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Climate Change Perceptions and Water Security: Evidence from Low-Income Urban Communities of Dar es Salaam, Tanzania

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Abstract

Background: Water scarcity is being exacerbated by climate change, especially in low- and middle-income countries with limited adaptation capacity. **Methods**: Between June and October 2023, we conducted a cross-sectional survey of 364 households in three districts of Dar es Salaam, Tanzania. We used structured questionnaires to evaluate the household's demographic characteristics, knowledge of climate change, water accessibility, perceptions of water quality and security, and adaptation strategies. Descriptive statistics, chi-square tests, and multivariable logistic regression models were used to identify socioeconomic predictors of perceptions. **Results**: Despite 98% of the household's respondents reporting access to improved water source, 67% have basic to limited access. They travel more than 30 minutes to collect water, and only 33% have access to safely managed water sources such as piped water and boreholes. Of the total (n=364), 22% have inconsistent water supply. Households with inconsistent water supply spend about 37% of their monthly income, which is well above the United Nation's (UNs) 3–5% benchmark on water cost despite most families living on less than $1/day. Among the households, gender inequality persists, as women carried the greater (58%) burden of water collection. While 85% of household's respondents were knowledgeable about climate change, 22% were unable to link climate change with waterborne disease risks, highlighting persistent knowledge gaps. The level of educational attainment was the strongest predictor of climate–water perceptions (OR = 1.81, 95% CI: 1.25–2.62, p = 0.002). Other socioeconomic factors like being divorced (OR = 0.57, 95% CI: 0.35–0.94, p = 0.030) and income level (OR = 1.35, 95% CI: 1.07–1.71, p = 0.012) also influence household perception on whether enough has been done to address climate–water challenges. Households perceiving climate change as a threat were more likely to treat water (p = 0.025) and use alternative sources (p = 0.018). **Conclusion:** Household resilience in Dar es Salaam is constrained by high water costs, gendered burdens, and awareness gaps. Expanding climate communication and education, addressing gender inequities, and investing in equitable water infrastructure are essential for achieving Sustainable Development Goal (SDG) 6, which aims to ensure equal access to safe drinking water for all.

Keywords: Climate change, Perception, Water security, Socioeconomic factors, Adaptation strategies, Tanzania

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1.0 Introduction

Climate change and global warming are among the most pressing challenges facing the world (1). Climate change is predicted to continue exerting a strong influence on human health, with the most vulnerable regions, such as Sub-Saharan Africa (SSA) and other developing countries, bearing the majority of the consequences due to high poverty rates and limited adaptive capacity (2,3). Many experts have projected serious impacts on both the availability and quality of water, posing significant challenges for communities (4–7). In regions already experiencing water scarcity, rising demand may force communities to rely on unsafe or contaminated sources, increasing health risks and medical costs. Water-dependent industries such as agriculture will also be severely affected.

SSA is especially vulnerable to the increasing impacts of climate change. Inadequate infrastructure for water and health systems will further exacerbate limited access to safe water and worsen public health outcomes. Poor governance, is further making effective water resource management more challenging, thus exacerbating water scarcity (8,9). In Tanzania, climate change poses an increasing threat due to extreme weather events, such as floods and droughts, which are projected to become more frequent and severe (10). The country has seen notable changes in rainfall patterns, resulting in erratic seasonal fluctuations aggravating already vulnerable areas (11). Dar es Salaam, Tanzania's largest city, exemplifies the issues faced with water management in the face of climate change. The city relies heavily on groundwater, which serves as a primary source for domestic and industrial use. Climate change is putting additional pressure on water resources through overuse, population growth, and contamination risks (12).

Community perception shapes community resilience and is an important step towards understanding resilience to climate change. However, there has been little research in SSA to find out how vulnerable groups are aware of and perceive climate change and how it can affect their well-being. Public perception encompasses collective beliefs, attitudes, and views of individuals and communities. Perception is influenced by personal experiences, cultural norms, and information accessibility. These impressions frequently diverge from scientific realities, especially regarding environmental change. People often base their understanding on localized experiences and visible environmental conditions, which may not reflect broader systemic issues or policy effectiveness (13,14). Understanding these perceptions is important, as they shape how people interpret climate risks, prioritize adaptive actions, and support environmental policies. Research has shown differences in climate change perception and willingness to adapt across different regions and populations (15–17). For example, Tanzania developed a National Climate Change Response Strategy for 2021-2026; limited forecasting capacity, insufficient funding, and inadequate infrastructure are some of the challenges preventing the effective implementation of these adaptation efforts (18). These challenges limit households' ability to respond effectively

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to climate-related stressors, particularly in securing consistent access to water resources (11,19–21).

Public perception plays a key role in shaping communities' ability to anticipate, absorb, and adapt to environmental stressors. At the household level, resilience to climate change may be linked to the adaptive capacity of the general community (22). Households' ability to perceive climate risks and respond appropriately is shaped by economic status, including income, education, and access to information. Trust in institutions such as government agencies, local authorities, and community organizations further determines how effectively households can adapt to these risks (19,20). When perceptions align with scientific evidence and are supported by reliable information and governance structures, communities are more likely to engage in sustainable and proactive adaptation strategies. As climate change continues to challenge water security and public health, particularly in urban settings like Dar es Salaam, addressing the gap between perception and reality becomes an urgent policy and public health priority (23,24).

The study aims to explore the complex relationship between household climate change knowledge, perceptions of water access and quality, lived realities, socioeconomic status, and their influence on adaptation practices in low-income communities with the following questions: (1) What is the level of households' awareness regarding the link between climate change and water quality/security, and is the threat perceived in these communities? (2) Which socioeconomic factors influence households' perceptions of climate change and water security? (3) What are the challenges or lived realities faced by households regarding climate change impacts on water access and security? (4) What is the association between perceived climate change threat to water access/quality and the likelihood of households adopting adaptive practices? Addressing these questions will provide deeper insights into how these factors affect real-world adaptation and resilience-building efforts at the household and community level in this region.

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2.0 Methods

2.1 Study Area

Tanzania is bordered by Kenya and Uganda to the north, Rwanda, Burundi, and the Democratic Republic of the Congo to the west, Zambia, Malawi, and Mozambique to the south, and the Indian Ocean to the east (**Fig. 1**). The region experiences a tropical climate, characterized by an average annual temperature of approximately 22°C. Temperatures reach a maximum of 35°C between November and February, while they are lower from May to September. There are distinct seasons - the wet season from October to May is characterized by heavy rainfall, and the dry season, with little rainfall, lasts from June to September (24).

Dar es Salaam boasts a young population with a large percentage of children and young adults. With over 64% of the city's population under 25, current estimates reflect a generally young demographic profile (25). About 41% of the overall population comprises children aged 0 to 14; those between the ages of 15 and 24 form roughly 20%, while about 3% are aged 60 years and older (26).

The economic center of Tanzania is Dar es Salaam. Dar es Salaam is located along the Indian Ocean coast. It is Tanzania's most populous city, holding a major commercial center and was historically the headquarters for government organizations (27). The region's economy is driven by trade and tourism. The city contributes to approximately 50% of Tanzania's Gross Domestic product (GDP), highlighting its vital role in the country economy (25).

Dar es Salaam has long struggled with unreliable water access—a problem tied to an outdated water system that dates back to the colonial era and has seen slight improvement since, leading to aging pipes and persistent leaks. The city's increasing population forces residents of Dar es Salaam to make impossible choices such as high cost of purchasing water (28,29). In Tanzania, climate change is experienced through rising temperatures, changing precipitation patterns, and an increased frequency of extreme weather events, including droughts, which cause a shortage of water resources (30,31). In Dar es Salaam, the provision of water supply has been the sole responsibility of the Dar es Salaam Water Supply and Sanitation Authority (DAWASA) since 1997. Despite DAWASA's claims of serving 76% of the population, the provision of water supply remains unequal (32). This inadequate access to public water supplies forces people to rely on unofficial and unreliable sources (33). Ensuring equitable water access remains a persistent challenge as gaps persist between official service coverage and the lived realities of many households' dependent on unofficial and unreliable sources.

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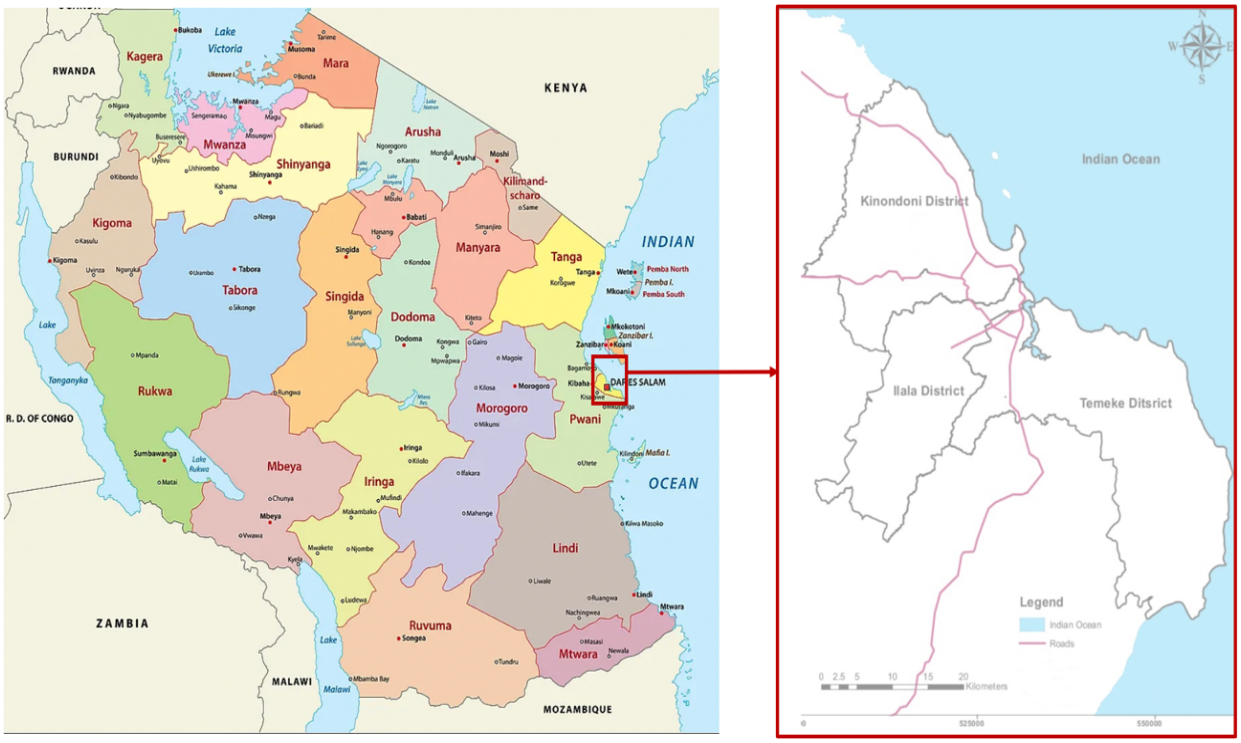

Fig. 1: Map of Tanzania showing the location of Dar es Salaam and the study areas

2.2 Study design

This study employed a community-based collaboration with Muhimbili University of Health and Allied Sciences (MUHAS) and the University of Arizona. A structured survey commonly used to describe and explore human behavior (34), was used to assess households' perception of climate change's threat to water security/quality, socioeconomic profiles, and adaptation efforts in the face of a changing climate. Door-to-door visits, a culturally acceptable way to recruit people in Tanzania, were used to get the sample of the districts of Kinondoni (n=136), Temeke (n=143) and Ilala (n=85) in Dar es Salaam. The survey included 180 research questions, with formats such as Yes/No, multiple choice, and Likert scale (**Appendix 1**). For this study, only 37 of the research questions were used. The survey was administered through REDCap (Research Electronic Data Capture 13.1.28, 2023 Vanderbilt University, Nashville, TN) (24) to participants who consented to the survey. The study was reviewed and approved by the University of Arizona Institutional Review Board (IRB) (STUDY00003095) and by MUHAS IRB (MUHAS-REC-05-2023-2451).

2.3 Data collection

Trained research assistants collected data using a survey developed in REDCap with structured closed-ended and open-ended questions in Kiswahili and English. These questions were orally

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administered to a household member aged 18 years and above who were residents of Dar es Salaam. Data was collected between June 2023 and October 2023. Trained interviewers conducted face-to-face interviews in Kiswahili. The study included module on socio-demographic information, climate change knowledge, perceptions, and adaptation strategies regarding its impact on water resources. A total of 364 households consented and participated in the study.

2.4 Statistical analysis

Data was first analyzed descriptively using Excel (35) (Microsoft Corporation) to summarize the distribution of variables as counts and percentages. The primary outcomes were six perception measures related to climate change and water security: perceived need for water action, lifestyle change willingness, investment support, mitigation support, adequacy of water measures addressed, and support for water policies. Multivariable logistic regression models were used based on the type of outcome: multinomial logistic regression for outcomes with more than two unordered categories, ordinal logistic regression for ordered responses, and binary logistic regression for outcomes with two categories. Additionally, relationships between perceptions of climate change, water treatment, and the use of alternative water sources were evaluated using the Pearson chi-square test. 95% confidence intervals (CI) were provided along with adjusted odds ratios (ORs). P-values less than 0.05 were considered statistically significant. For visualization, the R package ggplot22 (36) was used to generate a stacked bar chart of household climate change knowledge and perceptions. All analyses were conducted in R version 4.5.0 (R Foundation for Statistical Computing, Vienna, Austria).

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3.0 Results

Table 1 displays an overview of the socio-demographic characteristics of the 364 respondents from different households in Dar es Salaam. The results indicate that 70% (=274) of survey respondents were female, and 30% (n=110) were male. Marital status shows that 64% (n=233) were married, 27% (n=98) were single, and 8% (n=29) were widowed, while just 1% (n=4) were divorced. About 41% (n=141) had completed pre-primary to primary education, while 10% (n=35) had no formal education. The household income distribution shows that 65% (n = 229) of households earned between 0 and 10,000 TSh ($0–$3.8 USD) weekly, with approximately 5% of the households earning around 501,000–2,000,000 TSh ($189.8–$757.6 USD) weekly. Most households (66%, n=228) received income on a daily basis indicating those working in informal, self-employed, or "gig" sectors, while 12% (n=41) did not disclose their income frequency. Out of all the households, 61% (n=223) had one member contributing to the household's income, while 33% (n=119) had multiple members earning income. From our survey, 90% (n=328) of the respondents did not have any form of disability, while the rest, 10% (n=36), had a form of physical disability.

Table 1: Socio-demographic characteristics of low-income communities' households

General characteristics	Category	n	Percentage (%)
Gender	Female	274	70
	Male	110	30
Head of households	Respondent	149	41
	Other (female)	50	14
	Other (male)	163	45
Marital Status	Single	98	27
	Married	233	64
	Divorced	4	1
	Widow	29	8
Education	No formal education	35	10
	Pre-primary -completed primary	149	41
	Completed 'A' level	9	2

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	Some- 'O' level -completed 'O'level	149	41
	Some bachelors- Completed Bachelors	21	6
	Masters	1	0
Household income (TSh)	0 – 10, 000	229	65
	11, 000 – 50, 000	67	19
	51, 000 – 100, 000	4	1
	101, 000 – 500, 000	37	10
	501, 000 – 2, 000, 0000	16	5
Number of households members that earns income	No member	22	6
	One member	223	61
	Two members	79	22
	Three members	18	5
	Four members	7	2
	Five members	5	1
	Six members	10	3
No. of families in households	One family	247	68
	Two families	35	10
	Three families	38	10
	>Four families	44	12
Physically disabled	Absent	328	90
	Present	36	10

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3.1 Household's water access status

Approximately 98% (n=357) of households used improved water sources, such as piped water, boreholes, and protected wells. Among these respondents, only about 51% (n=182) disclosed the distance of their households to their water sources. Only 33% (n = 60) reported having access to water within their household's premises. The rest reported walking varying distances to collect water. Of those who did not have water in the household, 59% (n = 107) said they traveled around 1 Kilometer (km); 5% (n = 9) traveled around 2 km; 1% (n = 2) traveled around 3 km; and 2% (n = 4) traveled more than 5 km to collect water.

When asked about the consistency of their primary water source, 78% (n=284) reported having a consistent supply from their primary water source all week. The remaining 22% (n=80) reported inconsistent access. Among those experiencing irregular supply, 23% (n=18) only have access to water for just 1-2 days per week, 33% (n=26) had access for 2-4 days, and just 43% (n=34) could access their primary source of water for 4 or more days each week. Among households with inconsistent access to water supply, only about 44% (n=35) disclosed how much they spend monthly to supplement their water supply. On average, these households spend 27,143 TSh ($10.3 USD) monthly to supplement their water from a reported average income of 73,577.81 TSh ($27.9 USD), which is approximately 37% of their household's monthly income.

To better understand the burden of water collection by gender, we asked who was responsible for retrieving water. Of the 284 heads of households who disclosed which gender was responsible for collecting water in their households, 58% (n=107) reported that females were mainly responsible for collecting water. In contrast, 42% (n=78) reported that males were responsible for water collection. We found a significant difference between the observed and expected distribution for water collection responsibilities between females and males (p-value = 0.009). Shared water use is also widespread among these households. 96% (n=349) of respondents reported that the water source is shared with multiple families, with just 4% (n=15) having exclusive access. Due to the unreliable water supply, partly linked to climate change, we asked households if they stored water. Ninety-seven percent (n=353) of these households reported storing water in their homes, with just 3% (n=11) not engaging in water storage. Similarly, 19% (n=70) of the households reported carrying out climate adaptation practices such as building retention walls to prevent flooding, covering open wells, and harvesting rainwater. However, 81% (n=294) were not involved in any of these adaptation practices.

Finally, when asked if they had changed their primary water source, 91% (n=331) said they have never changed their water source, with 8% (n=29) acknowledging they had changed their water source because their previous water source had dried up, they got a cheaper water source, or

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their previous water source got too expensive. Approximately 1% (n=4) of households were unsure whether a change had occurred.

Table 2: Households water access status

Category	Households Response	(n)	Percentage
Water Source Type	Improved (piped, borehole, protected well)	357	98%
	Unimproved (unprotected well/spring)	7	2%
Consistency of Primary Water Source	Consistent	284	78%
	Inconsistent	80	22%
Days of Access (for inconsistent source)	1–2 days/week	18	23%
	2–4 days/week	26	33%
	4 or more days/week	34	43%
Distance to Water Source	Within household	61	33%
	< 1km	107	58%
	<2km	9	5%
	<3km	2	1%
	>5km	4	2%
Gender responsible for water collection	Female	107	58%
	male	78	42%
Water Source Shared with Other Families	Yes	349	96%
	No	15	4%
Water storage	Yes	353	97%
	No	11	3%
Practices that support climate adaptation	Yes	70	19%
	No	294	81%
Changed water source	No change	331	91%
	Yes (due to drying, cost, etc.)	29	8%
	Unsure	4	1 %

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3.2 Households' knowledge and perception between climate change and water quality/security

In this study, households' knowledge and understanding of the impact of climate change on water resources in their communities was assessed (Fig. 2). Most households' respondents ([85%] [n=311]) were aware of climate change, while the remaining 15% (n=53) were unaware. When asked where they received information about climate change, 6% (n=22) of household members cited newspapers as their source, 53% (n=193) cited television, 47% (n=171) cited radio, 19% (n=69) cited social media, and 15% (n=55) mentioned hearing climate change news from close friends. Additionally, 12% (n=44) reported receiving climate change information through their community, only 3% (n=11) mentioned the Ministry of Health, and 16% (n=58) stated they did not know. The majority 75% (n=269) of the respondents also believe that climate change can lead to increased waterborne diseases and water contamination. However, 3% (n=11) do not believe climate change can lead to increased waterborne diseases and contamination, while 22% (n=84) were unsure of any connection between climate change and health outcomes. Similarly, most believe that climate change poses a significant threat to water accessibility, except for 8% (n=30), who believe that assertion is not true, and 16% (n=58) were unsure of its threat to water accessibility. Among the households, 82% (n=299) believe that individuals and communities should take action to conserve water resources. Similarly, most participants, 90% (n=324), feel that education and awareness campaigns can help communities to better adapt to climate change and protect water resources. Similarly, the majority, 85% (n=309), are willing to make lifestyle changes to address climate change impacts on water resources. While 50% (n= 182) believe that climate change has impacted their water availability for the past 5–10 years, about 46% (n=167) believe there has been no impact, and the remaining 4% (n=15) are unsure of climate change's impact on their water availability.

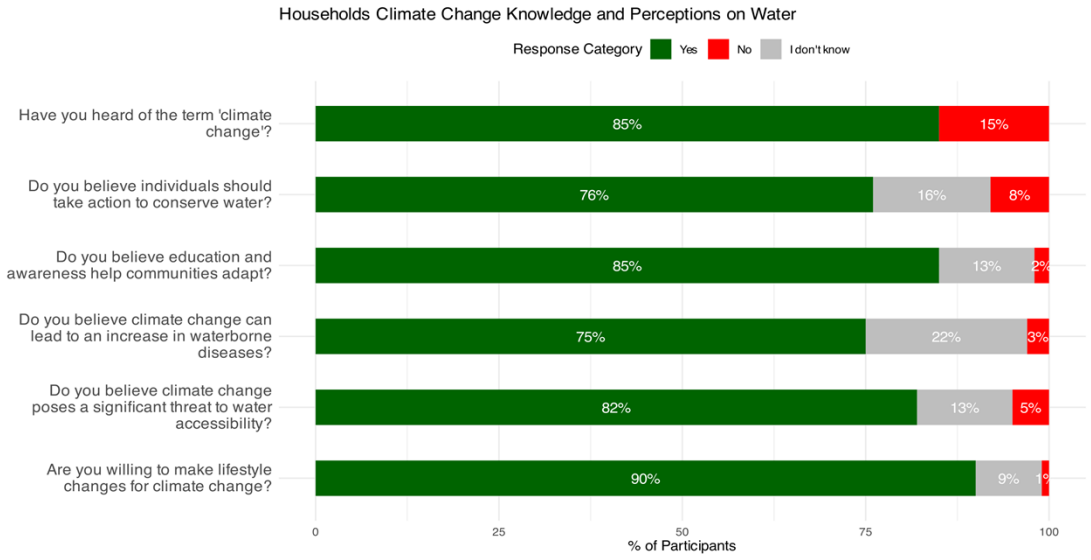

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Fig. 2: Households' knowledge and perception between climate change on water

3.3 Socioeconomic factors influencing climate-water perceptions

Community knowledge and perceptions about climate change influence the way households respond to mitigation, adaptation initiatives, and climate policies. However, socio-economic factors largely determine the level of awareness regarding climate change among households. This study assessed the relationship between socioeconomic factors, households' perceptions of climate change, and water security (**Table 3**). In our multivariable regression analyses, education level emerged as the strongest predictor of households' support for water policy initiatives that aim to mitigate the impact of climate change (OR = 1.81, 95% CI: 1.25–2.62, p = 0.002). Being divorced (OR = 0.57 CI: 0.35–0.94, p = 0.030), education (OR = 1.84, CI: 1.40–2.43, p = <0.001), and income level (OR =1.35 CI:1.07–1.71, p = 0.012) were also strong predictors of households perception if enough has been done to address the link between climate change and water quality and security. Being divorced also shaped households' support to invest in infrastructure and technologies that can adapt to climate change and improve water quality and security (OR = 0.39, 95% CI: 0.22–0.70, p = 0.002) and support for measures to mitigate the impact of climate change on water quality and security (OR = 0.31, 95% CI: 0.16–0.91). Conversely, none of our predictors influenced respondents' beliefs that individuals and communities should take action to conserve water resources in response to climate change and willingness to make lifestyle changes that address climate change impacts on water quality and security.

Table 3: Logistic regression analysis of socioeconomic factors influencing climate-water perceptions

Outcome Variable	Predictor	Category	OR (95% CI)	p-value
Need for water action (B)	Gender	Female	Ref	Ref
		Male	0.82 (0.30–2.22)	0.791
	Marital status	Single	Ref	Ref
		Divorced	1.22 (0.42–3.52)	0.778
		Married	0.33 (0.01–7.83)	1.000

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		Widow	0.68 (0.14–3.23)	0.669
	Education (1–5 scale)	—	2.20 (0.91–5.29)	0.079
	Income (per SD)	—	1.62 (0.58–4.50)	0.353
Lifestyle change willingness (B)	Gender	Female	Ref	Ref
		Male	1.25 (0.29–5.49)	1.000
	Marital status	Single	Ref	Ref
		Divorced	0.58 (0.09–3.60)	0.669
		Married	0.08 (0.00–2.55)	1.000
		Widow	0.15 (0.02–1.23)	0.115
	Education (1–5 scale)	—	1.14 (0.62–2.07)	0.669
	Income (per SD)	—	1.27 (0.63–2.58)	0.501
Investment support (O)	Gender	Female	Ref	Ref
		Male	0.63 (0.34–1.18)	0.148
	Marital status	Single	Ref	Ref
		Divorced	0.39 (0.22–0.70)	0.002**
		Married	1.00 (0.00–∞)	0.944
		Widow	0.52 (0.20–1.38)	0.188
	Education (1–5 scale)	—	1.24 (0.95–1.61)	0.114
	Income (per SD)	—	1.08 (0.84–1.40)	0.540
Mitigation support (O)	Gender	Female	Ref	Ref
		Male	1.07 (0.46–2.52)	0.869

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	Marital status	Single	Ref	Ref
		Divorced	0.38 (0.16–0.91)	0.031*
		Married	1.00 (0.00–∞)	0.972
		Widow	0.51 (0.12–2.16)	0.361
	Education (1–5 scale)	—	1.06 (0.82–1.37)	0.651
	Income (per SD)	—	1.12 (0.81–1.54)	0.484
Support for water policies (M)	Gender	Female	Ref	Ref
		Male	1.72 (1.00–2.96)	0.051
	Marital status	Single	Ref	Ref
		Divorced	1.18 (0.70–2.02)	0.581
		Married	0.63 (0.08–5.02)	1.000
		Widow	0.64 (0.27–1.51)	0.364
	Education (1–5 scale)	—	1.81 (1.25–2.62)	0.002**
	Income (per SD)	—	1.18 (0.88–1.58)	0.267
Adequacy of water measures addressed (M)	Gender	Female	Ref	Ref
		Male	1.16 (0.72–1.85)	0.628
	Marital status	Single	Ref	Ref
		Divorced	0.57 (0.35–0.94)	0.030*
		Married	0.85 (0.11–6.66)	1.000
		Widow	0.95 (0.42–2.16)	1.000

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	Education (1–5 scale)	—	1.84 (1.40–2.43)	<0.001***
	Income (per SD)	—	1.35 (1.07–1.71)	0.012*

Notes: *OR = odds ratio; CI = confidence interval; Ref = reference category; B = binary logistic regression; O = ordinal logistic regression (proportional odds); M = multinomial outcomes collapsed to binary (Yes vs Other). For binary outcomes, categorical predictors were analyzed with exact 2×2 methods (Haldane–Anscombe 0.5 correction; Fisher's exact p-values) to avoid separation. Education was coded 1–5 (1=Primary,2=O-level, 3=A-level, 4=Bachelor's, 5=Graduate degrees) and treated as a numeric ordinal predictor; odds ratios reflect the change per one-level increase. Income was standardized; odds ratios reflect change per 1 SD increase.*

3.4 Influence of perceived climate change risk on water treatment and use of alternative sources

Perceptions of climate change as a threat to water security and waterborne diseases was also explored as well as what influenced a households' decisions to use alternative water sources and treat their water (**Table 4**). In total, 76% (n=276) of household's respondents perceived climate change as a threat to water security and waterborne diseases. Among these households, 27% (n=74) reported using an alternative water source to supplement their primary water source, compared to 17% (n=5) who did not and 10% (n=6) who were unsure. An association (p= 0.018) was found between perception of climate change as a threat to water security and the use of alternative water sources among households. Similarly, water treatment varied by perception. Out of those who perceived climate change as a threat to waterborne diseases, 26% (n=71) treated their water, compared to only 7% (n=2) of those who did not and 10% (n=6) of those who were unsure. A significant association (p-value = 0.025) between climate perceptions and household water treatment was observed.

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Table 4: Influence of Perceived Climate Change Risk on Water Treatment and Use of Alternative Sources

	Is climate change a threat to water security and waterborne diseases?			
Category	No	Yes	Don't know	χ^2, p-value
Alternative source of water				8.08 (p = 0.018)
No	25(83%)	202(73%)	52(90%)	
Yes	5(17%)	74 (27%)	6(10%)	
Total	30	276	58	
Water Treatment				11.14 (p = 0.025)
No	28 (93%)	205 (74%)	52(90%)	
Yes	2 (7%)	71(26%)	6(10%)	
Total	30	276	58	

4.0 Discussion

4.1 Household's water access status

Although nearly all households reported getting water from improved water sources, only 33% have access to safely managed water. Safely managed water is considered an improved water source on households' premises, available when needed and free of contamination. This means that most households (67%) took less than 30 minutes round trip to fetch water, and those that traveled more than 30 minutes round trip had basic to limited water access as defined by the World Health Organization (WHO) and Joint Monitoring Programme (JMP) (35). About 22% of households reported having intermittent water supply. These challenges underscore the complexity of the current, informal water infrastructure that communities rely on. This can pose challenges to categorizing their water access and safety(?). This reflects broader gaps between coverage and reliable water services in SSA, where "improved" water does not always translate into "safely managed" or " access" as outlined in the UN's SDG 6 (36).

Another key concern from our study was inconsistent water supply, with one-quarter of households reporting irregular access, sometimes as little as 1-2 days per week. Such inconsistencies in supply and scarcity of water resources has been linked to higher water costs, conflict within communities, and increased burdens of collection, particularly for women (37–39). This is true for our study, where gender disparities in water collection emerged, with women primarily responsible for collecting water in most households. This is a trend echoed by several

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peer-reviewed papers (40–42). Gender disparities not only increases psychosocial stress, but also constrains opportunities for female education and paid labor (43,44). These inequalities support broader conversations about how climate change and poor infrastructure contribute to the increasing health and social problems faced by women. In these communities where most households (70.4%) live on less than $1 per/day, the cost of water further magnifies their challenges. These households spent about 37% their monthly income on water, far above the UN's and ADB's 3–5% recommended benchmark (45,46). Even among higher-income households, spending remained far above global guidelines, illustrating how water insecurity can exacerbate poverty cycles and limit household investment in health and education. Similar results have been documented in some low-income communities, where households incur significantly high costs for water services (47–49).

As earlier reported, only 29% of the households had access to safely managed water. This indicates that most households in our study are faced with the burden of water transportation, storage, and increased risk of water contamination. This is consistent with previous studies in Tanzania and LMICs, where the risks associated with collection, storage, and contamination during transport were highlighted (50,51). While the way water resources are being shared among these households is a good adaptation practice during water shortages, it may also increase their risk of microbial contamination if hygiene practices are inadequate (52,53). Therefore, interventions that enhance access and safety are required. However, unreliable water access has often been attributed to infrastructural weakness and governance issues rather than climate change. This is consistent with prior research conducted in Tanzania (29,54). As a result, most of these households normalize water storage as their routine coping strategy rather than a deliberate adaptation to climate risks. Only a small number of these households have adaptation measures such as rainwater harvesting or covering open wells. This gap suggests that cultural coping mechanisms dominate over proactive climate adaptation in these communities. This highlights the need to expand upon cultural practices for sustainability of adaptive practices to mitigate impact of climate change. This explains why most households reported to have never changed their primary water source, with those who had done so often citing economic pressures or resource depletion as drivers. This reflects both resilience and vulnerability: shared sources and communal strategies help households manage uncertainty, but they also reveal persistent inequities in sustainable access to safe and reliable water (55). Improved infrastructure alone is inadequate; in the absence of better governance, increased investment, and climate-informed adaptation, urban households in Dar es Salaam will continue to be reliant on cycles of coping instead of attaining genuine and planned water security policies.

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4.2 Households' knowledge and perception between climate change and water quality/security

Our study shows that awareness of climate change among households in Dar es Salaam was generally high, though important gaps remain. While the majority of household respondents recognized climate change and its links to waterborne diseases and water access, a small proportion were either uncertain or did not perceive such connections. These differences in climate literacy within these communities reflect patterns observed in other urban low-income settings, where higher awareness often coexists with misconceptions and knowledge gaps (56–58). This highlights an opportunity to integrate community perceptions and lived experiences into climate adaptation plans that genuinely reflect their realities and promote long-term sustainability. Such willingness to act indicates a readiness to engage in resilience-building efforts—provided that enabling structures and supportive policies are in place.

4.3 Socioeconomic factors influencing climate-water perceptions

Our study assessed how socioeconomic factors and households' perceptions of climate change and water security were associated. Respondents with higher level of education were more likely to support water policy initiatives that aim to mitigate the impact of climate change. Our study aligns with previous studies (59–62), which also reported that higher educational attainment is linked to greater climate change awareness and stronger support for adaptation measures. In our study, education may have enhanced individuals' access to and comprehension of climate information, thereby strengthening their engagement with climate adaptation. Our study also reveals that level of education, income level and being divorced played a crucial role among respondents who believe that enough has been done to address the relationship between climate change and water quality/security. Education has always been associated with greater awareness of climate-water risks, which often leads to stronger expectations of government accountability (63,64). Marital status, which affects the stability of households and the pooling of resources, has been demonstrated to impact community evaluations of institutional interventions (65,66). In our study, being divorced were less likely to perceive current water measures as adequate. This conforms with a study where divorced individuals often perceive current water measures as less adequate due reduced household resource efficiency and differing perceptions of environmental issues (67). The degree of vulnerability and dependence on public services is also influenced by income levels, with lower-income groups more likely to believe that government initiatives are inadequate (68,69). Divorced respondents were also less likely to support investing in climate mitigation action. This also emphasizes family structure's influence on adaptation decisions. This is consistent with the study of Van Aelst and Holvoet (56), which showed that marital status shaped adaptive capacity in rural Tanzania, with married households generally better positioned than widowed or divorced individuals. Alternatively,

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respondents who are single, divorced, or widowed may feel left out of decisions or less able to invest in adaptation.

Socioeconomic factors did not influence respondents' beliefs on individuals and communities taking action to conserve water resources in response to climate change, or their willingness to make lifestyle changes that address climate change impacts on water quality and security. This implies that support for adaptation at the community and household levels may transcend socioeconomic boundaries, unlike perceptions on government responsibility, which are influenced by education, income, and marital status.

4.4 Association between perceived climate change threat to water access, quality, and adaptive practices

The majority of the households perceived climate change as a threat to their water security and a risk to waterborne diseases. This widespread recognition underscores a growing community-level awareness of climate-related challenges. Yet, the extent to which such perceptions are translated into concrete adaptation practices varied across households. For instance, households who perceived climate change as a threat were more likely to diversify their water sources, a strategy often used to bridge gaps between supply and demand under conditions of uncertainty (70). While diversification may provide short-term resilience, it also raises concerns related to cost variability, quality, and potential health risks (71), highlighting the need for supportive regulation and monitoring. Similarly, households that associated climate change with water quality risks and waterborne disease were more likely to engage in water treatment, such as boiling or adding chlorine tablets. This pattern suggests that heightened risk perception encourages preventive health behaviors, consistent with evidence linking risk awareness to adaptive household practices (72). In Dar es Salaam, where cholera outbreaks often follow flooding events, households with prior experiences of waterborne disease or unreliable water supply may be particularly likely to adopt such practices if they attribute contamination to climate change (73). These findings highlight the importance of aligning perceptions with effective, actionable strategies. Generally, while awareness of climate risks is a driver of household adaptation, awareness alone cannot guarantee resilience. If accessible, affordable, and continued policy and infrastructural support are not put in place, households may remain limited to short-term coping practices rather than a long-term adaptive capacity.

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4.6 Study limitation

The major drawback to this study is its cross-sectional design, which inhibits causal inference, because self-reported judgments may be influenced by recall bias or social desirability bias. Even with these limitations, the persistent links shown between education and being divorced showed strong evidence for their role in shaping climate-water perceptions.

5.0 Conclusion

This study shows how household knowledge, socioeconomic factors, and adaptive practices shape perceptions of climate change and water security in low-income communities of Dar es Salaam. While most households were aware of climate change, important gaps and misconceptions remain. Even with widespread access to improved sources, 67% have basic to limited access and only 33% are considered to have safely managed water sources. Therefore, many still face inconsistent supply, high costs, and reliance on coping measures that are not always climate adaptive. Education and marital status were strong predictors of climate-water perceptions.

These results point to the need for stronger climate communication, investment in education and awareness, and reliable water infrastructure. Policies must also include vulnerable groups, especially women who bear the largest burden when it comes to water security. By addressing both knowledge gaps and structural barriers, Tanzania can build more climate-resilient urban communities and make progress toward SDGs 6 and 13.

Recommendation

The study findings demonstrate a high level of awareness and a strong willingness among community members to make lifestyle changes that strengthen resilience and adaptive capacity to climate change. To be effective, policies must reflect the lived realities of these communities. The study underscores the importance of developing inclusive adaptation pathways by 1) investing in targeted awareness campaigns to address knowledge gaps; 2) Enhancing water infrastructure to ensure equitable access, particularly for women and girls; 3) Implementing gender-sensitive policies to reduce the disproportionate burden of water collection; and 4) Integrating community perceptions into climate adaptation plans so that strategies align with community priorities and experiences.

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