

## Short Communication

# Impacts of flooding on drinking water access in Dar es Salaam, Tanzania: implications for the Sustainable Development Goals

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### ABSTRACT

Floods are the most common type of natural disaster and they impact human health and well-being. In cities such as Dar es Salaam, Tanzania, it is the poorest residents who experience the worst impacts from flooding. Yet although the negative effects of floods on drinking water quality are known, there is little empirical evidence on how they affect water access more broadly. This paper uses interviews from Dar es Salaam's Kigogo Ward to understand perceptions of drinking water source changes during floods. It frames these perceptions in the Sustainable Development Goals, which seek to achieve universal and equitable access to water. Results show that households experience flooding both inside and outside the house and that these episodes impact water quality, accessibility, and availability. In particular, floods can increase contamination, force residents to wait to fetch water, and require them to walk through floodwater to reach water sources. Floods also cause them to discard stored drinking water. These results demonstrate the need for additional research on the impacts of floods on water access.

**Key words** | Dar es Salaam, drinking water, flooding, Sustainable Development Goals, Tanzania, water access

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### INTRODUCTION

Many parts of Dar es Salaam experience regular flooding, which is attributed to more intense rainfall from climate change and the lack of city-wide storm water drainage infrastructure (Kiunsi 2013). Although flooding occurs across the city, residents do not experience its impacts equally. In the developing world, it is the poorest residents who tend to live in the most hazardous and unhealthy environments, including in areas most at risk of flooding (Douglas *et al.* 2008). Floods have clear impacts on human health and economic well-being. They are the most common type of disaster in the world, and they are expected to increase in intensity

and frequency (Alderman *et al.* 2012). An increase in floods will likely increase the global burden of disease, especially in low-resource countries (Alderman *et al.* 2012). These health impacts include diarrheal diseases, skin conditions, vector-borne diseases, and mental health disorders from the stress of floods. Floods can also create significant economic impacts by damaging homes and possessions, increasing vulnerability, and forcing people to spend time on flood prevention or clean-up rather than on income-generating activities (Cissé & Séye 2016).

Floods also impact water quality. Tests of drinking water supplies during and after floods in Bangladesh found contamination of total coliforms, fecal coliforms, and *Vibrio cholerae* (Islam *et al.* 2007). During flooding in Thailand, drinking water was found to be unfit for consumption

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(Chaturongkasumrit *et al.* 2013). Yet, there is little empirical evidence on whether floods impact other aspects of water access. The United Nations introduced the Sustainable Development Goals (SDGs) in 2015, and one of these goals is to achieve ‘universal and equitable access to safe and affordable water’ (WHO & UNICEF 2017). To meet this goal, water should be available when needed, free from contamination, and ideally located on premises; if not on premises, water should require a total collection time of less than 30 min. Thus, quality is just one component of water access.

Universal water access is an ambitious goal, and one concern is that the SDGs do not account for short-term changes to water access such as those from floods. This paper uses a case study of Kigogo, a flood-prone area of Dar es Salaam, to understand the potential impacts of flooding on all components of water access. Dar es Salaam’s climate is characterized by bi-modal precipitation, and its average rainfall is between 1,000 and 1,300 millimeters per year during these two rainy seasons (Kiunsi 2013). A short rainy season occurs from October to November and a longer one from March to May. The timing of these rains, however, is becoming more uncertain due to climate change, and rainfall intensity has increased over the past 15 years (Mutanga & Mwiruki 2013). In fact, the city received 174 mm of rain in one day in October 2017 – more than double the monthly average (Fox 2017).

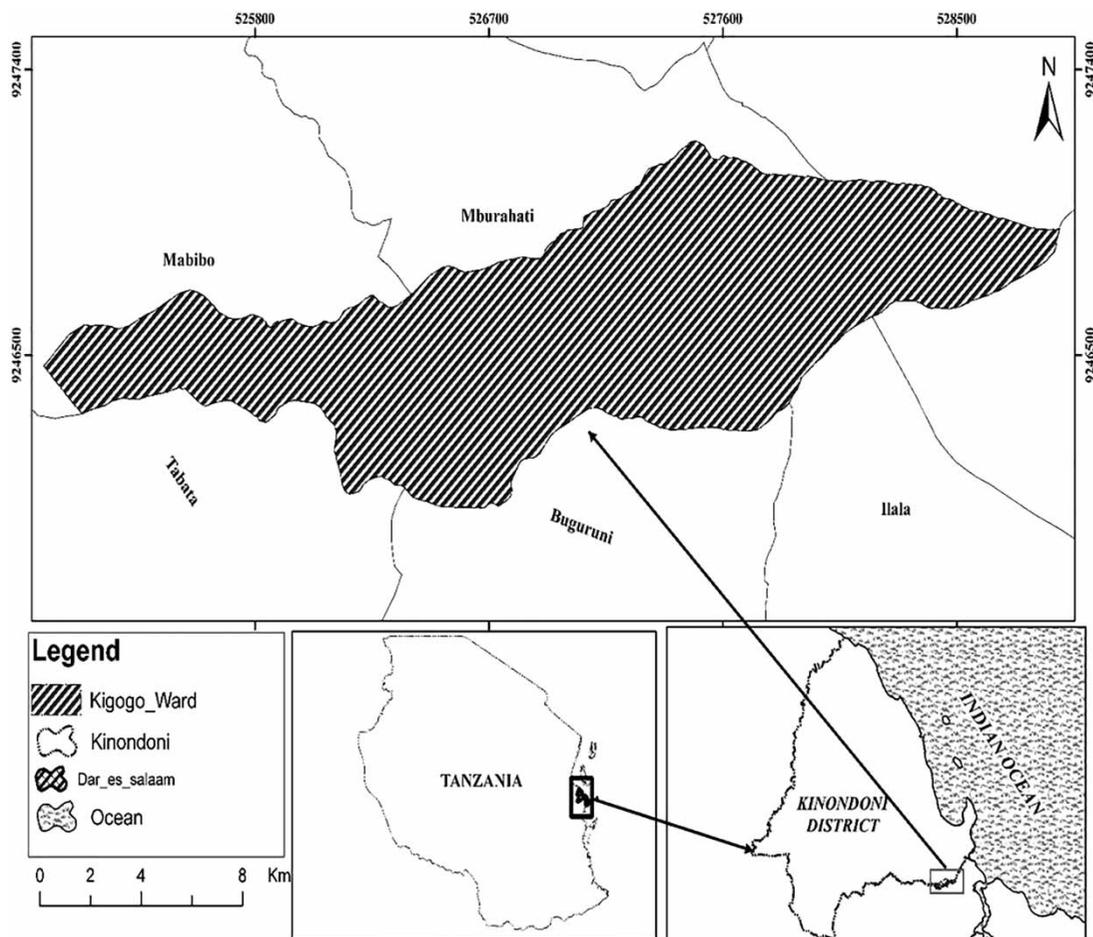
This paper builds on existing research on floods in Dar es Salaam, including on coping measures (Sakijege *et al.* 2014) and vulnerabilities (Hambati & Gaston 2015). It seeks to connect this literature with research on the city’s water access inequalities (Smiley 2016) and water shortages (Rugemalila & Gibbs 2015; Mapunda *et al.* 2018). The majority of residents in Kigogo drink water from the city’s piped network supplied by the Dar es Salaam Water and Sewerage Corporation (DAWASCO). There are regular issues with both the quantity and quality of this piped water; supply does not meet demand and low residual chlorine levels suggest inadequate treatment (Kjellén 2006; Smiley 2016). Flooding compounds these problems, as past floods have washed away pipes and caused water shortages (Kjellén 2006). Given that floods are expected to increase in frequency and severity, this study investigates whether they might complicate efforts to meet the goal of universal water access.

## METHODS

This paper uses interviews with 90 households in Kigogo Ward, a high-density unplanned area located in the city’s Kinondoni District. It is administratively divided into three subwards: Kati, Mbuyuni, and Mkwajuni. Its situation between the Kibangu and Msimbazi Rivers makes it an ideal study site (Figure 1). The central portion of Kigogo is higher in elevation, with the northern and southern areas sloping toward the rivers creating flood risks. Ramani Huria, a community-based mapping project, considers Kigogo one of the most flood-prone areas of Dar es Salaam. The project’s *Atlas of Flood Resilience in Dar es Salaam* (2016) identified 48% of Kigogo as flood-prone. It is noted that population growth increases flood risk, and a lack of drainage and solid waste collection exacerbates this risk. The regular flooding in Dar es Salaam destroys roads and homes, causes deaths, and necessitates expensive recovery.

To understand flooding impacts, semi-structured interviews were conducted in two stages. The first stage occurred in November 2017 in Kigogo’s three subwards and the second stage occurred in April 2018 in the Kati Subward. Both stages coincided with the two rainy seasons, and interviews occurred soon after flooding episodes. These interviews focused on flooding experiences and impacts, and the specific questions asked were: (1) What is the type and location of your drinking water source? (2) Does your home or its immediate vicinity experience flooding? (3) Does your water source change during floods and if so how? Thus, these interviews sought to understand the perceived impacts of flooding on water access. Interview responses were first coded for terms such as sediment, smell, wait, recede, and discard. After this initial round of coding, four categories emerged that corresponded to the literature on water access in Africa: quality, accessibility, availability, and stored water. As this study was interested in perceived changes, descriptive statistics were used to present the patterns that emerged from these interviews.

Households were selected from the areas of Kigogo identified as flood-prone by the Ramani Huria atlas (2016). Within those areas, convenience sampling was used to identify participants. All participants were adult heads of households and each provided verbal consent to participate in this project. It received ethical approval by the lead researcher’s university and the Tanzania Commission for Science and Technology.



**Figure 1** | Location of Kigogo Ward. Source: Cartographic Unit, Department of Geography, University of Dar es Salaam.

Interviews were conducted in Kiswahili with the assistance of a research assistant from the University of Dar es Salaam.

## RESULTS AND DISCUSSION

To begin to understand these perceived impacts, participants were first asked about their water source. All but one of these households normally drink piped DAWASCO water, although only 29% have on-premises connections; the majority of households (68%) fetch DAWASCO water from a neighbor's home, and the few remaining households have water delivered. Participants were also asked whether they had ever experienced flooding in the street outside their home or had floodwater inside their home. Even though all households lived in areas identified as flood-prone, 10 (11%) had never experienced water outside and 19 (21%) had never had water inside. Participants offered three explanations

for their lack of flooding experiences. First, some only recently moved to the area. They specifically stated that while they had heard about past episodes of flooding from landlords or neighbors, they had not personally experienced it. Second, some live at the top of slopes, so noted that rainwater immediately flows downhill rather than staying outside their home or entering it. Third, some households observe water outside but have successfully prevented it from entering through adaptation measures such as walls and elevated doorways.

The interviews then asked respondents if their drinking water source changed during floods, and 77 (86%) described some change. Thus, some people are impacted by floods even if they lack personal flooding experiences at their home. This discrepancy is due to the high rates of water fetching in Kigogo. The perceived changes described by participants were categorized into four impacts related to the water access literature. The goal of universal access requires

water that is available when needed, free from contamination, and located either on premises or in a location with a total collection time of less than 30 min.

First, 32 participants (36%) indicated that flooding affects their drinking water quality. Some participants (18%) observed increased amounts of sediment, mud, and dust in their water and were forced to let it settle before drinking. Others (3%) noted a strong chemical smell that they found offensive; they speculated that it was from increased treatment by DAWASCO. Another 7% of respondents indicated their water looked brown or red during floods. Two participants also noted that while they do not boil or chemically treat their drinking water during the dry season, they do so in the rainy season because they associate flooding with the contamination of drinking water. Perceived poor quality also forces some respondents (3%) to use a different drinking water source including bottled water, rain water, and well water.

Second, 16 participants (18%) noted impacts on their water accessibility. A small number of households (3%) indicated their water collection time increased because they were forced to walk to a source further from home. One household, however, noted its collection time decreased because of shorter queues at water sources; some people drink rain water rather than fetching DAWASCO water. The majority of the accessibility impacts described (17%) had to do with the actual water fetching walk. Past research in Dar es Salaam demonstrated that people encounter environmental challenges while fetching water such as proximity to sewage (Smiley *et al.* 2017). All of the impacts offered in these interviews involved walking through standing floodwater to reach their drinking water source, and respondents stated that they had walked through floodwater at depths of up to waist level. The Msimbazi River – which borders Kigogo – is highly polluted from solid, human, and industrial wastes, and it overflows during intense rains (Mbuligwe & Kaseva 2005). Thus, walking through these floodwaters could have potential health effects.

Third, 29 participants (32%) noted changes to their water availability. Some participants (13%) stated that they were forced to wait for floodwater to recede in order to fetch water. Some indicated short waits of less than an hour, others waited several hours, while one respondent indicated she once waited more than 2 days. Another 12% of participants noted that floodwater covered their water taps so they were unable to fill their containers until after

the water receded and sometimes also until after the tap was cleaned. Also, 4% of households stated that DAWASCO water becomes less reliable during floods. They experience more frequent cuts in service and one even suggested that DAWASCO just turns off the water supply completely.

Fourth, 48 participants (53%) described negative changes to their stored water. Since the DAWASCO water service is unreliable, the vast majority of households in Dar es Salaam store water to use during outages. Most households use either 10 or 20 liter plastic buckets with lids. Households often have a large number of containers; one participant showed the 30 containers she uses to minimize her weekly water fetching trips. Since 79% of the interviewed households have had floodwater inside their home, participants described how they dealt with their stored water after floods. The majority of these households (47%) either discarded their stored water entirely or only used it for cleaning if the buckets were covered, tipped over, or if the stored water mixed with floodwater. Two respondents indicated that they stacked their buckets and would still drink the top level but only use the bottom levels for cleaning. The remaining households (7%) either discarded their stored water or used it for cleaning if floodwater even entered the house. It is important to stress that these decisions were made by the respondents because they felt flooding compromised the quality of their stored water. One respondent explained that as long as the buckets were well covered, the water was safe but still only suitable for cleaning. If the buckets were not well covered, the water was considered unsafe and thrown out completely.

## CONCLUSIONS

This study outlines the ways that households in Kigogo perceive their drinking water to be impacted by floods. By situating these impacts in the SDG water access literature, it is possible to identify areas where more research and especially more empirical evidence is needed. Previous research indicated that floods decrease water quality by contaminating groundwater and piped water supplies. The interviews described here introduced another form of decreased quality: that of stored water. The fact that nearly half of the households interviewed refused to drink their stored water – even in cases when floodwaters did not actually touch the buckets – suggests an important area for future research.

These interviews also demonstrated the connections between the various components of universal water access. Households described increased sediment in their DAWASCO water during floods. Although sediment might have fewer health impacts than fecal contamination, it still impacts water access. If households must wait for their water to settle, it is not available when needed. Water availability is also compromised when households must wait to fetch water until floods recede. Even though waits of a few hours might be less concerning than the week long service cuts previously documented in Dar es Salaam (Smiley 2016), they still mean that water is not available when needed. When some households must walk longer distances to fetch water during floods, their collection time might surpass the 30-min threshold and thus become inaccessible under the SDG definition.

This paper demonstrates that floods do impact water access. These impacts vary: although some households experience no change in their drinking water source, many perceive the impacts as negative, and a few believe that their water access actually improves. In particular, water access may improve through rainwater harvesting. The use of rainwater shortens queues at DAWASCO sources and potentially offers water that is free from contamination, easily available, and with a minimal collection time. More empirical evidence is needed to better understand these perceived changes – including both positive and negative changes. These results also demonstrate a need for the SDGs to consider short-term changes in water access. The goal of universal water access is ambitious, but it will be difficult to meet if people lack equitable and consistent year-round access due to flooding.

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