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Water, Sanitation, and Hygiene Vulnerability among Rural Areas and Small Towns in South Africa: Exploring the Role of Climate Change, Marginalization, and Inequality

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Abstract: Access to water, sanitation, and hygiene (WASH)—including drainage-services—is essential for public health and socio-economic development, but access remains inadequate and inequitable in low- to middle-income countries such as South Africa. In South Africa, rural areas and small towns generally depend on a limited and climate-sensitive economic base (e.g., farming), and they have a limited capacity and are located in areas where transport challenges can increase WASH access risks. Climate change shifts hydrological cycles, which can worsen WASH access and increase susceptibility to the interlinked impacts of droughts and flooding in already vulnerable regions. We adopted a transdisciplinary approach to explore the needs, barriers, and vulnerabilities with respect to WASH in rural areas and small towns in South Africa—using two case studies to explore climate risk and vulnerability assessment (CRVA) in one rural village in the northern Limpopo province and a small town in the Western Cape province. This holistic approach considered natural (environment and climate) and socio-economic (economic, social, governance, and political) factors and how they interplay in hampering access to WASH. Extreme weather events characterized by frequent and intense droughts or floods aggravate surface and groundwater availability and damage water infrastructure while threatening agriculture-dependent livelihoods. The lack of reliable transport infrastructure increases risks posed by flooding as roads to vital supplies are prone to damage. High inequality linked to rising unemployment and the Apartheid legacy of a segregated service delivery system result in inequitable access to WASH services. The intertwined ways in which natural elements and historical, social, economic, governance, and policy aspects are changing in South Africa increase WASH vulnerability in rural areas and small towns.

Keywords: adaptation; developing countries; resilience; WASH; drainage; water quality; drought; vulnerability

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1. Introduction

Access to water, sanitation, and hygiene services (WASH) is essential for public health and socio-economic development. However, in low- to middle-income countries such as South Africa, access to WASH remains inadequate and inequitable, specifically in remote rural areas and small towns where skills, capacity, and funding shortages also hamper efforts to ensure equitable access. These areas continue to face challenges in service delivery and are highly dependent on the central government for funding due to their limited revenue base [1,2]. The economic base of these areas is generally climate-sensitive (e.g., farming, tourism) making them vulnerable to climatic changes and extreme weather events.

Since the 1970s, two-thirds of the South African population have moved to larger cities to seek economic opportunities resulting in the depopulation of small towns and

rural areas [3], further reducing the economic prospects of these areas. Lower population numbers also result in low revenue collections by service providers and a limited ability to finance WASH services. In the rural and small-town settings, municipal capabilities can be very limited such that they may not have the human capacity or skills to manage already limited infrastructure and systems, thus emphasizing their vulnerability [4,5]. In addition, when remote, their location can worsen access to vital resources necessary for WASH. Thus, small towns and rural areas are vulnerable areas that require a research focus to understand the potential impacts of environmental and socio-economic factors on WASH. Climate change has brought shifts in hydrological cycles, which can worsen access in already vulnerable regions. In South Africa, standard Climate Risk and Vulnerability Assessments (CRVAs) are difficult to complete for varying reasons, i.e., limitations of available local data, the inclusion of irrelevant fields (for the specific context), or the reality that most assessment tools undervalue or neglect local and context-specific areas of concern. For example, a strong focus on drainage, as is needed in many southern African informal housing areas and water sites (that are used as part of local healing practices), is often absent.

Although there are several CRVAs developed in South Africa, these assessments often provide quantitative vulnerability indices that indicate relative vulnerability. However, indices have the potential to hide certain realities and nuances of the lived experiences. Applying census data to assessments can conflate socio-economic differences, which is particularly problematic in South Africa due to extreme inequality and can obscure important aspects such as the reliability of a service [6]. Given these shortfalls, case-study assessments, such as the one we undertook, can reveal lived realities and offer a nuanced understanding of drivers and factors affecting WASH, including drainage.

1.1. Aims and Objectives

This paper emanates from a short-term project where we were tasked with exploring the application of WASH vulnerability assessments in the South African context, and specifically in small towns and rural areas where access to detailed data on the provision of WASH services is often lacking. Layered on top of that was the added challenge of COVID during the period in which the case studies were compiled (June to August 2020). As such, we drew on existent engagements and WASH-related research in places where we already had good insights into local conditions, in an attempt to undertake vulnerability assessments in places where other data may not be available. To this end, we created WASH-focused case studies to show how, in very different settings, similar contextual aspects become centrally important but difficult to assess, or even consider, when using standard CRVA tools. In other words, we ultimately argue that assessments without contextual understanding provide little by way of actually understanding how WASH access will play out in extreme climate situations. Rather, an understanding of context, for example, local history and inequalities in combination with contemporary organizations and actors, when paired with standard assessment tools, can provide insights as catalysts for actions targeting barriers to inclusive access to WASH; see Ezbakhe et al. [7].

A transdisciplinary team of researchers from the Future Water research institute at the University of Cape Town undertook a review of current CRVAs and developed two related case studies that explored the needs, barriers, and vulnerabilities to WASH among two arid regions in South Africa, one village in Limpopo and the other a small town in the Western Cape. This paper, drawing on the review of current CRVAs, provides: 1) an introductory historic context, 2) a brief outline of the research methods (treated in more detail in Abrams et al., forthcoming), and ultimately, 3) climate risk and vulnerability assessment summaries and comparisons emerging from our case studies.

1.2. WASH, Climate Change, and Vulnerability Assessments

Water, Sanitation and Hygiene (WASH) vulnerability assessments explore access to clean potable water, sanitation facilities, and sound hygiene practices—all essential for public health and socio-economic development. Diseases are transmitted through poor sanitation or hygiene and contaminated water sources; for example, an estimated 2.86 million cases and 95,000 deaths annually worldwide result from cholera alone [8]. The provision of WASH services including appropriate drainage (Appendix A) can reduce the disease burden considerably, such that sustainable development goals have prioritized the universal coverage of sanitation services, provision of safe water, and eradication of open defecation by 2030. However, access to WASH in South Africa remains inadequate and inequitable [9].

The provision of WASH is influenced by several factors—including environmental, climatic, economic, social, governance, and political aspects—which have interlinked impacts on the delivery of water and sanitation services. At the same time, climate variability and change add uncertainty and stress to already unequal and inadequate service delivery. Climate change impacts the availability and quality of water by shifting rainfall patterns and increasing temperatures, leading to extreme weather events that damage water and sanitation infrastructure, and changes the exposure to pathogens and other disease vectors (e.g., malaria) when sanitation and water services are disrupted and as water temperatures change. This has led to an increasing emphasis on reducing the vulnerability of WASH services to such change [10]. As summarized in South Africa's Third National Communication [11], southern Africa is generally expected to become drier along with warming trends; thus, planning for and reducing vulnerability to climate change is a priority. Such planning requires assessing what water-focused services are already in place and how climate changes might increase risk or vulnerability to the loss of these. This paper highlights key factors and considerations in such assessments by offering two case studies in very different (and yet very similar, with regard to WASH vulnerability) contexts. We suggest that for southern African WASH assessments, there is also a need to include specific considerations of drainage, making a case for 'WASHD' assessments as drainage concerns create specific pinch points in both case studies.

WASH-focused climate risk and vulnerability assessments (CRVAs) can assist in anticipating impacts from climate change on WASH service delivery and outcomes; they can help determine where the greatest vulnerabilities lie, and they support policy makers and operators to identify priorities for action and investments to increase the resilience of WASH services. While frameworks, such as the Strategic Framework for WASH Climate Resilient Development [12], are available to guide this process, ample local (and global) efforts are being made to consider existing risk and vulnerability assessment frameworks and tools, and how they can be applied to WASH. Climatic challenges further magnify historically shaped inequalities that mean that experiences of accessing WASH services can be starkly different from person to person and are particularly different from area to area. Managing and understanding WASH in the diverse South African context, thus, means dealing with a combination of understanding and managing biophysical as well as historical and current socio-economic contexts; this requires drawing on standard tools such as CRVAs to provide information that can be understood across contexts, but never in isolation, as these tools can also run the risk of obfuscating key areas of concern.

1.3. Climate Risk and Vulnerability Assessments (CRVA), and their Limitations

Climate Risk and Vulnerability assessments (CRVA) focus on social, economic, political, environmental, and governance aspects. As part of this research a scoping review was undertaken which determined that there is not a lack of CRVAs per se in South Africa, rather the South African CRV assessment landscape is highly diverse with a variety of actors. There is also an increasing number of relevant and sometimes overlapping South-African-based frameworks, platforms, and tools, including the framework for Climate

Change Health Risk and Vulnerability (DoH, not yet publicly available), the National CRVA Framework [13,14], the South African Risk and Vulnerability Atlas (SARVA), and the South African Green Book, an online portal that includes an interactive municipal-scale risk tool (https://riskprofiles.greenbook.co.za/; accessed 26 August 2020). As such, additional assessment frameworks or efforts should ideally build on an understanding of in-country work and add to, rather than duplicate or confuse, what already exists. This scoping review has thus attempted to address the current gaps existing from CRVAs in South Africa. In particular, explicit WASH CRVA assessments are lacking; this is because assessments are shaped by the thematic entry point or angle taken, and without explicit WASH entry points or angles in current CRVAs, there is a subsequent lack of WASH CRVA findings and recommendations. Our efforts here identify some key themes and entry points that appear in both case studies to address the need to build explicit WASH CRVA understanding in South Africa.

CRVAs may be collated to provide quantitative vulnerability indices exploring relative vulnerability; however, when applied uniformly, indices have the potential to hide certain realities if not applied with care. For example, Apostos [6] notes that nationally imposed assessments applying census data can potentially conflate socio-economic differences in South Africa and can also hide important aspects such as the reliability of a service. Large data sets do not detect or confirm interlinkages between bio-physical aspects, economics, and WASH or settlements/housing and WASH, nor the nuances of the lived experiences. For this, studies are required that explicitly investigate such connections and that document experiences. The methods for this research (Abrams et al., forthcoming) thus took into consideration both standardized vulnerability assessments and context-specific, detail-oriented qualitative data that led to assessment adjustments which are able to bring out the added context-specific realities that are largely missed in quantitative CRVA processes.

1.4. WASH in South Africa

South Africa's colonial and Apartheid history continues to challenge efforts to ensure access to WASH across the country. As with most postcolonial governments, a legacy of unequal distribution of infrastructure and services remains [15]. The 1996 census found that less than half of all South Africans (44.7%) had taps inside their dwellings [16]. In a country where black Africans made up 72% of the population, 96.4% of whites had taps inside dwellings, while only 27.3% of black Africans had taps [16]. Historic statistics on toilet facilities reflect a similar distribution. According to the latest South African community survey [17], access to piped water has increased, but complete coverage is still far from a reality. While more recent reports do not release statistics according to population groups, households with inside taps remained constant at around 44%, while piped water inside the yard doubled from 16.6% to 30%. Toilet facilities have improved, with 67.5% of the population accessing flush or chemical toilets [17]; however, Hemson [18] suggests that the presence of these facilities, particularly in rural areas, does not necessarily mean that they are operational, and when operational, water quality issues arise. This highlights the importance of looking beyond the mere presence or lack of piped water. The South African WASH context is layered and diverse; understanding the related risks and vulnerabilities requires going beyond the existing number of taps and toilets.

As argued by Ezbakhe et al. [7], inclusive WASH, where no one is left behind, requires understanding the experiences of the vulnerable and marginalized; this is particularly important to address in WASH assessments. In our case studies, we are able to assess this because the research included engaging with data beyond accessing numbers and tap counts to understand specifics around service delivery and lived experiences. In South Africa, more generally this requires understanding that there is a fragmented policy landscape (Appendix A) [19,20], but also it requires engaging with the often very different settings in which people are vulnerable and marginalized, and being aware of historic links to current manifestations.

1.5. Climate variability and WASH in small towns/rural villages in South Africa

Droughts and floods are regular features in South Africa, with extensive implications on health and livelihoods and economics. For instance, the March 2014 floods in the Mpumalanga province, including municipal infrastructure damage, cost over ZAR 61 million [11]. Floods damage road networks and other public infrastructure such as schools while also impacting agricultural land and livestock [21]. At the same time, South Africa's arid climate [11] and limited/changing rainfall patterns [18] add challenges to accessing WASH. Although during much of the 20th century the South Africa population was predominantly rural, this is rapidly changing.

2. Materials and Methods

2.1. Data Collection

Two very different contexts were chosen, i.e., HaSinari(Appendix A), a rural area in the Limpopo province, and Prince Albert, a small town in the southern part of the Western Cape province. Natural (environment and climate), and socio-economic (economic, social, governance, and political) factors were considered, and their interplay in hampering access to WASH services was analyzed. We used a mixed methodological approach including a review of published data, drawing on already completed face-to-face interviews with a wide sample of different stakeholders, and on-the-ground observations.

Field data on the Prince Albert Municipality were collected by a multi-disciplinary team of researchers on 17 and 18 May 2018 by way of observations within the town, and eight separate semi-structured interviews(Appendix A) (see [22] for more on methods) with residents, municipal officials, and relevant stakeholders who also included conservationists and agricultural water users were conducted. The interviews provided a perspective of a variety of stakeholders' experiences and responses to water management initiatives within the municipality—particularly related to drought conditions that were being experienced in the area at that time.

Field data in HaSinari were collected during long-term participant observations, in-depth interviews, surveys, focus groups, desk-based research, and a wide range of participatory exercises and activities were used for this research. Interviews averaged 1–1.5 h each, repeated with the same people on different topics, over four years; over 80 different interviewees were engaged with, some as many as 5 times. Interviewees were all HaSinari residents, living under the same traditional authority; the majority of residents were TshiVenda speakers, earning less than ZAR 3000 per month; however, five interviewees had considerably more socio-economic resources via their connections with the royal family or economic resources outside of the area (1x local headman's daughter; 3x residents with jobs in the private sector; 1x resident whose child provided them with a private borehole). For further methodological information, see [23]. This case study was conducted from 2013 through 2016, also a time of drought in the area; therefore, descriptions reflect that time period specifically.

2.2. Sites Description

2.2.1. Prince Albert Municipality, Western Cape Province

The Prince Albert Municipality (PAM), one of three municipalities in the Great Karoo District (GKD), is a semi-desert region. Prince Albert is the main town in a municipal area that covers 8,153 km^2, along with other smaller towns, farms, and rural areas including Klaarstroom, Prince Albert Road, Leeu Gamka, Welgemoed, Seekoeigat. In 2011, the municipality's population was 13,136 people, and this was estimated to grow to 14,091 by 2018 [24].

2.2.2. HaSinari, Vembe District, Limpopo Province

The Mutele (Appendix A) village falls within the HaSinari chieftaincy, located in the northeast of the Limpopo province. During Apartheid, this area was the Venda 'bantustan' (Appendix A) and, for a short time, the independent Venda nation [25]. Six villages, similar to Mutele, are situated 'on the edge' of, and share a fenceless boundary with, the Kruger National Park, managed by South African National Parks—this is important because it has bearing on water distribution in the catchment. Approximately six hundred Mutelians live in this geographically and logistically remote location, in large part because of colonial and Apartheid processes, including conservation protectionism that shaped land allocation, and 'ecological legacies' that continue to influence their lives [26] (p. 132).

2.3. Analysis and Conceptual Framework; Building Storylines and Assessments from what Is Available

For the purposes of these CVRA WASH case studies, we composed profiles based on existing publications and data already collected (published reports, interviews, etc.). We briefly addressed the following key components to build a background picture for the cases (as briefly summarized in the Results section):

1. Historic context—including land ownership/dispossession and resource access;
2. Climate, extreme weather events, natural resources context;
3. Socio-economic profile.

With these 'background' materials sketched out, we then undertook a review of each site using a local assessment tool, the Greenbook(Appendix A) (www.greenbook.co.za; accessed 26 August 2020). At the same time, having immersed ourselves in the data for the two sites, we addressed how some of those key components (history, climate, and socio-economics) intersect with WASH access, in narrative form, as a storyline to provide examples.

Finally, we undertook a specific, directed analysis with all of these previous factors in mind. The analysis included the following:

1. WASH specific analysis;
2. Catchment vulnerability assessment;
3. Source vulnerability assessment;
4. WASH management and community engagement capacity/vulnerability assessment;
5. WASH supply chain and supporting infrastructure vulnerabilities and capacity assessment.

For each of the five analyses above, we attempted to answer key pre-defined questions drawing on our observations and interviews (see [27]). A thematic content analysis of interviews was used to analyze interview materials, while relying on the expertise of our trans-disciplinary team to supplement interviewee perspectives with an observational analysis. We then compiled a list for each site that summarized the key components of vulnerability in each catchment that were not well addressed in standard tools (Table 1) thereby developing a list of interviewees' identified indicators. In this paper, we compare these lists and discuss the findings from our reports.

Table 1. Key challenges related to WASH access in case study area.

HaSinari	Prince Albert	Indicator Theme
Rain patterns have changed, as have the river levels in the area; Drought during research period	Drought during research	Weather change/weather vulnerability
Infrastructure failure/lack of municipal investment has led to community response and organization by local residents that make water access possible. Consistent drinking water and hygiene (hand and food washing) sources not available: All of these challenges combine to make consistent access to drinking water especially difficult.	Infrastructure failure/lack of investment. Groundwater recharge project was not completed; reticulation and taps are not available to all; some households still resort to the bucket system as a means of sanitation provision	Infrastructure failure
Municipal infrastructural failures mean that water delivery and access are reliant on community money collection	Dependence on community collection (or donation) in financially precarious setting	Community dependence on collection
With the failure of the municipality to manage local taps, residents had boreholes dug and pumps installed at their own cost through connections that tie into the existing tap system. The cost of diesel to run the pumps is covered through residents' contributions to the Water Committee, but it is not simply collecting funds (already a burden in this cash-strapped setting) because there is no local fuel station	Previous flooding damaged roads, rendering areas inaccessible. Major supplies for WASH infrastructure are sourced from cities. Municipal supply chain processes may not always support effective maintenance of water services, e.g., a breakdown or depletion of water treatment chemicals will result in WASH service disruption	Supply chain concerns
Transport challenges: The dirt road and limited road options are further complicated by the reality that in extreme weather events, the roads are significantly impacted, and when navigable, the roads are slow.	See above	Transport challenges
Residents suggest that drastic changes in rain patterns (rainy season shifting from Jul/ Nov to Oct/Feb) and reduced rain and river flows changed local agricultural practices and significantly influence daily life	Prince Albert is renowned for both extreme droughts and flash floods resulting from poorly designed stormwater drains with major public health impacts as well as economic consequences (e.g., through decimating the agricultural sector)	Extreme weather events
Apartheid era interference in local governance led to conflicting claims over official Chieftaincy and land rights/controls. Different aspects of land and water management are variably contested, and clear directives on who has ultimate control and decision-making abilitites are not established	It is unclear if the municipality has oversight on water and sanitation services installed by third parties. For example, no water quality data for Leeu-Gamka village boreholes (installed by Transnet) are available; residents rely on water smell as the quality attribute. There is a skilled water management team with reasonable support from the Water Board (agricultural interests), but engagement is limited to better-resourced parts of town	Political oversight
Historic environmental racism/inequality/exposure to toxins add to the burdens of this region, including an incomplete removal and clean-up of coal mine debris after the local mine closed in 2014, and this means that water quality is further challenged	Apartheid-era segregation and provision of services based on race left a highly unequal society which persists in service delivery when Prince Albert town's provision of water and sanitation services is compared to others in the area	Colonial/Apartheid Legacies
Economies of water emerge along both monetary and moral lines (see Abrams, 2018); access to water is leveraged to make income; at the same time, income is needed to contribute to the water committee	Agricultural activities are an important economic activity in Prince Albert. Worsening droughts impact these activities, resulting in job losses and downstream social and financial impacts	Economic aspects

3. Results

3.1. Key Components

3.1.1. Historic Context: Entrenched Inequality

The earliest inhabitants of the semi-desert Great Karoo region were the San people. During the mid-eighteenth century, early trek 'Boers', nomadic pastoral farmers, arrived and established stock farms, causing conflict with the San over the control of resources; the white settlers began to appropriate land and the sparse springs [28]. In the 20th century, a series of ravaging droughts and the Anglo-Boer war resulted in a massive out-migration and long-term economic decline which led to the marginalization of the area [29]. The Group Areas Act (1950) and the Population Registration Act (1950) entrenched racial segregation in Prince Albert; for example, 1962 forced relocations 2 km out of town

into the drier semi-desert North End township [30]. Since then, the town center has remained the predominant business area (infrastructure support and budget) and is occupied by white residents, while the predominantly colored 'North End' struggles with an array of social and service challenges [31]. Apartheid-era segregation and the provision of services based on race have created extreme inequality that remains today in the Prince Albert Municipality.

The Venda homeland created in 1962 by the South African government was systematically ignored when developments to road and sewerage infrastructure, healthcare, electricity, and telecommunications services were undertaken elsewhere in the country—this all continues to impact and challenge efforts such as WASH, making these former homelands particularly vulnerable to flooding, drought, and other extreme weather events. The Apartheid regime forced 'independence' on Venda in 1979 [32]; this included the governments' infrastructural disengagement with these areas, justified by 'independence', which led to further resource access inequality. Environmental injustices and (infra)structural violence combined during independence to create impoverishment and under-development (Appendix A), as the unpopular, imposed government failed in local service delivery 'and environmental protection' [33]. Venda's period of independence has significant impacts on environmental policies, current economic opportunities, and services delivery (such as sanitation and water). The HaSinarichieftaincy had no electricity until 2013 and currently has no sewerage, consistent water provision, or reliable roads, but it continued to provide coal for South Africa until 2014. Complicated policies around land ownership and resource use, particularly where customary law, traditional councils, and individual (civil) rights are not always aligned, exist—in fact, in Venda, customary lineages (i.e., royal family lines) have been challenged (Appendix A). Land rights and resource access are shaped by Apartheid and colonial histories in who has say over who has access, what lands are currently inhabited, and the (lack of) infrastructures/service delivery. Added to these challenges, for the WASH context, is the reality that the closest rivers are inaccessible due to large game fences for parks established during Apartheid, so that contemporary government failure to deliver water to local taps is magnified by conservation practices; see [23].

In both case study sites, colonial and then Apartheid histories result in an architecture of neglect and different forms of water rights and access to scarce resources and habitable lands across different populations.

3.1.2. Climate and Landscape

The Prince Albert Municipality is a semi-desert characterized by temperature extremes and erratic average annual rainfall (Appendix A) [34]. The rainy season ranges from April to early October. Groundwater is the most reliable source of water in the agriculture-dependent economy of Prince Albert. Between 2015 and 2018, Prince Albert experienced its worst drought since 1904 [35]. In 2017, a thunderstorm destroyed roads and boreholes which provide drinking water to Prince Albert, damaged reservoirs, and left vehicles trapped or washed away [36]. Several motorists were stranded for more than a day, and an ambulance was washed away. The floods also caused extensive damage to the Swartberg Pass between Prince Albert and the town of Oudtshoorn [36]. In 2018 and 2019, the situation, described as 'frightful', resulted in farmers in Prince Albert and Leeu Gamka relying on donations of water—directly impacting 322 families of farmers and farm workers [37,38]. In July 2020, the Karoo region remained in drought, with Oukloof dam water levels (in Prince Albert) at only 3.78% of full capacity, while other dams in the Karoo region ranged from 0.1 to 29.2% [39]. This led the municipality to implement level 4 water restrictions (level 5 is the most restricted) [40]. These climatic shifts are expected to persist into the near future but are not expected to change drastically in the next 30 years.

HaSinari is significantly more arid than its neighbours 30 km in either direction, with temperatures ranging from 10 to 40°C [41]. The average rainfall per year is approximated

between 300 and 400 mm [41]. Seasonal summer rains in February 2013 devastated the area; swelling rivers uprooted baobabs, destroying everything in their paths, washing out roads and homes. Dangerous conditions emerged from the absence of road infrastructure, and a lack of rainwater control measures led to erosion. Following the 2012–2013 rainy season, HaSinari experienced what many residents called 'drought'. Dried-up rivers compounded the government's failure to provide drinking water, and crops failed. While winter nights can bring frost, temperatures soar to 40°C in the summer. Although the heat is not new, the periods of intensity are perceived to be increasing as rain patterns change. In fact, a HaSinarian in his late fifties explained the challenges experienced as a result of the drought: 'No rain, none. We don't even know when to plant anymore'. This lament of changing patterns in rainfall, which challenge local knowledge of planting seasons, provides insight into the impacts of the precarious relations to water access people experience in this setting, magnified by local declines in rainfall and river levels [33], in the context of regional and global climate change. The drought meant that challenges in municipal piped service delivery were felt more acutely.

In both settings, arid contexts are magnified by extreme weather events, and in both cases, alternating experiences of flood then drought stretched already scarce resources even further since the turn of the century. Increasingly, these extremes and events are expected with climate change, with knock-on implications for systems such as sewerage, water reticulation, and stormwater drainage.

3.1.3. Socio-Economic Aspects and Demographics

The Prince Albert Municipality is well-known for agricultural produce, architectural monuments, and tourism, which provide the main sources of employment. Agricultural activities include sheep farming, olive groves, and fruit exports which account for about a third of all jobs and generated 20% of the municipality's gross domestic product, with retail and tourism contributing 15% [24]. The unemployment rate is 20% and increasing. The majority (84.5%) of the population self-identifies as Colored, 11.8% as White, and 2.8% as Black African. Among those aged 20 years and older, 4.8% had no formal schooling, 23.7% completed matric, and 2.4% had higher education [42]. Tourism in the region has been growing [43]. At the same time, worsening droughts impact tourism and farming activities, resulting in job losses and downstream social and financial impacts on revenue and service delivery, thus increasing economic vulnerability. Current trends showing increasing unemployment and inequality have the potential to impact revenue collection which may impact service delivery, including WASH and other social services.

Limpopo's capital production is generated through mining, agriculture, and tourism. This predominantly rural area (90%) is resource rich (minerals and agriculture), but the population is generally poor, and unemployment is extremely high [44]. Organizationally, wives generally move to their husbands' village; however, migrant labor demands result in many female-headed households [44]. While the region relies on agriculture [44], only 11.3% of households in the Mutale sub-district are agricultural [41], possibly because of low rainfall there. Mutele homesteads vary, but some have cattle and goats, and even more have chickens and small vegetable gardens. HaSinari lacks infrastructure. Monthly, on social grant distribution day, markets spring up, as individuals gather at collection points. A lack of infrastructure constrains livelihood opportunities, job opportunities, and transport networks [45], making people rely on their natural surroundings to supplement their livelihoods [46], for example, by foraging and gathering—e.g., edible insects and bushmeat [47]. Other forms of supplementary livelihood practices, such as selling firewood and raising cattle for wages, require access to land and resources, which are increasingly constrained. Coal mining—the dominant economic opportunity in the Mutale area [44] until the mine closed in 2014—is being replaced increasingly by eco-tourism.

3.2. Climate Vulnerability WASH Assessments

WASH Access, Acceptability, and Management

Since the 1990s, the main source of bulk water for Prince Albert town and surrounding farming communities is groundwater supplemented by surface water [24]. One remnant of the Apartheid/colonial settler era is seen in how water is allocated. The Dorps River, which supplies surface water, is diverted from the upper reaches of the Swartberg mountain to a storage reservoir. This water comprises the municipal allocation as well as that of the water furrow system ('leiwater') that supplies irrigation water to the South-End community of Prince Albert via a distribution network of concreted channels. The 'leiwater' system is managed by the Kweekvallei Irrigation Board, which operates as the Water User Association for the town and manages the 'leiwater' allocation and agricultural usage. The Board plays an important role in ensuring equitable access to water, although this is limited to only those residents who have allocation rights written into historical title deeds. The municipality reports that approximately 97.7% of the population has access to potable water, with 70% of residents having piped water inside their dwellings [24]. Despite occasional interruptions caused by floods, the piped water supply is generally reliable. Iron rich borehole water is first treated to reduce excess iron. The 'leiwater' and borehole water in the municipal supply are disinfected by chlorination followed by sand filtration. Quality is generally tested quarterly unless there is a suspicion of contamination.

Prince Albert town has an oxidation pond system as wastewater treatment works (WWTW). Solid waste collection and disposal services are generally reliable and are provided weekly by the municipality [31]. Solid waste is collected every week, and each service point (household) is supplied with black bags by the the municipality.

The Prince Albert municipal area was declared a provincial drought disaster area at the beginning of 2016 [24]. During the height of the drought, bottled water was distributed to vulnerable households in Klaarstroom and Leeu-Gamka by the Department of Local Government: Disaster Management [24]. The research team was informed by multiple stakeholders that two distinct 'communities' exist within Prince Albert town, the North-End and South-End communities—particularly when discussing how the 'leiwater' system allocates water to some (South) but not others (North). The inequality of this practice is magnified by drought. For example, during the 2016–2018 drought, water use was restricted to 90 L/person/day, and water tariffs increased. Interviewees in the North-End noted that 'there isn't enough water for everyone', and boiling water from other sources to make it safe to drink was not feasible for all, as not every household can afford electricity.

In HaSinari, the municipal system has failed (Appendix A) [23,48]; water is no longer delivered to communal taps—situated anywhere from 3 to 100 m from each homestead and shared by approximately 7 to 10 homesteads. Instead, the water is intermittently turned on according to a rotation and available diesel supplies for the pumps. Local water committees organize the collection of funds from village residents to pump water that is generally used for drinking, washing, cleaning; however, some people collect rainwater in tanks, and that water is most often not used for drinking. Nearby protected areas have resulted in the closest rivers being made inaccessible due to game fences which were once sources for (and the location of) washing, laundering, and watering cattle. In addition, in this water catchment area, water is directed to nearby parks, away from local residents, to provide for charismatic species and sites (watering holes) for tourists (Appendix A).

Water access, quality, and acceptability challenges in HaSanari are experienced widely, albeit to different degrees depending on various factors such as income, proximity to water sources, and power dynamics. One resident explained: 'The challenge we have here in Mutele is water. Our water tanks and reservoirs are cleaned after a long time. Even though the authorities purify water some of the time using chlorine, this is done after a long time'. Even when the taps are running, many residents question whether these water

sources are safe; similar concerns were raised by interdisciplinary teams of researchers in the area (see[49]). Most often, water for drinking is kept in sealed plastic containers; however, these containers often sit for long periods of time, in the sun or outdoors. In a setting where nearby rivers are inaccessible, municipal taps are often dry or broken, and government delivery of basic services continues to be, according to many HaSanarians, 'empty promises'. The absence of an effective municipal water department resulted in the village taking over water service delivery via the Water Committees.

Every homestead in HaSanari has a pit latrine; some have multiple latrines as one has filled up and another was dug nearby. In most cases, latrines are dug on the opposite end of the property from the home and cattle, but in some cases, this is not true. The school, crèche, and churches also have pit latrines. There is no reticulation system, nor are there services to remove effluent from the pits. Many residents make use of buckets at night, and night soil is not centrally managed. Waste and refuse are not removed, nor are there any bulk services for such removal; often, waste is burned at individual homesteads.

Accessible water sources pose several health- and wellbeing-related challenges in HaSanari including bilharzia. In a setting where water access via rivers is limited and/or polluted, the increased costs of needing to overcome the failures of municipal water delivery add extra strain and burden to already cash-strapped households. The general lack of drainage and sewerage challenges basic WASH standards or expectations, even in places and contexts where people are diligent about hygiene.

Since there is no formal sewerage or drainage, greywater from showering/face washing, oral hygiene, clothes and bedding washing, and dishes is normally disposed outside of the house, on the edges of the property or on plants (often ornamental plants, but sometimes near food sources). These various forms of greywater are mostly absorbed by the arid soil in the area but occasionally run down into low-lying areas, and in some cases, these lower-lying areas are sites of shared standpipes. In this way, run-off from greywater can potentially end up pooling at water collection sites. The lack of a system to dispose of effluent, greywater, blackwater, or stormwater poses challenges for environmental hygiene in this context—this is complicated further by the lack of organized solid waste disposal by the municipality, leaving this task to individual homesteads. Waters of all kinds (run-off, storm, grey, etc.) potentially mix, and contaminants stay within local environments. Table 1 outlines and compares similar findings related to the challenges of WASH access in our two case studies.

3.3. Specific Catchment and Source Vulnerability Assessments

As part of the assessment process, we identified vulnerabilities in the catchment and with respect to the water sources. In HaSanari, water sources (rivers and boreholes) are downhill of steeply sloping bare soil/community orchards; there are limited to no flood protection measures. The setting is not densely populated, but there are pit latrines that can potentially contaminate some water sources; other water users do impact the quality of the water source, i.e., there are some open defecation practices and cattle/cultivation runoff. Protection legislation may be in place (in many cases there is legislation), but often there is no by-law for monitoring; for example, irrigation schemes draw from rivers without much oversight and no penalty. With the failure of the municipality to manage or support infrastructure and the fragmented oversight over land/water control, a consolidated understanding of water rights access and uses are not in place. In addition, the nearby, upstream coal mine, closed in 2014, left coal tailings and debris that are not managed or contained. Situations such as these are indicative of the lack of oversight of upstream water sources.

The surface water component for Prince Albert town is sourced from the Dorps River system through an open canal to a reservoir and to a water treatment facility; this use of open canals exposes the water to contamination. The town's landfill site is located next to the Dorps river and is a potential source of microbial and chemical pollutants for downstream users and the environment. The washing and storage of buckets used as night soil

containers in areas that are not serviced with toilets raise the risk of contamination of water sources in these settlements where groundwater is being accessed for the water supply. Important information to be collected with regard to assessing source protection in this context also includes the location of septic tanks in relation to water supply boreholes, and the protection of springs and the weir in the river.

The catchment vulnerability for Prince Albert Municipality was assessed based on recent data on climate risk profiles drawn from the Greenbook. The vulnerability was assessed based on analyzing the social, environmental, economic, physical, and institutional dimensions and the absorptive, adaptive, and transformative capacities of the community —currently and into the future. The average risk across all categories is currently calculated as 3.94 out of 10. The average risk profile across all indicators in the area where HaSanari falls (Appendix A) was 6.0 out of 10. The highest risk factors relate to climatic/environmental stressors and socio-economic vulnerability. Similarly in Prince Albert, the highest risk factors relate to socio-economic vulnerability as a consequence of population growth rates (highest in Prince Albert town itself), as well as climatic/environmental factors, with impacts on water availability (particularly groundwater). Notable were unprotected boreholes and poorly maintained pumping systems and flood damage to pipe networks, leading to water supply outages at times. Potable water quality is generally good. Notable in HaSanari are unprotected boreholes and poorly maintained pumping systems, regular water supply outages, problems with flood damage to pipe networks, and an ongoing lack of maintenance. Residents complain about occasional changes to water smell and color.

4. Discussion

Issues of access inequality are embedded; colonial-system architects designed water and sewage systems to serve the needs and preferences of the European elite, creating racially segregated service provisions [15], and the Apartheid government further structured and solidified such disparities. For example, contemporary South African 'informal' settlements—emerging from segregated settlement patterns imposed from the 1940s—largely lack water and sanitation infrastructure. Relatedly, South Africa has one of the highest inequality rates in the world, principally along racial lines, maintained in housing structure and location, including service delivery [50] and access to education and economic opportunities. There are also significant differences between rural and urban areas; rural households depend largely on a combination of subsistence agriculture, social grants, and remittances [51], and are at greater risk of being cut off from services and losing road access following extreme weather events [11]; at the same time, within rural areas, there is great diversity in access, usually fragmented to reflect historic inequalities [22]. Despite these differences, in both case studies, what emerged was that standard WASH assessments miss key factors, including colonial/historic legacies, leading to fragmented political oversight and infrastructure failure, and variability in weather, extreme weather events, and transport and supply chain challenges, all linked to drainage concerns. For this reason, in addition to the WASH specific assessments, which we describe in detail below, which were prescribed in our terms of references for the project we undertook, we suggest the need to explore WASH as WASHD.

4.1. WASH Management and Community Engagement Capacity and Vulnerability Assessment

Despite the drought having an overall negative impact on water access and quality in PAM, it motivated some members of the community to adapt. At the same time, community engagement is hampered by tensions around equity concerns. North-End community interviewees mentioned the disparities that exist between their own and the South-End water use practices—including swimming pools in South-End and 'leiwater' access not available in the North. There is limited cooperation between these areas around resource sharing and water access. The issue of 'water rights' was not limited to the North-End/South-End; there are also disputes between members of the Irrigation Board and the

municipality over the 'leiwater'. While overall there seems to be very little cohesion across Prince Albert, among smaller groups of people, or through individual relations, some forms of cooperation are emerging. For example, some employers have assisted employees in purchasing rainwater-saving measures for their homes. These efforts are limited and not large scale in Prince Albert. It is difficult to determine, from our limited interactions and data, what Prince Albert's capacity to manage WASH locally might be. It is likely that emergent groups and committees, such as the one described below in HaSanari, would become evident to the research team with more time.

Unlike in Prince Albert, in HaSanari, at least at the village level, the water crisis forced cohesion and collective action such that each village's Water Committee is essentially proving its capacity to manage WASH. The municipality's failure to deliver water means that residents are often 'waiting for water' on average for two weeks for the taps to run. Appendix A).Taps run for a set period of two to three hours, most often in the evening, from a borehole system purchased through communal collection by the Water Committee, instead of relying on the municipality. The Water Committee, an elected group of village residents, collects funds from each homestead monthly and consults with the wider village population through village meetings to set limits on water containers filled per homestead. Taps accessed in are managed between residents for example, no one allows a family to go without water, and when someone takes more than their share at the tap, everyone else waiting regulates such actions with shouting and teasing.

The vulnerabilities and capacity of WASH management and community engagement within this case study are hampered by the following key pinch points:

a. Transportation challenges
b. Extreme weather events—further exacerbating transportation challenges
c. Fragmented oversight and conflict over rightful leadership

At the same time, the lack of government support, in the form of capacity (human), funding and resources (infrastructure), has meant that local, community-driven organization to solve concerns has emerged and is becoming well established. In this way, local capacity could be drawn on, and with WASH training, local residents could be WASH practitioners and managers with buy-in from local residents if they made us of pre-existing committees and democratic processes (e.g., this model is already in place with Community Healthcare Workers).

In both case studies, transportation challenges interrupt supply, while extreme weather events further exacerbate inequalities. In addition, although different forms of tension and conflict arise, in both case studies, tensions and conflicts are evident challenges to equitable access to WASH.

4.2. WASH Supply Chain/Supporting Infrastructure Vulnerabilities and Capacity Assessment

When specifically considering the supply chain, it became clear that in both settings, access to water is supposed to be delivered at the municipal level, but systems often fail. Supplies to remedy such failures are not always at hand. In both cases, because smaller towns and villages do not have stores or outlets to buy supplies quickly and easily, WASH access may be challenged, but in each case, the challenges faced are a little different as outlined below.

Prince Albert is relatively remote, located about 400 km northeast of Cape Town and approximately 170 km south of Beaufort West. The shortest route from Prince Albert town to the reliable N1 highway is a 45 km tarred road. Previous flash floods left other access roads impassable and several motorists, including an ambulance, stranded (https://ewn.co.za/2017/04/10/flash-floods-in-central-karoo-cause-havoc-on-roads This scenario makes accessing emergency supplies challenging. The nearest town, Beaufort West, is a small town, with a population of only 34,000 and mostly small retail shops. Major cities are thus sources of essential supplies such as water treatment chemicals and

spares. Most supplies are sourced from Cape Town which is accessible via the N1 highway and can take up to 5 h. In this way, supplies to repair emergencies are not easily accessible. In addition, all water pumps are electricity powered; therefore, a reliable supply of electricity is important. Without alternative backup systems and readily available spares, water supply can be interrupted, particularly if electricity infrastructure is damaged by extreme weather events.

The remoteness of HaSanari, combined with the lack of infrastructure, equates to a seriously under-resourced sub-district. Limited road infrastructure makes accessing emergency supplies especially challenging. Traveling north, the dirt road starts approximately 7 km before the villages, with a drop-off in road traffic as donkey carts replace motor vehicles, and the road gets narrower and less well maintained. HaSanari is 80km from the nearest (small) city, Thohoyandou, on average a two-hour journey due to poor road quality. Similarly, the distance between Thohoyandou and Makhado is also approximately 80 km, but the drive can take more than two hours as it is a busy trucking route and single lane. Both Thohoyandou and Makhado have limited outlets for buying supplies. Alternatively, Polokwane is a major city, with multiple options for buying supplies and is accessible once through Makhado by a major highway. It is approximately 240 km from HaSanari and takes 4+ hours to reach. In this way, supplies to repair emergencies are not easily accessible.

4.3. WASH Resilience and Adaptive Capacity

In both sites, we considered and looked for examples that could indicate potential inroads for supporting adaption and resilience as well as potential pinch points—described below.

As discussed in the community engagement section above, since our engagement in Prince Albert was limited, it is likely that groups and committees that might indicate resilience and adaptive capacity, as with the HaSanari example, may emerge over time. One potential point that challenges resilience in this setting is the lack of economic diversity, and thus the growth of tourism provides one means of diversifying economic activity beyond agriculture.

The level of infrastructural failure in the HaSanari setting results from a serious lack of municipal investment. The dependence on community collections for diesel to run pumps to ensure water access highlights a form of resilience in the village's ability to organize and generate money from residents. However, the precarious financial setting poses a risk to water security if residents are unable to contribute financial resources. Additionally, water pumps rely on access to diesel, which is not available locally. The availability of diesel and the distances needed to travel to get it represent one major potential pinch point in the supply of water to the area. The dirt road and limited road options are further complicated by the reality that in extreme weather events, the roads are significantly impacted, often made impassable, and when navigable the roads are slow and treacherous. The financial insecurity also means that the construction of sanitation and reticulation systems, including long-term maintenance, is not always individually affordable, and a program sponsored by the government would be needed to provide these services to this area, as it is remote and not near any treatment, reticulation, or sewerage systems.

4.4. Local Government Support and National Policy

4.4.1. National Policy

WASH-related mandates mainly sit between the Department of Health (DoH) and the Department of Human Settlements, Water, and Sanitation, with climate change coming in under the mandate of the Department of Environment, Forestry, and Fisheries (DEFF). Through DEFF's National Climate Change Response Policy (NCCRP) (RSA, 2011) [52], national departments are directed to integrate climate change into their policies and

programs, while the more recent draft of the National Climate Change Adaptation Strategy [53] requires national departments to develop sector adaptation plans and strategies. A peripheral yet relevant policy is the Disaster Management Amendment Act 16 of 2015, directing municipalities and provinces to develop and implement climate change response implementation plans and disaster management plans that consider climate change risks and vulnerabilities [54].

4.4.2. Local government Support

In the Prince Albert Municipality, according to the Chairperson of the Water and Sanitation Forum, the local government actively engaged the public around the 'Drop the block program' to reduce the amount of water flushed. Another example was the municipality's efforts to lay the groundwork for establishing a satellite radio station (Radio Gamkaland) to reach the rural and farming areas which improved communication [24].

In HaSanari, although the right to water is promised to all South Africans , the municipal and national governments have failed to provide this civil and human right [55–57]. Whilst the national Department of Water Affairs and Forestry implemented a Free Basic Water policy, including national funding for municipalities [55], water delivery continues to fall on the backs of local residents. The water management team at the municipality are rarely seen by village residents, making it difficult to ascertain management skills. Managers come from outside the village network which means that there is little communication between local residents and potential WASH managers. There is little to no support for infrastructure, supplies, or processes. Wait times for municipal responses to infrastructure concerns range anywhere from two weeks to numerous months, and there seem to be no formal risk management programs in place.

4.5. Generalizability and International Relevance

While WASH-related concerns and assessments intersect with a number of SDGs, SDG6, which aims to ensure the availability and sustainable management of water and sanitation for all, becomes centrally relevant to our findings that highlight the importance of attention to drainage. As such, this work intersects with efforts in the sanitation research literature that highlight the importance of sustainability in sanitation [58,59]. Our work provides insights into the limitations of standard assessments, calling for local residents' inputs; while similar contemporary efforts in sustainable sanitation [59] are emerging, our data highlight the importance of incorporating storylines and qualitative/narrative aspects alongside pre-defined indices.

5. Conclusion—Perspectives for Improving WASH in Rural Areas and Small Towns

WASH services in rural and small towns in South Africa are influenced by several factors—history, natural elements, and socio-economic aspects are intertwined and influence WASH vulnerability. The case studies highlight the importance of any WASH CRV assessments (or sustainable sanitation indices) engaging in the literature and practice beyond just that of the climate change discourse or standardized assessments; our work also indicates the importance of fieldwork and engaging outside the academic sphere. Standardized methods using quick assessments can provide some information, but often miss out on the finer details that are relevant and important to explain why and how WASH (and sustainable sanitation) efforts are supported, facilitated, and/or challenged.

These case studies highlight some potential pinch points for vulnerabilities as well as contextual information that can provide insights for others attempting similar assessments and analyses. For example, in both case studies, especially during flooding events, water accessibility is challenged by issues of access to spare parts; one recommendation that could assure some forms of resilience in a flooding event would be keeping ample stocks of spare parts for all essential WASHD infrastructure. Additionally, managers and management teams should have local interests, and preferably be known to residents so

that trust is established. Finally, where emergent local organizations take over water delivery, there should be mechanisms in place (via policy and funding) to support such efforts.

While this work is based on primary data, the data were collected for other projects, and thus, we acknowledge there are gaps in our understanding. The methods used were pragmatic given the short timeline and emerging pandemic; we made use of layered methods, drawing on multiple theories and disciplines to provide the most robust case studies possible. While we briefly addressed the methods here, a specific methodological paper is in progress that will outline in more detail how the case studies were built, and our understanding of the limitations of these methods.

Our efforts show that to improve WASHD in rural areas and small towns, political will, capacity, finances, and infrastructures would ideally all align; however, this alignment is rare. In addition, it is important that national and local policies speak to one another without conflicting claims over control. These case studies also highlight the importance of citizen action and organization. Our work sheds light on emergent organization and community action that ensures water delivery in the place of failed efforts by municipalities. In this way, the research shows that resilience and adaptive responses can emerge when those living in close proximity find ways to work together to ensure WASHD access; at the same time, we make a case for the D in WASHD.

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Institutional Review Board Statement: The study in Limpopo was conducted according to the guidelines of the Declaration of Helsinki, and approved by the School of Anthropology and Conservation, University of Kent Ethics Committee (protocol entitled "PhD Upgrade/Proposal"; presented (virtual) and approved 21 July 2013). The Prince Albert study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the School of Engineering and Built Environment at the University of Cape Town Institutional Review Board (SALGA protocol version 1, approved 15 May 2018).

Informed Consent Statement: Informed consent was obtained from all subjects involved in both studies. The research projects from which the data for these case studies were taken both had ethical review and approval. In addition, for the Limpopo study, verbal consent included explanation (in TshiVenda) that consenting to interviews meant that data could be used for other research in the future, but individual identity and anonymity would be maintained unless specific permission was sought. For the study in PAM, verbal permission was given, at the time of collecting the data, for the data from these interviews to be used in other applications. In both cases, the data used to draw comparisons has already been published and referenced. As this particular comparison of case studies required no new data to be collected, ethical approval for this desk-based comparison was not sought.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available as interviewees were promised confidentiality and anonymity.

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Appendix A

drainage	here refers to infrastructure (natural or built) that is purposely designed and implemented to remove excess surface water (including wastewater in non-sewered areas) so as to prevent flooding as well as manage public and environmental health impacts.
fragmented policy landscape	Multiple restructurings of national ministries and related departments over the last two decades make it challenging to track South African policy development through time. For example, the latest changes in May 2019; Environmental Affairs was combined with Forestry and Fisheries; the department of Human Settlements was combined with Water and Sanitation; and the department of Rural Development and Land Reform was combined with Agriculture [19]. A challenge in the climate change and WASH context is the coordination and alignment across the many spheres of policy on which it touches. While a study specifically on climate change and WASH policy coordination and alignment does not exist, a study by Momberg [20] looking at WASH and child undernutrition in South Africa finds that the policy environment is highly complex, with a lack of communication between departments. At the same time, there are attempts at setting up a variety of coordinating committees, including the National Committee on Climate Change (NCCC) and the Inter-Ministerial Committee on Climate Change (IMCCC).
HaSinari	A pseudonym
semi-structured interviews	See [22] for more details on methods. Interview questions informed by a comprehensive water services thematic mapping exercise followed the desk-based review. Interviewees ranged in socio-economic status, from wealthy land-owning elites to residents renting in informal settlements and working as day laborers; demographics ranged with people self-identifying as white, colored, and Black/African.
Mutele	A pseudonym
bantustan	Bantustans, or homelands, created through the Group Areas Act and the 1951 Bantu Authorities Act, were left to their own devices to develop systems to cope with the harsh inequalities in service provision, funding, arable land allocation, and resources. Relatedly, as Apartheid policies mounted, formal disenfranchisement was imposed by making these areas 'independent' and installing government-picked 'customary' leaders [25].
the Greenbook	The Green Book is an online tool to support municipal planning with the development of climate resilient settlements while facilitating climate change adaptation into local government planning instruments and processes. See www.greenbook.co.za for further information on the tool
Venda period of 'statehood'	During this 'nominal statehood' (1979–94), 'Venda was not so much 'independent' of South Africa as isolated from it' (p. xix) [33]. This political, legal, and social 'isolation' reinforced Venda's 'geographic and economic marginalization', while explaining historic differences in 'political regulatory framework[s], and enforcement system[s]' between Venda and the rest of South Africa (ibid: xix).

Land ownership in former homelands	The Apartheid era interference in local governance led to conflicting claims over official Chieftaincy and land rights/controls resulting in contestation of the current customary leadership in place. At the same time, the land management policies in place require the customary authority to agree with the Limpopo Province on management plans, all of which are meant to happen in consultation with all the residents who fall within the royal authority, but no management plan for the lands have been agreed upon. Similarly, issues surrounding water catchment management, as water is directed away from this catchment to deliver water to Kruger National Park, are challenging to engage with as municipal water management was devolved to districts, and this district has been mismanaged (evidenced by the administrative takeover in 2016). Different aspects of land and water management are variably contested, and clear directives on who has ultimate control and decision-making abilities are not established.
erratic average annual rainfall	Ranging 50–200 mm/year, the annual rainfall varies greatly because the mountains can receive 250–500 mm higher rainfall than the plains. For example, the Groot Swartberg mountain range in the south receives rainfall varying between 474 and 926 mm annually [34].
municipal system has failed	When water provision was devolved to the municipalities with the establishment of the constitutional right to water, the Luvhuvhu water supply system was already over-subscribed [48], leading to water shortages, even at the district hospital. https://www.dwa.gov.za/Projects/Luvuvhu/Documents/Web%20Doc%20CD2/WCWDM%20Strategy%20and%20Business%20Plan_Vhembe%20Polokwane.pdf
water access in HaSinari	At the same time, while the municipal infrastructure system is built to draw HaSinarians' water from the Luvhuvhu catchment, they live within the Shingwedzi catchment, where 'no sustainable yield is derived from surface flow' as those waters are directed into river systems that flow through Kruger National Park [48].
area where HaSinari falls	The Green Book analysis for the Limpopo region does not clearly outline where HaSinari fits in the new district classifications. It sits on the border of Musina and Thulamela districts, thus by exploring both of these districts one can have a better understanding of the climate risk profiles for the region. While the area most likely overlaps more with Musina, a small portion of HaSinari may have been absorbed into Thulamela since the Vhembe district came under administration in 2016.
residents are often 'waiting for water'	Elsewhere in South Africa, waiting two days for water was considered a burden (see https://theconversation.com/south-africas-water-sector-a-case-study-in-state-capture-69581). In HaSinari, very few people could afford a borehole; thus, most residents were accustomed to periods of inaccessible water

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