

A socio spatial assessment of water scarcity and its effects on student wellbeing in rural university settings

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Research Article

Keywords: water scarcity, water insecurity, infrastructural violence, student wellbeing, rural universities

Posted Date: October 15th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10931796/v1>

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Additional Declarations: No competing interests reported.

Abstract

Water scarcity in South Africa continues to reflect apartheid-era spatial inequalities, leaving historically disadvantaged rural universities acutely vulnerable to chronic municipal supply failures. Drawing on Critical Infrastructure Studies and the concept of infrastructural violence, this paper investigates the socio-spatial dimensions of water insecurity and its impacts on student wellbeing at a university in the Eastern Cape. Anchored in an interpretivist paradigm and a qualitative phenomenological design, the study collected empirical data through semi-structured interviews with 50 purposively selected residential students (25 female, 25 male). Data were systematically analysed using Braun and Clarke's six-phase thematic framework. Findings reveal that campus water insecurity is driven by a compounding convergence of environmental pressures such as severe climate variability and prolonged drought and institutional shortcomings, including municipal mismanagement, decaying utility networks, and structural spatial neglect. Recurring water outages disrupt academic continuity by causing class cancellations, practical lab suspensions, facility closures, and assessment congestion. Furthermore, shortages severely compromise physical health, personal hygiene, and mental wellbeing, placing a disproportionate burden on female students regarding menstrual dignity. Students adapt through informal, point-of-use coping mechanisms, such as treating turbid water and purchasing bottled water. These strategies impose hidden financial and temporal taxes, effectively shifting institutional service delivery obligations onto individual students. The study concludes that chronic municipal supply breakdown acts as a form of infrastructural violence that erodes academic equity and student health. Key recommendations include institutional investment in autonomous campus water systems, gender-responsive emergency protocols, and formal inter-governmental task teams to build long-term infrastructural resilience.

Introduction

Water is a fundamental resource indispensable for human survival, public health, and socio-economic development. Yet globally, usable freshwater constitutes merely 0.3% of total water reserves, leaving over one billion people without reliable access to safe drinking water [14]. In South Africa, contemporary water insecurity remains deeply entangled with a racialized spatial legacy rooted in apartheid policy. Under the Water Act of 1956, water allocation and infrastructure development were explicitly structured to serve white-dominated urban, industrial, and agricultural hubs, while Black South Africans were systematically relegated to under-resourced homelands (Bantustans) characterized by deliberate infrastructural neglect [18]. As Olley et al. [25] observe, water access was effectively weaponized as an instrument of socio-spatial oppression, institutionalizing long-term spatial divides that endure across former homeland regions today. The democratic transition in 1994 ushered in major legislative reforms aimed at dismantling these historical inequalities. The White Paper on Water Supply and Sanitation (1994), the Water Services Act 108 of 1997, and the National Water Act 36 of 1998 redefined water as a public asset and a fundamental human right, enshrined under Section 27 of the South African Constitution [1]. National strategies, such as the National Water Resource Strategy (NWRS2), were introduced to operationalize equitable redistribution.

Despite these legal protections, South Africa faces acute physical and economic water scarcity driven by climate change, multi-year droughts, deteriorating municipal supply networks, financial mismanagement, and systemic governance failures [19]. While extensive research documents the impacts of water scarcity on household livelihoods, its disruptive effect within higher education institutions remains under-researched. This analytical oversight is particularly severe for historically disadvantaged, rural-based universities. The University of Fort Hare (UFH) main campus in Alice situated within the Raymond Mhlaba Local Municipality in the Eastern Cape serves as a clear illustration of these vulnerabilities. Unlike urban campuses, the Alice campus is chronically exposed to prolonged municipal water failures. This stark contrast highlights how historical socio-spatial divisions continue to impact the South African higher education landscape, threatening both institutional functionality and student wellbeing.

Research Objectives

- To analyse the cascading impacts of municipal water shortages on student wellbeing, personal finances, and pedagogical operations.
- To examine student coping mechanisms during water outages and formulate sustainable, autonomous water solutions for rural-situated campuses.

Problem Statement

While rural water scarcity in South Africa is well-documented, its cascading impact on higher education institutions specifically regarding student health, academic continuity, personal finances, and institutional operations remains undertheorized. At historically disadvantaged, rural-situated campuses like UFH Alice, chronic municipal water failures directly destabilize daily student life. Students endure severe personal burdens, facing health risks from unhygienic residence conditions, compromised female hygiene, and financial strain caused by diverting scarce allowances to purchase commercial bottled water. Simultaneously, persistent outages interrupt academic schedules and compressed calendars, penalizing student performance.

At the organizational level, municipal infrastructure breakdown places an exorbitant financial strain on the university. To maintain basic operations and prevent public health hazards, institutional management is forced to divert capital toward emergency measures. Procuring commercial water tankers, continually refilling static JoJo tanks, purchasing bulk emergency bottled water, and maintaining temporary filtration equipment create a continuous drain on operational budgets. Capital intended for academic programs and research infrastructure is instead redirected to cover local government service failures. Despite these expenditures, relief measures often remain reactive, forcing students to rely on risky, self-funded coping strategies such as treating turbid tap water or hauling water over long distances. There is an urgent need to examine how chronic municipal supply failures erode student wellbeing while straining university budgets, to inform autonomous water solutions for rural campuses.

Theoretical Framework

To critically analyse the lived experiences, health risks, financial burdens, and coping strategies of students as well as the operational pressures placed on the institution, this study is anchored in Critical Infrastructure Studies, focusing on the concept of infrastructural violence. Advanced by critical scholars such as Anand [3], Anand et al. [4], and McFarlane and Rutherford [20], this framework conceptualizes water systems not as neutral networks of pipes and valves, but as political apparatuses that mediate spatial citizenship and distribute vulnerability. Rodgers and O'Neill [27] define infrastructural violence as the ways in which the design, operation, breakdown, or absence of infrastructure inflicts systematic harm, marginalization, and precarity.

Applied to UFH Alice campus, infrastructural violence frames chronic municipal water collapse not as an accidental technical glitch, but as an active structural harm. When municipal networks fail, the university experiences an institutional form of infrastructural violence, forced to divert core capital toward temporary emergency relief. Simultaneously, students embody AbdouMalik Simone's [28] concept of "people as infrastructure," undertaking strenuous, uncompensated labour such as hauling heavy water containers up residence stairs, queueing at storage tanks, and altering sleep schedules to collect water. This framework links municipal service failure directly to bodily degradation, connecting unhygienic living spaces, compromised dignity, and health risks to state neglect. Furthermore, it highlights out-of-pocket student spending on bottled water, institutional budget diversions, and facility closures as cascading forms of spatial injustice. Viewing student coping strategies through the lens of infrastructural violence reveals how rural municipal breakdown actively undermines health, institutional sustainability, and academic equity.

Methodology

This study adopts an interpretivist paradigm paired with a qualitative phenomenological design. Interpretivism posits that social reality is subjective, complex, and constructed through the lived experiences of social actors [30]. A phenomenological design allows researchers to capture the essence of how individuals navigate ongoing socio-spatial challenges [11]. Prioritizing student narratives provides a detailed understanding of how water insecurity impacts physical health, personal dignity, mental wellbeing, financial stability, and academic progression within a rural campus setting. The study was conducted at the University of Fort Hare's main campus in Alice, located in the Raymond Mhlaba Local Municipality, Eastern Cape. This site was selected due to its location in a historically under-resourced rural periphery plagued by chronic municipal service disruptions. The target population comprised full-time residential students living in university-managed accommodation.

A purposive sampling strategy was utilized to select participants [6]. Inclusion criteria required students to have resided on campus for at least two consecutive academic terms, ensuring direct, ongoing experience with campus water outages. A total sample of 50 residential students participated. To ensure

balanced representation across living environments and daily routines, the sample was split equally between female (25) and male (25) students, comfortably reaching data saturation.

Primary qualitative data were collected through face-to-face, semi-structured individual interviews with all 50 participants. Semi-structured interviews provide a flexible framework that maintains focus on core topics while allowing exploratory space for emergent narrative paths [17]. This method allowed for deep exploration of sensitive issues, including hygiene management, personal dignity, health complications, financial strain, and academic disruption. An open-ended interview protocol ensured thematic consistency across interviews. With explicit written informed consent, sessions were audio-recorded in quiet campus spaces to guarantee privacy and confidentiality [32]. Interviews typically lasted between 45 and 60 minutes. The qualitative data generated from the verbatim interview transcripts were analysed using Braun and Clarke's six-phase thematic analysis framework [2].

Discussion of Findings

Drivers of Campus Water Scarcity

The empirical accounts provided by students at the university reveal that water scarcity is experienced not as a single, isolated problem, but as a complex convergence of environmental pressures and institutional failures. When students reflect on why water availability continually collapses on their campus, their perspectives fall into two major thematic categories: natural drivers centred on climatic shifts and prolonged drought, and human or structural drivers rooted in municipal mismanagement, and historical spatial neglect.

Environmental Drivers: Climate Change and Drought Dynamics

The empirical findings demonstrate that students perceive environmental degradation, shifting climate patterns, and prolonged droughts as fundamental, baseline drivers of the ongoing water scarcity crisis. Within the localized geographic context of Alice (Dikeni), participants consistently identified severe rainfall deficits, intense heat waves, and increasingly unpredictable weather cycles as natural pressures that directly compromise regional water security. Students observed that these persistent environmental stresses result in the critical depletion of surrounding rivers and dam reservoirs that is the primary bulk water sources feeding both the Raymond Mhlaba Local Municipality and the university campus.

These findings align with established empirical research across South African environmental and hydrological literature. Studies by Machete et al. [16] and Eriksen et al. [8] broadly document how regional climate change manifested through rising ambient temperatures and erratic, declining annual rainfall serves as a primary catalyst for acute water stress across Southern Africa. More specifically, the student testimonies directly reflect localized findings by Pamla et al. [23] and Hove & Osunkunle [12], who highlight that the Eastern Cape, and the Raymond Mhlaba Municipality in particular, is chronically

exposed to severe, multi-year droughts that paralyze bulk water storage and disrupt institutional operations.

When analysed through the theoretical lens of Critical Infrastructure Theory (CIT), these student observations and literary alignments expose critical vulnerabilities within the physical systems that sustain university life. CIT conceptualizes bulk water provision networks as vital life support infrastructure which is essential for foundations required to guarantee public health, basic hygiene, and institutional continuity. A core tenet of CIT is that critical physical infrastructure must possess built-in structural resilience and adaptive capacity to absorb and mitigate exogenous environmental shocks such as acute droughts. In the context of UFH, however, the empirical evidence reveals an infrastructure network operating without sufficient adaptive mechanics, such as integrated groundwater extraction fields, automated rainwater harvesting systems, or high-capacity secondary storage reserves. Consequently, when an environmental shock occurs, the physical supply network suffers an immediate, unmitigated failure. Ultimately, the harsh climatic conditions of the Eastern Cape do not merely reduce surface water levels; through the lens of CIT, they actively expose a profound lack of built-in structural redundancy within the physical infrastructure assets that support the university community.

Institutional and Governance Failure: Municipal Breakdown and Structural Neglect

While climatic shifts establish baseline water stress, the empirical findings reveal that students overwhelmingly view human agency, administrative inefficiency, and governance failures within the municipality as the primary drivers of acute water interruptions. Participants expressed intense frustration regarding recurring municipal worker strikes, unpaid staff salaries within the Raymond Mhlaba Municipality, neglected aging pipelines, and the university's total operational reliance on external municipal systems. Furthermore, students articulated strong critiques of spatial inequality, asserting that historically Black rural institutions (HBIs) endure a degree of infrastructural abandonment rarely experienced by urban or historically privileged campuses [13, 22]. Students do however note that the university is in the process of developing its own water supply as means to deal with water challenges in campus.

This qualitative evidence directly validates core arguments within contemporary South African governance and infrastructural literature. The distinction made by students between natural shortages and operational failures echoes the conceptual framing of Patrick [26], who argues that water scarcity across South African municipalities is frequently an "institutional scarcity" a product of administrative mismanagement, financial distress, and deferred physical maintenance rather than an absolute absence of natural water. Moreover, student reflections on spatial neglect align with historical analyses by Nkomo [22] and Gumbi et al. [10], who demonstrate how the enduring spatial legacies of apartheid leave rural municipalities and HBIs equipped with fragile, underfunded, and poorly maintained utility networks compared to metropolitan centres.

Analysing these student accounts through Critical Infrastructure Theory (CIT) illuminates the complex socio-technical dimensions of infrastructure networks. CIT asserts that critical infrastructure is not merely a static collection of physical pipes and treatment plants, but an integrated system deeply bound to human labour regimes, municipal governance, and institutional management. Within this theoretical framework, the findings highlight two vital dynamics:

- **Institutional Interdependence and Cascading Failure:** CIT stresses that extreme operational dependency on an external entity creates acute vulnerability. Because UFH does not control or maintain autonomous bulk-water infrastructure, any labour strike, financial dispute, or maintenance collapse within the Raymond Mhlaba Municipality triggers an immediate cascading failure. A governance dispute at the municipal depot directly cascades into unhygienic residence halls, compromised public health, and suspended academic operations on campus.
- **Systemic Infrastructure Marginalization:** CIT examines how socio-political power dynamics dictate where capital investment, maintenance, and structural redundancies are allocated. The stark contrast drawn by students between rural HBIs and urban institutions exemplifies infrastructure marginalization—a state where peripheral socio-technical networks operate without essential backup loops or emergency fail-safes, leaving dependent communities perpetually vulnerable to predictable administrative and political breakdowns.

Impact on Academics and Student Wellbeing

Disturbance to Academic Routines

Water is an indispensable utility for human functioning and daily institutional operations. At the University of Fort Hare (UFH) Alice campus, recurring water outages systematically disrupt the basic routines of students including bathing, sanitation, meal preparation, and hydration forcing the university to repeatedly suspend or compress its academic calendar. When water infrastructure fails, educational institutions are left with few immediate operational alternatives. Consequently, teaching schedules are halted, study periods are consumed by catch-up lectures, and test timetables are congested, placing severe strain on students' ability to prepare adequately for assessments. For instance, during a severe outage in 2019, the university was compelled to pause academic operations entirely for two weeks [21].

From the perspective of Critical Infrastructure Theory (CIT), physical utilities such as water supply, energy, and sanitation constitute the foundational bedrock of organizational survival and human development. When these critical systems suffer structural collapse, the disruptive effects cascade into every sphere of institutional life, compromising the university's ability to fulfil its core mandate of teaching and learning. However, this infrastructural fragility is not distributed equally. Through the lens of Spatial Injustice, the persistence of water insecurity at UFH is directly linked to deeply rooted historical and spatial inequalities inherited from colonialism and apartheid. Historically Black Universities (HBUs) like UFH were intentionally under-funded and situated in geographically peripheral, rural areas with

under-resourced municipal networks. In contrast, Historically White Institutions (HWIs) benefited from heavy state capitalization, private investments, and prime urban locations with resilient municipal services. While UFH has historically been forced to shut down during municipal outages, HWIs situated in urban centres demonstrate greater infrastructural resilience; for example, when Rhodes University faced severe drought conditions in 2019 after Settlers Dam fell below 11% capacity, the institution mobilized alternative engineering solutions by drawing water from the Melville Dam and collaborating directly with the local municipality to reopen the James Kleynhans Water Treatment Works [23]. This stark contrast highlights how historical funding disparities leave rural HBUs with decayed, legacy infrastructure, forcing them to remain dependent on struggling local authorities such as the Amathole District Municipality.

This pattern of institutional paralysis mirrors historical trends across the Southern African region, such as in 2009 when public universities in Zimbabwe were forced to close for an entire academic year due to a catastrophic municipal water crisis [5]. Following independence in 1980, the Zimbabwean government rapidly expanded access to basic and tertiary education to redress colonial exclusion. However, this massification occurred without a corresponding expansion in municipal water and sanitation infrastructure, eventually overwhelming state resources and leading to service collapse. Similarly, in South Africa, section 27 of the Constitution mandates the state to ensure access to adequate water, and Sustainable Development Goal 6 (SDG 6) obligates institutions to ensure sustainable water and sanitation management for all. Yet, more than three decades into democracy, rural tertiary institutions remain severely vulnerable to municipal failures.

These empirical accounts highlight how infrastructural disruptions translate into direct academic penalties. Under Environmental Stress Theory, chronic environmental disruptions such as closed libraries, cancelled laboratory practical's, and unhygienic living spaces deplete a student's cognitive bandwidth. When water outages occur, essential facilities like the campus library and Great Hall are shut down for safety and hygiene reasons, while laboratory practical's in science disciplines are cancelled or delayed because they require running water. When operations resume, lost curriculum time is compressed into brief periods, forcing students to absorb complex material, complete backlogged practical's, and sit for multiple assessments within short windows. To cope with this congestion, students resort to extreme sleep deprivation ("crossing nights") and sacrifice basic self-care routines. Ultimately, these findings demonstrate that while municipal service providers like the Municipality have failed in their mandate, institutional delay in establishing independent water security measures leaves students carrying the academic cost. The persistent cycle of campus shutdowns and academic congestion undermines student performance, turning what should be an environment of higher learning into a continuous struggle for basic survival and academic endurance.

Compromised Wellbeing, Health Hazards, and Gendered Vulnerabilities

The persistent water crisis at the Alice campus severely disrupts students' personal lives, basic health practices, and social interactions, with residential students bearing the heaviest burden due to their complete reliance on institutional utility systems. Water supply networks serve as essential social infrastructure designed to safeguard public health, maintain environmental sanitation, and preserve human dignity. Critical infrastructure operates on the premise that when foundational utility systems function seamlessly, everyday human activity proceeds unhindered; however, when structural failures occur, the disruption cascades directly into domestic and personal spheres. In the context of UFH, the failure of municipal water delivery forces students into acute resource rationing, restricting their scarce water reserves exclusively to immediate survival tasks like drinking and minimal meal preparation while abandoning routine sanitation and hygiene. This structural breakdown directly compromises students' physical wellbeing and personal hygiene.

This systemic degradation of basic living conditions aligns with established socio-hydrological literature in Southern Africa [7, 24], which documents how municipal supply disruptions undermine sanitation standards, degrade domestic living environments, and restrict nutritional practices. When water outages persist for days, students face heightened health risks, including dehydration, gastrointestinal complications, and skin infections caused by prolonged inability to bathe. Furthermore, CIT emphasizes that infrastructure collapse strips away basic protections of human dignity. The cessation of indoor plumbing forces students to resort to open defecation in campus bushes because toilets remain unflushed. This practice creates severe biological hazards across the campus environment while degrading basic human standards.

Crucially, the empirical evidence and broader literature demonstrate that infrastructure failure is not gender-neutral; female students experience a disproportionately severe and unique burden during water outages. Integrating a gender-sensitive lens into Critical Infrastructure Theory highlights that access to reliable water and sanitation is fundamentally linked to reproductive health, menstrual hygiene management, and personal safety. Female students face acute physiological and biological challenges when water stops flowing, as maintaining menstrual hygiene requires consistent access to clean running water, private washing facilities, and proper sanitation for waste disposal. During prolonged outages, the inability to manage menstruation safely and hygienically leads to severe physical discomfort, risk of reproductive tract infections, and intense psychological anxiety over menstrual leakage or odour.

Beyond direct health hazards, the failure of critical water infrastructure creates a cascading psychological and social strain on students. Literature on resource scarcity and social presentation suggests that personal hygiene serves as a key prerequisite for public engagement and social confidence [9, 29]. When water shortages render students unable to bathe, wash laundry, or clean their living spaces, they experience acute anxiety, self-consciousness, and shame regarding personal presentation. To avoid perceived social stigma and peer judgment associated with poor hygiene, many students voluntarily withdraw from social spaces and choose self-isolation, opting to skip lectures and collaborative study groups entirely. Conversely, students who prioritize academic attendance despite the crisis adapt through minimal coping mechanisms such as washing only their faces before attending

class while enduring continuous physical discomfort and social anxiety. Through the lens of Critical Infrastructure Theory, these empirical findings demonstrate that campus water scarcity is not a minor operational inconvenience, but a structural infrastructural failure that directly destabilizes student health, compromises bodily dignity, and forces a trade-off between personal wellbeing and academic participation.

Student Coping Strategies

When formal utility networks experience persistent failure, affected populations are forced to develop informal, decentralized coping mechanisms to secure basic survival needs. At the Alice campus, the breakdown of critical water infrastructure is further compounded by severe quality degradation when municipal supply is intermittently restored. Students report that when water finally returns after prolonged outages, it flows through the distribution network turbid, contaminated, and brown. Grounded in Critical Infrastructure Theory, a functional utility system must satisfy both quantitative supply demands and qualitative safety standards. When treatment plants and filtration systems fail, the infrastructure ceases to perform its primary protective function, transferring the burden of water purification from the state and municipality directly onto the individual consumer. In response, residential students deploy localized, thermal, and chemical treatment methods primarily boiling turbid water or adding Jik bleach to make the contaminated water safe for drinking and domestic use.

These self-directed purification tactics reflect broader socio-hydrological literature on informal resource management in under-serviced Southern African contexts [21, 29]. While thermal boiling and household chemical disinfections are recognized point-of-use purification techniques, student narratives reveal deep residual distrust regarding water quality. Due to persistent discoloration, many students restrict boiled tap water exclusively to non-ingestive domestic tasks such as floor mopping, dishwashing, and laundry while purchasing bottled water for drinking when financial resources permit. While these adaptive strategies demonstrate agency and localized resilience, Critical Infrastructure Theory cautions against viewing self-reliance as an acceptable substitute for state provision. Relying on manual point-of-use purification imposes a hidden "coping tax" on students, consuming limited financial resources (for electricity, gas, or bottled water) and time that should otherwise be dedicated to academic study.

Ultimately, the necessity for students to manually purify basic tap water directly violates core national and international human rights frameworks. In 2002, the United Nations Committee on Economic, Social, and Cultural Rights issued General Comment No. 15, establishing that access to safe, clean, and affordable drinking water is an indispensable prerequisite for the realization of all other human rights [31]. In the South African constitutional context, Section 27 explicitly guarantees the right to sufficient food and water, while Section 24 protects the right to an environment that is not harmful to health or wellbeing. Furthermore, as highlighted by the World Health Organization (WHO), when municipal failures force students to drink contaminated water or expend critical study time securing basic utilities, their constitutional right to education under Section 29 is directly compromised. The empirical evidence confirms that when critical infrastructure collapses, the state's constitutional obligations are effectively

outsourced to vulnerable students, who must continuously engineer their own survival within an institutional setting.

Conclusion and Summary of Findings

The empirical findings of this study demonstrate that the recurring water crisis at the University of Fort Hare's (UFH) Alice campus is far more than a routine operational inconvenience; it is a structural crisis that destabilizes academic continuity, undermines student health, degrades human dignity, and disproportionately penalizes vulnerable demographics. Grounded in Critical Infrastructure Theory, essential utility networks such as municipal water treatment, pipeline distribution, and institutional bulk storage serve as the foundational physical substrate required for public health, safety, and societal stability. When these critical systems fail, the disruptive effects cascade into non-water sectors, exposing the deep dependencies between external municipal service providers like the municipalities and dependent public institutions.

Across the findings, this infrastructural fragility manifests through severe academic disruptions, compromised personal wellbeing, acute health hazards, and forced self-reliance. Academic calendars are repeatedly paused or compressed, science practicals requiring running water are cancelled, and key learning spaces like libraries and lecture halls are forced to shut down for hygiene reasons. When operations resume, curriculum delivery is congested into brief assessment windows, shifting student focus from intellectual engagement to survival management and cognitive overload. This disruption is further compounded by deep spatial and historical inequities: as a rural, Historically Black University (HBU), UFH continues to struggle with legacy infrastructure deficits, leaving it far more vulnerable to municipal service collapses than urban or Historically White Institutions (HWIs) that possess private auxiliary reserves and greater engineering resilience.

At the personal and social level, the breakdown of critical water infrastructure directly erodes human dignity and public health. Residential students face severe water rationing, restricting scarce reserves to basic consumption while sacrificing personal hygiene, laundering, and room cleanliness. The cessation of indoor plumbing forces individuals to resort to open defecation in campus bushes, introducing biological hazards across the living environment. These conditions impose acute physical and psychological strains that are fundamentally gendered: female students face elevated health and safety risks related to menstrual hygiene management and physical vulnerability when seeking alternative sanitation. Furthermore, when supply returns dirty and brown, students are forced to adopt informal coping mechanisms such as boiling water or adding chemical disinfectants effectively absorbing a manual coping tax to secure safe drinking water. Ultimately, these findings reveal that infrastructural collapse outsources basic constitutional rights to health, clean environment, human dignity, and education onto vulnerable students who must continuously navigate survival within an environment meant for higher learning.

Recommendations

To address the root causes and cascading impacts of the water crisis at UFH's Alice campus, sustainable institutional interventions must transition from reactive short-term relief to long-term infrastructural autonomy and student support:

The university is currently investing on an independent, long-term water infrastructure to achieve operational self-reliance. This is a good initiative to ensure that it counter effects the impact and reliance of water supply from the university. Because the population at the university is large other water supply initiatives such as boreholes, erecting large-scale rainwater harvesting grids across academic and residential buildings, and constructing an on-site, solar-powered water filtration and treatment plant to ensure continuous, clean supply during municipal shutdowns. Institutional management must retrofit all student residences and central facilities with high-capacity backup water tanks connected to dual-piping system gravity feeds. This ensures that essential sanitation specifically toilet flushing, and basic handwashing facilities remains fully operational during municipal outages, preventing campus closures, open defecation, and public health hazards.

The University health and housing services must prioritize the specific needs of female students during water disruptions. Emergency protocols should include the immediate distribution of sanitized emergency water kits, dedicated mobile sanitation units in secure areas, and free provision of specialized hygiene supplies to safeguard menstrual health and physical safety. The academic administration should establish flexible learning frameworks to prevent curriculum congestion during water-related operational pauses. This involves expanding asynchronous digital learning resources, adjusting assessment schedules to avoid compressed test weeks, and protecting designated study periods so students are not penalized academically for infrastructural failures beyond their control. Lastly the institutional executive leadership must form a joint infrastructure task team with the municipality and the Department of Higher Education and Training. This body should mandate real-time communication protocols for impending service interruptions, secure priority maintenance timelines for university supply lines, and leverage national infrastructure grant funding aimed at historical redress for rural HBUs.

Declarations

Acknowledgements

We thank the participants for participating in this research and making this study possible.

Author contribution

M.M; A.K. and M.K conceptualized the study, conducted the interviews, led the thematic analysis and data analysis. T.K.Q. contributed to the literature review, theoretical framework, data interpretation, provided methodological guidance, contributed to the conclusion.

Funding

None

Clinical trial number

Not applicable

Ethical Approval

This study was reviewed and approved by the Faculty of Humanities Research Ethics Committee of the University of Fort Hare, in accordance with the guidelines of the University of Fort Hare Research Ethics committee under the Inter-Faculty Research Ethics Committee (IFREC). All research procedures involving human participants were conducted in full compliance with relevant institutional guidelines, the South African National Health Act 61 of 2003 regulations (Relating to research with human participants). Informed consent was obtained from all individual participants involved in the study.

Consent to participate

All participants involved in the study were above 18 years and completed a informed consent form indicating willingness to participate in the study.

Consent to publish

Not applicable. No images are presented in this study.

Conflicts of interest

The authors declare no competing interests.

Data availability

The authors confirm that all data generated or analysed during this study are included in this article.

References

1. Adom RK, Simatele MD. Overcoming systemic and institutional challenges in policy implementation in South Africa's water sector. *Sustainable Water Resour Manage*. 2024;10(2):69.
2. Ahmed SK, Mohammed RA, Nashwan AJ, Ibrahim RH, Abdalla AQ, Ameen BMM, Khedhir RM. Using thematic analysis in qualitative research. *J Med Surg Public Health*. 2025;6:100198.
3. Anand N. *Hydraulic City: Water and the Infrastructures of Citizenship in Mumbai*. Duke University Press; 2017.
4. Anand N, Gupta A, Appel H, editors. *The Promise of Infrastructure*. Duke University Press; 2018.
5. Chikoore RM, Bowora J. (2011). The impact of water shortages on educational delivery in selected schools in Harare East District. *Zimbabwe J Educational Res*, 23(3).

6. Creswell JW, Poth CN. *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*. SAGE; 2016.
7. Demie G, Bekele M, Seyoum B. Water accessibility impact on girl and women's participation in education and other development activities: The case of Wuchale and Jidda Woreda, Ethiopia. *Environ Syst Res*. 2016;5(1):1–12.
8. Eriksen S, O'Brien K, Rosentrater L. *Climate Change in Eastern and Southern Africa: Impacts, Vulnerability and Adaptation*. University of Oslo; 2008.
9. Goffman E. Embarrassment and social organization. *Am J Sociol*. 1963;62(3):264–71.
10. Gumbi BP, Moodley B, Birungi G, Ndungu PG. Detection and quantification of acidic drug residues in South African surface water using gas chromatography-mass spectrometry. *Chemosphere*. 2017;168:1042–50.
11. Hossain MS, Alam MK, Ali MS. Phenomenological approach in qualitative study: Data collection and saturation. *ICRRD Qual Index Res J*. 2024;5(2):148–72.
12. Hove C, Osunkunle OO. Social media use for water conservation education in South Africa: Perceptions of Raymond Mhlaba Local Municipality's residents. *J Asian Afr Stud*. 2020;55(3):351–69.
13. Kativhu S, Netshandama V. (2024). Pathways for rural-based universities transformation into entrepreneurial institutions in South Africa. *Int J Entrepreneurship Bus Dev*, 7(1).
14. Kılıç Z. The importance of water and conscious use of water. *Int J Hydrology*. 2020;4(5):239–41.
15. Lochmiller CR. Conducting thematic analysis with qualitative data. *Qualitative Rep*. 2021;26(6):2029–44.
16. Machete R, Lopes A, Gómez-Martín M, Fraga H. (2014). Tourism and climate in Lisbon: An assessment based on weather types.
17. Magaldi D, Berler M. Semi-structured interviews. *Encyclopedia of Personality and Individual Differences*. Springer; 2020. pp. 4825–30.
18. Maphela B, Cloete F. Johannesburg's implementation of the National Water Act, 1998 in Soweto, South Africa. *Dev South Afr*. 2020;37(4):535–52.
19. Matimolane S, Mathivha FI. Tackling rural water scarcity in South Africa: Climate change, governance, and sustainability pathways. *Front Environ Sci*. 2025;13:1550738.
20. McFarlane C, Rutherford J. Political infrastructures: Governing and experiencing the fabric of the city. *Int J Urban Reg Res*. 2008;32(2):363–74.
21. News24. (2019). Two Eastern Cape university campuses closed over water shortages. *News24*.
22. Nkomo M. Rural-based universities in South Africa. *Int J Sustain High Educ*. 2007;8(2):234–46.
23. Ocheri MI, Mile II. Spatial and temporal variation in groundwater quality of Makurdi sedimentary formation. *J Environ Plann Dev*. 2010;6(1):141–6.
24. Olley J, Cvitanovic M, Ginige T, Bunt-MacRury L. A systematic literature review of sustainable water management in South Africa. *Sustainable Water Resour Manage*. 2024;10(5):162.

25. Otufale GA, Coster AS. Impact of water scarcity and drudgery of water collection on women's health in Ogun, Nigeria. *J Hum Ecol.* 2012;39(1):1–9.
26. Pamla A, Thondhlana G, Ruwanza S. Persistent droughts and water scarcity: Households' perceptions and practices in Makhanda, South Africa. *Land.* 2021;10(6):593.
27. Patrick MJ. (2020). The framing of institutional water scarcity in South Africa.
28. Rodgers D, O'Neill B. Infrastructural violence: Introduction to the special issue. *Ethnography.* 2012;13(4):401–12.
29. Simone A. People as infrastructure: Intersecting fragments in Johannesburg. *Public Cult.* 2004;16(3):407–29.
30. Steenkamp L, Williams M, Ronaasen J, Feeley A, Truter I, Melariri P. Handwashing knowledge and practices among caregivers of pre-school children in underprivileged areas of Nelson Mandela Bay. *South Afr J Clin Nutr.* 2022;35(1):8–12.
31. Turin TC, Raihan M, Chowdhury N. (2024). Paradigms of approaches to research. *Bangabandhu Sheikh Mujib Med Univ J*, 17(2), e73973.
32. Welch AR. Obligations of state and non-state actors regarding the human right to water under the South African Constitution. *Sustainable Dev Law Policy.* 2005;5(2):58–64.
33. Xu A, Baysari MT, Stocker SL, Leow LJ, Day RO, Carland JE. Researchers' views on, and experiences with, the requirement to obtain informed consent in research involving human participants: A qualitative study. *BMC Med Ethics.* 2020;21(1):93.