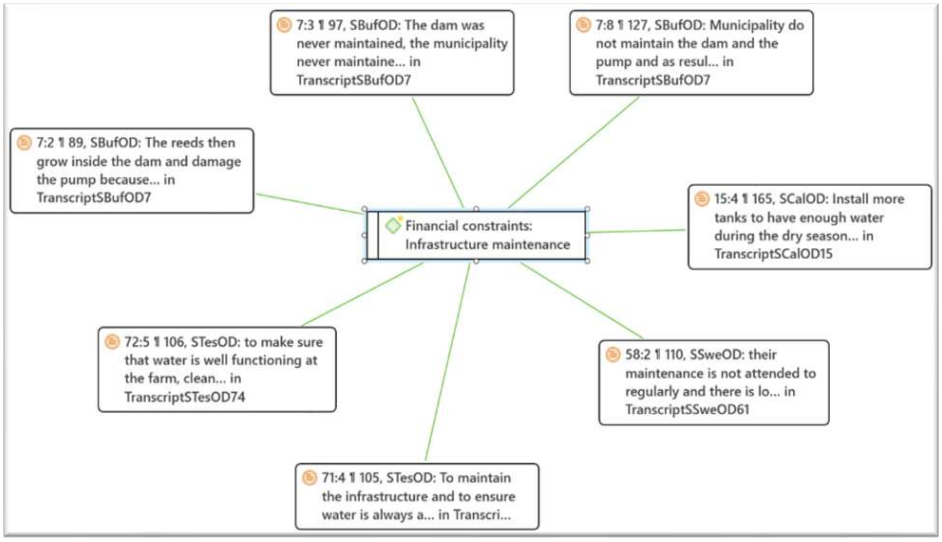

Figure 5.14 Summary of one-on-one interview narratives for infrastructure maintenance for smallholder farmers in Overberg and West Coast Districts

For example, SBufOD7 stated that:

> *"The reeds grow inside the dam and damage the pump because there is no dam maintenance. The roots of the reeds also damage the pump. The reeds also take water from the dam. The dam was never maintained, and the municipality never maintained the pump. The plants are growing in the dam. The roots of the plants are causing the pump to break. The reeds need to be removed or cleared. Some pipes are underground but the pipes on top of the soil need to be replaced because they are burnt by the sun."*

SSweOD61 also added,

> *"Their maintenance is not attended to regularly and there is load shedding which cuts the water supply."* In support of the above views, STesOD74 said, *"There is a need to maintain the infrastructure and to ensure water is always available at the farm by pumping it daily."*

Some participants wished for increased funding for water infrastructure. SCalOD15 felt that:

> *"There is a need to install more tanks to have enough water during the dry season and because there is a river nearby, we would appreciate it if we could be connected from that river to extract water via a pipeline and then store it in our tanks."*

STesOD74 also added:

> *"To make sure that water is well functioning at the farm, we should clean the dam at all times from the algae and remove dam mud using a hired digger loader."*

The findings reveal that financial constraints are a significant barrier to maintaining and improving water infrastructure for smallholder farmers. Participants reported the deteriorating state of key infrastructure, such as dams, pumps, and pipelines, which suffer from neglect, overgrowth of vegetation like reeds, and exposure to harsh environmental conditions. Issues such as damaged pumps, sun-scorched pipes, and algae-infested dams were frequently cited as urgent challenges. Likewise, irregular maintenance schedules and disruptions like load shedding exacerbated water access problems. Participants expressed a strong desire for increased funding to address these issues and solutions such as additional water storage tanks, pipelines to nearby rivers, and equipment like digger loaders to clear dams.

Dissatisfaction

The results indicate widespread dissatisfaction among participants regarding government support for water infrastructure, with the majority (55%) expressing discontent (see Figure 5.15). However, a notable minority (38%) reported satisfaction, suggesting that while some efforts by the government are acknowledged, they are either inconsistent or insufficient to meet the broader needs of the farming communities. This disparity indicates an argument for targeted and equitable government interventions to improve water infrastructure support.

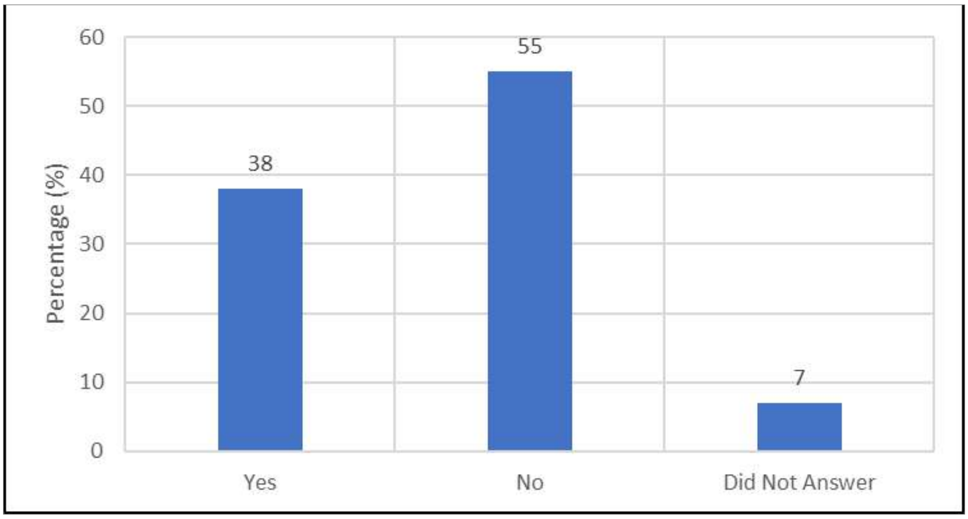

Figure 5.15 Government support for smallholder farmer water infrastructure (N=119)

Inequity

Concerns were also expressed about inequity in water distribution and lack of support from the water governance institutions (Figure 5.16). A recurrent theme in the interviews was a sense amongst interviewees that farmers had differing levels of assistance from the government, with smallholder farmers arguably getting little support.

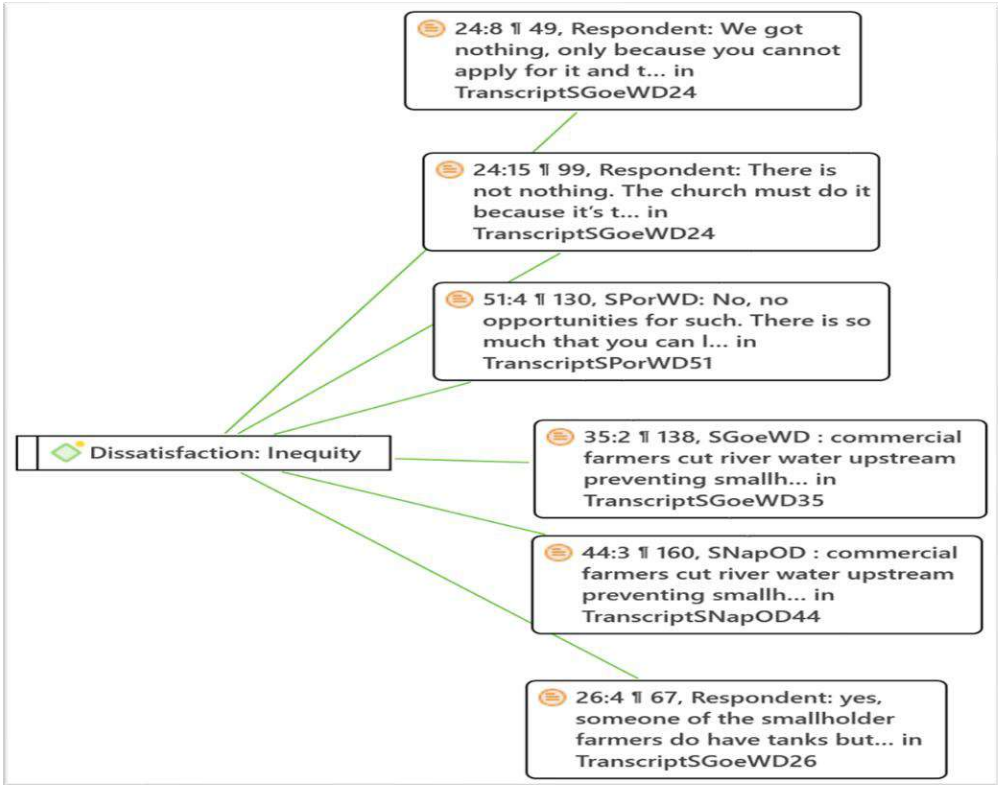

Figure 5.16 Summary of one-on-one interview narratives for inequity in funding among smallholder farmers in Overberg and West Coast Districts

For example, SGoeWD35 said, *"Commercial farmers cut river water upstream, preventing smallholder farmers from receiving water."* As SPorWD51 maintained, *"there are no opportunities, although there is so much that you can learn as a farmer."*

Inequities also exist among smallholder farmer groups as argued by SGoeWD24:

> *"We got nothing (in terms of funding), only because you cannot apply for it and the church is the boss. Without contracts, you get nothing. Some of the smallholder farmers do have tanks but where I am working there are no tanks."*

Inequity was also caused by a focus on other priorities than water for smallholder farmer irrigation:

> *"The lack of interest in farming among the new generation, who aspire to pursue careers like becoming doctors, has negatively impacted the farming rate in our community. This shift in focus has led to poor maintenance of essential waterways. The priority placed on education over farming by our descendants has further exacerbated the challenges associated with climate-related issues and water management."* (FGDGoeWD3)

These findings demonstrate notable inequities in government support for farmers, with smallholder farmers receiving disproportionately less assistance than commercial farmers. Participant narratives show instances where upstream water access was dominated by commercial farmers, effectively marginalising smallholders. Disparities within smallholder farming groups were evident, with some farmers benefitting from resources like water tanks. In contrast, others were excluded, often due to bureaucratic obstacles or institutional controls, such as church governance. Beyond structural inequities, shifting generational priorities were also identified as a factor, with younger community members prioritising education and non-agricultural careers over farming. This shift contributed to reduced maintenance of critical water infrastructure and an overall decline in farming activity.

Lack of Support

When the participants were asked if they were receiving funding for water infrastructure, the majority commented that they were maintaining their infrastructure and wished that the Department of Agriculture would assist them in maintaining it (Figure 5.17).

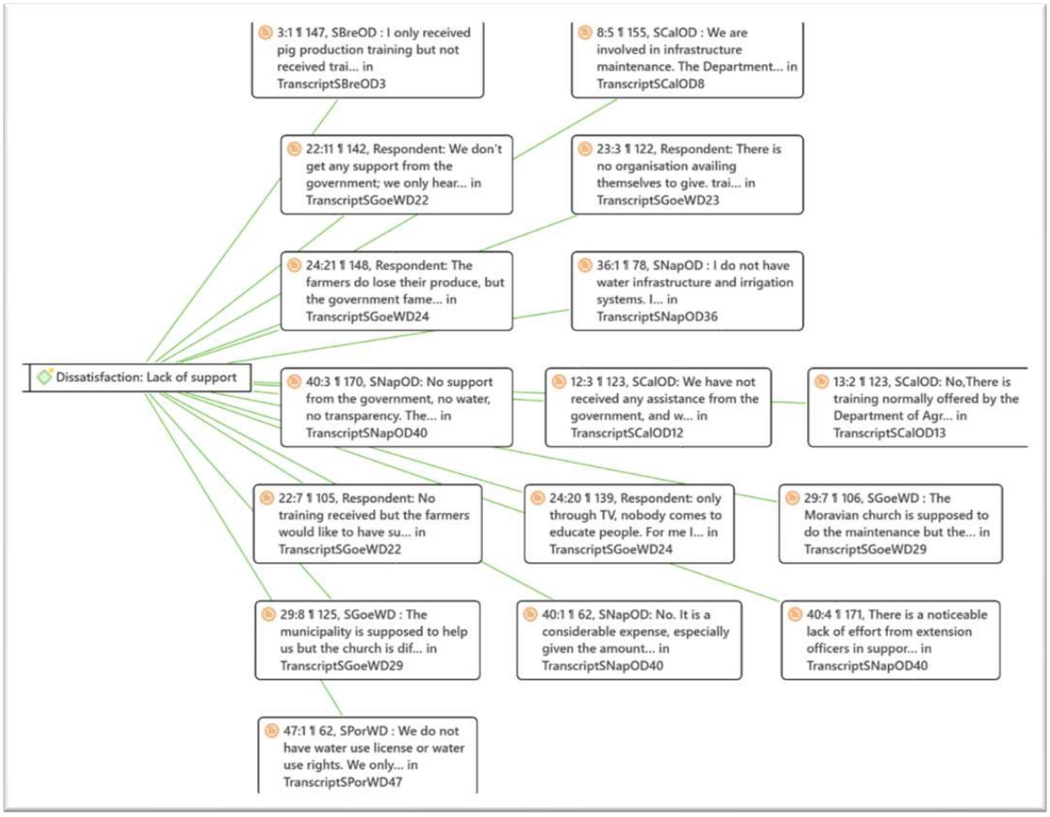

Figure 5.17 Summary of one-on-one interview narratives for lack of support for smallholder farmer water infrastructure in Overberg and West Coast Districts

For example, SCalOD8 said:

> *"We have not received any assistance from the government, and what the government says often does not align with their actions. It is frustrating because many white commercial farmers claim that the government should allow them to invest in black farmers. We have been requesting assistance from them, but they have not provided any help. They are rather condescending towards us and seem to be attempting to push us out because they do not want black farmers near them."*

This was supported by several participants, for example, SGoeWD22, who said, *"We do not get any support from the government; we only hear about the government on television."* SGoeWD2 perceived that government farmers (presumably, white farmers) are well equipped with fire protection equipment and *"they have water resources at government farms and pumps, they are not even affected by the load-shedding and have solar panels."* Conclusively, according to SNapOD40, *"There is no support from the government. The municipality always asks for money for their services."*

A few participants felt that the Moravian church was supposed to a lesser extent fund and/or maintain infrastructure since they claim title deeds to the land. For example, SGoeWD29 commented:

> *"The municipality is supposed to help us, but the church is difficult. The church is just taking the money from us and not helping us, and they use the money for their uses. The church just takes the money and not rendering its services and it is a big challenge."*

Another interviewee alluded to the notion of lack of support for water infrastructure:

> *"There is a noticeable lack of effort from extension officers to support smallholder farmers in this area. While farmers in Bredasdorp have received tanks from the government, we, on the other hand, have not received any assistance. The only time we received any support was during the COVID-19 period, and it was facilitated by one of our fellow farmers, who is not an extension officer. Unfortunately, only three farmers in our community received those tanks. I have lived in this area for 24 years, and I have never personally encountered these extension officers."* (SNapOD40)

Per the present results, previous studies have demonstrated the importance of mobilizing financial resources and adopting innovative financing approaches to address the water infrastructure needs of smallholder farmers, thereby enhancing agricultural productivity, food security, and resilience to climate change. For instance, Mdemu and van Koppen's

(2018) study demonstrates the importance of innovative financing mechanisms, such as microfinance, crowdfunding, and public-private partnerships, in improving smallholder farmer access to water infrastructure in Africa. They argue that these approaches can complement traditional funding sources and help overcome financial barriers to irrigation development. Additionally, Foster and Wodon (2019) examined the role of international aid and development assistance in supporting water infrastructure projects for smallholder farmers in Africa. They suggest that targeted investments and capacity-building initiatives can enhance the effectiveness of aid interventions and promote sustainable water management practices among farmers. Furthermore, Zougmoré et al. (2018) investigated the potential for climate finance to support agricultural adaptation and water infrastructure development in Africa. Their research highlights the need for climate-resilient water infrastructure investments that benefit smallholder farmers, particularly in vulnerable regions prone to climate variability and extreme weather events.

In South Africa, Mabhaudhi et al. (2019) urged increased water infrastructure investment to improve agricultural productivity and resilience among smallholder farmers. Their study highlights the role of government subsidies, grants, and innovative financing mechanisms in supporting farmers' access to water resources and irrigation infrastructure. Furthermore, Nhamo et al. (2018) examined the financing mechanisms for agricultural water management in South Africa, stressing the importance of public-private partnerships and community-based initiatives. They argue that diverse funding sources, including government funds, international aid, and private sector investments, are essential for expanding access to water infrastructure and promoting sustainable agriculture among smallholder farmers. Ziervogel et al. (2017) investigated the challenges and opportunities for financing climate change adaptation in South Africa's agricultural sector, including investments in water infrastructure. They show the importance of integrating climate adaptation strategies into funding mechanisms and policy frameworks to ensure the resilience of smallholder farmers to climate-related risks and uncertainties.

Climate change information dissemination for smallholder farmers

Participants (smallholder farmers) were asked about their sources of information on climate change and drought. The participants were allowed to state as much media of climate change information as they could. Of the 74 participants who answered the question, 38% indicated that they obtained climate change information from the television, followed by the radio (35%), the internet (15%), extension services (14%) and the farmers' union (11%) (Figure 5.18).

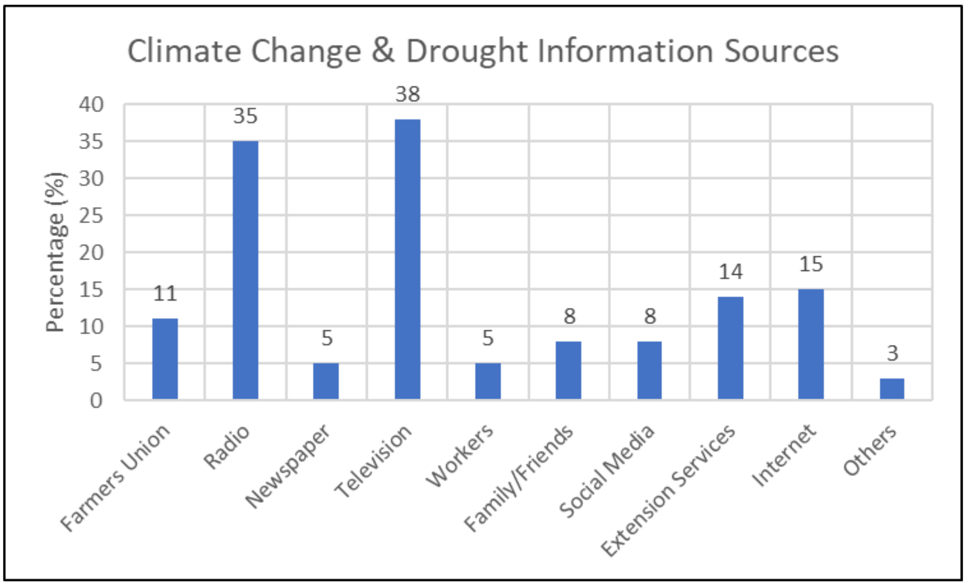

Figure 5.18 Climate Change and Drought Information Sources (N=119)

These results demonstrate a wide spectrum of information on climate change. Disseminating climate-change information to smallholder farmers is crucial for enhancing their adaptive capacity and resilience to climate-related risks. Several studies have found similar results. For example, Ziervogel et al. (2016) investigated the effectiveness of extension services and agricultural advisory systems in providing climate information to smallholder farmers in South Africa. They found that while extension services play a vital role in disseminating climate information, there are challenges related to the capacity of extension agents and the relevance of the information provided to farmers' needs. Gbetibouo et al. (2010) explored the role of agricultural research institutions in generating and disseminating climate information to smallholder farmers in Zimbabwe. Their research argues for collaborative research efforts between scientists, extension services, and farmer organizations to develop context-specific climate information and advisory services that are accessible and relevant to farmers. Challinor et al. (2019) also examined the potential of mobile phone technology in delivering climate information to smallholder farmers in sub-Saharan Africa. They argue that mobile phone-based platforms can bridge the gap between climate scientists and farmers, providing timely and tailored information that supports decision-making and adaptive actions. Moreover, Khan et al. (2020) explored the role of information and communication technologies (ICTs) in enhancing transparency and citizen engagement in water governance in South Africa. They argue that ICT platforms can facilitate real-time monitoring, data sharing, and public participation, thereby improving transparency and accountability in water management practices.

5.4 Smallholder farmer capacity for adaptation to climate change

5.4.1 Water Resources

Water resource themes included water management and water conservation (Figures 5.19, 5.20 and 5.21).

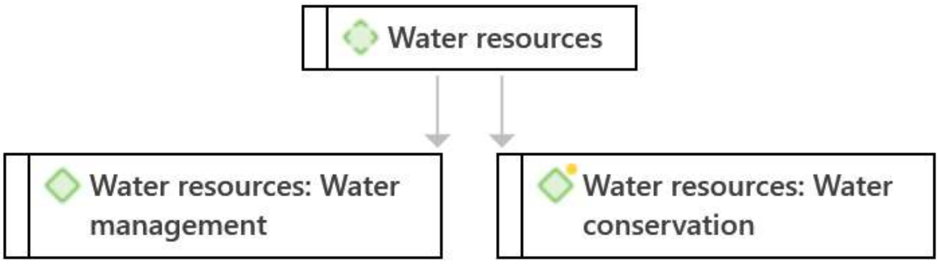

Figure 5.19 Conceptual map of findings for Water Resources Theme

Water Management

Almost two-thirds of the participants (69%) viewed improvement in water management as crucial to adaptation to climate change. For example, FGDGoeWD4 argued:

> *"The drinking water supply system is not adequately built to meet our needs. While some individuals have gardens that benefit from this water, it is also utilised for irrigation by those farming in the gardens. There is a pressing need for the individual's claiming ownership of the land to take responsibility for fixing the existing infrastructure. Improving the overall management of water-related issues is crucial to enhance the situation for agriculture. Additionally, it is imperative to address stormwater management to mitigate the impact of storms and ensure sustainable water usage in the community."*

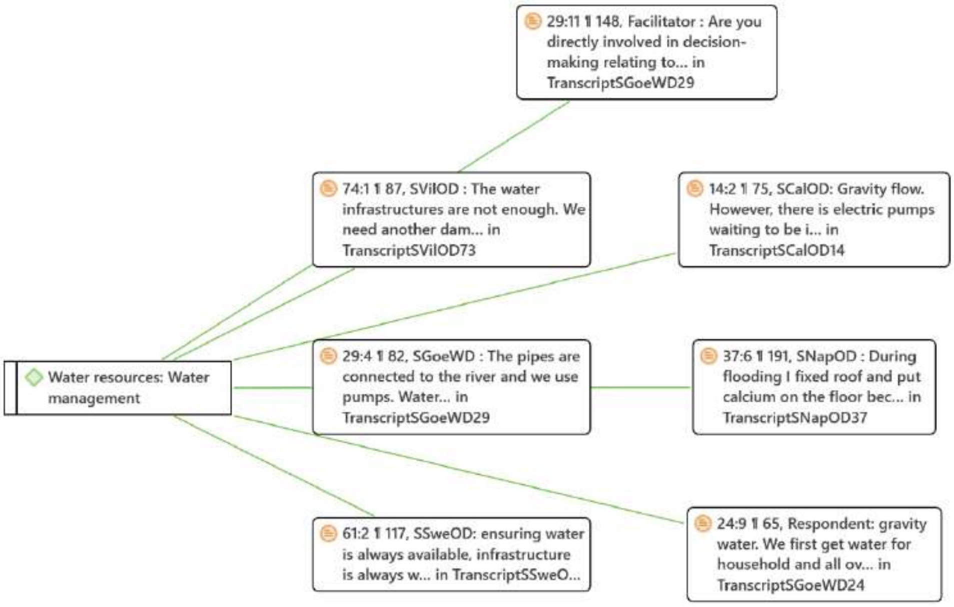

Figure 5.20 Summary of one-on-one interview narratives for water management among smallholder farmers in Overberg and West Coast Districts

Other participants managed water through gravity flows, although many used electric pumps to get enough irrigation pressure; thus, they had fewer challenges with climate change. As reported by FGDSwelenOD3:

> *"Climate change is not that much of a problem because I buy some water from the municipality for the piggery and use some for my garden, so it (climate change) did not affect me because I do not have dams to be filled. I have got some tanks, and I buy the water and fill the tanks and the pigs drink from the puzzles, so it did not affect me that much."*

Sixty-nine per cent of participants strongly agreed that improving water management is essential for adapting to climate change, enhancing infrastructure, and addressing stormwater management. Several participants noted the importance of community responsibility in maintaining and upgrading water systems to support agricultural activities. Notably, some farmers were relatively insulated from climate change impacts, as evidenced by those who rely on gravity flows or purchase water to fill tanks, reducing their vulnerability. These farmers report fewer challenges with water availability, suggesting that adaptive strategies, such as purchasing water or relying on controlled irrigation systems, can mitigate the effects of climate change. However, the broader trend indicates that most smallholder farmers face significant risks tied to inadequate infrastructure, and this calls for more comprehensive water management solutions to ensure long-term resilience.

Water Conservation

The overwhelming majority of the participants reported adapting to climate change through water conservation.

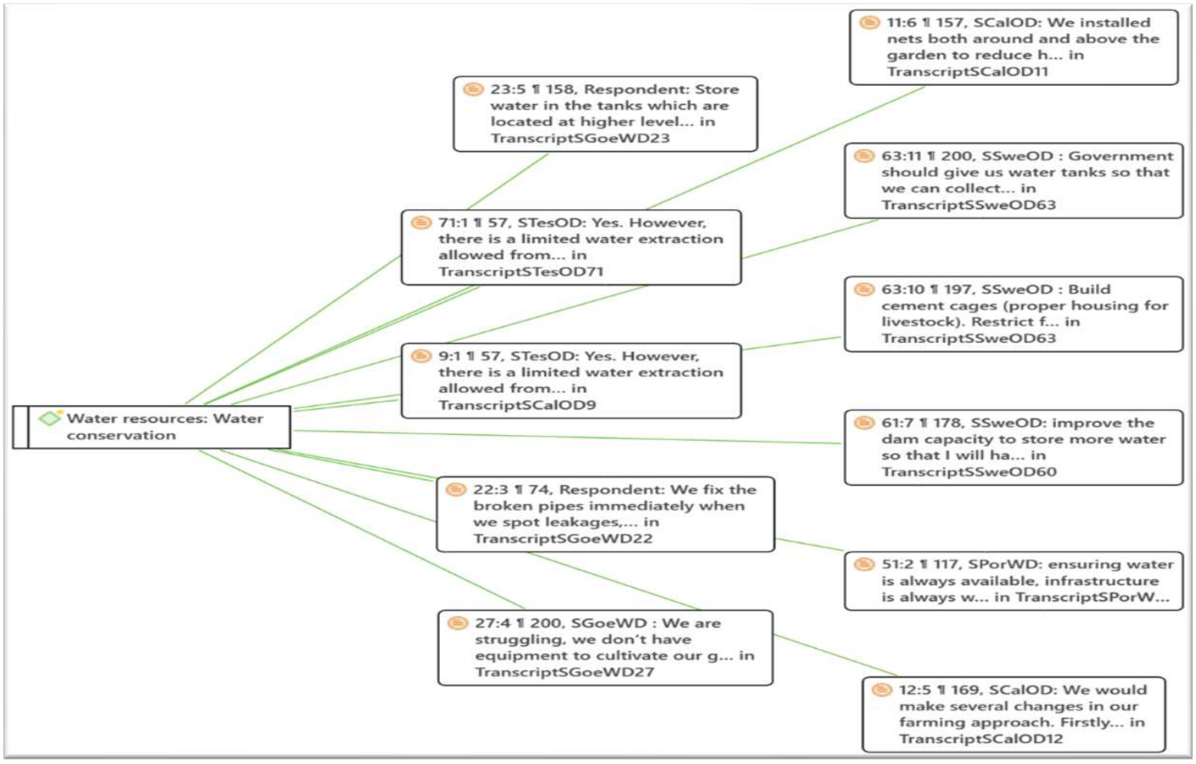

Figure 5.21 Summary of one-on-one interview narratives for water conservation among smallholder farmers in Overberg and West Coast Districts

STesOD71 said, *"There is a limited water extraction allowed from the river (less than 50mm diameter allowed)."* SCalOD11 added:

> *"We installed nets both around and above the garden to reduce heat, which in turn minimises evaporation. Additionally, we dug channels around the garden's perimeter to control flooding. To make the most of available resources, we have been using greywater from our households. Furthermore, we have received assistance from the municipality when they provided water to our community."*

SCalOD9 also commented:

> *"We would make several changes in our farming approach. Firstly, to transition to hydroponic farming methods. Additionally, we will focus on raising livestock and cultivating*

crops that are more resilient to the extreme weather conditions we face. Another important step is to enhance our water storage capacity by either installing new boreholes or repairing the existing borehole system on the farm. We fix the broken pipes immediately when we spot leakages because we need water, we cannot let the water go to waste. We also store water in the tanks which are located at higher levels as the farmer and use the tank water for irrigation when there is drought."

Some participants suggested that although climate change has not affected rainfall, rising temperatures required a great deal of adaptation:

"The changing weather patterns in our area primarily impact drinking water, not agricultural water supply. My observations suggest an increase in rainfall, but simultaneously, we are facing extremely high temperatures during the summer seasons. Fortunately, this heat does not adversely affect water availability for smallholder farmers operating on farming plots near the river. However, those with small gardens may face challenges, as their water supply from the dam can run low." (FGDBredOD3)

"In our circumstances and our habitats, we are acclimatised to our environment. So, if you want to be a farmer you must be acclimatised to your environment. We use exceptional rainwater that is for household use and for our animals for drinking but not for gardening. You cannot use your drinking water for gardening. If you have a garden, you must have extra water. Therefore, we cannot rely on municipal sources and therefore we must be geared for that, therefore, I have a tank, a reasonably strong bakkie so that I can go to the river and pump 1000 litres of water and come home and give my animals water." (FGDSwelenOD2)

The findings indicate that most participants have adopted a variety of water conservation strategies in response to climate change, demonstrating a proactive approach to managing water resources. These strategies include installing nets to reduce heat and evaporation, digging channels to control flooding, and using greywater for irrigation. Several farmers have also focused on improving water storage capacity by repairing existing infrastructure and installing boreholes to ensure a reliable water supply during dry spells. While some participants reported that climate change has not significantly affected rainfall patterns, rising temperatures have posed challenges, particularly for those with smaller gardens. The reliance on local water sources, such as rivers, and the adaptation to using household rainwater for livestock highlight the importance of being self-sufficient and prepared for climate-related shifts. Generally, the prominence of water conservation and infrastructure improvement reflects the farmers' resilience and adaptive capacity in the face of climate change.

5.4.2 Infrastructure

Most participants cited the need for water infrastructure to adapt to climate change and drought optimally. As shown in Figure 5.22, participants mentioned infrastructure development and resource management concerning the theme.

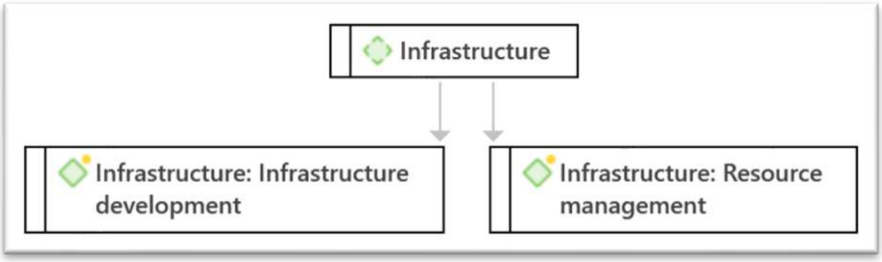

Figure 5.22 Conceptual map of findings for Infrastructure Theme:

Infrastructure Development

Although they acknowledged the realities of climate change, FDG participants reported using a cocktail of water infrastructure as an adaptation mechanism (Figure 5.23).

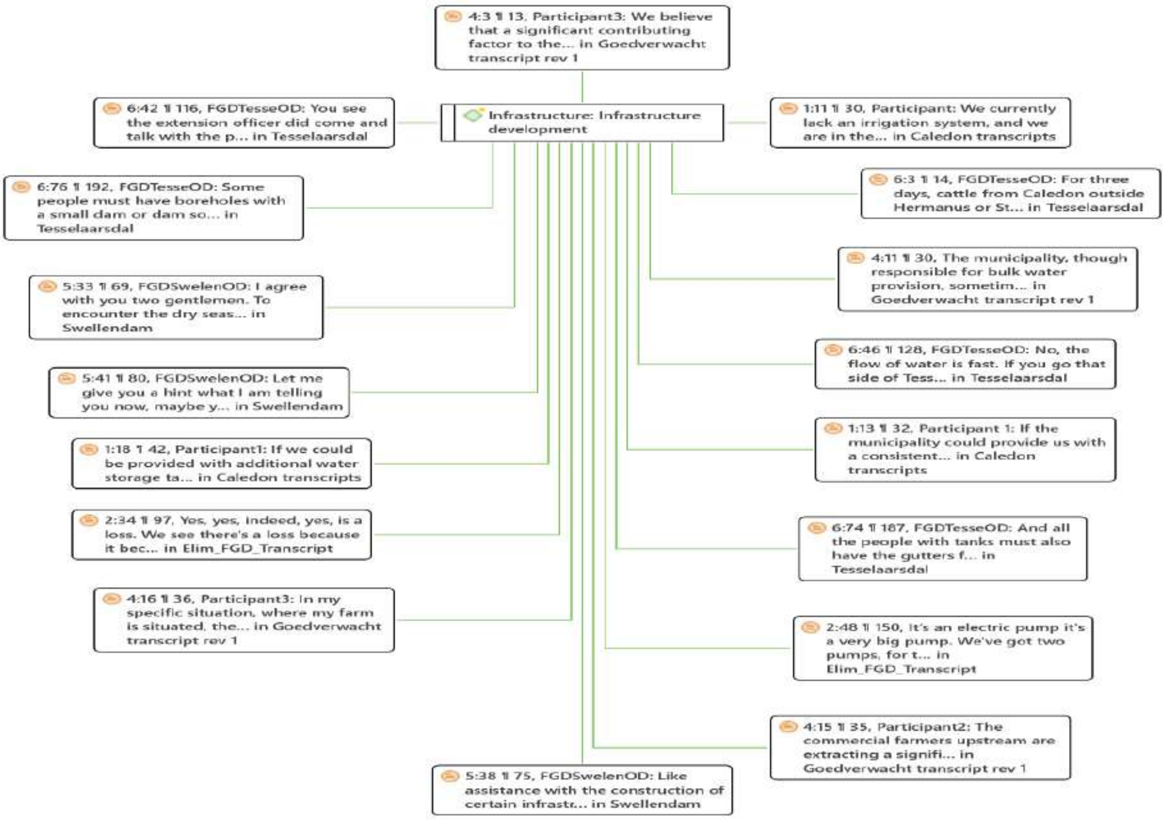

Figure 5.23 Summary of one-on-one interview narratives for infrastructure development among smallholder farmers in Overberg and West Coast Districts

The most reported were water tanks to store water, clean waterways, and build more dams. Below are narratives from the participants:

> *"I am not impacted by floods due to the favourable terrain where I plant. The terrain prevents runoff from destroying my produce. In the event of water depletion, I approached the Theewaterskloof municipality to assist me in refilling my water tank, and they have consistently been helpful."* (FGDTessOD1)

> *"There were times in the past, say 10 years when we were facing challenges during that drought period. So, there was a shift, and we were forced to make plans to get excess water for farming purposes, as most of the rivers were dry but luckily there were no losses. So at least there was an opportunity to get storage water."* (FGDElimOD3)

> *"Given that it is evident that climate change is currently underway, manifesting in various fluctuating weather events such as recent flooding, I would like to explore additional strategies to mitigate the effects of these occurrences. One strategy that comes to mind is the cleaning of waterways to ensure their functionality during floods, thereby minimising the adverse impacts on our agricultural land. One of the challenges some of us face is the presence of old and leaking pipes, which complicates matters, especially during the summer when we rely on rainfall for irrigation."* (FGDGoeWD7)

> *"With livestock farming, we try to see if we can get more dams or make more dams in a camp so that when there is good rainfall at least we have options not just one dam in one camp."* (FGDSwelenOD4)

However, there was a consensus among the participants that they faced competition for irrigation water from commercial farmers and lacked proper irrigation systems. If the central government could provide adequate water storage infrastructure and the municipality consistently supplied water, it would make a significant difference for them in climate change adaptation. Some participants suggested the following:

> *"If we could be provided with additional water storage tanks, it would make a significant difference. Moreover, having experts visit us to guide us on the importance and best practices of agriculture would greatly benefit our community."* (FGDGenOD2)

> *"We believe that a significant contributing factor to the decline in water levels in the river is the extraction of water by commercial farmers upstream. The installation of boreholes and well points by these commercial farmers results in the excessive withdrawal of water, which should ideally flow downstream to us as smallholder farmers. In previous years, when commercial farmers did not have as many dams, well points, and boreholes, water*

availability was more consistent. However, with the development of these infrastructures, the impact on water availability for us has become noticeable." (FGDTessOD1)

"The commercial farmers upstream are extracting a significant amount of water, impacting us downstream. The existing irrigation system lacks a centralised dam from which pipes can be connected. I believe a key disadvantage of the system is that if we construct dams near our farms and connect pipes directly from these dams, it will substantially improve our water situation, especially during the summer season when rainfall is minimal or non-existent." (FGDGoeWD8)

"One would like for the department officials to perhaps visit each farm and to get an estimate or idea like each farm has perhaps individual needs so that something can be tailor-made to fit certain criteria or to fit certain farmers so that the solution that is given works for you." (FGDSwelenOD3)

The findings reveal that smallholder farmers actively employ various water infrastructure strategies to adapt to climate change. Commonly used measures include the installation of water tanks, cleaning waterways to prevent flooding, and constructing additional dams to enhance water storage. Participants acknowledged the increasing frequency of climate events, such as droughts and floods, which have compelled them to innovate and seek assistance from local authorities. However, challenges remain, particularly in competition for water from upstream commercial farmers, who are perceived to extract disproportionate amounts of water through boreholes and well points. This has significantly impacted downstream water availability for smallholder farmers. Participants strongly desired increased government support through additional water storage infrastructure, irrigation system upgrades, and expert guidance tailored to individual farming needs. The lack of a centralised irrigation system and equitable water allocation were noted as critical barriers to effective climate change adaptation.

Resource Management

Participant narratives showed that water and land resources are linked, and crucially, their management in sync could assist smallholder farmers in adapting to climate change (Figure 5.24).

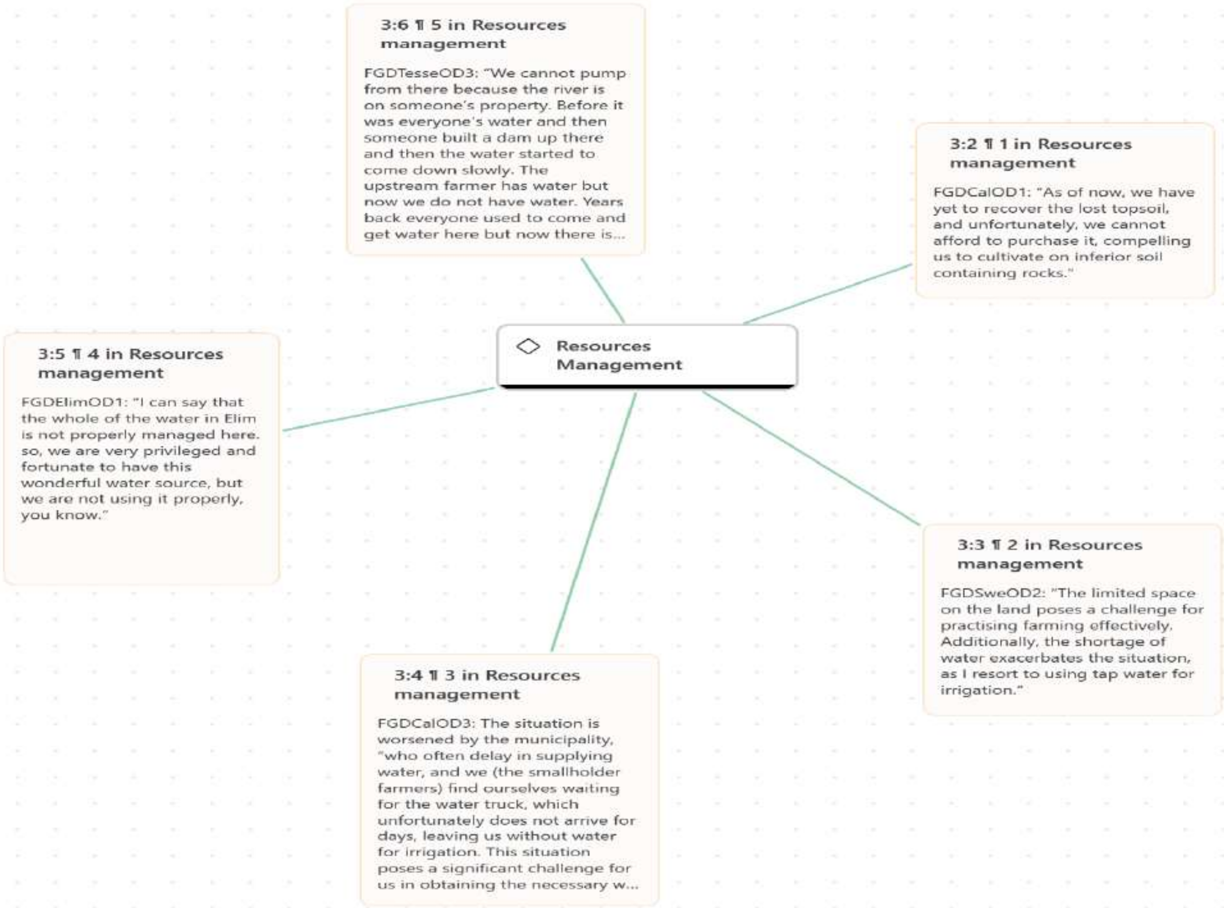

Figure 5.24 Summary of one-on-one interview findings for resource management among smallholder farmers in Overberg and West Coast Districts

For example, in 2021, Caledon experienced a severe water shortage due to low rainfall and extreme temperatures, which significantly negatively impacted smallholder farmers as they heavily depend on water for their crops. They also faced additional challenges with floods that destroyed crops and washed away the crucial topsoil needed for farming. Thus, as FGDCalOD1 puts it, *"As of now, we have yet to recover the lost topsoil, and unfortunately, we cannot afford to purchase it, compelling us to cultivate on inferior soil containing rocks."* Moreover, *"the limited space on the land poses a challenge for practising farming effectively. Additionally, the shortage of water exacerbates the situation, as I resort to using tap water for irrigation."* (FGDCalOD3) The situation is worsened by the municipality, *"who often delay in supplying water, and we (the smallholder farmers) find ourselves waiting for the water truck, which unfortunately does not arrive for days, leaving us without water for irrigation. This situation poses a significant challenge for us in obtaining the necessary water resources."* (FGDSweOD2) Thus as another participant argued, *"I can say that the whole of the water in Elim is not* *properly managed here. so, we are very privileged and fortunate to have this wonderful water source, but we are not using it properly, you know."* (FGDElimOD1). However, the major challenge is that some water sources are within privately owned commercial farms. FGDTesseOD3 reported that:

> *"We cannot pump from there because the river is on someone's property. Before it was everyone's water and then someone built a dam up there and then the water started to come down slowly. The upstream farmer has water but now we do not have water. Years back everyone used to come and get water here but now there is no water"*

This study supports evidence from previous observations (Deressa et al., 2011; Chiputwa et al., 2018). For instance, research by Deressa et al. (2011) in Ethiopia found the importance of access to credit, extension services, and agricultural inputs in enhancing farmers' adaptive capacity. Similarly, Chiputwa et al. (2018) argue that leveraging indigenous knowledge and fostering collective action can improve farmers' adaptive capacity and promote sustainable agricultural development. Manda et al. (2019) further argue that gender inequalities should be eradicated to ensure inclusive and effective climate change adaptation initiatives. Manyena et al.'s (2018) study in South Africa showed the importance of social capital, knowledge, and resource access. Nhemachena et al.'s (2019) study found that farmers with higher levels of education and income tend to adopt more climate-resilient agricultural practices and technologies. O'Brien et al. (2019) argue for the need to address gender-specific barriers and inequalities in accessing resources, knowledge, and decision-making power to enhance women farmers' adaptive capacity.

5.5 Conclusions

The findings from this chapter show the relative importance of accountability in smallholder farmer water governance and context-specific approaches that promote transparency, participation, and oversight. The results also showed a gap in the efforts between the government, development agencies, and the private sector to mobilise financial resources and support smallholder farmer water infrastructure development. Smallholder farmers face a complex interplay of challenges and opportunities. While there are examples of community-driven initiatives and municipal support, such as training sessions, maintenance collaboration, and emergency assistance, significant gaps remain. These include inequitable water distribution, especially between smallholder and commercial farmers, inadequate funding for infrastructure maintenance, and limited government intervention in addressing systemic issues. Smallholder farmers are resilient through self-organisation, water conservation, and adaptation strategies, but structural barriers like outdated irrigation systems, competition for resources, and insufficient policy implementation often constrain their efforts.

The next section is on the development of climate-resilient pathways for water resource management and agricultural production for smallholder farmers. It shows cross-sectoral and multi-stakeholder approaches for climate change and drought adaptation for smallholder farmers. It focuses on the desired future as perceived by stakeholders in agricultural water in the study areas.

6. CLIMATE-RESILIENT PATHWAYS FOR WATER RESOURCE MANAGEMENT AND AGRICULTURAL PRODUCTION

6.1 Introduction

Water resource management and agricultural production are crucial for sustaining livelihoods in regions vulnerable to climate change and natural resource limitations. The Western Cape province in South Africa exemplifies such a region, where farmers face significant challenges due to erratic weather patterns, insufficient infrastructure, and limited access to essential resources. The impacts are even more pronounced for the mostly resource-poor smallholder farmers. The situation is worsened by the threat of climate change. Therefore, the need for sustainable climate-resilient pathways is urgent, as these farmers are often the most affected by environmental changes and resource constraints. This section uses the Three Horizons framework to explore current challenges, emerging innovations, and future water management and agricultural production possibilities among smallholder farmers in the Western Cape. By engaging with farmers, agricultural officials, and other stakeholders across six sites — Goedverwacht, Bredasdorp, Caledon, Genadendal, Tesselaarsdal, and Barrydale — the study sought to understand the existing system's weaknesses, identify seeds of innovation that could transform these challenges, and outline desired futures that can guide sustainable development. Through a series of workshops, participants discussed their experiences and perspectives, providing valuable insights into the practical realities of smallholder farming in the Overberg and West Coast Districts. This section captured participants' voices, connected them with sustainable agriculture and water management literature, and presented a comprehensive view of the pathways leading to a more resilient agricultural water sector.

6.2 Methodology

Futures studies provide a variety of techniques to help societies investigate conceivable, realistic, and normative futures that enhance decision-making and assist in navigating paths towards such futures. These techniques can help individuals explore new possibilities and make their assumptions about the future clear. For instance, Jarva (2014) argues that although people's visions of the future are active and passive, they do not exist in the real world. The Three Horizons Framework is useful for envisioning and planning future scenarios. It is often used for strategic planning. We used the framework in this study to explore climate-resilient pathways in water resource management and agriculture. (Figure 6.1)

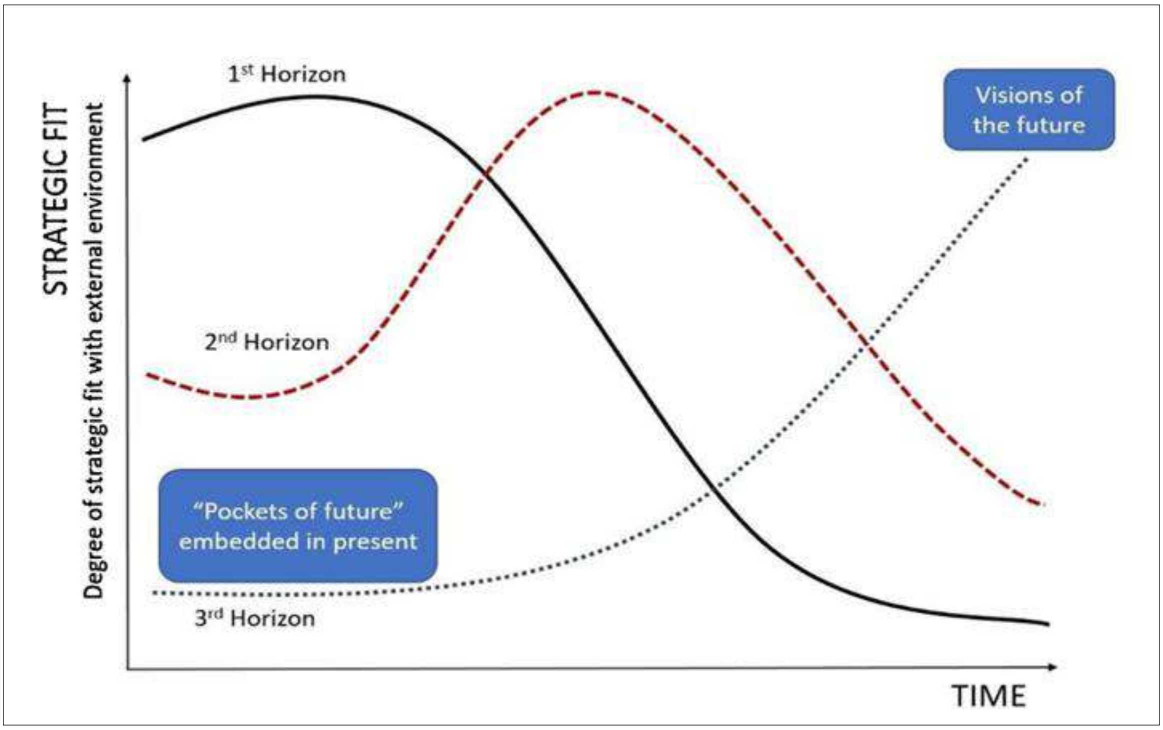

Figure 6.1 Three Horizons Framework (Jordan, 2021)

Horizon 1 represents the current situation in the framework, focusing on existing systems, practices, and challenges. This horizon examined the status quo of water availability, farming practices, and climate impacts affecting smallholder farmers in the Western Cape's Overberg and West Coast Districts in water resource management and agricultural production. Horizon 2 envisioned implementing new strategies and technologies that bridge the gap between current practices and future goals. It represents the gradual shift towards more adaptive and resilient practices that respond to emerging challenges and opportunities. Horizon 3 projects into the future, imagining an ideal state where long-term goals and visions are realised. This horizon focuses on a fully transformed system where water resource management and agricultural practices are highly resilient to climate change and environmental stresses. Horizon 3 envisions a future where sustainable practices are deeply embedded and contribute to thriving, resilient farming communities.

6.2.1 Participant selection and recruitment

Six, three-hour workshops were held in July 2024 to meet the two study goals. There were divergent viewpoints on the challenges to climate change resilience, water management and agricultural production among smallholder farmers through earlier individual interviews and focus group discussions. Workshop participants were chosen to mirror the many opinions held by agricultural water stakeholders in the Overberg and West Coast Districts to develop desired futures that embrace this varied range of values and perceptions. Owing to the three horizons framework's systemic structure, efforts were made to include diverse individuals who played various roles in water management and the agricultural sector. These included officials from the Western Cape Department of Agriculture (WCDoA), the Breede-Olifants Catchment Management Agency, municipalities within Overberg and the West Coast Districts, plus other significant organisations and personnel operating in that field. Invitations were sent by email or voice call to more than 40 individuals who were recommended to the team by other persons previously interviewed for the project or important stakeholders. Flyers with invitation dates were prepared and sent to key informants for onward communication to smallholder farmer WhatsApp groups. Overall, 63 participants attended the six workshops (Goedverwacht (n=13), Bredasdorp (n=3), Caledon (n=11), Genadendal (n=12), Tesselaarsdal (n=8) and Barrydale (n=18)).

6.2.2 Workshop process

During the workshops, plenary discussions alternated with group discussions, which varied in composition to ensure diverse perspectives were captured. Across all six workshops, participants were asked to address key topics related to water resource management and agricultural production (see Appendix D). Specifically, they were tasked to:

- Identify the current situation in water resource management and agricultural production.
- Discuss what they would like to keep from the current system.
- Identify the seeds of the future they want that exist now.
- Describe the characteristics of the future system that they want.
- Suggest ideas that disrupt existing patterns and create opportunities for a different future.

Participants were facilitated through these discussions using a Three Horizons chart affixed to the wall, which served as a visual aid. The stakeholders were grouped within the same workshop to discuss each question, after which they posted their thoughts on sticky notes onto the charts. These notes were then used as a basis for plenary discussions, allowing the entire group to analyse and refine the ideas presented collectively.

6.2.3 Data analysis

Every session was voice-recorded in which participants reported findings from their small-group research to the larger group and had conversations with everyone else after getting their oral consent. All the written workshop results that each group produced were also retained. Every recorded workshop conversation was accurately transcribed. An inductive technique was used to group the written workshop outputs into major topics. The project team utilised the workshop transcripts to aggregate themes derived from the discussions, ensuring that key insights from previous workshop outcomes were systematically captured. These aggregated themes were then uploaded to Atlas.ti, a qualitative data analysis software, where they were further analysed and categorised. This approach allowed the authors to comprehensively understand the recurring issues and emerging patterns across different workshops, facilitating a thorough analysis of the data collected from the participants.

6.3 Pathways by site

A total of six workshops were conducted at Goedverwacht, Bredasdorp, Caledon, Genadendal, Tesselaarsdal and Barrydale. Each group selected a challenge or combination of challenges in the existing system (Horizon 1) which they wished to fix and a goal for the future that they wished to pursue (Horizon 3). Through discussions, they outlined routes towards desired futures and ideas that would disrupt the existing patterns and create an opportunity for a different future (Horizon 2). The following figures (6.2-6.7) show a range of approaches to problems, hopes for the future, and strategies for bringing about change to create better futures. In the figures, yellow represents the major challenges currently faced by the smallholder farmers, green represents the current good practices that farmers wish to continue in the future, pink represents the seeds for the future, which are systems already in place, but need to be built on, orange represents the desired future, i.e. where the farmers want to be in the long term, and lastly blue represents the actions and activities that need to be undertaken to achieve that desired future.

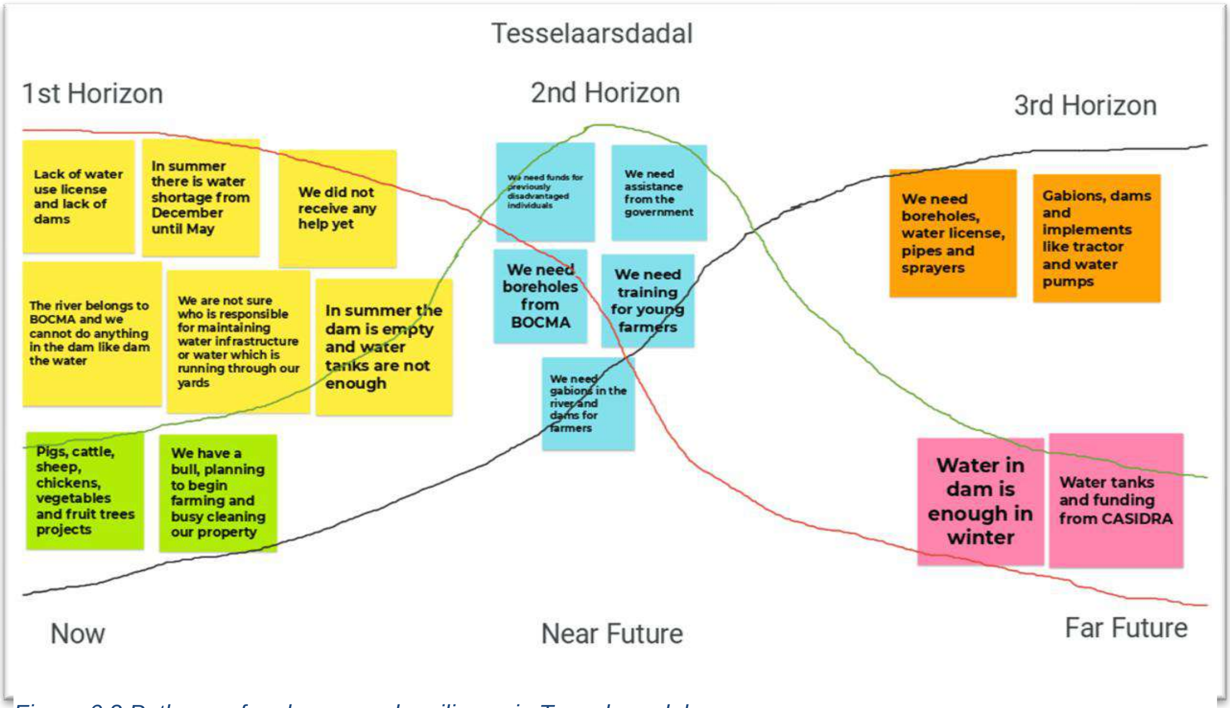

Figure 6.2 Pathways for change and resilience in Tesselaarsdal

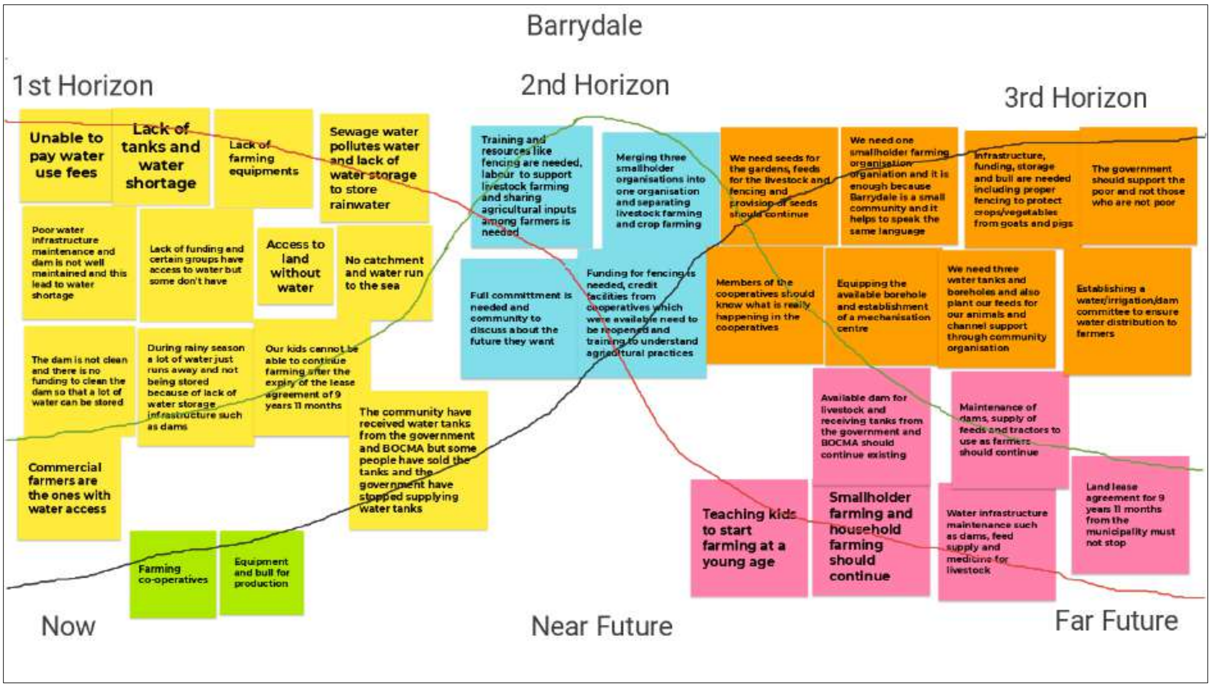

Figure 6.3 Pathways for change and resilience in Barrydale

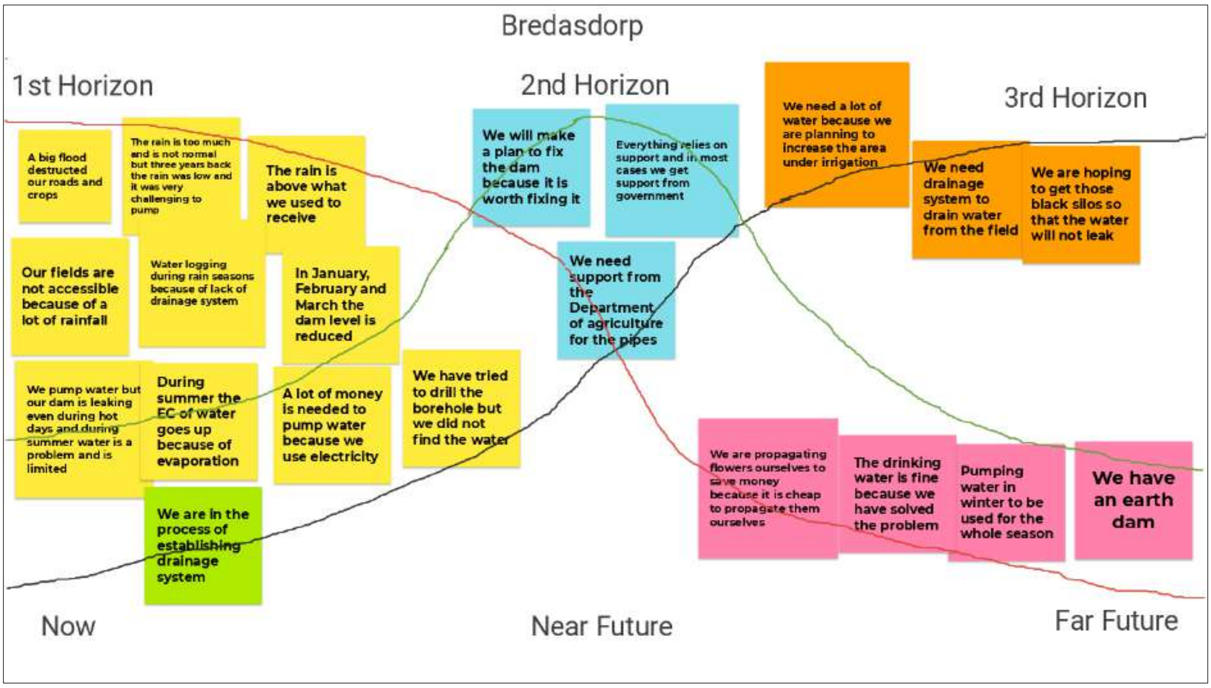

Figure 6.4 Pathways for change and resilience in Bredasdorp

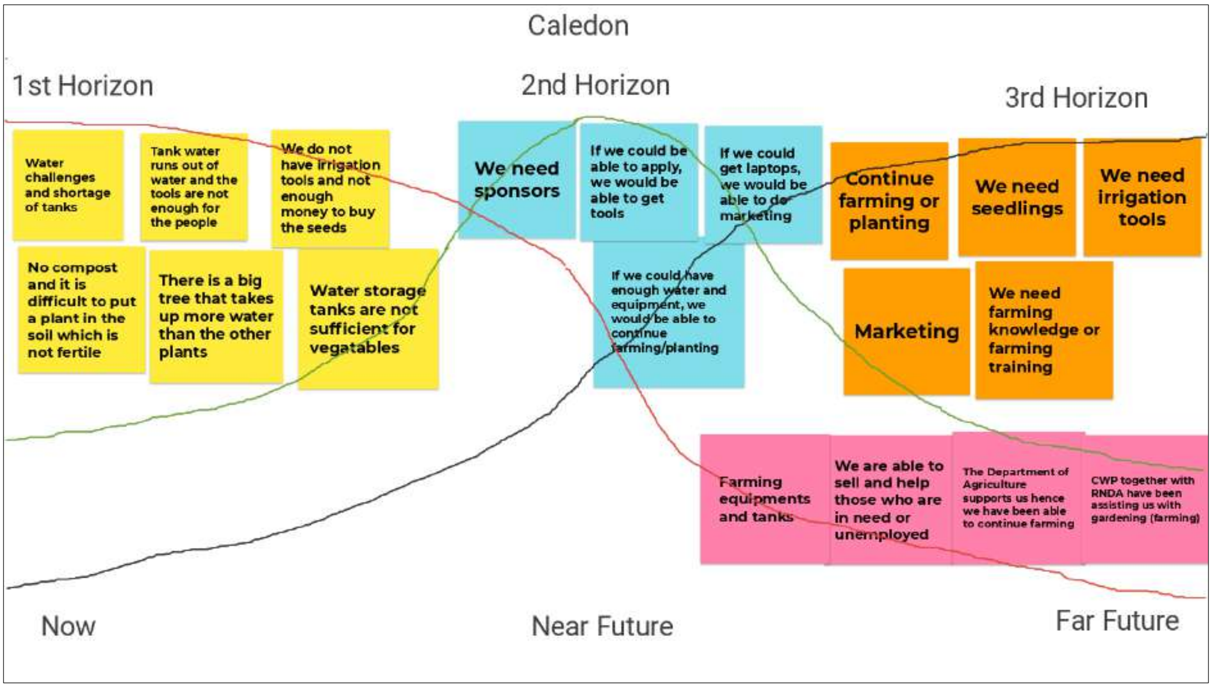

Figure 6.5 Pathways for change and resilience in Caledon

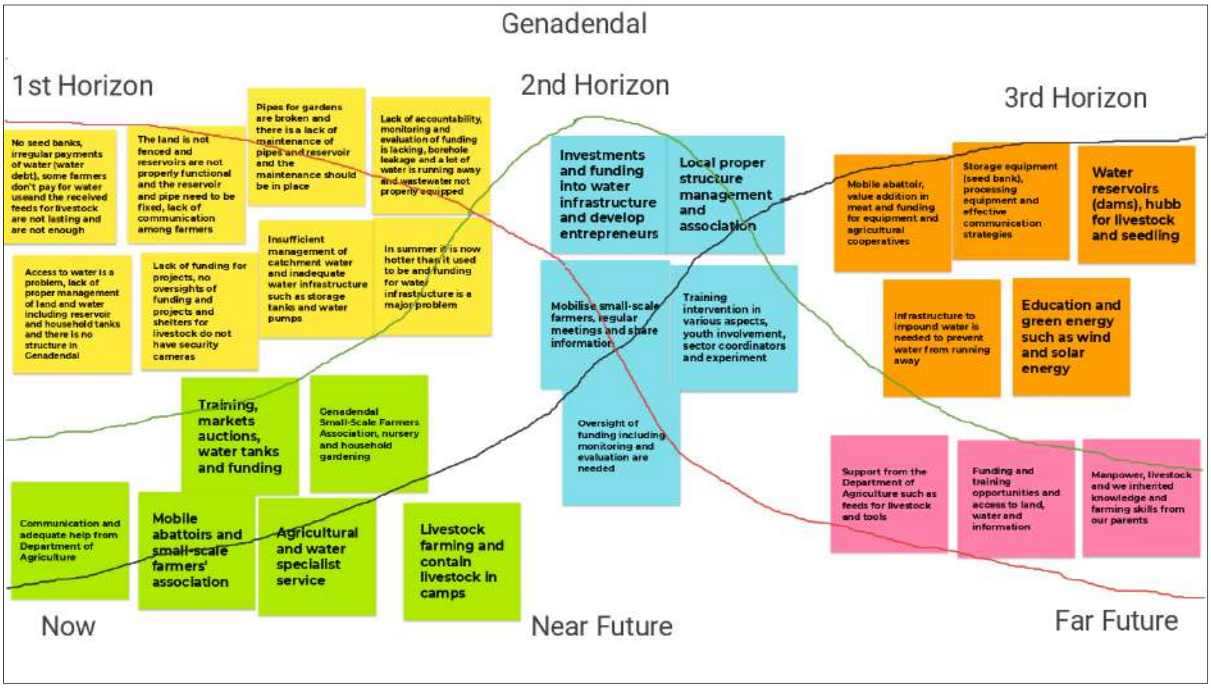

Figure 6.6 Pathways for change and resilience in Genadendal

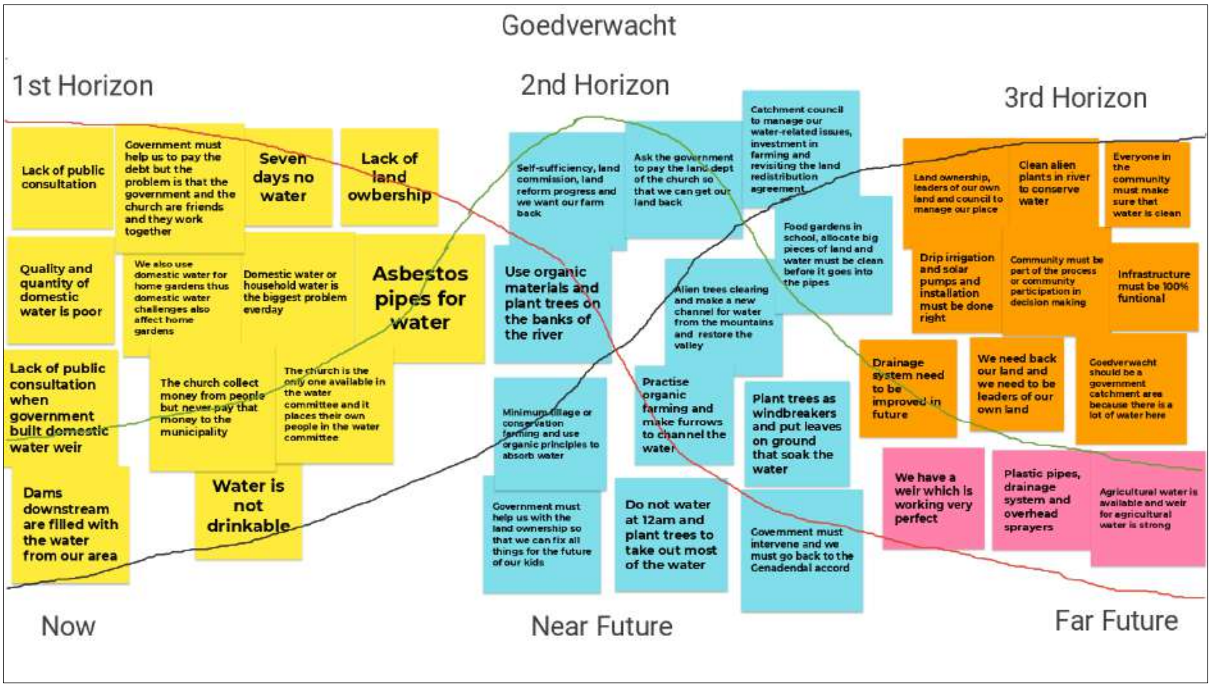

Figure 6.7 Pathways for change and resilience in Goedverwacht

Despite the common reliance on government support, the specific focus of pathways varied significantly between locations, reflecting local priorities and conditions. For instance, water infrastructure provision was a central concern in Tesselaarsdal (Figure 6.2), where participants suggested the need for boreholes to ensure water availability. In contrast, participants in Barrydale (Figure 6.3) and Bredasdorp (Figure 6.4) prioritised funding for dams, boreholes, fencing, cooperatives, and credit facilities, illustrating a broader approach to addressing multiple facets of agricultural sustainability. Caledon participants (Figure 6.5), on the other hand, focused more narrowly on the provision of irrigation equipment and tools to boost farm productivity. These differences show the varied nature of the challenges across different areas, with each community tailoring its pathways to address the most pressing local issues.

In addition to the infrastructure-focused pathways, some workshops identified more comprehensive strategies, including governance and environmental sustainability. Genadendal participants (Figure 6.6) suggested the need for local water management structures and funding oversight, including monitoring and evaluation, to ensure resources are used effectively.

Goedverwacht participants (Figure 6.7) advocated for a more holistic approach, including investing in green energy, implementing the Genadendal Mandela Accord of 1996, clearing alien trees, and promoting smallholder farmer self-sufficiency. This broader vision suggests an understanding of sustainability beyond immediate agricultural needs, including environmental stewardship and long-term community resilience.

The diversity of pathways across the workshops reflects how farmers perceive building climate-resilient agricultural systems across the landscape in the Western Cape. However, a synthesis and analysis of Atlas ti results reflect some interesting common threads across the sites.

6.4 Horizon 1: Challenges

In small group conversations, participants pointed out many elements that demonstrated why they thought the existing system would not work in the future. They identified significant challenges in areas such as water infrastructure, where issues like leaking dams and poorly maintained irrigation systems were prevalent. Water access was another major concern, with many participants noting disparities in availability and the impact of seasonal changes on water supply. Additionally, funding was seen as inadequate and poorly managed, leaving many smallholder farmers without the necessary financial support. Climate change was also recognised as a critical issue, with participants observing increasingly unpredictable weather patterns that threaten crop and livestock production. Land ownership emerged as a significant challenge, with many participants feeling that the lack of secure land tenure hindered their ability to invest in and develop their farming operations effectively.

6.4.1 Water infrastructure

The most prominent theme across the six workshops was the lack of or poorly maintained water infrastructure. There were general issues with water infrastructure. For instance, dams were reported to be not in satisfactory condition and leaking, leading to significant water loss. There were further infrastructure issues, such as leaking water pipes, due to poor maintenance and a lack of irrigation infrastructure. One participant said:

> *"Due to the leaking dam, we repeatedly pump water, and this is very expensive. We will plan to fix the dam to save us a lot of money."* (SBreOD1)

Another participant supported this:

> *"Our main challenge is the leaking reservoir, and all the water is running away. The pipeline for the gardens is also broken."* (SGenOD4)

Several groups mentioned the need for tunnelling for crop farmers to sustain their cropping. However, they wished to get funding for the tunnels. Additionally, most smallholder farmers pump water from the river, including pumps, piping, and irrigation equipment. Most participants reported that this is what most smallholder farmers needed farmers but lacked.

Some farmers mentioned issues related to catchment areas, specifying that in places such as Genadendal, they only had two catchment areas, and their water ran out. The participants also reported previous discussions on building dams in their respective regions to impound flowing water. Their challenge was implementation, which would help maintain water levels in the dams in the summer.

Participants, especially in Goedverwacht, had a challenge with the municipally built weir, which was not working. The municipal weir built for houses did not work, and it was overflowing, although the one built by the smallholder farmers was working perfectly and running. Some farmers had backyard gardens, and the lack of running water affected their production. The farmers identified public consultation and the municipal unwillingness to learn from the farmers as the major challenge. One participant said:

"You cannot teach them something and they are not learning from us who stay here. If they go to the vlei, they will tell you that you cannot build a weir in this river like that. They will tell you that the weir is built wrong." (SGoedWD4)

6.4.2 Water access

A common view amongst workshop participants was access to water, especially from the municipality. Whereas some participants said they received water for their gardens, some who used it for agricultural purposes felt they were excluded. Additionally, several participants attributed the reduced water availability for crops to big trees that extract water. Some lacked water storage facilities. One participant attributed this to excessive heat.

"We do pump water now not in summer because there is a runoff. In summer is very limited you can't pump because the rivers must have water. It becomes dry when it's hot because in summer it becomes hot. Most of the water evaporates. Now that we are using more water you found that from February to March, the heat is causing us a problem. You can see the dam drastically going down." (SBarrOD7)

Due to the summer heat, several participants indicated that the water levels dropped to a level where they could not even irrigate their farms. Thus, they wished to have catchment areas to impound water. Although ten years ago, there was a discussion on a piping system from a dam in Genadendal, which would connect an irrigation system to their area for crops and livestock, nothing materialised. A small number of workshop participants indicated that they lacked household water. Household water is important for backyard gardens in Goedverwacht and Barrydale. There were suggestions that domestic water affects everyone, but they have water for one hour a day.

6.4.3 Funding

The participants lamented the lack of oversight on funding in the agriculture sector, as most smallholder farmers could not access the same. The participants were particularly critical of some undeserving people who got funding on the pretext of having eight or nine hectares of land. Yet, they do not even have half of a hectare, and there was a lack of oversight. Thus, the funds were wasted. Several participants suggested an oversight on funding agricultural water resources.

6.4.4 Climate change

The participants agreed with the statement that climate change was caused by changing weather patterns, as they did not get the usual rain. Sometimes, there is excessive rainfall, and since most smallholder farming areas are on slopes or beside rivers, they flood. Some smallholder farmers reported losing livestock and crops in those areas. In addition, the soil for crop farming was being washed away because of the excess of water. A hailstorm in 2023 damaged cornfields, pumpkins, and tomatoes in a short space of time. We used to have snow on the mountain once a year. This year (2024), farmers reported colder temperatures, which affect seedlings as they take far longer to grow when it is colder. Excessive summer temperatures, which record 39 to 45 ^{0}C destroy crops. This also affects livestock, as they need more excess water. Some participants questioned the wisdom of cutting down trees in the mountains. They argued that the mountains used to be covered with pine trees, but they were cut off, removing the buffer for the wind from these mountains. Since those trees were cut down, the wind has been causing damage, such as blowing roofs and houses.

6.4.5 Land ownership

A recurrent theme in the workshops was a sense amongst participants that land ownership was a major challenge. The participants felt that they could not properly develop the land without ownership. For example, in Goedverwacht, smallholder farmers indicated that they could do farrows to take the water, but the Moravian church, which owns the land forbade them. The participants reiterated that if they had land ownership, they would have solved the challenge of water abstraction. In Genadendal, the land is owned by the community but is in the trust of the Minister. Every household has access to a piece of land, but it is not their land. They have user rights tied to payment for water. However, there are no systems in place in the agriculture sector, so irregular payments and updates are made. In addition, if a farmer fails to use the land for three years, it is repossessed and given to someone else. In Barrydale, farmers are given 9-year, 11-month leases with no guarantee of renewal. In addition, participants were extremely dismissive of being allocated land without access to water.

Discussion

The challenges related to water infrastructure identified in this study resonate with findings from previous studies, which consistently show the inadequacies of water management systems in South Africa. Earlier studies, such as those by Enqvist and Ziervogel (2019), have highlighted the critical state of water infrastructure, noting that outdated and poorly maintained systems contribute significantly to water loss and inefficiency. This study further confirms these issues, with participants reporting leaking dams and broken pipelines as primary concerns. These findings suggest the need for infrastructure improvements, such as the construction of tunnels and new dams, and this aligns with past recommendations that call for urgent investment in water infrastructure to enhance water security and support agricultural productivity (Leal Filho et al., 2022). However, the current findings suggest that while these issues have been recognised for some time, there has been little progress in implementing the necessary solutions, pointing to a gap between policy recommendations and on-the-ground action.

In terms of water access, the experiences of smallholder farmers in this study echoed the broader literature on water scarcity and its impact on agriculture. Previous research, including studies by Ncube (2018), Talanow et al. (2021), Fanadzo et al. (2021), Magidi et al. (2021), and Pili and Ncube (2022) has documented the unequal distribution of water resources, with smallholder farmers often receiving less water than commercial farmers, exacerbating their vulnerability to climate variability. This study adds to this discourse by highlighting the specific issues faced by smallholder farmers, such as the limited availability of water for irrigation during the summer months and the challenges posed by extreme heat. The participants' concerns about the need for catchment areas and better water storage facilities are consistent with earlier calls for more adaptive water management strategies that can buffer the effects of seasonal water shortages (Calverley and Walther, 2022).

The findings on land ownership and its impact on agricultural development also find strong parallels in the existing literature. A study by Serote et al. (2023) argued that insecure land tenure is a significant barrier to sustainable agricultural practices in South Africa. The current study's participants voiced similar concerns, particularly in towns like Goedverwacht and Genadendal, where communal land ownership or short-term leases hinder long-term planning and investment in land improvements. Similar findings were reported by Ncube (2018) in Barrydale. This reflects the broader challenges of land reform and tenure security in South Africa, which scholars such as Lee and Gambiza (2022) have identified as critical for empowering smallholder farmers and enhancing their capacity to adapt to climate change. The study findings reinforce the notion that without secure land rights, smallholder farmers remain marginalised and unable to capitalise on agricultural opportunities fully. This theme has been prevalent in land reform discussions for decades.

6.4.6 Essential to keep

The participants believed that the existing system should keep several features. They suggested continuing house gardens and organic farming, which contributed significantly to local food production and sustainability. Additionally, they wanted to maintain existing government support, particularly in the form of equipment and resources provided by the Department of Agriculture. The participants also highlighted the value of their skills and manpower, noting that the knowledge passed down through generations and their technical expertise are crucial for their farming activities' ongoing success.

House gardens and organic farming

Participants generally believed that house gardening and organic farming were vital and should continue as they contribute significantly to local agriculture. One participant commented that:

> *"We have small household gardens allocated to small houses. We had a meeting with them to say that whatever crop we grow, the money must always stay in our community. Some of our farmers brought their vegetables to these spaza shops and sell. So that is the relationship we are having with these spaza shops instead of getting things from Cape Town, and other places."* (SCalOD7)

In Goedverwacht, participants argued for the continuation of organic farming. They reported that they made pipes with organic matter and planted a lot of trees on the river edges so that they suck excess water. They only did minimal tillage so that the subsoil was always intact.

Government support

The participants wished to see continued support from the Department of Agriculture, which is vital for ongoing success. There is a desire for continued support, especially with equipment. They got support from the Department of Agriculture, especially equipment such as pipes, household tanks and livestock feed. The participants also urged strengthening the Community Work Programme (CWP) group for community benefit, including children. Several participants expressed a desire for continued workshops from the Department of Agriculture to increase farming knowledge and share it with other farmers nationwide, enhancing food production.

Skills and manpower

Although some felt that land ownership was a challenge, others considered that smallholder farmers had access to land and manpower. One participant argued that:

> *"We have the knowledge passed from our grandfathers who have been farming these areas for years. We know how to do this. We have the technical know-how."* (SGoedWD9)

The participants wished to harness those skills and continue accessing land and water. Because the system is in place, then funding and training should increase. They reported that the Department of Agriculture recently trained the broader community. The farmers had technical knowledge of their area and knew exactly where to plant and graze their livestock.

Discussion

The findings on the importance of household gardens and organic farming align with previous literature that shows the important role of small-scale, sustainable agriculture in enhancing food security and community resilience. Scholars like Jouzi et al. (2017) have found the benefits of organic farming practices, particularly in resource-poor settings, where such methods can enhance soil fertility, conserve water, and reduce reliance on external inputs. The current findings buttress these ideas, with participants noting the economic and environmental benefits of keeping production local and practising minimal tillage. However, the specific mention of integrating organic matter into infrastructure, such as piping and the strategic planting of trees along riverbanks, provides a more localised and practical approach than is often detailed in the broader literature.

In contrast to some literature, which often critiques the adequacy and sustainability of government support in agricultural development, this study's participants expressed a strong desire for continued and even expanded government intervention. While studies like those by Mkgomo et al. (2022) have criticised the inefficacy and misallocation of government resources in supporting smallholder farmers, the current findings suggest that when properly managed, such support can be highly valued by the farming communities. The participants' appreciation for equipment provision, training programmes, and strengthening community-based initiatives highlights the potential of government intervention to make a positive impact. However, this contrasts with the more sceptical views found in the literature, which often focus on the failures and inconsistencies of government programmes (Ncube, 2020). The findings of this study suggest that with better oversight and alignment with community needs, government support can indeed be an essential component of a successful agricultural system.

The acknowledgement of skills and manpower as critical assets in smallholder farming reflects a common theme in the literature, which supports the importance of indigenous knowledge and local expertise in sustainable agriculture. Wheeler and Root-Bernstein (2020) documented the value of traditional knowledge systems in managing land and water resources, often arguing that such knowledge is as crucial as modern scientific approaches. The findings are consistent with this perspective, as participants indicated their inherited agricultural knowledge and deep understanding of local conditions. However, this study diverges in its findings on the need for additional funding and training to complement these existing skills. While traditional knowledge is invaluable, the participants acknowledged that without external support to modernise certain practices and enhance infrastructure, their ability to sustain and expand farming operations would be limited. This suggests a more integrative approach, blending traditional knowledge with modern agricultural support, which is not always fully explored in the literature.

6.5 Horizon 3: Seeds for the Future

A portion of the future-focused goals are already included in the current system. Insights of the seeds of the future they want were, therefore, already emerging. They expressed a strong desire to form and strengthen smallholder farmers' cooperatives and associations to improve collective access to resources and support. They also supported ongoing support projects, such as the provision of small tractors, livestock, and irrigation systems, which are crucial for the growth of their agricultural activities. The participants stressed the need for improved water drainage systems, seeing that proper drainage is essential to prevent waterlogging and enhance the efficiency of their farming practices.

These emerging elements represent the foundational steps toward achieving the future agricultural system they desire to build.

6.5.1 Smallholder farmers' cooperatives and associations

Some participants indicated that there were recently formed farmers' cooperatives and associations and suggested merging cooperatives to improve access to water resources. Since funding is challenging due to the lack of structures, participants reported recently setting up small-scale farming associations. As put by one participant:

> *"We are very young. We started about 3 months ago. I can get you the database of all the members. This is the constitution of the small-scale farmers. I can get you the names of all the members. There are about 95 members that belong to the association."* (SGenOD9)

There are, however, still lingering challenges to this setup, as another participant added:

> *"We had a cooperative, and the Department of Agriculture helped us to set that up. But it does not work anymore because the church came to take us back, and then we just left them."* (SGoedWD10)

6.5.2 Support projects

Participants indicated that they had recently received support from the government for small tractors and livestock (for example, bulls). The Regenerative Neighbourhood Development Agency (RNDA) and Expanded Public Works Programme (EPWP) projects were also ongoing, supporting farming and gardening initiatives. The irrigation projects were underway, with installation pending the arrival of qualified personnel to set up the pump systems.

6.5.3 Water drainage

To prevent waterlogging, farmers are installing were installing drainage systems. Some are planning to put some pipes to drain water. They argue that gardens will never flood if there is proper drainage. They have draining pipes that channel the underground water to the river. Some farmers reported recently installing sprayers and refraining from using flood irrigation.

Discussion

The emergence of smallholder farmers' cooperatives and associations as a vital component of future agricultural resilience is consistent with existing literature that reveals the importance of collective action among small-scale farmers. Previous studies, such as those by Ngalande (2022), have documented the benefits of cooperatives in enhancing access to resources, improving market linkages, and strengthening the bargaining power of smallholder farmers. The current findings align with this literature, showing how recently formed cooperatives and associations are beginning to organise and build a membership base, which is critical for long-term success. However, unlike the more established cooperatives discussed in previous studies, the cooperatives in this study are still in their infancy and face unique challenges, such as interference from external entities like the church. This suggests that while the foundational benefits of cooperatives are recognised, their sustainability and effectiveness may be contingent on overcoming localised challenges that are not always covered in broader studies.

The role of government support projects in bolstering smallholder farming initiatives is another area where the current findings echo with existing literature yet also reveal some contrasts. Ndhlovu et al. (2021) have pointed out the critical role of government intervention in providing resources and technical support to smallholder farmers, especially in the context of South Africa's land reform and rural development programmes. The current study confirms the positive impact of such support, with participants acknowledging the receipt of essential resources like small tractors, livestock, and ongoing projects like RNDA and CPWP. However, the contrast lies in the implementation phase, where the current findings indicate a dependence on external expertise to complete projects, such as the irrigation system, which is still pending due to the unavailability of qualified personnel. This suggests that while government support is crucial, its effectiveness is often hampered by delays and logistical challenges that need to be addressed to realise the full potential of these initiatives.

Adopting water drainage systems as a forward-looking solution to water management challenges represents continuity and innovation. The significance of effective water management in agriculture is well-documented, with studies by Zerssa et al. (2021) revealing the need for appropriate irrigation and drainage systems to combat issues like waterlogging and drought in smallholder farming. Our findings echo this need, with participants actively installing drainage systems and transitioning from flood irrigation to more controlled methods like sprayers and drip irrigation. However, the innovation here is the proactive approach taken by the farmers, who implement these solutions and plan for future infrastructure improvements. This self-initiated effort contrasts with the more reactive or externally driven solutions often discussed in the literature, indicating a shift towards greater autonomy and resilience among smallholder farmers in the study areas. This evolution suggests that while traditional challenges persist, these communities have a growing capacity to address them through local knowledge and innovation.

Desired Futures

Participants listed a wide variety of characteristics of desirable futures. They suggested establishing local area catchment councils to oversee water distribution and management, ensuring fair and efficient use of water resources. They also desired robust infrastructure provision and maintenance, such as expanding and repairing boreholes and improving irrigation systems to support sustainable farming practices. Access to markets was also identified as crucial, allowing smallholder farmers to sell their produce more effectively and secure better prices. The establishment of seed banks was seen as vital to preserving and promoting non-genetically modified seeds, ensuring that farmers have access to reliable and resilient crop varieties for future planting seasons.

Local Area Catchment Council

Regarding setting up community structures, participants wanted to see the establishment of a catchment council to oversee and improve water distribution to farmers. In water management, participants proposed a local catchment area council or committee. Some emphasised a catchment council, not a water committee, since the latter focuses on one water source. The catchment area council would do the necessary planning for winter and summer. If there is a catchment area council, they can build the farrows and channel the water from the mountain into the river.

Infrastructure provision and maintenance

Participants discussed a range of water infrastructure provisions and maintenance they desire in future. This includes expanding and repairing boreholes to ensure all farmers have access to water. They also desire the creation of a mechanisation centre to provide tractors and other equipment to farmers. They reiterated that they would like to see adequate tools for all farmers and the completion of irrigation projects. Some also wanted tarpaulins to cover the base of the dams to prevent leakages. One participant commented.

> *"We would love it if maybe we could get the tarpaulins. I can see those big guys putting a black sail inside the dam so the water cannot leak. If we had 200 cubic meters or 1090 cubic meters, there would never leak, but only evaporate If we can get this tarpaulin, according to our books, the capacity of the dam is 1090 cubic meters of which, if that water does not leak it can sustain us three years, but seemingly it cannot at this stage because the water leaks."* (SBreOD2)

A few participants suggested drip irrigation augmented by solar water pumps to force the water through and to put in more water servers. They could then fill up all the dams downstream.

Markets and seed bank

A common view amongst the participants was that they needed access to markets. They also desired a small-scale farmer seed bank because most seeds they access are genetically modified and cannot reproduce. They suggested that farmers be taught to build up a seed bank to have seeds that they could plant again. They also desired green energy from the wind and the sun to pump water to their plots.

Discussion

The desire for a Local Area Catchment Council as a governance structure for water management among smallholder farmers reflects a trend discussed in previous literature, particularly in regions facing similar water scarcity issues. Mugejo et al.'s (2022) study found the effectiveness of decentralized water governance structures in improving water distribution and addressing local needs in the Western Cape, South Africa. The study findings align with this literature, as participants advocated for a catchment council that goes beyond the scope of traditional water committees, stressing the importance of holistic, community-driven water management strategies. However, a contrast emerges in the specificity of the participants and vision, which includes planning for seasonal variations and the construction of irrigation channels (farrows). This level of detailed planning, which incorporates traditional knowledge and local environmental conditions, is less accentuated in broader studies that often focus on the overarching governance structures without delving into the specific infrastructural needs voiced by the participants in this study.

The focus on infrastructure provision and maintenance aligns with the extensive studies on the importance of reliable infrastructure for agricultural productivity in smallholder farming contexts. A previous study by Baldwin and Stwalley (2022) reveals the critical role of infrastructure — such as irrigation systems, boreholes, and mechanization — in enhancing the efficiency and sustainability of small-scale farming. The findings corroborate these studies, as participants expressed a clear need for improved infrastructure, including borehole repairs, mechanization centres, and irrigation completion. However, what sets these findings apart is practical, context-specific solutions, such as using tarpaulins to prevent dam leakages and adopting solar-powered water pumps for drip irrigation. These innovations reflect a growing appreciation among smallholder farmers of the need to adapt infrastructure to local conditions and resource availability, a nuance often underrepresented in broader infrastructure-focused studies.

The participants' suggestions on markets and establishing a seed bank parallel findings in prior literature on the importance of market access and seed sovereignty for smallholder farmers. Scholars like Kliem (2024) have argued for preserving local seed varieties and creating seed banks to support agroecological resilience and reduce dependence on genetically modified seeds. Our findings echo these concerns, with participants expressing a desire for a seed bank to preserve seeds that can be replanted, thereby ensuring the sustainability of their farming practices. The call for improved market access is consistent with studies highlighting smallholder farmers' challenges in accessing markets, which often limits their economic opportunities and overall agricultural productivity. However, our findings also introduce a forward-looking aspect, with participants advocating for green energy solutions, such as wind and solar power, to support these initiatives. This integration of market access, seed sovereignty, and renewable energy reflects an evolving understanding among smallholder farmers of the interconnectedness and nexus of these factors in achieving long-term sustainability and resilience in the face of climate change. This perspective is increasingly recognised but not always fully explored in earlier literature.

6.6 Horizon 2: Pathways to the desired future

The workshop participants also discussed pathways into the desired futures. They suggested official meetings to discuss and strategize the merging of various local organisations and address the ongoing land ownership issues. These meetings were crucial for fostering collaboration and ensuring that land reforms align with the needs of smallholder farmers. Securing government support was seen as essential for the success of these initiatives, with participants advocating for a comprehensive approach that involves multiple government departments, not just the Department of Agriculture. Education and training were also key components, particularly in equipping both current and future generations of farmers with the knowledge and skills necessary for sustainable farming practices and effective water management.

6.6.1 Official meetings pathway

In this pathway, the major issues included organising official meetings to identify processes for accelerating the merging of organisations within the community. The group, especially from Goedverwacht, felt they must return to the 1996 agreement that Nelson Mandela made with them. They would ask the national government to implement the Genadendal Accord of 1996 in the meetings. These developments may kick start a land reform process where the government pays the church's debt and asks the church to cede control of the land to the smallholder farmers. The merging of organisations within the community as a preliminary step adds a unique local dimension, suggesting that participants see community solidarity and organisation as foundational to achieving broader land reform goals.

6.6.2 Securing government support pathway

In this pathway, securing government support will be crucial in achieving the desired outcomes for farming activities. The group saw a change from a whole-government approach instead of relying only on the Department of Agriculture. This would also mean increased initiative by the communities to generate seeds and seedlings to complement government support. This represents a shift towards a more collaborative model of development, where farmers are not just recipients of aid but active participants in their agricultural and economic empowerment.

6.6.3 Education and training pathway

In this pathway, the participants envisioned training of a current and future generation of farmers. The group focused on change that started with youth involvement from the primary school level about the environment and water conservation. The participants also advocated for education on how to produce green energy. The participants' vision for a comprehensive educational pathway reflects an understanding of the need for a holistic approach to sustainability that prepares future generations to navigate the complex challenges of modern agriculture.

Discussion

The official meetings pathway, which involves organising formal meetings to address land issues and seek government support for land reform, mirrors themes in existing land reform literature that found the importance of structured negotiations and agreements. Research by Sihlangu and Odeku (2021) shows the necessity of formal mechanisms to address historical land injustices and facilitate equitable land distribution. The participants' focus on revisiting the 1996 Genadendal Accord reflects a commitment to resolving long-standing land issues through legal and political processes, aligning with the literature's emphasis on the need for comprehensive, legally backed reforms. However, the unique aspect of this study is the participants' desire to merge community organisations as a precursor to land reform. This community-driven approach suggests an additional layer of grassroots organisation and solidarity that is less frequently discussed in broader land reform discussions, which often concentrate on top-down government actions.

In securing the government support pathway, the participants' call for a whole-government approach to support smallholder farmers aligns with literature findings that advocate for integrated and multi-sectoral strategies for rural development. Research by Woodhill et al. (2022) has shown that relying solely on agricultural departments is insufficient for addressing the diverse needs of rural communities. The study findings expand on this by suggesting that smallholder farmers should actively generate seeds and seedlings, thus complementing governmental efforts. This proactive stance reflects a shift from viewing farmers as passive recipients of aid to recognising them as active contributors to their development. This echoes the findings by Ncube (2018) in Barrydale. However, this contrasts with older models in the literature that concentrated on a more dependent relationship between farmers and government support, signifying an evolving perspective that acknowledges the potential for community-driven initiatives to enhance agricultural sustainability.

The education and training pathway proposed by participants demonstrates the critical role of education in fostering sustainable agricultural practices, which is well-supported by existing literature (e.g. Ncube 2018 findings in Barrydale). A study by Reddy (2021) found the importance of integrating environmental education and agricultural training into early education to build future resilience. The participants' focus on involving youth from primary school and teaching about green energy aligns with this literature, reinforcing the idea that education is pivotal in achieving long-term sustainability. However, the specific emphasis on green energy production represents a forward-looking addition to the traditional education and training focus. This reflects a more recent trend in the literature that explores integrating renewable energy concepts into agricultural education, acknowledging the intersection of energy and agricultural sustainability in the context of climate change. The water-energy-food nexus has gained huge focus at all levels (local to national). The participants' vision thus supports established educational strategies and advances them by incorporating modern sustainability practices.

Implications for agricultural water management

The challenges identified in Horizon 1, the seeds of change emerging in Horizon 2, and the desired futures envisioned in Horizon 3 collectively inform a strategic approach to building climate-resilient pathways for smallholder farmers.

In Horizon 1, the primary challenges identified include inadequate water infrastructure, restricted access to water, lack of funding, climate change impacts, and land ownership issues. These challenges present significant barriers to sustainable agricultural production. The deteriorating state of dams, leaking water pipes, and insufficient irrigation infrastructure lead to substantial water loss and inefficiencies in water use, which are critical in a province that already experiences relative water scarcity. The limited access to water, worsened by poor infrastructure and inequitable distribution, hinders smallholder farmers' ability to maintain crop yields and sustain livestock, particularly during the hot and dry summer months. The lack of funding further aggravates these issues, as smallholder farmers struggle to invest in necessary infrastructure improvements or adopt innovative practices that could mitigate climate change impacts. The land ownership issues, particularly the inability to secure land rights, also stifle farmers' capacity to implement long-term water management strategies, as they lack the security needed to make significant investments in their land.

Horizon 2 reveals emerging strategies and innovations that could address these challenges. Forming smallholder farmers' cooperatives and associations represents a crucial step towards collective action and resource pooling, enabling farmers to better negotiate for water rights and funding. The recent support projects, such as the provision of small tractors and livestock, along with ongoing irrigation projects, illustrate the potential for targeted interventions to enhance agricultural productivity. Moreover, implementing water drainage systems and adopting more efficient irrigation methods, such as sprayers, reflect a growing awareness of the need to conserve water and optimize its use. These emerging practices indicate a shift towards more sustainable water management and agricultural production. Yet, they remain in their infancy and require further development and support to reach their full potential.

The desired futures articulated in Horizon 3 provide a roadmap for achieving long-term sustainability in water management and agricultural production. As proposed by participants, the establishment of local area catchment councils would create a formal structure for overseeing water distribution, ensuring that all farmers have equitable access to this vital resource. The suggestions on infrastructure provision and maintenance, including the repair and expansion of boreholes, the completion of irrigation projects, and the introduction of solar-powered water pumps, align with the need to modernise water infrastructure to support resilient agricultural systems. The participants' desire for access to markets and the creation of seed banks is vital in producing food locally and ensuring its economic viability and sustainability.

The comparison of pathways across different workshops reveals both commonalities and local-specific approaches. This suggests that while certain strategies, such as securing government support, are universally necessary, the specific interventions must be tailored to the unique needs of each community. The cross-cutting theme of government support demonstrates the critical role that public institutions play in enabling smallholder farmers to overcome systemic challenges. The suggestions on community-driven initiatives, such as creating cooperatives, local water management structures, and seed banks, point to the importance of empowering local actors to take charge of their development. Combining top-down support with bottom-up initiatives could be key to achieving sustainable water management and agricultural production in South Africa.

6.7 Conclusions

The section sought to find the critical challenges and potential pathways for water management and agricultural production among smallholder farmers in two districts in the Western Cape, using the Three Horizons framework. The findings reveal that smallholder farmers face significant challenges, including inadequate water infrastructure, restricted access to water, insufficient funding, and the impacts of climate change, all of which hinder agricultural productivity and long-term sustainability. These challenges are intensified by issues related to land ownership, which further complicate efforts to implement effective water management strategies. However, the study also identifies emerging innovations and strategies that offer hope for the future. The formation of farmers' cooperatives, government support projects, and the adoption of more efficient irrigation methods are positive steps toward addressing water scarcity and improving agricultural productivity. These emerging practices, however, are still in their early stages and require further development and support to realise their full potential. The desired futures envisioned by the participants provide a roadmap for sustainable water management and agricultural production. Establishing local area catchment councils, investing in infrastructure maintenance, and creating seed banks and access to markets are crucial steps toward building a resilient agricultural sector. The study advocates for a dual approach, combining top-down government support with bottom-up community-driven initiatives, to achieve long-term sustainability.

7. CONCLUSION AND RECOMMENDATIONS

7.1 Proposed Policy Changes

7.1.1 Strengthening water governance and institutional capacity

Effective water governance is critical for equitable access to water resources, yet challenges such as incoherent policies, lack of accountability, and inadequate capacity hinder progress. The South African government should prioritise streamlining water governance policies to address these issues and reduce bureaucratic delays in processes such as water use licensing. Establishing a centralised digital system for water use applications and verification could enhance transparency and efficiency. Capacity building within Catchment Management Agencies (CMAs) and Water User Associations (WUAs) is also essential. The government must invest in training programmes to equip these institutions with the technical and managerial expertise necessary to support smallholder farmers. Special emphasis should be placed on gender and racial inclusivity to ensure all stakeholders have a voice in water-related decision-making processes. Formalising partnerships with non-governmental organisations and private sector entities could provide technical and financial support to strengthen governance structures.

7.1.2 Investing in agricultural water infrastructure

The government should allocate targeted funding for the refurbishment and modernisation of critical infrastructure smallholder farmer irrigation systems, reservoirs, and distribution networks. Introducing public-private partnerships (PPPs) could mobilise additional financial resources while ensuring efficient implementation and maintenance of these systems. A dedicated maintenance fund for smallholder farmer infrastructure should be established, supported by annual government budgets and contributions from development agencies. This fund would ensure ongoing upkeep and minimise water losses due to leakages. Policies should also encourage the use of water-efficient technologies, such as drip irrigation and rainwater harvesting, by providing subsidies or tax incentives to farmers who adopt these methods. A national inventory of agricultural water infrastructure should be developed to identify priority areas for intervention.

7.1.3 Promoting climate-resilient farming practices

Given the impacts of climate change on water availability, policies must focus on fostering resilience among smallholder farmers. Programmes to disseminate climate-smart agricultural practices, such as crop diversification, conservation agriculture, and the use of drought-resistant seeds, should be expanded. These efforts can be supported through partnerships with research institutions and agricultural extension services. Establishing seed banks to preserve and distribute drought-tolerant varieties is another critical step. Financial incentives and grants should be made available to smallholder farmers who adopt climate-adaptive practices, reducing their vulnerability to extreme weather events. Additionally, local government bodies must create contingency plans to support farmers during droughts, including subsidies for alternative water sources and emergency relief programmes.

7.1.4 Enhancing farmer participation and equity

Smallholder farmers often face systemic inequalities in water access compared to commercial farmers. Policies must prioritise equitable water allocation by revising water-use policies to address historical disparities. Local area catchment councils should be established to provide a platform for farmers to participate in water resource management and decision-making. These councils should be supported by clear mandates, adequate funding, and legal authority to resolve disputes and oversee equitable distribution. Gender-sensitive approaches should be integrated into water management policies to empower women farmers and ensure their active participation. Innovative financing models such as cooperative financing schemes or microloans tailored to smallholder farmers should be promoted to address funding disparities.

7.1.5 Fostering collaboration and innovation

Collaboration between government agencies, development partners, and farmers may address water resource management challenges. Policies should promote multi-stakeholder initiatives to mobilise resources, share knowledge, and scale up successful pilot projects. Support for farmer cooperatives and collective action should be formalised, enabling farmers to pool resources, share infrastructure, and access markets more effectively. Encouraging the private sector to invest in agricultural water infrastructure through tax benefits and subsidies can also drive innovation. Lastly, a dual approach combining top-down policy frameworks with bottom-up community-driven initiatives will ensure solutions are both scalable and locally relevant, paving the way for a resilient and sustainable agricultural sector in South Africa.

7.2 Recommendations for future research

Future research should prioritise exploring innovative and sustainable solutions to address the multifaceted challenges of water resource management for smallholder farmers in the Western Cape. There is a need for studies focused on the integration of advanced technologies, such as remote sensing, GIS-based water monitoring, and smart irrigation systems, to improve water use efficiency and resource allocation. These technologies could provide data-driven insights into water availability, consumption patterns, and the impacts of climate change. Additionally, research should investigate the socio-economic barriers hindering smallholder farmers' access to these technologies, including cost, technical know-how, and infrastructure requirements.

Another critical area for research is the role of community-based approaches and local knowledge in promoting water governance and climate adaptation. Understanding how traditional practices can be blended with modern techniques to enhance resilience could provide valuable insights for policy development. Research should also explore the effectiveness of institutional frameworks, such as Catchment Management Agencies (CMAs) and Water User Associations (WUAs), in facilitating equitable water access. Specifically, studies could assess how governance structures can be reformed to ensure transparency, inclusivity, and accountability, with a focus on addressing gender and racial inequalities. Moreover, comparative studies are needed to analyse water governance models in other regions or countries to identify best practices that could be adapted to the South African context.

Future research should explore how peace engineering principles can be integrated into water resource management and agricultural practices for smallholder farmers in South Africa. This interdisciplinary approach could address technical and environmental challenges and the socio-political dimensions of water governance. Studies may explore how conflict-sensitive design and implementation of water infrastructure can reduce tensions among water users, particularly in areas where resource competition coincides with climate change effects. Research should also assess how participatory approaches — such as stakeholder dialogue, mediation, and consensus-building — can foster cooperative water management frameworks that prioritise inclusivity and equity.

Finally, financial models for supporting smallholder farmers should be an important focus area. Investigating innovative funding mechanisms, such as microfinance, blended financing, and public-private partnerships, could provide sustainable infrastructure maintenance and modernisation solutions. Research on cooperative-based funding systems, where farmers collectively manage and maintain water infrastructure, may yield promising results. These studies should aim to bridge the gap between theoretical frameworks and practical, implementable strategies, contributing to a resilient and sustainable future for smallholder farmers in South Africa.

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9. APPENDICES

Appendix A: Focus Group Discussion Guide

WATER RESEARCH COMMISSION PROJECT: C2022/2023-00845

Water governance, institutions, and infrastructure integration for climate-resilient pathways for smallholder farming systems in the Western Cape, South Africa

Focus Group Discussion Guide for Smallholder Farmers

1. Introduction

a. Welcome

b. Introductions

c. Overview of the Focus Group Discussion

d. Permission – Consent form, photographs, recording

2. Questions

Climate change

a. How did changing rainfall and temperature patterns affect water availability in this area? When?

b. How did the changes in rainfall and temperature affect your crop yields and livestock production?

Drought Impacts

a. How did the mentioned drought affect your income and means of livelihood?

Water Management

a. What measures have you put in place to respond to water shortages? Crop, livestock, mixed?

b. What support did you receive to managing (coping) water shortages during drought?

c. What measures have you put in place for future droughts (adaptation)?

Water governance

a. What organisations do you work with in managing water?

b. What is your involvement in decision-making in these organisations?

c. What measures do you think should be put in place to deal with the impacts of water shortages?

Appendix B: Smallholder Farmer Questionnaire

Water Research Commission Project: C2022/2023-00845

Water governance, institutions, and infrastructure integration for climate-resilient pathways for smallholder farming systems in the Western Cape, South Africa

QUESTIONNAIRE FOR FARMERS

Questionnaire Number______________________________ Date_______________________

FARMER DETAILS

RESPONDENT NAME	
DISTRICT NAME	
TOWN NAME	
INTERVIEWER	

SECTION A: HOUSEHOLD DEMOGRAPHICS AND FARMING PRACTICES

A.1 Please complete the table below

1	Position in the household (*e.g., father*)	
2	Age (in years)	
3	Gender	
4	Household size	
5	Level of education (*Specify, e.g., Grade 4*)	
6	Source of income (*Specify, e.g., social grant*)	

A.2 How many years have you been involved in farming? ……………………………………………………………………………………………………..

A.3 What is the size of the farming land for your household? …………………………………………………………………………………………………….

A.4 Indicate your means of land ownership

[ ] Allocated [ ] Inherited [ ] Bought [ ] Borrowed [ ] Other (specify) ………………………………

A.5 Do you have a lease agreement on the land that you use for farming? [ ] Yes [ ] No

If yes, how long is your lease agreement in years? ……………………………………………………………………………………………..

A.6 Is your land enough for your farming activities? [ ] Yes [ ] No

A.7 Are you farming as a group or individual? ………

A.8 What type of farming are you practising?

Crops:

………
……………………………………………

Livestock:

………
…………………………………………….

A.9 What do you do with the farming products that you produce from your farming?

[ ] Mainly for sell [ ] Mainly for family consumption

[ ] Mainly for family consumption and sell excess [ ] Other (please specify): ……………………….....................

A.10 If you are selling your farm produce, how much money do you make from farming per year? ………………………………………………………..

A.11 Do you have access to any credit providers? [ ] Yes [ ] No

A.12 If yes in **A.11**, which of the following organisations provide credit to you? (Select all that apply)

Co-operative		Land Bank	
Commercial Bank		Other (Please specify)	

SECTION B: AGRICULTURAL WATER RESOURCES

B.1 What sources of water do you use for farming?

…….

B.2 Do you have a water use license or water use rights? [ ] Yes [ ] No

If **No**, please explain

……

…….

B.3 Do you pay any fees for using water for farming?

[ ] Yes [ ] No

B.4 If yes in **B.3**, how much do you pay for water use annually? ………………………………………………………………………………………………..

B.5 If yes in **B.3**, are you able to pay for the water that you need for your farming? [ ] Yes [ ] No

B.6 Have you ever experienced water shortages for farming from your sources in the past 20 years? [ ] Yes [ ] No

If yes, please explain

……

……

SECTION C: AGRICULTURAL WATER INFRASTRUCTURE

C.1 What kind of infrastructure do you use to transport water from the sources to your farm?

[ ] Lined canals [ ] Unlined canals [ ] Pipes

[ ] Other, specify: ………………………………………………………………………………………

C.2 How is water pumped from the source to your farm? [ ] Gravity [ ] Electric pump [ ] Diesel pump

[ ] Petrol Pump [ ] Other, specify ……………………………………………………………………………………………………….

C.3 Do you have water storage facilities on your farm? [ ] Yes [ ] No

If yes, please list those facilities

……

……….

C.4 Are the water infrastructures you mentioned in **C.3** able to store and supply enough water for your farming?

[ ] Yes [ ] No

If not, please explain

……

……

C.5 According to your knowledge, how old (years) are the water infrastructures you listed in **C.3**?

……

……

C.6 How often is the maintenance of the water infrastructures you mentioned in **C.3** being carried out?

……….

C.7 Is your water infrastructure fitted with water measuring devices (e.g., water meter)?

[ ] Yes [ ] No

C.8 If no, how do you measure the amount of water use in your farm?

……
…………………………………………….

C.9 Are there any observed leakages in your water infrastructure? [ ] Yes [ ] No

C.10 Who does the maintenance of water infrastructure?

……
…………………………………………….

C.11 How long does it take for the maintenance of water infrastructure to be attended to?

……
…………………………………………

SECTION D: WATER MANAGEMENT AND GOVERNANCE

D.1 Do you know the organisation(s) responsible for managing and allocating water to your farm? [ ] Yes [ ] No

D.2 If yes in **D.1**, please list the names of those organisations

……
……………………………………………

……
…………………………………………….

D.3 List the other roles and responsibilities of the organisations you have listed in **D.2**?

……
……………………………………………

……
……………………………………………

D.4 What challenges do you face in working with the organisations in D2?

……
……………………………………………

……
…………………………………………….

D.5 What is your role in water management?

……
……………………………………………

……
…………………………………………….

D.6 Are there any illegal water users in the area? [ ] Yes [ ] No

D.7 If yes in **D.6**, please explain what actions are taken to resolve the challenges of illegal water use or connections?

……
……………………………………………

D.8 Have there been conflicts in water sharing among farmers? [ ] Yes
[ ] No

D.9 If yes in **D.8,** please explain

……
……………………………………………

……
…………………………………………….

D.10 If yes in **D.8**, how are the conflicts are resolved?

……
…………………………………………….

D.11 Do you receive any training in water-related issues such as water conservation and application for a water use license?

[ ] Yes [ ] No

D.12 If no in **D.11**, please explain why

……
……………………………………………

D.13 Are you directly involved in decision-making relating to water use for your farming [ ] Yes
[ ] No

D.14 If no in **D.13**, please explain

……

……

SECTION E: CLIMATE CHANGE AND DROUGHT

E.1 What is your understanding of climate change and drought?

……

……

E.2 What do you think are the causes of climate change?

……

E.3 Where do you get the information about climate change in your area? (Select all that apply)

Farmers Union		Family/friends	
Radio		Social media	
Newspaper		Extension services	
TV		Internet	
Workers		Other	

E.4 What changes in temperature and rainfall did you observe in the past 20 years? (Select all that apply)

The temperature has Increased		Increased rainfall	
The temperature has decreased		Decreased rainfall	
No change in temperature		No change in rainfall	
Not aware		Not aware	

E.5 What extreme weather events have you experienced in the past 20 years? (Select all that apply)

Droughts	
Floods	
Heatwaves	
Forest fires	
Storms	
Other please explain	

E.6 What were the effects of extreme weather events you have selected in **E.5** on crops, livestock, and water for agriculture?

Crops:

……

……

Livestock:

……

…….

Water for agriculture:

……

…….

E.7 What measures have you taken to reduce the effects of extreme weather events you have selected in **E.5**?

………

………

E.8 Did you get any support from the government or other organisations to reduce the effects of extreme weather events you have selected in **E.5**? [ ] Yes [ ] No

E.9 If yes in **E.8**, please explain

………

……….

E.10 How did you cope with the extreme weather event you have selected in **E.5**?

………

……….

E.11 What challenges did you face in coping with the effects of extreme weather events you have selected in **E.5**?

………

………

E.12 What strategies are you most likely to employ to respond to the effects of extreme weather events in future?

……
……………………………………………

……
……………………………………………

E.13 Is there anything else you would like to add?

……
……………………………………………

Thank you for your time!

Appendix C: Key informant Questionnaire

Water Research Commission Project: C2022/2023-00845

Water governance, institutions, and infrastructure integration for climate-resilient pathways for smallholder farming systems in the Western Cape, South Africa

QUESTIONNAIRE FOR KEY INFORMANTS

Questionnaire Number_____________________________ **Date**_______________________

RESPONDENT INFORMATION

Name of institution/organisation	Profession	Age range	Years of experience

SECTION A: AGRICULTURAL WATER RESOURCES

A.1 What sources of water do smallholder farmers use for farming?

A.2 Do smallholder farmers have water use licenses or water use rights? Please explain

A.3 How much water is allocated for each farmer from the sources on **A1**?

A.4 Do smallholder farmers pay any fees for using the water for farming? [ ] **Yes** [ ] **No**

If **yes**, how much do they pay annually?

A.5 What support do you give to those smallholder farmers who are not able to pay water use fees?

SECTION B: AGRICULTURAL WATER INFRASTRUCTURE

B.1 What kind of infrastructure do smallholder farmers use to transport water from the sources to their plots?

B.2 According to your knowledge, how old (years) are the water infrastructures you listed in **B.1**?

B.3 Do you think the water storage and supply infrastructures of smallholder farmers are enough for their farming activities?

[ ] **Yes** [ ] **No** Please explain

B.4 Is the water infrastructure you listed in **B.1** fitted with water measuring devices (e.g. water meter)? [ ] **Yes** [ ] **No**

If **No**, how is the water usage for smallholder farmers measured?

B.5 Are you involved in the maintenance of the water infrastructure you listed in **B.1?** [ ] **Yes** [ ] **No**

If **yes**, how often do you carry out the maintenance work?

SECTION C: WATER MANAGEMENT AND GOVERNANCE

C.1 What are your roles and responsibilities in relation to the governance and management of agricultural water for smallholder farmers?

C.2 What are the challenges you are experiencing in terms of governance and management of agricultural water for smallholder farmers?

C.3 What measures are you taking in trying to solve the challenges you have stated in **C.2**?

C.4 What other organisations do you work with in the governance and management of agricultural water for smallholder farmers?

C.5 What challenges do you experience in working with the organisations you listed in **C.4**?

SECTION D: CLIMATE CHANGE AND DROUGHT

D.1 What climate-related disasters have been experienced in your area in the past 20 years?

D.2 How do you communicate information about climate-related disasters to smallholder farmers?

D.3 What were the effects of those climate-related disasters on water resources?

D.4 How did the impacts of climate-related disasters on water resources affect smallholder farmers?

D.5 What measures have you taken to help smallholder farmers to cope with the impacts of climate-related disasters?

D.6 What challenges did you face in trying to reduce the impacts of climate-related disasters on smallholder farmers?

D.7 What strategies are you most likely to employ in reducing the impacts of climate-related disasters on smallholder farmers in the future?

D.8 What can researchers do to assist in reducing the impacts of climate-related disasters?

Appendix D: Workshop Guide - Three Horizons Framework

Materials

- Multiple overlapping flipchart sheets on the wall
- Permanent markers to draw the 3H graphic
- Multi-coloured sticky notes
- Pre-printed change deck cards

Tasks	Time	Questions	Activities
Introductions	15 minutes		The workshop begins with the introduction of the Three Horizons framework, describing the horizons
H1	20-30 minutes	**What is the current situation in water resource management and agricultural production?** • What are the challenges to access to agricultural water? • How have changes to water availability over the past few years affected your farming practices? • What barriers are you facing in adopting new water-saving technologies or practices? • What are the main challenges you are facing in maintaining and upgrading water infrastructure? • What challenges do you face in implementing and enforcing current water management practices?	15 minutes brainstorming in pairs, jotting each item down on separate yellow sticky notes; facilitators help participants add sticky notes to the mural 15 minutes of clustering, discussing, and filling in the blanks.
	20-30 minutes	**What is essential to keep about the current system?** • What current farming practices do you find most effective in managing water resources and maintaining agricultural production? • What are the community practices or cooperatives that have been particularly successful? • What are the tools or technologies that have significantly improved your adaptation to climate? • Which parts of the current water infrastructure are functioning well and should	15 minutes brainstorming in pairs, jotting each item down on separate yellow sticky notes; facilitators help participants add sticky notes to the mural 15 minutes of clustering, discussing, and filling in the blanks.

		be preserved or built upon? • What existing policies or regulations have been successful in managing water resources sustainably? • What mechanisms for stakeholder engagement and participation have worked well in the current system?	
H3	30 minutes 45 minutes	**What are the seeds of the future we want that exist now?** • What are the recent changes in your farming practices that have yielded positive results? • What are the community-based initiatives or collaborative projects that have successfully addressed water management or agricultural challenges? • What current programmes aimed at improving water resource management have been particularly successful? • What new technologies or systems are being piloted for water management, and what early results are you seeing? • What funding or support programmes have effectively promoted sustainable water management practices? **What are the characteristics of the future system that we want?** • What are the key characteristics of the technologies that will shape the future of water management and agriculture? • What should the future water infrastructure look like to be resilient to climate impacts? • What governance structures are needed to support integrated and adaptive water management? • What strategic planning processes are necessary to ensure the long-term resilience of water resources and agriculture? • What are the core values and goals that should guide the development of the future system for water management and agriculture? • How can the future system be designed to be adaptable and resilient to changing climatic conditions? How can smallholder farming	15 minutes brainstorming in pairs, jotting each item down on separate blue sticky notes; facilitators help participants add sticky notes to the mural 15 minutes to review all the changes posted on the 3rd horizon and discuss 15 minutes brainstorming in pairs, jotting each item down on separate blue sticky notes; facilitators help participants add sticky notes to the mural 15 minutes reviewing the change deck cards, clustering, and posting on the 3rd Horizon – Deck card describe various trends and emerging issues, since there may be fewer suggestions from participants about these issues. The facilitators should spread the change cards out on a work table, and ask the pairs to review the cards, cluster them into related changes if they like, and choose what they feel are the most significant to post to the 3rd horizon on the wall poster 15 minutes to review all the changes posted on the 3rd horizon and discuss

		communities actively shape and implement the future system?	
H2	45 minutes	**What are the ideas that are going to disrupt the existing patterns and create an opportunity for a different future?** • What regulatory changes may disrupt existing patterns and encourage more sustainable practices? • What are the most promising innovations or ideas that could disrupt the current system and create opportunities for a different future? • How can local communities and stakeholders be involved in developing and implementing these disruptive ideas?	Pairs should join at a table to create a working group of 4-6 people. Review the assumptions on Horizon One and the emerging issues on Horizon Three. Choose two or three emerging changes that could be used to create an opportunity for a different future. Each group use emerging changes to create an interesting transition idea for the smallholder farming water sector that helps successfully bridge from Horizon One to Horizon Three.
Debriefing	15 minutes	**What have we learned?** • What changes and innovations hold the most promise?	In plenary, participants discuss key highlights from the exercise

Appendix E: Consent Form

Water Research Commission Project: C2022/2023-00845

Water governance, institutions, and infrastructure integration for climate-resilient pathways for smallholder farming systems in the Western Cape, South Africa

Consent Form

Interview/Focus Group Number…………………… Date…………………………….

This is to confirm that you agree to participate in a focus group discussion/interview concerning the project, Water governance, institutions, and infrastructure integration for climate-resilient pathways for smallholder farming systems in the Western Cape, South Africa. You confirm that you understand the project objectives as explained by the researchers.

Please be assured that the information you provide will only be used for research purposes. Your name will not be included in any report, and all the information will be treated with confidentiality. The discussion may require about 45 minutes of your time. Please be advised that to allow the researchers to capture what you say during this discussion and to give quality time to follow the discussion, a recording device may be used, with your permission. If there is any information that you are not comfortable providing during the discussion, you are free to remain silent. If, at any point, you feel that you no longer want to continue with the discussion, you may excuse yourself.

If agreeable, please sign in the space below.

Yours sincerely

Prof Bongani Ncube

Email: ncubeb@cput.ac.za, Tel: 021 959 6111

I willingly give my consent to participate in the interview/focus group discussion.

Name: ______________________________ Signature: ______________________________

Date: ______________________________

Appendix F: Capacity Building

1. Individual Capacity

The project has fostered significant individual capacity development among its team members, comprising experienced researchers and graduate students whose contributions have strengthened the project's overall impact. The Principal Investigator, Prof. Bongani Ncube has provided critical leadership and oversight for the project. As a seasoned researcher in agricultural water management and climate adaptation, her expertise has guided the team in achieving its objectives while fostering an environment conducive to academic and practical growth.

Dr Evans Shoko joined the project as a Postdoctoral Research Fellow, bringing a robust background in conflict-sensitive water governance and qualitative data analysis. Dr Shoko's involvement has enhanced the project's interdisciplinary approach, bridging technical water management strategies with governance frameworks.

The project has also provided a platform for graduate students to conduct research directly feeding into its broader goals. PhD candidate Kudzai Mugejo and master's students Aphiwe Manyiki and Pitso Mashile have been assisting in the project. Through their participation, the students have gained valuable skills in data collection, and participatory research contributing to both the project and their professional development.

2. Organisational Capacity

The project has significantly bolstered the capacity of the Centre for Water and Sanitation Research (CWSR). The CWSR has expanded its expertise in agricultural water management and climate adaptation, establishing itself as a leading hub for interdisciplinary research. The inclusion of new thematic areas, such as water infrastructure performance and governance, reflects a strategic effort to address pressing issues in water resource management under climate variability. The project has fostered collaborations with academic institutions, government agencies, and local stakeholders. These partnerships have enhanced the CWSR's ability to mobilise resources and share insights across various sectors. The project has also strengthened institutional linkages, creating opportunities for future research initiatives and capacity-building efforts. The CWSR has established itself as a key contributor to policy dialogues on water governance and agricultural resilience. The involvement of postdoctoral and graduate researchers has further enriched the Centre's knowledge base, ensuring sustainability and continuity in its research endeavours.

3. Community Development

The project has had a profound impact on the local farming communities in the Western Cape. Fieldwork and farmer engagements have provided a platform for smallholder farmers to voice their concerns while benefiting from the project's insights. The research conducted by graduate students has directly addressed issues faced by specific communities, such as the Goedverwacht historical settlement and the Overberg District Municipality. These studies provide actionable recommendations for improving water access, infrastructure efficiency, and agricultural productivity. The project's findings on the impacts of climate change have informed strategies for smallholder farmers to adapt to drought and variability. The project has laid the groundwork for community-driven initiatives that enhance agricultural sustainability and resilience.

Appendix G: Archiving of Data

Centre for Water and Sanitation Research

Cape Peninsula University of Technology

Bellville Campus, Symphony Way

PO Box 1906, Bellville 7535

Cape Town

South Africa

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The Centre for Water and Sanitation Research has a system of archiving project data that sits in a central server within the centre. All the field reports and project deliverables are filed in this system, with a back-up in a hard drive. Hard copies of all the questionnaires are locked up in a safe.

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The university has a records and archives department that keeps all university information and records. When the project is finalised all the deliverables and the final report will be sent to the department for archiving. Published reports and journal papers will be sent to the library for public access. Some of the reports will also be made available via the university website. Data from the theses and projects will be deposited in the CPUT repository, eSango for public access (https://esango.cput.ac.za/). Project communication is currently in a separate folder in the principal researcher's mailbox. The university periodically archives all emails within the university email system.

Water Research Commission

The Water Research Commission has its system of archiving all the reports submitted under projects. All deliverables are currently downloadable via the fund management system. In addition, the final report will be published in hard copy form as well as in electronic form for public access via the Knowledge Hub. Web address: http://www.wrc.org.za/