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Understanding the seasonal variations in access to improved water sources in Ghana: A call to action for policymakers

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ABSTRACT

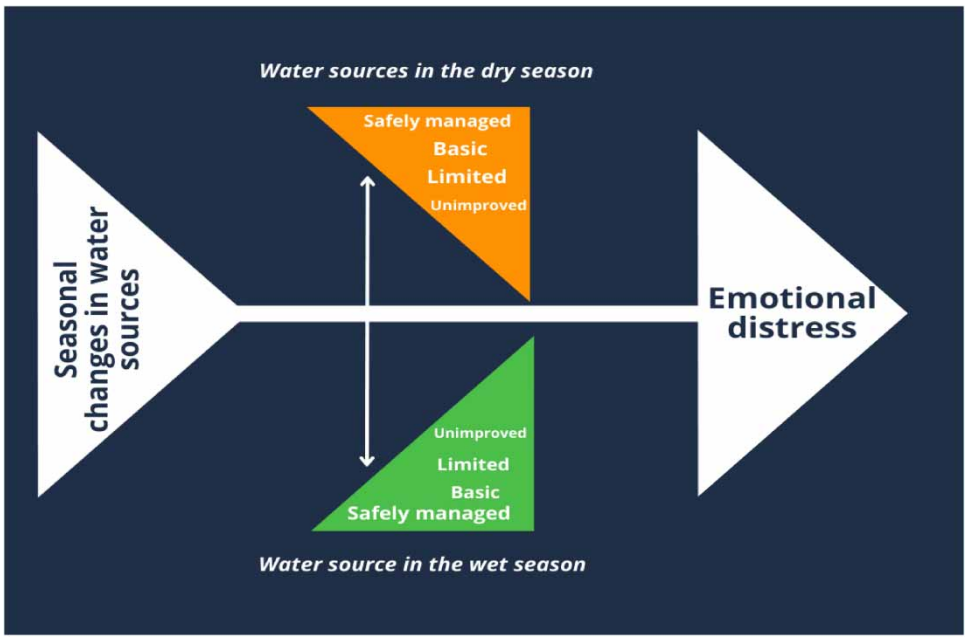
Although studies have explored the link between seasonal change in water sources and health, there is limited evidence on the psycho-emotional impact of seasonal shifts in primary water sources, particularly in a country with two different ecological zones. The primary water source for each participating household was categorized by season, and overall changes in water sources and seasonality were explored using Fisher's exact test and Pearson chi-square test. Regarding seasonal changes, 90.3% of the study participants use safely managed water sources across the seasons. Only 7.4% (45) of households switched from safely managed water sources in the dry season to limited sources in the wet season. Similarly, 2% (12) of participants switched from safely managed water sources in the dry season to unimproved water sources in the wet season. The Chi-square test indicates a significant association between emotional distress and the type of water source used in the dry ($\chi^2 = 35.6$, df = 3, $p = 0.00$) and wet ($\chi^2 = 37.8$, df = 3, $p = 0.00$) seasons. Future interventions that aim to increase access to and use of safe drinking water must consider seasonality and climate change and develop infrastructure accordingly.

Key words: change in water source, climate, Ghana, seasonality, water insecurity, water source

HIGHLIGHTS

- Seasonality is an essential determinant of water access.
- Seasonality results in changes in water sources, with poor households disproportionately impacted.
- Households use safer drinking water sources in the dry season than in the wet season.
- Seasonality and changes in water sources in tandem result in emotional distress for water-insecure households.

GRAPHICAL ABSTRACT



INTRODUCTION

Despite the significant progress Ghana has made in improving access to safe drinking water, a substantial portion of the population, particularly the urban poor and those in rural areas, still rely on unsafe water sources for their daily needs (Yengoh *et al.* 2010; Armah *et al.* 2018; GSS 2019). The Ghana Living Statistical Survey (GLSS) reveals alarming statistics, with 48.3 and 76.1% of Ghanaians consuming *Escherichia coli*-contaminated water at the point of collection and use, respectively (GSS 2019). The health implications are dire, with waterborne diseases such as diarrhea and respiratory infections often leading to death (Bain *et al.* n.d.; Kostyla *et al.* 2015; Williams *et al.* 2015; Prüss-Ustün *et al.* 2019; Kangmennaang *et al.* 2020). Globally, in 2015, over 1.7 million deaths and 95 million disability-adjusted life years (DALYs) were attributed to consuming water from unsafe sources (Forouzanfar *et al.* 2016). In the same year in Ghana, the fatalities and DALYs resulting from unsafe drinking water sources were 7,300 and 435,500, respectively, with children under 5 years disproportionately affected (Forouzanfar *et al.* 2016). The urgency to address this crisis is evident, as the availability of quality drinking water is crucial in reducing exposure to waterborne diseases and their associated complications – notably mobility and mortality.

Aside from factors such as water governance and availability of water infrastructure affecting water accessibility, in recent years, the lack of maintenance (Majuru *et al.* 2012, 2016), inadequate supply (Akudago *et al.* 2009), and seasonality (Ouyang *et al.* 2006; Kelly *et al.* 2018; Dongzagla *et al.* 2021) have been highlighted as essential determinants of water accessibility. For instance, water sources vary across seasons; consequently, most households harmoniously change their water sources to align with the available sources. These changes in water sources are mainly caused by seasonal changes in natural processes (e.g., rainfall patterns and hydrological changes). The water sources in the different seasons are associated with specific health outcomes and play an essential role in the seasonal variations in the burden of diseases, notably diarrhea (GBD 2019 Diseases and Injuries Collaborators, 2020). For instance, the wet season is reportedly accompanied by increased water-related diseases due to various water sources polluted with toxic chemicals, heavy metals, and pesticides from runoffs (Pearson 2004; Ouyang *et al.* 2006; Pearson & Muchunguzi 2011). The lack of access to water in the dry season is linked to poor health outcomes due to the lack of sanitation and hygiene-related activities such as handwashing and bathing (Pearson *et al.* 2016). In addition, the lack of water access in the dry season results in households, particularly women, walking long distances in search of water, which is associated with musculoskeletal diseases (Adams *et al.* 2020).

Previous literature in other contexts indicates that the contamination risk depends on the water source (Nguyen *et al.* 2014; Kostyla *et al.* 2015; Kelly *et al.* 2018; Ibrahim *et al.* 2021; Nguyen *et al.* 2021). These studies highlight the link between seasonality and change in water sources and their associated health outcomes, invariably signifying the fundamental role of

quality drinking water sources in promoting human health and well-being. Although studies have explored the link between seasonal change in water sources and biophysical health, there is limited evidence on the psycho-emotional impact of seasonal shifts in primary water sources, particularly in a country with two different ecological zones.

Using the JMP classifications below and building on previous studies, the aim of the current study is twofold. First, explore the impact of seasonality on change in water sources using two different ecological zones in Ghana–Accra and Tamale, classified as tropical and arid ecological zones, respectively. Second, examine the impact of changes in water sources on households' emotional distress.

MATERIALS AND METHODS

The data were obtained from a cross-sectional study conducted in Ghana to examine water sources in two different ecological zones and how these sources differed across the two seasons (wet and dry seasons). Data were collected from October to November 2022. We recruited participants from three different water-insecure neighborhoods in Accra and Tamale respectively. Men and women responsible for water collection within the households were recruited for the study, albeit more females (709) than males (483). This was expected since women in Ghana are primarily responsible for water collection within the household. The sampling was conducted using a two-step technique. In step 1, the primary sampling unit was randomly selected from a sample frame with a list of cities and enumeration zones. For step 2, a methodical approach called simple random sampling was employed to choose our second set of sampling units, houses, that struggle with water insecurity from each selected enumeration zone. The selected neighborhoods included Chorkor, Jamestown, KorleGono Lamashegu, Kukui, and Vitting in Accra and Tamale. A random number generator was used to select a beginning point, with every fifth house afterward. Cochran's formula (Cochran 1977) was used to estimate the sample size. The calculations returned a smaller size of about 320 participants. However, the number was increased to ensure proper representation.

The surveys were conducted in person using a questionnaire. The questionnaire captured questions relating to the primary drinking water source in the dry and wet seasons. Specifically, participants were asked to indicate what water source they use in the wet versus dry season, which were regrouped using the JMP classifications (Table 1). The water sources were classified into four instead of five because households did not indicate surface water use. This might be the case because our study settings were urban. Other questions captured by the questionnaire include distance to a drinking water source, the emotional impact of the lack of access to water, and some demographics, including age, gender, occupation, and income. Enumerators were trained on the ethical ways of collecting data. Participants were called for clarification when necessary. The Queens University ethics board provided ethical clearance for the study (GREB ref#: GSKHS-340-20; TRAQ#: 6028559).

JMP classifications

The Joint Monitoring Programme for Water Supply, Sanitation, and Hygiene (JMP) ladder, used as a benchmark to compare service levels across countries, classified water sources into five categories, including safely managed, basic, limited, unimproved, and surface water (UNICEF/WHO 2021). The definitions of these terms are provided in Table 1.

Table 1 | JMP classification of water sources

Indicator	Definition
Safely managed	Improved drinking water source located on-premises, available when needed, and free from fecal contamination (e.g., piped water, boreholes or tubewells, protected dug wells, protected springs, household connections, public standpipes)
Basic	Improved drinking water source, with collection time for a roundtrip, including queuing not more than 30 min (e.g., rivers, streams, lakes, reservoirs, springs, and ground water)
Limited	Improved drinking water source with collection time for a roundtrip, including queuing more than 30 min (e.g., piped water, tube well, borehole, protected spring or protected well, rainwater, tanker truck, cart with small tank, or bottled water)
Unimproved	Drinking water from an unprotected dug well or unprotected spring
Surface water	Drinking water directly from a river, dam, lake, pond, stream, canal, or irrigation canal

Measures

Emotional distress

Emotional distress was assessed using the HWISE (Young *et al.* 2019) by asking participants to identify the frequency of their feelings of worry, anger, or ashamed over the absence of access to safe water, as measured in prior studies (Wutich & Ragsdale 2008; Tsai *et al.* 2016). The level of worry, anger, and shame was assessed by inquiring about the frequency with which participants experienced concerns regarding insufficient water for their domestic requirements within the previous month. The questions were assessed using a five-point Likert scale ranging from 1 (never) to 5 (always). The responses were dichotomized into emotional distress (1) and no emotional distress (2). An individual is considered to have experienced the event (emotional distress) if their combined score is low.

Primary water source

The participants were asked to specify their primary source of drinking water, using the commonly utilized water sources identified by the Demographic and health survey (DHS) and Ghana Statistical Service (GHS; ICF International, 2015; GSS 2019). Furthermore, the participants were requested to specify the distance, which refers to the duration required to go to and from the water source, encompassing any waiting time in the queue. Subsequently, the data were utilized to classify the water sources into four categories: safely managed, basic, limited, and unimproved sources, as per the JMP WHO/UNICEF water ladder (WHO/UNICEF 2015).

Additional variables

Household demographic characteristics such as age, gender, employment status, marital status, level of education, and household size were considered. I hypothesized that the size of a home, for example, directly influences the quantity of water required, subsequently affecting emotions. The additional demographic variables were added based on their documented influence on water access and emotional distress, as evidenced by studies conducted by Wutich (2009) and Bisung & Elliott (2017).

Data analysis

Data analyses were conducted using Statistical Package for Social Sciences (SPSS version 27). Participants were asked to indicate their primary water source in dry and wet seasons. Seasonality differs between Accra and Tamale; the wet season in Accra spans from March to November, and the rest of the months are considered the dry season. On the other hand, Tamale experiences its wet season from April to mid-October, with the rest of the months considered dry season. Primary water sources for each participating household were categorized by season, and overall changes in water sources and seasonality were explored. Further, changes in water sources were examined for Accra and Tamale, respectively, given the differences in seasonality in the two cities. Using the JMP classifications, color codes indicate the risky nature of the water source, with green, blue, yellow, and red, indicating safely managed, primary, limited, and unimproved sources, respectively. In addition, the emotional distress associated with the different water sources was examined. Significance levels were set at alpha 0.05 and determined using Fisher's exact and Pearson chi-square tests. Fisher's exact test was used to test associations for tables (i.e., 3–5) where more than 20% of the cells have frequencies of less than 5.

RESULTS

Table 2 presents the descriptive statistics. The majority of the study participants in Tamale uses safely managed (low-risk) water sources in both dry (70.8%) and wet (68.3%) seasons (Figures 1 and 2). The opposite was observed in Accra, where 82.0% acquired water from unimproved (high-risk) sources in the dry season and 88.7% in the wet season (Figures 1 and 2). Females used more of all the water sources in both seasons compared to their male counterparts. The descriptive statistics also indicate that those employed acquired water from both safely managed and unimproved sources in both wet and dry seasons compared to the unemployed in both cities. Households in the low-income bracket turn to acquire more safe water in the dry season (63.0%) than in the wet season (61.4%). Similarly, married people acquired more water safely managed water across the dry (62.6%) and wet seasons (62.1%) than their single counterparts. The remainder of the descriptive statistics is displayed in Table 2.

Table 2 | Characteristics of primary water source across seasons

Independent variables Discrete variables		Primary drinking water source									
		Dry season					Wet season				
		Safely managed ($n = 589$)	Basic ($n = 33$)	Limited ($n = 59$)	Unimproved ($n = 511$)	Totals 1,192	Safely managed ($n = 586$)	Basic ($n = 25$)	Limited ($n = 119$)	Unimproved ($n = 462$)	Totals ($n = 1,192$)
City	Tamale	415 (70.8%)	10 (30.3%)	48 (81.4%)	92 (18.0%)	565	400 (68.3%)	9 (36.0%)	104 (87.4%)	52 (11.3%)	565
	Accra	174 (29.5%)	23 (69.7%)	11 (18.6%)	419 (82.0%)	627	186 (31.7%)	16 (64.0%)	15 (12.6%)	410 (88.7%)	627
Type of household	Traditional house	66 (11.2%)	2 (6.1%)	13 (22.0%	46 (9.0%)	127	71 (12.1%)	1 (4.0%)	26 (21.8%)	29 (6.3%)	127
	Compound house	284 (48.2%)	14 (42.1%)	31 (52.5%)	270 (52.8%)	599	290 (49.5%)	10 (40.0%)	53 (44.5%)	246 (53.2%)	599
	Single room	58 (9.8%)	9 (27.3%)	3 (5.1%)	98 (19.2%)	168	63 (10.8%)	6 (24.0%)	8 (6.7%)	91 (19.7%)	168
	Chamber and hall	67 (11.4%)	3 (9.1%)	4 (6.8%)	44 (8.6%)	118	65 (11.1%)	2 (8.0%)	9 (7.5%)	42 (9.6%)	118
	Detached	30 (5.1%)	1 (3%)	7 (11.9%)	8 (1.6%)	46	24 (4.1%)	5 (20.0%)	10 (8.6%)	7 (1.5%)	46
	Semi-detached	58 (9.8%)	4 (12.1%)	0 (0.0%)	32 (6.2%)	94	48 (8.2%)	1 (4.0%)	11 (9.2%)	34 (7.3%)	94
	Apartments	26 (4.4%)	0 (0%)	1 (1.7%)	13 (2.5%)	40	25 (4.3%)	0 (0%)	2 (1.7%)	13 (2.8%)	40
Gender	Male	256 (43.5%)	14 (42.4%)	12 (20.3%)	201 (39.3%)	483	260 (44.4%)	9 (36%)	28 (23.5%)	186 (40.3%)	483
	Female	333 (56.5%)	19 (57.6%)	47 (79.7%)	310 (60.7%)	709	326 (55.6%)	16 (74%)	91 (76.5%)	276 (59.7%)	709
Employment	Unemployed	123 (20.9%)	11 (33.3%)	14 (23.7%)	72 (14.1%)	220	124 (21.2%)	7 (28.0%)	24 (20.2%)	65 (14.1%)	220
	Employed	466 (79.1%)	22 (66.7%)	45 (76.3%)	439 (85.9%)	972	462 (78.8%)	18 (72%)	95 (79.8%)	397 (85.9%)	972
Marital status	Single	220 (37.4%)	14 (42.4%)	25 (42.4%)	283 (55.4%)	542	222 (37.9%)	11 (44%)	44 (37.0%)	289 (62.4%)	542
	Married	369 (62.6%)	19 (57.6%)	34 (57.6%)	228 (44.6%)	650	364 (62.1%)	14 (56%)	75 (63.0%)	197 (42.6%)	650
Income	δGhc1000	364 (63.0%)	22 (66.7%)	34 (57.6%)	344 (67.3%)	764	360 (61.4%)	17 (68.0%)	77 (64.7%)	310 (67.1%)	764
	Ghc1001-Ghc2000	147 (25.0%)	3 (9.1%)	18 (30.5%)	129 (25.2%)	297	147 (25.0%)	5 (20.0%)	18 (15.1%)	127 (27.5%)	297
	εGhc2001	78 (13.0%)	8 (24.2%)	7 (11.86%)	38 (7.4%)	131	79 (13.6%)	3 (12.0%)	24 (20.2%)	25 (5.4%)	131
Educational status	Up to primary	201 (34.1%)	14 (42.4%)	22 (37.3%)	161 (31.5%)	398	200 (34.0%)	13 (52.0%)	42 (35.2%)	143 (31.6%)	398
	Junior and senior high	224 (38.0%)	17 (51.5%)	23 (39.0%)	288 (56.1%)	552	226 (38.0%)	11 (44.0%)	51 (42.8%)	264 (57.1%)	552
	Tertiary	164 (27.8%)	2 (6.1%)	14 (23.7%)	62 (12.1%)	242	163 (28.0%)	1 (4%)	26 (22.0%)	55 (11.9%)	242
Continuous variables											
Number of people in a household	Mean (SD)	19.3 (5.3)	17.9 (4.4)	18.5 (4.2)	17.6 (4.1)	1,192	18.9 (5.0)	17.6 (3.9)	20.6 (5.5)	17.3 (4.0)	1,192
Number of years lived in a community	Mean (SD)	17.1 (13.9)	19.2 (14.4)	12.4 (10.7)	16.6 (13.6)	1,192	17.1 (14.2)	18.5 (14.2)	16 (12.4)	16.3 (13.4)	1,192
Age	Mean (SD)	37 (13.0)	36 (13.2)	31 (9.2)	35 (13.0)	1,192	37 (13.1)	36 (13.7)	34 (11.2)	35 (13.1)	1,192

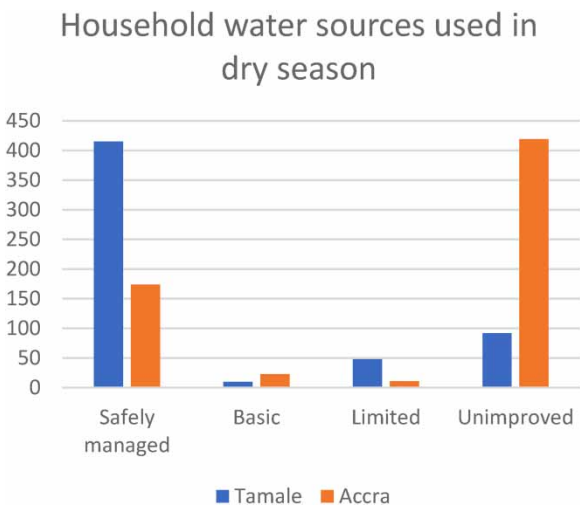


Figure 1 | Household water sources used in the dry season.

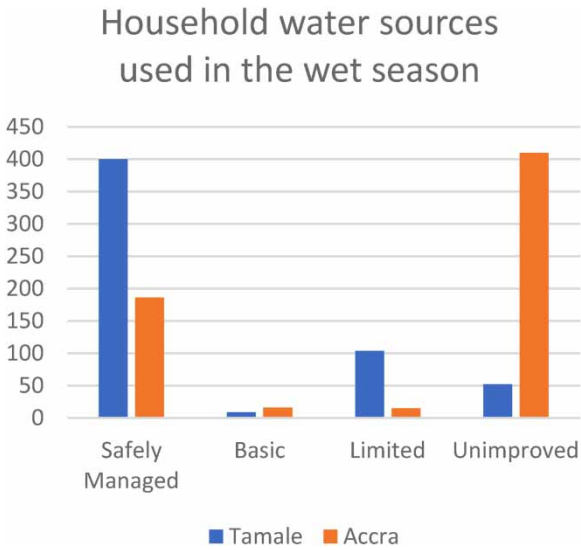


Figure 2 | Household water sources used in the wet season.

Seasonal change in water sources

Table 3 presents changes in water sources across dry and wet seasons. The water source type change evaluation indicates that more households use safely managed water sources in the dry season compared to the wet season. Regarding seasonal changes, 90.3% of the study participants maintained safely managed water sources across the seasons. Only 7.4% (45) of

Table 3 | Changes in water sources across seasons

		Wet season water sources				
		Safely managed (%)	Basic (%)	Limited (%)	Unimproved (%)	*P*-value
Water sources in the dry season	Safely managed	530 (90.3%)	2 (0.2%)	45 (7.4%)	12 (2.0%)	0.00
	Basic	11 (27.3%)	20 (66.7%)	1 (3.0%)	1 (3.0%)	
	Limited	10 (16.9%)	1 (1.7%)	45 (76.3%)	3 (5.1%)	
	Unimproved	35 (6.8%)	2 (0.4%)	28 (5.5%)	446 (87.3%)	

households switched from safely managed water sources in the dry season to limited sources in the wet season. Similarly, 2% (12) of participants switched from safely managed water sources in the dry season to unimproved water sources in the wet season. A total of 6.8% (35) of households also switched from unimproved sources in the dry season to low-risk sources (safely managed) in the wet season, while 87% (446) households maintained high-risk sources (unimproved sources) in both the dry and wet seasons (Table 3).

Tables 4 and 5 display seasonal changes in water sources varied by city. In Accra, 163 households, representing 93%, maintained the same low-risk water source across the seasons compared to 88% (367) households in Tamale. In Accra, 1 and 8% of households switched from safely managed water sources in the dry season to limited and unimproved water sources in the wet season. The switch in Tamale from safely managed to limited and unimproved are 8 and 2%, respectively. In Accra, 4% switched from basic to limited sources from the dry to wet seasons. More households in Tamale (75%) maintained the same limited water sources across the seasons than those in Accra (46%). More households in Tamale switched from unimproved sources in the dry season to other sources, including safely managed water sources (20%) and limited water sources (27%) in the wet season than their counterparts in Accra. In Accra, most (95%) households maintained unimproved (high-risk) water sources across the two seasons.

Table 6 displays an association between household water sources in the dry and wet seasons and their respective levels of emotional distress using Pearson chi-square. From the results, of the 191 households reported as not experiencing emotional

Table 4 | Comparison of seasonality and water source change in Tamale

			Water source in the wet season				
			Accra				
			Safely managed	Basic	Limited	Unimproved	*p*-Value
Water source in the dry season	Accra	Safely managed	164 (93%)	1 (1%)	1 (1%)	8 (5%)	0.00
		Basic	5 (22%)	16 (70%)	1 (4%)	1 (4%)	
		Limited	2 (18%)	1 (18%)	5 (46%)	3 (18%)	
		Unimproved	15 (4%)	1 (1%)	5 (1%)	398 (95%)	

Table 5 | Comparison of seasonality and water source change in Accra

			Water source in the wet season				
			Tamale				
			Safely managed	Basic	Limited	Unimproved	*p*-Value
Water source in the dry season	Tamale	Safely managed	367 (88%)	4 (2%)	40 (8%)	4 (2%)	0.00
		Basic	5 (40%)	3 (40%)	1 (10%)	1 (10%)	
		Limited	10 (21%)	1 (2%)	36 (75%)	1 (2%)	
		Unimproved	18 (20%)	1 (2%)	27 (27%)	46 (51%)	

Table 6 | Seasonal changes, water sources, and psycho-emotional distress

		Water source – dry season				Water source – wet season			
		Safely managed	Basic	Limited	Unimproved	Safely managed	Basic	Limited	Unimproved
Emotional distress	Not distressed count	128 (67%)	9 (5%)	5 (3%)	49 (26%	127 (67%)	8 (4%)	7 (4%)	49 (26%)
	Distressed count	461 (46%)	24 (2%)	54 (6%)	462 (46%)	459 (46%)	17 (2%)	112 (11%)	413 (41%)
		$\chi 2\ (p-value) = 35.6\ (p = 0.00)$				$\chi 2\ (p-value) = 37.8\ (p = 0.00)$			

distress, 67% have access to safely managed water sources in both the dry and wet seasons. Conversely, 46% of households using safely managed sources reported experiencing emotional distress in the dry seasons compared to the rest. Similar results were reported in the wet season, albeit with few changes. These associations were measured using the Chi-square significance test. The Chi-square test indicates a significant association between emotional distress and the type of water source used in the dry season ($\chi^2 = 35.7,\ df = 3,\ \ p = 0.00$). Similarly, there is a significant association between observed emotional distress and the water sources used in the wet season ($\chi^2 = 39.5$, df $= 3$, $p = 0.00$), with more households using other than safely managed water sources experiencing higher emotional distress.

DISCUSSION

The current study explored the impact of seasonal changes on water usage in two different ecological zones in Ghana and their differential implications for emotional distress. The study found that seasonality is associated with changes in water sources. Households in Tamale use safely managed water sources in the dry season. The opposite is experienced in Accra. This is probably because water sources, including basic, limited, and unimproved, unavailable in the dry season become readily available in the wet season in Tamale. For instance, surface and groundwater (high-risk water sources) are abundant in the wet season. Thus, households use these water sources because of their availability. Our findings align with previous studies (Edokpayi *et al.* 2018; Nguyen *et al.* 2021). For instance, a study in South Africa by Edokpayi *et al.* indicates that bacterial levels in surface water are higher in the wet season compared to the dry season. By using the same data, Nguyen *et al.* reported that, albeit minimal, households switch to high-risk sources, such as surface water in the wet season, from low-risk sources in the dry season. Similarly, a study by Kumpel *et al.* (2017) in Nigeria indicates that water source contamination by thermotolerant coliforms increased by 21% from dry to wet seasons. Water-related effects such as diarrheal diseases are also reduced in the dry season, and the plausible explanation for this is the increased use of quality water, such as borehole water acquired from nearby communities.

The study reported a variation in water sources between the different ecological zones (Accra and Tamale) in both dry and wet seasons. The switch from improved water sources in the dry season to other water sources (e.g., limited and unimproved) in the wet season is higher in Tamale compared to Accra. A possible explanation for this finding is the climate. Tamale is a temperate area with a long dry season spanning November to June. Studies have established a link between high temperature and unsafe drinking water sources. For instance, the multisite study by Buchwald *et al.* (2022) reported that low rainfall or high temperatures decreased the availability and use of basic drinking water sources. Furthermore, compared to Accra, households in Tamale have limited water sources and thus rely on unimproved water sources such as limited sources (e.g., dug wells) in the wet season. These open sources are associated with significant contaminants, including human and animal waste (Penakalapati *et al.* 2017; Kelly *et al.* 2018; Phan & Nguyen 2018). On the other hand, given the socioeconomic make-up of Accra, in instances where piped water is unavailable, most people rely on sachet water as their primary drinking water source.

The most important finding of this study is the link between seasonal changes and water-related emotional distress. Households reported significant water-related emotional distress in both wet and dry seasons. These findings are concomitant to findings reported by other studies, including Akinyemi *et al.* (2022), who found that irrespective of seasonal variations, there is an association between seasonality and experiences of water-related emotional distress. It was found that 4.0% of households experienced emotional distress while accessing water during the rainy season, while 8.1% experienced the same during the dry season. Our finding can be attributable to the overall water insecurity. Ghana is currently battling with issues of water insecurity. In fact, recent data show that over 60% of Ghanaians are battling with water insecurity at the household level (UNICEF Ghana 2023). This lack of access to water at the household level is reportedly associated with psycho-emotional distress (Wutich & Ragsdale 2008; Stevenson *et al.* 2012; Workman & Ureksoy 2017; Slekiene & Mosler 2019), psycho-social distress (Gaber *et al.* 2021), and mental health (Kimutai *et al.* 2023; Toivettula *et al.* 2023).

The current study also found an association between the sociodemographic characteristics of households and the type of water source used. The study found that (i) women use more improved water sources than their male counterparts. This finding might be linked to the sociocultural roles of women in Ghana. In addition to their responsibilities, women within the study settings serve as informal caregivers for the sick in the household. Thus, women are mindful of the quality of water they supply to their households as they care about the well-being of the household members. This invariably results in unintended consequences as women also tend to experience more emotional distress compared to their male counterparts. (ii)

Overall, high-income households use more improved water sources. Households with high incomes mostly have pipes in their households. When pipe water is unavailable, they can easily acquire water from other safely managed sources (Oskam *et al.* 2021).

Limitations

Although the current study has made significant contributions to the water insecurity literature, including providing evidence on how seasonal differences from extreme weather events affect water access, there are a few limitations worth highlighting. The study used cross-sectional data, which is thus associated with cross-sectional data limitations such as the inability to establish causation. Second, the study examined short-term emotional distress caused by water insecurity. Future studies can explore long-term water-related emotional distress and seasonality. There is also the possibility of recall bias. Participants are likely to remember their water sources of the season in which the data were being collected than those of the past season. This might result in misclassifications of the water sources. Finally, the study was conducted in an urban setting; future studies should explore the rural area.

CONCLUSION AND POLICY RECOMMENDATIONS

This is one of the first papers to examine the psycho-emotional impact of seasonal changes in water sources. Understanding the impact of seasonal changes in water access and its associated psychological impact is imperative to address water insecurity. The study established associations between seasonality and water insecurity due to changes in water sources, which have significant implications for emotional distress among inhabitants of the study sites. The study also reported differences in seasonality, water sources, and emotional distress between Tamale and Accra, which are attributable to geographic and sociocultural practices. Thus, instead of one-size-fit interventions currently being instituted, water-related interventions should consider these factors (i.e., geography, topography, culture). Each region in Ghana should be allowed to plan, institute, and execute water-related interventions that meet the needs of its locality while conforming to the general country-level plans of the Ghana Water Company Limited (GWCL).

Infrastructure development, policy reforms, technological advances, and community engagement are needed to address seasonal water access unpredictability. Installing rainwater harvesting systems, water storage facilities, and effective irrigation are vital interventions. These strategies save water during wet seasons for dry seasons. Integrated Water Resources Management (IWRM) and tiered water pricing can also promote water sustainability. Smart water management systems and weather forecasting technologies optimize water distribution and predict shortages and surpluses, enabling proactive planning. Implementing these interventions requires sector- and region-wide coordination, finance, stakeholder engagement, and local communities. Adaptive management and regular monitoring and review keep initiatives effective. A solid legislative framework that encourages water conservation is crucial. In addition, fostering community involvement through educational initiatives and establishing local water management committees can strengthen resilience and guarantee long-term access to water resources (World Bank 2019).

In addition to infrastructural investments, the government of Ghana, through the GWCL, can reduce water-related emotional distress by improving reliability, implementing emergency supply plans, and engaging communities with public awareness campaigns and feedback mechanisms to build trust. These activities tend to reduce water-related anxiety and stress. Beyond this, economic and social support systems like inexpensive water tariffs and alternative livelihood programs such as cash incentives for the poor can reduce both financial and emotional distress.

Climate change is predicted to worsen the seasonal variations in water supply and access by intensifying the occurrence and intensity of droughts and floods, changing rainfall patterns, and accelerating the melting of glaciers. This will reduce water availability during dry seasons (UN Water 2020). The impacts of seasonality, coupled with the consequences of climate change (Javan *et al.* 2023), will devastate public and population health through water insecurity in the coming years. Although the dry season is associated with safe drinking water sources, these safe sources also result in adverse health outcomes as households are forced to walk long distances to get safe water (Sukri *et al.* 2023). Walking long distances, for instance, is linked to musculoskeletal health problems. Thus, achieving sustainable development goal 6, which seeks to achieve clean water and sanitation for all, will require investing in seasonal and climate change-related initiatives. Seasonality and climate change should not be tackled in silos, given their combined effect on water access (DeNicola *et al.* 2015; Gosling & Arnell 2016). Future interventions that aim to increase access to and use of safe drinking water must consider seasonality and climate change and develop infrastructure accordingly. Implementing proactive steps, such as constructing

state-of-the-art water storage facilities, adopting IWRM strategies, and utilizing efficient irrigation systems, is essential for reducing the effects of these impacts (IPCC 2018).

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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