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Investigating water security and climate vulnerability in urban informal settlements: a case of Kanyama township, Lusaka, Zambia

Indagine sulla sicurezza idrica e la vulnerabilità climatica negli insediamenti informali urbani: un caso del compound di Kanyama, Lusaka, Zambia

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Abstract

Climate change has profound implications for water security, sanitation, and hygiene in Zambia, particularly in vulnerable peri-urban settlements like Kanyama in Lusaka. Rapid population growth, weak enforcement of environmental regulations, and inadequate infrastructure intersect with climate-induced hazards - such as recurrent flooding - to exacerbate water scarcity and public health risks. Although the Lusaka Water Supply and Sanitation Company treats and distributes water exploiting both surface (Kafue River) and ground- water, Kanyama's per capita access remains critically low due to system inefficiencies and distribution losses. Infrastructure deficiencies lead to frequent leakages and contamination, compromising water quality before it reaches consumers. Poor drainage and sewage systems further increase exposure to waterborne diseases during extreme weather events. These dynamics underscore the need for rigorous chemical and microbiological monitoring to trace contamination sources along the supply chain. This study critically examines water insecurity and climate vulnerability in Kanyama, emphasizing the structural and environmental determinants of public health risk. This was a mixed-method approach involving 100 residents of Kanyama township aged between 15 and 49 years. Data were collected using both questionnaires containing both open and closed ended questions, and interviews. Data were analyzed using IBM® SPSS® (Statistical Package for the Social Sciences) software and Microsoft Excel, and presented in tables and graphs, with percentages and frequencies. Results showed Kanyama's critical dependence on municipal water, with pronounced vulnerabilities due to the lack of alternative sources, intermittent supply, and sporadic contamination. These water security issues are compounded by climate change, rapid urban population growth, substandard infrastructure, and ineffective water governance. While hygiene practices among residents are relatively acceptable, sanitation remains a major concern, as many households rely on shared facilities and store water unsafely. Recurrent flooding, intensified by climate variability, overwhelms inadequate sewer systems and leads to water source contamination, heightening the risk of diarrheal diseases. Despite these risks, the community displays strong awareness of climate-related health impacts, indicating openness to adaptive health strategies. A multi-sectoral approach encompassing water infrastructure improvements, sanitation expansion, and climate-resilient systems is vital for mitigating these public health threats. Integrating public health education with infrastructural upgrades can foster sustainable health behaviours and improve environmental health outcomes in peri-urban populations like those in Kanyama

Riassunto

I cambiamenti climatici hanno profonde implicazioni per la sicurezza idrica, i servizi igienico-sanitari e l'igiene personale in Zambia, in particolare negli insediamenti periurbani vulnerabili come Kanyama a Lusaka. La rapida crescita demografica, la scarsa applicazione delle regolamentazioni ambientali e le infrastrutture inadeguate si combinano con i pericoli indotti dal clima, come le inondazioni ricorrenti, aggravando la scarsità d'acqua e i rischi per la salute pubblica. Sebbene la Water Supply and Sanitation Company di Lusaka gestisca e distribuisca l'acqua sfruttando sia le risorse idriche superficiali (Fiume Kafue) sia quelle sotterranee, l'accesso pro capite a Kanyama rimane estremamente basso a causa dell'inefficienza del sistema e delle perdite nella distribuzione. Le carenze infrastrutturali causano frequenti perdite e contaminazioni, compromettendo la qualità dell'acqua prima che raggiunga i consumatori. I sistemi di drenaggio e fognari inadeguati aumentano ulteriormente l'esposizione alle malattie trasmesse attraverso l'acqua durante gli eventi meteorologici estremi. Queste dinamiche sottolineano la necessità di un rigoroso monitoraggio chimico e microbiologico per tracciare le fonti di contaminazione lungo la catena di approvvigionamento idrico. Questo studio esamina criticamente l'insicurezza idrica e la vulnerabilità climatica a Kanyama, sottolineando i fattori strutturali e ambientali determinanti per il rischio per la salute pubblica. È stato utilizzato un approccio metodologico misto che ha coinvolto 100 residenti del compound di Kanyama di età compresa tra i 15 e i 49 anni. I dati sono stati raccolti utilizzando sia questionari con domande aperte e chiuse, sia interviste. I dati sono stati analizzati utilizzando il software IBM® SPSS® (Statistical Package for the Social Sciences) e Microsoft Excel, e presentati in tabelle e grafici, con percentuali e frequenze. I risultati hanno mostrato la significativa dipendenza di Kanyama dall'acqua comunale, con vulnerabilità pronunciate dovute alla mancanza di fonti alternative, all'approvvigionamento intermittente e alla contaminazione occasionale. Questi problemi di sicurezza idrica sono aggravati dai cambiamenti climatici, dalla rapida crescita della popolazione urbana, dalle infrastrutture inadeguate e da una governance idrica inefficace. Sebbene le pratiche igieniche dei residenti siano relativamente accettabili, i servizi igienico-sanitari rimangono una delle principali preoccupazioni, poiché molte famiglie utilizzano strutture condivise e conservano l'acqua in modo non sicuro. Le inondazioni ricorrenti, intensificate dalla variabilità climatica, sovraccaricano i sistemi fognari inadeguati e portano alla contaminazione delle fonti idriche, aumentando il rischio di dissenteria. Nonostante questi rischi, la comunità mostra una forte consapevolezza degli impatti sulla salute legati al clima, dimostrando apertura verso strategie sanitarie adattive. Un approccio multisettoriale che comprenda il miglioramento delle infrastrutture idriche, l'espansione dei servizi igienico-sanitari e sistemi resistenti ai cambiamenti climatici è fondamentale per mitigare queste minacce alla salute pubblica. L'integrazione dell'educazione alla salute pubblica con il miglioramento delle infrastrutture può favorire comportamenti sostenibili in materia di salute e migliorare le condizioni ambientali nelle popolazioni periurbane come quelle di Kanyama.

Parole chiave:
sicurezza idrica, vulnerabilità climatica, urbano, periurbano, Zambia.

Introduction

Urban informal settlements, like Kanyama in Lusaka, Zambia, are increasingly vulnerable to climate change impacts, particularly affecting water security due to inadequate infrastructure (Lusaka Baseline Report, 2016). Climate change poses significant challenges to water availability, sanitation, and hygiene, with adverse consequences for public health (WHO, 2020). In Zambia, climate change has notably affected water supplies, heightening the risk of waterborne diseases (Kloos et al., 2013). Understanding how resilience is developed and maintained is essential for designing effective interventions, particularly in vulnerable contexts like low-income settlements. Research conducted by the Intergovernmental Panel on Climate Change (IPCC) emphasizes the global repercussions of climate change on water resources (Konda et al., 2019), with Zambia facing heightened risks due to its geographical and socioeconomic context (Nyirenda et al., 2020). Changes in precipitation, rising temperatures, and extreme weather events like droughts and floods significantly impact water supplies, sanitation, and hygiene practices (Nyirenda et al., 2020).

Kanyama, a rapidly growing informal settlement, exemplifies the challenges posed by climate change. Limited access to safe water sources amplifies its vulnerability to water shortages and contamination (Mulenga et al., 2015). A more localized investigation, focusing on communities like Kanyama, is essential for creating targeted interventions and adaptation strategies (Garrick et al., 2018). This study

aims to explore water security and climate vulnerability in Kanyama Township to inform more effective and context-specific responses.

Materials and Methods

Study design, time-period, and setting

This study employed a mixed-methods approach, combining both quantitative and qualitative data collection and analysis. Using a deductive approach, the study aimed to describe and quantify data. The research design was descriptive and cross-sectional, which allowed for fact-finding and included in-depth open interviews to capture the unique experiences of participants. The recruitment period for the study spanned three months, starting in September 2024 and ending in November 2024. Participants provided informed consent prior to their inclusion in the study. Written consent was obtained to ensure clear documentation of their voluntary participation. For participants who were minors, consent was obtained from their parents or guardians. Ethical approval for this study was secured, and the need for informed consent was acknowledged and implemented in compliance with the requirements of the ethics committee (see Supplementary Material). Data were collected over the same three-month period (September, 2024 to November, 2024). This comprehensive data collection effort included both quantitative surveys and qualitative interviews to provide a holistic understanding of the subject matter. The study site for this project was Kanyama Township, a peri-urban settlement located 7 kilometers west of Lusaka's central business district.

Study area

Kanyama is a densely populated township located approximately 7 km west of Lusaka's central business district, covering an area of approximately 14 km². Situated at coordinates 15°26'S, 28°14'E, and an elevation of approximately 1,270 meters above sea level, Kanyama is part of Lusaka Province and falls within the Kanyama constituency (Figure 1). The township is bordered by major local roads, including Los Angeles and Mumbwa roads, facilitating connectivity to other parts of Lusaka. Lusaka itself is situated on a central plateau in south-central Zambia, serving as the country's political and economic hub (Zambia Demographic Health Survey,2020).

Lusaka, including Kanyama, experiences a monsoon-influenced humid subtropical climate. The climate is characterized by a warm, wet season from November to March, a cooler dry season from April to August, and a short hot season in September and October. Mean monthly temperatures typically range from around 15°C during the cool season nights to the low-30s°C during the hot months. Rainfall is strongly seasonal, concentrated in the November–March period, producing most annual precipitation in the wet season, while the remainder of the year is relatively dry. This seasonality is central to hydrological variability, leading to floods during heavy rains and lower flows in the long dry season (Zambia Demographic Health Survey,2020).

Therefore,Kanyama was selected as the study area because its high population density, limited access to formal water infrastructure, and exposure to both flooding and dry-season water scarcity make it a representative case for examining water security and climate vulnerability in low income settlements. Understanding the local geographic and climatic context is essential for assessing how residents experience water scarcity, contamination risks, and infrastructure limitations under the pressures of climate variability.

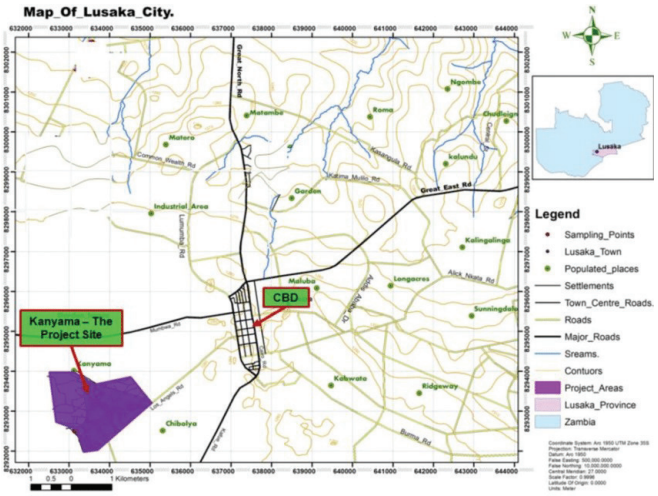

Fig. 1 - Location map of the Kanyama study area in Lusaka, capital city of Zambia. Source: Tembo et al. (2019).

Fig. 1 - Ubicazione dell'area di studio di Kanyama in Lusaka, Zambia. Da: Tembo et al. (2019).

Study population and eligibility criteria

Kanyama Township, in Lusaka City, consists of a population of approximately 400,170 inhabitants, according to the 2020 census. The study focused on residents aged 15–45 years, reflecting the average life expectancy and age distribution of Zambia's population. People who did not give consent or were unavailable during the study period were excluded from the survey.

Sampling techniques and sample size determination

The probability method was used in both quantitative and qualitative approach, involving a simple random selection to ensure that each unit of the sample is chosen based on chance. This study used simple random sampling because the population members are similar to each other and it ensures a high degree of representativeness.

The optimal size of the population was calculated using the Yamane formula (1967):

$$n = \frac{N}{1 + N(e)^2} \qquad (1)$$

n=400, 170/[1+400,170(0.10)]=100

Where: n is the required sample size,
N is the population size (400,170), and
e is the level of precision (margin of error 10%).

Considering a study population of 400,170, a 90% of confidence level and 10% (e=0.10) of error level, the sample size is equal to 100. Therefore, a sample size of 100 individuals was used in this study. The sample included both male and female participants.

Data collection, procedure, and quality assurance

Primary data for this study were collected using both qualitative and quantitative methods. The qualitative approach focused on understanding general themes and the perspectives of interviewees, utilizing semi-structured or in-depth interviews with key informants. Oral interviews were conducted for illiterate householders, while self-administered questionnaires were used for management and community members. Secondary data were gathered through desk reviews of published and unpublished sources related to the topic. Both methods aimed at enhancing the reliability and validity of the study's key concepts. Quantitative data were analyzed using IBM® SPSS® (Statistical Package for the Social Sciences, Version 46) and Microsoft Excel, with results presented in tables, and graphs showing percentages and frequencies. Quantitative data were analyzed descriptively, focusing on independent and dependent variables, as explained by Collins et al. (2002). Qualitative data were analyzed using subjective methods, particularly by grouping responses into themes. Validity, defined as the extent to which a research instrument accurately measures its intended object, was assessed by examining relevant literature and questioning research findings. Reliability, which refers to the consistency of results over time and the accurate representation of the population, was ensured through triangulation. This involved comparing data from interviews with stakeholders, secondary reports, and questionnaires distributed among participants, to confirm the accuracy and consistency of the findings.

Results

Demographic information

Table 1-4 and Figures 2-7 summarize the demographic information on the respondents. The majority of respondents (75%) are young, aged (15-34) years, with only 25% aged (35-49) years, indicating a youthful population. In terms of marital status, 60% are single, while 40% are married. Regarding education, 30% have completed secondary education, with 10% primary education. Employment-wise, 50% are employed, and 30% are self-employed, indicating diverse economic participation. Religiously, 80% identify as Christians, while 15% are Muslims, and about 5% are Hindus. All respondents live in Kanyama. Family dynamics show that 40% of respondents have 0-1 children, and 35% have 2-3 children. Additionally, 30% of spouses have secondary or higher education, indicating a relatively high level of educational attainment.

Tab. 1 - Demographic information of participants with frequencies and percentages.

Tab. 1 - Informazioni demografiche dei partecipanti con frequenze e percentuali.

Demographic Variable	Count (100)	Percentage (100%)	Male (Count & %)	Female (Count & %)
Age of Respondents				
15 - 24 years	40	40.0	20 (50.0%)	20 (50.0%)
25 - 34 years	35	35.0	15 (42.9%)	20 (57.1%)
35 - 44 years	15	15.0	8 (53.3%)	7 (46.7%)
45 - 49 years	10	10.0	5 (50.0%)	5 (50.0%)
Marital Status				
Single	60	60.0	30 (50.0%)	30 (50.0%)
Married	40	40.0	18 (45.0%)	22 (55.0%)
Highest Level of Education				
Secondary	60	60.0	28 (46.7%)	32 (53.3%)
Tertiary	30	30.0	16 (53.3%)	14 (46.7%)
Other	10	10.0	6 (60.0%)	4 (40.0%)
Occupation				
Employed	50	50.0	25 (50.0%)	25 (50.0%)
Self-employed	30	30.0	12 (40.0%)	18 (60.0%)
Other	20	20.0	10 (50.0%)	10 (50.0%)
Religious Denomination				
Islam	15	15.0	8 (53.3%)	7 (46.7%)
Christianity	80	80.0	38 (47.5%)	42 (52.5%)
Hinduism	5	5.0	2 (40.0%)	3 (60.0%)
Living Location				
Kanyama	100	100.0	50 (50.0%)	50 (50.0%)
Number of Children				
0-1	40	40.0	18 (45.0%)	22 (55.0%)
2-3	35	35.0	17 (48.6%)	18 (51.4%)
4-5	15	15.0	8 (53.3%)	7 (46.7%)
6-8	5	5.0	3 (60.0%)	2 (40.0%)
9 and above	5	5.0	2 (40.0%)	3 (60.0%)
Spouse's Educational Level				
Primary	10	10.0	4 (40.0%)	6 (60.0%)
Secondary	30	30.0	14 (46.7%)	16 (53.3%)

Impact of water availability, quality, and accessibility

Table 2 summarizes the results on water availability, quality, and accessibility among the respondents. The results show that 70% of respondents rely on municipal water sources, while 30% use hand-dug wells, indicating varying access to water. While 70% of respondents lack access to other water sources, such as commercialized water bottles, only 30 % use other sources of water. Most of the respondents (60%) believe that water quality is good for general use,

Tab. 2 - Impact of water availability, quality, and accessibility with frequencies and percentages.
Tab. 2 - Impatto della disponibilità, qualità e accessibilità all'acqua con frequenze e percentuali.

Water Access Variable	Count(n=100)	Percentage (%)
Source of Water		
Municipal tap water	70	70.0
Hand dug well	30	30.0
Other sources of water; e.g., Commercialized bottles		
Yes	30	30.0
No	70	70.0
Belief in Water Quality Generally		
Yes	60	60.0
No	40	40.0
Water Storage Method		
Big closed storage tanks	50	50.0
Small container covered on top	40	40.0
Other	10	10.0
Time to Collect Water		
Less than 30 mins	70	70.0
30 mins - 1 hour	20	20.0
More than 1 hour	10	10.0
Municipal Payment for Water		
Yes	50	50.0
No	50	50.0
Fairness of Payment		
Yes	30	30.0
No	70	70.0
Willingness to Pay for Better Access to Water		
Yes	65	65.0
No	35	35.0

with 40% not believing in it, pointing to a need for public health education due to cases of diarrheal diseases (WHO, 2023). Half of the respondents (50%) use big storage tanks covered on top to store the water, 40% use small containers closed on top, and 10% use other methods of storage (e.g., open drums, clay pots, or buckets). Most respondents (70%) collect water in less than 30 minutes, though 30% spend longer time, impacting daily routines. The study shows an equal split (50%) regarding payment for water, indicating varied service arrangements, while 65% are willing to pay for better water access, signalling a desire for improved services and investment opportunities.

Existing sanitation and hygiene practices

Table 3 summarizes the hygiene practices and sanitation access among the respondents. The results show high rates of handwashing before meals (70%) and after toilet use (80%). However, only 50% clean a baby's nappy, which could be improved. A significant portion (75%) washes their hands at least once today, reflecting hygiene awareness, although the 25% who did not wash their hands raises concern. Sanitation access is relatively good, with 80% of families having a toilet, although the 20% without toilets indicates a need for improvement. The majority of respondents (65%) prepare food in enclosed spaces, reducing exposure to waste and potential pollutants compared to the 35% who cook outdoors.

Tab. 3 - Existing sanitation and hygiene practices with frequencies and percentages.
Tab. 3 - Pratiche igienico-sanitarie esistenti con frequenze e percentuali.

Hygiene Practice Variable	Count (100)	Percentage (100%)
Handwashing with Soap		
Before eating	70	70.0
Before preparing food	60	60.0
Before feeding a child	65	65.0
After using the toilet	80	80.0
After cleaning a baby's nappy	50	50.0
Frequency of Handwashing Today		
Once or more	75	75.0
None	25	25.0
Family Toilet Availability		
Yes	80	80.0
No	20	20.0
Food Preparation Location		
Enclosed place	65	65.0
Outside in the open	35	35.0

Factors associated with water security and climate vulnerability

Table 4 shows the perception of respondents regarding water security and climate vulnerability. The results show a mixed perception of water availability, with 40% rating it as good, 35% as fair, and 25% as poor, highlighting areas for service improvement. Over half of respondents (55%) experience water scarcity, significantly affecting community health and quality of life. While 50% are somewhat confident in the water supply's reliability, 25% express doubts about its sustainability. A notable 60% of respondents report changes in water resources, with 45% attributing these changes to climate change and 30% to population growth, pointing to the need for adaptive water management. Examples of changes reported by respondents include a decrease of water level in hand-dug wells or boreholes, reduction in river discharge, drying up of seasonal streams, and declining water quality (e.g. increased turbidity). Water accessibility remains a challenge, with 70% facing difficulties at least weekly,

emphasizing the urgency of intervention. Half of respondents (50%) are very concerned about climate change's impact on water resources, showing strong community awareness. Additionally, 85% are aware of health risks linked to poor water quality and sanitation access, indicating readiness for health promotion initiatives.

Tab. 4 - Factors associated with water security and climate vulnerability with frequencies and percentages.

Tab. 4 - Fattori associati alla sicurezza idrica e alla vulnerabilità climatica con frequenze e percentuali.

Community Perception Variable	Count (100)	Percentage (100%)
Rating of Water Availability		
Good	40	40.0
Fair	35	35.0
Poor	25	25.0
Experience of Water Scarcity		
Yes	55	55.0
No	45	45.0
Confidence in Water Supply Reliability		
Very confident	25	25.0
Somewhat confident	50	50.0
Not confident	25	25.0
Primary Factor Contributing to Water Scarcity		
Climate change	45	45.0
others	55	55.0
Frequency of Water Access Challenges		
Daily	30	30.0
Weekly	40	40.0
Monthly	20	20.0
Rarely	10	10.0
Never	0	0.0
Concerns about Climate Change Impact		
Very concerned	50	50.0
Somewhat concerned	35	35.0
Not concerned	15	15.0
Awareness of Health Risks		
Very aware	45	45.0
Somewhat aware	40	40.0
Not aware	15	15.0

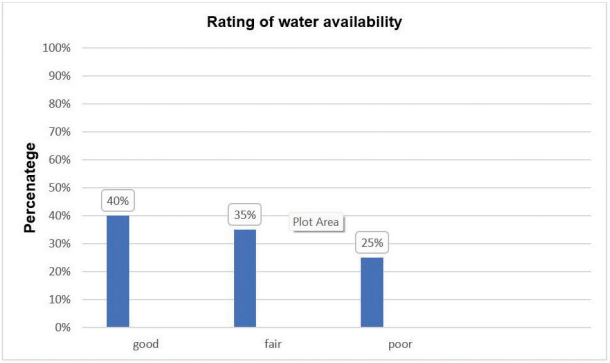

Fig. 2 - Rating of water availability (100%).

Fig. 2 - Classificazione della disponibilità idrica (100%).

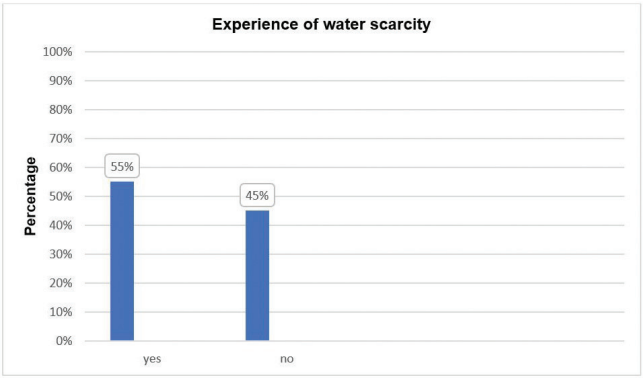

Fig. 3 - Experience of water scarcity (100%).

Fig. 3 - Esperienza di scarsità idrica (100%).

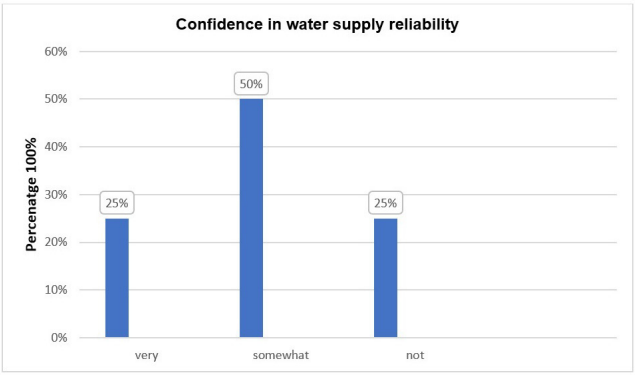

Fig. 4 - Confidence in water supply reliability (100%).

Fig. 4 - Fiducia nell'affidabilità dell'approvvigionamento idrico (100%).

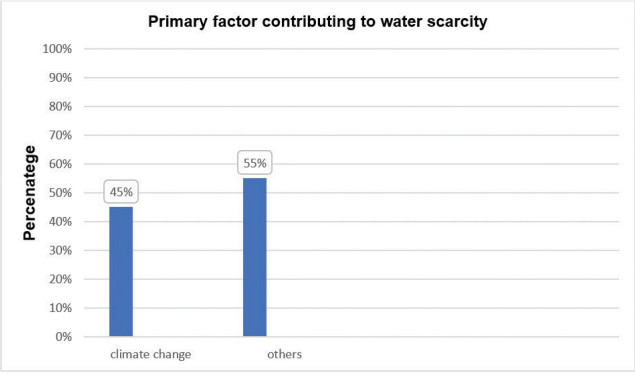

Fig. 5 - Primary factor contributing to water scarcity (100%).

Fig. 5 - Fattore primario che contribuisce alla scarsità idrica (100%).

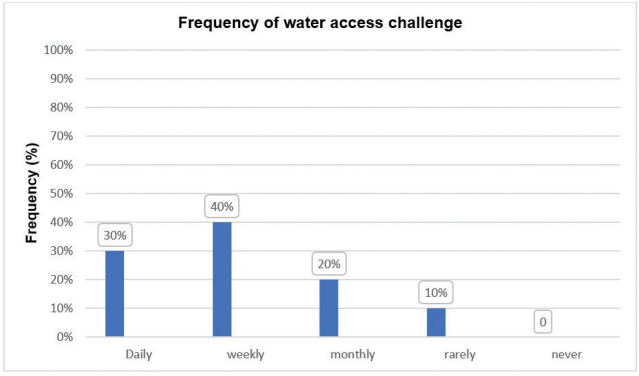

Fig. 6 - Frequency of water access challenge (100%).

Fig. 6 - Frequenza di difficoltà di accesso all'acqua (100%).

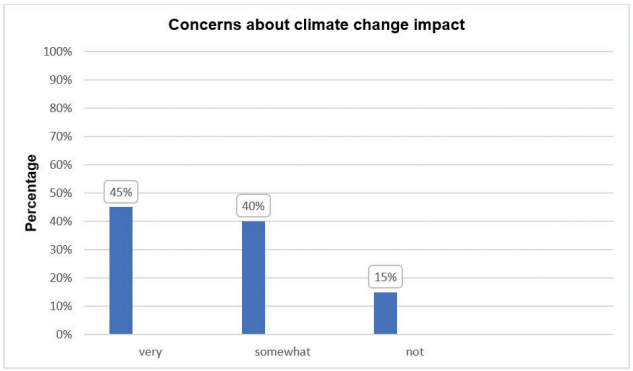

Fig. 7 - Concerns about climate change impact (100%).

Fig. 7 - Preoccupazioni riguardo all'impatto dei cambiamenti climatici (100%).

Discussion

The study conducted in Kanyama Township indicates several demographic trends that reflect broader regional and global patterns. In terms of gender distribution, the sample was evenly split, with 50% male and 50% female respondents, ensuring balanced representation. This equal participation of both sexes provides a reliable basis for interpreting gender-related differences in perceptions and practices within the study population. In Kanyama, 75% of respondents are between 15-34 years old, mirroring the youthful populations in many developing countries, particularly sub-Saharan Africa, where approximately 60% of the population is under 25 years old (UNFPA, 2021). Zambia's 2020 census also shows that 67% of the population is under 35 years old, underscoring the need for youth-centric policies focusing on employment, health, and education. This aspect contrasts with Western countries, which face aging populations (Central Statistics Office, 2020). In terms of marital status, 60% of respondents in Kanyama are single, and 40% are married. This trend mirrors studies showing that urban populations, especially young people, tend to delay marriage for educational and economic reasons (Ahinkorah et al., 2022; World Bank, 2021). This is consistent with Zambia's trends, where 45% of women aged 20-24 are married (Zambia Census, 2020), and contrasts with lower marriage rates in Western countries, such as the United States (UNESCO, 2020). Education levels in Kanyama show that 60% have completed secondary education, and 30% have tertiary education, aligning with national trends where urban areas have better access to education (ZDHS, 2019). This result aligns with the country and continent level of education as tertiary education access remains low in Zambia (20%), and sub-Saharan Africa faces a whole lag behind global averages for tertiary enrollment (UNESCO, 2020). In contrast, developed countries report higher rates of higher education enrollment (OECD, 2020). Economically, 50% of respondents in Kanyama are employed and 30% self-employed. This mirrors broader trends in sub-Saharan Africa, where the informal sector constitutes a large portion of the workforce (ILO, 2019). Globally, developed economies like those in Organisation for Economic Co-operation and Development (OECD) countries have smaller informal sectors, emphasizing the contrast between formal job markets in the Global North and informal employment in developing nations. Religiously, 80% of respondents in Kanyama identify as Christians, reflecting Zambia's religious landscape, where Christianity dominates (Pew Research Center, 2019).The high percentage (100%) of respondents living in Kanyama reflects Zambia's growing urban population, particularly in peri-urban areas, with 44% of Zambia's population living in urban and peri-urban areas (Pew Research Center, 2019). Globally, urbanization rates are the highest in Asia and Latin America, with Africa urbanizing more slowly (World Bank, 2020). In terms of family size, 40% of Kanyama respondents have 0-1 children, and 35% have 2-3 children. This mirrors the global trend of smaller family sizes in urban areas due to economic pressures and access to family planning (UNICEF, 2019). Zambia's fertility rate remains high at 4.7 children per woman, but urban areas like Kanyama reflect global trends toward smaller families (ZDHS, 2019). Finally, 70% of spouses in Kanyama have secondary or higher education, indicating that education positively influences family economic opportunities. Educated couples tend to have better economic outcomes, as seen globally (World Bank, 2019). In Zambia, educated couples have better healthcare access and higher incomes, though disparities between urban and rural areas persist (CSO, 2019). In Kanyama, 70% of residents rely on municipal water sources, such as standpipes, while others still use alternative sources like boreholes and hand-dug wells. Studies in other countries, like Nepal and Ghana, also emphasize vulnerabilities in water access due to infrastructure limitations, financial barriers, and dependence on private vendors, which increase the difficulty and cost of accessing safe and clean water (Pandey et al., 2018; Gupta et al., 2019; Anim & Ofori-Asenso, 2020). A similar study in Nairobi's informal settlements highlights the risks associated with inadequate water and sanitation infrastructure (UN-Habitat, 2021). In Zambia, urban areas like Kanyama have better access to piped water compared to rural regions. According to the Zambia Demographic and Health Survey (ZDHS) conducted in 2018 (ZDHS, 2018), 65% of urban Zambians had access to improved water sources, which is consistent with findings in Kanyama. In this context, improved water

sources refer to those that are more likely to provide safe drinking water because they are protected from outside contamination, particularly faecal matter. These include piped water into dwellings, public taps or standpipes, boreholes, protected dug wells, protected springs, and rainwater collection (WHO/UNICEF Joint Monitoring Programme, 2017).On a global scale, 74% of the world's population had access to safely managed drinking water by 2020, but sub-Saharan Africa lagged behind, with only 61% of population having access to basic drinking water services (WHO, 2020). The 70% of Kanyama residents who lack alternative water sources face heavy dependence on the primary water supply system, mainly exploiting groundwater resources, which can be vulnerable to disruptions due to power outages and aging infrastructures. Similar challenges are observed across Africa, where outdated water infrastructures contribute to periodic shortages, especially during droughts (AfDB, 2019). In contrast, countries with diversified water sources, like Singapore, experience fewer disruptions by relying on desalination, imported water, and rainwater collection (United Nations, 2020). Water quality perceptions in Kanyama are mixed, with 60% of respondents considering the water good, while 40% express skepticism. This highlights a common issue across sub-Saharan Africa, where even if water is accessible, concerns about safety and contamination persist. UNICEF (2020) reports that only 44% of people in sub-Saharan Africa have access to safely managed drinking water. The mixed perception in Kanyama suggests a need for improved water quality analyses and public health education on safe and clean water practices (UNICEF, 2020). Comparatively, water quality in regions like Europe is generally higher thanks to the adoption of safety regulations, which Kanyama may lack, contributing to public skepticism (UNICEF, 2020). The use of closed containers by 50% of Kanyama respondents is a positive sign for safe water storage, but 40% using open containers still pose contamination risks. This issue is well-documented across sub-Saharan Africa, where inadequate infrastructure and unsafe water handling contribute to waterborne diseases (World Bank, 2019). In Zambia, the National Water and Sanitation Council (NWASCO) has reported gaps in hygiene practices, particularly regarding safe water storage, even in areas with improved water access (NWASCO, 2018). Regarding water collection time, 70% of Kanyama residents spend less than 30 minutes collecting water, reflecting relatively easy access compared to other African regions. The World Health Organization (WHO, 2021) reports that many households in sub-Saharan Africa still spend over 30 minutes collecting water due to inadequate infrastructure. This disparity is even more pronounced in rural areas of Zambia, where long distances for water collection remain common (ZDHS, 2018). In contrast, high-income countries with universal piped water systems, like in the U.S.A., experience virtually no water collection time.The equal division between residents who pay for water (50%) and those who do not indicate the existence of both formal and informal water service arrangements.In Zambia, water services are often managed by local utilities, but informal settlements or peri-urban areas may rely on unregulated sources where payment is not required (Zambian Ministry of Water Development, 2019). Globally, cities with metered and regulated water services, like Cape Town, have more consistent pricing structures, whereas informal vendors are common in many other African cities (CDC,2018). Countries with universal water systems, such as Canada or France, have established tariffs to ensure sustainable water infrastructure (UNESCO, 2020). A strong willingness (65%) to pay for improved water access in Kanyama reflects the community's desire for better services, aligning with trends observed in other African cities, where residents are often willing to pay for reliable water services (World Bank, 2019). This supports infrastructure development and public health improvements, as evidenced by Zambia's National Water Supply and Sanitation Council (2019), which found a similar willingness to pay for better services in urban areas.

The data from Kanyama indicates relatively good hygiene awareness, with high rates of handwashing before meals (70%) and after toilet use (80%). However, handwashing after handling babies' nappies remains an area for improvement, with only 50% of respondents practicing it. This compares favorably with sub-Saharan Africa, where less than 30% of households have access to handwashing facilities with soap and water (UNICEF, 2018). The World Health Organization (WHO, 2020) acknowledges handwashing as a key preventive measure for infectious diseases, with the potential to reduce diarrheal diseases by up to 40%. However, concerns persist due to 25% of Kanyama residents not washing their hands on the day surveyed (CDC, 2019). Sanitation access in Kanyama is also relatively high, with 80% of families having access to toilets, a notable achievement compared to the national urban average of 54% (ZDHS, 2018). However, the remaining 20% without toilets highlight ongoing challenges in achieving universal sanitation coverage. The Zambian Ministry of Water and Sanitation (2020) emphasizes the need for improvements in informal settlements to reduce open defecation and associated health risks. In sub-Saharan Africa, only 28% have access to safely managed sanitation services, and 20% still practice open defecation (WHO, 2020). Shared toilets, used by 37.5% of Kanyama residents, raise hygiene concerns due to contamination risks, especially in overcrowded areas (UNICEF, 2019). Private toilet ownership is a positive indicator in Kanyama, with 62.5% of respondents having private toilets, significantly higher than the 29% national urban average (ZDHS, 2018). However, shared toilet usage remains a risk for sanitation-related diseases. Globally, private toilet ownership is much higher in developed countries, like Sweden and Canada, where nearly 100% of households have access to private sanitation (World Bank, 2020). Regarding food preparation, 65% of Kanyama respondents cook in enclosed spaces, reducing contamination risks. This trend is in line with improving housing standards in urban Zambia, where enclosed cooking spaces are becoming more common (Zambia Housing and Health Survey, 2020). In contrast,

outdoor cooking is still prevalent in many low-income areas, exposing food to environmental contaminants (WHO, 2019). Developed countries, such as those in Europe, benefit from nearly universal access, significantly reducing foodborne illnesses (FAO, 2019).

The distribution of opinions on water availability (Figure 2) in Kanyama is mixed, with 40% of residents rating it as good, 35% as fair, and 25% as poor, indicating varying levels of satisfaction with water access. This is similar to findings by Moser and Satterthwaite (2021), who noted that informal settlements face climate risks such as floods and droughts, which worsen vulnerabilities due to inadequate infrastructure. Pandey et al. (2022) also highlighted household-level factors, like financial constraints, as key contributors to vulnerability. The perception of inadequate water access is linked to higher incidences of waterborne diseases, as noted by the WHO (2020), and is a common issue across Africa, where 36% of urban residents lack reliable access to safe water (AfDB, 2021). Kanyama also faces critical water scarcity, with 55% of residents reporting water shortages, a situation mirrored in other regions such as South Asia, where water scarcity affects adaptive capacity in informal settlements (South Asia Informal Settlements Report, 2021). The World Bank (2021) highlighted that water scarcity in urban Africa is exacerbated by rapid population growth and infrastructure deficiencies. In Zambia, urban areas are particularly vulnerable to water shortages, contributing to public health risks (ZDHS, 2018). Additionally, it can be observed from Figure 4 that 50% of Kanyama residents expressed some confidence in the reliability of their water supply, but the 25% who lack trust reflects ongoing concerns, similar to findings in East Africa (GWI, 2020), and global reports highlighting that water insecurity can cause socio-political tensions (UN, 2021). The fact that 60% of respondents observed changes in water resources indicates potential impacts of climate change, with 45% attributing these changes to environmental shifts. Respondents reported several changes that could be related to climate change, including decreases in water levels in hand-dug wells or boreholes, reductions in river discharge and stream flow, drying up of seasonal streams or small rivers, increased frequency of water quality issues such as turbidity or contamination, and irregular or reduced rainfall patterns affecting water availability. These observations underscore the need for adaptive water management strategies to address the effects of changing climate conditions (ZDHS, 2018). The IPCC (2021) projects that climate change will worsen water scarcity, particularly in vulnerable regions. The World Resources Institute (2020) also emphasized the role of population growth and climate change in increasing water scarcity in Africa. Furthermore, 70% of residents face weekly challenges accessing water, reinforcing the need for urgent intervention to address these systemic issues, as highlighted by the African Development Bank (2021). The community's awareness of climate change and water-related health risks is significant, with 50% expressing concern about the impacts of climate change on water resources and 85% aware of the health risks associated with inadequate water and sanitation. This awareness could foster greater community engagement in environmental and health care initiatives, which could significantly improve health and quality of life in Kanyama, as also noted by UNEP (2021).

Study limitations

This study has several limitations that may affect interpretation of its findings. The reliance on self-reported data introduced potential bias, as responses could have been influenced by personal perceptions or inaccuracies. As a cross-sectional study, it provided only a snapshot, limiting its ability to capture long-term trends. Language barriers and cultural nuances also hindered accurate interpretation of responses, affecting the validity of the findings. Additionally, the medium response rate introduced selection bias, as those who chose to respond may have differed from those who did not, further affecting generalizability.

Competing interest

The authors declare no competing interest.

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Additional information

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