



Frequency and perceived difficulty of household water experiences in Morogoro, Tanzania: Evidence of the psychosocial burden of water insecurity

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1. Introduction

Water insecurity is the inability to reliably access, use, and benefit from safe and sufficient water for domestic and livelihood needs and aspirations (e.g., Cook and Bakker, 2012; Gimelli et al., 2018; Grey and Sadoff, 2007; Jepson et al., 2017a; Rosinger, 2023; Shah, 2021; Young et al., 2022). Climate change and variability, infrastructure degradation, and water demand growth will continue to increase water stress (United Nations [UN], 2018; UN, 2023), challenging water security across multiple scales and contexts. In the past decade, numerous tools and metrics have been developed to quantify experiences of household and individual water insecurity, estimate its burden globally, and identify its causes and consequences (e.g., Garrick and Hall, 2014; Jepson et al., 2017b; Octavianti and Staddon, 2021; Young et al., 2019; Young et al., 2022). The application of these tools, and broader approaches, has demonstrated that water insecurity is common globally (e.g., Stoler et al., 2021; Young et al., 2019; Young et al., 2022), and undermines food security and nutrition (Brewis et al., 2020; Miller et al., 2021; S. Young et al., 2023); mental health, including individual

psycho-emotional and interpersonal psycho-social outcomes (Brewis et al., 2021; Sultana, 2011; Tallman, 2019; Workman and Ureksoy, 2017; Wutich et al., 2020; Wutich and Ragsdale, 2008); citizenship, trust, and belonging (Harris et al., 2017; Méndez-Barrientos et al., 2022; Sultana, 2020; Wilson et al., 2022); and physical health across the life course (Rosinger and Young, 2020).

The Water Insecurity Experiences (WISE) Scales are the first cross-culturally comparable experiential measures of water insecurity that have been validated for use in low- and middle-income countries (see Young et al., 2019; Young et al., 2022). The household (HWISE)¹ and individual (IWISE)² versions ask individuals to report how frequently they experienced 12 different water-related issues, ranging from worrying about water insufficiency to going to sleep thirsty, over a standardized recall period (Young et al., 2019, 2022). Responses are then aggregated to generate water insecurity scores that are comparable across settings and time. The WISE Scales depart from conventional water indicators that assess water availability (e.g., cubic meters of water per capita; Falkenmark et al., 1989), by capturing dimensions of water accessibility, use, and stability. Numerous governmental agencies,

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¹ For more information, see: <https://hwise-rcn.org/>.

² Recently, the first nationally representative estimates of experiential water insecurity reveal regional disparities, with higher prevalence observed in Sub-Saharan Africa (Young et al., 2022). Individual water insecurity scores ("IWISE") from 45,000 individuals in 31 LMICs indicate a prevalence of water insecurity of 14.2%, and a prevalence of 36.1% in sub-Saharan Africa (Young et al., 2022).

developmental organizations, and academics have implemented the WISE Scales for their noted ability to provide a more holistic understanding of water insecurity (Young et al., 2023).

The construction and validation of the WISE Scales are analogous to that of other experiential indicators, particularly food insecurity. Unlike food insecurity, however, there is not a universal continuum of difficulty along which water insecurity manifests. For instance, the development of the Food Insecurity Experiences Scale (FIES) revealed an inherent ordering to food insecurity experiences: individuals first worry about insufficiency, then reduce the quality of foods consumed, and as situations worsen, reduce the frequency of meals consumed before skipping them and going whole days without eating (Coates et al., 2007). In contrast, the difficulty of each water insecurity experience, estimated using Rasch modeling, varied considerably across sites (i.e., experiences estimated to be the most difficult were not common across settings), necessitating the use of classical test theory, which assumes equal weighting of all items in a scale (Young et al., 2019).

Growing theoretical and qualitative scholarship suggests that local, subjective conceptualizations of difficulty, rather than difficulty scores derived from frequency and item endorsement likelihood, may inform how water insecurity is embodied (Stoler et al., 2023). For instance, Tesfaye et al. (2020) found general alignment between water insecurity experiences and perceived severity in Amhara, Ethiopia, however, they found notable variations in perceived severity by inter- and intra-community residence. Their results did not support predictable differential weighting of items based on severity and underscore important local experiences of water insecurity. Thus, while cross-culturally validated water insecurity scales may be useful for developing comparative data across sites, they may not capture all salient factors necessary to comprehensively understand site-specific water insecurity. We therefore assessed both frequency and perceived difficulty of multiple water insecurity experiences in Morogoro, Tanzania to provide more detailed water insecurity data in a lower water insecurity context and to offer comparative data for the Amhara, Ethiopia study (Tesfaye et al., 2020). More broadly, our results enable us to engage in current methodological debates on understanding how water insecurity manifests in everyday life.

2. Theoretical background and study contributions

Experiential water insecurity measures capture issues with water access, availability, use, and stability across time (e.g., Garrick and Hall, 2014; Jepson et al., 2017b; Octavianti and Staddon, 2021), including psycho-emotional responses to water-related challenges such as stress and worry. These experiences, which are integrated into instruments, such as the HWISE Scale (Young et al., 2019), reflect a broader scholarship demonstrating that limited access to safe water is associated with greater psychological distress, perceptions of inequitable and unfair water arrangements, and inter-personal conflict (Brewis et al., 2020; Bulled, 2017; Ennis-McMillan, 2001; Harris et al., 2017; Stevenson et al., 2012, 2016; Sultana, 2011, 2020; Tremblay and Harris, 2018; Truelove, 2019; Wutich and Ragsdale, 2008). This established body of literature has documented psycho-emotional experiences of water insecurity, such as stress and worry, as well as psycho-social, or individual psychological affect that derives from, and contributes to, interpersonal and larger socio-structural relations. For example, when households do not have enough water or the available water is of poor quality, household members shift their schedules, cancel engagements, reprioritize chores, and may be unable to uphold important cultural and behavioral expectations and norms. To this end, water is often conceptualized as a “total social fact” (Orlove and Caton, 2010) because it is both individual and social. In other words, concerns about water are often concerns about the intricacies of water access, infrastructure, and social arrangements and relations (*ibid*; Jepson et al., 2017a; Anand, 2017). Moreover, studies suggest water insecurity need not be catastrophic for daily effects to meaningfully impact well-being – experiences of water

insecurity can be mundane, yet impactful (Mawani, 2022; Sultana, 2015; Truelove, 2019). Such theoretical and empirical underpinnings complicate our understanding of what it means to be water insecure.

To this end, measuring the frequency of water insecurity exposures, and their perceived severity remains important (Garrick and Hall, 2014). Does information about the frequency of water-related problems provide sufficient information to estimate the burden of water insecurity? Or does the measurement of water insecurity require consideration of the complex interrelationship between frequency of water problems and their subjective difficulty?

Social sciences literature demonstrates that experiences of water insecurity are shaped through multiple, compounding processes of marginalization, including but not limited to class and caste oppression, patriarchy, and racism (e.g., Harris et al., 2017; Sultana, 2020; Gerlak et al., 2022; Shah et al., 2023; Truelove, 2019). Prior observational studies have demonstrated different gendered experiences of water insecurity (Brewis et al., 2019, 2023; Mawani, 2022; Stevenson et al., 2016; Sultana, 2009, 2020; Wutich and Ragsdale, 2008). That water insecurity is shaped by socio-economic status and the ability to afford water is well-supported by multi-site studies (Adams et al., 2020; Shah et al., 2023; Stoler et al., 2020; Young et al., 2022), whereas studies of single locales demonstrate the financial challenges associated with water procurement (Adams, 2018; Bisung and Elliott, 2018; Wutich and Ragsdale, 2008). Overall, context-specific social expectations and intersectional dynamics are important factors that should be considered when examining water insecurity (Gerlak et al., 2022; Shah et al., 2023; Sultana, 2020; Thompson, 2016; Truelove, 2019).

Household coping and water management behaviors (e.g., water sharing and storage) that moderate water insecurity experiences, and their impacts on well-being, are shaped by individual and household economic and social positionality (Brewis et al., 2020; Collins et al., n.d.; Rosinger et al., 2020; Stoler et al., 2023; Venkataramanan et al., 2020; Wutich et al., 2022). As it relates to scale development, Stoler et al. (2023) assert that water insecurity metrics should further address dimensions of adaptation, resilience, and severity. That is, surveys ought to assess the frequency of experiences, the extent to which they disrupt daily activities, and the roles of coping and adaptation behaviors and actions in reducing observed water insecurity experiences and impacts (*ibid*). Others, like Lemos et al. (2016), emphasize the importance of measuring relationships and feedbacks between adaptive capacity and experiences of water security. The implications of this work is that metrics aimed at only one dimension of water insecurity – exposure, sensitivity, or adaptation – will be less effective than those that account for the totality of these dynamics (e.g., Garrick and Hall, 2014; Stoler et al., 2023).

Current experiential water insecurity scales do not capture perceived difficulty or adaptations to water problems. To respond to the limitations of the former, Tesfaye et al. (2020) implemented an experiential water insecurity module to assess the relationship between reported item frequency and perceived difficulty in Amhara, Ethiopia. Drawing on data collected from 259 women, the authors found that, in general, the proportion of the population reporting a particular water insecurity experience was inversely associated with mean subjective severity scores (*ibid*). That is, more subjectively severe items were more infrequently experienced (*ibid*). However, there was an important exception to this pattern: “drinking water that might not be safe” was both relatively common and perceived as highly severe. They further cautioned against using average perceptions of item severity in a population to assign weights to scale item given the variation in how women in their study perceived the severity of water insecurity items: using average perceptions as item weights would ignore the extent to which an individual’s perception diverges from the average, which, they argued, could over or underestimate the amount of psychological distress the individual experiences as result of their difficulties with access. Based on these findings, the authors cautioned against using item weights derived from the prevalence of the experience in a population (e.g., with

items that are experienced more rarely assigned a greater weight to account for their relative severity) because an item's prevalence is not always an accurate estimate of average perceptions of item severity in a population.

Our study draws on similar data collected in Morogoro, Tanzania, to further understand how perceived difficulty is associated with the frequency of water insecurity experiences. Participants in Morogoro have lower mean water insecurity scores than those in Amhara, allowing for novel exploration of how water insecurity experiences and subjective difficulty may differ across and within sites. Such an approach addresses recent calls to concurrently evaluate the frequency and perceived difficulty of water insecurity experiences to contribute to larger discussions about the value of multi-sited and local data (Shah et al., 2023). Further, ascertaining patterns across sites, as well as the heterogeneity between and within them, is key to understanding how water insecurity manifests at different scales. In sum, this paper contributes to methodological and conceptual discussions about the relationship between the frequency and perceived difficulty of water insecurity experiences, and how this relationship manifests within and between more and less water-insecure sites. Findings from this project can be used to inform efforts to (re) design interventions and monitoring and evaluation tools in ways that are sensitive to local realities.

3. Methodology

3.1. Study setting

This research was conducted in Morogoro Urban (2012 population: 315,866), one of six districts in the broader Morogoro Region (2012 population: 2,218,492). Morogoro Urban is divided into 29 wards, with wards comprised of *wakaa* (*mka* singular), which translates to “streets” but may be interpreted as small neighborhoods. The sampling frame was provided by the Ward Executive Officer (WEO) using ward-level census data from a USAID-funded malaria project. A cluster approach by *wakaa* was implemented with each of *wakaa* serving as a cluster ($n = 15$). Random sampling was used (World Health Organization [WHO] Random Walk³) to enroll households proportionate to cluster size. Participants were eligible to participate if they were adults (over 16 years of age) and reported being knowledgeable about their household's water situation (per Young et al., 2019).

Residents of Morogoro Urban, rely primarily on municipal water drawn from the Mindu Reservoir (URT, 2017). There are community taps that sell water, but most households purchase water from a neighbor or use standpipes located either in their homes or a shared courtyard. Water schedules are common with water infrequently available at all times of the day. Morogoro is facing rapid urbanization, affecting both water availability and security (MCC, 2019). As the reservoir is dependent on rain and river flow from the Uluguru mountains, the city faces challenges reliably providing water in the context of shifting precipitation patterns. These data were collected at the end of the rainy season and, overall, respondents reported being able to secure enough water for their daily needs (or have implemented water management strategies to mitigate intermittency and water scheduling). The HWISE survey data indicate respondents infrequently experienced many aspects of water insecurity, however, in depth interviews revealed frustration with water cuts and insufficient infrastructure.

3.2. Study sample

The parent HWISE study consisted of cross-sectional surveys implemented among 8127 households across 28 sites in 23 low- and middle-

income countries (Young et al., 2019). In Morogoro, Tanzania, 300 individuals were recruited and asked to report on 29 candidate household water insecurity items, a subset of which comprise the final HWISE Scale. For each item, all participants were asked how frequently in the prior 4 weeks they experienced a particular water issue (Young et al., 2019). A randomly selected sub-sample ($n = 149$) also completed a second survey that asked individuals to assess the difficulty of each water insecurity experience, hereafter referred to as “perceived” difficulty. Based on health sciences literature (McDonald, 2011), we define perceptions as cognitive processes of sensation, memory, or reaction that reflect personalized experiences or situations about water insecurity. Household and individual perceptions of difficulty or severity involve reacting to the *lived experiences* of water insecurity or to *potential scenarios* associated with such challenges.

Household demographic information was collected for all individuals, including respondent gender, household head, household size, number of children, household type, as well as information about drinking water source and water storage capacity. Additionally, individuals were asked to rank their household's socioeconomic (SES) and water standings relative to other households in their community using a modified MacArthur Scale of Subjective Social Status (Adler et al., 2008). For both, responses were coded such that 1 was the lowest and 10 the highest (Young et al., 2019). These data were collected at the end of the long rainy season (*masika*) in April and May of 2018. The questionnaires an open-ended question about the perceived causes of water issues in the community ($n = 300$). In addition, the first author conducted 30 structured interviews with a sub-sample of the survey participants about household and community water experiences.

3.3. Amhara, Ethiopia site study

From the larger HWISE parent study, only the Amhara and Morogoro sites have both frequency and difficulty data. For detailed methods and analytic procedures for the Amhara study site, see Tesfaye et al. (2020). While we assess frequencies and proportions for key water insecurity variables to compare perceptions of difficulty to Amhara data, our studies are analytically distinct. Below we discuss shared procedures (section 3.5.1) and analyses specific to Morogoro (section 3.5.2-3.5.4).

3.4. Ethical approvals

Research approval was obtained from Northwestern University (USA), Sokoine University of Agriculture (Morogoro, Tanzania), Morogoro Municipality, the WEO, and *mwenyekiti* and *wenyeviti wa wakaa* (ward-level and street-level chairpersons/recognized community leaders).

3.5. Analytic approach

We explored the relationships between frequency and severity of water experiences to assess four propositions developed *a priori*.

3.5.1. Proposition 1: water insecurity experiences perceived to be the most difficult will differ between Morogoro and Amhara

The water insecurity module assessed the frequency with which water issues were experienced in the 4 weeks prior to survey implementation. Response options for each item included: “never” (0 times; scored as 0), “rarely” (1–2 times; scored as 1), “sometimes” (3–10 times; scored as 2), and “often/always” (11+ times; scored as 3) (Young et al., 2019). The full list of the 29 implemented household water insecurity items is included in the **Supplemental Materials**.

A second survey was conducted with a sub-sample to assess the relative difficulty of the 29 household water insecurity experiences. A pictorial representation of difficulty, provided by the Amhara, Ethiopia research team (Fig. 1; Tesfaye et al., 2020), was used to help participants

³ The WHO Random Walk selects a point in space and enumeration occurs every n number of structures. In this study, it was the central street in each neighborhood (*wakaa*), and every other structure was selected.

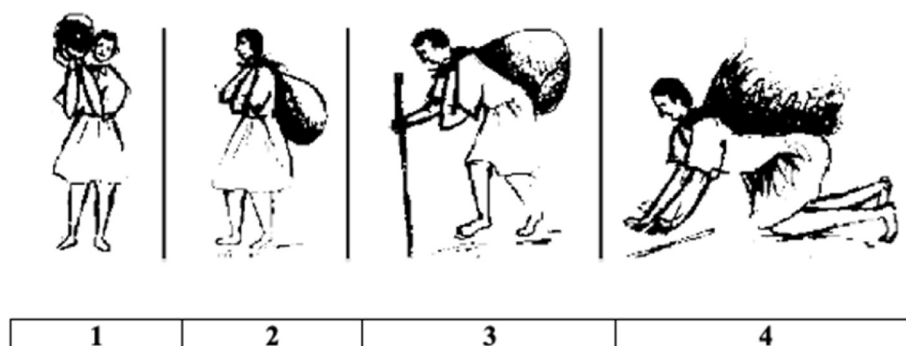


Fig. 1. Visual tool provided to participants rate the relative difficulty of water insecurity experiences. **Source:** Reproduced from Bolton and Tang (2002).

rate the difficulty of each experience using a Likert scale (1 = not hard to 4 = very hard). The Kiswahili word *ugumu* was used and translates to English as “hard” or “difficult.” We calculated the mean and standard deviation (SD) for each item, and the proportion (%) of respondents who rated each as being low (1), mild (2), moderate (3), or severe (4) difficulty. In subsequent analyses, we dichotomized severity as low (score of 1) or at least mild (score of 2 or higher) given that few participants rated experiences as being “moderate” or “severe”.

Water insecurity scores, based on the 12-item HWISE Scale, have been reported elsewhere for Morogoro (e.g., [Stoler et al., 2021](#)). To compare the means between Morogoro and Amhara, variables were rescaled to match the coding schema applied by [Tesfaye et al. \(2020\)](#). The minimum values for item frequency and item difficulty were set to 1 and the maximum to 4 using SPSS v28. For statistical tests which use an ordinal score for individual items (see below), the suggested scaling of 0–3 was maintained (see [Stoler et al., 2021](#); HWISE User Guide, 2020).

3.5.2. Proposition 2: infrequently experienced items will be perceived as being more difficult

Linear regression was used to assess whether the proportion of individuals who experienced a particular water issue was associated with the proportion who affirmed that issue as being at least mildly difficult. Additionally, Fisher’s exact tests were conducted to assess whether having experienced a particular water problem in the prior 4 weeks (yes/no) was associated with rating that water issues as being at least mildly difficult (yes/no).

3.5.3. Proposition 3: the relationship between the reported frequency of water insecurity experiences and their perceived severity will differ by demographic characteristics

Fisher’s exact tests and *t*-tests were conducted to assess whether difficulty ratings for each item differed by participant gender (male or female), amount of water stored in the household (fewer than 30 L or 30 or more liters), and perceived relative household SES (1–10).

3.5.4. Proposition 4: water insecurity measurement models that incorporate both frequency and difficulty information will have better fit than conventional models that only use frequency data

Confirmatory factor analysis was used to evaluate whether observed data fit a hypothesized underlying water insecurity construct. Guided by prior theoretical work ([Stoler et al., 2023](#)), we tested several competing models to determine whether concurrent consideration of both the frequency and perceived difficulty of experiences with water issues would produce a measure of water insecurity with better fit. To do this, we first loaded frequency data for the 12 items included in the HWISE Scale onto a single water insecurity construct – the approach used for development of the HWISE Scale ([Young et al., 2019](#)). Additional models incorporated information on perceived difficulty by: i) multiplying frequency data with ordinal rankings of difficulty for each experience; ii) multiplying frequency data with a binary indicator that reflected whether an

experience was perceived to be at least mildly difficult; iii) adding frequency data with ordinal rankings of difficulty for each experience; and iv) adding frequency data with a binary indicator that reflected whether an experience was perceived to be at least mildly difficult. For instance, under the first schema, an item would receive a score of 12 if it was described as occurring “often” in the prior month (scored as 3) and as being “difficult” when experienced (scored as 4). This strategy was undertaken to compare potential additive and multiplicative effects of item difficulty. Models were considered to have good fit if the Root Mean Square Error of Approximation (RMSEA) was ≤ 0.05 and both the Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) were > 0.95 ([Boateng et al., 2018](#)). A Cronbach’s alpha of 0.80 was considered to demonstrate good reliability. All analyses were performed in Stata v17.

4. Results

Household water insecurity scores in Morogoro were low compared with other sites included in the HWISE parent study ([Stoler et al., 2021](#)). Among participants with complete experiential water insecurity data ($n = 256$), the mean household water insecurity score was 4.2 and highest individual score was 33 ([Stoler et al., 2021](#)). In contrast, among those who answered the severity module and had complete data to calculate HWISE Scale scores ($n = 129$), the mean HWISE Scale score was 3.7 and the highest score was 15. Of the sub-sample who completed the severity module ($n = 149$), most were women (79%), and the mean age was 40 (min: 16, max: 79). Households had around two children (median: 2, mean: 2.6), although the number of children ranged from zero to 10. Most households had three adults (median: 3, mean: 3.4), with a range from one to 12. Most participants lived in a home they owned (64%), followed by living in a rental home (17%), informal settlement (13%), and rental room/apartment (4%). Using a one to 10 scale, with 10 being the best off, median relative household SES and water security scores were 4 and 6, respectively. That is, at least half of surveyed households considered themselves to have lower SES than others in their community whereas a similar proportion considered themselves as having a better water standing than others in their community. Most respondents (89%) reported that they stored drinking water in their homes, with households storing an average of 42 L (max: 400).

4.1. Proposition 1

4.1.1. Comparison of mean frequency and difficulty scores for Morogoro, Tanzania and Amhara, Ethiopia

Respondents sampled in Amhara, Ethiopia were more water insecure than those in Morogoro, Tanzania. In Amhara, mean difficulty scores were also typically higher, and the nature of water insecurity experiences reported differed. For example, residents of Amhara reported it difficult (literally: heavy, *kebad* in Amharic) to go a whole day without water, go to sleep thirsty, consume water that was not safe or came from a polluted source, and be in situations that would result in quarreling

(see Tesfaye et al., 2020). These items were often rated as being maximally difficult using the provided pictorial scale.

In Morogoro, the most frequently affirmed water insecurity experiences among the sub-sample (i.e., the 149 individuals who completed the difficulty survey) included being angry about one's household water situation (66.7%), water supply interruptions or limitations (54.6%), being unable to access preferred water (52.7%), being worried about water insufficiency (52%), and drinking water that looked, tasted or smelled bad (38.6%) (Table 1). Having children miss school (3.6%), being unable to wash hands (3.1%), going to sleep thirsty (2.3%), and feeling ashamed, excluded, or stigmatized because of one's water situation (2%) were the least affirmed experiences (Table 1).

Changing schedules or plans (83%), water supply interruptions (83%), being unable to access preferred water sources (80%), lack of money to buy water (76%), and anger about the water situation (74%) were most affirmed as being at least mildly difficult (Table 1). Nearly one-fifth (19.5%) of respondents in Morogoro rated supply interruptions as severely difficult. Having nowhere to purchase water (17.5%) and lacking money to purchase water (17.1%) were similarly rated as severely difficult. Experiences considered low in difficulty included going to sleep thirsty (86.8%), unable to wash children's faces and hands (84%), and thoughts of moving dwellings (82.7%). Being unable to provide water to livestock was generally considered low difficulty (87.5%), but this latter score reflects that of only 15 respondents. Of note, in contrast to Amhara, drinking water believed to be unsafe was commonly experienced in Morogoro (34.6%) but few individuals considered it to be moderately (15.9%) or severely difficult (8.3%) (Table 1).

4.2. Proposition 2

4.2.1. Frequency of experience and severity ranking in aggregate

We observed a positive linear trend between the proportion of individuals who affirmed a water insecurity experience and the proportion who ranked the experience as being at least mildly difficult ($B = 0.50$;

95% CI: 0.16, 0.84) (Fig. 2).

4.2.2. Frequency of experience and severity ranking at the household level

In general, a greater proportion of individuals who experienced a water problem rated it as being at least mildly difficult relative to those who did not report having experienced that issue (Fig. 3). For 12 water-related challenges, there was a meaningful difference in perceived difficulty between those who did and did not report having experienced the water problem: supply interruptions or limitations, inability to access preferred water, worry about insufficiency, lack of money to buy water, anger about water situation, change schedule or plans, drink water that looked, tasted or smelled bad, drink water thought to be unsafe, inability to wash clothes, no useable or drinkable water in the household, inability to attend social or cultural events, and being unable to wash body. These results suggest that individuals who report experiencing particular household water issues, including psycho-emotional distress such as anger or worry over one's household water situation, are more likely to rank these issues as being at least mildly difficult relative to their counterparts who did not report the experience. Further, it is worth highlighting feelings of shame, stigma, and exclusion due to water problems were not commonly reported (2%) but were perceived as at least mildly difficult among all those who affirmed the experience (Fig. 3).

4.3. Proposition 3

4.3.1. Variations in perceived difficulty of water insecurity experiences by respondent characteristics and household conditions

There were no substantial differences by gender, although a greater proportion of women typically evaluated household water issues as being at least mildly difficulty compared to men (Fig. 4). In general, a greater proportion of individuals who stored more than 30 L of drinking water reported water problems as being at least mildly difficult compared to their counterparts who stored less water (Fig. 5). Across most water problems, individuals who rated a water issue as being at

Table 1

Affirmation and perceived difficulty of household water insecurity experiences among adult participants in Morogoro, Tanzania.

Experience	N	Affirmed experience (%)	Low Difficulty (%)	Mild Difficulty (%)	Moderate Difficulty (%)	Severe Difficulty (%)
Supply interrupted or limited	119	54.6	24.4	41.5	14.6	19.5
Unable to access preferred water	148	52.7	31.1	31.1	26.4	11.5
Worry about insufficiency	148	52.0	33.8	35.1	19.6	11.5
Lack money to buy water	120	37.5	35.8	30.9	16.3	17.1
Angry about water situation	135	66.7	36.0	33.8	18.4	11.8
Unable to earn money	124	22.6	38.0	38.8	12.4	10.9
Change schedule or plans	130	22.3	43.2	31.1	14.4	11.4
Drank water that looked, tasted, or smelled bad	132	38.6	45.1	30.1	15.0	9.8
Borrowed water	99	21.2	48.1	27.7	16.1	8.0
Drank water thought to be unsafe	130	34.6	48.5	27.3	15.9	8.3
Nowhere to purchase water	99	18.2	48.5	24.3	9.7	17.5
Loaned water	116	45.7	50.4	37.4	5.7	6.5
Unable to wash clothes	125	28.8	51.9	28.7	10.9	8.5
Worried about safety of collector	110	19.1	55.6	21.4	15.4	7.7
Difficulty with community members	107	7.5	57.8	27.6	6.9	7.8
No useable or drinkable water in household	117	29.1	61.5	21.4	11.1	6.0
Difficulty with household members	110	11.8	62.7	26.3	5.1	5.9
Change what was being eaten	102	9.8	64.8	25.7	4.8	4.8
Children missed school	83	3.6	67.8	20.0	5.6	6.7
Unable to attend social or cultural events	110	16.4	69.0	19.5	6.2	5.3
Unable to wash body	111	20.7	70.5	14.3	4.5	10.7
Unable to drink as much water as desired	103	10.7	72.1	15.4	2.9	9.6
Feel ashamed, excluded, or stigmatized	98	2.0	74.5	10.8	3.9	10.8
Unable to wash hands	98	3.1	76.0	20.0	3.0	1.0
Water situation impacted garden or crops	18	16.7	76.9	15.4	7.7	0.0
Thought of moving dwellings	79	5.1	82.7	11.1	4.9	1.2
Unable to wash faces and hands of children	93	5.4	84.0	10.0	4.0	2.0
Gone to sleep thirsty	89	2.3	86.8	5.5	0.0	7.7
Water situation impacted livestock	15	6.7	87.5	4.2	4.2	4.2

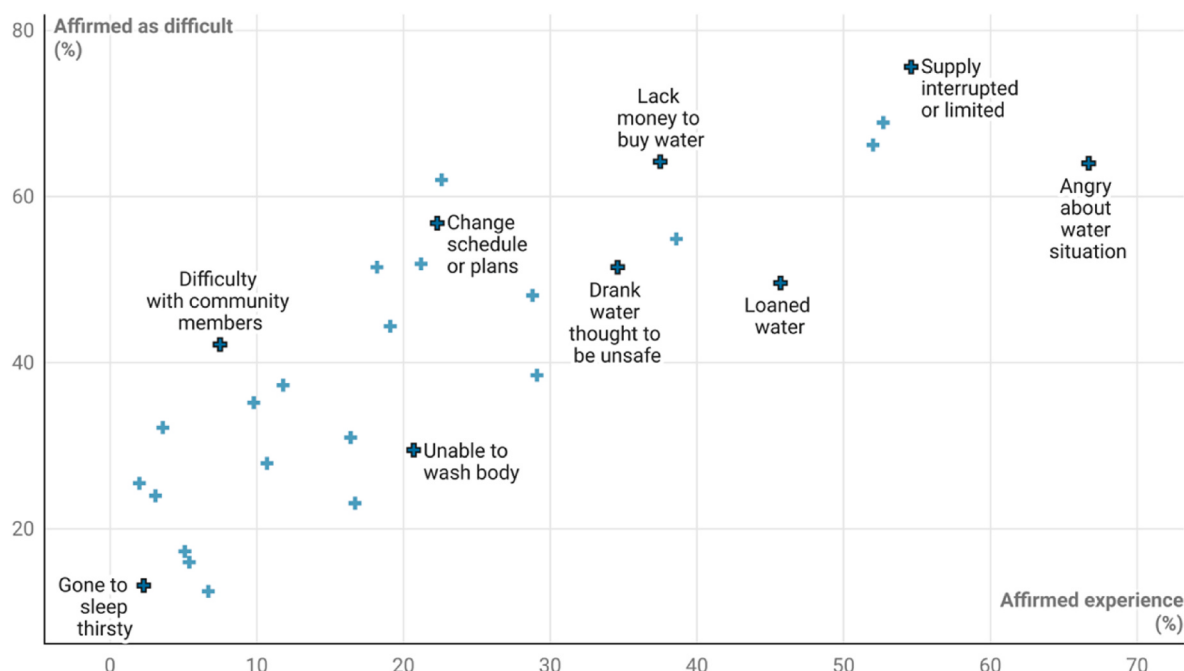


Fig. 2. Proportion of participants in Morogoro, Tanzania who affirmed a water insecurity experience in the prior 4 weeks by the proportion who rated the experience as being at least mildly difficult. Values are available in Table 1.

least mildly difficult considered their households to have, on average, a lower relative SES compared to households that rated the issue as being less than mildly difficult (Fig. 6).

4.4. Proposition 4

4.4.1. Comparing methods for operationalizing water insecurity

Among the 73 respondents with complete frequency and difficulty data, no measurement models of water insecurity had good fit (Table 2). The model using frequency data only, however, had the best model fit indices. This suggests that, within this population, the incorporation of perceived difficulty does not improve the measurement of water insecurity. In fact, the model that used the product of frequency data and ordinal difficulty ratings did not converge.

5. Discussion

Amhara, Ethiopia and Morogoro, Tanzania differ in their summed water insecurity scores, indicating different insecurity states. We expanded on these indicators to explore how affirmations, and perceived difficulties, of water insecurity experiences in Morogoro (more urban) compared to those in Amhara (more rural). Such an approach enabled a more nuanced understanding of water insecurity in each site. The data from Morogoro demonstrate considerable heterogeneity across households, with some substantially affected. Our analyses demonstrated certain experiences were affirmed as more frequent, more difficult, and crucially, both frequent and difficult. The distribution of these items also differed between Amhara and Morogoro, suggesting different experiences of water insecurity and policy intervention points across sites.

Several frequently affirmed experiences were considered difficult (Table 1, Fig. 2). These included feeling angry about one's household water situation, having the water supply interrupted, worrying about having enough water, having to change plans, and not being able to access preferred water. Of note, drinking unsafe water was considered difficult in Amhara (see Tesfaye et al., 2020). In Morogoro, fewer than 40% of residents reported drinking water they thought was not safe (Table 1) and it was not in the top 10 most difficult experiences, with only 8% considering it severely difficult. Drinking unsafe water was,

however, considered more difficult among those who had recently experienced it relative to those who did not (Fig. 3) and, interestingly, by those with more than 30 L of stored water compared to those with less (Fig. 5). Participants who considered this water problem to be low difficulty had a higher mean perceived SES compared to those who rated it as being at least mildly difficult (Fig. 6). Thus, perceived difficulty is associated with SES and the related ability to store water, the latter of which is suggestive of buffering or adaptation. For example, households that previously experienced having to drink water they felt was not safe and found it to be difficult might have responded by storing greater amounts of drinking water and their responses may reflect an adaptation.

In Morogoro, some of the most substantial differences in difficulty rankings by frequency of experience were observed for psychosocial-related water issues, including feeling angry about one's water situation (see Fig. 3). This aligns with prior research demonstrating that because adequate access to safe water is tied closely to social relations (e.g., Jepson et al., 2017a) and cultural expectations, experiences of water insecurity are often strongly negatively associated with psycho-emotional and psychosocial well-being as well as interpersonal and community relations (Stevenson et al., 2012, 2016; Wutich et al., 2020). In Morogoro, fewer than a third of respondents reported not washing clothes (29%), changing plans (22%), skipping bathing (21%), or not attending events (16%) due to water problems, but those who experienced it typically rated it as being at least mildly difficult. For instance, only 36% of individuals who did not report issues with washing clothes rated the issue as being at least mildly difficult compared to 75% who did experience problems with doing laundry. Thus, these experiences, while not frequently reported, are difficult for those who experience them. These behaviors reflect social and cultural expectations, and individuals who are unable to effectively uphold these expectations may experience shame (Wutich et al., 2020).

There is strong theoretical justification that water insecurity experiences have varying associated difficulty. It is often assumed that problems that directly impact health are more severe than those that disrupt daily functioning. For instance, going to bed thirsty may be conceptualized as being more stressful than being unable to do laundry, yet individuals consistently rated the latter experience as being more

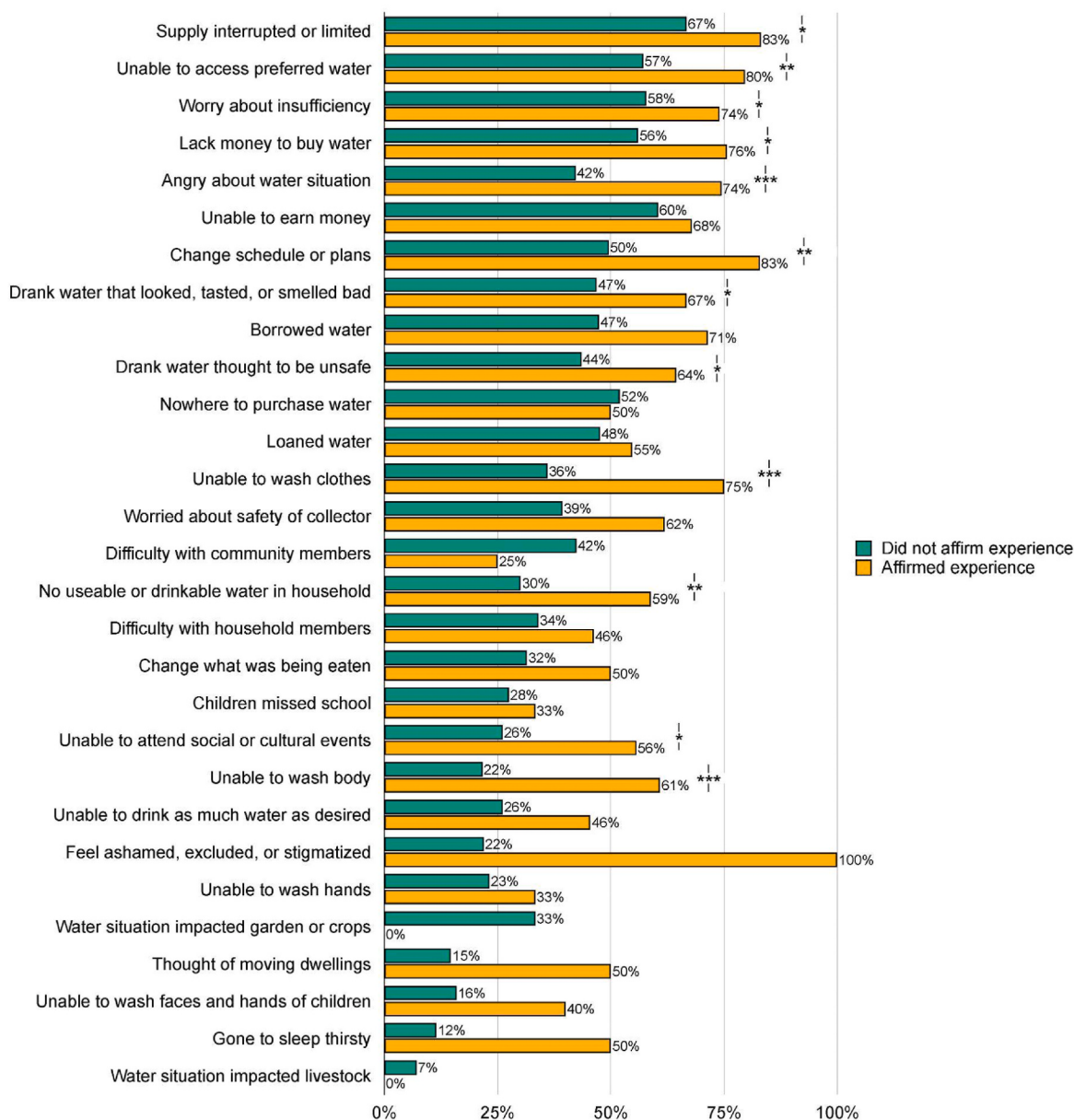


Fig. 3. Proportion of participants in Morogoro, Tanzania who rated water insecurity experiences as being at least mildly difficult, by affirmation of water insecurity experience in the prior 4 weeks.

difficult. These findings make evident that considering the totality of lived experiences, both *in extremis* and the seemingly inconvenient, is necessary to understand water insecurity and its impacts on well-being (Mawani, 2022; Sultana, 2015; Truelove, 2019). That is, people's everyday lived experiences may be underappreciated if their experiences are conceptualized as merely bothersome and not burdensome.

Anger is frequently experienced as a consequence of household water problems, as demonstrated in the analysis of 27 HWISE sites in 22 countries (Stoler et al., 2021). Even in sites with relatively low water insecurity like Morogoro, anger is both frequent and difficult. Residents are, more broadly, angry because they recognize that the service malfunctions and intermittency are due to poor governance and infrastructure management. Even in relatively water-secure sites such as Morogoro, residents frequently reported anger and other manifestations of psycho-emotional and psychosocial stress. Wutich et al. (2020) have outlined pathways through which experiences of water insecurity may affect mental health. These findings substantiate several of these

theorized pathways, including material deprivation and uncertainty, loss of opportunity or self-sufficiency, and shame of social failure (*ibid*). Our data further speak to the impact of not being able to undertake household responsibilities in a preferred way or having to socially accommodate water-related impacts.

Greater perceived difficulty of water issues was associated with lower perceived relative household SES. This finding aligns with a multi-sited study that found that individuals who reported difficulty getting by on their present income had higher water insecurity scores, on average, compared to those who did not report difficulty (Young et al., 2022). Residence in the outskirts of a city, relative to living in a city, was also associated with higher water insecurity scores (Young et al., 2022). The *wakaa* sampled for this research are similarly found on the outskirts of Morogoro, and these studies speak to important intra-urban differences (Adams, 2018). While not captured in these data, the association between SES and water insecurity is likely moderated by a households' adaptive capacity or resilience. That is, more affluent or relatively

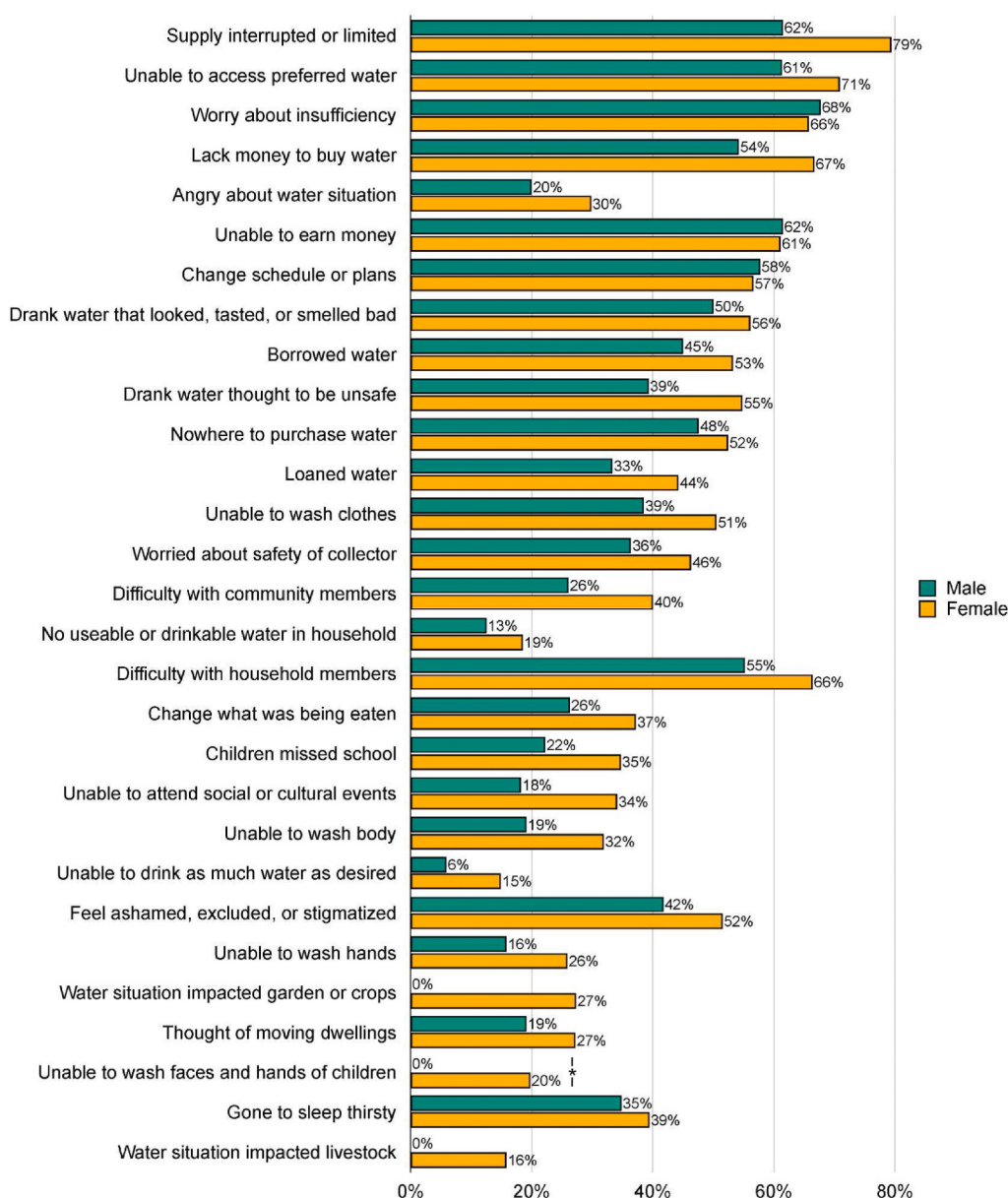


Fig. 4. Proportion of participants in Morogoro, Tanzania who rated water insecurity experiences as being at least mildly difficult, by respondent gender.

water-secure households may have more capacity to withstand water shocks, thereby minimizing the effects on their day-to-day lives (Achore et al., 2020; Venkataramanan et al., 2020). Households in Morogoro have likely implemented various strategies for water procurement and/or storage. This is a critical area for future research.

Methodologically, these findings support assertions (Tesfaye et al., 2020) that weighting items in scales is not straightforward. There is context-specificity associated with experiences, indicating that subjective item weighting is not consistent across sites. Weights cannot be assigned to individual items and used without knowing the broader socio-spatial context. While examining ratings of difficulty for individual items proved informative, there was not evidence that incorporating this information into measurement models improved upon existing water insecurity scales. Summed scores are useful for comparisons of overall experiences, but capturing specific intra-site dimensions may require different methodological approaches. Moreover, heterogeneity within and between sites is multi-scalar and requires multi-scale approaches to assess the spatial, temporal and social differences in water

insecurity. The utility of information about item difficulty may not lie in quantification of water insecurity, but in understanding which issues should be targeted given their greater perceived burden (Stoler et al., 2023; Tesfaye et al., 2020).

Finally, these data speak to ongoing challenges to provide greater depth to frequency measures. Our data suggest that multiplicative or additive approaches to combining frequency and difficulty scores may need further consideration, including, but not limited to, increased sample sizes. While we found a linear trend for frequency and perceived difficulty (Fig. 2), and further found that people who experienced a specific item had higher odds of reporting it as at least mild difficulty, the specific calculus of frequency and difficulty is experience-specific and scores may need to account for buffering or coping.

6. Future research

Water insecurity is the totality of water-related experiences – and how these experiences are produced reflects multiple drivers. While we

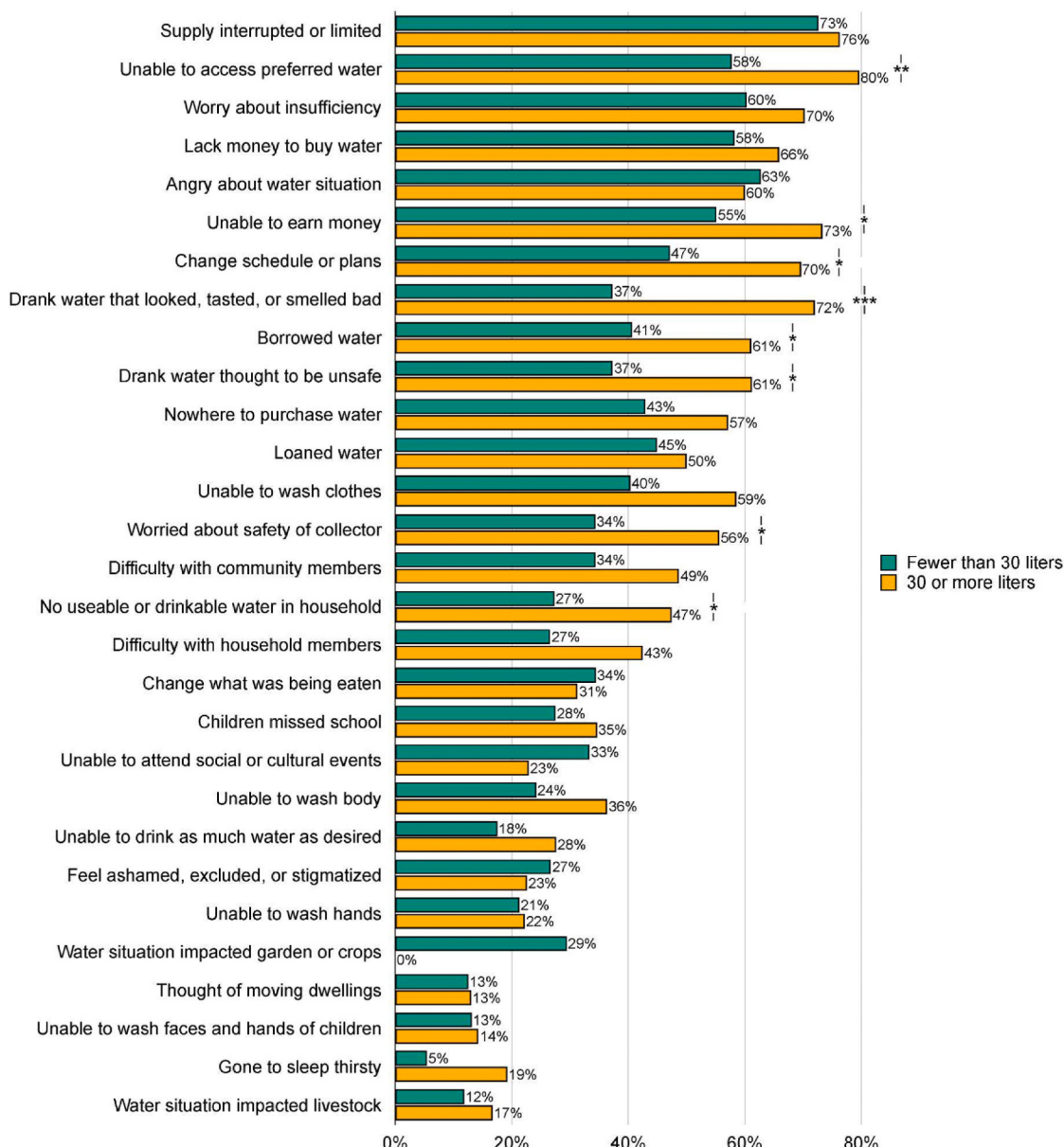


Fig. 5. Proportion of participants in Morogoro, Tanzania who rated water insecurity experiences as being at least mildly difficult, by amount of drinking water stored in the household.

are not advocating for weighting items across sites, it is nonetheless important to explore which facets of water insecurity are driving psycho-emotional and psychosocial effects. Scholars have theorized pathways through which water insecurity affects mental health (Wutich et al., 2020) and these data support several pathways as described above. Further empirical research can strengthen our understanding of how these pathways function.

Coping and household water management strategies have emerged as critical foci of water insecurity studies (Achore et al., 2020; Collins et al., n.d.; Stoler et al., 2023; Wutich and Ragsdale, 2008; Venkatar-aman et al., 2020). Coping strategies may mitigate the effects of water insecurity, but frequently come with tradeoffs (Brewis et al., 2019). For example, strategies such as intra-household water sharing are stressful, even if water security is immediately bolstered (Wutich et al., 2022). Future research and interventions must consider not just coping, but resilience, that is, to identify which management strategies are sustainably beneficial (Stoler et al., 2023). Longitudinal studies of water

insecurity and water management are needed to parse out the effects of adaptation and coping on perceptions of difficulty. These studies could further provide detail about how additional research should be designed, specifically, how to compare across groups given locale-specific experiences and how to measure perceptions of difficulty given the moderating effects of coping.

SES measures, such as having enough income for all needs, is significantly associated with individual water insecurity scores (Young et al., 2022). High proportional water expenditures are, however, found across higher and lower socio-economic groups and thus expenditures are complicated by class and other intersectional identities (Shah et al., 2023). Future research should explore water-related costs and points at which households can no longer cope and are unable to effectively manage water expenses.

Finally, current approaches predicated on the frequency of insecurity experiences reflect a “hazard-based” approach (e.g., Adger, 2006; Gar-rick and Hall, 2014; Ribot, 2010) to understanding water insecurities. In

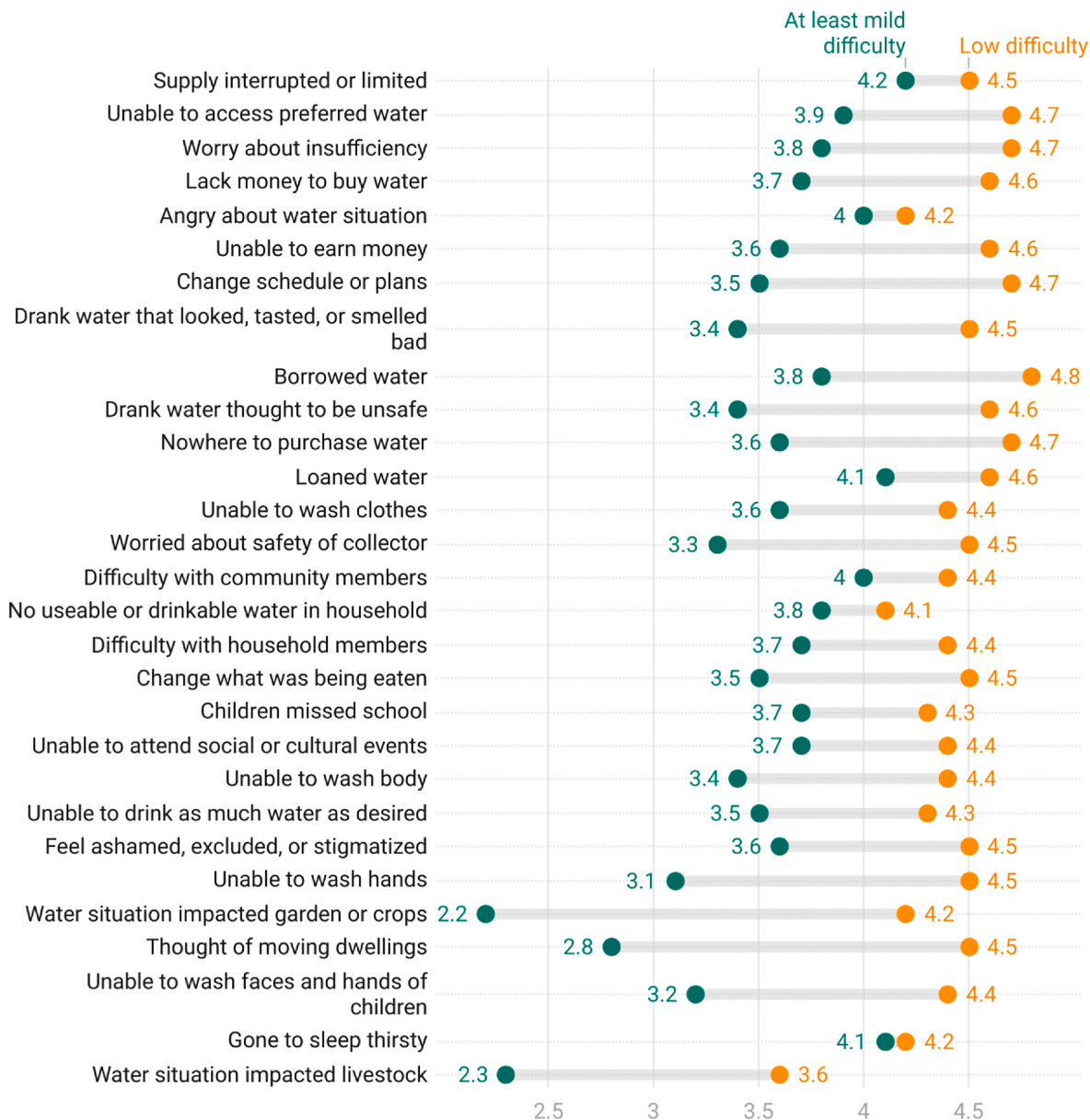


Fig. 6. Mean perceived socioeconomic status (range: 1–10, higher scores indicate greater perceived socioeconomic status) by perceived water insecurity experience difficulty (low difficulty in orange, at least mild difficulty in green). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 2
Comparison of fit indices for different measurement models of household water insecurity among adults in Morogoro, Tanzania.

	Frequency only	Frequency times binary difficulty rating	Frequency plus ordinal difficulty rating	Frequency plus binary difficulty rating
RMSEA (≤ 0.05)	0.117	0.139	0.217	0.158
CFI (> 0.95)	0.784	0.718	0.543	0.665
TLI (> 0.95)	0.736	0.655	0.441	0.591
Cronbach's alpha (> 0.80)	0.704	0.646	0.815	0.768

other words, such approaches equate household water insecurities (a vulnerability) with the degree to which a household is exposed to certain experiences (cf. *ibid*). A point of contention here is the degree of correlation between the exposure or experience of water insecurity and its impact on a household. While we recognize any experience of water insecurity is not acceptable and highlights larger problems of water governance, it is important to recognize that water insecurity experiences can be moderated by coping or adaptive capacity (Shah et al., 2023; Stoler et al., 2023). As a hypothetical example, households

experiencing water interruptions may be able to rely on a secondary water source to mitigate food insecurity or broader well-being risks; such events may alleviate immediate material impacts, but could still be highly stressful.

7. Limitations

The questionnaires in Morogoro and Amhara had overlap but did not include all respective questions, thus precluding complete comparison.

In the Morogoro data, given the infrequency of some specific water insecurity experiences, there were small cell values in certain tables. Additionally, there were relatively small sample sizes for analyses related to some experiences, such as not having enough water for livestock. Together, these features may result in wide confidence intervals and less precise point estimates. Finally, given the observational nature of these data, we cannot infer causality, that is, we cannot state that greater frequency of experiences results in greater perceived difficulty.

8. Conclusions

We found that different water experiences are endorsed as being difficult in Amhara, Ethiopia compared to Morogoro, Tanzania, suggesting potential differences by urbanicity or overall local water insecurity burden. Indeed, data from Amhara and Morogoro reflect larger concerns that security is not just a state of “net” water access (Jepson et al., 2017a), but rather, specific experiences with important biopsychosocial impacts that depend on site-wise exposures, sensitivities, and broader contexts (Stoler et al., 2023). Items endorsed as difficult in Amhara were not commonly identified as such in Morogoro. In Morogoro, some experiences were both frequent and difficult (e.g., feeling angry about one’s household’s water situation, having water supply interruptions, worrying about having enough water, and not being able to access preferred water) but others could be infrequent yet difficult for those who experienced it (e.g., having to go without bathing because of water, not having enough water to wash clothes, having to change plans because of the water situation, and missing social events due to water problems).

In sum, data from Morogoro indicate that the experience of water insecurity is locally specific and experiences of people in environments of scarcity (Amhara, Ethiopia) are qualitatively different than in less water-insecure environments (Morogoro, Tanzania). Summed scores provide a broad understanding of water issues, but not the context-specific granularity of water insecurity experiences. Moreover, it is evident that different people within a community, such as those with lower SES, remain more impacted by water insecurity than others. Overall, these findings underscore the need for the implementation of monitoring and evaluation tools that can capture everyday social experiences with water insecurity, such as psychosocial stress, and not solely gross shortages of water.

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CRedit authorship contribution statement

Cassandra L. Workman: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Joshua D. Miller:** Data curation, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Sameer H. Shah:** Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Kenneth Maes:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Yihenew Tesfaye:** Conceptualization, Writing – original draft,

Writing – review & editing. **Kenneth M. Mapunda:** Investigation, Project administration, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmmh.2023.100295>.

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