

Barriers to Clean and Safe Water Access in Juba: AA-QQ-RD Framework on SDG 6 in South Sudan

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ABSTRACT

Juba, the capital city of South Sudan while, presenting a unique case as a rapidly growing city in a post-conflict country, its water infrastructure has been severely affected by decades of conflict, leaving it inadequate and underdeveloped. This study was conducted with the main objective of establishing factors causing the inadequacy of clean and safe water among households in Juba City. This study employed a proposed AA-QQ-RD (Availability, Affordability, Quality, Quantity, Reliability, and Distance) framework. The research employed a qualitative methodology, gathering data through in-depth interviews, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs) with household heads, government officials, and community leaders. The findings reveal significant challenges across all components of the AA-QQ-RD model. Availability of water is severely impacted by poor infrastructure which collectively disrupt water distribution while affordability issues arise from the high cost of water. In addition, water quality is compromised at multiple stages posing serious health risks while quantity of water is insufficient, particularly in larger households and densely populated areas. Further, reliability is undermined by irregular water supply and frequent service interruptions whereas distance to the nearest water points is a significant barrier with many residents traveling long distances to fetch water. These findings underscore the need for comprehensive infrastructural improvements, effective regulatory frameworks, and community-driven initiatives to address these barriers. The study's implications for Sustainable Development Goal 6 (SDG 6) highlight the critical need for coordinated efforts to ensure the availability and sustainable management of water and sanitation for all.

Contribution/Originality: The paper's primary contribution is finding that the AA-QQ-RD framework reveals critical issues related to availability, affordability, quality, quantity, reliability, and distance, which significantly impact equitable access to safe water in post-conflict urban settings. This comprehensive analysis provides a crucial

foundation for developing more effective water management policies and strategies.

1. Introduction

Clean and safe water refers to water that is free from contaminants and pathogens, making it suitable for human consumption and domestic use. Ensuring water safety involves various treatment processes, including filtration, disinfection, and purification, to remove harmful substances such as bacteria, viruses, and chemical pollutants (Salehi et al., 2022). Access to clean and safe water is not only a matter of health but also a fundamental human right recognized by international standards and declarations.

The concept of access to clean and safe water can be comprehensively understood through the framework of Availability, Affordability, Quality, Quantity, Reliability, and Distance (AA-QQ-RD). This framework is proposed based on extensive review of the literature. Availability as defined by Nowicki, Koehler, and Charles (2020) refers to the presence of sufficient water resources that households can obtain when needed. Affordability as explained by Amit and Sasidharan (2019), addresses the economic aspect, ensuring that water services are priced reasonably so that households do not face financial hardship. Quality as indicated by Bior (2018), ensures that the water meets health and safety standards, free from contaminants that could pose health risks. Quantity pertains to the adequate volume of water required for daily needs, including drinking, cooking, bathing, and sanitation (Gunda et al., 2019). On the other hand, reliability indicates the consistency and dependability of the water supply, ensuring that water is available continuously and without interruption (Appiah, Adamowicz, Lloyd-Smith & Dupont, 2019). Distance in this context refers to the proximity of water sources to households (Nygren et al., 2016), highlighting the importance of having water points within a reasonable distance to reduce the physical burden of fetching water, particularly for women and children. In the context of SDG 6, which aims to "ensure availability and sustainable management of water and sanitation for all," these dimensions are critical.

Juba, the capital of South Sudan, presents a unique case as a rapidly growing city in a post-conflict country. The city's water infrastructure has been severely affected by decades of conflict, leaving it inadequate and underdeveloped. The master plan for Juba, designed over a decade ago, has not been revised to accommodate the city's bulging population and changing needs. Most residents lack access to piped water and rely on water from the Nile River, delivered by private vendors using tanker trucks (Bior, 2018). This water is often untreated and contaminated. The high cost of water from private vendors also makes it unaffordable for many households, forcing them to resort to unsafe water sources. This has made the country to be ranked the top in terms of frequent outbreaks of waterborne diseases such as cholera and diarrhea, and even the high cases of associated mortalities (Borgomeo et al., 2023). Unlike Rwanda and Sierra Leone, South Sudan has struggled to implement comprehensive water infrastructure improvements that can support clean and safe water distribution systems (Bior, 2018; Kut et al., 2019). Given these challenges, it was crucial to conduct a comprehensive study to determine the existing barriers to clean and safe water access in Juba City. The main objective of this study was to investigate factors that cause inadequate access to clean and safe water among households in Juba City.

1.1. Research Objectives

The main objective of this study was to investigate factors that cause inadequate access to clean and safe water among households in Juba City. Therefore, this article aims to discuss the initial findings on the barriers to clean and safe water access among households in Juba city using the comprehensive AA-QQ-RD framework.

2. Literature Review

2.1. Sustainable Development Goal 6 (SDG 6)

The principles of sustainable development advocate for responsible stewardship of resources, equity, and social inclusion, and the maintenance of environmental integrity. This entails using resources efficiently and responsibly to ensure their availability for future generations. The SDGs, adopted by the United Nations, provide a comprehensive framework for addressing interconnected global challenges. The 17 SDGs goals reflect a long-term perspective, aiming to create a just, equitable, and sustainable world by 2030. The SDGs emphasize the importance of integrated approaches that consider the interconnections between different sectors and domains, promoting holistic solutions that address multiple challenges simultaneously ([United Nations, 2023](#)).

In particular, SDG 6 aims to ensure the availability and sustainable management of water and sanitation for all. This goal recognizes that access to clean water and sanitation is essential for human health, environmental sustainability, and economic development ([United Nations, 2023](#)). SDG 6 encompasses several specific targets designed to address various aspects of water and sanitation. This study focuses on targets 6.1 and 6.3. Target 6.1 seeks to achieve universal and equitable access to safe and affordable drinking water for all by 2030. This target emphasizes the importance of ensuring that all individuals, regardless of their socio-economic status or geographic location, have reliable access to water that is safe for consumption. On the other hand, target 6.3 aims to improve water quality by reducing pollution, eliminating dumping, and minimizing the release of hazardous chemicals and materials. This target also calls for halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally ([United Nations, 2023](#)). Improving water quality is essential for protecting ecosystems and human health.

Achieving SDG 6 is thus fundamental for improving health outcomes (SDG 3), reducing poverty (SDG 1), and promoting gender equality (SDG 5). Access to clean water and sanitation is intrinsically linked to many other aspects of development, such as education (SDG 4), economic productivity (SDG 8), and environmental sustainability (SDG 13). Clean water and sanitation are essential for preventing waterborne diseases, improving hygiene, and ensuring that communities can thrive ([United Nations, 2023](#)). The integration of SDG 6 with other SDGs as outlined, underscores the interconnected nature of sustainable development and highlights the importance of comprehensive and coordinated efforts to address global water challenges.

2.2 Historical context and water infrastructure in South Sudan

South Sudan, a country that gained independence in 2011, has a long history of conflict that has significantly impacted its development and infrastructure. The prolonged civil wars, spanning several decades, have led to the destruction of critical infrastructures,

including roads, healthcare facilities, and water supply systems (Fonkeng, 2021). The conflict has not only hampered economic growth but also worsened the humanitarian crisis, leaving millions of people without access to basic services. The impact on water infrastructure has been particularly severe, with many water supply systems damaged or left in disrepair (Haselow et al., 2022).

The aftermath of the civil wars saw South Sudan emerge as the world's youngest nation. However, the legacy of conflict has left deep scars on its infrastructure. The newly independent country faced immense challenges in rebuilding its water infrastructure to meet the needs of its rapidly growing population (Fonkeng, 2021). According to Bior (2018), the existing water supply systems were inadequate to provide clean and safe water to the population, leading to widespread reliance on untreated water sources. Despite efforts to rehabilitate and expand water infrastructure, the pace of development has been slow due to ongoing political instability, financial constraints, and logistical challenges. The capital city, Juba, has experienced rapid urbanization, further straining the already limited water resources. The city's water supply master plan, designed over a decade ago, has not been updated to reflect the growing population and changing needs, resulting in significant gaps in water service delivery.

Previous studies on barriers to clean and safe water access reveal a complex interplay of infrastructural, economic, geopolitical, and environmental factors. Maréchal et al. (2022) found that while the supply of drinking water is generally sufficient and affordable for most residents in rural Greenland, access remains a significant challenge. The study, however, did not explore the qualitative aspects of water quality and its impact on health, nor did it delve into the potential consequences of water-saving practices on water quality and public health. Similarly, Achore, Bisung, and Kuusaana (2020) highlighted that household water insecurity in Haiti is significantly associated with increased levels of anxiety and depression, both directly and through food insecurity. However, this study did not account for confounding factors such as access to healthcare or social support systems, which could also influence mental well-being.

Economic factors also significantly hinder access to clean and safe water. Mallick, Mandal, and Chouhan (2020) emphasized the role of improved sanitation facilities in reducing childhood diarrhea in India but did not specifically address the impact of inadequate access to clean drinking water. This oversight leaves a gap in understanding the full scope of water access issues on child health. Similarly, studies in urban areas, such as those by Boying et al. (2020) in Juba, South Sudan, found that raw water from the Nile River is unsuitable for drinking without treatment, necessitating the installation of drinking water plants. However, this research primarily focused on water quality and pollution rather than directly addressing access challenges for households.

The existing literature therefore underscores the intricate barriers to clean and safe water access, highlighting the critical need for comprehensive and context-specific solutions aligned with SDG 6 which aims to ensure the availability and sustainable management of water and sanitation for all, emphasizing universal access to safe and affordable drinking water by 2030. This goal is particularly relevant in the context of South Sudan, a nation emerging from decades of conflict that has left its water infrastructure severely damaged and underdeveloped. The literature reveals significant gaps in understanding the qualitative impacts of water quality, economic burdens, and socio-psychological effects of water inadequacy on households. Therefore, this research seeks to bridge these gaps by exploring the barriers to clean and safe water access

among households in Juba city, focusing on the availability, affordability, quality, quantity, reliability, and distance to water sources, thereby contributing to the broader objectives of SDG 6.

3. Research Methods

This study employed a qualitative research design to explore the barriers to clean and safe water access in Juba City, South Sudan. Data collection was conducted through in-depth interviews, and FGDs. In-depth interviews were carried out using semi-structured guides with household heads, focusing on their experiences with water access and its impacts on their well-being. KIIs were also conducted to gather expert opinions from individuals with specific knowledge or expertise in water access issues. FGDs were organized with groups of 6 to 8 participants to explore collective experiences and social dynamics. Secondary information was sourced from government reports, academic publications, and international organizations' databases.

Purposive and snowball sampling techniques were employed, targeting 31 households across three payams (Munuki, Juba, and Kator) in Juba City, with interviews stopping at the point of data saturation. Critical case sampling targeted key stakeholders, including government officials, civil society organizations, and community leaders, who provided detailed knowledge about the water supply situation and legal frameworks.

Data analysis was conducted through thematic content analysis to identify recurring themes and patterns in the interview transcripts. Open coding allowed the emergence of new themes, and the constant comparison method iteratively refined categories. Thematic content analysis and domain analysis matrix was generated from the content analysis process that was based on the data from household semi-structured in-depth interviews, KII and FGDs. The resulting themes were further aligned to the AA-QQ-RD framework. Triangulation enhanced the reliability and validity of the data by incorporating multiple data collection methods and sources. Ethical considerations included obtaining informed consent, maintaining confidentiality, and emphasizing voluntary participation.

4. Results

The findings from the thematic content analysis reveal a comprehensive understanding of the barriers contributing to the inadequate access to clean and safe water among households in Juba City. These factors are grouped into several key themes including infrastructural deficiencies, economic constraints, socio-political factors, and environmental challenges. The themes were later linked to relevant main domains in the AA-QQ-RD framework.

4.1. Availability

Availability of water is a critical factor influencing the adequacy of clean and safe water access in Juba City. This issue is significantly manifested through poor water infrastructure, which includes outdated and poorly maintained pipes that frequently burst and leak, disrupting the consistent availability of water in Juba City. One of the most critical points raised by participants is the inadequacy and poor installation of water pipes at the source. A participant said that,

"At this point in time, there is a crisis we are having. The crisis leads to so many damages to the water infrastructure. Water cannot reach those ends of Juba and also parts of Kator and the rest" (JPFGD-2, Line 43).

Furthermore, participants highlighted that the limited number of water points and sources worsens the problem, as the existing infrastructure fails to meet the growing demands of the population in Juba, Munuki, and Kator payams, thereby affecting water availability. This situation forces residents to rely on alternative, often unreliable sources, such as water trucks and communal taps, compromising the availability of clean water. Many residents reported issues with the existing infrastructure that prevent consistent and reliable water delivery. This inadequate distribution is often linked to the outdated and poorly maintained pipelines, as well as the insufficient number of boreholes and community wells. The impact is severe in peripheral areas where the infrastructure is most neglected.

"Also, the other reason I think there is a lack of infrastructure. It is not well developed [...]. Some areas here in Juba, water tankers don't go to some areas where infrastructure is not well developed" (KP02, Line 85-87).

Participants expressed frustration with the city's failure to address the deteriorating infrastructure. This lack of coordinated effort between the government and the community leads to a cycle of neglect and deterioration, making sustainable water access increasingly unattainable. In their study, Armah et al. (2018) pointed out that the lack of infrastructure development forces households to prioritize essential uses of water, which often means compromising on other activities critical to health and hygiene.

4.2. Affordability

According to economic theory, when the price of a basic necessity such as water increases, it becomes less affordable for households, particularly those with limited financial resources. As a result, households may be unable to purchase the quantity of water needed to meet their daily needs, leading to inadequate access. Participants in this study expressed that the high prices of water in the market make it difficult for the household to afford an adequate supply for their needs. The participant stated the following during a household semi-structured interview:

"The expenses are already there related to fuel because fuel is expensive and these guys have increased the cost of water, and if you don't have that money, you will be forced to fill the bucket, which will not last long and you continue suffering. So, you either sacrifice that amount [of money] for the water and then you economize or if you are a stubborn person, then you suffer and spend more [on water] and that means you will spend less on food." MP01, Line-111.

"You know the economic crisis now. If you don't have 100 dollars, accessing this clean water also becomes a problem [...]. In our area there, they are selling water at 2,000 SSP [South Sudan Pounds]. This is costly." JPFGD-1, Line-68.

It is evident that the financial strain caused by high clean and safe water prices has a higher possibility of forcing households to prioritise other sources (which may not be purely clean or safe) as well as other essential expenses over water, further reducing their ability to secure an adequate supply. In India, [Mallick, Mandal, and Chouhan \(2020\)](#) revealed that low-income households were less likely to have access to improved sanitation facilities, correlating with inadequate water access and higher incidences of waterborne illnesses among under-five children. Additionally, [Zvobgo and Do \(2020\)](#) highlight the financial mechanisms required to invest in water infrastructure, noting that inadequate funding and poor governance intensifies the water crisis in under-resourced municipalities.

4.3. Quality

The quality of water in Juba city is impacted at several handling stages, with contamination occurring during supply and storage at the household level. Factors such as interaction with animals at water sources, the use of water tankers that are allegedly sometimes employed for sewage collection, and improper storage practices contribute to significant health risks for residents. Many households store water in containers that are inadequately sealed, making them susceptible to contamination from environmental pollutants. Moreover, there are concerns about the integrity and safety of water tankers which distorts the levels of quality. It has been reported that some water tankers apart from not being cleaned or washed, under the cover of night, are used for sewage collection. This practice severely compromises the water quality and puts residents at risk of consuming contaminated water. Some participants expressed this concern,

"[...] the water tankers also carry water in our area. They are not washed. [...] They still go to the riverside and then get water directly from there. [...] That water is dirty and is contaminated with many things because of the environment." JP01, Line-7, 11.

"We have heard of some being used at night for sewage collection, so it's very difficult to trust. It's unclear if the government actually monitors these water tankers. There are rumors that some in the middle of the night go out and do sewage extraction and then in the morning they're collecting water for people." MP03, Line-65-67.

Additionally, water contamination was found to occur at storage points within households. Many residents store water in containers that are often uncovered or inadequately sealed, making them susceptible to contamination from dust, insects, and other environmental pollutants. [Akhtar et al. \(2021\)](#) pointed out that geological processes, natural disasters, climate change, and surface water and groundwater interactions are primary natural causes of contamination. On the other hand, [Salehi et al. \(2022\)](#) concluded that the intermittent water supply systems can lead to contamination through microbial intrusion and the backflow of contaminants during low or negative pressure events. This comprehensive view aligns with the situation in Juba City, where industrial activities and improper waste disposal practices lead to the contamination of local water sources.

4.4. Quantity

The quantity of water available in Juba City is a critical issue, significantly affecting access to clean and safe water. Insufficiency of water associated with increased social tensions and conflicts further complicate water access in the city. In some areas, competition for water resources has led to disputes among community members and even between different communities. Additionally, household size and population density were significantly linked to water access. Larger households require more water, which increases demand and stretches limited resources thin. In densely populated areas, the competition for water is high, leading to conflicts and increased stress on the water supply infrastructure. Moreover, the physical strain of queuing for water and the fear of potential conflicts can discourage people from collecting water, leading to further shortages and health risks. Another participant noted,

"I sometimes avoid going to the water point because I don't want to get into a fight or argument. But then we run out of water at home, and it's a big problem" (JPFGD-2, Line 53).

"Water is a big issue here, and it often causes fights between different communities. People are already stressed, and this just makes things worse" (JP03, Line 38).

Extensive literature corroborates these findings. The study by [Emenike et al. \(2017\)](#), found that limited access to government-provided water facilities led to disputes over private water sources. Similarly, [Achore, Bisung, and Kuusaana \(2020\)](#) revealed that water-related conflicts often arise in areas where competition for limited water resources is high. Furthermore, the research by [Mallick, Mandal, and Chouhan \(2020\)](#) highlighted that those larger households and densely populated areas faced greater challenges in securing sufficient water that is sufficient quantity. This finding aligns with the current study's observation that household size and population density significantly strain water resources, leading to increased competition and conflicts. Further, [Belay et al. \(2022\)](#) in Ethiopia revealed that in highly populated regions, the demand for water far exceeded the available supply, leading to frequent disputes and social tensions. This scenario mirrors the situation in Juba City, where high population density intensifies the challenges of water access and fuels conflicts.

4.5. Reliability

Despite efforts to improve water access, the city continues to grapple with irregular water supply and unreliable service delivery. Residents often face challenges such as erratic water distribution schedules, frequent service interruptions, and inadequate maintenance of water infrastructure. Many residents rely on informal water vendors or small-scale providers due to the inconsistent and unreliable nature of city water services. These informal providers often lack the infrastructure and resources to ensure consistent water supply, leading to frequent shortages and service disruptions.

"Sometimes we spend hours just waiting for our turn to fetch water. The queues are very long, and if you are not patient, you might leave without water" (KP02, Line 18).

"Like, let me say, like, when was that when the dollar just spiked abruptly? So, these tankers were not moving. I don't know whether they were planning for a strike, or they were planning to increase prices..." (JP03, Line-101).

"[...] this water is being supplied by one group of people. As a result of insecurity in South Sudan, like when one of them was killed, there was a strike. At that time, there was no water at all. People also suffered. That's my point" (Line 49).

These findings reflect how fluctuations in the economy directly affect water supply. The lack of regulation and oversight illustrated contributes to the inconsistent distribution of water. The monopoly of water supply by certain groups contributes to these inconsistencies. Service delays also contribute to the inconsistency of water provision.

This issue is particularly problematic in the mornings when water is needed for essential activities like preparing for school or work. Further supporting this perspective, [Salehi et al. \(2022\)](#) discussed the impact of intermittent water supply (IWS) systems on water quality. The study notes that, IWS can lead to pressure transients that damage water mains, resulting in the intrusion of microbial contaminants and degradation of water quality. This situation mirrors the conditions in Juba City, where the municipal water system's frequent breakdowns and leaks contribute to the inconsistency of water supply and the reliance on alternative sources.

4.6. Distance to nearest water points

Further, the distance (longer distance) to water points emerges as a significant factor contributing to the inadequacy of clean and safe water access. Participants in the study repeatedly highlighted the challenges posed by having to travel long distances to fetch water, especially for those residing in remote or peri-urban areas. For many households, the journey to fetch water involves walking considerable distances, which is particularly strenuous for women, children, and the elderly. The physical effort required to transport water over long distances is a daily hardship. For instance, one respondent mentioned that,

"Water prices in areas like Gudele are significantly higher compared to Munuki because of the distance, with prices reaching up to 2,500 SSP compared to 1,500 SSP in closer areas (MPFGD-2, Line 68; KII-2, Line 161).

This discrepancy in pricing illustrates the financial burden placed on residents living further from water sources. Moreover, the distance to water points disproportionately affects the most vulnerable groups. The elderly and physically challenged individuals face particular difficulties. Extensive literature supports these findings. A study by [Emenike et al. \(2017\)](#) in Nigeria found that many households relied on private sources because of the limited accessibility of government-provided water facilities. Similarly, [Belay et al. \(2022\)](#) in Ethiopia demonstrated that in regions with limited drinking water services, households often had to travel significant distances to fetch water. This situation not only increases the physical burden on individuals but also limits their time for other productive activities, resonating with the findings from Juba City.

5. Conclusion

Statistics from available reports and studies indicate that there is no established water distribution system in Juba city, South Sudan. It is estimated that between 13% and 20% of the residents of Juba city have access to the limited municipal water supplied through a small distribution network, boreholes, and a couple of public water filling stations. This study was therefore conducted with an aim of identifying significant barriers to clean and safe water access among households in Juba City, South Sudan, utilizing the AA-QQ-RD model. The study concludes that the availability of water is severely hindered by outdated and poorly maintained infrastructure, with limited water points forcing residents to rely on unreliable sources. The lack of proper road infrastructure further exacerbates the issue, particularly during the rainy season. Affordability is another major barrier, as high-water costs driven by economic instability make it difficult for households to secure an adequate supply, especially given the weakened South Sudanese Pound. Water quality is compromised at various stages, with contamination occurring during supply and storage, leading to serious health risks for residents. Additionally, the quantity of water available is insufficient, particularly in densely populated areas, leading to social tensions and conflicts over limited resources. The reliability of water supply is undermined by irregular service delivery and inadequate infrastructure maintenance, forcing residents to depend on unreliable informal vendors. The distance to water points further adds to the burden, especially for women and children who must travel long distances to fetch water.

The findings of this study have significant implications for achieving SDG 6, which aims to ensure the availability and sustainable management of water and sanitation for all. In emerging cities like Juba, the persistent barriers to clean and safe water access undermine progress toward SDG 6 and its corresponding targets, such as achieving universal and equitable access to safe and affordable drinking water (Target 6.1) and improving water quality by reducing pollution (Target 6.3). The study highlights the urgent need for coordinated efforts between the government, private sector, and communities to address these barriers and develop sustainable solutions. For Juba City and similar emerging cities, the path to achieving SDG 6 involves not only improving water infrastructure and affordability but also ensuring reliable and safe water distribution systems. This requires substantial investment in infrastructure, robust regulatory frameworks, and community engagement to address the unique challenges of water access.

Ethics Approval and Consent to Participate

The researchers used the research ethics provided by the Human Research Ethics Committee Universiti Sains Malaysia. All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee. Consent and agreement to participate in this study was also obtained from all study participants.

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Conflict of Interest

The authors declare no conflict of interest in this study.

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