



Water journeys: Household water insecurity, health risks, and embodiment in slums and informal settlements

Ellis Adjei Adams^{a,*}, Sydney Byrns^b, Save Kumwenda^c, Richard Quilliam^b,
Theresa Mkandawire^d, Heather Price^b

^a Keough School of Global Affairs, Eck Institute for Global Health, University of Notre Dame, 1010 Jenkins Nanovic Halls, Notre Dame, IN, 46556, USA

^b Department of Biological and Environmental Sciences, Faculty of Natural Sciences, University of Stirling, Stirling, FK9 4LA, UK

^c Malawi University of Business and Applied Sciences (MUBAS), Department of Environmental Health, Private Bag 303, Chichiri, Blantyre 3, Malawi

^d Malawi University of Business and Applied Sciences (MUBAS), Department of Civil Engineering, Private Bag 303, Chichiri, Blantyre 3, Malawi

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ABSTRACT

Water insecurity is a critical public-health challenge in Africa's urban informal settlements, where most of the population often lacks access to household taps. In these settings, water fetching is disproportionately performed by women. While water fetching is physically laborious and exposes women to multiple risks, the water-insecurity literature has predominantly focused on household experiences, ignoring women's water-collection journeys. This paper uses the water journey as a window into the embodied dimensions of water insecurity. Combining theoretical insights from embodiment, embodied political ecology of health, and time geographies, we use video-recorded walking interviews to analyze women's everyday water journeys in Ntopwa, an urban informal settlement in Blantyre, Malawi, from initial decision making through exposure to water-fetching risks and household practices regarding use and storage. We identify three principal sources of environmental risk—terrain, built environment, and human behavior—that present challenges for water collectors. Using the walking interview as a heuristic, we show how the seemingly simple practice of water fetching is compounded by complex decision making, constant spatiotemporal trade-offs, and exposure to diverse risks, all of which have embodied health consequences. Based on our findings, we conclude that interventions seeking to improve household water insecurity must consider the embodied effects of water-fetching journeys. This study also provides methodological insights into using walking interviews and videos for water and health research.

1. Introduction

Unsafe water remains a major contributor to the global burden of disease and mortality (Prüss-Ustün et al., 2019; Anthonj, 2021). Globally, nearly 2 billion people do not have access to safe water. Of these, 1.2 billion are without basic water services, defined as drinking water from an improved source with total collection and queuing time of no more than 30 min (WHO and UNICEF, 2021). These numbers likely underestimate the challenge, because water access indicators often do not adequately consider the multiple layers of water insecurity. For example, not all improved sources yield water of acceptable quality, and water that may be clean at the source can get contaminated through transportation, storage, and handling at the household (Boateng et al., 2013; Smiley, 2017; Cassivi et al., 2021). Global statistics on water

supply often focus on international, national, and regional patterns of water insecurity, obscuring the impact of water insecurity and associated health effects on a finer scale (Price et al., 2019; Price et al., 2021). In rapidly expanding informal settlements in sub-Saharan Africa, unsafe water is compounded by population growth, poverty, poor housing, and myriad physical and environmental risks, which can compromise health and well-being (Adams et al., 2020). Poor sanitation and overcrowding can cause fecal contamination (Adams et al., 2019; Price et al., 2021). Intermittent supply in informal settlements leads to long waiting times (Adams, 2018), whereas privately sold water, a common option in many cities, can be costly and unsafe (Sarkar, 2020).

The most recent Joint Monitoring Programme data reports that upwards of 46% of urban households in sub-Saharan Africa depend on water sources outside of the home, and this figure reaches a staggering

* Corresponding author.

E-mail addresses: eadams7@nd.edu (E.A. Adams), s.c.byrns@stir.ac.uk (S. Byrns), skumwenda@mubas.ac.mw (S. Kumwenda), richard.quilliam@stir.ac.uk (R. Quilliam), tmkandawire@mubas.ac.mw (T. Mkandawire), heather.price@stir.ac.uk (H. Price).

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89.5% when expanded to consider rural contexts (WHO and UNICEF, 2021). The burden of water fetching falls disproportionately on women and girls and usually entails multiple steps: walking to a source, joining long queues, filling containers, and carrying them home (Sorenson et al., 2011; Sarkar, 2020). Water fetching predisposes women and girls to musculoskeletal injuries, fatigue, and physical pain (Asaba et al., 2013; Venkataramanan et al., 2020). Recurrent injuries from water collection can also lead to disability (Geere et al., 2018). Water fetching after dark increases the risks of rape, sexual harassment, gender-based violence, and other physical attacks (Caruso et al., 2015; Choudhary et al., 2020). Water collection is also linked with higher emotional distress and reduced daily functioning (Tomberge et al., 2021). Cumulatively, water insecurity affects women's mental and psychosocial health by increasing levels of stress, anger, anxiety, shame, and stigma (Bisung and Elliott, 2016; Wutich et al., 2020).

Though a large body of literature underscores the strong relationship between place and health (Cutchin, 2007; King, 2010; Adams and Nyantakyi-Frimpong, 2021), studies on water insecurity have not paid sufficient attention to place-based environmental risks of the water fetching journey. Specifically, they have largely overlooked how exposure to risks during water fetching contributes to embodied experiences of water insecurity. The meager literature that addresses the water-fetching journey usually limits the burdens of water collection to number of trips, waiting time, and the weight of water-collection containers (Bapat and Agarwal, 2003; Crow and Odaba, 2010; Adams, 2018). In one of the few exceptions, a study in Dar es Salaam, Tanzania, employed spatial video and mapping to uncover the many challenges in the water-fetching environment, including trash, open drains, uneven terrains, and people (Smiley et al., 2017).

To address this research gap, we used walking (go-along) interviews, videos, and risk coding to examine how women's everyday struggles for water in informal settlements expose them to environmental risks and compromise their health and well-being. Our specific objectives are to 1) examine women's everyday struggles for water, 2) identify the environmental risks on women's water-fetching paths and their potential health impacts, and 3) examine the embodied dimensions of these experiences. We define *risks* as physical, social, or environmental factors that might cause harm. We use the term *informal settlements* to indicate unplanned residential areas where the lack of many public services is pervasive - including access to safe water - which others may refer to as urban unplanned settlements or slums. Through a combined focus on observed (via video) and perceived risks (via interview), this study draws from and contributes to the anthropological and geographic concepts of embodiment, the embodied political ecology of health, and time geographies. We argue that water journeys, beginning with the seemingly simple practice of water fetching, is compounded by complex decision making, constant spatiotemporal trade-offs, and exposure to diverse risks, all of which have embodied health consequences.

2. Theoretical framework

While the construct of embodiment has origins in epidemiology and medical/biological anthropology, it has increasingly become a useful framework in human geography for theorizing the impact of resource insecurity on bodies. Embodiment acknowledges that humans are simultaneously social and biological (Csordas, 1999; Robinovich et al., 2018). It asserts that bodies reflect real livelihood challenges closely intertwined with power and inequality (Petteway et al., 2019). Krieger (2005), for instance, highlights that 1) bodies tell stories about—and cannot be divorced from—the conditions of our existence; 2) bodies tell stories that often—but not always—match people's stated accounts; and 3) bodies tell stories that people cannot or will not tell. These stories provide insights into how historical processes deepen social inequalities and create uneven exposure to health risks (Krieger, 2005). It invites careful analysis of how social and environmental experiences “get under our skin” to affect health (Petteway et al., 2019, p. 1). Analysis of

embodiment requires keen attention to how ecological conditions and social processes such as power relations, institutions, culture, inequality, and behavior are entangled in the stories that bodies tell (Krieger and Davey Smith, 2004).

Critical scholars of political ecology of health (PEH) acknowledge that the subfield has not focused sufficiently on embodiment (Jackson and Neely, 2015). This critique has prompted renewed interest in embodiment among PEH researchers. For instance, one emerging body of work, broadly classified as political ecology of the body (see Kinkaïd, 2019), takes seriously the body as an analytical site for understanding society-environment relations (Doshi, 2017; Mountz, 2018; Petteway et al., 2019). Embodied political ecology of health (EPEH) allows for more rigorous analyses of often-invisible dimensions of socio-environmental struggles tied to the body. For example, Nyantakyi-Frimpong (2021) uses an EPEH approach to examine how climate change increases women's workloads and causes undernutrition by altering child-feeding practices, while Kinkaïd (2019) uses the framework to interrogate the embodied health impacts of chemical farming in north India.

Recent work on gender in urban spaces has, similarly, examined the body as infrastructure (Andueza et al., 2021; Desai et al., 2015; Ramakrishnan, O'Reilly and Budds, 2021; Truelove and Ruszczyk, 2022). Such scholarship illustrates how bodies express uneven experiences and politics of resource flow in cities. For example, Truelove and Ruszczyk (2022) demonstrate how the body as infrastructure underpins not just social and material workings of the city but the everyday politics that enable and constrain resource flows. Attention to “embodied infrastructural configurations,” they argue, reveals important social and political dimensions of everyday urban life (Truelove and Ruszczyk, 2022, p. 2). Similarly, in examining the politics of open defecation by looking at the entanglements of the body with urban sanitation infrastructures, Desai et al. (2015) reveal the urban micro-politics that shape how infrastructures are made, unmade, and experienced unevenly by different bodies.

Despite many studies theorizing that water insecurity can become embodied, empirical analysis in this area remains underdeveloped (Rosinger and Brewis, 2019; Brewis et al., 2020). Recently, Rosinger et al. (2021) established how water insecurity becomes embodied through injuries and chronic stress. Elsewhere in Dhaka, Bangladesh, Sultana (2020) found connections between water, embodiment, and urban citizenship. We build on these emerging streams of inquiry by extending the EPEH framework to an urban context and focusing on the water-fetching journey as an embodied but largely overlooked dimension of water insecurity. By looking at both observed and perceived risks, we contribute to EPEH by uncovering less visible aspects of socio-environmental struggles and their embodied impacts. Importantly, our paper moves the water insecurity literature forward by conceptualizing embodiment as simultaneously physical and emotional.

We also borrow insights from time-geographical approaches that emphasize that spatial and temporal interdependencies between individuals and their environment influence health (Rainham et al., 2010). Examining how humans allocate scarce time resources among different, competing activities in geographic space (Miller, 2005), is particularly useful in understanding the role of space-time constraints in women's everyday water journeys and decision making. Further, it is useful for understanding how women survive different environmental conditions and cope with spatiotemporal constraints by reshuffling everyday livelihoods (Fajarwati et al., 2022). Thus, engaging with time geography is important for at least two reasons: 1) water journeys are about how individuals' everyday water collection activities are arranged and coordinated in time and place; and 2) time-varying exposures through water collection have health consequences.

Water journeys are far from straightforward and are often embedded in temporal, emotional, and structural calculations and trade-offs (Panchang, 2021). In the present conceptualization of the water journey, we situate urban water-insecurity experiences in the body

while combining insights from time geographies to further illuminate spatial and temporal dimensions. This combined approach opens new possibilities for understanding how different experiences of water insecurity produce diverse physical, emotional, and health effects, particularly among women, and how everyday practices, social relations, politics, gender, and emotions influence water insecurity experiences in urban environments (Doshi, 2017; Truelove, 2019).

3. Methods

3.1. Setting

We undertook this study in Ntopwa, a crowded informal settlement in Blantyre, the second-largest city and commercial center in Malawi (Fig. 1). Data were collected in the rainy season (January 2018). While Malawi has made significant progress toward improving access to safe water, it is far from achieving the universal coverage of safe drinking water specified in the United Nations' Sustainable Development Goal Six (United Nations, 2018). Over the last few decades, growth in the urban supply of potable water has not kept pace with growth in demand from population increase and rapid urbanization. Further, widespread inequalities in access to potable water persist between affluent neighborhoods and informal settlements (Adams, 2018). The major water-access challenges in Malawi's urban areas include intermittent water supply, frequent breakdowns of communal water kiosks, and long waiting times at water points (Adams, 2018). In Ntopwa, most residents are unable to pay the high cost of publicly available water from improved sources (Coulson et al., 2021). These factors force people to seek alternative, often unimproved, sources of water, such as streams, rivers, and shallow open wells. One study found that use of river water for cooking and cleaning was associated with increased risk of typhoid fever in Blantyre (Gauld et al., 2020). Other studies have established that even water sources generally considered safe by Ntopwa residents have significant concentrations of *E. coli* (Price et al., 2021), a finding that is consistent with recent work showing that allegedly safe sources in Malawi may be contaminated (Holm et al., 2016; Boakye-Ansah et al., 2016).

3.2. Participants

As women are primarily responsible for household water collection in Malawi, we focused on female water collectors. Using convenience

sampling, we recruited 25 women at 5 different types of water points in Ntopwa: boreholes, water kiosks, public taps, small ponds, and shallow wells. Participating women were aged 18 years or older and provided written or verbal consent. The University of Stirling's General University Ethics Panel approved this study (reference GUEP169). We submitted the study proposal and ethical clearance to the Blantyre City Council, which reviewed it, provided an acceptance letter, and put us in touch with community leaders.

3.3. Data collection

We used video-recorded walking (go-along) interviews to gather data on perceived (by the participant) and observed (by the researcher) risks during water fetching. This approach built on previous work using spatial video to explore risks at the water point during water collection (Smiley et al., 2017). A trained local female research assistant (RA) undertook the interviews in Chichewa, a common local language of Malawi. Questions explored water access, water use, experiences of water collection, and perceived risks during water journeys. Interviews were semi-structured, allowing flexibility to explore topics that arose during the interview and to enable place-based questioning dependent on dynamic observations and experiences of the RA and interviewee during the walk. The RA wore a GoPro HERO5 on a chest strap to video record the route and audio record the interview. This method supported more natural conversation since the interviewee wore no recording devices and the RA had her hands free. The method was piloted locally before data collection began.

3.4. Audio data analysis

All audio files were translated into English, transcribed, and saved as a Word document. Following established procedures in qualitative data analysis, we analyzed the transcripts using five steps: data familiarization, independent coding, code consolidation, thematic sorting, and content extraction and analysis (Miles et al., 2014). First, two coauthors (EAA and SB) hand-coded the transcripts independently using a thematic analysis approach to identify common and recurrent themes related to the research objectives. Coding was done both deductively to identify predetermined themes related to water-fetching risks and inductively to explore additional dimensions of risks and water-fetching challenges. The coders generated about 40 codes, falling under topics including water insecurity, risk types, contamination, perceptions of

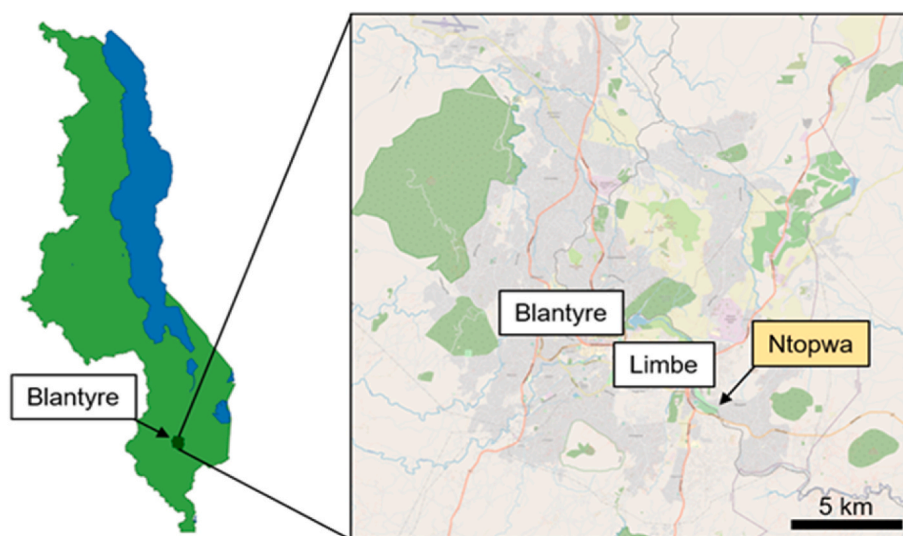


Fig. 1. Map of Malawi showing the location of Ntopwa relative to the twin centers of Blantyre and Limbe. Background map for the right-hand panel from © OpenStreetMap contributors.

water quality, and water use. Through a series of iterations and discussions regarding their independent sets of codes, the two coders agreed on the final codes. The selected codes were then combined under three overarching themes: 1) water insecurity experiences and coping strategies; 2) everyday planning and decision making; and 3) perceptions of risks, contamination, and hygiene.

3.5. Video data analysis

We used an approach similar to Smiley et al.'s (2017) to code the walking routes for risks and challenges. First, two researchers watched 30% of videos together to develop a consistent approach to code generation. Both researchers were familiar with Ntopwa, having been present during data collection (HP) or worked there previously (EAA). Using observation and discussion, researchers identified risks and challenges the water collectors experienced under each of three categories: terrain, built environment, and people and behavior. We considered built environment to be any aspect of the environment with less human footprint or one that is more structural and less likely to change with time. People and behavior, on the contrary, denote risks that change more rapidly and can more easily be linked to everyday decisions by people, such as vehicles, washing lines, and waste. Researchers then coded the remaining videos independently. Once independent coding was complete, the researchers discussed their experiences of coding and areas of divergence before reaching a consensus on codes. Risks and challenges were then grouped into themes. GPS data from the water-collection journeys were combined with the video data to explore the spatial distribution of observed risks and challenges using QGIS (version 3.20.2). Route data were available for 92% of walking interviews ($n = 23$).

4. Results

4.1. Water insecurity experiences and coping strategies

Based on observations and qualitative analysis of audio interviews, we found that participants collected water from public taps, kiosks, boreholes, wells, and rivers/ponds (Fig. 2). Depending on level of demand, water from small ponds and shallow wells could be fetched for free, while water from kiosks and public taps cost between 35 and 80 Malawi Kwacha per 25-L bucket. Most participants used public tap and water kiosk water for drinking and the water from the other sources for household cleaning, bathing, laundry, and cooking. However, families who could not afford tap water relied entirely on wells and rivers. Daily expenditure on water varied widely; households spent 100 MK (0.12 USD) to 400 MK (0.48USD) daily depending on factors including cost per bucket, family size, daily need, and number of water-related chores. Most women did not know their exact monthly water expenditure because of daily variation in water purchase and use. Some of those who

could not afford to buy water every day leveraged friendships with water vendors to fetch water and pay later.

Many women shared frustrations about unpredictable water supply and long waiting times at the water kiosk. For example, some women reported arriving at the water point as early as 2 a.m. to mitigate for intermittent supply, especially during the dry season. While the walking times to primary sources, which we defined as the main source for most household needs, were short—with one-way trips ranging from 25 s to 7 min and an average of 3 min across all participants—waiting times were long, often extending beyond an hour. Coupled with the need for multiple trips, often to supplementary sources, water fetching was a significant time burden, especially for those with fewer buckets. Some women lamented that wait times were unpredictable and therefore derailed daily plans to complete household chores such as cooking. Conflicts often occurred between women at the water point because of disagreements over arrival time, position in queue, bucket theft, and number of buckets one person could fetch. On rare occasions these conflicts escalated into fist fighting.

Women used diverse strategies to cope with different aspects of water insecurity. When taps stopped flowing, the most popular alternatives were water kiosks in other communities, private taps owned by individuals, boreholes, and rivers and wells, which many described as unsafe for drinking. To carry water over longer distances, most women used small buckets, which reduced how much water they could access per trip. Finally, communal practices of water sharing at the water point were critical to how women dealt with intermittent supply. These practices included, for example, allowing only one bucket at a time per person until everyone in line had water. These norms were started either by individual water fetchers, water sellers to prevent conflicts, or traditional leaders to ensure fair water access.

4.2. Navigating water insecurity through everyday planning and decision making

Everyday decisions, planning, and budgeting were critical to how women navigated the uncertainties of water insecurity. To minimize water use, reduce water expenditure, and cope with intermittent water supply, women triaged water-related tasks at home, used water from different sources for different needs, and planned when and how to complete household tasks. To reduce water expenditure and reduce water carrying, some washed dirty clothes in the river. Most women would first secure safe drinking water from the taps before fetching water from wells and rivers for other uses.

Interviewees reported a range of decisions that underpinned their water-fetching journeys (compiled in Fig. 3), beginning with a thorough assessment of needs and capabilities. This assessment included, at minimum, how much water was needed on a given day, income versus cost of water, choice of route, and household storage capacity. Planning for the journey also involved budgeting money and time while being



Fig. 2. Examples of key local water sources used by Ntopwa women: a) public tap, b) water kiosk, c) borehole, d) well, e) pond, and f) river.

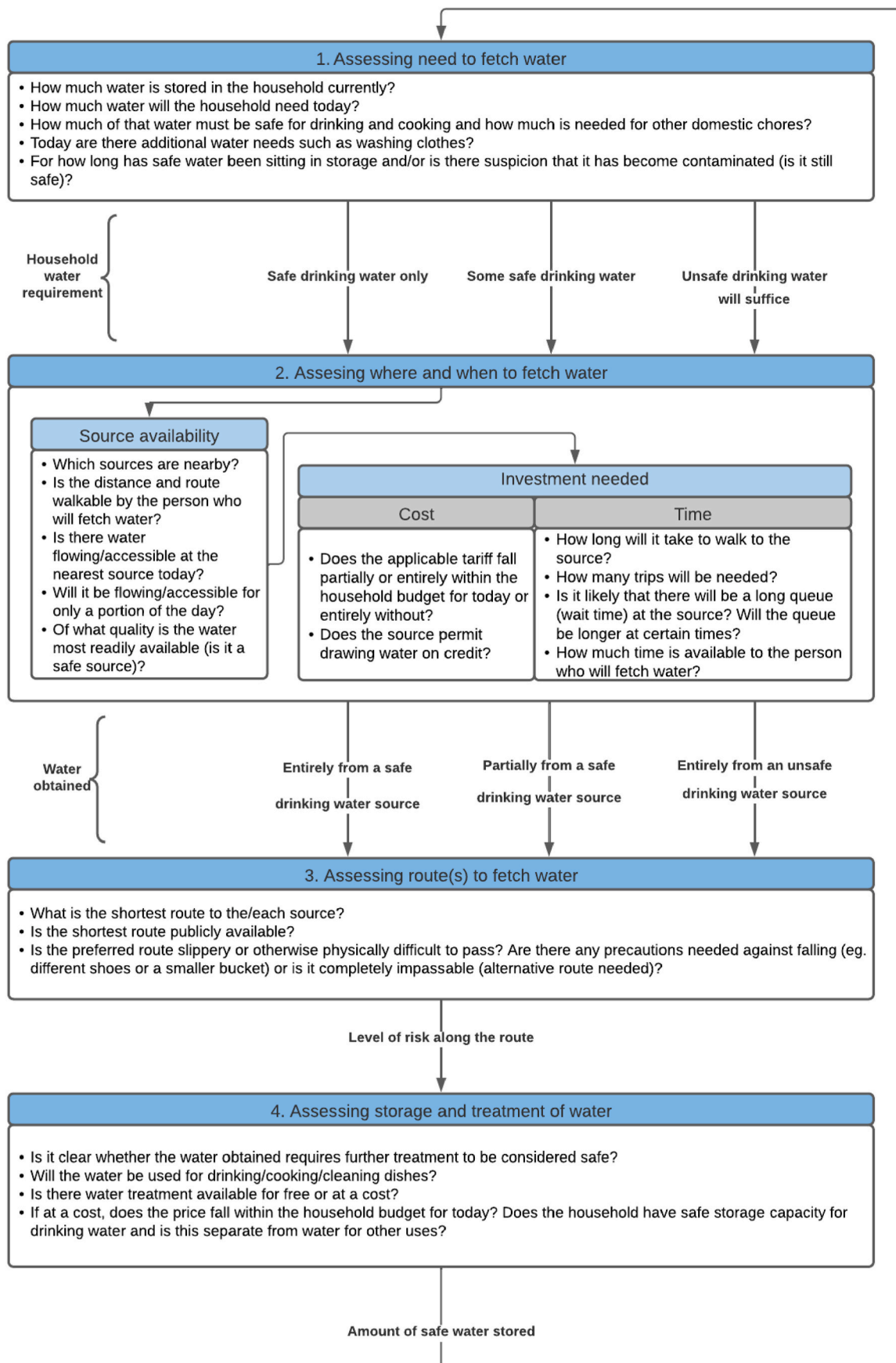


Fig. 3. Domains of decision making for women collecting water in Ntopwa.

cognizant of uncertain water supply. These domains of decision making are neither chronological nor idealistic. Rather, the order in which they are considered, and the weight given to each on a given day may be influenced by different factors, including day, season, cost, competing household chores, and other space-time considerations.

Women also described the multiple measures they took once home with the water to prevent cross contamination, including separating used and unused drinking cups, allocating specific cups for water fetching from buckets, and keeping used cups far from buckets. Mothers reported monitoring young children regularly to ensure that used and unused cups were not mixed, and fingers were not dipped in stored water. In some households, if water originally earmarked for drinking displayed visible signs of contamination, they discontinued using it for drinking and instead used it for cleaning and washing dishes. Some households separated buckets for everyday use from storage buckets to prevent mixing of clean and unclean water.

The decision-making process for water fetching is rife with trade-offs, many of which have consequences either on the quality of water obtained or on the physical, financial, or time burden placed on the water bearer. Fig. 4 shows the difference between four participants that described one aspect of decision making – where to fetch water – and the resulting trade-offs. Those participants who were able to avoid a trade-

off on water quality, whether through proximity to a reliable safe water source and/or greater financial security or otherwise, experienced less water insecurity. However, all participants in this study experienced a high base level of water insecurity, as water journeys can be unpredictable and costly. Women can leave their homes not knowing where they will find water, how much they will need to pay, or how long they will have to wait for it.

4.3. Perceptions and experiences of risks described in interviews

The most common risks reported by women on their water-fetching routes were slippery terrains, sharp objects, muddy paths, rocks and stones, mosquitoes, and conflicts. Table 1 illustrates some of the common complaints about environmental risks. Many women indicated that water fetching was more difficult during the rainy season because of muddy and slippery terrain. Slippery paths littered with rubbish were even more difficult to pass. Some women said falling was quite common, but they accepted it as part of their water journey. To avoid slipping, some women chose to go without shoes, but this strategy also exposed their feet to sharp objects that could similarly cause harm to their bodies. Some removed their footwear to avoid slipping while fetching water, especially from rivers and streams. Some women tried walking slowly

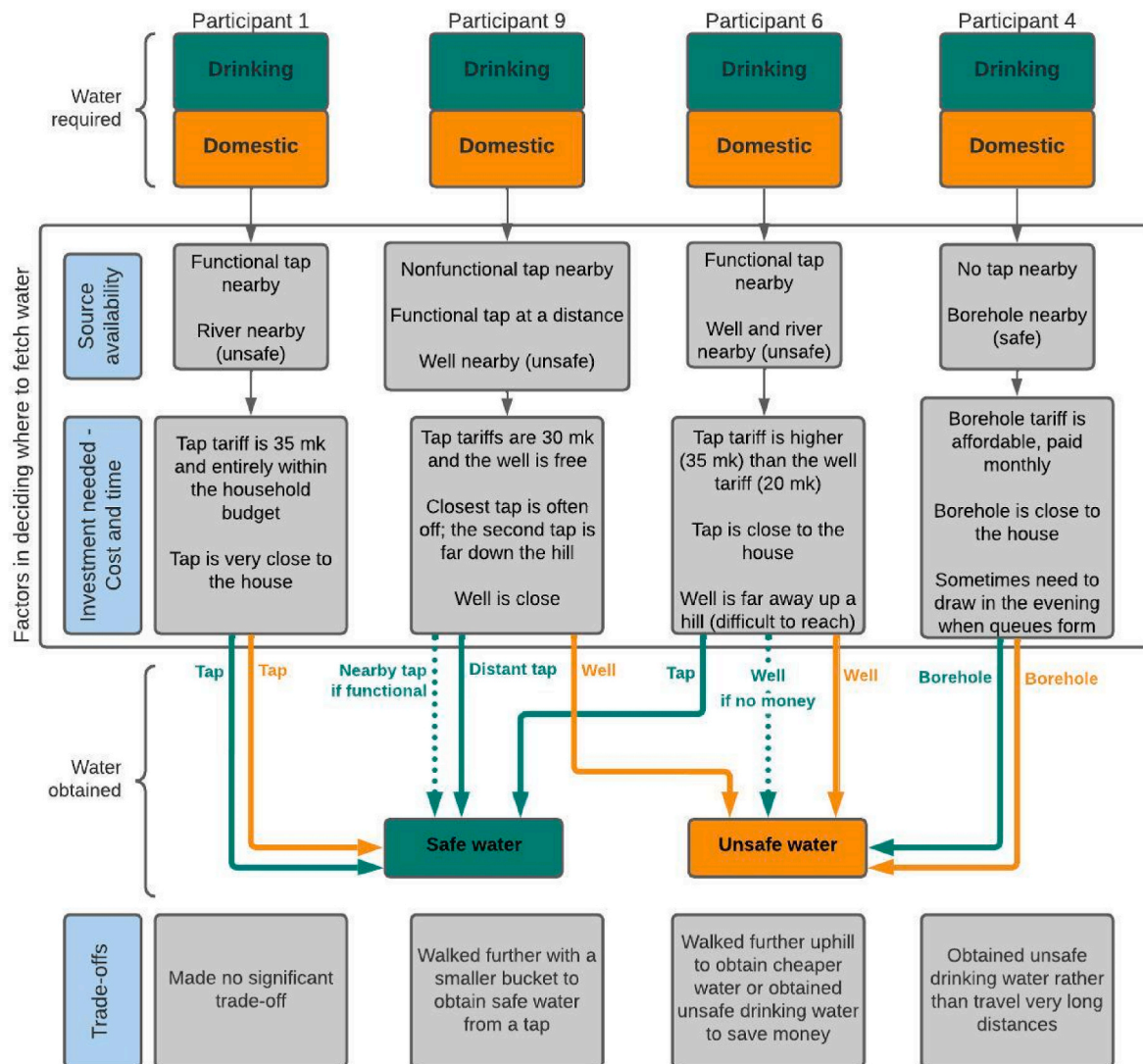


Fig. 4. Examples of factors that led four participants to make different trade-offs when fetching water. Participants listed from left to right as least to most water insecure.

Table 1
Perceived water-fetching risks and illustrative quotes from transcripts.

Risk	Illustrative Quote
Slippery terrain	"You can lose your footing and fall of course when it gets slippery at times. I have fallen before" (#13)
Falls	"It's possible that I can fall, and if it happens that the water has spilled, then I return to the tap, wash the bucket out, refill it, and return home with it." (#14)
Drowning	"A child can drown, but an adult cannot. The well is waist deep. A child can drown. If I were to stand in the well, the water will only be level with my waist." (#21)
Sharp objects	"... the problem is thorns and sharp objects that we regularly step on as we are walking." (#4)
Mosquitoes	"Obviously there are mosquitos breeding here for sure." (#1)
Muddy path	"It's muddy here. When it rains, this place is very muddy, making walking difficult." (#7)
Rocks/stones	"We walk through the stony path, what else can we do?" (#12)
Route conflict	"We get shouted at. We get told that 'this is not a public road.'" (#16)
Road crossing	"We must cross the tarmac road to get there when water is scarce. We wait for the cars to pass before we cross the road." (#14)

and watching every step to guard against potential falls. Others complained of thorns and other sharp objects that cause stumbling, falling, and injuries. Many used expressions of acceptance, such as 'We are used to it' (#11), 'We just keep walking' (#10), 'We pick ourselves [up] and continue walking; what else can we do?' (#6), 'We have no other option' (#5), 'You just have to be strong. What else can I do?' (#5), and 'What else can we do since water is life?' (#2). In one instance, a woman said the following about her experience on slippery terrain: 'It gets slippery of course, but what can you do? As a woman, you must just use your feet and knees until you get home.' (#24).

Most women recognized potential sources of water contamination and took steps to minimize exposure to fecal pathogens. During their water journey, some avoided sticking their fingers into the water bucket. Others took preventative steps at home to avoid compromising the quality of their water. For example, those who fetched water with buckets or containers with no covers would improvise covers at home to try to keep the water safe. Some avoided using water from boreholes constructed near toilets because of fear of contamination through groundwater leakage. Those women who failed to take preventative measures stated that they knew about the risks of using contaminated water but were constrained by other factors such as finances, time, or mobility.

4.4. Risks and challenges observed from videos

We identified 442 risks or challenges during 25 walks from the water source to the house (one-way trip) through observations of the routes taken (Table 2). On average, there were 6.3 risks or challenges per minute (range 1.9–15.2). The most common of these were rocks and stones ($n = 82$; terrain), uneven/sloping ground ($n = 74$; terrain), muddy or slippery ground ($n = 52$; terrain), water-filled drainage channels ($n = 46$; terrain) and waste ($n = 39$; people & behavior). Narrow paths ($n = 26$; built environment), steps ($n = 24$; built environment) and dry drainage channels ($n = 22$; terrain) were also common. Most of the risks and challenges related to terrain (68.8%; $n = 304$), followed by people & behavior (17.6%; $n = 78$), and built environment (13.6%; $n = 60$). It is worth noting that because dense urban areas such as Ntopwa often have shorter walk times to off-premise supply compared to the national average, which is driven more substantially by rural contexts and statistics, the volume and variance of risks observed on an average water journey in Malawi would likely be greater. Examples of the challenges and risks encountered are shown in Fig. 5.

We plotted observed risks and challenges on a map to explore spatial patterns (Fig. 6). Women experienced risks and challenges relating to terrain across the community, including along the major routes through

the settlement, as highlighted by the concentration of terrain-related challenges observed along the main horizontal path/road through Ntopwa (Fig. 6a; black arrow). Risks and challenges relating to the built environment were observed predominantly in the most densely populated parts of the settlement and around water points (e.g., steps down from the kiosk to the path). Risks and challenges relating to people and behavior were observed where people were using and sharing spaces, for example along main routes through Ntopwa and in more densely populated parts of the settlement which were used for multiple purposes at once, for example, walking through to fetch water, drying, washing, or cooking. In Fig. 6b, we combine the spatial patterns of risks and challenges with frames from video footage to illustrate in more detail what a typical walk to fetch water looked like for one woman.

Use of the video during the walking interviews enabled researchers to observe the women's footwear, facial expressions, and carrying techniques. For example, while crossing a wide, deep ditch with a full bucket of water, one woman removed the bucket from her head (Fig. 7a–c), carried it in her hands in front of her (Fig. 7d–h) while stepping across the ditch (Fig. 7i), rested it on a rock shelf once across the ditch (Fig. 7j), and put the bucket back on her head before continuing her walk (Fig. 7k–l). This example highlights the varied physical strains water collection places on bodies and the high number of body movements involved in navigating a single hazard.

5. Discussion

Many of our findings align with the literature on urban water insecurity, showing high household expenditures on water, intermittent water supply, and a heavy time burden of multiple trips and long waiting times (e.g., Adams, 2018; Sarkar, 2020; Cassivi et al., 2021; Stoler et al., 2020). Our finding that some areas coped with water insecurity by instituting one-bucket-at-a-time rules at the water point is consistent with the emerging literature on water sharing (Wutich et al., 2018; Bukachi et al., 2021). Some coping mechanisms illustrated inequalities in water-insecurity experiences – for example, households with more buckets could store more water and therefore limit the number of trips, and households who could afford additional tap water did not have to do their laundry in the river.

Our approach of using video-recorded walking interviews during everyday water journeys allows us to go beyond examining these experiences of water insecurity, to map the different pathways through which an activity like water fetching predisposes people in a community to different environmental risks. Direct observation of water fetching encouraged us to broaden our initial conception of risks from primarily physical to important social dimensions such as conflicts on private routes. It has also enabled us to consider urban water insecurity as an embodied experience from decision making through trips to water points and household practices for use and storage. The following analyses advance both the embodiment and the EPEH literatures by bringing to light how social and environmental struggles 'get under the skin' and affect health through visible and invisible pathways (Krieger, 2005; Petteway et al., 2019).

5.1. Bodies as infrastructure: physical embodiment

Water-insecurity experiences become physically embodied through impacts on women's bodies and livelihoods (Rosinger et al., 2021), in part due to a reliance on bodies as infrastructure (Truelove and Ruszczyk, 2022). In the present study, there are at least two salient ways in which women's bodies act as infrastructure. The first is obviously through the transportation of water from the source to the home which would, in other contexts, be performed by pipes. As in previous work, we found that women are exposed to many risks of injury during water fetching including not only the carrying of heavy containers but also navigating difficult physical environmental factors such as slippery terrains, narrow paths, ditches, puddles, sharp objects, stones, and tree

Table 2
Risks and challenges encountered during journeys from water source to home identified from videos.

#	Source	One-way trip time (mm:ss)	Terrain										
			Lid	Ditch	Drainage channel – dry	Drainage channel – wet	Muddy/slippery ground	Narrow path	Puddles	Rocks and stones	Step	Uneven/sloping ground	Tree branches and roots
1	Tap	03:31	N	0	1	2*	1	0	1	1	0	3	0
2	Tap	02:21	N	1	1	2*	0	0	0	3	0	1	0
4	BH	01:43	N	1	0	0	1	0	0	2	0	2	0
5	Kiosk	03:42	N	0	1	0	0	0	0	2	0	3	0
6	Well	05:07	N	1	5	5	3	0	0	7	0	7*	0
7	Kiosk	01:31	Y	0	1	1	0	0	0	3	0	2	0
8	Pond	02:22	N	1	0	2	2	0	0	2	0	1	0
9	Kiosk	02:29	N	0	0	1	1	0	0	2	0	0	0
10	Tap	04:57	N	1	4	3*	1	0	0	6	4	2	0
11	River	01:39	N	0	2	0	1	0	0	6	0	6	0
12	Tap	02:00	N	0	1	0	0	0	0	2	0	3	0
13	Tap	01:33	N	0	1	1	0	0	0	1	0	1	0
14	Tap	00:25	N	0	1	0	0	0	0	1	0	1	0
15	Kiosk	00:50	N	0	0	0	1	0	0	2	0	2	1
16	Kiosk	06:00	N	0	0	7*	7	1	1	8*	0	4*	0
17	Pond	03:10	N	0	0	3	4	0	0	7	1	5	0
18	Pond	05:44	N	0	0	5	9	0	1	9	0	8	0
19	Well	07:36	N	2	1	3	4	0	2	1	0	4	0
20	BH	04:11	N	0	0	0	5	0	1	3	0	1	1
21	Pond	01:59	N	0	0	3	1	0	0	1	0	1	0
22	Kiosk	02:55	Y	1	0	2	3	0	0	1	2	3	1
23	Tap	04:02	Y	0	2	1	2	0	0	6	0	5	0
24	Tap	04:18	Y	0	1	3	4	0	0	4	0	6	0
25	Kiosk	01:26	N	0	0	1	1	1	0	1	0	2	0
26	BH	02:37	N	0	0	1	1	0	0	1	0	1	0
	TOTAL:			8	22	46	52	2	6	82	7	74	3

For each specific risk or challenge, the number shows how many times it was encountered on the water fetching route and n* indicates that one or more instances of the risk or challenge were sustained for part of the journey. For the water sources outlined, all taps refer to public taps and BH = borehole. The 'Lid' column relates to whether the water fetcher put a lid on the bucket (Y) or not (N).

branches (Geere et al., 2018; Venkataramanan et al., 2020; Patil and Sangle, 2022). Another way in which women's bodies act as infrastructure is by sacrificing sleep to join early morning queues, or traveling even longer distances to access alternate sources, to compensate for intermittent supply – a challenge often addressed through infrastructure such as municipal storage tanks.

A large portion of the risks women encountered during water journeys stemmed from the built environment as well as from people and their behavior (Fig. 5). As established elsewhere, social and behavioral factors in densely populated areas elevate the risk of falls and injuries because women have to carefully move around people who are using the same route and navigate wet terrains and puddles created by roadside laundry and cooking (Smiley et al., 2017). Women in our study had to cross constructed ditches, move sideways through narrow spaces between buildings, and bend under clotheslines while carrying water, all of which could result in musculoskeletal and spinal injuries (Venkataramanan et al., 2020). While crossing ditches, women oriented their bodies in ways that could lead to pain and lumbar injury (Fig. 6). These findings support calls for more systematic biomechanical analyses on how different postures and movements during water carrying affect the spine (Patil and Sangle, 2022). Further impacts on women's bodies occurred at the water point, through conflicts over arrival time, bucket thefts, and contested positions in the queue that were commonplace and sometimes escalated into brawls. Some suffered verbal assaults while looking for water from private sources in other neighborhoods.

Analysis of the videos revealed significantly more risks in both number and type (442 risks in 23 categories across 25 journeys; Table 2) than women self-identified during the interviews, suggesting that many

risks are so embedded within the everyday water-fetching experience that they are invisible to those experiencing them. We found that on average, women tended to identify risks related to terrain or social conflicts more readily than risks stemming from the built environment. That many observed risks were not perceived by participants has implications for practitioners designing urban policies and programs, in that relevant risks may not be identified through community consultation alone.

5.2. Mental burdens of water insecurity: emotional embodiment

Previous work has illustrated how fear of injuries from water fetching can induce psychosocial stress (Bisung and Elliott, 2016). Our study found that another pathway that water insecurity becomes embodied is through the emotional burden of planning and decision making, which shapes several aspects of women's daily lives. These decisions are neither simple nor casual and comprise a complex web of considerations involving difficult trade-offs (Panchang, 2021). Participants in the present study reported making complex choices as they planned their daily water-fetching journey: assessing household water needs, deciding where to fetch water and the route they would take, and deciding how water would be stored and whether it would be treated. Within the framework of time geographies, this contingent decision-making process considering multiple factors such as availability, cost, and time, highlights not only the spatial and temporal limitations of a single trip but also daily fluctuations in water insecurity and related decision making (Magnus, 2018; Price et al., 2019; Pers et al., 2022). These decisions are also embedded in social influences, which

Terrain	Built environment					People & behavior							TOTAL
	Low door	Low roof	Narrow path	Step	Other	Fingers in water	Household items on path	People and animals	Vehicles	Washing lines	Waste	Other	
0	0	0	0	1	0	1	0	2	0	0	2	0	15
0	0	1	0	0	0	1	0	1	0	1	1	0	13
0	0	0	2	0	0	0	0	0	0	0	0	0	8
0	0	0	0	1	0	0	0	0	0	0	1	0	8
0	0	0	3	1	0	0	0	0	0	0	5	0	37
0	0	0	2	1	0	0	0	0	0	1	0	0	11
0	0	0	0	0	0	0	0	1	0	0	1	0	10
0	0	0	0	1	0	1	3	0	0	1	1	0	11
0	0	1	6	0	0	0	1	0	0	2	2	0	33
0	0	0	3	0	1	0	3	0	0	1	2	0	25
0	1	0	1	2	1	0	0	0	0	2	0	0	13
0	1	0	0	0	1	0	0	2	0	0	0	0	8
0	0	0	0	0	0	0	0	2	0	0	0	0	5
0	0	0	2	1	0	0	0	1	0	0	0	0	10
1	0	0	1	0	1	0	0	0	0	0	7	0	38
0	0	0	2	1	0	0	0	0	0	0	0	2	25
0	0	0	1	1	0	0	0	0	0	0	4	0	38
1	1	0	0	2	0	1	0	1	2	0	2	0	26
0	0	0	0	0	0	0	1	0	0	0	3	0	15
0	0	0	3	2	0	0	0	0	0	0	1	0	12
0	1	0	0	2	0	0	1	0	0	1	3	0	21
0	0	0	0	2	0	0	0	0	1	0	1	0	20
0	0	0	0	3	0	0	1	2	0	0	1	0	25
0	0	0	0	2	0	0	0	0	0	0	2	0	10
0	0	0	0	1	0	0	0	0	0	0	0	0	5
2	4	2	26	24	4	4	10	12	2	9	39	2	442

Krieger and Davey Smith (2004) show can then become embodied into health. Furthermore, the sheer number of decisions and the trade-offs involved implicitly add to the mental energy as well as the time required for water fetching.

Each decision or incident along the way can also compound the number of worries a woman might experience on a water journey. For example, our study uncovered a cascade of consequences from a fall that participants worried about. A woman falling while carrying water loses both the cost of the water and the time they took to walk and queue for it. A broken bucket from a fall necessitates a trip back home for another bucket and reduces overall household storage capacity. One less bucket at home could also mean cross-contamination of water for drinking and domestic purposes. In this way, the psychosocial stress caused by fear of falling extends well beyond the fear of physical injury. These dimensions of psychosocial stress underscore the increasing importance of analyzing the embodied impacts of water insecurity, which are not just physical, but also emotional.

5.3. Water fetching: an survival and acceptance as embodiment

Perhaps the most striking sign of embodiment of urban water insecurity we observed was women’s acceptance and normalization of the many risks, uncertainties, and challenges associated with the water journey—illustrated by expressions such as ‘We are used to it’. Other statements, like ‘As a woman, you just have to use your feet and knees until you get home,’ illustrate how women sacrifice their bodies daily as infrastructural labor to make up for uneven flows of water in cities (Lancione and McFarlane, 2016; Truelove and Ruszczyk, 2022). Women normalized their everyday experiences of water insecurity for different reasons. First, because water is indispensable for household functioning,

many women viewed water fetching as an act of survival, normalizing risk in the interest of self-preservation and avoidance of debilitating stress. As one participant said, “Human life depends on water, so if we get discouraged after a fall then there won’t be anything good” (#24). This view suggested that the daily need for water is normal, so all aspects of fetching water must also be normal. Second, there was a general sense of recurrence among women, most of them well accustomed to water-insecurity experiences. Obtaining water required them to repeatedly optimize labor, time, and cost. It also required them to internalize risk because the trade-off involved water, a necessity for their family’s well-being. Third, women communicated an undercurrent of helplessness associated with institutional and sociopolitical failures to address water challenges. Statements such as ‘We have no choice’ show that women recognized how little they could change about deep-seated institutional failures that produce water insecurity.

Such acknowledgements of state failure, no matter how subtle, are manifestations of how water insecurity is tied to historical processes of social inequality and embodied through social and material struggles (Brewis et al., 2020). It is also a notable critique of the often all-or-none thinking behind water strategies that prioritize technical drinking water standards over ease of access. For example, in Malawi there has historically been controversy over self-supply approaches, with proponents arguing for incremental improvements while opponents say it compromises on water quality and other technical standards. Those opposed to self-supply for reasons of water quality, though likely considering health and wellbeing, may be overlooking the negative health impact on women’s bodies when fetching water for domestic use from a distant source. Our study shows that most women were already well-aware of the dangers of drinking unsafe water and drawing from different water sources accordingly. Private sources for domestic use could therefore

help to reduce the number of long-distance water journeys required without increasing consumption of contaminated drinking water.

5.4. Lessons and limitations

Recent geographical scholarship has called for consideration of walking interviews as a valuable data-collection method, especially for understanding urban phenomena (Pierce and Lawhon, 2015). Despite having a long history in ethnographic research (Kusenbach, 2003), walking interviews have only become central to geographic research in the last decade. Our study affirms walking interviews as a powerful method for eliciting everyday lived experiences in informal settlements in support of embodiment research. This method is useful for understanding human interactions with the natural environment and people's lived experiences in different social and physical contexts (Carpiano, 2009; Evans and Jones, 2011). It also enables the researcher to build rapport with research subjects and develop useful networks in study communities (Carpiano, 2009). In urban environments, this method can uncover otherwise-invisible experiences of inequality.

Walking interviews enabled us to achieve more in-depth findings than traditional household interviews or surveys would have yielded. They enabled the RA to use dynamic questioning in response to place-based observations regarding relevant social and physical phenomena (Carpiano, 2009), reduced the power imbalance between the interviewer and the interviewee by situating the interview on a route familiar to the interviewee and avoiding the pressure of face-to-face interviews, and decreased the time burden placed on participants since the interview took place during an activity they were already undertaking. Occurrences during the water-fetching journey triggered emotions about water insecurity and water-fetching risks that women might not otherwise have communicated. The present study provides a useful example of combining interviews and spatial video that could be used in future studies to achieve a fuller understanding of the water journey. By combining interviews with video data, we can better understand 'the stories bodies tell in conjunction with those recounted—or hidden or denied—by individuals' (Krieger, 2005, pg 351).

Despite these advantages, we encountered a number of challenges inherent to these methods that researchers wishing to use them in future studies should consider. Because interviews happen along an uncharted path, the interviewer must be sufficiently skilled to adapt questioning to the surrounding environment and, potentially, to operate multiple pieces of equipment simultaneously (e.g., video recorder, GPS). This complexity necessitates that interviewers undergo enhanced training on methods and that the methods are piloted locally. Informal settlements often have significant background noise, including, as in our case, the noise of wind and the in-built microphone scratching against clothing. Adding a clip-on audio recorder to the interviewer, and even the interviewee if possible, can ensure that the audio is audible throughout the interview recording, which is vital for transcription and translation. Additional straps to reduce the swinging of the video recorder while walking would also be beneficial to ensure a more stable image is captured and reduce noise interference if relying on the in-built microphone. Finally, it is important that at least two people code the videos independently and then compare results to validate coding and ensure consistency across codes.

6. Conclusion

By tracing water journeys using video-recorded walking interviews, we have shown how the seemingly simple practice of water fetching is compounded by the need for complex planning and decision making, omnipresent trade-offs, and exposure to diverse risks, all of which have both physical and emotional embodied consequences. Findings contribute empirical evidence to the study of water insecurity and embodiment (Rosinger et al., 2021) and strengthen the theoretical framework centering bodies as analytical sites (Doshi, 2017; Mountz, 2018) and as infrastructure (Andueza et al., 2021; Truelove and Ruszczyk, 2022).

By demonstrating that environmental risks and embodiment are important dimensions of water insecurity in informal settlements, our study provides important lessons for the global monitoring of safe water and the design of water-insecurity interventions. The world is currently not on track to achieve the United Nations' Sustainable Development Goal number six (SDG 6), which seeks to ensure availability and sustainable management of water and sanitation for all by 2030 (UN Water, 2021). While piped water on premises is a proven path to household water security (Bisung and Elliott, 2018), it remains a distant goal for the nearly 1 billion people living in urban informal settlements. Therefore, although communal taps and basic water-service infrastructure remain important for achieving global targets on safe water, the burdens of water insecurity in dense urban settlements extend beyond the physical availability of public water points.

In order to achieve desired health outcomes, interventions must also address the myriad risks associated with water fetching journeys by incorporating improvements in the water-fetching environment. These may include, but are not limited to: extending water point installation and maintenance guidelines to include a suitable throughfare for water fetchers; upgrades or arrangements at existing communal water points for water storage – through simple tank systems and either a pumping system or a rota for night workers to fill them; and incentivising and/or regulating water supplied from private individuals when accessed during public water shortages. Important changes to policies regarding private sources, water point allocation criteria, and built environment regulations may also be required where relevant.

Finally, our findings suggest areas for further research. While a rapidly growing body of scholarship has established a strong relationship between the physical burden of water carriage and emotional distress (Tomberge et al., 2021), it is unclear whether normalization of the burden of water fetching—as observed in the present study—attenuates or elevates this distress. Further, the question of whether different natural or built environmental and behavioral risks, as well as total number of risks, are associated with different psychosocial outcomes requires systematic inquiry.

Credit author statement

Ellis Adjei Adams: Conceptualization, Writing – original draft, Writing – review & editing; **Sydney Byrns:** Writing – review & editing; **Save Kumwenda:** Review & Editing; **Richard S. Quilliam:** Review & Editing; **Theresa Mkandawire:** Review & Editing; **Heather Price:** Conceptualization, Writing – review & editing.

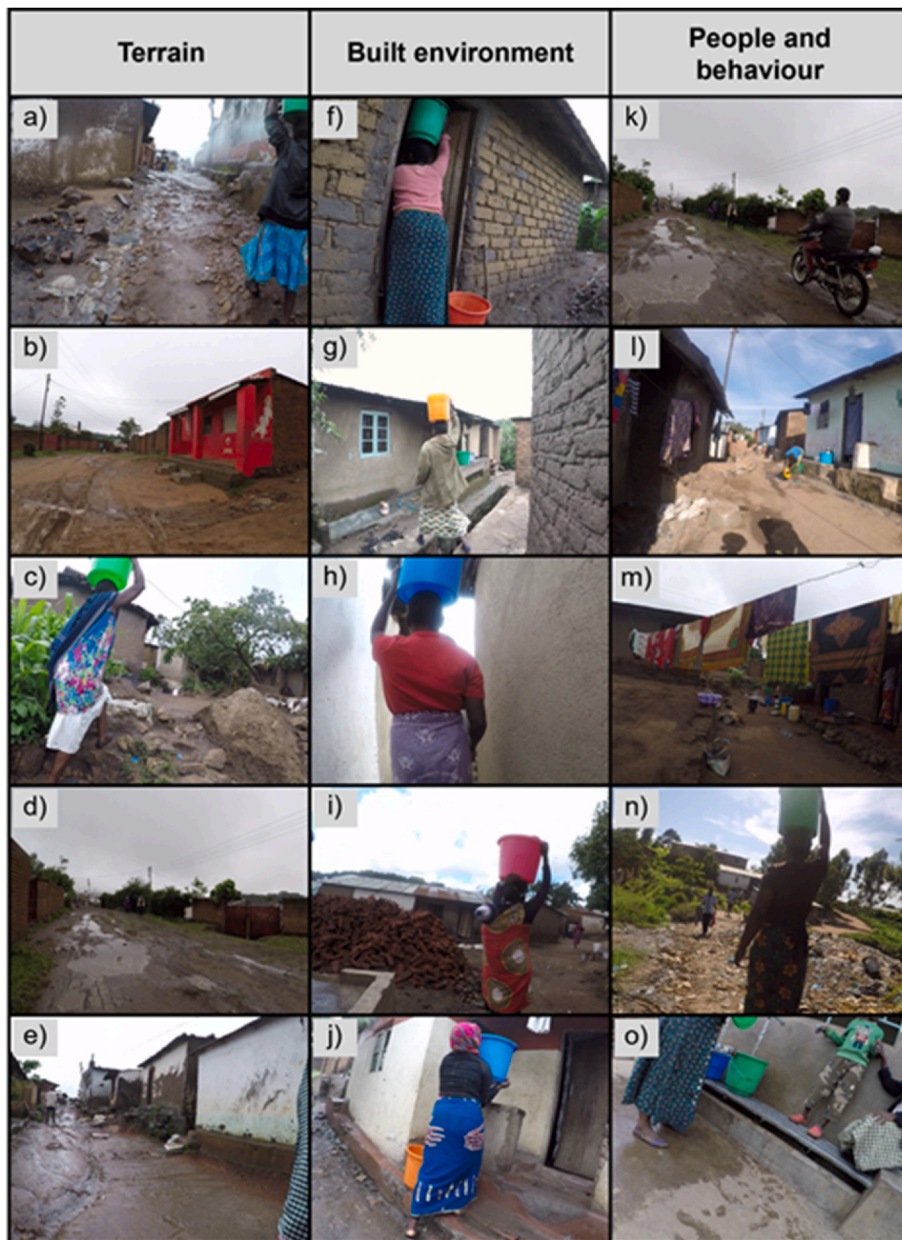


Fig. 5. Examples of the risks and challenges commonly experienced by Ntopwa women during water collection as captured on video during the walking interviews included 1) **terrain**: a) rocky, uneven/sloping ground made slippery from rain, b) muddy ground, c) rocky steps, d) muddy ground with large puddles, e) muddy/slippery ground with a wet drainage channel on the left; 2) the **built environment**: f) low door, g) stepping over a dry drainage channel, h) narrow path, i) large pile of bricks (coded as ‘other’), j) steps into the house; and 3) **people & behavior**: k) sharing the path with a motorcyclist, l) sharing the path with someone washing dishes, m) clotheslines across the path, n) large waste pile, o) children playing with taps at a kiosk.

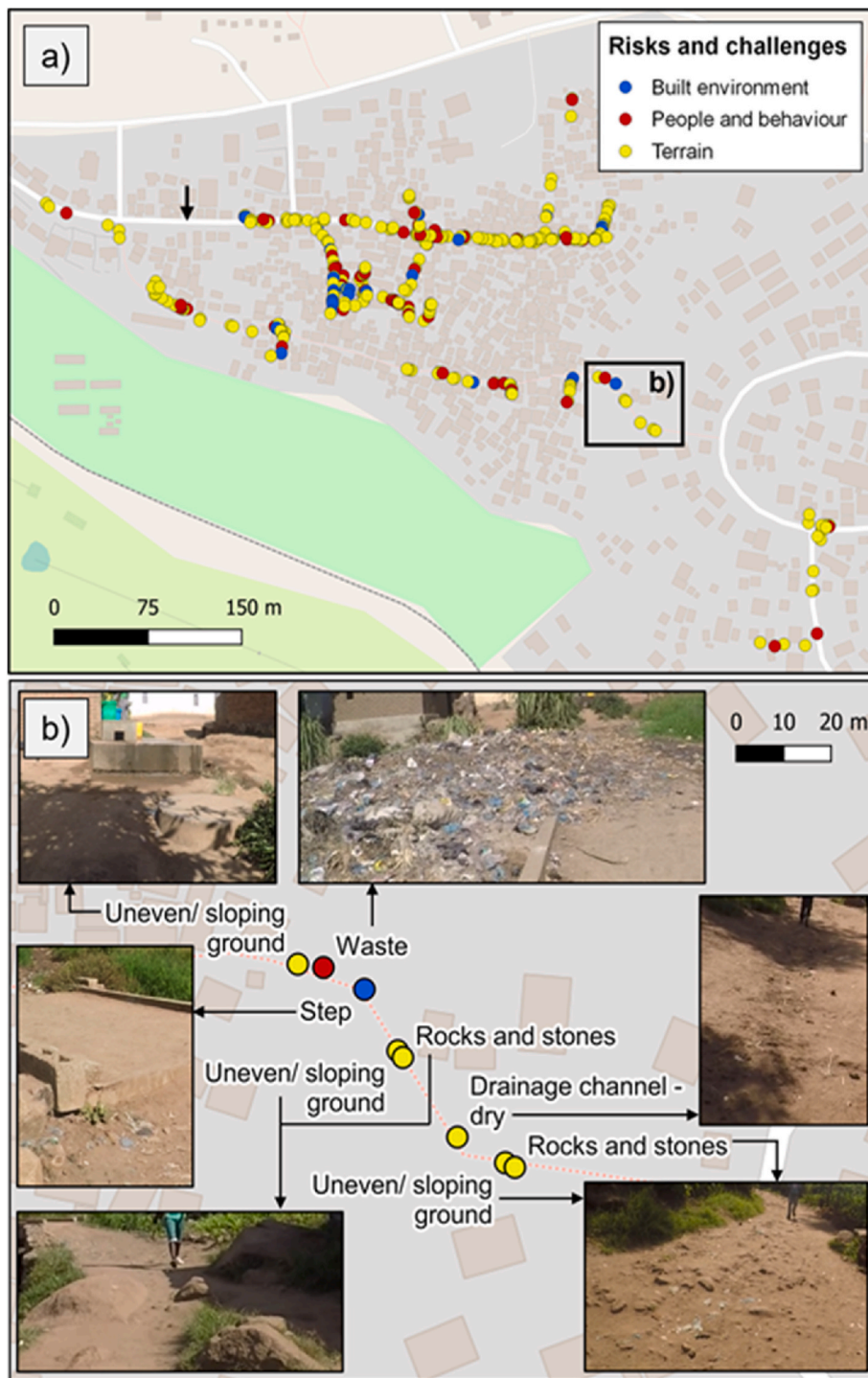


Fig. 6. a) Spatial distribution of risks and challenges observed from video-recorded walking interviews undertaken during 23 water-fetching journeys with women in Ntopwa. The categories of risks/challenges (people and behavior, built environment, and terrain) align with data in Table 2. The black arrow highlights one of the main routes through Ntopwa. b) Zoomed-in map from (a) highlighting the risks/challenges of one woman's journey to collect water (participant 5). Still images from the video illustrate some of the risks/challenges experienced on the route.

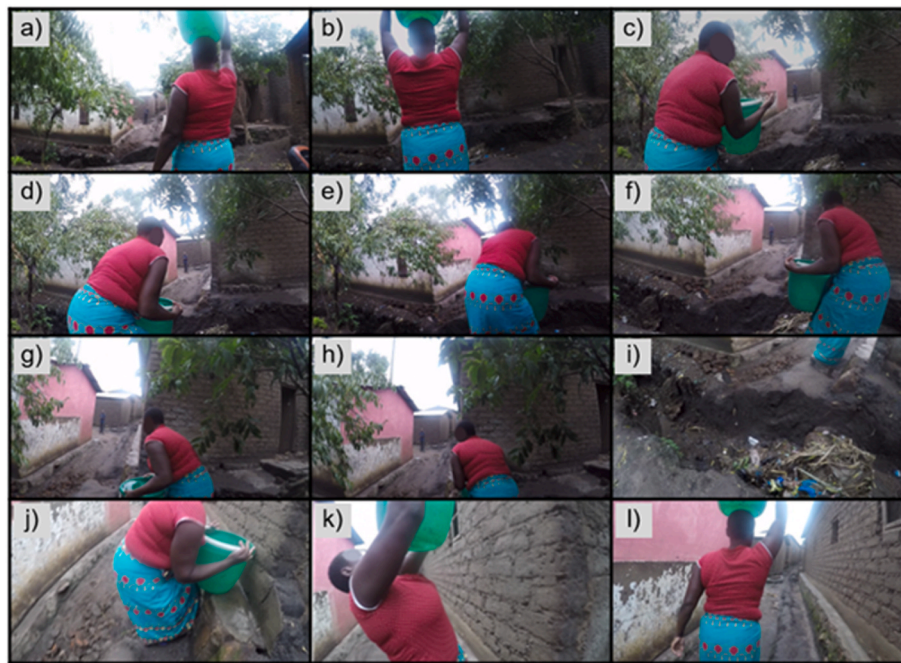


Fig. 7. Still images taken from a video recording of a woman crossing a ditch while holding a bucket of water. a–b) approaching the ditch, c) removing the bucket from her head in preparation for crossing, d–h) crossing the ditch with the bucket held in front of her body, i–l) putting the bucket back on her head and continuing her journey.

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Data availability

The authors do not have permission to share data.

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