INFRASTRUCTURE PERFORMANCE AND IRRIGATION WATER GOVERNANCE IN GENADENDAL, WESTERN CAPE, SOUTH AFRICA

by

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DECLARATION

I, Kudzai Mugejo, student number 216041686, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

14 September 2022

Signed **Date**

ABSTRACT

Genadendal is a small historic town situated in the Theewaterskloof Municipality within the Overberg District of the Western Cape, South Africa. Water resources in and around the town were identified as a critical concern requiring urgent attention as a result of the recent 2015-2018 drought that occurred in the Western Cape Province. The town is a product of historic imbalances in terms of access to resources, including water for agriculture. This study assessed the performance of water infrastructure and water governance systems as well as the availability of water from the current water sources. Performance of the infrastructure and water governance were both assessed based on the perceptions of smallholder farmers and key informants. A focus group discussion was conducted with 15 smallholder farmers and key informant interviews were conducted with eight officials from the Department of Water and Sanitation, the Western Cape Department of Agriculture and the Breede-Gouritz Catchment Management Agency. A questionnaire was also administered to eight smallholder farmers. Hydrologic data were acquired from the Agricultural Research Council and the Department of Water and Sanitation and graphical analysis was used to analyse the data. Qualitative data from farmers and key informants were analysed using thematic content analysis. The study found that there were adequate water resources for most of the smallholder farmers, especially the ones who relied on water extracted from the mountain streams. Their sources held sufficient water even during the 2015–2018 drought period that occurred in the Western Cape Province. On the other hand, the study revealed that the water resources for smallholder farmers who depended on the Riviersonderend river were severely affected during the 2015–2018 drought period. Both livestock and crop production of these farmers were affected by water shortages. The study concludes that poor water governance systems are the main factor contributing to water insecurity challenges for most smallholder farmers. The lack of funding and accountability of responsible institutions has led to the dysfunctionality of irrigation water infrastructure. This was compounded by the lack of participation of farmers in the maintenance activities of irrigation water infrastructure. The study recommends funding for the operation and maintenance of infrastructure to be made available within the institutions that are responsible for the governance of water resources for smallholder farmers. Instead of being fully dependent on government institutions for infrastructure maintenance, smallholder farmers should be supported with training skills. Further studies are recommended to quantify the amount of water that is being lost as a result of the poor performance of water infrastructure.

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DEDICATION

This thesis is dedicated to my wife, Tinashe and son, Tinotenda.

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ABBREVIATIONS AND ACRONYMS

ARC	Agricultural Research Council
BGCMA	Breede-Gouritz Catchment Management Agency
CMA	Catchment Management Agency
CPR	Common-pool resource
DoA	Department of Agriculture
DRDLR	Department of Rural Development and Land Reform
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
FAO	Food and Agriculture Organisation
GFA	Genadendal Farmers Association
GTC	Genadendal Transformation Committee
Ha	Hectare
HDI	Historically Disadvantaged Individual
IB	Irrigation Board
IFAP	International Federation of Agricultural Producers
IWRM	Integrated Water Resources Management
MCM	Million Cubic Metres
NEPAD	New Partnership for Africa Development
OECD	Organisation for Economic Cooperation and Development
SA	South Africa
SDG	Sustainable Development Goals
TAP	Transparency, accountability, and participation
TWKLM	Theewaterskloof Local Municipality
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational Scientific and Cultural Organisation
WAR	Water allocation reform
WGI	Water Governance Initiative
WC	Western Cape
WCDA	Western Cape Department of Agriculture
WHO	World Health Organisation
WMA	Water management area
WUA	Water Users Association
ZWUA	Zonderend Water User Association

CHAPTER 1
INTRODUCTION

1.1 Background to the study

Water security especially its accessibility in an adequate amount and in a reliable way is crucial not only for the human right to water but also to the human right to food (Cotula et al., 2006). The United Nations (UN) has pointed out water as being very important in ensuring sustainable development, supporting human communities and ensuring economic development as well as maintaining various functions of ecosystems (United Nations Development Programme [UNDP], 2016). As a result, the UN Sustainable Development Summit developed the “2030 Agenda for Sustainable Development” which is composed of 17 Sustainable Development Goals (SDGs) aimed to fight inequality and injustice, tackle climate change and end poverty by 2030 (UNDP, 2016). To achieve the SDGs, significant improvements in the management of water resources are a necessity (Water Integrity Network, 2016). Worldwide, both in rain-fed and irrigated agriculture, water is considered one of the most essential resources that are needed by farmers to boost agricultural production (Molden, 2007; Rosegrant et al., 2009). The UNDP argues that water security will be the major contributor to agricultural production in the coming years rather than sufficient arable land (UNDP, 2016). Unfortunately, increasing agricultural production with the limited availability of sufficient and reliable water to meet the rising demand for food is one of the biggest challenges faced by many farmers globally. The security of water is influenced by several factors such as over-extraction, competing uses, poor land management and social-political-economical issues exacerbated by climate change (du Plessis, 2019).

Globally, the food supply is becoming threatened by water shortages as a result of the continuous growth of the world’s population, which is increasing at an average of about 80 million people per year (World Health Organisation [WHO], 2003). An additional estimated three billion people that will require 20% more water than what is currently available, are expected to be included in the world’s population by 2025 (Besada & Werner, 2015). About 1.2 billion people are currently suffering from absolute water scarcity, especially the world’s poor (Klümper et al., 2017). By 2050, the global water consumption from irrigation, livestock, domestic, and industrial uses is expected to increase by 21% (Rosegrant et al., 2009).

In many African countries, low agricultural production due to water insecurity challenges is now very apparent. More than half of the total population in Africa is dependent on agriculture (Besada & Werner, 2015) and approximately 30% of the population are suffering from chronic hunger, which is ranked among the highest rates globally (Food and Agriculture Organisation [FAO], 2019). Even South Africa (SA), a country that is relatively well-developed in terms of economy, is also experiencing water struggles mainly due to poor management practices and insufficient investment in water infrastructure (Besada & Werner, 2015). Rising water demand as a result of economic growth compounded with extreme climate events such as droughts is a contributor to the dwindling water resources in SA (Muthige et al., 2020). Huge pressure on scarce and limited water resources in SA also poses a challenge to water allocation and management to ensure water security (Department of Water Affairs & Forestry, 2013). The Department of Water and Sanitation (2018) indicates that water insecurity is one of the critical challenges in the 21st century that is facing SA.

According to the International Federation of Agricultural Producers (IFAP) (2005), without water security, there is no agriculture. To enhance food production to meet the rising global food demand, both the world's rainfed and irrigating smallholder farmers have a pivotal role to play as these farmers occupy approximately 500 million farms and contribute a significant amount of agricultural production (Giordano et al., 2019). In key bodies such as the United Nations Commission on Development, smallholder farmers' role in contributing to world food supply is increasingly gaining centre stage (International Fund for Agricultural Development, 2011). However, even though smallholder agriculture is critical in contributing to the future of global food production, many smallholder farmers involved in rainfed agriculture have been reported to fail to produce adequate food due to the increasing variability of rainfall as a result of extreme climate events such as drought (Dejen, 2015). Given the unreliable and erratic rainfall in many countries in arid and semi-arid regions such as SA, it is very challenging to depend only on dryland farming and this makes irrigation farming a necessity to achieve successful agricultural production (Moyo et al., 2016). According to Obadire et al. (2011), irrigation has since played a critical role in feeding growing populations and undoubtedly it will continue to play the same critical role in the future, given the uncertainty of climate change.

To reduce the harmful impacts of changes in seasonal rainfall, the FAO of the UN and various governments of countries in Asia, America and Africa have supported programmes of irrigation development (Yedra et al., 2016). The New Partnership for Africa Development (NEPAD)'s Comprehensive African Agriculture Development Programme also emphasises the necessity to increase agricultural areas under irrigation, especially smallholder irrigation farmers to boost agricultural production and to raise the reliability of food supplies (NEPAD, 2003). During drought periods, irrigation can also act as a mitigation measure to enable farmers to intensify agricultural production (Moyo et al., 2016). Despite the promotion of smallholder irrigation farming, several irrigation systems implemented in most water-scarce countries around the world to improve agricultural production have been reported as not fully functional to achieve their intended objectives (Dittoh et al., 2010). In many developing countries, the underperformance of irrigation infrastructure for smallholder farmers has been reported to be mainly a result of insufficient technical capacity and poor institutional arrangements, which ultimately led to irrigation water insecurity (Moyo et al., 2016).

Water infrastructure such as canal systems has been reported as a very useful tool in improving water resource management practices and enhancing water security (Awulachew & Ayana, 2011; Gomo et al., 2014; Dinka, 2016; Haileslassie et al., 2016; Abera et al., 2018; Elshaikh et al., 2018; Ngasoh et al., 2018; Karimi et al., 2019). In SA, numerous studies have been conducted on smallholder irrigation schemes but with little attention to smallholder farmers in small historical towns such as Genadendal. Other studies have found that water security in developing countries can also be achieved by improving water governance (Araral & Wang, 2013; 2015; Araral & Yu, 2013; Makaya et al., 2020). To secure water security in SA, Pillay (2016) argues that effective governance of water resources is a necessity. At the 2001 Bonn International Conference on freshwater, a predecessor to the 2002 Johannesburg World Summit on Sustainable Development, water governance was also identified as one of the areas requiring priority action to enhance water security (Lautze et al., 2011). Given the water insecurity situation in SA, the Breede-Gouritz Catchment Management Agency (BGCMA) (2017) highlights that if effective water management is not taken into consideration there will be insufficient water supplies to meet demands.

SA is a democratic state which values equity in the decision-making related to the (re)allocation of natural resources such as water to address past inequalities that were created under the Apartheid regime (Rawlins, 2019). Section 27(1)(b) of the Bill of Rights states that all South Africans have the right to access adequate water and food. Recent policy developments such as the 2013 National Water Resources Strategy and National Water Policy Review have also prioritised equity in decision-making concerning water (re)allocation to ensure water security. Water allocation is a fundamental component of water governance and the reallocation of water is increasingly considered a dynamic tool for managing water resources in the face of the changing demand dynamics and unpredictable water supply system (Rawlins, 2019). Also, water allocation involves rules, procedures and incentives that govern who can access water, how much, where, when and for what it can be used (Rawlins, 2019). Reallocation is whereby water is transferred between uses and/or users that have been appointed a specific amount either informally or formally through various forms such as water entitlement, right, agreement or use permit (Rawlins, 2019).

Even though water is a very important component of agricultural production, many smallholder farmers in SA are still faced with persisting water access inequalities. Muller et al. (2009) argue that SA cannot yet be regarded as a fully water-secure country if water security is attained when both the social and productive potential of water is required to be harnessed sufficiently for the benefit of all citizens. According to Hoogendoorn and Nel (2019), many small South African historical towns such as Genadendal are considered a research lacuna in terms of water resource management to ensure water security for enhancing agricultural production. Genadendal is a product of historical imbalances in terms of access to resources, including water. Palchick (2008) found a decline in agricultural production in this town despite its historical background as a self-sufficient agricultural community in terms of local food production. Water is considered one of the key limiting factors hindering agricultural production for smallholder farmers in the town despite various water sector reforms such as the National Water Act No 36 of 1998 and the Water Allocation Reforms (Department of Water Affairs and Forestry [DWAF], 2008) that aimed to correct injustices of the past in terms of water access. Considering the three-year drought in the WC that started in 2015, there is a possibility that the available water resources for productive uses (irrigation) in Genadendal have been affected. In a previous study conducted in Genadendal, some farmers reported challenges such as water losses due to degrading water infrastructure and some had no access to agricultural water due to irrigation channels being closed off by other farmers (da Costa, 2018), which resulted in water conflict among smallholder farmers. This indicates that institutional arrangements and water governance are very complex in this town. There was, therefore, a need to understand the relationship between access to water and infrastructure management in the town and surrounding areas.

Even though irrigation was found to be one of the most important climate adaptation strategies for smallholder farmers in Genadendal (da Costa, 2018), little is known about the sustainability of different irrigation methods used by smallholder farmers. To enhance the sustainability of irrigated agriculture, the development and management of water resources are critical, especially in areas where water insecurity is of great concern (Azizi et al*.,* 2009).

Previous studies in Genadendal focused mainly on how smallholder farmers could adapt during drought periods and paid little attention to the performance of irrigation water infrastructure and the underlying governance issues affecting water access. In this study, it was, therefore, necessary to quantify water resources in Genadendal as well as assess the performance of water infrastructure and water governance systems for smallholder farmers. This is crucial in developing appropriate water management strategies to ensure that there is an adequate and reliable agricultural water supply to enhance agricultural production and the livelihoods of smallholder farmers in this town.

1.2 Problem statement

In most arid and semi-arid countries such as SA, water insecurity is becoming a serious challenge (Kahil et al*.,* 2015). The 2015–2018 drought in the WC province left many farmers unable to irrigate crops due to water shortages that led to severe water restrictions. In the Overberg District, water resources were identified as a critical concern requiring urgent attention (Birch et al., 2017). The district is vulnerable to both food and water insecurity in the face of climate change. External stakeholders and municipal officials report that water resources will decrease as a result of increased frequency of drought, variability in rainfall and increase in temperature (Birch et al., 2017). Also, deteriorating infrastructure and system losses have worsened the situation, especially in small historical towns, such as Genadendal, that depend on canal systems. Investment in maintaining water infrastructure is recommended to prevent water loss as well as maximize water storage (da Costa, 2018), but the problems of water insecurity in Genadendal seem to go beyond just infrastructure. There is, therefore, a need to take a holistic approach to solve water insecurity challenges to assist the farmers in increasing their resilience during drought periods. The determinants of water security (water access) for agriculture by smallholder farmers in Genadendal are poorly understood, hence the need to explore them by assessing the performance of water infrastructure and irrigation water governance as well as determining the availability of agricultural water resources. Genadendal was chosen as a study area because of its historic racial inequalities in terms of access to natural resources such as water.

1.3 Aim of the study

The study aimed to investigate the determinants of agricultural water access by smallholder farmers in the Genadendal area by considering the dimensions of water resource availability, infrastructure performance and irrigation water governance.

1.4 Study objectives

The objectives of the study are:

- To assess the availability of agricultural water for smallholder farmers in Genadendal;
- To assess the status and performance of irrigation water infrastructure supplying water to smallholder farmers in Genadendal;
- To assess the current state of irrigation water governance systems in Genadendal; and
- To explore the determinants of agricultural water security for smallholder farmers in Genadendal.

The research questions of the study are:

- Is there adequate agricultural water for smallholder farmers in Genadendal?
- What is the status and performance of irrigation water infrastructure for smallholder farmers in Genadendal?
- What is the current state of irrigation water governance systems in Genadendal?
- What are the factors determining agricultural water security for smallholder farmers in Genadendal?

The hypotheses guiding this study are:

i. There is no shortage of water in Genadendal even during drought periods.
ii. Lack of infrastructure maintenance is causing artificial water shortages for smallholder farmer production.

iii. Challenges to accessing agricultural water by smallholder farmers in Genadendal are mainly caused by dysfunctional water governance systems.

1.5 Significance of the study

The study helps to provide a better understanding of water availability in Genadendal, including the impacts of the recent 2015–2018 drought on agricultural water resources for smallholder farmers. The results also provide the current status and performance of irrigation water infrastructure, especially canals supplying irrigation water to Genadendal. This allows water providers to come up with new strategies to maintain and replace the infrastructure. Revealing the current state of water governance systems in Genadendal is also likely to assist water authorities in the area to address some of the challenges that have led to the breakdown of the system. At Catchment Management Agency (CMA) level, the study assists stakeholders and policymakers to address the challenges of agricultural water management in Genadendal; the same approaches can be used in other small historical towns that are facing similar challenges. The recommendations from the study have the potential to influence national policy on water resource management in small towns and smallholder irrigation systems.

1.6 Outline of the study

The study is structured in five chapters as follows:

Chapter 1 presents the background, problem statement, objectives and significance of the study.

Chapter 2 presents the literature review.

Chapter 3 provides the research design as well as the methodology used for the study. Additionally, this chapter describes the study area and the methods that were used to collect and analyse data as well as their limitations.

Chapter 4 presents the results of the study.

Chapter 5 presents the discussion of the findings.

Chapter 6 provides conclusions and recommendations of the study.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature relevant to water governance, institutions, water security and smallholder farmers, as well as irrigation supply water systems. An overview of the determinants of water security is discussed, as well as water resources and drought occurrence in SA.

2.2 Concepts and definitions

The concepts of the smallholder farmer, water security, institutions and water governance have been defined and described differently by various scholars. This section discusses the concept of these terms, drawing from several scholars.

2.2.1 Smallholder farmer

Globally, there is no universally-accepted definition of a smallholder farmer (Khalil et al., 2017). Various approaches have been used to define smallholder farmers and the definition differs between countries and agroecological zones. Most often, the term “smallholder farmer” is used interchangeably with “subsistence farmer”, “family farmer”, “resource-poor farmer”, “small-scale farmer”, “low-input farmer”, “low-technology farmer”, “small” or “low-income farmer” (Abele & Frohberg, 2003; Nagayets, 2005). Assessing the common characteristics of farmers such as their accessibility to land and capital, exposure to risk and technologies, and orientation of the market are considered some of the aspects that are generally used to define smallholder farmers (Chamberlin, 2008).

Concerning land size, smallholder farmers are usually characterised by the possession of plots of land that are very small in accordance with the local landholding standards of a particular country. For instance, the World Bank defines smallholders as farmers that occupy cropland that is less than 2 ha (World Bank, 2013). In SA, the size of the land cultivated by smallholder farmers varies in size but it is generally extremely small, in the range of 0 to 1.5 ha household (Pienaar & Traub, 2015). However, a considerable number of South African smallholder farmers are farming on less than 5 ha while a small percentage farm on plots that are larger than 5 ha (Pienaar & Traub, 2015).

Vincent (2003) described smallholder farmers as those farmers that are involved in the production of agricultural commodities on a small scale, either for their subsistence use or local market, or both. Similarly, the South African Department of Agriculture (DoA) (2014) and Aliber and Hart (2009) define smallholder farmers as those farmers who produce mainly for household consumption on a small scale and supply relatively few products to the local or other markets to earn income for the family. Narayanan and Gulati (2002) describe a smallholder farmer as someone who practises a combination of commercial and subsistence production. In their study, Pienaar and Traub (2015) characterised smallholder farmers based on their limited resources in comparison to commercial farmers. The definition of a smallholder farmer by Lipton (2005) is based on whether or not family members supply most of the farm labour.

In SA, smallholder farmers are generally described as poorly resourced farmers located in less developed former homeland areas where almost all the land is communally owned (Kirsten & van Zyl, 1998; Vink & Kirsten, 2003; Aliber & Hart, 2009; May & Carter, 2009; Thamaga-Chitja & Morojele, 2014). Additionally, Pienaar and Traub (2015) report that the majority of South African smallholder farmers comprise women, children and aged people. These farmers are categorised as historically disadvantaged individuals (HDIs) and emerging farmers. The term emerging farmers refers to farmers that participate in the market intending to produce and sell agricultural products (Mmatsatsi, 2007). According to Saruchera (2008), emerging farmers are farmers that have leased or bought agricultural land and they are characterised by poor natural, physical and economic resources. Smallholder farmers are also described as cultivators who practise permanent and intensive farming as well as diversified farming, particularly in densely populated rural areas on relatively small pieces of land. These farmers are usually made up of diversified individuals and households who experience challenges regarding the capability to carry out profitable agricultural activities (van Averbeke et al., 2011). In the context of this study, smallholder farmers are defined as those farmers who are less developed, poorly resourced and practise agricultural production on a small scale for their household consumption and market some products to the local or other markets to earn income for the family.

2.2.2 Water security

The importance of water security has been identified by various organisations and groups, including the Global Water Partnership, the World Economic Forum, Asia-Pacific Water Forum and United Nations Educational Scientific and Cultural Organisation (UNESCO) Institute for Water Education. For instance, the UNESCO Institute for Water Education considered water security as one of its research themes and the Asia-Pacific Water Forum held its first summit in 2007 entitled “Water Security: Leadership and Commitment” (Cook & Bakker, 2012). In their review of key definitions of water security, Lautze and Manthrithilake (2012) highlight that the meaning of water security has changed extensively since it started to be used. Cook and Bakker (2012) report that literature concerning water security had mainly focused on the concepts of availability of water, the vulnerability of humans to hazards, sustainability and the development of human needs, with a particular focus on food security. Some scholars have highlighted the shortcomings in the existing approaches to water security including, (1) an overemphasis and reliance on physical aspects of water security, (2) water policy that is driven by environmental determinism, and (3) isolation of water security from other security-related aspects (Strickert et al., 2016).

The term water security is used to frame numerous water problems, ranging from flooding and drought to pollution, poor sanitation and lack of access (Strickert et al., 2016). The perceptions of stakeholders and rights holders regarding water security can shape the values and beliefs about how water should be managed (Strickert et al., 2016). For instance, drought experiences may influence the views of security of policy-makers regarding maintaining water sufficiency during increasing water scarcity, while the experiences of flooding may influence water managers to act in a way that reduces the harm to humans by managing water flows through the construction of infrastructure and operations as well as reallocation and conservation (Strickert et al., 2016). The concept of water security has received a lot of attention, especially in the debates of policy and academics. Several definitions of water security have been developed by various scholars (Grey & Sadoff, 2007; Muller et al., 2009; Cook & Bakker, 2012; Sinyolo et al*.,* 2014; Klümper et al., 2017). Most of these definitions are based on a specific context and disciplinary perspective regarding water use (Cook & Bakker, 2012). Unfortunately, the major disadvantage of most of these definitions is that they are only applicable when analysing water security at national and global levels (Asian Development Bank, 2013).

Various scholars have defined water security as an overarching goal, where every person has access to sufficient safe water that is affordable in terms of cost to lead a clean, healthy and productive life while ensuring the environment is protected and water-related disasters such as droughts and floods are prevented (Global Water Partnership, 2000; Grey & Sadoff, 2007; Cook & Bakker, 2012; Wheater & Gober, 2013). In the agricultural sector, water supply reliability is of utmost importance because an adequate, reliable amount enables farmers to plan for water use for their farming practices (Molden & Gates, 1990). The Food and Agricultural Organization (FAO) describes water security as the supply of sufficient and reliable water to meet the needs of agricultural production for populations that live in the drier areas of the world (FAO, 2000). Singh (2017) defines water security as access at all times to sufficient good quality water to satisfy varied needs. Singh (2017) further points out that both quantity and quality, as well as access at all times, are important components of water security. Swaminathan (2001) mentions that water security "involves the availability of water in adequate quantity and quality in perpetuity to meet domestic, agricultural, industrial and ecosystem needs." From a legal point of view, water security is generally linked to the allocation rules that aim to secure the rights to a desired amount of water (Tarlock & Wouters, 2009). Water security also involves power-sharing of the governance and management of water (Ncube, 2018) and the capability of water users to claim their rights to water against other water users (Sinyolo et al., 2014).

Water security can vary with space and time. The spatial variability of water security usually ranges from an individual household to a village, municipality, district, province, country, continent or the whole world, while the time dimension of water security varies from a day, week, month, or season (winter, spring, summer or autumn), to a year, decade, or century. Concerning the time dimension of water security, a region can be water-secure in a specific part of the year and not in other parts of the year. Most often the time dimension of water security is directly linked to the variation of climate, which ultimately impacts the availability and supply of water (Singh, 2017). This implies that even places that are usually water-secure have the possibility of becoming water-insecure during extreme climate events such as drought.

Very few studies have addressed water security at the farm household level (Cook & Bakker, 2012) and none of them links water security to the agricultural sector. Klümper et al. (2017) highlight the importance of redefining water security to make it applicable at the farm household level. This is particularly important in communities where water plays a crucial role in local agricultural production. Focusing on the agricultural sector, Klümper et al. (2017) suggest the definition of water security is associated with the hydrological condition (water availability) and the governance (water access) option needed by each farm household to strengthen their agricultural needs, either for commercial or subsistence (smallholder) farming. Klümper et al. (2017) report that if farmers are experiencing a lack of availability of water, the dimension of water security that is being affected is dependent on hydrology and this may be a result of factors such as a drought period. However, if farmers are facing any challenge in accessing water, the dimension of water security that is affected is dependent on governance. Klümper et al. (2017) conclude that farmers experience water insecurity if the results of one or both dimensions are not achieved. In many developing countries, irrigation canals are also utilised for domestic purposes such as drinking water and providing water for livestock. The achievement of water security at farm household and community level in this regard would be associated with the costs of supplying clean water that is suitable for drinking, which is very difficult, particularly in developing countries (Klümper et al., 2017). Under such circumstances, farmers are deemed to be water insecure only if either one of the dimensions (quantity and quality) or both are challenged. The use of irrigation water for domestic purposes has been described as one of the highest value uses (Klümper et al., 2017).

In this study, water security is centred on three dimensions: (1) hydrology, (2) governance and (3) two in one (hydrology + governance) and it includes the use of irrigation water for both crop and livestock production. Here, water security is defined as equitable access to reliable and adequate good quality water by smallholder farmers at the farm household level or local level to satisfy their agricultural water needs as well as their capability to claim or protect their water use rights. According to Sokile and van Koppen (2004), water use rights are mechanisms that enable water users to access water for a particular use without threatening the rights of other users. Water use rights can be customary or local, implying that users may access water and develop mechanisms for water allocation among themselves. The mechanisms can be established without necessarily developing a written document that stipulates the amount of water and times for abstraction. Most often, water use rights are thought to be statutory, whereby a government issues a blueprint document outlining the amount of water allocation and sometimes the period for that particular allocation, and to whom it is to be allocated (Sokile & van Koppen, 2004).

2.2.3 Determinants of water security

Many factors determine water security and these factors can be categorized into the physical environment or built infrastructural, institutional and organizational, and socio-economic-political (Zeitoun, 2011; Sharaunga & Mudhara, 2016). Figure 2.1 illustrates water security factors.

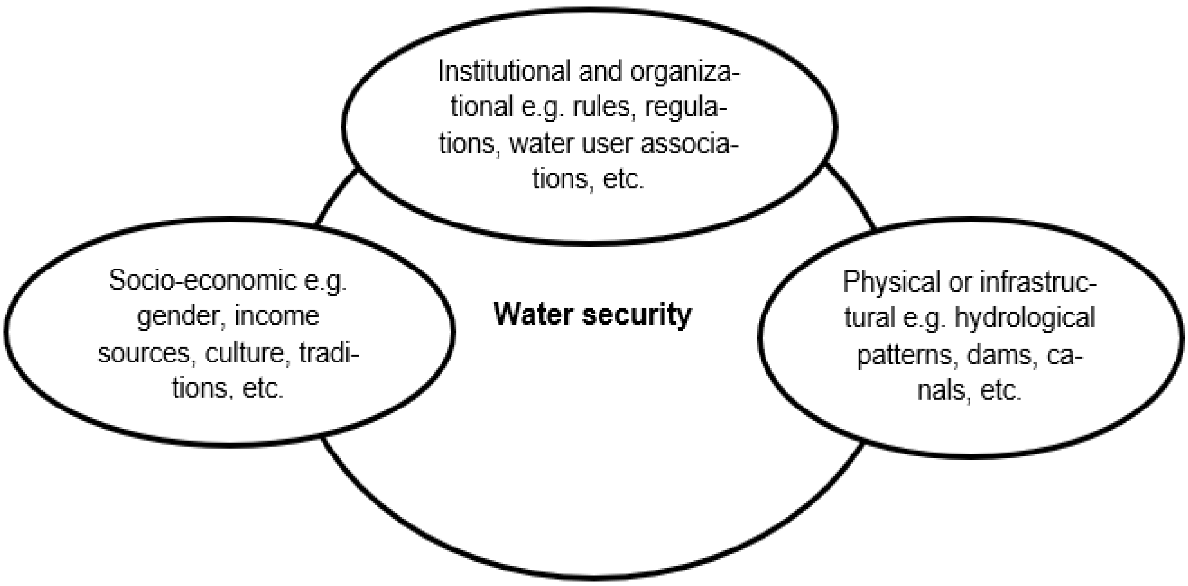

Figure 2.1: Factors affecting water security at the farm household level

(Samian et al., 2014)

The physical factors include the natural hydrological flows (i.e. availability of water in sources) and topographical features of an area (Norman et al., 2010; Zeitoun, 2011) whereas built infrastructural factors relate to artificial water infrastructures such as dams, canal systems and pumps for ensuring reliable water supply (Sharaunga & Mudhara, 2016). Institutional and organizational, and socio-economic-political factors are classified as part of the governance dimension of water security. The socio-economic factors include aspects such as income sources, gender, traditions and culture, which affect access to water and/or the capability to pay for water use and other water-related services. According to Sinyolo et al. (2014), institutional and organisational factors include local governance structures, water committees, water user associations (WUAs) and power relations as well as rules and regulations that enable water rights to be respected and conflicts to be resolved. Faysse (2010) avers that the governance dimension of water security entails two types of water access that must be fulfilled to gain access to water—legal access as well as technical and financial water access. Legal access involves the acquisition of entitlement such as water rights or permits to withdraw a certain amount of water from sources. The technical and financial aspects of water access include the availability of equipment and infrastructure that can transport water from sources to the site where it is required as well as the ability to pay the associated costs of distribution.

Tekken and Kropp (2012) posit that global water insecurity is a phenomenon that is generally a result of both human and natural causes. Natural phenomena include climate change and global warming that will lead to physical scarcity whereas economic scarcity mainly occurs when people lack the monetary means to make use of sufficient water sources (Naik, 2017). Other scholars argue that the water insecurity crisis is usually due to a crisis of management and accessibility (water governance crisis) rather than natural limitations in water supply (water quantity) (Jacobson et al., 2013). Klümper et al. (2017) argue that water security is usually determined by both hydrology (water availability) and governance (water access) dimensions. This is because the many variables that are linked to hydrology can also be influenced by governance. Primarily, not having adequate water does not necessarily translate to a lack of water security (Muller et al., 2009). However, at times the hydrology dimension of water security can result in the abundance of water and consequently provide water security even if the water governance dimension is weak (Klümper et al., 2017). Biggs et al. (2013) argue that an abundance of freshwater resources does not necessarily lead to water security if effective water governance such as equitable access is not taken into consideration. Even water-abundant countries can be affected by water insecurity if effective governance is neglected (Klümper et al., 2017). For instance, although Nepal is considered one of the world's countries with abundant water resources, inconsistency in spatial and temporal distributions of water and limited accessibility as a result of policy and political-related instability are reported to contribute to its water insecurity status (Vörösmarty et al., 2010). There are abundant water resources in sub-Saharan Africa (SSA) in overall terms, however, the distribution is unequal in time and space (FAO, 2008). In SA, Muller et al. (2009) state that the existing and future water insecurity challenges are mainly a result of deficient institutional capabilities and financial resources rather than the limitations of the water resource itself.

Payus et al. (2020) indicate that the physical approach procedure is usually used to assess the availability of water resources by making use of the threshold to show the status of water security. However, their opinion of focusing on the physical aspect of water security has been questioned since the issue of attaining water security is not only about physical aspects but also entails governance aspects such as social, economic, political, administrative and distributional matters (Movik, 2011). The physical availability of water should be supported by additional factors such as institutional capabilities to guarantee its security for use (Sharaunga & Mudhara, 2016). For instance, water policies in many countries have reportedly failed to achieve water security as a result of placing more emphasis on physical processes (Zeitoun, 2011). According to Ncube (2020), it is now critical to move from the perspective of physical water scarcity to the one which involves access, rights, entitlements, governance and resource allocation. Regmi (2007) also indicates institutional capability as the most important factor that enables the attainment of water security in comparison to the physical availability of water resources. Even though the availability of water is a very important factor that enhances water security, it does not automatically guarantee water security (Sharaunga & Mudhara, 2016), it is how water resources are governed and managed that enables the security of access to water. According to Pascual-ferrer et al. (2014), governance and management are the main factors that determine water security rather than physical conditions.

In developing countries, many people are not able to access water as a result of economic barriers resulting from a lack of infrastructure investment and financial resources (Giordano et al., 2019). Water infrastructure is crucial in managing natural assets to maintain water security and meet the growing water demand (Grey & Sadoff, 2007). Regardless of having water use rights, water users can still experience the challenges of water insecurity if they lack the equipment and infrastructure to convey water from sources (Faysse, 2010). Imburgia (2019) found that water access for smallholder farmers was also highly linked to the performance of irrigation water infrastructure and this technical dimension of irrigation farming has significantly affected the capability of both women and men to access water reliability and affordably. In regions where climate change affects water supply or leads to water supply variability, adequate water infrastructure is also a necessity to reduce water risk during extreme climate events such as drought (Biggs et al., 2013). Faysse (2010) stresses that imposing temporary rules for water allocation during drought periods is critical to improving water security. In their study examining the challenges of governance of water resources in SA, Makaya et al. (2020) found that the performance of water governance systems is critical to enhancing water security. Deteriorating water infrastructure due to inadequate maintenance can also lead to water insecurity. If the maintenance of water infrastructure is not sufficient, water is not usually distributed properly to users (Imburgia, 2019). According to Ncube (2020), infrastructure maintenance plays a critical role in conserving water resources during drought periods and consequently enabling water security but this is very challenging, especially in smallholder irrigation schemes.

Madani (2014) and Madani et al. (2016) point out that governance challenges are the root causes of water insecurity rather than technical and engineering issues. In many parts of the world, the water insecurity problem is usually a result of poor governance rather than water shortage or insufficient technical knowledge (Gutiérrez et al., 2013). In countries such as Pakistan, Central Asia and Egypt, water infrastructure such as canal systems have been primarily constructed and operated with a technocentric approach to solve water insecurity challenges (Molden & Gates, 1990; Klümper et al., 2017; Siddiqi et al., 2018). However, other scholars argue that the development of water infrastructure alone cannot achieve water security (Inocencio et al., 2007; Faurès & Santini, 2008; Zeitoun, 2011). To ensure water security, the development of infrastructure should occur concurrently with policy and institutional arrangements (Cook & Bakker, 2012). To increase the physical access to productive water for smallholder farmers, issues of distribution such as irrigation infrastructure availability and the capability to operate, manage and maintain the infrastructure are required to be handled simultaneously (Kemerink et al., 2011). De Bruijn and Herder (2009) further assert that water governance and infrastructure are strongly linked and the management of water infrastructure is rooted in a very complex institutional system that consists of several stakeholders. Dirwai et al. (2018) also indicate that even though infrastructure is crucial for water delivery and to ensure water security, it is required to be closely related to laws, regulations, institutions (formal and informal), management practices and policies to ensure that water resources and water-related services are managed effectively and efficiently. According to Muller et al. (2009), investment in infrastructure for storing and delivering water as well as in institutions for water resource management is critical in ensuring water security. In irrigation, well-managed water infrastructure can control the spatial and temporal supply of water to enhance water security (Obadire et al., 2011).

Improving water security is very challenging since it depends on several factors, including technical, geophysical, social, economic and institutional/legal factors (Cotula et al., 2006). Water insecurity is considered multi-dimensional and various groups of people are influenced at various levels. Most often the poor and powerless such as smallholder farmers are gravely affected (Denby, 2014). Throughout the world, water insecurity is regarded as one of the major risks which are threatening both social and economic development, including agricultural production. In the past, geophysical and technical aspects were mainly considered to enhance water security while neglecting social, institutional and legal factors (Cotula et al., 2006). Some studies have asserted that addressing water insecurity challenges requires approaches that can connect social and hydrological systems (Pahl-wostl, 2002; Gober & Wheater, 2014). In his study on assessing challenges in meeting water security, Singh (2017) states that an integrated approach involving both technical and non-technical aspects is critical for ensuring water security. Singh (2017) further highlights that the management of water to enable the achievement of water security is considered as much non-technical as technical. Effective governance is a requirement for promoting and improving water security (Biggs et al., 2013). Water governance and water security should form a relationship that is synergetic (Cook & Bakker, 2012). Such symbiosis is reliant upon effective water governance that requires accountability, equity and social inclusion for ensuring strategies that are effective and flexible (Grey & Sadoff, 2007). Rogers and Hall (2003) highlight that bad governance may result in increasing social and political risks as well as institutional failure, and reduces the capacity to deal with water-related challenges. If water governance is ineffective, for example, if policy frameworks are incoherent and fragmented, water security cannot be attained (Biggs et al., 2013). According to the Organisation for Economic Cooperation and Development (OECD) (2015), coping with water insecurity challenges raises the question of “what to do?”, “who does what?”, “why?”, “at which level of government?” and “how?”. Therefore, to improve the security of water or minimise the scarcity of water more emphasis should be placed on creating institutional environments that strengthen and support the governing capacities of local resource users (Sharaunga & Mudhara, 2016).

2.2.4 Institutions

The definition of the term institution is usually limited to referring to only organisations. Institutions also involve both formal and informal ‘sets of rules, regulations, procedures, laws, norms, and conventions of the game’ within an organisation that determine how water is governed (Bandaragoda & Firdousi,1992). Institutions are used by a group of individuals to organise repeated activities that produce consequences that affect those individuals and potentially others. Formal institutions exist at different levels and they can have a direct and indirect effect on water governance. On the other hand, informal water institutions include contemporary and traditional social rules, customs, beliefs, and norms that enable the decision on the management, distribution, allocation, and use of water resources (Kabote & John, 2017). Most often these institutions manifest in the form of various groups such as the local private sector, religious associations and community-based organisations as a result of continuous interactions and practices in response to prevailing situations. In some cases, informal institutions are interdependent with formal institutions. For instance, Sokile et al. (2005) concluded that both formal and informal institutions are crucial for water governance and they are inseparable. This implies that sometimes if the two are not coordinated it will result in the duplication of interventions and consequently the proper governance of water resources cannot be attained. In this study, water institutions refer to the formal organisations that are responsible for the governance and management of irrigation water for smallholder farmers.

2.2.5 Water governance

Water governance has been approached from various orientations (Lautze et al., 2011; Havekes et al., 2016). The concept of water governance is very broad and it includes the processes of political, social and economic as well as regulations through which civil society, governments and private sectors make their decisions regarding how best can water resources be used, developed, allocated and managed (Tortajada, 2010). Generally, most definitions of water governance are based on specific disciplines with inputs drawn from various academic fields such as economics, engineering and sociology (Olagunju et al., 2019).

The OECD (2015) defines water governance as:

> …the range of political, institutional and administrative rules, practices, and processes (formal and informal) through which decisions are taken and implemented, stakeholders can articulate their interests and have their concerns considered, and decision-makers are held accountable in the management of water resources and the delivery of water services.

Jacobson et al. (2013) argue that water governance should include:

> …principles such as equity and efficiency in water resource and services allocation and distribution, water administration based on catchments, the need for integrated water management approaches and the need to balance water use between socio-economic activities and ecosystems as well as clarification of the roles of government, civil society, and the private sector and their responsibilities regarding ownership, management, and administration of water resources and services.

Wiek and Larson (2012) list the key features of water governance as "a systemic perspective, a governance focus on social actors, a transparent and accessible discourse on values and goals, and a comprehensive perspective on water sustainability." Vyas-Doorgapersad and Ababio (2010) describe governance in the form of 10 principles, namely rule of law, transparency, equality, responsiveness, vision, accountability, oversight, efficiency and effectiveness and professionalism. In their study to examine the politics and development of water, Mollinga (2008) used a political sociology approach to investigate water governance, arguing that water governance is a domain that is politically contested. Similarly, Stein et al. (2011) applied social network analysis to assess the structure of the water governance network in Tanzania and concluded that social network analysis is a necessary tool for building a favourable environment for developing locally established institutions. Water governance can also be defined as the allocation of rights such as rights to water and technology and decision-making rights as well as resources, including water and maintenance and investment funds (Mollinga, 2008).

Tropp (2007) describes water governance in terms of the "evolution of formal and informal networks, partnerships, joint- decision-making processes, including dialogue and negotiated outcomes as mechanisms for steering water governance." Mofokeng (2017) emphasises that water governance entails the development, establishment and enactment of water policies, institutions and legislation as well as clarification of the roles and responsibilities of the private sector, government and civil society dealing with water resources and services. Focusing on the behavioural approach, Pahl-wostl et al. (2008) define water governance as “the development and implementation of norms, principles, rules, incentives, informative tools, and infrastructure to promote a change in the behaviour of actors at the global level in the area of water governance”, while Kashyap (2004) explains water governance in the context of climate change as “the ability to develop adaptive capacity”.

In the agricultural sector, particularly in irrigation, water governance entails the processes, rules and regulations that can be used in the management, administration, coordination and maintenance of irrigation systems such as irrigation water infrastructure (Ostrom, 1994; 2005; Howarth et al., 2007; Lautze et al., 2011; Bastakoti & Shivakoti, 2012). Herrera et al. (2014) also describe water governance in irrigation as the rules and regulations that enable the determination of the use and management of irrigation resources by local users. In their study on the governance of irrigation water, Munaretto and Battilani (2014) describe water governance as the totality of interactions that take place among the public and private sectors. Additionally, Munaretto and Battilani (2014) state that water governance in irrigation is mainly concerned with the allocation of water resources efficiently and equitably among water users, balancing the uses of water and the needs of ecosystems and integrated water management, and the management of water at catchment level. Gallaher and Heikkila (2014) maintain that water governance is associated with collective decisions and choices concerning the use and management of water resources that emerge through institutions. Water governance also involves the process of establishing rules and institutions for managing water resources. According to Dirwai et al. (2018), water governance is a process that involves multi-level and multi-actor decision-making about water-related activities. The multi-actors can be classified as formal and informal institutions and they collectively influence how irrigation water infrastructure is managed or operated (Dirwai et al., 2018). In the current study, water governance is described as formal principles, processes, rules and regulations used by institutions in the management of water resources to ensure water security for smallholder agricultural production.

2.3 Water supply in South Africa

2.3.1 Freshwater supply

The freshwater supply in SA is under stress (Singh, 2017). SA is a semi-arid country with limited and scarce water resources (Muller et al., 2009) where rainwater is regarded as the main input to water resources (Botai et al., 2018). The amount of rainfall it receives is also highly variable (Department of Water and Sanitation [DWS], 2018). Globally, SA is considered the 30th driest country, receiving a low average rainfall of about 465 mm per annum compared to the world's average of 860 mm per annum (Pitman, 2011; DWS, 2018). The greatest amount of rainfall in SA occurs in the summer season except for the southwestern region (WC province) where most of the rainfall occurs during the winter season. Additionally, few places in the WC also receive rainfall all year round (Botai et al., 2017). On average, the WC province receives an average annual rainfall of approximately 350 mm which is below the country's average annual rainfall of 500 mm (Muthige et al., 2020). The WC province is also regarded as a water-stressed region (Pegram & Baleta, 2014).

2.3.2 Drought impacts on water supply

Climate-related risks such as drought usually give rise to considerable challenges to agricultural production. According to Singh (2017), climate change can result in a greater frequency of droughts which ultimately lead to uncertainty and reduction in the availability of freshwater as well as changes in the water supply. Natural resources managers, policymakers and farmers have acknowledged the risks of Africa concerning climate change and variability such as drought periods (Muthige et al., 2020). In most countries situated in SSA, such as SA, drought is linked to agricultural loss, famine, mortality and economic setbacks (Muthige et al., 2020). The Intergovernmental Panel on Climate Change (IPCC) has defined drought as a prolonged deficiency or absence of rainfall that can result in a shortage of water for some group or activity (IPCC, 2007). Drought is also considered a natural phenomenon that can affect various sectors such as agriculture, tourism, energy, water resources and ecosystems in society. There are four main forms through which drought can arise. Initially, drought arises as a meteorological drought characterised by below-normal rainfall for a period ranging from one to three months. When the conditions of drought continue such that the impact leads to inadequate soil and sub-soil water, thereby influencing the growth of crops, this stage is termed agricultural drought. The third stage is referred to as hydrological drought whereby the conditions of drought result in the reduction of water levels in water reservoirs (Botai et al., 2017). Lastly, when the physical shortage of water starts to affect human activities, this stage is called a socio-economic drought. Water scarcity can be intensified by droughts that can negatively affect people's health and productivity (Payus et al., 2020). Drought can change severe imbalances in water cycles such as changes in the availability of soil moisture, precipitation and evaporation processes (Payus et al., 2020), leading to the reduction of water resources in streams, rivers and reservoirs. In comparison to other natural disasters, drought is considered a major disaster that can be very costly (Payus et al., 2020). It can also result in serious fires that have various socioeconomic and environmental impacts (Payus et al., 2020).

Generally, SA is prone to frequent droughts which ultimately affect the national economy as well as communities (Zwane, 2019). The impacts of drought have affected smallholder farmers for several years (Mpandeli et al., 2015). During drought periods, commercial farmers have a variety of choices to cope with and adapt to as compared to smallholder farmers. Most often the majority of commercial farmers have good irrigation water infrastructure (Mpandeli et al., 2015). The forms of drought are a result of high variability in rainfall and temperature (Araujo, 2014), which implies that drought is linked to low rainfall compounded by high temperatures. Historically, the WC has been the most disaster-prone province in SA (Overberg District Municipality, 2018). It is generally susceptible to various climate-related risks such as droughts (Western Cape Department of Agriculture [WCDA], 2017) that are usually associated with significant harmful impacts (Pasquini et al., 2013). During the 2015–2018 period, the WC experienced the worst drought since 1904 (Botai et al., 2017). This three-year shortage of rainfall, a rare event with the likelihood of occurring in approximately 150 years, led to severe distress within the whole WC province (Muthige et al., 2020). The drought was characterised by all four types of droughts and severely affected the availability of water resources in the province. The Overberg District Municipality (2018) reports that water resources are considered the primary medium through which the effects of climate change will be experienced by many South Africans. The water shortage crisis has forced the government to implement intensified water restrictions for the users. Several sectors, including agriculture, were seriously affected as a result of water shortages (Botai et al., 2017). Inadequate winter rainfall compounded with warm temperatures intensified evaporation that caused crop stress as well as depletion of water in reservoirs (Botai et al., 2017).

2.4 Water governance systems

2.4.1 Principles of good water governance

Principles of good governance are critical in ensuring water security. The sustainable management of water to ensure water security can be achieved by good governance (Akhmouch & Correia, 2016). Equity and fairness in water distribution among users are some of the characteristics of good water governance. Water governance is also considered as good when a combination of top-down and bottom-up approaches are used to solve water challenges and resolve water-related conflicts (OECD, 2015). According to Rogers and Hall (2003), good governance systems are critical to providing structures and processes that facilitate actions for all water management actors. In the absence of principles of good water governance, it is very challenging to attain various water-related intended results such as effective and efficient ways of dealing with periods of shortage of water (e.g. drought) in a way that is sustainable, inclusive and integrated (OECD, 2015; Havekes et al., 2016).

The OECD has highlighted that the main obstacle to achieving sustainable and good water governance is the existing governance gaps that hinder water policy. Various principles of governance can be used to assess whether water resource is governed properly or not and these include transparency and cooperation, accountability, participation, conflict management, equity and fairness, corruption control and sustainable management (Rogers & Hall, 2003). Jacobson et al. (2013) and Klümper et al. (2017) consider transparency, accountability and participation (TAP) as the main principles to be considered when assessing the performance of the governance of water resources.

To enhance good water governance, the OECD Water Governance Initiative (WGI) was created in 2013 as an international network for stakeholders to share their water reforms experience and peer review analytical work as well as to produce bottom-up knowledge and guidance. This initiative is regarded as one of the most comprehensive initiatives and it has managed to develop a set of 12 water governance principles (Figure 2.2) based on three main dimensions (effectiveness, efficiency, and trust and engagement).

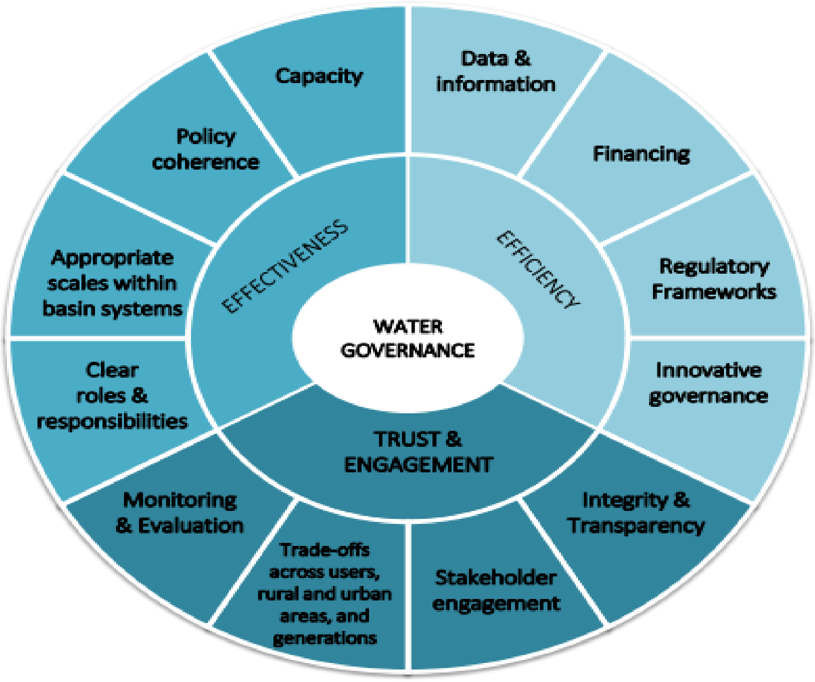

Figure 2.2: OECD principles on water governance

(OECD, 2015)

The OECD principles on water governance apply to all infrastructure sectors at local, national and international levels to promote water security (Havekes et al., 2016). These principles were formulated based on the premise that the worldwide water crisis cannot be solved by making use of one particular solution. Thus, there is no one-size-fits-all governance model for water since the governance systems, institutional structures and dynamics of stakeholders as well as problems and priorities differ for every country. This implies that the solutions for water challenges are adaptive, place-based and dependent on a particular context (UNDP & Water Integrity Network, 2013; OECD, 2018).

Assessing the performance of water governance systems is also very important in identifying and addressing the challenges of governance in the water sector at any particular level (Tropp, 2007). Several scholars have used various water governance frameworks to assess the performance of water governance systems to overcome water insecurity challenges. However, it is very challenging to find and choose an appropriate framework since good governance is associated with political connotations (Kaufmann et al., 2010). Some studies on general governance of irrigation have evaluated the governance by making use of observations of the physical status of irrigation infrastructures as well as the availability of concrete institutions for irrigation water management (Akuriba et al., 2018) such as the technical aspects of irrigation governance on the availability of infrastructures and whether the available infrastructures are functioning or not.

The OECD has formulated the comprehensive Multi-level Governance Framework (see Figure 2.3) based on 12 OECD water governance principles as depicted in Figure 2.2 under the motto "Mind the gaps, bridge the gaps" (Akhmouch & Correia, 2016). This framework can be used to better manage water resources by identifying and bridging gaps in water policy to solve water governance challenges.

Figure 2.3: Multi-level governance gaps

OECD (2011)

The OECD's framework is regarded as one of the most comprehensive frameworks applicable in all countries at any level of government, regardless of the institutional settings (OECD, 2011) and it groups the water governance gaps or challenges into seven categories of (policy, accountability, funding, information, capacity, objective and administration (Table 2.1).

Table 2.1: Key co-ordination gaps in water policy

The OECD Multi-level Governance Framework: Key Co-ordination Gaps in Water Policy
1) The **policy gap** is a result of the fragmentation of roles and responsibilities of water-related tasks across ministries and agencies. The coherent water policy is reliant on institutional settings as well as on the allocation of tasks at different levels of government.
2) The **accountability gap** occurs when it is difficult to ensure the transparency of practices across the various constituencies, mainly as a result of insufficient users' commitment and lack of concern, awareness, and participation. Without monitoring the procedures and actions taken by governments and citizen participation, it is not possible to ensure accountability.
3) The **funding gap** entails an insufficient or unstable budget to enable the undertaking of required water management activities such as construction, maintenance, and repairs of infrastructure. This will also undermine the effective implementation of water responsibilities.
4) The **information gap** occurs when there is a weakness in producing information (quantity, quality, type) between various stakeholders involved in water policy as well as when governments are not able to share the existing water data. This indicates the scattering of water data across different ministries and agencies.
5) The **capacity gap** is when there is insufficient scientific, knowledge, obsolete infrastructure and technology, and lack of human resources as well as the insufficient infrastructural capacity of local actors to design and implement water policies (size and quality of infrastructure, etc.) including relevant strategies.
6) The **objective gap** refers to unclear objectives of water governance structures as well as conflicts among them concerning issues related to social, economic and environmental. The different rationales will create obstacles to adopting convergent targets, especially in the case of a motivational gap (referring to the problems that reduce the political will to engage greatly in organising the water sector).
7) The **administrative gap** is when there is a geographical "mismatch" between hydrological and administrative boundaries and this can be at the origin of both resource and supply gaps. The type and number of agencies that are involved in water-related activities and processes should be addressed in this category.

Source: OECD, 2011

2.4.2 Water governance and water conflicts

Water is considered the main source of conflict, insecurity and risk, particularly in places where it is in short supply (drought) or in excess (floods) (Bogardi et al., 2012). Good water governance is very necessary to avoid water conflicts, especially in the allocation of water. Rogers and Hall (2003) posit that poor water governance may result in increasing social and political risks as well as institutional failure and reduces the capacity to deal with water-related challenges such as water conflicts. In the agricultural sector, water conflict is defined as the differences and disputes occurring among farmers over access to water (Bijani & Hayati, 2015). Water conflict usually occurs when the amount of water distributed to farmers is not shared equitably. According to Carius et al. (2004), drought can also be the driver of water conflict due to inadequate water resources. Bijani and Hayati (2018) argue that water conflict arises as a result of the inadequate way in which a water resource is governed and managed other than the unavailability of the water resource. Various reasons can lead to the ineffectiveness of water management and these include insufficient administrative capacity, inadequate water institutions, shortage of essential infrastructure, fragmented institutional structures, lack of transparency, overlapping roles and responsibilities and ambiguous jurisdictions (Bijani & Hayati, 2015).

In an attempt to resolve the conflicts of water allocation, formalisation of the water rights system has been attempted by many governments whereby users are permitted to use a fixed amount of water at a particular place and time (Komakech et al., 2012). However, at times the allocation of water is not necessarily based only on formal licences but can also depend on local understanding such as taking turns when using water (Bruns, 2007). Water conflicts can also be resolved if there are shared values and a balance of power and interests that enable an equitable and acceptable distribution of water to all users (Howarth et al., 2007) as well as if leaders of water institutions are willing and capable to consider the interests of all water users. Smallholder farmers usually lack formal water regulations (formal institutional arrangements) and this creates a platform for opportunistic behaviours as well as stimulating potential water conflicts among water users due to poor social capital such as lack of trust between water users and perceptions that the solutions of water scarcity should come from external authorities (Theesfeld, 2004; Hamidov et al., 2015).

2.4.3 A historical perspective of water governance in South Africa

The perceptions of water scarcity have driven many countries to reform their water policies. In the sub-Saharan region, SA is one of the countries that has responded to the crisis of water insecurity by reforming its water laws (Pillay, 2016). SA's historical legacy, especially the Apartheid regime landscape, is very important to better understand the evolution of its water governance and the current water dispensation. During the Apartheid era, there were inequalities between whites and blacks in terms of access to natural resources such as water and land. The allocation of and access to water, especially for agriculture, was hugely biased and conducted along racial lines as a result of policies that favoured the white minority population (Förster et al., 2017). The Apartheid government was mainly interested in formulating laws and rules that favoured their political, economic and civil interests without considering the interests of the indigenous black South African people (Kemerink et al., 2011). Institutional structure and water resource management approaches were mostly centralised and the participation of citizens, especially blacks, in the management of water was very limited. The allocation of water was carried out by the State without taking into consideration the issues of sustainability and equity (Tewari, 2009). Access to water for both agricultural and urban purposes was mainly driven by the Water Act 54 of 1956 through the riparian rights system. Under this system, water rights were given based on the ownership of land under the discriminatory Land Act of 1913. Unfortunately, most of the land was in the hands of the white minority and about 13% of the land was reserved for 70% of the majority poverty black population who were situated in segregated geographical areas (Denby, 2014). Most of the black farmers were excluded from owning land, which excluded them from accessing water since ownership of land was associated with water access (Madigele, 2018). As a result, access and control of water were mainly in the hands of a few white minority commercial farmers since land ownership was dominated by them.

In 1994, when the Apartheid era ended, it paved the way for the democratic South African regime. The arrival of democracy led to the development of a new Constitution (Act 108 of 1996) and a huge law-reform process, including thorough changes to the law governing the management of water resources (Kapfudzaruwa & Sowman, 2009). The new Constitution aimed to redress imbalances of the past, including the allocation and management of water resources whilst considering the constitutional rights of all citizens (Kapfudzaruwa & Sowman, 2009). It resulted in the formulation of the Water Services Act of 1997 and the National Water Act of 1998. The National Water Act (NWA) of 1998 was enacted to govern South African national water resources and adopted the principles of equity, efficiency and sustainability from the Integrated Water Resources Management (IWRM) as guiding principles for the development, use, protection, conservation, control and management of water resources (Funke & Jacobs, 2010). The Act aimed to redress inequalities of the past (gender and racial discrimination) that were created by the Apartheid government concerning water access (Dlangalala & Mudhara, 2020). Enabling historically disadvantaged individuals to access water for productive uses, such as smallholder farmers, was also the objective of the Act (Barrett et al., 2012). The NWA also changed the riparian water rights system to an administrative system whereby water use licences would be granted by institutional authority. To accomplish equitable water allocation, it is clearly stated in sections 43 to 48 of the NWA that compulsory licensing requires every water use authorisation in certain areas to be reviewed. Compulsory licensing is a process in which all water uses in areas considered to be water stress is cancelled and a call for licences issued. Compulsory licensing is also considered a major component of the WAR (water allocation reform) programme, which permits the re-allocation of water from currently water-allocated users to historically disadvantaged individuals and all commercial farmers are required to register their water use and apply for water use licences.

Additionally, the NWA has also encouraged the involvement of various stakeholders in the decision-making process through the development of new water management institutions (WMI), such as catchment management agencies (CMAs) and WUAs (Faysse, 2010). These institutions were established to ensure that all the interests of water users concerning water governance are represented (Kahinda et al., 2015). This was meant to be put into practice by decentralising and integrating the management of water through assigning the responsibilities of water management to the catchment or regional level, thereby involving communities.

2.5 Functions of water management institutions in South Africa

In SA, there are several formal institutions within a particular water management area (WMA) that are involved in the management of water resources and interacting with water users such as smallholder farmers. These water management institutions include WUAs, CMAs, DWS and municipalities. According to Ncube (2018), the highest water authority after the Minister is the DWS followed by CMA, followed by the WUA. The DoA as well as the Department of Rural Development and Land Reform (DRDLR) are also found within the WMA to provide support to farmers regarding water use licence applications (Ncube, 2018).

2.5.1 Department of Water and Sanitation

In SA, the allocation of water and issuing of water use licences were the key functions of the DWA to be carried out by the CMAs. The DWS is the custodian of the South African national water resources. The DWS acts through the Minister to manage the water resources of SA, develop a national water resource strategy, manage national water resources effectively, oversee the performance of other water management institutions as well as manage and maintain infrastructure such as storage reservoirs, dams and boreholes for communities in both rural and urban areas. The National Water Act also permits the Minister to assign many duties and powers to water boards, water management institutions, advisory committees and departmental officials. Developing national policy as well as a regulatory framework that governs how other institutions manage water resources are considered some of the long-term responsibilities of the department. Bulk water supply as well as the monitoring and controlling (water rights and licensing) is also the responsibility of the DWS.

2.5.2 Catchment Management Agencies

The CMAs were developed to be involved in the governance of water resources at a larger catchment level. The main aims of CMAs include coordinating and promoting public participation in water resources management within its WMA in accordance with catchment management strategy (Movik, 2011). The responsibilities of CMAs include the setting and collection of water charges as well as issuing water use licences (Movik, 2011). Catchment Management Forums (CMFs) and Catchment Management Committees (CMCs) are also found within CMAs. Unlike CMAs, CMFs have not been established through the NWA 36 of 1998. CMFs are non-statutory bodies established through the National Water Resources Strategy II. CMFs were established to democratise the participation of stakeholders in the management of water resources and give support to CMAs. They are regarded as suitable platforms to enhance cooperative governance between local government, CMAs and other stakeholder groups in the interest of integrated management to promote the management of water resources.

2.5.3 Water User Associations

WUAs are meant to oversee the governance of water resources at a local level. They were established to play a role in the transformation of the former Irrigation Boards (IBs). The IBs that were established under the 1956 Water Act through which farmers were working as a group to develop infrastructure and manage their water supply together were essentially a type of WUA. IBs qualified for a one-third capital subsidy on their shared water supply infrastructure but the membership was limited to the individuals who had land rights to receive services rendered by the IBs. Blacks were excluded from being a member of the IBs because the majority of them were not allowed to own land in white areas and no institution was available to cater for the needs of blacks. WUAs are made up of a group of individual water users who are willing to work together for their mutual benefit in water-related activities. The responsibilities of the WUAs are determined by their constitution and include investigating the quality and use of water, preventing illegal use of water; managing the existing water allocations, operating and maintaining water infrastructure, conserving water resources and supervising water resource use in their area of jurisdiction (Republic of South Africa, 1998). WUAs are also supposed to have equal representation in terms of gender, race and sector, as well as bringing together several water users to participate in the management of water resources. Additionally, WUAs are supposed to work very closely with the CMAs and they are responsible to collect fees for water use on behalf of the CMAs (Woodhouse, 2012).

2.5.4 Challenges of water management in South Africa

According to Kemerink et al. (2011), the legacy and segregation of the past still dominate the political and economic arena in SA, particularly how water is managed and allocated as well as people's involvement in the governance of water resources. Enqvist and Ziervogel (2019) believe that SA is still struggling with the racial inequality of the past, including its implications on water justice. Correcting injustices of the past to create a fair society regarding water access was one of the major aims of South African government policies such as the NWA (Hope et al., 2008). Unfortunately, despite the wide global recognition of the NWA as one of the most comprehensive water laws that aimed to redress inequalities from the past (Movik, 2009), little progress has been made on equitable water allocation. The distribution of water resources is still contested by the elite group. White farmers who acquired water licences a long time ago during Apartheid are still favoured in accessing water in comparison to black smallholder farmers (Chikozho et al., 2020). About 95% of the water is still possessed by white commercial farmers (DWS, 2018) and conflicts concerning agricultural water access are still experienced by smallholder farmers (Ncube, 2018). Most South African disadvantaged individuals, especially smallholder farmers, are still struggling to increase their access to productive water sources (Kemerink et al., 2011).

According to Rawlins (2019), the South African government has failed to fully drive and implement the reforms of water allocation through constructive reallocation which is considered the primary pathway for water reform. Several challenges have contributed to the unsuccessful implementation of the water policy, including insufficient funding, complexities of the legal framework for allocating water and poor cooperation between various government departments responsible for the contribution of successful water use applications as well as the administrative burden of water applications (Williams, 2018; Rawlins, 2019). Restrictive water rights or permit systems have hindered equitable water access and marginalised many smallholder farmers in SA who are involved in irrigation farming (van Koppen & Schreiner, 2019). Smallholder farmers are required to apply for a permit to access water for productive uses (irrigation). Unawareness of the requirements needed to apply for a permit, the inadequate administrative capacity of the State to inform and educate smallholder farmers about permit applications and enforcing and monitoring the conditions that are tied to the permit, are the cause of many smallholder farmers not having permits (van Koppen & Schreiner, 2019). Additionally, the development, regulation, implementation, administration, monitoring and enforcement of all policies related to water allocation are still centralised with the DWS (Rawlins, 2019). Even though the water policy in SA has been transformed, formal water institutions remain unknown to many smallholder farmers (Dlangalala & Mudhara, 2020). If the institutions that are responsible for governing the use of water resources are not known, it is very challenging to achieve effective outcomes of any efforts for improving water allocations.

To reallocate water from the advantaged to the economically highly disadvantaged individuals, the water allocation reform (WAR) policy was implemented in 2006. Unfortunately, the rate of implementation of the WAR was very slow, and its intended outcomes have not been met. For instance, compulsory licensing, which is regarded as one of the mechanisms of the WAR programmes, has not been implemented widely (Dlangalala & Mudhara, 2020). Compulsory licensing is the main legal and administrative process through which the initial allocation of water is conducted (Rawlins, 2019) and reallocations can only take place through the review process of licensing. However, in approximately 20 years since the enactment of the NWA of 1998, only 2.77% of water availability has been allocated through the process of compulsory licensing, which shows how slow the implementation of compulsory licensing by the DWS is (Rawlins, 2019). Current licensing processes are very lengthy, costly, bureaucratic and inaccessible to many South Africans (DWAF, 2013). Also, the NWA has been reported to be only progressive on paper, with slow implementation on the ground to achieve its intended water allocation objectives as stipulated by the South African Constitution. Inconsistency in access to water resources as well as the inhibition of smallholder farmers in challenging their unequal access to water for productive uses and asserting their rights due to structural, racial, and gender inequalities are also indications of the slow progress of the implementation of water reform in SA (Denby et al., 2016). The WAR aimed to allocate water to about 30% of historically disadvantaged individuals by 2014, of which 50% was supposed to be allocated to women (Williams, 2018). Unfortunately, in 2015 these targets were not achieved.

The exclusion of smallholder farmers in the frameworks of water management such as water governance processes and water management, as well as lack of information on the availability of water, are further water governance challenges experienced in the South African smallholder farming sector. Additionally, the disconnection between the reform programmes of land and water also places South African smallholder farmers in the dilemma of obtaining water without land or land without water (Kemerink et al., 2011). Pahl-Wostl (2015) notes that the impact of Apartheid ideology and the political system on the water sector shows that white farmers had a large water footprint compared to black smallholder farmers. This was because water access was linked to the ownership of land that was only assigned to white farmers. Lack of skills and empowerment to manage water resources compounded with poor technological skills have also been reported to limit the accessibility of water by smallholder farmers (Thamaga-chitja & Morojele, 2014). Also, even though WUAs were established to create agricultural water markets, various challenges emanate from accountability, inadequate representation of the interests of farmers and insufficient professional knowledge (Barrett et al., 2017).

2.6 Irrigation water

2.6.1 Irrigation water supply systems

An irrigation system is defined as a set of physical infrastructure and institutional components that are employed to convey, facilitate and control water movement from naturally concentrated sources to the root zone of crops at needed intervals (Small & Svendsen, 1990). The purpose of an irrigation system is to deliver an adequate and dependable supply of water equitably and efficiently to users served by the system (Molden & Gates, 1990). If there is a reliable water supply from a source, a properly operated and maintained irrigation system is capable of delivering an adequate and reliable amount of water to the required point of use. However, during water distribution, the diverted water from the source cannot reach its destinations without conveyance losses (Martin & Gates, 2014). In a canal system, seepage and evaporation are considered the main sources of conveyance losses (Ghazaw, 2012). Seepage refers to the amount of water that seeps through the sides of the canal bed and it is the major contributor to conveyance loss in most cases rather than evaporation. Swamee et al. (2002) report that the loss of water from evaporation is only significant in water-scarce areas that are associated with high rates of evaporation. Apart from reducing the amount of water delivered, seepage loss also causes problems such as waterlogging, groundwater contamination and salinization (Chahar, 2007; Ghazaw, 2012), as well as reducing the conveyance efficiency of irrigation systems. Conveyance efficiency indicates the amount of water that is lost in a distribution system and it is used to address the objective of efficiency in water delivery systems.

2.6.2 Irrigation water supply systems as common-pool resources

Irrigation water supply systems, just like forests, fisheries and pastures, are examples of common-pool resources (CPRs). There are two characteristics of a common-pool resource: (1) subtractability and (2) exclusion cost is high (Ostrom, 2005). Subtractability is the degree to which the consumption of the resource by one user diminishes resource availability to other users. Exclusion is defined as the difficulty of restricting the accessibility of the resource to the users. The sustainability of CPRs is dependent on the ability of users to overcome the problems of collective action during the management of their resources (McCord, 2017). The problems of collective action are usually created when the incentives of individuals differ from group incentives. For instance, in an irrigation system, the intention of upstream users might be to take a lot of water to boost their harvest but if all users act in the same manner the resource will be depleted. To solve these challenges of CPRs, rules that account for the divergence of individual and group interests are necessary. In irrigation systems, the challenge of excludability poses the risk of free-riders undermining the efforts that are required to maintain the infrastructure of irrigation systems (McCord, 2017). If the water supply is less than demand, water users will be forced to withdraw excessive water for fear that others might take their share if they do not use it (Ostrom et al., 1994). To prevent upstream users from taking excessive water at the expense of downstream users, effective allocation rules need to be in place, which will create a balance between the demand and supply of downstream water.

2.6.3 Performance evaluation of irrigation systems

The performance of the irrigation system entails the effectiveness of both the operation and physical systems for delivering irrigation water from a source (Irmak et al., 2011). According to Molden and Gates (1990), the success of an irrigation water delivery system is measured based on whether water is delivered according to predetermined water delivery goals in an adequate, dependable, efficient and equitable fashion and it can be determined by conducting a performance evaluation. Bos et al. (2005) describe the performance evaluation of irrigation and drainage systems as a systematic task that involves observation, documentation, and interpretation of the systems' management. There are various reasons for carrying out a performance evaluation of an irrigation system, such as to improve the management of the system (Clemmens & Molden, 2007), to determine the overall state of the system (Pereira et al*.,* 2012), to compare the performance of the system with others, and compare the performance of the system with its performance in previous years (Zardari & Cordery, 2010), to detect elements causing trouble in the system (Shakir et al*.,* 2010), to identify deficiencies in design, planning, management, maintenance and operation of the system (Sharma et al*.,* 2019). An irrigation water delivery system needs to be dependable as it enables farmers to plan. A dependable irrigation system with inadequate water supply is better than one which delivers adequate water unpredictably because it is impossible for farmers to plan if the water supply is unpredictable.

Various indicators have been used to evaluate the performance of irrigation systems (Gorantiwar & Smout, 2005). The indicators are grouped into external and internal performance indicators. External performance indicators are the major approaches that are usually used to evaluate the performance of irrigation systems (Clemmens & Molden, 2007), which include gross production and water use efficiency. According to Sharma et al. (2019), advancement in irrigation has led to the introduction of other approaches for evaluating irrigation system performance, such as the performance of water delivery in terms of equity, adequacy, efficiency and dependability as well as efficiency and system productivity. Determination of conveyance efficiency and seepage losses have also been widely used to assess the performance of irrigation canal systems (Sheng et al., 2003; Akkuzu et al*.,* 2007; Korkmaz et al., 2009; Kinzli et al., 2010; Sultan et al., 2014; Zhang et al., 2016; Eshetu & Alamirew, 2018).

2.6.4 Smallholder irrigation farmers in South Africa

There are about two million smallholder farmers in SA, many of which reside in areas where water resource availability is inadequate due to poor rainfall (Mabaya et al., 2011; Obi et al., 2012). Studies have shown that these farmers play an important role in creating job opportunities and alleviating poverty, especially in rural areas where they are situated (van Averbeke et al., 2011; Sinyolo et al., 2014). Despite some livelihood strategies such as social grants and pension remittances for most households in South African rural and marginalised areas, Thamaga-chitja and Morojele (2014) argue that smallholder farming will continue to play a leading role in providing required subsistence mainly in the form of food. About 70% of crop production in SA is rainfed but unfortunately, it is very challenging to achieve successful rainfed (dryland) crop production since only 35% of the country receives adequate rainfall (Council for Scientific and Industrial Research [CSIR], 2010). Despite the unreliability of rainfall in SA, Sinyolo et al. (2014) highlight the importance of smallholder irrigation farmers in enhancing agricultural production. In most parts of the country, rainfall is undependable and this makes smallholder irrigation critical for a variety of field and tree crops (Cousins, 2013).

The smallholder irrigation sector in SA is made up of about 5–8% of irrigable land. In 2013, less than 10% of the total farmable land, which is about 1.3 million hectares, was under irrigation, of which around 7.7% or 100 000 ha was utilised by smallholder farmers (Cousins, 2013). Initially, smallholder irrigation farmers were categorised into three groups, namely irrigation scheme farmers, independent irrigators and community gardeners or food-plot farmers. Irrigation scheme farmers are farmers who carry out farming activities on an irrigation scheme and they share infrastructure, a water source and at times irrigation equipment with other members within the scheme (du Plessis et al., 2002). Many of these farmers own land greater than 5 ha and are mainly situated in the former homelands and other places that are characterised by limited resources. Independent irrigators are individuals who are farming on land that was not part of an irrigation scheme and most often they do not have the title deed to their farmland (du Plessis et al., 2002). Additionally, the individuals run their irrigation systems and usually pump water from adjacent rivers or boreholes that they have developed themselves (Denison et al., 2016). Community gardeners or food-plot farmers are farmers who usually form part of community garden projects and they farm on very small plots of about a hundred square metres (du Plessis et al., 2002). These farmers also share irrigation equipment and a common water source. In their study, du Plessis et al. (2002) identified a fourth group of smallholder irrigation farmers called backyard farmers but other researchers call this group home-garden farmers. Backyard farmers or home-garden farmers are farmers who operate on a small plot which is similar to those of food-plot farmers but they do not form part of a group. They conduct farming within their homestead and irrigation water is normally supplied from municipal domestic piping systems, roof water tanks or greywater reuse (Denison et al., 2016).

Many smallholder irrigation farmers face various challenges that limit their expected extent of agricultural production to alleviate poverty. Zwane (2019) assert that the inadequate availability of water is one of the major factors contributing to the limitation of agricultural production in SA. Denby (2014) also indicates that water insecurity, particularly the inaccessibility of adequate and reliable water by smallholder farmers, is still a persisting challenge that has not been fully addressed since the end of the Apartheid era and the situation is exacerbated by extreme climate events such as drought. Most of the irrigation systems for smallholder farmers were reported to be performing below expectations. Weak institutional and organisational arrangements were regarded as the major causes for the dysfunction of these irrigation systems rather than the deficiencies of infrastructure (van Averbeke et al., 2011; Fanadzo, 2012). A review of the performance of irrigation systems conducted by van Averbeke et al. (2011) found that the poor performance of irrigation infrastructure for smallholder irrigation farmers was linked to inadequate maintenance and this can lead to artificial water shortages. In KwaZulu-Natal, infrastructure performance for smallholder farmers was reported to be deteriorating as a result of poor institutional arrangements and poor participation (Sharaunga

& Mudhara, 2018). Sinyolo et al. (2014) also point out that the governance of irrigation systems for smallholder farmers in SA has not received sufficient attention.

2.7 Conclusion

Smallholder irrigation farmers play a critical role in alleviating poverty, especially in rural areas. Unfortunately, many of these farmers in developing countries, including SA, are still faced with water insecurity challenges. Water insecurity is regarded as multi-dimensional whereby several groups of people are affected differently. Most often poor individuals such as smallholder farmers are greatly affected. In SA the situation of water insecurity is compounded by extreme weather events such as drought. During drought periods smallholder farmers are the most affected since most of these farmers lack adaptive capacity. Based on the reviewed literature, many factors influence water security. Generally, these factors are categorised into hydrology and governance dimensions. Hydrology dimensions entail the availability of water resources whereas the governance dimension involves issues about water access. Engineering and technical approaches are mostly used to solve water insecurity challenges. However, most often the crisis of water insecurity is a result of a water governance crisis rather than the unavailability of water resources. SA is generally not considered a fully water secure country when issues about governance are needed to be harnessed for the benefit of every citizen. The main objective of this study was to investigate the factors influencing water security for smallholder farmers by assessing the availability of agricultural water resources as well as the performance of irrigation infrastructure and water governance systems. This study is crucial in developing strategies for improving the water security status of smallholder farmers. Improving water security also plays a pivotal role in enhancing agricultural production.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Study area

The study was conducted in Genadendal (meaning the Valley of Grace) which is located approximately 120 km east of Cape Town in the WC province of SA (Figure 3.1). The GPS coordinates for this town are 34.0432º S and 19.5497º E.

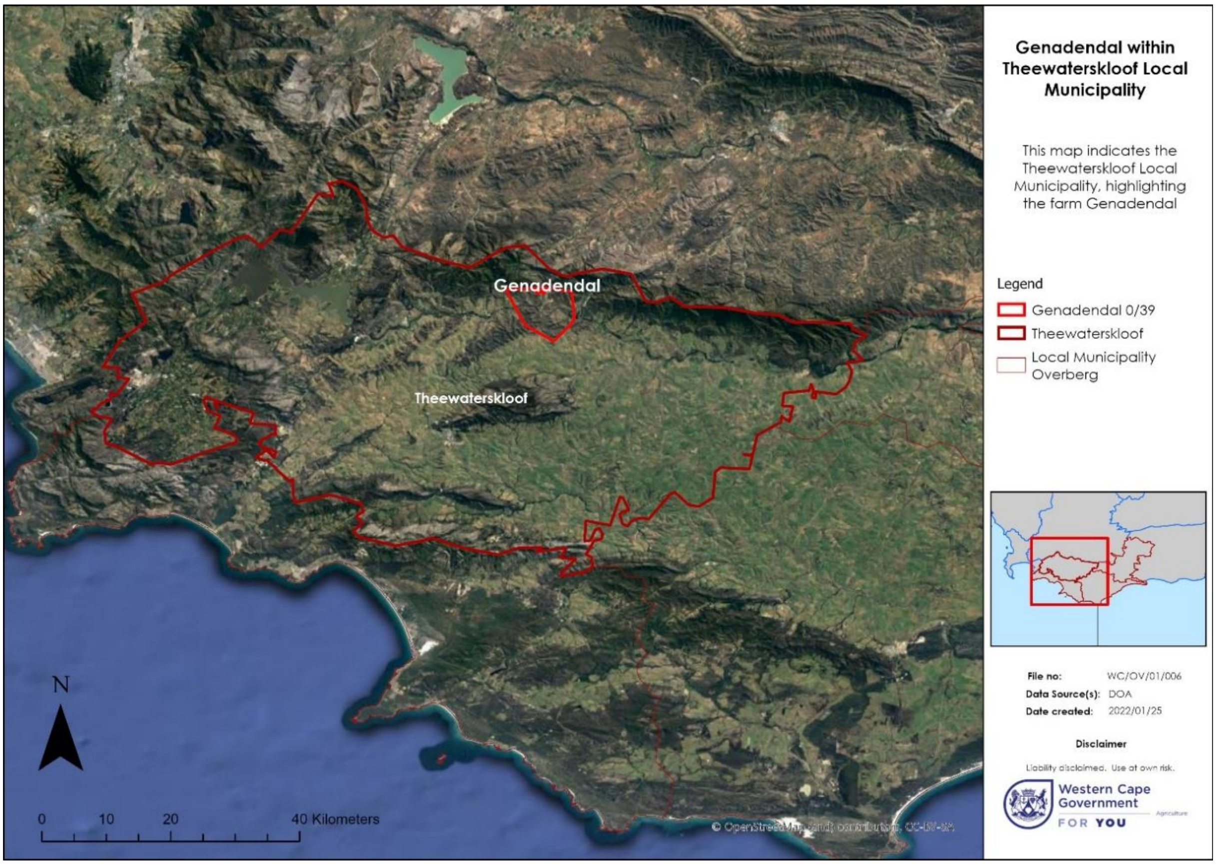

Figure 3.1: Location of Genadendal in the Western Cape Province, South Africa

Western Cape Government (2017)

Genadendal is a small historical town and the oldest Moravian mission station not only in SA but in Africa (Roos, 2002). It is situated in the foothills of the Riviersonderend Mountains in the Theewaterskloof Local Municipality under the jurisdiction of the Overberg District Municipality within the BGCMA and Breede River Valley/Basin close to the Theewaterskloof Dam which is the main storage reservoir for Cape Town. The town comprises about 4,500 ha of both urban and agricultural land (Swart et al., 2009). This town includes the outstation villages Voorstekraal, Bereaville and Boschmanskloof with a total population of 5,663 and 1,593 households (Statistics South Africa [Stats SA], 2011). For this study, the main village

(Genadendal), outstation villages and agricultural land are all referred to as Genadendal. Genadendal was the first industrial town and home to the first Teachers Training College (1838). At one time it was the second-largest formal settlement in the Cape with Cape Town being the largest (Swart et al., 2009). It used to be the bread basket of the Cape Colony where crops such as potatoes, cabbage, beans, onions, grain, almonds and apples used to be grown and processed for export. The economy of the town is dominated by various development projects that are mainly driven by local organisations as well as smallholder farming (Theewaterskloof Municipality, 2019). With regards to employment, most of the workforce is dependent on the surrounding fruit farms that assist in driving the seasonality of the local economy.

The formation of Genadendal was a result of the work of a Moravian missionary named Georg Schmidt. On 23 April 1738, Georg Schmidt moved to the end of Baviaanskloof (which was renamed Genadendal in 1806) and erected a hut, an irrigation water furrow system and a garden. Initially, the land in Genadendal was owned by the Moravian Church but later it was transferred to the State to enable it to be held in a trust for the community. Currently, Genadendal falls under the Rural Areas Act 9 of 1987 where the Minister of Land Affairs is the custodian and Theewaterskloof Local Municipality (TWKLM) is responsible for the management. This Act aimed to provide support for controlling, improving and developing rural areas that were reserved for coloureds. Just like other coloured communities in the WC province, Genadendal is a product of a difficult history characterised by high poverty and low levels of formal education. Agricultural development is mostly driven by the Genadendal Farmers Association (GFA) which comprises commercial farmers and smallholder farmers.

Genadendal has a Mediterranean climate, receiving most of its rainfall during winter and has an average Mean Annual Precipitation (MAP) of about 700 mm as well as the average Mean Annual Evaporation of 1,400 mm. The residents of Genadendal are dependent on smallholder farming on the floor of the valley of the Sonderend River below the settlement on the other side of the road opposite the residential houses. The town consists of a series of community allotment gardens for cultivating crops and vegetables divided by tree avenues, wire fences and quince hedgerows to allow livestock to graze freely in the open areas. These garden plots are very small in size and the locals call them '*tuine*' which means 'gardens' in Afrikaans. The traditional shared canal irrigation system of open water furrows (*leiwater vore*) that extends over the valley floor of Sonderend River on the southern slopes of the Riviersonderend Mountains is used to irrigate gardens (Swart et al., 2009). Community members are mainly reliant on surface water extracted from local rivers and streams in the Riviersonderend Mountain catchment Area, including the Riviersonderend river (Sonderend River). The mountain is regarded as the most important catchment for the Breede River draining directly into the Riviersonderend river which is one of the major tributaries of the Breede River.

Irrigation water for smallholder farmers is mainly gravity-driven and extracted from dammed reservoirs that are fed by the local rivers and streams from the mountains. The town has two dams and two reservoirs. One of the reservoirs is located above the residential area to collect water from the mountain streams and the other one is situated below the residential area to collect runoff from the upper reservoir.

3.2 Research design

Various approaches can be used to conduct any research. This study used both qualitative and quantitative approaches to answer the research questions and to achieve the objectives of the study. Qualitative research offers a broad understanding of concepts that far surpass those provided by quantitative analyses (Tewksbury, 2009). In this study, a qualitative approach was appropriate to provide an in-depth understanding of the perceptions of smallholder farmers and officials from water management institutions about the availability of water resources and the current state of water governance systems as well as the status and performance of irrigation water infrastructure in the study area. Qualitative research does not require any quantification means to produce research findings (Golafshani, 2003). Qualitative data for the study were collected through key informant interviews with officials from water management institutions as well as through a survey questionnaire and the focus group discussion conducted with smallholder farmers. In addition to a qualitative technique, a quantitative approach was also relevant to give a better understanding of the availability of water resources. Quantitative research refers to any kind of research that produces findings by making use of quantification means such as statistical procedures (Golafshani, 2003). Quantitative data were obtained from Agricultural Research Council (ARC) and DWS.

3.3 Sampling

The respondents were selected by purposive sampling (also called judgmental sampling). Purposive sampling involves the use of the judgement of an expert to identify respondents with essential experience to provide informative answers to the research questions (Neuman, 2014). The respondents (farmers and key informants) were identified and selected with the assistance of an agricultural extension officer of the WCDA. The purposive sampling technique was selected because it provided an opportunity for the selection of respondents who were knowledgeable about the issues under investigation.

3.4 Key informant interviews

Key informant in-depth interviews using semi-structured qualitative questions were conducted with relevant stakeholders and institutions involved in the management and governance of agricultural water resources in Genadendal. A semi-structured interview is one of the approaches used in qualitative research and involves outlining issues or topics that need to be covered. However, it does not restrict the interview to follow the order of the questions and wording. It also provides an opportunity to explore the views of respondents and to gain transparency of their way of interpreting issues under investigation. Qualitative questions are classified as open-ended whereby participants are allowed to respond in their own words. Open-ended questions are useful when possible answers to questions are not known or for collecting unexpected information (CDC, 2018c). The main aim of the interview is to gain in-depth information about perceptions, experiences, attitudes, insights or beliefs (CDC, 2018b). A high response rate is usually attained by conducting in-depth interviews because when the interviewer is not satisfied with the response it allows for follow-up questions to ensure clarity on the issue under investigation. However, this method is prone to bias and is time-consuming in terms of conducting the interview, transcribing responses and analysing the data collected (Boyce & Neale, 2006). An in-depth interview is not only about asking questions but also involves recording and documentation of responses as well as intense probing to get a deeper meaning and understanding of the responses.

In this study, the number of key informants interviewed was eight, which was feasible within the scope of the study, however, the goal was to interview as many key informants as possible until a saturation point was reached when no new information was obtained. Respondents that were interviewed included five officials from the BGCMA, two from the Western Cape Department of Agriculture (WCDA) and one from the DWS. The main purpose of the interviews was to collect data on the availability of water resources as well as the performance of irrigation water infrastructure and water governance systems from the perspectives of key informants. Questions on the impacts of drought on the availability of water resources were included in the interview. Interviews were conducted electronically because it was not possible to carry out face-to-face interviews due to the lockdown restrictions of COVID-19 that were imposed during the study. Conducting face-to-face interviews using qualitative questions is recommended rather than electronic interviews because face-to-face interviews are believed to capture more in-depth answers and the interviewer can observe how the interviewee is responding to questions physically. There is evidence that answers provided electronically are not significantly different from those in a face-to-face interview situation (Bryman, 2008). In addition, electronic interviews are advantageous in terms of cost and time saving as well as efficiency because large volumes of data can be captured.

3.5 Survey questionnaire

A questionnaire is defined as a set of questions (open-ended or closed-ended questions or both) used to gather information from individuals (CDC, 2018c). Closed-ended questions are composed of a list of predetermined answers from which respondents can choose whereas open-ended questions allow respondents to answer in their own words. Questions can be administered by telephone, mail, as handouts, electronically (that is by e-mail or through Web-based questionnaires) or in face-to-face interviews. Questionnaires are useful when there are limited resources and data from many people are needed, in maintaining the privacy of participants especially when sensitive information is gathered and in gathering unique information from individuals such as knowledge or attitudes (CDC, 2018c). Evaluation results are strengthened when a higher response rate is achieved. Response rate refers to the number of participants that responded to the questionnaire divided by the total number of participants included in the evaluation (CDC, 2018c). Response rates can be increased in various ways such as communicating the value of the questionnaire to the participants, providing incentives to the participants and following up with participants, especially if the questionnaire was administered electronically or by mail. A questionnaire is more appropriate to measure quantitative data but it can be used to obtain both qualitative and quantitative data (Abawi, 2017). In this study, the questionnaire was made up of both structured open-ended and closed-ended questions. The questionnaire was administered electronically to eight smallholder farmers with the assistance of an agricultural extension officer. The questionnaire captured information on the perceptions of farmers about the availability and governance of water resources for smallholder farmers as well as the performance of irrigation water infrastructure.

3.6 Focus group discussion

A focus group refers to a group interview for gathering qualitative data from participants with similar characteristics or sharing common interests (CDC, 2018a). It is a qualitative data collection method guided by a facilitator based on topics that have been predetermined. This method enables participants to share their views and perceptions. The data obtained using this method are descriptive and cannot be measured numerically. Focus groups are useful in gathering in-depth information from key stakeholders and collecting additional information as a supplement to the data that have been collected using quantitative methods and as part of a mixed-method approach to increase the validity of findings obtained from other methods.

A focus group discussion was held with 15 smallholder farmers to collect qualitative data. The purpose of the focus group discussion was to obtain an explanation of the issues about the availability of water resources as well as the performance of irrigation water infrastructure and water governance from the perspective of smallholder farmers. Issues concerning the impacts of drought on water resources were also asked during the focus group discussion.

3.7 Rainfall and runoff data

Climate data (rainfall) for the period 2013–2019 at Boontjieskraal weather station were obtained from ARC. Boontjieskraal weather station was chosen because it is the closest station to Genadendal in comparison to other weather stations. Also, streamflow data of Riviersonderend river and in the Riviersonderend river catchment recorded at H6H009 gauging station as well as dam level data of Theewaterskloof Dam recorded at H6R001 gauging station for the period 2013–2019 were acquired from an official of the DWS. This was because some smallholder farmers in Genadendal are reliant on water extracted from the Riviersonderend river which flows from Theewaterskloof Dam and also most smallholder farmers are primarily dependent on surface water extracted from various streams in the Riviersonderend catchment area. Additionally, the Riviersonderend river was selected because the various streams in the Riviersonderend catchment area do not have gauging stations. Only the data for the period 2013–2019 was considered because the study was mainly focused on the 2015–2018 drought period in the WC province and its effects on water resource availability in Genadendal.

3.8 Data analysis

Thematic analysis is a qualitative data analysis method that involves identifying, analysing and reporting themes or repeated patterns within the data set (Braun & Clarke, 2006). This method is appropriate when one needs to understand a set of thoughts, behaviours or experiences across a set of data. A theme is used to capture something which is crucial about the data concerning the overall research question of the investigation and it represents some degree of meaning or patterned feedback within the set of data. Thematic analysis is a widely used qualitative data analysis method whereby a six-step process is followed which includes familiarisation with the set of data, creating preliminary data codes, searching for patterns or themes, reviewing themes, interpreting and naming themes and developing the report (Kiger & Varpio, 2020). Besides describing data, the thematic analysis also involves interpretation during the processes of choosing data codes and developing themes. One particular disadvantage of thematic analysis is its susceptibility to inconsistency (Kiger & Varpio, 2020). However, this method offers flexibility and can be applied to a broad range of study questions, sample sizes and designs and it allows a researcher to summarise and highlight important aspects in a broad data set (Kiger & Varpio, 2020). The thematic analysis method was applied in this study to analyse qualitative data that was obtained from the interviews conducted with key informants and farmers. The six-step process as described by Kiger and Varpio (2020) was followed and Microsoft Word was used for coding the data. Line graphs were used to analyse the trends of monthly rainfall, streamflow and dam levels as well as the trends of weekly dam levels. Additionally, the trends of total annual rainfall and streamflow were analysed making use of bar graphs.

3.9 Ethical considerations

Before data collection was conducted, ethical approval was granted by the Ethics Committee of the Cape Peninsula University of Technology (see Appendix A). A permission letter to conduct this research in the selected study area was also issued by the WCDA (see Appendix B). Informed consent forms (see Appendices C and E) were prepared for respondents to sign before participation. The details of the study were fully explained to the participants. They were informed of their right to withdraw from the study at any time, without giving reasons, and that they would not suffer any prejudice. Participants were assured that all information obtained from them would be treated as strictly confidential and all information would be used only for this study. Respondents were also informed that their anonymity was assured. Permission to record the interviews was requested and granted by the participants, to enable the researcher to fill in gaps in the notes.

3.10 Research limitations

The study intended to conduct field measurements to assess the technical performance of irrigation water infrastructure. Unfortunately, due to the lockdown restrictions that were imposed as a result of the Covid-19 pandemic, it was not possible for the researcher to go into the field. However, to uphold the ethical standards of the research, protect the health of the participants and maintain the reputation of the WRC and CPUT, the researcher decided to use the perceptions of key informants and farmers that were gathered from the interviews that were conducted electronically.

CHAPTER 4

RESULTS

4.1 Introduction

This chapter presents the empirical data that were collected from smallholder farmers and officials of the DWS, BGCMA, WCDoA and ARC. The main purpose of the study was to investigate the determinants of agricultural water access by smallholder farmers in the Genadendal area by considering the dimensions of water resource availability, infrastructure performance and irrigation water governance.

4.2 Availability of agricultural water

The results on the availability of agricultural water resources, particularly for smallholder farmers in Genadendal, are presented based on changes in rainfall, streamflow and dam levels as well as on the perceptions of smallholder farmers and key informants. The hypothesis tested was that there is no shortage of water in Genadendal even during drought periods.

4.2.1 Changes in rainfall at Boontjieskraal weather station

The changes in average monthly rainfall at Boontjieskraal station for the 2013–2019 period are illustrated in Figure 4.1. The highest average monthly rainfall of 134.6 mm was attained in August 2013 and the lowest of 2.0 mm was recorded in December 2019. During the winter seasons, the highest average monthly rainfall was received during August (2013–134.6 mm), June (2014–101.6 mm), July (2015–97.3 mm), July (2016–84.3 mm), August (2017 51.1 mm), June (2018–58.7 mm) and July (2019–41.4 mm). Low average monthly values of winter rainfall were also observed during June (2017–15.5 mm) and July (2017–8.9 mm). Based on the trendline, the average monthly rainfall was decreasing over the reporting period.

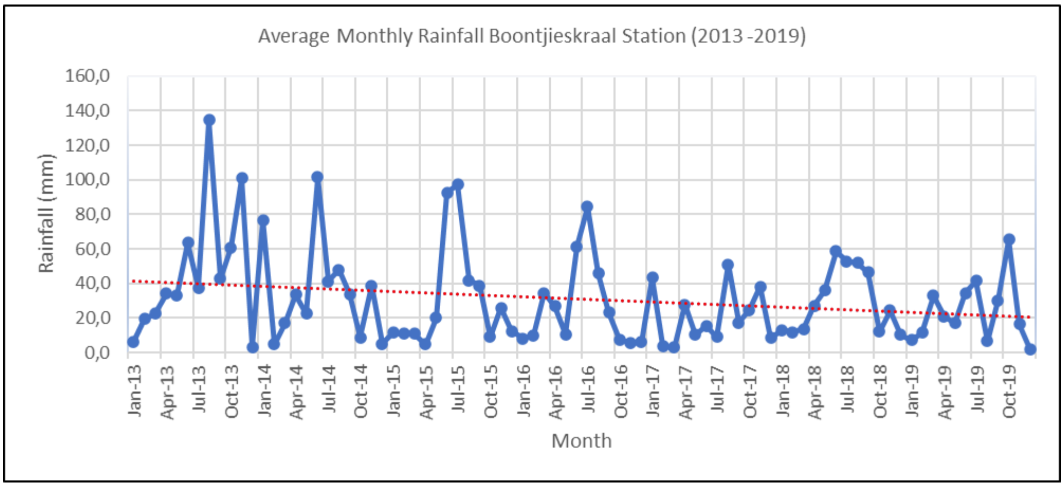

Figure 4.1: Average monthly rainfall for the Boontjieskraal weather station for the period 2013–2019

Figure 4.2 depicts the changes in total annual rainfall for the Boontjieskraal weather station for the period 2013–2019. The highest total annual rainfall of 558.81 mm was attained in 2013 and the lowest total annual rainfall of 251.7 mm occurred in 2017. The average annual rainfall received in 2017 was below 350 mm, which is considered the annual average rainfall of the WC province. The total annual rainfall was decreasing during the reporting period as shown by the trendline. Additionally, total annual rainfall was declining from the years 2013 to 2017.

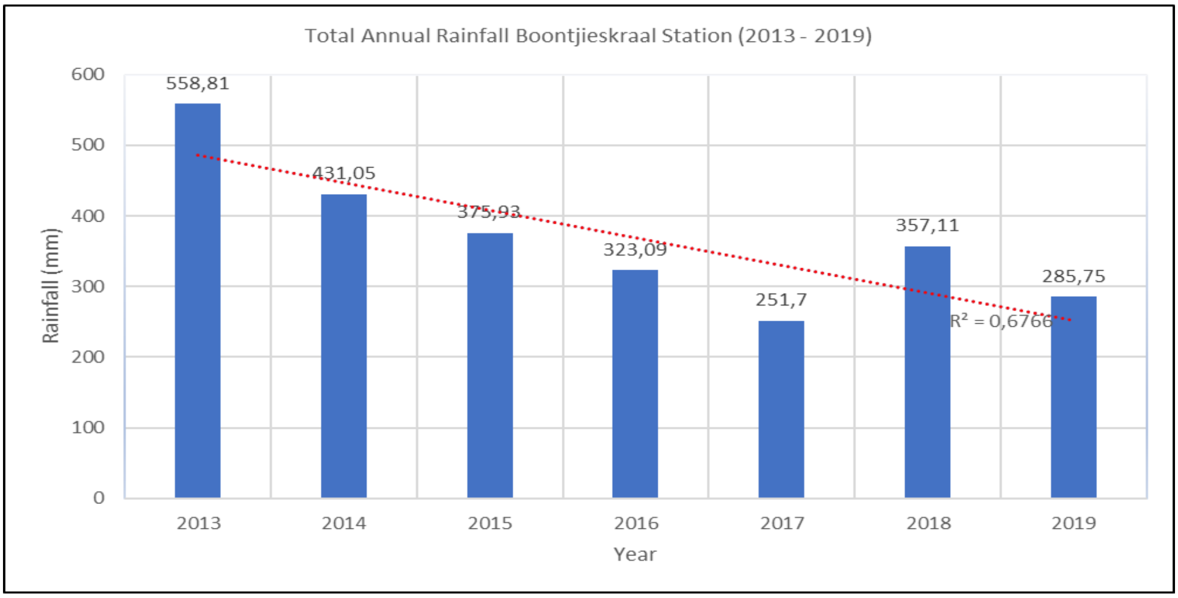

Figure 4.2: Total annual rainfall for the Boontjieskraal weather station for the period 2013–2019

4.2.2 Changes in streamflow for Riviersonderend River

Figure 4.3 indicates changes in average monthly streamflow in the Riviersonderend river recorded at the H6H009 gauging station for the period 2013–2019. The highest value of average monthly streamflow of 62.84 m^3/s was experienced in January 2014. The low values were in the range of 0.08 to about 3 m^3/s and were mostly attained from October 2016 through to February 2019. During the winter seasons, the peak average monthly streamflow was received during September (2013–50.09 m^3/s), August (2014–21.52 $m^3/2$), July (2015–19.62 m^3/s), September (2016–7.54 m^3/s), September (2017–1.81 m^3/s), September (2018–3.23 m^3/s) and July (2019–2.77 m^3/s). The trendline shows a decrease in average monthly streamflow during the reporting period. Low average monthly values of winter streamflow were observed during June (2017–0.98 m^3/s), June (2018–0.7 m^3/s), August (2019–0.91 m^3/s), and September (2019–0.04 m^3/s).

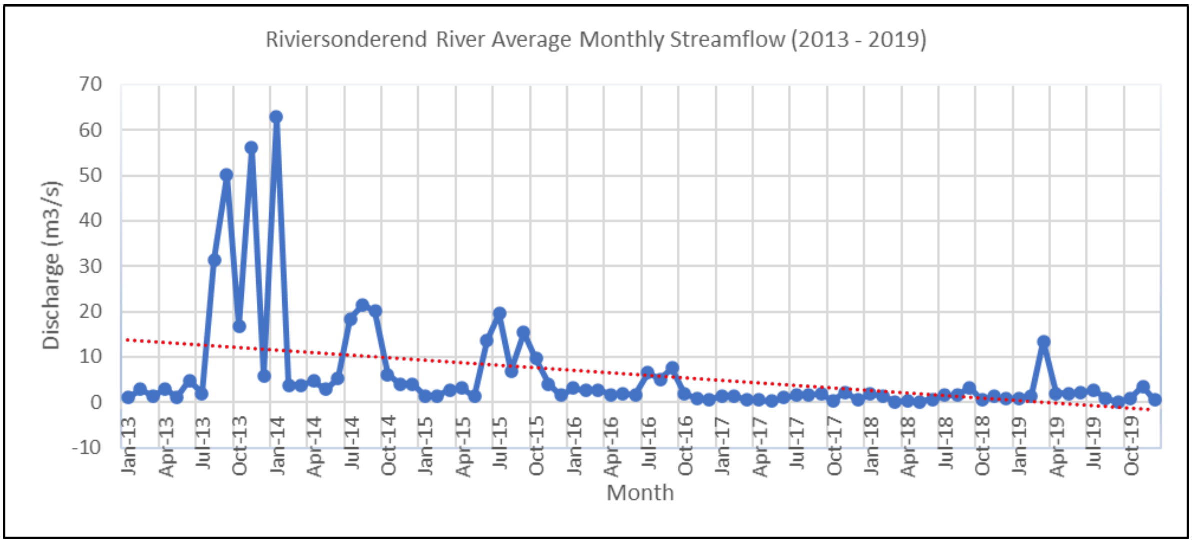

Figure 4.3: Average monthly streamflow in the Riviersonderend river for the period 2013–2019

Figure 4.4 below illustrates the annual total streamflows in the Riviersonderend river catchment recorded at the H6H009 gauging station for the period 2013–2019. The residents of Genadendal are mainly reliant on surface water drawn from the Riviersonderend catchment. Annual total streamflows decreased during the reporting period. The highest annual total streamflow of 460.7 million cubic metres (MCM) was obtained in 2013 and the lowest value of 33.49 MCM in 2017.

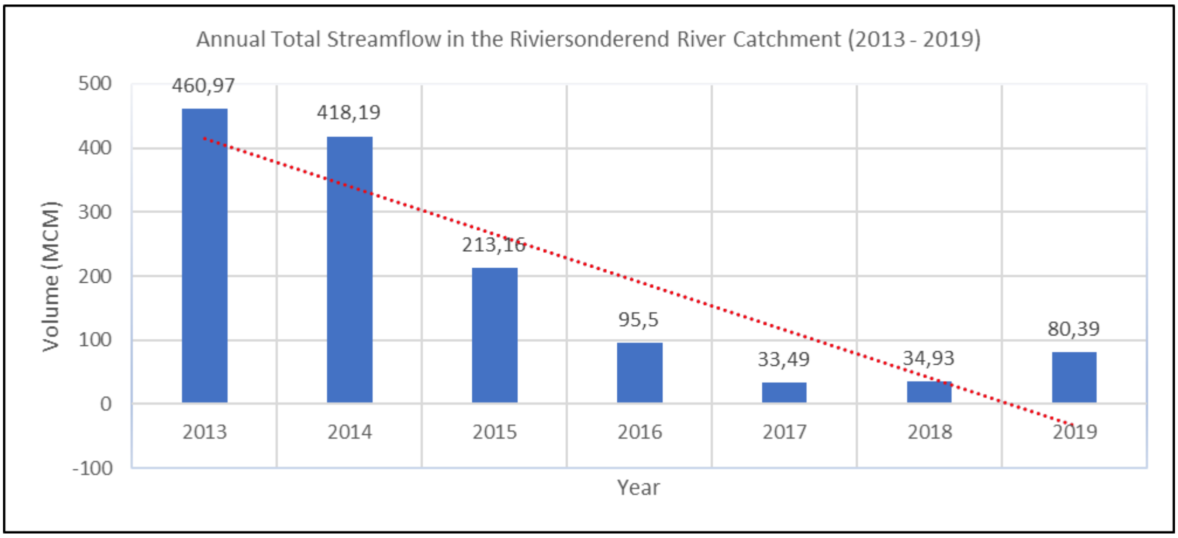

Figure 4.4: Annual total streamflow in MCM in the Riviersonderend river catchment for the period 2013–2019

4.2.3 Changes in water levels for Theewaterskloof dam

Figure 4.5 illustrates the monthly percentage storage of Theewaterskloof Dam at the H6R001 gauging station for the period 2013–2019. The highest percentage storage of 107 was in September 2013 and the lowest percentage storage of 10.3 was in April 2018. During winter seasons, peak monthly percentage storage was experienced during September (2013–107%; 2014–105.7%; 2015–73.4%; 2016–51.7%, 2017–26.1%; 2018–47.7%; 2019–71.7%). Generally, monthly percentage storage decreased from 2015 to 2017 and the winter monthly percentage storages were very low in 2017 in comparison to other years. Low percentage storage below 30% was also observed from March 2017 to June 2018.

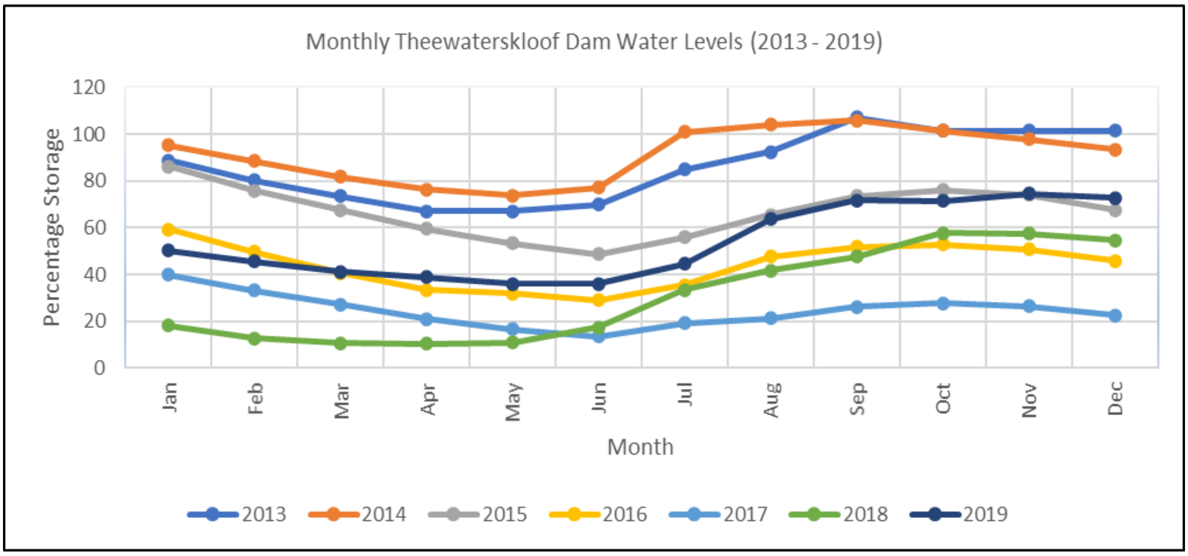

Figure 4.5: Monthly percentage storage of Theewaterskloof dam for period 2013–2019

Figure 4.6 demonstrates distinct peaks of the weekly percentage storage of Theewaterskloof Dam at the H6R001 gauging station for the period 2013–2019. The highest peak of weekly percentage storage of 107.4 was observed during the first week of September 2013 and the lowest peak of about 28.2 was during the third week of September 2017. Generally, the lowest peak weekly percentage storage was observed during the year 2018.

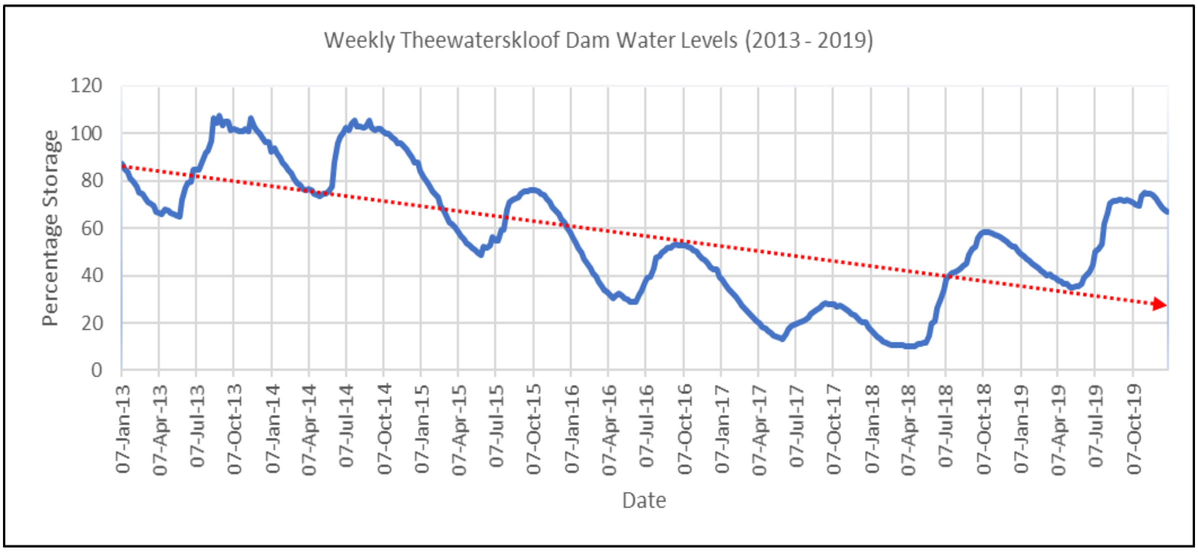

Figure 4.6: Weekly percentage storage of Theewaterskloof dam for the period 2013–2019

4.2.4 Views of smallholder farmers on their water resources for agriculture use

Table 4.1 illustrates the profile of eight smallholder farmers that were interviewed and their views concerning water resources and the impact of drought on water resources in Genadendal during the 2015–2018 drought period. Results from the focus group discussion that was conducted with 15 smallholder farmers concerning water resources in Grenadendal are also presented.

Table 4.1: Profile of smallholder farmers

Farmer	Gender	Farming Practise	Farming experience	Farming purpose	Ownership of Land	Land Use Security	Water License	Water Use Payment
Farmer 1	Male	Livestock	24 years	Mainly for sell	Leasing	No	Yes	Yes
Farmer 2	Male	Livestock	9 years	Mainly for sell	Inherited	No	No	No
Farmer 3	Male	Livestock	2 years	Mainly for sell	Leasing	Yes	Yes	Yes
Farmer 4	Male	Livestock and vegetables	18 years	Mainly for sell	Leasing	Yes	Yes	Yes
Farmer 5	Male	Livestock and vegetables	20 years	Mainly for sell	Leasing	Yes	Yes	Yes
Farmer 6	Male	Livestock and vegetables	33 years	Mainly for sell	Inherited	No	No	No
Farmer 7	Female	Vegetables	14 years	Mainly for sell	Inherited	No	Yes	Yes
Farmer 8	Male	Livestock and vegetables	30 years	Mainly for sell	Leasing	Yes	Yes	Yes

Table 4.1 shows that most of the farmers interviewed (n = 7 out of 8) were males. Half of the farmers (n = 4 out of 8) practised mixed farming (livestock and vegetables) and it was also mentioned during the focus group discussion that most farmers practised livestock and vegetable farming. All of the farmers practised farming with the main purpose of selling their agricultural produce. Concerning farming experience, more than half of the farmers (n = 6 out of 8) had more than 10 years of experience in farming, 18 years was the average farming experience with 2 years being the minimum. In terms of water use licences, almost all farmers (n = 6 out of 8) were holders of water use licences and paid their water use fees. Most of the farmers (n = 5 out of 8) leased land from the municipality and half of the farmers (n = 4 out of 8) did not have land use security.

Table 4.2 shows the perceptions of farmers regarding water sources and drought occurrence in Genadendal

Table 4.2: Perceptions of farmers regarding water sources and drought occurrence in Genadendal

Farmer	Sources of Water	Water is sufficient from water sources throughout the year	There were drought or water shortages during the 2014–2018 period	There were drought or water shortages during the 2009–2018 period
		Responses		
Farmer 1	River	No	Yes	Yes
Farmer 2	Dam	No	Yes	Yes
Farmer 3	Dam and river	Yes	No	No
Farmer 4	Two dams	Yes	No	No
Farmer 5	River	Yes	Yes	Yes
Farmer 6	Dam	Yes	No	No
Farmer 7	Dam	Yes	No	No
Farmer 8	River	Yes	Yes	Yes
Total respondents (n)		Yes (n = 6) No (n = 2)	Yes (n = 4) No (n = 4)	Yes (n = 4) No (n = 4)

Table 4.2 reveals that most of the farmers (n = 5 out of 8) were reliant on water drawn from the irrigation dams. Farmers 5 and 8, who depend on water from the Riviersonderend river, had the view that their water source could hold enough water all year round. However, despite relying on the same river as farmers 5 and 8, farmer 1 indicated that their river did not have adequate water throughout the year. Farmers 2, 6 and 7 were reliant on water extracted from the same irrigation dam but farmer 2 had a different view from farmers 6 and 7 regarding the adequacy of water from their source. Farmers 6 and 7 pointed out their water source carried sufficient water throughout the year while farmer 2 held the opposite view. Farmer 6 further explained that their dam used to be dry throughout the year while water from the mountain and overflow of the municipal dam flowed next to that dam but since a trench was made to direct that water into the dam, water was now available all the time. Farmer 7 further pointed out that the water that is available to them was always sufficient for their farming activities. Regarding water from the dam, it was stated during the focus group discussion that there was enough water and this was expressed by one of the farmers who indicated that they are lucky on their side because that dam was always supplied with enough water from the perennial mountain streams. Farmer 3 relied on water extracted from a dam and the river while farmer 4 was supplied with water from two dams. Both farmers 3 and 4 stated that their water sources were dependable in terms of holding enough water all year round. During the focus group

discussion, it was highlighted that there are many fountains in Genadendal that have been flowing ever since and this indicated that water was always available.

Farmers were asked if they had experienced drought or water shortages during the 2009–2018 period to check if they had been affected by the recent 2015–2018 drought which occurred in the WC province. Farmers 1, 5 and 8, who extract water from the same river, and farmer 2 who uses water from a dam, share the same perceptions that they had experienced water shortages during the 2009–2018 period. This indicates they had been affected by the 2015–2018 drought. Farmer 8 further emphasised that the water levels in their river were very low during the 2015–2018 period. This view was also expressed by one of the farmers during the focus group discussion, who indicated that the river that supplied them with water was very dry and they had to move their livestock to the other side of the river. Other farmers also stated that they had been severely affected by the 2015–2018 drought and their oats and tea crops had died because it was very dry and the wind was very strong. Additionally, some farmers were of the view that the river only started to get dry when the alien plants were removed from the river, which was also expressed during the focus group discussion.

> In Genadendal it is not a matter of having rain or water or not. I think ever since alien clearance started, the water supply changed and it went down. In the past, the river never dried, once the alien clearance was done it affected the water supply. We have the water but the infrastructure is down. We can show you at the foot of the mountain there used to be plants growing and always water flowing, but ever since they cut alien trees they dried. And the authorities who were responsible for cutting alien plants also claimed that pine trees affected the supply of water. (Focus Group Discussion)

Additionally, farmers believe that when the trees were cut down the wind started to get stronger, increasing the rate of evaporation from the river and there was nothing that could help them to reduce the loss of water due to evaporation.

> Once again, human impact is bigger here and climate. When they cut the pine trees the wind gets stronger here, the wind blows out. There is nothing that can help us to reduce evaporation. (Focus Group Discussion)

Additionally, farmers 3, 4, 6 and 7 expressed that there were no water shortages during the 2009–2018 period. Farmer 6 further highlighted that they never experience water shortages because the municipal dam overflow is always flowing into their dam and they could only suffer from water shortages if the municipality decided to close its dam. Farmer 7 also pointed out that they have never faced a water shortage challenge because they have their water which always flows from the perennial mountain streams into their dam. During the focus group discussion, it was also stated that smallholder farmers were not seriously affected by drought in Genadendal because they believe that the grace of God is upon them. Also, farmers indicated that the drought had only seriously affected those farmers outside of Genadendal.

> Here in Genendendal not too much drought, we live in a graced area and I think the grace of God is upon us. But outside Genendendal you can see it clearly, but not here. (Focus Group Discussion)

4.2.5 Perspectives of institutions regarding water sources for smallholder farmers

Table 4.3 illustrates the profile of the key informants from institutions who were interviewed, regarding agricultural water resources for smallholder farmers in Genadendal.

Table 4.3: Profile of key informants from institutions

Key informant	Organisation
Key informant 1	Western Cape Department of Agriculture (WCDoA)
Key informant 2	Western Cape Department of Agriculture (WCDoA)
Key informant 3	Breede-Gouritz Catchment Management Agency (BGCMA)
Key informant 4	Breede-Gouritz Catchment Management Agency (BGCMA)
Key informant 5	Breede-Gouritz Catchment Management Agency (BGCMA)
Key informant 6	Breede-Gouritz Catchment Management Agency (BGCMA)
Key informant 7	Breede-Gouritz Catchment Management Agency (BGCMA)
Key informant 8	Department of Water and Sanitation (DWS)

Concerning water sources, key informants 1, 2 and 8 indicated that some smallholder farmers in Genadendal are reliant on surface water drawn from the Riviersonderend river which is situated within the Riviersonderend catchment as well as from the irrigation dams. Key informant 2 pointed out that the Riviersonderend river flows from the Theewaterskloof Dam which is the main dam supplying water to the City of Cape Town. Besides relying on water from the river, Key informant 1 also stated that agricultural water for farmers who depend on irrigation dams flows from the perennial mountain streams.

The key informants were asked for their perceptions about the adequacy of water in water sources for smallholder farmers. Key informants 1, 2 and 8 shared the same opinion, that there is enough water in Genadendal which opinion was supported by key informants 1 and 2. Key informant 2 highlighted that the average or normal rainfall of Genadendal is adequate to provide water for the year and key informant 1 also stated:

> Genadendal is situated in a winter rainfall area and during the rainy season irrigation water is harvested in irrigation dams for utilisation during the summer production season. The Riviersonderend river and the streams that flow from the mountains in the Genadendal area normally run through the summer season therefore water remains available throughout the year. Water used during the day from the irrigation dams is restored during the night flow.

Key informants were questioned if smallholder farmers in Genadendal had been faced with the 2015–2018 drought which occurred in the WC province. Key informants 1 and 2 agreed that smallholder farmers did face water shortages for farming during the 2015–2018 drought period. Key informants 1 and 2 also highlighted that smallholder farmers, especially the ones using water from the Riviersonderend river, were severely impacted by the drought. These key informants further indicated that because of the limited availability of water during the 2015–2018 period, some smallholder farmers were forced to scale down their normal vegetable production and other smallholder farmers were forced to transport water to their livestock. Concerning smallholder farmers who practise vegetable farming, key informant 2 pointed out that their production was reduced to less than 10% of their capacity. Key informant 1 also asserted that up to 80% of summer water use restrictions were imposed during the 2015–2018 drought period.

4.3 Conditions of irrigation water infrastructure

The results on the status and performance of irrigation water infrastructure supplying water to smallholder farmers in Genadendal are presented, based on the perceptions of smallholder farmers and key informants. The hypothesis tested was that lack of infrastructure maintenance is causing artificial water shortages for smallholder farmer production.

4.3.1 Views of smallholder farmers about irrigation water infrastructure performance

Table 4.4 illustrates the type of irrigation infrastructure used by smallholder farmers as well as the description of how water was transported from the sources to the fields of the farmers. Farmers 1, 3, 5 and 8 were reliant on water extracted directly from the river using petrol pumps through pipes to the fields while farmers 2, 3, 4, 6 and 7 were dependent on water from irrigation dams and their water was moved by the force of gravity through pipes to the fields. Farmer 6 used a petrol pump to extract water from the earthen canal system to the field and the water in the earthen canal system flowed from the dams.

Table 4.4: Type of irrigation infrastructure

Farmer	Infrastructure	Description
Farmer 1	Concrete canals, pipes and petrol pump	Water is pumped from the river through pipes via concrete canals to the field
Farmer 2	Irrigation dam and earthen canals	Water flows from the dam by gravity through earthen canals to the field
Farmer 3	Irrigation dam and pipes	Water is pumped from the river to the field through pipes to the field. Some water flows by gravity from the dam through pipes to the field
Farmer 4	Irrigation dams and pipes	Water flows from the dams by gravity to the field through pipes
Farmer 5	Pipes and petrol pump	Water is pumped from the river through pipes to the field
Farmer 6	Irrigation dam, pipes and petrol pump	Running water from the mountain is pumped through pipes to the garden and also water flows from the dam by gravity through pipes to the field
Farmer 7	Irrigation dam and pipes	Water flows by gravity from the dam through pipes to the field
Farmer 8	Pipes and petrol pump	Water is pumped from the river through pipes to the field

The performance of irrigation water infrastructure is critical to ensure that water is distributed efficiently, reliably and equitably to the fields of farmers**.** Table 4.4 shows that most of the farmers (n = 7 out of 8) relied on pipes to transport water from the sources to their fields. Farmers 6 and 7 emphasised that water for smallholder farmers is mainly transported through pipes from the irrigation dams to the field of each smallholder farmer for about six hours. Only farmer 2 transported water from the dam to the field using an earthen canal and farmer 1 used concrete canals to transport water from the river. This indicates that very few farmers used canal systems because most of the canal systems were not operational. It was stated during the focus group discussion that many canal systems have been blocked. Another farmer during the focus group discussion pointed out that they were forced to use municipal water because the canal systems from the dam were not functional due to a lack of maintenance. This view was supported by one of the farmers who had access to 15 ha of the land but unfortunately, was only able to cultivate 2 ha because access to water through canal systems had been blocked. It was also expressed during the focus group discussion that there is plenty of water in Genadendal and it is not a matter of having rain or not but the irrigation infrastructures for delivering water from the source to the fields are not fully operational.

Smallholder farmers also highlighted that each farmer used to be responsible for cleaning and maintaining the canal systems in their area but unfortunately it is no longer possible because they do not have time due to off-farm employment outside Genadendal. Both canal systems and pipelines faced inadequate maintenance challenges. This was indicated during the focus group discussion when farmers expressed that on top of the canal systems, even the pipelines were not maintained. Farmers also expressed their concerns that there was funding that was invested by responsible organisations for canal maintenance but unfortunately no funding was assigned for the Genadendal area. As a result, pipelines were installed in other areas but not in Genadendal. According to farmer 6, there are no organisations that support them with water infrastructure and a lot of water flowing from the mountain and dam is being wasted and their water storage infrastructure is not sufficient so most of the water is lost to the rivers.

4.3.2 Irrigation water infrastructure management in Genadendal

The profile of key informants interviewed from institutions is shown in Table 4.3. Key informants were asked what were the responsibilities of their institutions as well as the challenges concerning water infrastructure management for smallholder farmers in Genadendal. Key informants 1 and 2 indicated that their institution's focus is on the development and maintenance of irrigation infrastructure, including dams, canals and pipelines for smallholder farmers. Additionally, key informant 1 indicated that their institution helps with electrical water pumps and water meters. Key informants 1, 2 and 8 further pointed out that there is a shortage of technical staff and it is very challenging to carry out water infrastructure maintenance work for smallholder farmers in Genadendal. Key informant 2 indicated that their institution is not able to fully support smallholder farmers with infrastructure maintenance and can only assist to a certain degree. Key informant 1 asserted that due to inadequate technical staff, some committee members who are part of smallholder farmers in Genadendal worked voluntarily to maintain infrastructure, despite not having enough resources.

Key informants 4 and 5 highlighted that they assist smallholder farmers to apply for funding that they can use to maintain all infrastructure that needs to be maintained. However, the applications that they received from farmers requesting funding had not been successful due to insufficient funding from the institution which was responsible for supporting farmers with funding. Key informant 4 also indicated that most often the funding is restricted to farmers who are part of a WUA but most of the smallholder farmers in Genadendal were not members of any WUA. Supporting smallholder farmers with water infrastructure development and maintenance was also reported by key informant 5 as the biggest challenge not only facing Genadendal but the whole of SA. Additionally, key informant 5 highlighted that the smallholder farmers who complained about the water problems, in most cases the water might be available but the problem was the absence of or dysfunctional irrigation infrastructure to extract water from the source and transport it to the field.

4.4 State of irrigation water governance systems

The results on the performance of water governance systems for irrigation water in Genadendal are presented based on the perceptions of smallholder farmers and key informants. The hypothesis tested was that the challenges of access to agricultural water by smallholder farmers in Genadendal are mainly caused by dysfunctional water governance systems.

4.4.1 Awareness of water management institutions and their roles as perceived by smallholder farmers

Table 4.5 lists the names of institutions that are responsible for managing irrigation water in Genadendal as well as their roles and responsibilities as perceived by smallholder farmers. More than half of the respondents (farmers 1, 2, 3, 4, 6 and 7) listed Genadendal Transformation Committee (GTC) as the local water management institution for smallholder farmers in Genadendal. However, these farmers had different views on the roles and responsibilities played by GTC. Farmers 1, 4, 6 and 7 indicated that the responsibility of GTC is to allocate water use rights to smallholder farmers. On the other hand, farmers 2 and 3 pointed out that the GTC is responsible for land redistribution in Genadendal. Farmers 1, 4 and 5 also highlighted that over and above issuing water use rights, GTC is also responsible for collecting water use fees from farmers. Less than half of the respondents (farmers 1, 5 and 8) highlighted ZWUA and GFA as the institutions responsible for the governance of water in Genadendal. Farmers 1, 5 and 8 added that it is the duty of ZWUA and GFA to issue water use rights. Additionally, farmers 5 and 8 pointed out that ZWUA and GFA also have the responsibility of collecting water use fees and managing the Genadendal area in general.

Table 4.5: Water management institutions in Genadendal and their functions from the perspective of smallholder farmers

Farmer	Organisations	Roles and Responsibilities
Farmer 1	GTC and GFA	Collect the water fees from water users and issue letters to allow farmers to use water.
Farmer 2	GTC	Redistribution of agricultural land in Genadendal.
Farmer 3	GTC	Implementing the transformation of the land and managing the village of Genadendal
Farmer 4	GTC	Collect water fees and allocate water use.
Farmer 5	ZWUA and GFA	Water use licensing and local management of the Genadendal area.
Farmer 6	GTC	Give authority to have water use rights.
Farmer 7	GTC	Collect water fees and give authority to have water use rights.
Farmer 8	ZWUA and GFA	Collect water fees and allocate water use rights.

4.4.2 Smallholder farmers' views on selected water governance indicators

Table 4.6 illustrates the distribution of responses of farmers who agree or disagree with each water governance indicator statement. Out of eight smallholder farmers, only six provided complete responses.

Table 4.6: Distribution of responses per water governance indicator statement

Indicators	Number of respondents (n)		
	Agree	Neutral	Disagree
Capacity Building	2	0	4
Sustainability	5	1	0
Equity	5	0	1
Participation	2	0	4
Accountability	1	0	5
Rule of law	3	0	3
Transparency	5	0	1
Cooperation	5	0	1
Conflict Resolution Mechanisms	3	0	3
Conflict Resolution Satisfaction	2	0	4

More than half of the smallholder farmers (n = 4 out of 6) pointed out that they did not receive any training about the optimal use of irrigation water. Almost all respondents (n = 5 out of 6) indicated they conserved irrigation water to ensure its future availability. Unequal allocation of water can result in water insecurity. Almost all smallholder farmers (n = 5 out of 6) highlighted that there was equity regarding water use in Genadendal. These respondents also pointed out that everyone had equal access to irrigation water regardless of gender and there was fairness in the handling of irrigation water issues. The participation of farmers in irrigation and water management activities could assist in improving their water use security. Concerning participation, more than half (n = 4 out of 6) of the smallholder farmers stated that they were not directly involved in the processes that involve development, planning and decision-making for irrigation water.

Almost all respondents (n = 5 out of 6) were of the view that decision-makers were not accountable to the farmers in the case of maladministration as well as not fully committed to their roles and responsibilities. Also, during the focus group discussion, farmers indicated that they were not usually given opportunities to discuss their water challenges with government officials.

> The meeting arrangement for growing tea with an official from ARC was postponed and it never happened. We wanted to discuss water problems and we were eagerly waiting for the promise. (Focus Group Discussion)

Half of the respondents (n = 3 out of 6) highlighted the availability of mechanisms and practices for addressing water conflicts. Respondents also indicated that farmers who break rules were usually given sanctions according to the set procedures and rules. Almost all respondents (n = 5 out of 6) pointed out that information concerning the governance and management of irrigation water was usually made known to farmers. Half of the respondents (n = 3 out of 6) indicated the availability of conflict resolution mechanisms. Less than half (n = 2 out of 6) of the respondents stated that conflict resolution relating to irrigation water allocation was not usually resolved to the satisfaction of those farmers who are involved.

4.4.3 Roles played by institutions in the governance of irrigation water

Key informants were asked about the roles and responsibilities played by their institutions concerning the governance and management of irrigation water for smallholder farmers in Genadendal. The profiles of the key informants from institutions who were interviewed are shown in Table 4.3.

Key informant 2 reported that the WCDoA is not directly involved in the governance and management of irrigation water in Genadendal. Key informant 1 indicated that the WCDoA assists with the procurement of water rights, especially for smallholder farmers who use irrigation water extracted from the Riviersonderend River. In addition, key informants 1 and 2 stated that the Genadendal area is a licensed water user and it is the responsibility of the ZWUA to regulate water use as well as to guide other local organisations, mainly GTC and GFA about water use. Key informant 2 further added that the ZWUA is governed by the South African National Water Act to carry out its roles and responsibilities. Key informant 1 also asserted that it is the responsibility of the local committees, especially the GTC and GFA, to collect water use fees and pay them over to water authorities.

According to key informant 3, the BGCMA is responsible for water use management, water resource planning, water allocation, and water resource protection. Key informants 3, 6 and 7 also stated that the BGCMA is involved in assisting farmers with the process of applying for water use rights so that they can get access to water.

Key informant 4 highlighted that in some cases the BGCMA also intervenes to bring together institutions that are not willing to assist smallholder farmers concerning water access. In terms of water allocation for smallholder farmers, key informant 5 stated that the BGCMA is a recommending authority, only plays a legislative role, and it is the responsibility of the DWS to make a final decision. Key informant 6 pointed out that BGCMA also plays a major role in facilitating discussions between smallholder farmers, the WCDoA and the local municipality since not all smallholder farmers are supposed to apply for water use licences through the BGCMA and that some are required to apply through the WCDoA. Lastly, key informant 8 stated that the DWS is the custodian of the country's water and it is responsible for water use authorisation as well as regulating financial assistance relating to access to water for smallholder farmers.

4.4.4 Challenges of irrigation water governance for smallholder farmers

The key informants were asked about the challenges with governance and management of irrigation water for smallholder farmers in Genadendal. Various challenges were identified with water institutions as well as with smallholder farmers. According to key informants 1, 2 and 8, their institutions do not have the sufficient technical staff to manage water resources in Genadendal. They added that the water uses for smallholder farmers in Genadendal are very difficult to control. Key informant 2 highlighted that only two persons are available to handle all irrigation water-related issues, including the collection of water use fees. Key informant 2 also stated that farmers are not fully committed to paying the annual water use fees. Key informant 1 indicated that smallholder farmers in Genadendal believe that they are not supposed to pay water use fees because the water is free from the mountain. Additionally, there are no water meters for measuring water usage by smallholder farmers in Genadendal. Key informant 1 highlighted the absence of water metres as a limitation in terms of governance of irrigation water since farmers with small pieces of land are forced to pay the same amount for water use as farmers who have large pieces of land. Key informant 1 further stated that the water usage bill is often equally divided among farmers regardless of their different land sizes.

Key informant 2 indicates that capacity building to engage farmers concerning the use of irrigation water is limited and the responsibility relating to irrigation water access and management is usually carried out by a few individual farmers. Also, as a result, the decisions that are made by those few individuals are binding or forced down onto the rest of the farmers. Inadequate frameworks to enhance equity across smallholder irrigation water users through promoting non-discriminatory participation in decision-making were also stated by key informant 2 as one of the major governance challenges.

Key informant 3 stated that it is very challenging for their institution to fully assist smallholder farmers regarding irrigation water access as most of the smallholder farmers are not willing to approach them and share their challenges regarding water access. According to key informant 4, their institution engages with smallholder farmers who are members and non-members of WUAs but unfortunately, farmers who are not members of a WUA are usually not willing to participate in meetings about water allocation. Key informant 8 also indicated that the capacity of smallholder farmers to participate equitably in water resource management is still lacking, especially for women. The absence of sufficient transparency, accountability and participation in irrigation water-related use decisions was expressed by key informant 2 as one of the main limitations of the governance of water in Genadendal.

Concerning water allocation, key informant 4 indicated that most smallholder farmers do not know the procedures of water allocation and as a result, whenever they see a furrow of flowing water, they usually think of extracting that water despite not possessing a water use licence. Key informant 7 stated that most of the smallholder farmers were not aware of the necessary information they are supposed to submit to apply for a water use licence. According to key informant 4, most smallholder farmers were not well organised and they usually did not cooperate even if they shared the same problem about irrigation water access. Key informant 4 added that smallholder farmers always approached institutions individually to get assistance and this caused their challenges to take a long time to be resolved. Key informant 8 said that the mechanisms and processes that are supposed to promote cooperation among smallholder irrigation water users failed due to inadequate support from government departments as well as political interference. Additionally, key informant 1 indicated that it is only GFA in cooperation with GTC that usually tries to promote cooperation among smallholder farmers and that even though the local community structures work closely with the ZWUA and BGCMA, the cooperation with the local municipality is not sufficient and needs improvement.

Key informant 5 stated that it does not help even if smallholder farmers are given water use licences because the biggest challenge is that most of them do not have the infrastructure to transport water from the source. This implies that water can be allocated to the smallholder farmers but the challenge is how to transport it. According to key informant 5, funding to support smallholder farmers with water infrastructure to access water is inadequate and there is also a lack of coordination among institutions to support smallholder farmers with water infrastructure development. Additionally, key informants 1 and 2 highlighted that there is no mechanism to engage smallholder irrigation farmers who are likely to be affected by irrigation water-related decisions, such as women and youth. Key informant 1 added that lack of financial resources was one of the contributing factors that limited such engagements. Key informant 6 reported that it was very challenging to fully assist smallholder farmers with the water allocation process due to time constraints as most of the time the officials of the BGCMA were committed to other roles and responsibilities. Key informant 6 added that only 6% of the time of BGCMA officials is allotted to carrying out water allocation duties.

Key informant 8 expressed weak internal coordination, lack of integration and poor external alignment of water reform with other reform programmes as one of the greatest gaps in water management that contributes to the lack of fruitful and progressive realisation of equity goals in terms of water allocation for smallholder farmers. Key informant 2 also identified the unavailability of mechanisms, rules and processes to solve water irrigation disputes among farmers as limitations in the governance of irrigation water in Genadendal. Lastly, key informant 2 reported that improved management of irrigation water in Genadendal was needed and that there were no formal communication channels in place regarding the governance of irrigation water.

CHAPTER 5

DISCUSSION

5.1 Introduction

This chapter presents and discusses the results of the study. It also explores the factors that influence water security for smallholder farmers in Genadendal as well as the challenges faced by smallholder farmers and water institutions in ensuring water security.

5.2 Water resource availability for smallholder farming during the 2015–2018 drought period

Zwane (2019) argues that the availability of water resources can also be reported based on changes in rainfall received in a particular area. According to Hagemann et al. (2013), changes in rainfall can give rise to significant changes in the availability of water resources**.** Theron et al. (2021) add that if an area receives low rainfall it can lead to reduced streamflow and reservoir storage. Insufficient and reduction of rainfall trends were also reported to cause water insecurity (Fissahaye et al., 2017). In this study, the results show that the amount of rainfall received in winter seasons decreased from 2015 to 2017 and the lowest total annual rainfall was attained in the year 2017. Similar results were found by other scholars who focussed on the 2015–2018 drought in the WC province of SA. According to WCDA (2017), there was less rainfall in the WC during the winter rainfall season of 2017. Wolski (2018) and Dube et al. (2020) also found that the lowest average annual rainfall was in the year 2017. In their studies, Oldenborgh et al. (2018), Naik and Abiodun (2019), Dube et al. (2020) and Odoulami et al. (2020) found that the WC province had experienced three successive years (2015–2017) where there was below average rainfall that led to severe water shortages. Muthige et al. (2020) state that the three-year deficiency in rainfall has caused a lot of distress within the whole WC province.

The study also found that the water levels of Theewaterskloof Dam were very low during the first half of 2018. According to Roux (2017), low dam levels in the WC that were recorded in June of 2017 were because winter rain was below normal. Pascale et al. (2020) confirm that major storage reservoirs in the WC province, including Theewaterskloof Dam, dropped to about 20% of their capacity in May of 2018. According to WCDA (2017), dam levels were extremely low in most areas of the WC and this was mainly a result of low winter rainfall during the 2015–2017 period compounded with temperatures and evaporation that were high. This implies that the impacts of drought on water resources, particularly on dam levels, were magnified by the high temperatures during the 2015–2017 period (WCDA, 2017). In a study to investigate the impacts of drought during the 2014/2015 period in Brazil, Nobre et al. (2016) found that the deficient rainy season was the main factor that contributed to the serious decline of storage water levels of major reservoirs and consequently water resources. This shows that dwindling rainfall can place strain on the water supply and lead to an increase in competition for water, which ultimately reduces the availability of adequate water resources and water security. Additionally, the Nobre et al. (2016) study found that the streamflows for the Riviersonderend river declined from 2015 to 2017. The findings align with Otto et al. (2018) who state that rainfall deficit during 2015–2017 was the main factor that led to low runoff, particularly from source catchments in the WC province. According to the WCDA (2017), there were low flows in streams and rivers during the 2015–2018 drought period and it was mainly a result of low winter rainfall. In their study, Dobriyal et al. (2016) indicate that analysing the changes in streamflow is critical in providing baseline information about the status of water resources in an area for a particular period.

Based on the results of the perceptions of smallholder farmers and key informants, it was found that the water resources for smallholder farming in Genadendal are mostly sufficient throughout the year. However, during the 2015–2018 drought period, smallholder farmers who rely on water extracted from the Riviersonderend river experienced water shortages. The water shortages were very serious, to the extent that strict water restrictions were imposed, which ultimately affected both vegetable and livestock production for smallholder farmers. This was mentioned by one of the officials during the key informant interviews. Similar results were found by Zwane (2019), who pointed out that the water situation in the WC deteriorated severely during the recent 2015–2018 drought period and resulted in negative performance as well as stricter actions in administering irrigation water. Otto et al. (2018) also found that the water resource shortage due to drought was very serious at the beginning of 2018 and as a result, strict water restrictions were implemented in February of 2018 which led to the complete reduction of irrigation.

The results show that the livestock and vegetable production of the smallholder farmers who relied on irrigation water from the Riviersonderend river was severely affected during the 2015–2018 drought period. A study on coping and adaptation strategies for smallholder farmers in the WC province (Ncube, 2020) also found that livestock production was affected by the 2015–2018 drought, to the extent that farmers were forced to reduce their number of livestock and had to transport water from other places for their livestock. In the current study, this was confirmed by one of the key informant interviewees. Naik and Abiodun (2019) found that agricultural and livestock production in the WC's farmlands was severely affected by the lack of rainfall during the 2015–2018 drought period. Archer et al*.* (2019) add that in some places it was reported that farmers ceased to plant low-priority crops such as tomatoes, vegetables and onions due to limited availability of water for irrigation. This was also highlighted during the key informant interviews. Interestingly, the current study found that most of the smallholder farmers who relied on water from irrigation dams did not experience water shortages during the 2015–2018 drought period. This is because the dams are supplied by perennial streams from the mountains. It shows that the 2015–2018 drought was not experienced in all places in the WC province. This was revealed during the focus group discussion by the farmers who indicated that there was no drought in Genadendal but in other areas, it was very serious.

5.3 Water governance performance based on OECD water governance framework

The OECD water governance framework in Figure 2.3 was applied to discuss the water governance challenges or gaps faced by smallholder farmers as well as institutions supporting smallholder farmers concerning water security. The following category of water governance challenges was identified from the results of the farmers and key informants: policy, accountability, funding and capacity.

5.3.1 Policy

The study found that there was a lack of mechanisms, rules and processes in place to solve water conflicts among farmers and to ensure compliance in the use of water. This was revealed by one of the key informants. Surprisingly, farmers were of the view that rules of law and mechanisms for resolving irrigation water-related conflicts among themselves were available. However, despite the availability of conflict resolution mechanisms, farmers were not satisfied with the way conflicts were resolved. This indicates that conflict resolution mechanisms were very inadequate. The study also found that political interference and inadequate support from institutions contributed to the failure of mechanisms and processes to promote cooperation among farmers. Poor water management, as a result of political interference, can lead to inefficient irrigation water systems and subsequently, water insecurity. Ncube (2020) found that the serious water governance issues experienced in Genadendal resulted in water conflicts. According to Wang et al. (2013), the establishment of WUAs could help to improve the management of irrigation water-related issues such as resolving conflicts among water users. In this study, it was found that most of the smallholder farmers were not members of any WUA, especially the farmers who were dependent on irrigation dams.

Water crises and water conflicts will continue to increase if water resources are not managed efficiently and if there is inequitable access to water by various sections of the population (Poricha & Dasgupta, 2011). The current study revealed that there was equity in terms of water access among farmers, which was based on the perceptions of farmers. This was not expected because most of the smallholder farmers in SA are associated with inequity in terms of water access. The abundance of water resources, especially for farmers who were reliant on mountain streams, seems to have made farmers think that water is being shared equitably. According to Klümper et al. (2017), sometimes water abundance can result in water security even if water governance is poor. The current study also found a misalignment of objectives among institutions that were responsible for managing water-related issues in Genadendal. There was a lack of coordination among institutions that are responsible for supporting smallholder farmers with water infrastructure. Similar results were also found in Zimbabwe. Moyo et al. (2016) highlight the confusion of the roles and responsibilities (powers) of irrigation associations as one of the contributing factors to the lack of sustainability of irrigation infrastructures in Zimbabwe. Also, Dirwai et al. (2019a) argue that the deterioration of irrigation water infrastructure was a result of poor institutional arrangements that were not clearly defined in terms of who does what and when. It is very challenging to improve the sustainability of irrigation in the absence of clarity on who owns, maintains, manages and pays for water infrastructure structures, as well as a lack of funds and enforcement of rules in the maintenance of water infrastructure (Pittock et al., 2017).

5.3.2 Accountability

In water resources management, lack of accountability was the major obstacle to attaining efficient water management (Jiménez et al., 2018). According to Tropp et al. (2017), accountability involves sets of controls, counterweights and modes of supervision that make officials and institutions in the water sector answerable for their actions and ensures that sanctions are applied in cases of poor performance, illegal acts and abuse of power. In the management of irrigation water, leaders should be answerable to the group they are serving if things go wrong and are praised when things go well (Marimbe & Manzungu, 2003). Leaders are also expected to show commitment to their responsibilities by enabling the free flow of information regarding all activities (Akuriba et al., 2020).

Participation in decision-making processes concerning water management is very important in ensuring water security. Unfortunately, this study found that farmers were not actively involved in issues concerning water management. Most farmers were not members of a WUA and this has contributed to their lack of participation in water management. In their study, Muchara et al. (2014) found that it is critical for farmers to be part of a formal institution such as a WUA as this helps them to be involved in capacity-building programmes and increases their participation. In India, the lack of people's involvement in the management of local water resources was found to be one of the contributing factors that led to the water insecurity crisis (Poricha & Dasgupta, 2011). The capacity of farmers to participate equitably in water resource management was lacking, especially for women. Poor representation of water users such as women who were marginalised in water-related issues can lead to a lack of transparency and accountability (Singh et al., 2020). In their study, Sharaunga and Mudhara (2018) found that households with older heads who experienced a severe shortage of water for irrigation, as well as those with large plots of irrigation land with good soil quality, were likely to be involved in irrigation infrastructure maintenance. Surprisingly, most household heads in Genadendal were older and had much farming experience but they were still not fully committed to the maintenance of their infrastructure. Also, Letsoalo and Averbeke (2006) found that the degradation of parts of the canal system was mainly a result of farmers not bearing full responsibility for the maintenance activities. Water users can influence and agree on irrigation water-related issues such as the sharing of water and maintenance of irrigation infrastructures when they are involved in decision-making processes. Howarth et al. (2007) report that weak social relationships between water users and the WUA and with other water users have contributed to the poor maintenance of infrastructure and disorganised water distribution. To enable the sustainable management of communal smallholder irrigation systems, it is very important to motivate farmers to be involved equally in all water management activities because the failure or success of a certain activity can affect the water security status of other farmers. Institutions that are responsible for the management of water resources were not accountable in their functions and committed less time to assisting farmers with water allocation. The key informants emphasised that farmers were not willing to participate in meetings on water allocation. Only a few individual farmers were involved in issues relating to water governance. Off-farm employment was revealed by the farmers as one of the factors that hindered them from being fully committed to carrying out maintenance activities of their infrastructure. This could affect the reliability and access to irrigation water as those who have off-farm occupations may have minimal time for negotiating and guarding water supplies. According to Howarth et al. (2007), lack of discipline in following rules in increasing order and equity is a challenge, especially amongst those farmers without off-farm activities because these farmers tend to irrigate in their own time and at their convenience.

5.3.3 Funding

The study found that any available funding for infrastructure development or maintenance was limited to farmers who were members of WUAs. Unfortunately, most of the smallholders in Genadendal were not members of any WUA. In their study, Huppert et al. (2003) found that lack of funds can contribute to the inadequate maintenance of infrastructure and consequently water insecurity. In this study, inadequate funding also affected support to farmers concerning water infrastructure. A lack of financial resources can limit the establishment of mechanisms to engage farmers who are likely to be affected by water-related decisions. Farmers were not committed to paying irrigation water use fees, which could be used for funding of operation and maintenance of irrigation water infrastructure. Kujinga (2002) asserted that if farmers did not pay water charges, it could lead to poor water management and inadequate access to water. Dirwai et al. (2019b) found that farmers who did not pay irrigation water use fees were contributing to water insecurity. Most of the farmers from the study area believed that water is from God, hence they were not supposed to pay for it.

5.3.4 Capacity

Farmers' lack of training reduces their ability to save water which consequently affects their water security. This study found that smallholder farmers lacked training in irrigation water management skills. This is consistent with Mvelase (2016) who indicates that most South African smallholder farmers lack skills. According to van Koppen et al. (2018), investing in soft skills training for farmers can improve agricultural production. Water scarcity, capacity building and empowerment of farmers plays important role in enhancing their adaptation capacity (Fissahaye et al., 2017). Training for optimal use of agricultural water can also assist farmers to cope during periods of drought (Bijani & Hayati, 2015). Dirwai et al. (2019b) found that water management training was very important in ensuring the efficiency of water use in smallholder irrigation schemes. Farmers reported that they conserved their irrigation water uses. This was surprising because many farmers had not received any training regarding the optimal use of irrigation water. It shows that the farmers were training themselves informally to conserve water. Cousins (2013) highlights that informal water management training, whereby farmers train themselves through information-sharing, is crucial because at times their access to extension services is very challenging. In irrigated agriculture, it requires both the human resource capacity and institutional arrangements to enable the management of water, ensure equitable distribution of water, collection of water payments, conflict management and maintenance of irrigation infrastructure by carrying out repairs (Mutiro & Lautze, 2015). Failed institutions can lead to the breakdown and lack of maintenance of irrigation infrastructure (Pittock et al., 2017).

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study assessed infrastructure performance and irrigation water governance in Genadendal in the WC. The factors that influence water security for smallholder farmers were identified. Most of the smallholder farmers practised mixed farming (livestock and crop production) with the main aim of selling their agricultural products. The results show that the smallholder farmers depended on various surface water sources for their agricultural production. Some farmers relied on water extracted from the Riviersonderend river, while most of them used water from irrigation dams that were fed by several streams from the mountain. Most of the farmers had more than ten years of farming experience and leased their land. The study found that during the 2015–2018 drought in the WC province, the water security of the smallholder farmers who extracted water from the Riviersonderend river was affected. There were severe water shortages in the river and both livestock and crop production were affected. Interestingly, the results show that the water security for smallholder farmers who used water from the mountain streams was not affected by water shortages during that drought period. This indicates that even during drought periods there were adequate water resources for most smallholder farmers in Genadendal because most of them were mainly reliant on surface water drawn from the perennial mountain streams.

Concerning infrastructure performance, the study found that the performance of the irrigation infrastructure (canal system) supplying water to smallholder farmers was poor. This resulted in water conflict among farmers who were dependent on the canal systems from the mountain and this is despite the availability of abundant water resources from the mountain streams. It shows that the abundance of water resources does not automatically translate to water security if the infrastructure for delivering water from the source to the farming plots is dysfunctional. The poor performance of infrastructure can lead to artificial water shortages even if the physical availability of water is abundant. The results indicate that the poor performance of irrigation water infrastructure was mainly a result of inadequate maintenance by both the farmers and the responsible institutions. Farmers were not committed to maintaining their infrastructure and were of the view that it is not their responsibility. The results also indicate that the institutions responsible for maintaining the infrastructure were challenged by inadequate technical skills and a shortage of funding. Some farmers did not pay their water use fees that were supposed to contribute to funding infrastructure maintenance activities.

Good water governance systems are critical to enabling the achievement of water security by water users. The study found that the WCDA, DWS and BGCMA were responsible for the water governance of irrigation water for smallholder farmers in Genadendal. Surprisingly, the results show that these institutions were unknown to many smallholder farmers. When formal water institutions are not known by water users, it is very challenging to attain water security. It was also found that farmers were not willing to participate in water management activities and their cooperation in addressing the water-related challenges with the responsible institutions was very weak. The results also indicate that most of the farmers were not members of any WUA, especially the farmers who utilised water from the mountains. In conclusion, the study generally found that the water resources in Genadendal are sufficient even during drought periods but the dysfunctionality of water governance systems has contributed to the poor performance of water infrastructure and artificial water shortages, and consequently water insecurity. The results have implications for improving the water security status of smallholder farmers by enabling policy-makers to strengthen decisions relating to the governance of agricultural water resources as well as creating opportunities for private institutions to support smallholder farmers with water infrastructure maintenance. This helps to improve agricultural production and consequently livelihoods of smallholder farmers.

6.2 Recommendations

The study found that besides the availability of water resources, the performance of irrigation infrastructure and water governance systems was in a very poor state and this threatened the water security of smallholder farmers in Genadendal. Infrastructure performance and water governance are strongly linked and both play a critical role in ensuring water security. The sustainability and reliability of water infrastructure are reliant on good governance systems. The study recommends funding for the operation and maintenance of infrastructure to be made available to the institutions that are responsible for the governance of water resources for smallholder farmers. The funding can be provided by the government and/or non-governmental organisations. Instead of being fully dependent on government institutions for infrastructure maintenance, smallholder farmers need to be supported with training skills so that they can perform some infrastructure maintenance activities on their own. Training will also assist farmers to realise the importance of participating in water-related management activities. The study further found that much of the water flowing from the mountain was being lost, therefore, it is recommended that government institutions provide water storage infrastructure such as tanks so that farmers can capture and fully utilise their water resources. Further studies are recommended to be undertaken to quantify the amount of water that is lost as a result of the poor performance of water infrastructure. Additionally, the study recommends that future studies should consider informal institutions as well as catchment management forums and catchment management committees when assessing the performance of water governance systems. Also, further studies need to investigate the factors that are influencing land security for farmers who are leasing land. Finally, aspects of gender also need to be explored to understand whether men and women face similar problems.

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APPENDICES

APPENDIX A: CPUT ethical clearance certificate

Cape Peninsula
University of Technology

FACULTY OF ENGINEERING & THE BUILT ENVIRONMENT

On 05 February 2020, the Engineering and Built Environment Ethics Committee of the Cape Peninsula University of Technology granted ethics approval to Mr **KUDZAI MUGEJO** student number **216041686** for research activities related to his research proposal at the Cape Peninsula University of Technology.

Title of Proposal	Infrastructure performance and irrigation water governance in Genadendal, Western Cape, South Africa.

Comments:
Data collection required, see attached letter of permission

[signature]	27/02/2020
Prof TV Ojumu **Research and Innovation Coordinator – Faculty of Engineering and the Built Environment (Acting)**	**Date**

APPENDIX B: Letter of permission from Western Cape Government

Western Cape Government

Agriculture

Germishuys, Hennis
Farmer Settlement and Development
Email: HennisG@elsenburg.com
tel: +27284254807

Attention Farmers

TO WHOM IT MAY CONCERN

This letter serves to confirm that our office is aware of the commissioned Water Research Commission Project entitled: "*Improving smallholder farmer livelihoods through developing strategies to cope and adapt during drought periods in South Africa*". Overberg District was selected as one of the study sites, in addition to the West Coast Districts and two other districts in the Limpopo Province. The project was introduced to us at the Department of Agriculture Offices in Bredasdorp on the 9th November 2017. The project leader, Dr Bongani Ncube, together with her team presented the objectives of the project together with the proposed methods. The team confirmed that they had presented the project to the Directorate of Farmer Support Development and a research collaboration agreement is being drawn. However, the project needs to commence data collection with the participation of farmers and other relevant officials from the district. Permission was therefore sought to commence the data collection.

I therefore, confirm that the above request is granted based on our interest in the project results. One of our extension officers is also part of the research team. However, the people involved in data collection may participate based on their understanding of the needs of the project and their willingness to do so.

We wish the team success and look forward to support them in the best way possible.

Regards

MR JERRY ARIES
ACTING CHIEF DIRECTOR:
FARMER SUPPORT AND DEVELOPMENT

17/11/2017
DATE

APPENDIX C: Informed consent letter for smallholder farmers

Cape Peninsula University of Technology

My name is Kudzai Mugejo from the Cape Peninsula University of Technology. I am conducting a study on agricultural water resources and the performance of irrigation water infrastructure and water governance systems in Genadendal, particularly for smallholder farmers. I am kindly requesting your assistance in filling in questionnaire form.

The questionnaire is aimed at understanding the challenges you are facing concerning irrigation water access and the underlying factors causing those challenges. The information will be useful in improving the accessibility of sufficient and reliable irrigation water by farmers to enhance their agricultural production.

The survey will not take you more than twenty minutes and all information that will be obtained from this questionnaire will be treated as confidential and will only be used for this research. Please be assured that your name will not appear in any report related to this research. You will be assisted to complete this questionnaire. If you feel uncomfortable answering some questions at any time, please feel free to withdraw from the survey process without the requirement to give any explanation, reason or prejudice.

If you agree to take part in filling in this questionnaire, please sign in the space below.

Signed ……………………………… **Date ……………………………………………**

If you have any questions about the survey, feel free to contact the following persons:

Supervisors:

Dr Bongani Ncube

Email: NcubeB@cput.ac.za

Tel: +27 (0) 21 953 8706

Mr Crispen Mutsvangwa

Email: MutsvangwaC@cput.ac.za

APPENDIX D: Questionnaire for smallholder farmers

Infrastructure performance and irrigation water governance in Genadendal, Western Cape, South Africa

Name of interviewer: ………………………………………………
Date: …………………………………………………………………
Questionnaire number: ……………………………………………

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	Marital status	
5	Level of education (*Specify, e.g. Grade 4*)	

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/leasing
[ ] Other (specify) ………………………………
A.5 In general, are you satisfied with the present security of your land?
[ ] Yes [ ] No
A.6 What type of farming do you practice?
……
A.7 What do you do with the farming products that you produce from your farming?
[ ] Mainly for sell [ ] Mainly for family consumption
[ ] Mainly for giving away [ ] Other (please specify): ……………………........................

SECTION B: AGRICULTURAL WATER RESOURCES AND IRRIGATION WATER INFRASTRUCTURE

B.1 What sources of water do you use for farming?
……
………………………………………………
B.2 Do you have a water use licence or water rights?
[ ] Yes [ ] No
B.3 Do you pay any fees for using water for farming?
[ ] Yes [ ] No
B.4 Do all your water sources hold enough water throughout the year?
[ ] Yes [ ] No

B.5 What means do you use to transport water from the sources?
[ ] Lined channels; [ ] Earthen field channels; [ ] Pipes
[ ] Other, specify: ……………………………………………………………………

B.6 Are the current water infrastructures able to store and supply enough water for your farming?
[ ] Yes [ ] No

B.7 Has your community ever faced drought or water shortages for farming during the last 5 years?
[ ] Yes [ ] No
B.8 Has your community ever faced drought or water shortages for farming during the last 10 years?
[ ] Yes [ ] No

B.9 List the names of organisations that are responsible for managing and allocating water for agriculture?

………
………
…………………………………………………………………………………………

B.10 List the roles of the organisations you have listed in **B.9**?

………
………
…………………………………………………………………………………………

SECTION C: GOVERNANCE AND MANAGEMENT OF IRRIGATION WATER

Below are some statements regarding the governance and management of irrigation water to your plot(s). Please indicate with an **X** the extent to which you agree or disagree with each statement. (1 = Strongly agree 2 = Agree 3 = Neutral 4 = Disagree 5 = Strongly disagree).

Indicators	Governance Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
		(5 pts)	(4 pts)	(3 pts)	(2 pts)	(1 pt)
Capacity building	I have received training for the optimal use of irrigation water					
Sustainability	Irrigation water is conserved to ensure availability for future use					
Equitability	Everyone (men and women) has equal access to irrigation water					
	There is fairness in the handling of irrigation water issues					
Participation	Farmers are directly involved in the development, planning and decision-making process concerning irrigation water					

Accountability	Decision-makers are always committed to their roles and responsibilities and accountable to the farmers for maladministration					
Rule of law	Farmers who break rules are normally sanctioned according to laid down rules and procedures (rule of law)					
Transparency and cooperation	Information about decisions on irrigation water governance and management is made known to the farmers (not hidden information)					
	Farmers are fully committed to the maintenance of irrigation water infrastructure (e.g. maintenance of canals, etc)					
Conflict resolution	There are mechanisms and practices for addressing water conflicts and sanctioning farmers who break rules (graduated sanctions)					
	Conflicts relating to the allocation of irrigation water are usually resolved to the satisfaction of those involved					

APPENDIX E: Informed consent letter for key informants

Cape Peninsula University of Technology

My name is Kudzai Mugejo from the Cape Peninsula University of Technology. I am a Masters student and I am conducting a study on agricultural water resources and the performance of irrigation water infrastructure and water governance systems in Genadendal, particularly for smallholder farmers. I am kindly requesting your assistance in answering a few interview questions.

The interview is aimed at understanding the challenges that are facing smallholder farmers concerning irrigation water access and the underlying factors causing those challenges. The information will be useful in improving the accessibility of sufficient and reliable irrigation water by farmers to enhance their agricultural production.

The survey will take about 15-30 minutes and all information that will be obtained from you will be treated as confidential and will only be used for this research. Please be assured that your name will not appear in any report related to this research. If you feel uncomfortable answering some questions at any time, please feel free to withdraw from the survey process without the requirement to give any explanation, reason or prejudice.

If you agree to take part in this interview, please type your name in the space below.

Signed ……………………………… **Date ……………………………………………**

If you have any questions about the survey, feel free to contact the following who are my supervisors:

Supervisors:

Dr Bongani Ncube Email: NcubeB@cput.ac.za;

Tel: +27 (0) 21 953 8706

Mr Crispen Mutsvangwa Email: MutsvangwaC@cput.ac.za;

APPENDIX F: Key informants interview guide

RESPONDENT'S INFORMATION

Name of institution	Profession (optional)	Date

SECTION A

A.1 What are the responsibilities of your organisation concerning the governance and management of irrigation water for smallholder farmers in Genadendal?

A.2 What do you think are the challenges of irrigation water governance and management for smallholder farmers in Genadendal?

A.3 What do you think are the solutions to the challenges of irrigation water governance and management for smallholder farmers in Genadendal?

A.4 Which are the main water sources for smallholder farmers in Genadendal?

A.5 Do all water sources for smallholder farmers in Genadendal hold enough water throughout the year? [ ] **Yes** [ ] **No** Please explain

A.6 Did smallholder farmers in Genadendal face drought or water shortages for farming during the last six years? [ ] **Yes** [ ] **No** Please explain

SECTION B

B.1 Below are some statements regarding the governance and management of irrigation water for smallholder farmers in Genadendal. Please indicate your level of agreement or disagreement with each statement. Where (**1 = Strongly agree; 2 = Agree; 3 = Neutral; 4 = Disagree & 5 = Strongly disagree**).

Principles	Water Governance Principles Questions	Level of agreement or disagreement	Please provide further explanation for the level of agreement or disagreement
P1	There is a water law that clearly states and distinguishes the roles and responsibilities of organisations managing irrigation water for smallholder farmers in Genadendal		
P2	There are mechanisms and processes that promote cooperation among smallholder irrigation water users		
P3	There are integrated policies and strategies in Genadendal that promote coherence across sectors in irrigation water		
P4	There are enough technical staff to manage water resources and processes		
P5	Water information such as the status of water resources (e.g quantity, quality, rainfall data, water flow, irrigation water consumption, irrigation water charges etc) exists in Genadendal		
P6	There are governance arrangements (polluter-pays and irrigation user-pays) in Genadendal that help water institutions or organisations to collect the necessary irrigation water fees from smallholder farmers in Genadendal		
P7	There are mechanisms, rules and processes to solve irrigation water-related disputes (be they water-specific or not) among smallholder farmers in Genadendal and to ensure compliance in the use of irrigation water		
P8	There are tools and processes to build capacities, raise awareness, engage		

	smallholder farmers and share information with smallholder farmers in relation to the use of irrigation water		
P9	There are mechanisms and tools to track transparency, accountability and participation in irrigation water-related use decisions		
P10	There are formal and informal mechanisms to engage smallholder irrigation farmers who are likely to be affected by irrigation water-related decisions such as women and youth		
P11	There are frameworks to promote equity across smallholder irrigation water users (ensure irrigation water users are treated fairly) through promoting non-discriminatory participation in decision making		
P12	There are monitoring, evaluation and reporting mechanisms of irrigation water governance, to effectively guide decision making		

APPENDIX G: Grammarian letter

22 Krag Street
Napier
7270
Overberg
Western Cape

11 January 2022

LANGUAGE & TECHNICAL EDITING

Cheryl M. Thomson

INFRASTRUCTURE PERFORMANCE AND IRRIGATION WATER GOVERNANCE IN GENADENDAL, WESTERN CAPE, SOUTH AFRICA

Supervisor: Dr Bongani Ncube

This is to confirm that I, Cheryl Thomson, executed the language and technical editing of the above-titled Master's thesis of **KUDZAI MUGEJO, Student number 216041686,** at the CAPE PENINSULA UNIVERSITY OF TECHNOLOGY in preparation for submission of this thesis for assessment.

Yours faithfully

CHERYL M. THOMSON

Email: cherylthomson2@gmail.com

Cell: 0826859545