Full title: The impact of a climate-related disaster on sanitation coverage in rural Chiradzulu District, Malawi, pre- and post-Cyclone Freddy

Short title: The impact of Cyclone Freddy on sanitation coverage in rural Malawi

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Abstract

Background: Climate-related disasters, such as extreme rainfall and flooding, pose a significant threat to progress towards Sustainable Development Goals (SDG) for water, sanitation, and hygiene (WASH). The Water, Sanitation, and Hygiene for Everyone (W4E) programme aims to reach universal WASH coverage in Chiradzulu District by end of 2024. Traditional Authority (TA) Likoswe, a programme area in Chiradzulu District, Malawi, achieved Open Defection Free (ODF) status in December 2022 following a Community-led Total Sanitation (CLTS) intervention. In March 2023, Cyclone Freddy caused widespread damage to essential infrastructure in Chiradzulu District. Using routine monitoring data from implementing partners, this study compares sanitation coverage in TA Likoswe pre- and post-cyclone Freddy.

Methods: Longitudinal household surveys completed at baseline and one year follow-up of the W4E programme were used to estimate changes in household sanitation coverage according to global standard indicators before and after Cyclone Freddy. ODF status verification data was also used to estimate sanitation access at baseline. The analysis quantified climate-vulnerability of sanitation infrastructure.

Results: Of the 311 households surveyed at both baseline and endline, 5% had basic sanitation, 3% limited, and 92% at least unimproved prior to Cyclone Freddy. Sixty-eight percent of sanitation facilities, primarily unimproved facilities, collapsed due to the cyclone. At follow-up, 36% of surveyed households had no sanitation facilities and 50% had unimproved sanitation three months post-cyclone. Of the 211 households with a collapsed latrine, 43% rebuilt an unimproved sanitation facility three-months post-cyclone.

Discussion and conclusion: Sanitation facilities that do not meet global standards for SDG targets are particularly vulnerable to extreme weather events, which are expected to increase in frequency and intensity. Programmes that aim to achieve universal sanitation coverage need to address the environmental sustainability of sanitation infrastructure, even in settings which have reached high levels of sanitation coverage.

Keywords: flooding; cyclone; climate change; sanitation; Malawi

Introduction

Floods are the most common type of disaster globally. They are expected to increase in frequency and intensity due to rising sea levels and more frequent and extreme precipitation events (1). Flooding events are also expected to increase the global burden of disease, especially in countries where most major floods occur and vulnerability is highest (2,3). A systematic review on the relationship between flooding and health found that infectious disease outbreaks post-flooding events are more likely to occur in areas with poor water, sanitation, and hygiene (WASH) services (2).

Extreme water-related weather events, such as severe cyclones and heavy rainfall, threaten progress towards Sustainable Development Goals (SDGs) and pose significant health risks to affected communities (3). Sanitation facilities, particularly pit latrines located in low-lying areas or floodplains, are prone to overflowing, filling with silt, and collapsing following extreme water-related events, thereby making them inaccessible and non-operational (4). This leads to spillages and potential increases in the practice of open defecation, exposing affected communities to harmful pathogens. Safe and climate-resilient sanitation services are therefore essential for protecting public health, as well as achieving SDGs for WASH (SDG 6.1).

The effect of flooding on sanitation infrastructure, services, and practices is generally well documented (5), however few studies quantify the damage to infrastructure (6,7). Post-flooding household surveys in a suburb of Dakar, Senegal, found that 86% of surveyed individuals reported that household improved sanitation facilities (e.g., septic tanks and cesspits) were damaged or made inaccessible due to flooding (8). Another study in Burkina Faso found that 20% of surveyed latrines, primarily unimproved pit latrines constructed during a CLTS programme, collapsed due to heavy rains (9). Evidence on the magnitude of the effect of floods on sanitation infrastructure and services can inform future climate-resilient sanitation strategies and help identify which type of sanitation facilities

are most vulnerable to flooding. For example, a study in Kibera, Nairobi, Kenya, found that toilet facilities connected to a piped sewer and septic tank demonstrated higher levels of resilience to extreme rainfall and flooding compared to latrines and hanging toilets (10).

The evidence on household sanitation reconstruction decisions following a flooding event is also limited. One study in Ethiopia found that of the 380-flood affected surveyed households, 43% of households did not reconstruct a latrine. In addition, a household was more likely to choose an improved latrine post flooding if they had a larger household size and the head of household had higher educational attainment and was older (11). A better understanding of latrine reconstruction decisions can inform strategies to maintain and even improve access to sanitation.

Aim

In this analysis, we compare sanitation coverage pre- and post- a tropical cyclone in a rural area of southern Malawi using routine monitoring and evaluation data from local non-governmental organisations. The objectives were to: 1) quantify the impact of the cyclone on sanitation infrastructure in a programme area that achieved open defecation free status, and 2) understand short-term household sanitation reconstruction efforts and decisions post-cyclone.

Materials and methods

Study setting and population

This case study focuses on the Traditional Authority (TA) Likoswe, located in Chiradzulu District, Malawi (Figure 1). Chiradzulu District is in the Southern Region of Malawi (12), approximately 25 kilometres from Blantyre, the country's commercial and industrial centre. Chiradzulu is comprised of ten TAs, or administrative areas, and has a population of approximately 350,000. TA Likoswe, situated on the western side of the district, has a population of approximately 76,000 persons living in 142

villages, which are clustered into Group Village Heads (GVH) (12). Chiradzulu District is predominantly rural with historic low access to improved sanitation. In 2019, 47% percent of households did not have access to sanitation in TA Likoswe (12).

Figure 1. Left: Map of the 28 districts in Malawi, with Chiradzulu District highlighted in red. Right: Map of the TAs in Chiradzulu District, Malawi, with TA Likoswe situated on the western side of Chiradzulu District. Sources: World Vision Malawi.

Community-led Total Sanitation (CLTS) in Chiradzulu District, Malawi

Data were obtained from the Chiradzulu Water, Sanitation, and Hygiene for Everyone (W4E) programme implemented by World Vision and Water for People in partnership with the Government of Malawi. W4E is a three-year initiative (2022 – 2024) that aims to expand access to drinking water, sanitation, and hygiene services across the entire district of Chiradzulu. TA Likoswe was part of the first phase of W4E implementation from April 2022 to December 2022. W4E intervention activities

focused on Community-led Total Sanitation (CLTS), with additional sanitation marketing and hygiene promotion campaigns.

CLTS is an approach that focuses on behavioural change and community self-enforcement to end open defecation (13). It is a widely adopted strategy to generate demand for sanitation and end open defecation. CLTS was introduced in Malawi in 2008 and is a key component of the national sanitation and hygiene strategy for making Malawi Open Defecation Free (ODF) (12). As part of W4E, CLTS was predominantly delivered by government-employed Community Health Workers (CHWs), also known as village-level health surveillance assistants (HSAs).

CLTS was implemented according to the official CLTS handbook and followed three broad implementation phases (13). These include pre-triggering (evaluation of pre-existing social and physical conditions so that triggering activities can be adapted), triggering (collective action towards ending open defecation), and follow-ups (monitoring of the triggering phase) (13). Triggering events in TA Likoswe took place during April 2022. Follow-up visits started approximately two weeks later and continued until ODF status was achieved. TA Likoswe was declared ODF by the Government of Malawi in December 2022, signifying universal sanitation coverage of any sanitation type in the TA at that time. The Government of Malawi defines ODF as no human faeces evident in the environment, where 95% of households have a latrine, and latrines are in good condition and show evidence of being used (14).

Cyclone Freddy

Tropical Cyclone Freddy hit the southern region of Malawi on 11 March 2023. Torrential rain brought 400 to 500 millimetres of rain in the first 72 hours and six-days of rainfall exceeded average rainfall normally received over a six-month period (15). The World Meteorological Organization (WMO) declared Tropical Cyclone Freddy as the longest-lasting tropical cyclone on record at 36 days (16).

Heavy rains resulted in flash floods and landslides. The continued flooding in the lowlands areas resulted in a second wave of damage to infrastructure, including households, schools, health centres, and roads and bridges. The President of Malawi declared a 'State of Disaster' in 10 districts of the southern region, including Chiradzulu District where TA Likoswe is situated.

Data collection: household survey

A household survey was conducted among 311 households in TA Likoswe in April 2022 before CLTS implementation activities started. A follow-up survey was repeated in June 2023, approximately three months after Cyclone Freddy landed in Chiradzulu District. Households were randomly selected at baseline based on a population-level sampling frame developed by the W4E implementation team and re-interviewed in June 2023. Records were linked via a unique household identification number. The household survey captured household information on demographics and WASH facilities and practices. Questions related to Cyclone Freddy were added to the follow-up survey. Household survey responses were recorded on tablets with forms in mWater, a data collection platform for WASH programmes. The forms were written in English and Chichewa, the local language in Malawi. All data were encrypted and stored on a secure server.

Data analysis

Reported and observed sanitation facilities were used to classify households according to standard global indicators of sanitation coverage according to the WHO and UNICEF Joint Monitoring Programme sanitation ladder (17). Log-binomial regression was used to assess the probability of damage to latrine facilities post-cyclone. Data was analysed in STATA v18 (Stata Corp, College Station, Texas, USA).

Ethics

Ethical approval was obtained from the London School of Hygiene and Tropical Medicine Research and Ethics Committee (Ref: 28249) and in Malawi by the National Commission for Science and Technology (P01/23/718). Consent was obtained from the Chiradzulu District Council and community leaders. Informed written consent was obtained from all household survey respondents.

Results

311 households had data that could be linked across both survey rounds. In the first survey round, 5% of households had basic sanitation, 3% limited, 49% unimproved, and 43% had no sanitation facility. The most common form of unimproved sanitation were pit latrines without slabs. TA Likoswe was declared ODF eight months after the baseline survey, indicating that all households in the TA had at least access to an unimproved sanitation facility. Based on ODF verification status, the 43% of households with no sanitation facility at baseline survey were assumed to have at least unimproved sanitation by the end of 2023. Pre-Cyclone, an estimated 92% (n= 284) of surveyed households had at least unimproved sanitation (Figure 2).

Among the 311 households included in this case study, 68% (n= 211) had latrines that were significantly damaged or collapsed (i.e., rendered unusable) due to Cyclone Freddy over the two-month cyclone period (Figure 1). Unimproved sanitation facilities were the most impacted by the cyclone (96%, n= 203) and were over twice as likely to collapse compared to improved facilities (Risk Ratio: 2.4; 95% CI: 1.32 – 4.33; p = 0.003). Of the households that did not have a collapsed latrine (n= 100), 60% (n= 60) stated that they built their latrine with durable materials and 6% (n= 6) stated that the cyclone was not as strong in their community.

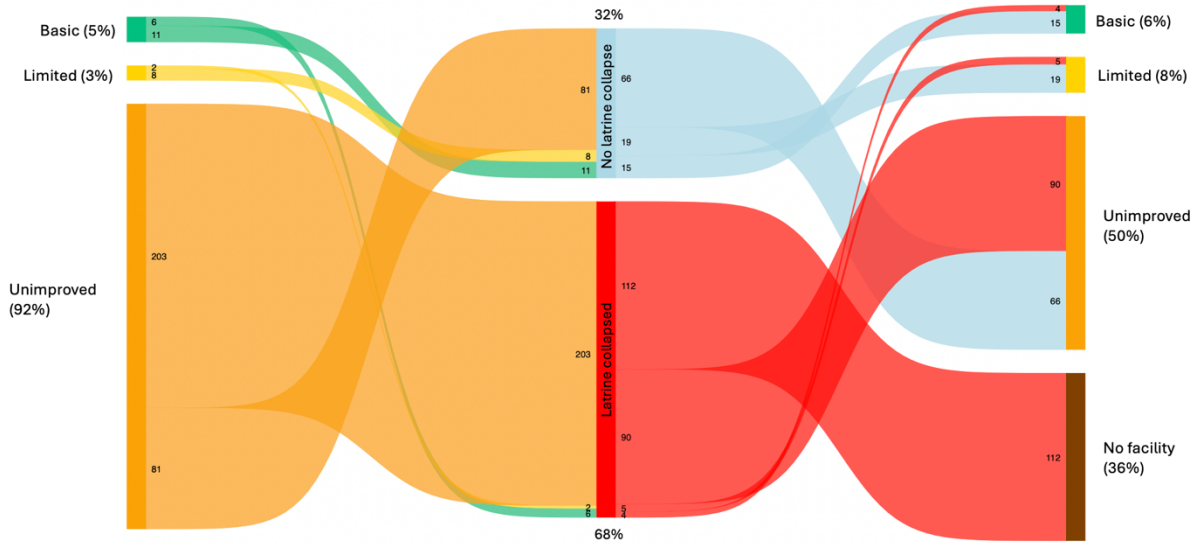

Figure 2. Sankey diagram depicting sanitation access by JMP sanitation ladder category pre- and post-Cyclone Freddy.

The follow-up survey conducted in June 2023 showed that three months post-Cyclone, 6% of households had basic sanitation, 8% limited, 50% unimproved, and 36% had no sanitation facility (Figure 2). Over half of the 211 households with a damaged or collapsed latrine did not have a sanitation facility three months after the cyclone (n = 112) (Figure 3). Of these, 90% (n = 101) reported using their neighbour's sanitation facility while reconstructing their own latrine. Among the 99 households that had rebuilt facilities, 91% (n= 90) were unimproved facilities, 5% (n= 5) were limited facilities, and 4% (n= 4) were basic sanitation facilities. Among those who rebuilt an unimproved facility, 66% (n= 65) stated that they built their latrine with cheap materials, while 10% (n= 10) stated that they selected more durable materials. The number of people in the household and the presence of children under five in the household were not associated with rebuilding a latrine ($p > 0.05$).

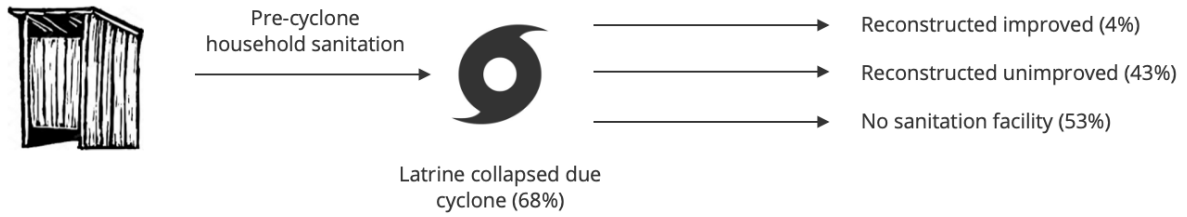

Figure 3. Household sanitation access in TA Likoswe at the time of the follow-up survey, approximately three months post Cyclone Freddy among households whose latrine collapsed during the cyclone (n= 211).

Discussion

This case study quantifies the extent of the damage of a climate-related extreme weather event on various types of household sanitation infrastructure in a rural area of Malawi. Sixty-eight percent of surveyed household sanitation facilities in TA Likoswe collapsed due to Cyclone Freddy, highlighting the vulnerability of environmental health infrastructure to climate-related shocks. Specifically, we found that unimproved pit latrines without slab were more likely to collapse than improved sanitation facilities. This is consistent with infrastructure and expert assessments of sanitation facility resilience to flooding and extreme rainfall (10,18,19). Unimproved pit latrines are particularly vulnerable to flooding as pits can overflow. This in turn results in the spread of potentially pathogenic materials into the environment (3), such as the increased risk of cholera during heavy rains and floods (18,20), Understanding which types of sanitation facilities are most vulnerable to flooding can help prioritise investment in sanitation infrastructure in future programmes.

Our findings also highlight the ongoing impacts of extreme events, such as Cyclone Freddy, on sanitation access in affected areas. Three months after the cyclone, half of the affected households in the study area no longer had a sanitation facility. Households with an unimproved sanitation facility that collapsed during the cyclone and then rebuilt a sanitation facility primarily rebuilt a pit latrine without a slab, which remains vulnerable to future flooding or other extreme weather events. Other studies found that households in rural areas often did not immediately rebuild or repair their latrines

damaged by heavy rainfall or flooding (11,21). Households without sanitation post-cyclone may return to open defecation or use their neighbour's latrine (21). Various factors can influence why a household does or does not rebuild a latrine. A study in Mozambique found that several physical (e.g., soil condition), socio-demographic (e.g., education level), and social factors (e.g., social cohesion) were associated with rebuilding a latrine following heavy rainfall in 2015 (21). While factors that led people to rebuild their latrine are unknown in this setting, understanding post-cyclone sanitation reconstruction decisions can inform future disaster recovery strategies.

Extreme weather events may limit the effectiveness and cost-effectiveness of sanitation interventions that rely on small or rudimentary changes in sanitation coverage like CLTS. The CLTS approach does not promote any type of sanitation technology, which often results in the widespread adoption of unimproved sanitation facilities (22) that are not strong enough to withstand extreme weather (10). W4E implementing partners have focused programme efforts on closing the sanitation coverage gap post-cyclone, which increased staff and field costs associated with the intervention. The average lifetime of a standard pit latrine is approximately 10 years depending on the number of users and operation and maintenance practices (23). However, this decreases in settings vulnerable to extreme weather events, such as TA Likoswe. The life cycle cost of the sanitation intervention in settings with high risk of extreme weather events is therefore likely to be underestimated. In addition, CLTS, as originally intended, focuses on improving sanitation coverage of any type but may not be appropriate in settings that require specific climate-resilient sanitation technologies. Future interventions that focus on promoting inclusive climate-resilient sanitation technologies are needed to avoid interruptions to sanitation access and reduce the risk of slippage to open defecation (4,24).

Conclusion

Sanitation facilities that do not meet global standards for SDG targets are particularly vulnerable to extreme weather events, which are expected to increase in frequency and intensity. Sanitation

programmes should therefore consider the environmental sustainability of sanitation infrastructure, even in settings that have reached high levels of sanitation coverage. The prioritisation of climate-resilient sanitation infrastructure is also essential for reaching universal sanitation coverage and reducing the burden of disease in flood-affected areas.

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