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Contemporary and discursive narratives on the impacts of climate change on water, sanitation, and hygiene (WASH) services in Southern Africa

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Abstract

This paper examines the impact of climate change on water, sanitation, and hygiene (WASH) in Southern Africa using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology. This was achieved by offering informed perspectives on the persistent lack of integrated responses to climate change's negative impacts on WASH services, persists and how these challenges can be addressed and reversed. We highlight the major challenges posed by the lack of integrated responses to the adverse effects of climate change on WASH services. We discuss how unpredictable climate change-induced extremes such as droughts, cyclones, floods, heatwaves, and outbreaks of climate-sensitive diseases like malaria, cholera, dysentery, and typhoid, exacerbate these challenges. Given the difficulties in predicting the occurrence and impact of these extremes, there is an urgent need for actionable

information from the scientific community to improve the response strategies. By providing selected examples and proposing potential solutions, this paper aims to contribute to the development of more effective and integrated WASH service responses in the face of climate change.

Keywords: *Climate change, water, sanitation, hygiene.*

Introduction

In recent years, the impacts of climate change (CC) on water sanitation and hygiene (WASH) have increasingly become a hot topic worldwide (Bobbins et al.2023). Despite the ticking CC clock, governments and societies worldwide have not fully realised or acted upon the urgency to address it (Chirgwin et al., 2021; Anthonj, 2021). CC in Southern Africa is characterised by rising temperatures, prolonged droughts, and erratic rainfall, which significantly affect water resources (Brockliss et al., 2022). These climatic changes have led to increasing water scarcity that poses significant threats to WASH services across the region. Examining CC impacts on WASH in Southern Africa enhances understanding of necessary actions and methods. This reasoning is premised on the empirically established distressing situation in developing countries where ~90% of untreated sewage and effluent is discharged into water bodies which compels~1.8billion people to use faecally contaminated sources of potable water (Bhaduri et al., 2016; Bain et al. 2014). Despite global efforts, severe pollution persists.

By 2023, the World Health Organisation (WHO) estimated that two billion people relied on drinking water contaminated with faeces, an increase from 1.8 billion in 2016 (Bhaduri et al., 2016; WHO/UNICEF, 2023). In Zimbabwe, nearly 400 million litres of raw sewage are discharged daily into water sources serving major cities (Sunday Mail, 2022). In Sudan, a cholera outbreak in Kosti in 2025 resulted in 58 deaths and 1,300 illnesses within three days, following damage to the local water system (AP News, 2025). These examples underscore that untreated sewage and unsafe water continue to pose critical public health threats in 2025.

The situation is projected to worsen and lead to high mortality rates as CC-related uncertainties and associated externalities further limit humanity's access to secure water supplies (Zerbro et al., 2021; Nijhawan

and Howard, 2022). This distressing situation is aggravated by the fact that developing countries are more affected by the dire consequences of inadequate sanitation infrastructure compared to their developed counterparts. As a result, these countries continue to face significant challenges regarding the contamination of their water sources (Mutschinski and Coles, 2021, Schwikowski, 2022; Ziervogel G, 2018). These challenges led African Ministers' Council on Water Strategy (AMCOW) members and government entities to jointly explore strategies for sustainable WASH access (AMCOW, 2018) (AMCOW, 2018). Although the AMCOW achieved partial success, such as improved policy frameworks and increased investment in WASH infrastructure in some regions, significant gaps in access and service delivery remain (AMCOW, 2024).

Like other regions especially those in developing countries worldwide, Southern Africa is experiencing several CC-related impacts (Muchaku, Magaiza & Hamandawana, 2023), which argue for the immediate need to enhance our understanding of the intricate links between CC and WASH services (Doing this is not only necessary but long overdue because it provides valuable insights that help us to achieve SDG 6, which aims to ensure the availability and sustainable access to water and good sanitation for all (Bobbins et al. 2023; Gagan et al. 2022). Therefore, there is an urgent need to revolutionise our behaviours to ensure access to WASH services and amenities for all people.

In Southern Africa evidence strongly suggests that CC disproportionately affects vulnerable populations, particularly those in low-income and rural areas (Calow et al., 2016; Chirgwin et al., 2021) thereby exacerbating existing disparities in access to WASH services (Stoler, Guzmán & Adams; 2023). These disparities are evidenced by resource-limited communities facing increasing challenges: regular water supply disruptions, diminishing sanitation access, and poor hygiene due to erratic rainfall and extreme weather (Stoler et al., 2023). Although urban areas may have better infrastructure, they are also equally affected because sizeable proportions of their populations live in areas that are poorly serviced, while those in areas where infrastructure is available face similar challenges due to increased demand constant breakdowns and planned water cuts (Chirgwin et al., 2021). These observations are supported by the fact that in 2020, for example, only 54% of the world's population had access to safe sanitation while only 21% of the entire population in sub-Saharan Africa had access to safe sanitation (Brockliss et al., 2022; Bobbins et al. 2023). In Sub-Saharan Africa, 794 million people lack safe drinking water. Only 39% of the population has piped

water at home, a figure that plummets to just 19% in rural areas, underscoring the significant disparities in water accessibility (World Economic Forum, 2022, 2023).

Despite rapid population growth in Southern Africa, WASH services remain unjustly inadequate, especially in rural areas historically lacking sufficient state-sponsored support. According to Nijhawan and Howard (2022), ~ 60% of diarrhoea-related deaths in developing countries are associated with poor WASH services. This asseveration is supported by the fact that although sub-Saharan Africa is well-known to be one of the world's areas with sub-optimal access to WASH (Zerbro et al., 2021), little continues to be done on how this bottleneck can be addressed (Chirgwin et al., 2021; Anthonj, 2021; Stoler et al., 2023). In response, some regions are adopting different strategies selected examples of which include decentralised water management, community-based adaptation initiatives, and the integration of CC adaptation strategies into WASH policies (Zerbro et al., 2021). Although these initiatives promise to improve the situation, disparities persist, highlighting the need for comprehensive and inclusive approaches that are practically implementable in Southern Africa's diverse contexts.

In academic parlance, many have debated is the factors responsible for poor WASH delivery worldwide. Yates et al. (2023), list several factors such as politics, population growth, and socio-economic status as some of the major challenges facing WASH service provision. At the policy and socio-economic service provision interface, Tseole et al. (2022) list the following additional factors as some of the major hindrances that undermine the provisioning of adequate WASH services in Africa: 1) the proliferation of non-functional or intermittently functional of 70% water schemes in rural areas, 2) poverty induced unsafe sanitation behaviours with more than 28% the people still practising open defecation. Unfortunately, however, little is being done to address the challenges faced by under-resourced developing regions most affected by changing climate conditions. This assertion is supported by the findings of researchers like Stoler et al., 2023, which indicate that sub-Saharan Africa remains severely affected by WASH-related diseases such as diarrhoea, cholera, dysentery, typhoid along with malaria, which is transmitted by Anopheles mosquitoes that breed in stagnant water resulting from poor sanitation.

Communities in this sub-region deserve immediate attention because of their limited capacities to adapt to natural disasters and extreme events

examples of which include but are not limited to diminishing access to potable water supplies and forced reliance on unclean water due to pollution, system failures to cope as demand increases and non-inclusive formulation of operational strategies (Anthonj et al., 2022; Zerbro et al., 2021). Selected examples of system failures and non-inclusive formulation of operational strategies that undermine the provisioning of adequate WASH services include 1) the lack of collaboration between different state and non-state organisations, 2) conspicuous of unified perspectives and implementable policies on safe water provisioning strategies, 3) insufficient WASH expertise 4) lack of community engagement and 5) service delivery failures in most of the world's low-income countries. These observations are supported by Rickert et al. (2019) who report that in developing countries, the most common barriers to safe WASH are financial, legal, and institutional, land use change spatial trade-offs and ecosystem disservices.

The adverse effects of CC on WASH are increasingly being acknowledged in sub-Saharan Africa (Grasham et al., 2019; Joshua et al., 2022). In Namibia for example, the most prominent barriers to WASH are land use change spatial trade-offs, and financial constraints at a household level, with CC aggravating the situation by affecting water quality and reducing supplies. For instance, recently in South Africa, cholera outbreaks have been reported in several provinces due to deteriorating access to WASH services (Department of Health South Africa, 2023). One way of addressing this challenge is by mainstreaming CC into WASH services by enhancing our understanding of how these factors co- influence each other (Wu et al., 2016). This research aimed to accomplish this by exploring the current knowledge and findings on the impact of CC on WASH in Southern Africa with emphasis being placed on water availability, water quality, and sanitation. We hope that by collating and systematically synthesising what is available in the literature this review will provide valuable insights on how to address the adverse effects of CC on WASH in Southern Africa.

Methods

The methodology used comprises a systematic review of the literature on the effects of CC on WASH services in Southern Africa. This study retrieved relevant articles from the Scopus database. The collected data underwent qualitative analysis using ATLAS. ti software, a well-established tool in the field of qualitative research analysis. This methodology was purposefully designed to identify peer-reviewed

publications that relevantly address WASH issues. These papers were identified using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al., 2009). Figure 1 shows the sequence of steps that were followed in this screening process. Figure 1 outlines the screening process, which involved retrieving peer-reviewed articles from the Scopus database.

Figure1: Identification, screening, and selection of relevant articles

The procedure above relied on deliberate criteria of exclusion and inclusion parameters aimed at facilitating the identification of relevant, open-access and peer-reviewed articles in widely recognised international journals and book chapters that were published in English between 2010-2023. These articles were further screened for relevance by ensuring they adequately address the impacts of CC on WASH services in Southern Africa. Figure 1 provides a synoptic overview of the above-described retrieval process.

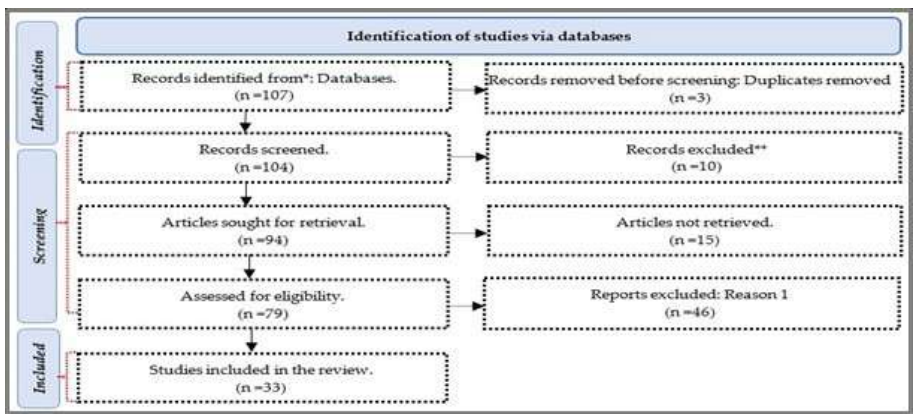


Figure1: *Inclusion andexclusionliterature-basedcriteria usedin thesearch anddocument selection phase.*

Results

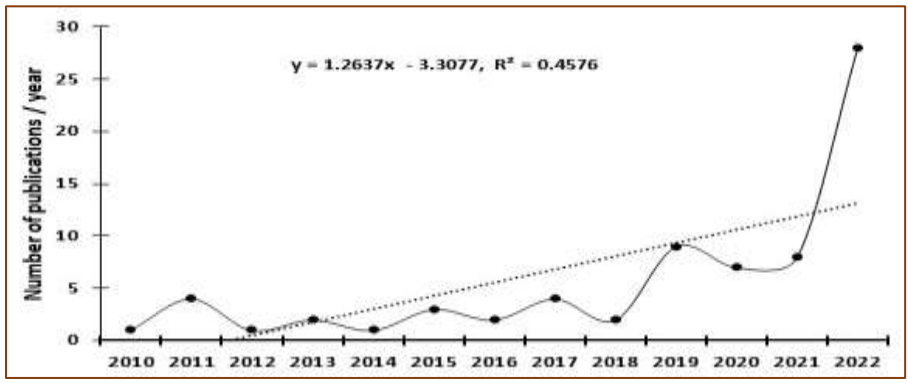
Boolean operators automated this retrieval, initially identifying 107 articles (Table 1).

Table 1: Boolean operators that were used and the number of articles they retrieved.

Boolean operator	**Number of articles**
TITLE-ABS-KEY ("climate change" AND "WASH" OR "Sanitation" OR "Hygiene" AND impact OR effect AND "Africa")	107
TITLE-ABS-KEY ("climate change" AND "WASH" OR "Sanitation" OR "Hygiene" AND impact OR effect AND "Africa") AND PUBYEAR > 2009 AND PUBYEAR < 2024	104
TITLE-ABS-KEY ("climate change" AND "WASH" OR "Sanitation" OR "Hygiene" AND impact OR effect AND "Africa") AND PUBYEAR > 2009 AND PUBYEAR < 2024 AND (EXCLUDE (DOCTYPE, "cp") OR EXCLUDE (DOCTYPE, "ed"))	94
Total excluded using Boolean operators	*33*

At the end of the search, a total of 107 articles were retrieved of which three were first excluded before systematic screening. This was achieved through the rigorous elimination of duplicate articles, verified by uploading the articles to Mendeley, which identified 104 articles. Thereafter, a multi-step process was applied to ensure that the sampled publications were relevant to the scope of the study. The first stage involved purposefully screening publication titles and abstracts to capture the study's most relevant papers. This screening eliminated 10 publications which did not meet this investigation's discrimination criteria and produced a total of 94 publications some of which 15 could not be retrieved from online databases. This stage yielded 79 articles. The third screening stage involved informed readership of each article using the word cloud function from ATLAS ti.23 software to ascertain its contextual relevance and the entire article to objectively ascertain its relevance in line with what is published in the literature. This terminal eliminated 46 and produced 33 focused papers that covered the scope of the study. In addition to the 33 peer-reviewed articles systematically selected from the Scopus database for analysis, eight supplementary publications and reports from reputable sources such as the WHO and credible media outlets like the Sunday Mail were included to provide relevant case-specific examples. Figure 2 provides a graphical overview of publications over the 12 years between 2010 and 2023 which were covered by this literature-based search of publications which address the impacts of CC on WASH services in Southern Africa.

Figure 2: Number of peer-reviewed publications on the impacts of WASH services in South Africa



As shown in Figure 2 there has been a periodic but increasing trend in the number of peer-reviewed publications on impacts of CC on WASH services in Southern Africa. This trend is indicative of the scientific community's recognition of the need to provide information which helps to enhance the meaningful realisation of the MDGs to enhance our capacities to equitably provide adequate access to WASH services.

Discussion

CC significantly hinders WASH service provision to resource-poor communities in Southern Africa, exacerbated by the region's high susceptibility to its adverse effects. This vulnerability stems from its dependence on limited water resources in most areas, and numerous socio-economic challenges. Beyond the immediate concerns of water security and quality, the impacts of CC on WASH services extend to the very infrastructure supporting these essential services (Stoler et al., 2023). Furthermore, the evolving climate scenario necessitates a dynamic adaptation of WASH service policies that are practically implementable (Joshua et al.,2022). These policies should be purposefully structured not only for immediate responses to climate-induced disruptions but also for the long-term because CC is projected to continue.

Climate Change-Induced Water Scarcity for WASH Services

A key effect of climate change (CC) on WASH in Southern Africa is water scarcity. The current study revealed that short and long-term

changes exampled by the increased reoccurrence of drought and rising temperatures are the drivers that continue to contribute to persistent shortages of potable water in Southern Africa (Matchawe et al., 2022). Recent studies on the impacts of CC on access to emergency health services in 5 African countries by Theron et al. (2022) show that CC-driven changes in rainfall are some of the major causes of the unpredictable outbreak of infectious diseases which are often difficult to respond to due to the lack of scientifically informed adaptation strategies (Ario et al., 2019). This deficiency is primarily driven by CC-induced changes in rainfall patterns, including increased variability, prolonged droughts, and more intense rainfall events (Ziervogel, 2018, Rieckmann et al., 2018). These stochastic shifts provide a partial explanation of periodic shortages of potable water in most countries in sub-Saharan Africa.

In this sub-region, climate projections indicate point to increased water scarcities as global temperatures continue to rise with some areas being destined to experience abnormally high rainfall events (UNECA, 2011), which are evidenced by the recent cyclone Idai in Zimbabwe and the disastrous floods in South Africa's KwaZulu Natal province (TeWierik et al., 2022). These events highlight ongoing challenges undermining Southern Africa's ability to achieve equitable WASH services under the MDGs. This assertion is supported by the fact that in some areas affected by floods for example, the incidence; the increasing incidence of bacterial blooms, water-borne diseases, and discharge of contaminated effluents into freshwater terrestrial ecosystems.

Similarly scaled increases in widespread wildfires adversely affect WASH services by disrupting clean water and sanitary service provisioning (Rickert et al., 2019; Buchwald et al., 2022). This and other additional pressures further exacerbate the lack of access to adequate water supplies under deteriorating climatic conditions and similarly skewed surface and groundwater utilisation practices (Mwalwiba et al., 2023), which undermine the sustainable delivery of WASH services (Urama and Ozor, 2023; Oates and Doczi, 2014). The inadvertent outcome of this scenario is naturally induced and self-inflicted scarcity of adequate supplies of usable water for our day-to-day sanitary requirements (Howard et al., 2016).

Evidence from the literature indicates that, although the adverse impacts of global warming on WASH services are well-known, we continue to rely on unsustainable use of the limited fresh water resources at our disposal. Based on instructive insights from the literature, it is evident that periodic shortages and excesses of CC-driven shortages and excess portable water supplies always lead to inadvertent pollution and

degradation of freshwater supplies. The challenge is that, although the dooms day clock is ticking under our watch, we continue to subscribe to CC-un-friendly water resource use practices as if everything is okay. This reasoning prompts us to urge society to act now and not tomorrow for the benefit of present and future generations because unfounded and futuristic imaginations of a better tomorrow may not be realistically achievable without acting now. The time to act is now; tomorrow may never come.

Reduction in Water Quality Due to Climate Change

CC drives most of the empirical changes and shortfalls in Southern Africa's access to WASH services. Long-term temperature changes and prolonged dry spells have induced persistent water quality deterioration by facilitating the growth and spread of episodic algal blooms in oceanic waters and related terrestrial freshwater resources. Added to this is the impact of wildfires and other externalities like floods which have devastating impacts on our abilities to provide acceptable WASH infrastructural services. CC is a major threat that poses a substantial risk to the resilience and structural soundness of WASH infrastructure by amplifying damage to infrastructure and imposing continuous maintenance (Abrahams et al.,2021).

The fluctuations in climatic patterns are characterised by extreme weather events that undermine our abilities to provide adequate WASH facilities and services (Joshua et al., 2022; Stoler et al., 2023), partly because they always require a costly reassessment of damage to infrastructure, persistent repair, and frequent adoption of different maintenance methodologies. Addressing these challenges requires proactively implementing informed responses, including innovative risk-aversion strategies. One of the main ways through which the impacts of CC on WASH can be addressed is by monitoring reoccurring short, medium and long-term changes in changes rainfall. As posited by Thorn et al. (2021), this approach helps advance our understanding of how CC continues to adversely impact the delivery of WASH services in this subregion. This leads to uneven water availability and increases the risk of water scarcity in some regions (Abrahams et al., 2021). Increased frequency of heavy rainfall for example is well known to be one of the major causes of disastrous storm-water run-offs which pollute our day-to-day surface water supplies (Gagan et al. 2022; Nijhawan and Howard,

2022). Zimbabwe's 2019 Cyclone Idai exemplifies this, having destroyed numerous pit latrines and household water services. The severity is further shown by the unprecedented contamination of boreholes and hand-dug wells in Malawi and Mozambique (Joshua et al., 2022; Rivett et al., 2022).

Mozambique, one of the most economically disadvantaged countries in Southern Africa, has been severely impacted by the frequent occurrence of severe floods and droughts which repeatedly affect WASH conditions (WHO/UNICEF,2023). Are view of the literature indicates that faecal contamination of water resources is a major reason for poor WASH infrastructure (De Buck et al., 2017; Rivett et al., 2022). In support of this view, some of the documented effects of CC on WASH include (1) sea level rise-induced salinisation of fresh water ground water resources and, (2) landward intrusion of saline seawater into rivers and estuaries. Hence, effective science communication can enhance the relevance of the current study by ensuring that the observed impacts of CC on WASH services in Southern Africa reach a wider audience, including policymakers, communities, and other stakeholders (Gagan et al., 2022). This broader dissemination can contribute to informed decision-making, increase public awareness, and stimulate the adoption of collaborative efforts to address the identified challenges in the region. The insights from this study are extremely useful, providing valuable knowledge to guide implementable policy formulation in Southern Africa and globally. The paper's overall message is that we possess everything needed to respond accordingly before it is too late (Rickert et al., 2019; Joshua et al., 2022; Stoler et al., 2023). We are running out of time to act.

Building Climate-Resilient WASH Services by Integrating Traditional Wisdom With Modern Innovations

This study integrates findings from the literature to develop sustainable pathways for WASH services in vulnerable communities, utilising both traditional and modern approaches (Figure 3).

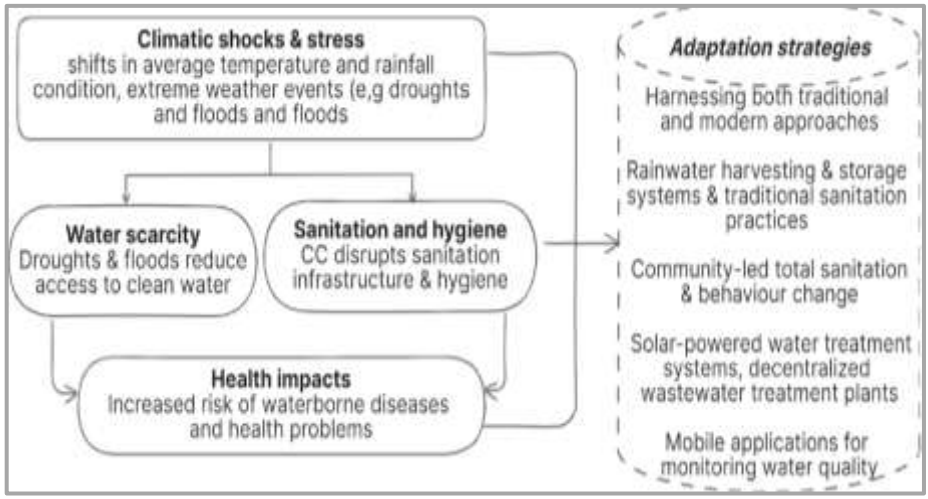


*Figure 3*Pathways to climate-resilient WASH services

The synthesis found that CC poses significant threats to water supply and sanitation infrastructure both of which have substantial impacts on WASH that need to be addressed by adopting appropriately structured adaptation strategies. The importance of traditional sustainable ways that utilise indigenous knowledge and practises, such as rainwater harvesting in clay pots and other related storage systems like stone-wall reservoirs and affordable traditional sanitation practices like the hand hoe-based burial of human faeces instead of open-air defecation can be blended with Blair toilets to provide WASH services in areas were these are badly needed but not accessible. These low-cost, low-tech approaches can augment the widely encouraged modern facilities like piped water and flush toilets and are easily implementable because socially acceptable in most resource-poor communities.

In addition to the above-described traditional approaches, and modern sustainable pathways there are also other science-based solutions that can be sustainably implemented through the participatory engagement of local communities. Examples include solar-powered water treatment systems, decentralised waste water treatment plants and mobile water quality monitoring applications. As shown in Figure 3, these and other modern approaches that emphasise community-led sanitation (CLS) and behaviour change communication strategies deserve to be seriously considered to promote the uptake of good hygiene practices. While modern approaches can be more effective and efficient,

their long-term sustainability depends on careful consideration of local social and environmental conditions and affordability. The insights from this study are extremely useful, providing valuable knowledge to guide implementable policy formulation in Southern Africa and globally. Overall, there is a conspicuous absence of informed assimilation of implementable strategies which needs to be addressed by communicating to and sharing the knowledge we have with those in need in a manner that enhances the provisioning of WASH services and amenities in Southern Africa. The take-home message of this paper is that we have everything that is needed for us to respond accordingly before it is too late.

Conclusions and Recommendations

Overall, the findings of this study show that CC has a significant impact on the provision of WASH services and facilities to resource-poor communities in Southern Africa. The findings of this research highlight the vulnerability of these important services to CC and point to the urgent need for all countries in this region to adopt implementable adaptation strategies. These findings also show that the impacts of CC on WASH services are interlinked, adversely affecting most communities, ecosystems, and public health. The findings also offer useful insights by pinpointing major knowledge and research gaps. Effectively addressing the challenges identified in the study is not only in line with SDG 6 but also in line with broader societal goals such as promoting environmental sustainability, strengthening the resilience of communities to the impacts of CC and improving access to education which cannot be realised in the absence of adequate access to good WASH services. Given these and other considerations, we conclude by recommending that the way forward is for us to assimilate actionable WASH delivery strategies that are objectively informed by insights and urging other researchers to complement our efforts by further exploring how the challenges we identified can be addressed.

Conflict of Interest: The authors have no conflict to declare.

Author Contributions: SM conceptualised the paper, searched for literature, ran the ATLAS ti, and developed the paper; LZ reviewed the manuscript and coordinated the paper writing. HH edited the paper, shared some relevant articles, and coordinated its writing. All authors have read and agreed to the published version of the manuscript.

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