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Infrastructure Performance and Irrigation Water Governance in Genadendal, Western Cape, South Africa

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Abstract: Disasters such as the 2015–2018 drought in South Africa usually negatively impact agricultural water, especially in smallholder farming systems. This study assessed the availability of irrigation water, performance of irrigation infrastructure, and water governance systems in Genadendal, Western Cape, with a focus on smallholder farmers. Data for streamflow, dam levels, and rainfall were acquired from water institutions and analysed using Microsoft Excel. The performance of the infrastructure and water governance were assessed based on the perceptions of smallholder farmers and key informants. A questionnaire was administered to eight smallholder farmers, followed by a focus group discussion with fifteen smallholder farmers. Interviews were conducted with eight key informants who worked in water-related institutions. Qualitative data from the interviews were analysed using thematic content analysis. The study showed adequate agricultural water resources during the 2015–2018 drought period for the smallholder farmers who relied on water from dams. However, smallholder farmers who relied on the Riviersonderend River experienced severe water shortages during the same period. The findings showed poor performance of irrigation water infrastructure due to inadequate maintenance. Lack of coordination among institutions, insufficient funding, political interference, fragmentation of roles and responsibilities, lack of human resources, and farmers' lack of participation and commitment in water resource management all contributed to the dysfunctionality of irrigation water governance systems, leading to water insecurity. This study concludes that while agricultural water resources in Genadendal are sufficient, water governance systems need improvement in order to strengthen the water security status for smallholder farmers. This study recommends adequate funding for the operation and maintenance of infrastructure. Furthermore, water institutions need to support smallholder farmers with training skills in agricultural water management and infrastructure maintenance. Further studies are recommended to quantify the amount of water lost due to the poor performance of water infrastructure and to develop effective water governance in Genadendal. In addition, issues relating to crop varieties and changes in cropping intensity during drought periods need to be considered in future studies.

Keywords: drought; institutions; smallholder farmers; water security

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1. Introduction

Water is one of the main factors limiting agricultural production, particularly in countries that are situated in arid and semi-arid regions, such as South Africa [1]. Increasing agricultural production with limited water availability to meet the rising demand for food is one of the biggest agricultural water management challenges in the 21st century. In order to meet the global food demand, the world's rainfed agriculture and irrigation by smallholder farmers are considered important contributors, with approximately 500 million farms that contribute a significant amount of agricultural production [2]. Smallholder farmers are defined as those farmers who produce for household consumption and markets. Their farming businesses are the source of income for the family, and are not usually the

major source of income. Various non-farm activities exist as a source of income to sustain the family [3].

Many smallholder farmers involved in rainfed agriculture fail to produce adequate food because of increasing rainfall variability due to climate change [4] and droughts. In order to boost agricultural production to feed an ever-increasing world population, it is imperative to rely on and promote smallholder irrigation farmers [5]. Despite the promotion of smallholder irrigation farming, the irrigation water infrastructure that has been implemented in most water-scarce countries around the world is not functional enough to achieve the intended objective of ensuring water security [6]. Various factors, such as insufficient technical capacity and poor institutional arrangements, have contributed to the underperformance of water infrastructure [7]. To enhance water security, assessment of the performance of irrigation water infrastructure has been reported to be a very useful tool for improving water resource management practices [8–15]. In South Africa, numerous studies have been conducted on smallholder irrigation schemes, although with little attention to other categories of smallholder farmers, such as those practising irrigation in small historical towns. According to [16], many small South African historical towns are considered research lacuna in terms of water resource management to ensure water security for agricultural production. This is despite various water sector reforms such as the National Water Act No. 36 of 1998 and the Water Allocation Reforms [17] that aimed to correct past injustices in terms of water access.

Generally, South Africa is prone to frequent droughts, which ultimately affect water security, the national economy, and communities [18]. Drought has impacted smallholder farmers for several years [19] across the country, including in the Western Cape province. Historically, the Western Cape has been the most disaster-prone province in South Africa [20]. During 2015–2018, the Western Cape province experienced the worst drought since 1904 [21]. The three-year shortage of rainfall, a rare event with a likelihood of occurring once in approximately 150 years, led to severe distress within the whole Western Cape province [22]. In the Overberg District, water resources were identified as a critical concern requiring urgent attention [23]. The district is vulnerable to both food and water insecurity in the face of climate change.

Water resources are likely to decrease due to the increasing frequency of drought, rainfall variability, and temperature increase [23]. Furthermore, deteriorating infrastructure and system losses have exacerbated the situation, especially in small historical towns that depend on canal systems, such as Genadendal. Investments in maintaining water infrastructure are recommended to prevent water loss and increase storage [24]), however, the problems of water insecurity go beyond infrastructure. There is, therefore, a need to understand the relationship between access to water and infrastructure management. Previous studies in Genadendal have focused mainly on ways for smallholder farmers to adapt during drought periods, and have paid little attention to the performance of irrigation water infrastructure and the underlying governance issues affecting water access. This paper assessed the availability of agricultural water as well as irrigation water infrastructure and the associated water governance systems in Genadendal, a historical town in the Overberg District, Western Cape. The hypotheses guiding the study were that there is no shortage of water in Genadendal even during drought periods; rather, there is a lack of infrastructure maintenance that causes artificial water shortages for smallholder farmer production. Challenges in accessing agricultural water by smallholder farmers in Genadendal are mainly caused by dysfunctional water governance systems. The main objectives of this study were to (1) assess the availability of agricultural water for smallholder farmers in Genadendal, (2) to assess the status and performance of irrigation water infrastructure supplying water to smallholder farmers in Genadendal, and (3) to explore the current state of irrigation water governance systems in Genadendal.

2. Theoretical Framework

2.1. Determinants of Water Security

The International Federation of Agricultural Producers has stated that without water security, there is no agriculture [25]. Water security is defined as equitable access to reliable and good-quality water by farmers at the farm household level or local level adequate to satisfy their agricultural water needs, as well as their capability to claim or protect their water use rights [26]. Primarily, not having adequate water does not automatically lead to water insecurity [27]. In addition, an abundance of freshwater resources does not necessarily lead to water security if effective water governance systems are absent [28]. At times, an abundance of water resources can provide water security even if water governance systems are weak [29].

Water governance entails the processes, rules, and regulations used in the management, administration, and coordination of water resources and water infrastructure [30–34]. Water insecurity crises are usually caused by a crisis of management and accessibility (water governance crisis) rather than natural limitations on water supply (water quantity) [35].

In their study, [36] argue that accessing irrigation water depends on both the availability of water resources or water use rights and on the availability of water infrastructure for transporting water from water sources to where it is required. Water infrastructure plays a crucial role in managing water resources to attain water security [37]. However, the development of water infrastructure alone cannot achieve water security [38–40]. According to ref. [41], water infrastructure should be closely related to laws, regulations, institutions (formal and informal), management practices, and policies in order to ensure that water resources and water-related services are managed effectively and efficiently. In South Africa, even though water is a very important component of agricultural production, many smallholder farmers are faced with persistent water access inequalities.

2.2. The Organization for Economic Co-Operation and Development Multi-Level Framework

Effective water governance is very important in ensuring water security, especially considering that water insecurity challenges are now compounded by climate change, among other factors. In this study, the Organization for Economic Co-operation and Development (OECD) Multi-level Governance Framework was used to assess the performance of water governance at a local level. The framework is based on water governance principles which are described in detail in the document for OECD principles on water governance [42]. The principles are based on three mutually reinforcing and complementary dimensions of water governance: effectiveness, efficiency, and trust and engagement [42]. The OECD [42] describes these dimensions as follows:

- **Effectiveness** relates to the contribution of governance to define clear and sustainable water policy goals and targets at all levels of government, implement those policy goals, and meet expected targets.
- **Efficiency** relates to the contribution of governance to maximizing the benefits of sustainable water management and welfare at the least cost to society.
- **Trust and engagement** relate to the contribution of governance to building public confidence and ensuring inclusiveness for stakeholders through democratic legitimacy and fairness in society at large.

The OECD Multi-level Governance Framework can be used to better manage water resources by identifying and bridging gaps in water policy to solve water governance challenges. It groups the water governance gaps or challenges into seven categories (Table 1): policy, accountability, funding, information, capacity, objective, and administrative.

The OECD framework is a guideline for policy-makers which is applicable at any level of government regardless of institutional setting [43]. It has been applied to 17 OECD countries in 2011, 13 Latin American countries in 2012, Mexico in 2013, the Netherlands, Tunisia, and Jordan in 2014, and Brazil in 2015 [42]. In the United States of America, Alkharaz [44] applied this framework at the local level to small-scale community-based water projects. In this study, only four governance gaps (policy, accountability, funding,

and capacity) were selected and were applied to assess the performance of irrigation water governance for smallholder farmers.

Table 1. Key coordination gaps in water policy [43].

Coordination Gaps	Description
Policy	A result of the fragmentation of roles and responsibilities of water-related tasks across ministries and agencies.
Accountability	Occurs when it is difficult to ensure the transparency of practices across the various constituencies, mainly as a result of insufficient user commitment and lack of concern, awareness, and participation.
Funding	Entails an insufficient or unstable budget for undertaking of required water management activities such as construction, maintenance, and repairs to infrastructure.
Information	Occurs when there is a weakness in producing information (quantity, quality, type) among various stakeholders involved in water policy as well as when governments are not able to share their existing water data.
Capacity	When there is insufficient scientific knowledge, obsolete infrastructure and technology, and lack of human resources, as well as insufficient infrastructural capacity of local actors to design and implement water policies (size and quality of infrastructure) including relevant strategies.
Objective	Unclear objectives of water governance structures as well as conflicts among them concerning issues related to social, economic, and environmental aspects.
Administrative	When there is a geographical "mismatch" between hydrological and administrative boundaries, this can be at the origin of both resource and supply gaps.

3. Study Area

The study was carried out in Genadendal (34.0432 S, 19.5497 E), a small historical town and the oldest Moravian mission station in South Africa [24,45]. The town is situated in the foothills of the Riviersonderend Mountains in the Theewaterskloof Local Municipality, approximately 120 km east of Cape Town (Figure 1).

The town of Genadendal falls under the jurisdiction of the Overberg District Municipality in the Western Cape province. The town comprises approximately 4500 ha of both urban and agricultural land [46]. The area has a total population of 5663 and 1593 households [47]. The economy of the town is dominated by various development projects that are mainly driven by local organizations as well as smallholder farming [48]. As in other coloured communities in the Western Cape province, Genadendal is a product of a difficult history [49].

In terms of climate, Genadendal has a Mediterranean climate, receives most of its rainfall during winter, and has an average Mean Annual Precipitation of about 700 mm and average Mean Annual Evaporation of 1400 mm [50]. 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) [49].

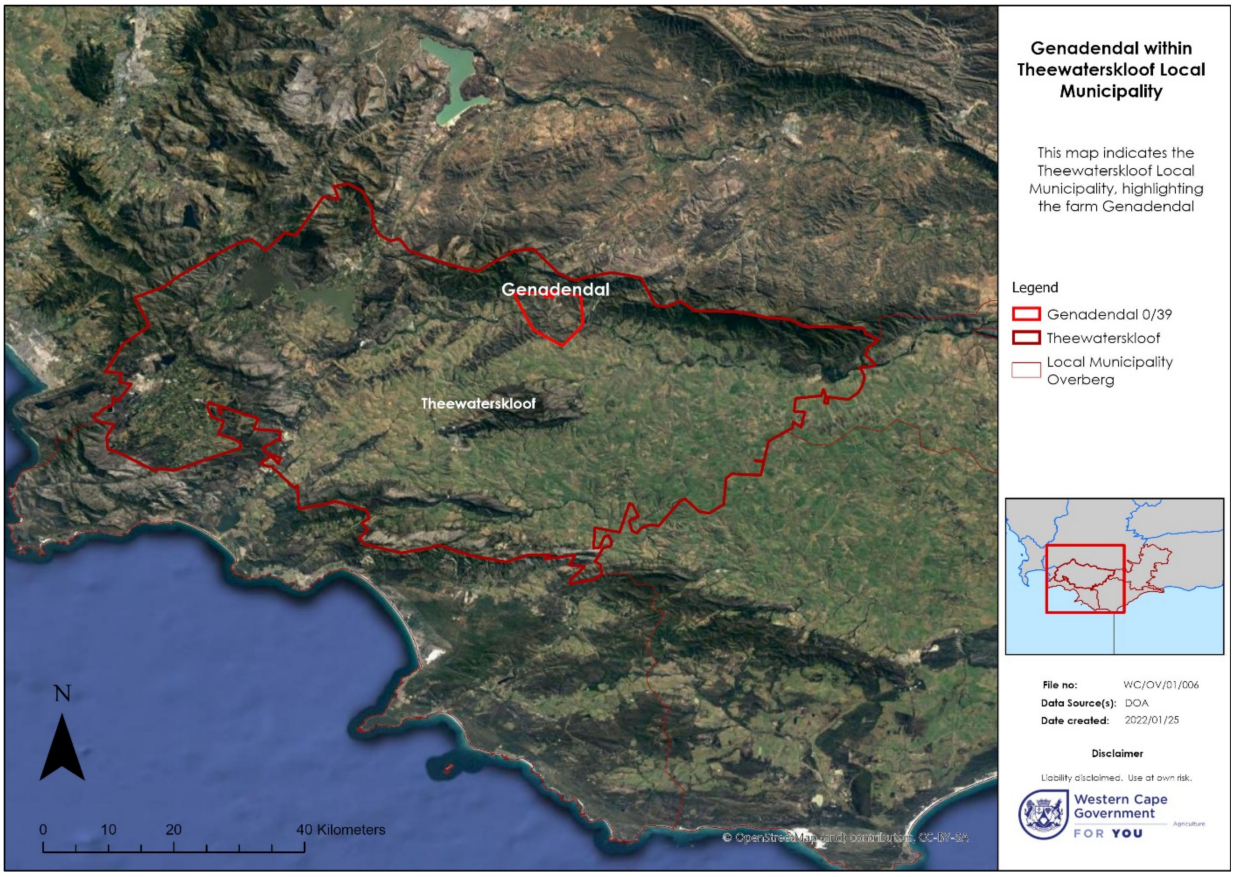

Figure 1. Location of Genadendal in the Western Cape Province, South Africa.

4. Methodology

The methodological model shown in Figure 2 constitutes data collection and data analysis methods that were used to achieve the objectives of this study. Before data collection was conducted, ethical approval was granted by the Ethics Committee of the Cape Peninsula University of Technology. A permission letter to conduct the research was issued by the Western Cape Department of Agriculture. Respondents were asked to sign informed consent forms before participation. Participants were assured that all information obtained from them would be treated as strictly confidential and all information would be used only for the study. Additionally, respondents were informed that their responses would be anonymised.

Quantitative data for rainfall, streamflow, and dam water levels from the year 2013 to 2019 were collected from responsible institutions that manage water resources. Rainfall data for the weather station closest to the study area was used because there was no weather station located within Genadendal. However, the weather is within the same catchment area where Genadendal is located; therefore, it closely reflects rainfall conditions in Genadendal. The streamflow of the river and water level of the dam supplying agricultural water to some of the smallholder farmers was used as well. Quantitative data from other streams and irrigation dams were not available due to the unavailability of gauging stations. The main aim of this quantitative data was to check whether there was a reduction in water resources in the study area, especially during the 2015–2018 drought that affected most parts of the Western Cape province. Graphs were plotted and used to analyze the trends or changes in rainfall, streamflow, and dam water levels during the 2013–2019 period.

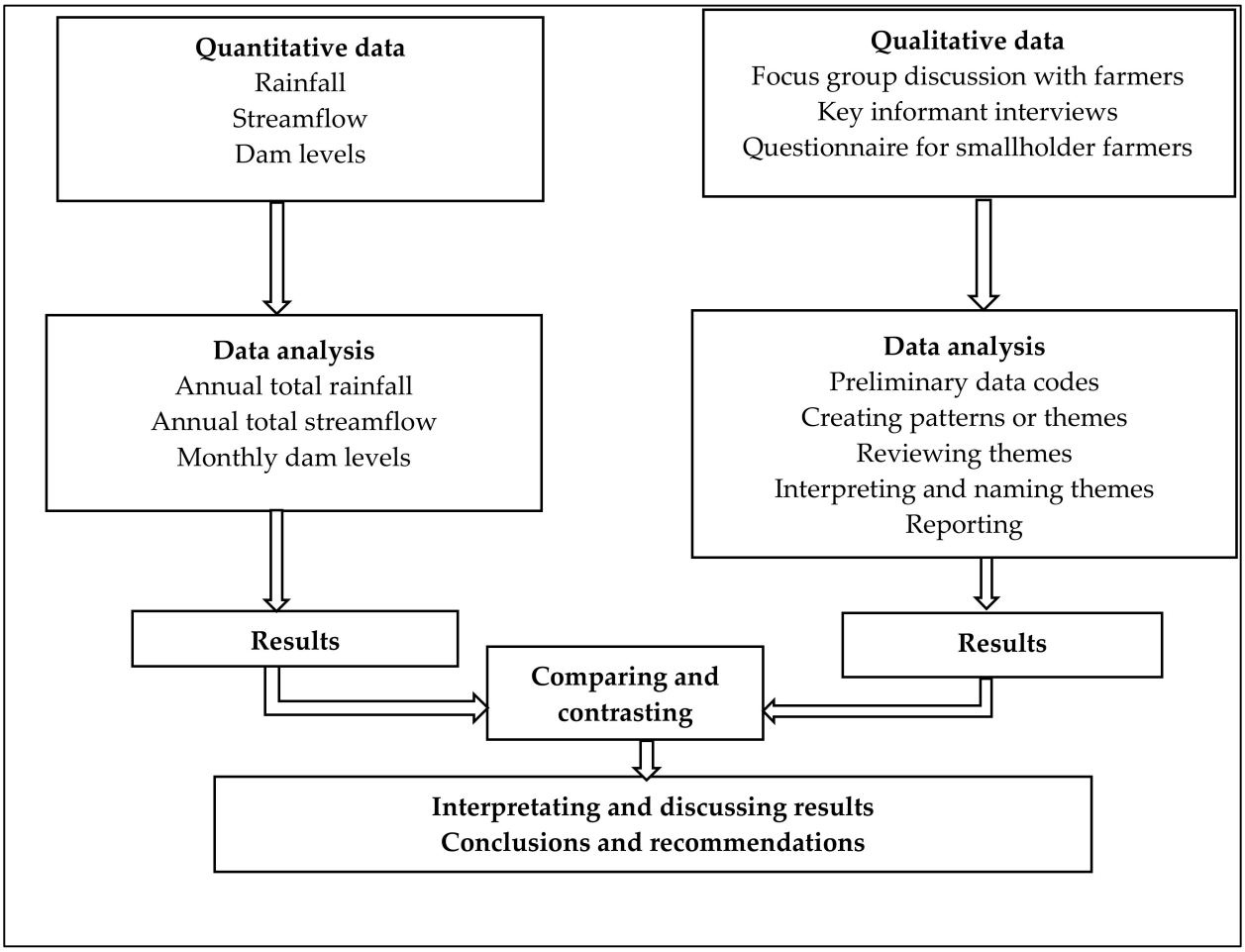

Figure 2. Methodological model.

The respondents were selected by purposive sampling with the assistance of an agricultural extension officer of the Western Cape Department of Agriculture who was knowledgeable about the study area. Purposive sampling is a sampling technique that involves the use of the judgment of an expert to identify respondents who have the essential experience to provide informative answers to the research questions under investigation [51]. Eight smallholder farmers and eight key informants were interviewed electronically using the phone. Key informants 1 and 2 were officials of the Western Cape Department of Agriculture, key informants 3, 4, 5, 6, and 7 were officials of the Breede-Gouritz Catchment Management Agency, and key informant 8 was an official of the Department of Water and Sanitation. Data from key informants 3, 4, 5, 6, and 7 were collected in August 2018 and September 2018, whereas data from key informants 1, 2, and 8 were collected between May 2020 and March 2021.

Qualitative data were collected from smallholder farmers through an electronically administered questionnaire. Data from farmers 6 and 7 were collected in July 2018, while data from farmers 1, 2, 3, 4, 5, and 8 were acquired between October 2020 and April 2021. A questionnaire is defined as a set of questions used to gather information from individuals [52]. A focus group discussion was conducted with fifteen smallholder farmers in May of 2018. The main purpose of the interviews was to understand the issues relating to the availability of water resources as well as the performance of irrigation water infrastructure and water governance from the perspective of both smallholder farmers and key informants. The main issues covered during interviews and focus group discussions are shown in Table 2.

Table 2. Main issues covered during interviews and focus group discussions.

Issues	Smallholder Farmer Questions	Key Informant Questions
Water sources	• Perceptions of water shortages	• Perceptions of water shortages
Infrastructure	• Types of water infrastructure • Adequacy and performance of water infrastructure	
Governance	• Water use license and payment • Mechanisms of accessing water • Roles of institutions that allocate water • Capacity building, Cooperation • Sustainability, Equitability • Participation, Accountability • Rule of law, Transparency, Conflict resolution	• Roles of institutions in water governance • Water governance challenges

Water governance information was collected around the four selected coordination gaps of the OECD framework, namely, policy, accountability, funding, and capacity. The main issues relating to the questions on the four selected water governance gaps are shown in Table 3.

Table 3. Main issues covered on questions relating to the four selected water governance gaps.

Gaps	Smallholder Farmer Questions	Key Informant Questions
Policy gap		• Availability of water law that clearly states and distinguishes the roles and responsibilities of organizations managing irrigation water for smallholder farmers • Availability of mechanisms and processes that promote cooperation among smallholder water users • Availability of integrated policies and strategies that promote coherence across sectors in irrigation water • Availability of mechanisms and processes to track transparency, accountability, and participation in water-related use decisions, and to engage farmers in water management activities
Funding gap	• Availability of adequate funding for managing water-related activities such as operation, maintenance, and development of infrastructure	• Availability of adequate funding for managing water-related activities such as operation, maintenance, and development of infrastructure
Accountability gap	• Involvement of farmers in the development, planning, and decision-making process concerning water use • Commitment of decision-makers to their roles and responsibilities • Accountability of decision-makers to the farmers for maladministration • Commitment of farmers to the water-related management issues such as maintenance of irrigation water infrastructure	
Capacity gap	• Farmers receiving any training for optimal use of irrigation water	• Adequacy of technical staff to manage water resources and processes involved

Table 4 shows the key informants from institutions who were interviewed regarding agricultural water resources for smallholder farmers in Genadendal.

Table 4. Profile of key informants from different 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)

Qualitative data were analyzed using the thematic analysis method, a widely used data analysis method whereby a six-step process is followed. The process includes familiarisation with the set of data, creating preliminary data codes, searching for patterns or themes, reviewing themes, interpreting and naming themes, and developing a report. The method involves identifying, analyzing, and reporting themes or repeated patterns within the data set [53]. The six-step process of the thematic analysis method was followed, and Microsoft Word software was used for coding the data.

5. Results and Discussion

5.1. Changes in Rainfall, Streamflow, and Dam Water Level

Figures 3 and 4 show the changes in total annual rainfall and streamflow at Boontjieskraal Station and Riviersonderend River Catchment, respectively, from 2013 to 2019. The monthly percentage changes in water level at Theewaterskloof Dam are shown in Figure 5.

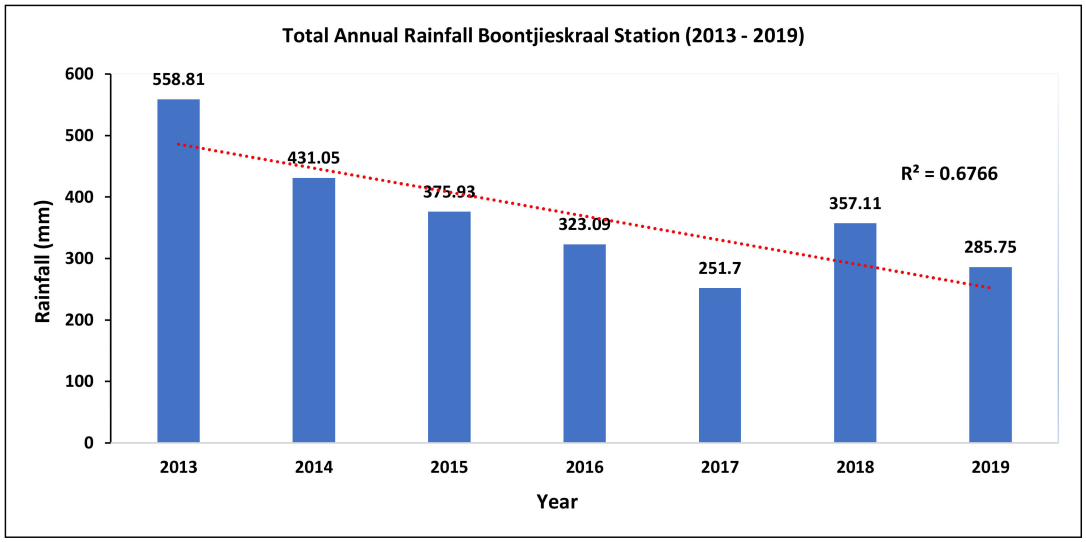

Figure 3. Total annual rainfall at the Boontjieskraal weather station for the period 2013–2019.

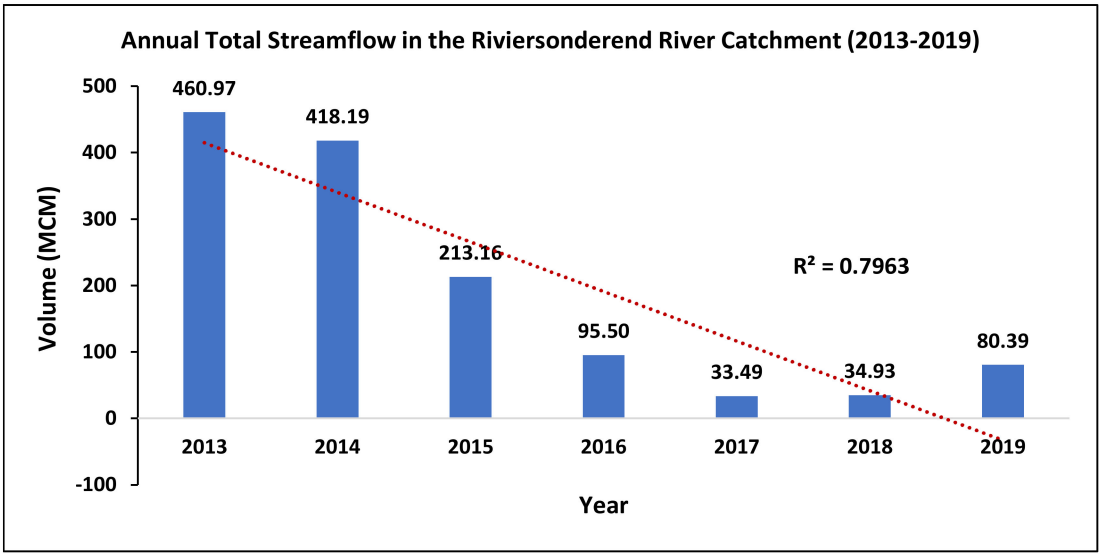

Figure 4. Annual total streamflow in million cubic meters in the Riviersonderend river catchment for the period 2013–2019.

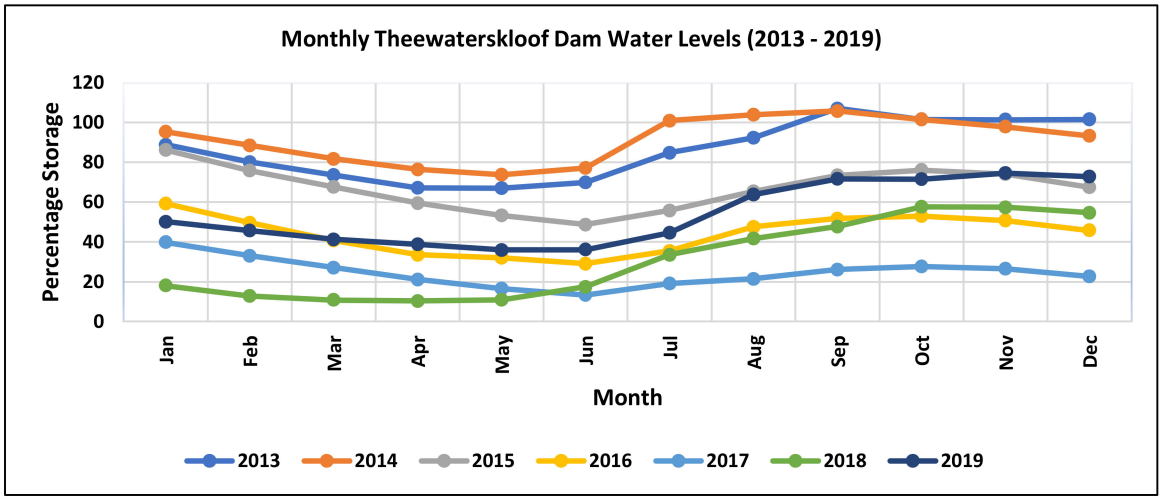

Figure 5. Monthly percentage storage at Theewaterskloof Dam for the period 2013–2019.

The results from Figures 3–5 indicate that the total annual rainfall and streamflow decreased from 2013 to 2017, while the monthly percentage of the dam water level decreased from 2014 to 2017. These results show that water resources in the Riviersonderend River and Theewaterskloof Dam were affected during the 2015–2018 drought period. This was mainly a result of the decrease in rainfall received. Low total annual rainfall was experienced in the year 2017, which resulted in low dam levels for Theewaterskloof Dam and low streamflows for Riviersonderend River. This indicates that rainfall deficiency is one of the major contributing factors to the serious decline of these water resources. Dwindling rainfall can strain the water supply and lead to an increase in competition for water, ultimately reducing both the availability of adequate water resources and water security.

The findings from this study are consistent with other studies conducted in the Western Cape province during the 2015–2018 drought period. Refs. [54,55] found that the lowest average annual rainfall was in the year 2017. In other studies, refs. [55–58] found that the Western Cape Province experienced three successive years (2015–2017) of below-average rainfall that led to severe water shortages. Ref. [22] reported that the three-year deficiency in rainfall caused a great deal of distress within the whole Western Cape Province.

5.2. Perspectives on Water Availability

Table 5 shows the perceptions of smallholder farmers regarding water sources and drought occurrence in Genadendal.

Table 5. 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

Six of the interviewed farmers pointed out that their water sources were able to hold enough water all year round. This view was supported by key informants 1, 2, and 8. Key informant 2 further highlighted that the average or normal rainfall of Genadendal is adequate to provide water for the year.

Genadendal is situated in a winter rainfall area; during the rainy season, irrigation water is harvested in irrigation dams for utilization during the summer production season. As the Riviersonderend River and the streams that flow from the mountains in the Genadendal area normally flow throughout the summer season, water remains available throughout the year. Water used during the day from the irrigation dams is restored during the night-time flow (key informant 2).

One farmer stated that their dam used to be dry throughout the year, but water from the mountain and overflow from the municipal dam remained running next to that dam. The farmer further explained that since a trench to direct water into the dam was made, water was now available all the time. This indicates that the lack of water conveyance systems for transporting water into the dam was the main factor that caused the previous unavailability of water. The availability of sufficient water in the irrigation dam was mentioned by another farmer during the focus group discussion, who pointed out that they were lucky because the dam always received an adequate supply of water from the perennial mountain streams.

During the focus group discussion, farmers highlighted that the numerous fountains in Genadendal always flow, which indicates that water is always available. Despite the availability of adequate agricultural water resources throughout the year, three interviewed farmers who depended on the Riviersonderend River and one interviewed farmer who relied on the irrigation dam indicated that they had experienced water shortages during the 2015–2018 period. One of the farmers emphasized that the water level in the Riviersonderend River was very low. This view was expressed by farmers during the focus group discussion as well; they indicated that the Riviersonderend River was very dry, and they had to move their livestock to the other side of the river. Other farmers stated that the water shortages severely affected their oats and tea crops because it was very dry, and the winds were very strong.

Key informants 1 and 2 highlighted that the smallholder farmers 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 others were forced to transport water for their livestock. Concerning smallholder farmers who were practising vegetable farming, key informant 2 noted that their production was reduced to less than 10% of their capacity. As a result of severe water shortages, key informant 1 asserted that up to 80% of summer water use restrictions were imposed during the 2015–2018 drought. Similar results have been reported by [18], who pointed out that the water situation in the Western Cape deteriorated severely during the 2015–2018 drought period, resulting in negative performance as well as strict action in irrigation water administration. Ref. [58] found that the water shortage due to drought was very serious at the beginning of 2018 and strict water restrictions were implemented as a result, which led to the complete reduction of irrigation. Ref. [59] study on coping and adaptation strategies for smallholder farmers in the Western Cape Province found that livestock production was affected by the 2015–2018 drought to the extent that some farmers were forced to reduce their livestock numbers, while others had to transport water from other places. Ref. [60] add that in certain areas it was reported that the planting of crops of lesser priority, such as tomatoes, vegetables, and onions, ceased because of the limited availability of water for irrigation. Ref. [56] found that agricultural and livestock production in the Western Cape's farmlands was severely affected by the extremely low rainfall during the 2015–2018 period.

Interestingly, smallholder farmers who relied on irrigation dams in Genadendal expressed that there were no water shortages during the 2015–2018 period. One of them highlighted that they never experienced water shortages because the municipal dam overflow always flowed into their dam, meaning that they would only suffer water shortages if the municipality decided to close the dam. Another interviewed farmer pointed out that water was always flowing from the perennial mountain streams into their dam. During focus group discussions, smallholder farmers reported that they were not affected by drought because they believed that the grace of God was upon them. They also indicated that the drought had only seriously affected those farmers who were outside Genadendal.

5.3. Perceptions of Farmers on the Condition of Water Infrastructure

The performance of irrigation water infrastructure is critical when ensuring that water is distributed efficiently, reliably, and equitably to the fields of farmers. Seven of the interviewed farmers relied on pipelines to convey water from irrigation dams and rivers to their fields. Two of the interviewed farmers further emphasized that water for smallholder farmers was mainly transported through pipes from the irrigation dams to the field of each smallholder farmer for about six hours. Petrol pumps were mainly used to pump water from the river. Only one farmer transported water from the dam to the field using an earthen canal. Another farmer used concrete canals to transport water from the river. Canal systems were not fully operational or used by farmers. It was mentioned during the focus group discussion that some farmers were forced to use municipal water because the canal systems from the dam were not functional due to lack of maintenance. This view was supported by one of the farmers, who had access to 15 hectares of land but unfortunately could only cultivate two hectares because access to water through the canal systems had been blocked. Canal systems and pipelines both faced challenges with inadequate maintenance. It was indicated during the focus group discussion that neither the canal systems nor the pipelines were well maintained. According to one of the farmers, there were no organizations that supported them with water infrastructure maintenance. During the focus group discussion, farmers highlighted that every farmer used to be responsible for cleaning and maintaining the canal systems in their area but unfortunately this was no longer possible because off-farm employment left them with no time to do maintenance. Deteriorating water infrastructure due to inadequate maintenance can lead to water insecurity. If the maintenance of water infrastructure is not performed, water is not distributed properly to users [61]. According to ref. [59], while infrastructure maintenance plays a critical role in conserving water resources during drought periods and consequently enables water security, this is very challenging, especially in smallholder irrigation schemes.

5.4. Analysis of Water Governance Challenges Using the OECD Multi-Level Governance Framework

Four water governance gaps were selected for this study, namely, policy, accountability, funding, and capacity. The four gaps are discussed below in relation to our findings from Genadendal. These gaps were found to apply to the study area and to contribute significantly to the water security status of smallholder farmers.

5.4.1. Policy Gap

Inadequate support for smallholder farmers and political interference in water-related issues were identified as among the policy-related issues in Genadendal. Key informant 8 stated that insufficient support from responsible water institutions as well as political interference contributed to the failure of mechanisms and processes that were supposed to promote cooperation among smallholder irrigation water users. Political interference and lack of sufficient support from responsible authorities contribute to the water insecurity status of water users. In a study assessing the challenges of water governance in Northern Iran, ref. [62] found that politicians usually attempted to influence decision-making relating to water issues with the main objective of gaining political power. The OECD notes that interference from influential political groups is one of the critical challenges in water governance [42]. Additionally, key informants 1 and 2 highlighted the absence of adequate mechanisms to engage smallholder irrigation farmers who were likely to be affected by irrigation water-related decisions, such as women and youth. Water security for water users can be threatened if they are not fully engaged in water-related decision-making. Lack of engagement of water users in water-related issues can lead to water insecurity [63].

Cooperation is considered one of the critical water governance principles for ensuring water security [64]. Key informant 1 indicated that it was only the local farmers association, Genadendal Farmers Association, in cooperation with the local Genadendal Transformation Committee, that tried to promote cooperation among smallholder farmers. Key informant 1 pointed out that even though the local community structures worked closely with the water user association and catchment management agency, cooperation with the local municipality was not sufficient.

Lack of coordination among institutions responsible for managing and supporting smallholder farmers concerning water access issues was another policy gap that was identified. Key informant 5 mentioned that coordination among institutions to support smallholder farmers with water infrastructure development was lacking. There was fragmentation of roles and tasks among institutions that were involved in the management of water-related activities, which could eventually lead to water insecurity. In their study on water governance in Bangladesh, ref. [65] found that the inadequacy of policy frameworks for promoting coordination among institutions further contributed to the fragmentation of roles across organizations.

Key informant 8 said that there was weak internal coordination within institutions as well as a lack of integration and poor external alignment of water reform with other reform programs. This had implications for water security status. Key informant 8 further revealed that lack of coordination within institutions contributed to the lack of fruitful and progressive realization of equity goals in terms of water allocation for smallholder farmers.

5.4.2. Accountability Gap

Lack of commitment to the roles and responsibilities of both farmers and institutions was one of the problems identified in the accountability gap. During the focus group discussion, farmers highlighted that off-farm employment outside Genadendal was one of the factors that hindered them from being fully committed to water-related management activities such as carrying out maintenance activities on their infrastructure. Farmers with off-farm occupations may have inadequate time for negotiating and guarding water supplies, which can affect reliability and access to irrigation water. Ref. [66] found that

the degradation of parts of the canal system was mainly a result of farmers not taking responsibility for maintenance.

According to ref. [31], indiscipline in failure to follow rules aimed at increasing order and equity may be encouraged in such situations, especially as those users without off-farm activities tend to irrigate as suits their time, availability, and convenience. More than half of the interviewed smallholder farmers were of the view that the institutions responsible for the management of their agricultural water were not accountable. According to [67], leaders in the management of water resources should be answerable to the group they serve in case things go wrong. In the governance of water resources, lack of accountability has been stated as the major obstacle to attaining efficient water management [68]. Key informant 6 indicated that due to time constraints it was very challenging for their institution to fully assist smallholder farmers with water management-related issues such as the water allocation process. Furthermore, key informant 6 emphasized that most of their time was committed to other roles and responsibilities.

Authors [69] indicated that water management leaders are expected to show commitment to their responsibilities. However, according to key informant 6, only 6% of their time was spent on water allocation duties, including assisting smallholder farmers with water-related management issues. Key informant 3 highlighted that it was very challenging for their institution to fully assist smallholder farmers regarding irrigation water access, as most of the smallholder farmers were not willing to approach them and share their challenges in this regard.

The absence of transparency in irrigation water-related decisions was identified as a contributing factor to the accountability gap. This factor was pointed out by key informant 2 and was regarded as one of the main limitations around the governance of water in the Genadendal area.

The participation of farmers in irrigation and water management activities can assist in improving water use security. Key informant 4 emphasized that their institution engaged with smallholder farmers who were members of Water Users Associations (WUAs) as well as non-members. Key informant 4 mentioned that farmers who were not part of a WUA were unfortunately not usually willing to participate during water allocation meetings, and they also did not commit themselves to attending the meetings. Ref. [70] found that the active participation of farmers in processes related to water access issues is necessary to achieve effective irrigation water management and water security. This is mainly because it provides them with strong motivation to respect rules and conserve water. In their study, authors [71] found that farmers needed to be part of formal institutions such as WUAs, as this helped them become involved in capacity-building programs and increased their participation. More than half of the interviewed farmers stated that they were not directly involved in the processes involved in development, planning, and decision-making around irrigation water. This indicates that a lack of active participation of farmers in issues concerning water management. In India, the lack of involvement of people in the management of local water resources was found to be a contributing factors leading to water insecurity crisis [72].

5.4.3. Funding Gap

A lack of financial resources to carry out water management activities was identified in the funding category. Key informant 1 indicated insufficient funding as one of the contributing factors that limited their engagement with smallholder farmers. Lack of funding can limit the establishment of mechanisms to engage farmers who are likely to be affected by water-related decisions. In addition, key informant 5 pointed out that funding to support smallholder farmers with water infrastructure development to access water was inadequate. One of the smallholder farmers who was interviewed asserted that there were no organizations that supported them with water infrastructure development and as a result, a lot of water flowing from the mountain and dam was wasted. It seemed that the lack of adequate infrastructure to store and transport water contributed to artificial

water shortages for smallholder farmers. During the focus group discussion, farmers expressed concerns that the funding that was invested by institutions responsible for canal maintenance was unfortunately not assigned to them. One of the farmers revealed that only farmers outside Genadendal were assisted with funding for infrastructure development. This means that assisting smallholder farmers in Genadendal with water infrastructure was not a priority for those institutions that were responsible for the governance of agricultural water resources.

Absence of adequate funding for infrastructure development and maintenance can lead to water insecurity even if water is available. In their study, authors [73] found that lack of funds can contribute to inadequate maintenance of infrastructure, resulting in water insecurity. Ref. [36] found that a lack of finance for investing in sustainable irrigation water supply systems contributed to water insecurity in South Africa. Adequate and reliable infrastructure is required to extract water from the source to the field. Key informants 4 and 5 highlighted that they assisted smallholder farmers in applying for funding that could be used to maintain all types of infrastructure. Key informants 4 and 5 added that, unfortunately, the applications that they had received from farmers were unsuccessful due to insufficient funding from the responsible institution. Key informant 4 pointed out that most often the funding was restricted to farmers who were members of a water users association. Of the eight farmers who were interviewed, only two indicated that the Zonderend Water User Association was one of the institutions that were responsible for managing agricultural water resources for smallholder farmers. This means that most of the farmers were not members of that water user association.

According to [27], investment in infrastructure for storing and delivering water as well as in institutions for water resource management is critical to ensuring water security. Key informant 2 indicated that farmers were not fully committed to paying their annual water use fees. According to key informant 1, farmers believed that water was a free product from God, hence they were not supposed to pay for it. Funds generated from water use payments can be used to assist the development, operation, and maintenance of irrigation water infrastructure, thereby ultimately enhancing water security.

Key informant 1 highlighted that because of the absence of water meters, farmers with small pieces of land were forced to pay for the same amount of water as farmers who owned large pieces of land. In addition, key informant 1 stated that the water usage bill was often equally divided among farmers regardless of differences in the size of their land. This seems to have contributed to the unwillingness of some farmers to pay for water use. Ref. [74] asserted that if farmers do not pay their water charges it can lead to poor water management and inadequate access to water. In their study on smallholder farmers in South Africa, ref. [41] found that farmers who did not pay their irrigation water use fees contributed to water insecurity. If water users do not pay for using water, it can compromise the sustainability of water infrastructure and consequently lead to water insecurity.

5.4.4. Capacity Gap

More than half of the interviewed smallholder farmers reported that they had not received any training on the optimal use of irrigation water, which means that irrigation water management training skills were lacking. Farmers' lack of training reduces the probability of them saving water, and consequently affects their water security status. This finding is consistent with [75], who indicated that most South African smallholder farmers lack skills. According to ref. [76], investing in soft skills such as farmer training can improve agricultural production. In cases of water scarcity, capacity building and empowerment of farmers play an important role in enhancing their adaptation capacity [77]. Training for optimal use of agricultural water can assist farmers in coping during periods of drought [78]. In their study, Dirwai et al. (2019) [41] found that water management training was very important in ensuring the adequacy of water in smallholder irrigation schemes. More than half of the farmers interviewed in this study revealed that they conserved irrigation water to ensure its availability for future use. This was surprising because these farmers did not

receive any training from any institutions regarding the optimal use of irrigation water. This shows that the farmers informally trained themselves to conserve water. Ref. [79] highlighted that informal water management training whereby farmers train themselves through information sharing is crucial, as at times smallholder farmers' access to extension services can be very challenging.

According to key informants 1, 2, and 8, their institutions did not have sufficient human resources capacity, particularly technical staff, to manage water resources for smallholder farmers in Genadendal, which appears to have contributed to the difficulty of controlling water use for smallholder farmers. When there is no control over water use, it can lead to water insecurity among users. Key informant 2 highlighted that only two persons were available to handle all irrigation water-related issues, including the collection of water use fees. Furthermore, key informant 1 mentioned that due to inadequate technical staff in their institution, some committee members who were smallholder farmers ended up working voluntarily to maintain infrastructure despite not having enough resources. The maintenance of water infrastructure is a task that requires sufficient and skilled human resources. Human resource capacity is critical to enabling the management of water, ensuring equitable distribution of water, collecting water payments, maintaining irrigation infrastructure, and managing conflicts [80], all of which assist in attaining water security. Lack of human resource capacity can lead to difficulties in controlling and monitoring water resources [81].

6. Conclusions

This study assessed infrastructure performance and irrigation water governance as well as the availability of agricultural water resources for smallholder farmers. Farmers depended on surface water extracted from the river and irrigation dams for their farming. Farmers who relied on the river were affected during the 2015–2018 drought period, leading to severe water shortages for both livestock and crop production. On the other hand, this study shows that smallholder farmers who utilized water from the irrigation dams were not affected. This study concludes that there are adequate agricultural water resources for smallholder farmers in Genadendal even during drought periods, especially for the farmers who depend on irrigation dams. In addition, this study shows that the poor state of irrigation infrastructure, particularly the canal system, is mainly due to inadequate maintenance. The lack of infrastructure maintenance was mainly due to insufficient funding and human resource capacity, as well as a lack of commitment from farmers and institutions to carry out maintenance.

Farmers were not committed to paying water use fees that could be used to contribute towards funds for the operation and maintenance of water infrastructure. This study shows that the irrigation water governance systems for smallholder farmers are dysfunctional. Lack of coordination within and among institutions along with inadequate support and mechanisms to engage smallholder farmers contributed to the dysfunctionality of irrigation water governance systems. Finally, this study concludes that while there are sufficient agricultural water resources in Genadendal, the performance of its water governance systems needs improvement in order to enhance water security for smallholder farmers. The findings from this study can assist stakeholders and policymakers in understanding and addressing the challenges facing agricultural water management in Genadendal. The same approaches can be used in other small historical towns that are facing similar challenges.

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