

Construction of large-scale primary drainage infrastructure reduced flooding in residential properties in Lusaka, Zambia

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BACKGROUND

- Seasonal flooding of residences is a perennial issue in Lusaka, Zambia with economic and public health consequences. During the 2017-2018 cholera outbreak in Lusaka, a central market was shut down for two weeks to prevent flooding-related disease transmission (Source: [Zambia Daily Mail Limited](#))
- The Millennium Challenge Corporation (MCC) and the Government of Zambia (GoZ) invested over \$75M to design and build a 23km-long concrete-lined primary drain to reduce flooding, which was completed in 2020
- MCC and GoZ also worked with the city of Lusaka to create a garbage collection utility with the intent to prevent garbage-related drainage blockages
- Mathematica evaluated the performance of the drainage in reducing flooding between 2016 (pre-construction) and 2022 (post-construction) and the potential for sustainably maintaining the infrastructure.

OBJECTIVES

Mathematica's evaluation of the drainage infrastructure focused on two research questions:

- How was household-level flooding affected by the new drainage and mediated by other factors?
- What are the prospects for future functionality of the drainage?

PARTNERS



METHODS

Data:

- Surveyed households in neighborhoods near the drainage about household flooding experiences and physical features of residences that may mediate flooding
- Survey conducted in 2022 (n = 1,019); repeated cross-section of a baseline data collected in 2016 (n = 3,140)

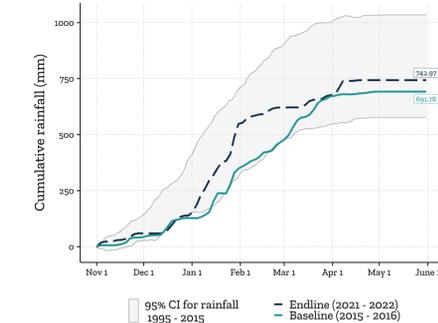
Analysis:

- Flooding reduction and related impacts (2016 vs. 2022):** Population-weighted linear probability model; controlled for demographics and precipitation
- Household-level determinants of flooding (2022 only):** Population-weighted linear probability and negative binomial models to assess flooding likelihood and intensity. Controlled for demographics, precipitation, physical features of residences, spatial factors in flooding

Research Question 1:

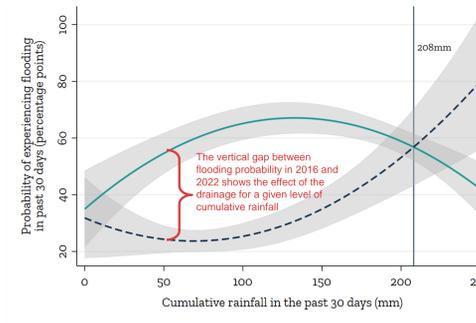
How was household-level flooding affected by the new drainage and mediated by other factors?

Figure 1. Annual cumulative rainfall in Lusaka, 2016 and 2022



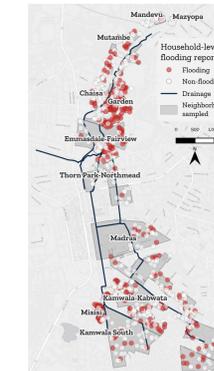
Rainfall for baseline and endline years (2016 and 2022) fell in a normal range, but that large differences in accumulation throughout the two seasons required us to control for rainfall in analysis models. Data source: CHIRPS

Figure 2. Flooding response to cumulative rainfall, 2016 and 2022



Marginal response of flooding probability to accumulated rainfall in 2016 and 2022 shows that as monthly rainfall increases, the probability of experiencing flooding increases in 2016, but stays low in 2022. However, at high levels of rainfall accumulation (>= 208mm), households in 2016 and 2022 were equally likely to experience flooding.

Figure 3. Map of household flooding reports, 2022

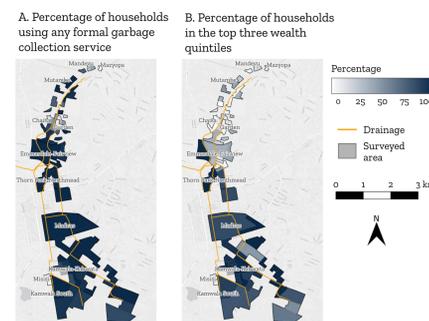


Lack of a clear spatial pattern in reported 2022 flooding suggests that household-level factors play a major role in mediating flooding.

Key findings: Research Question 1

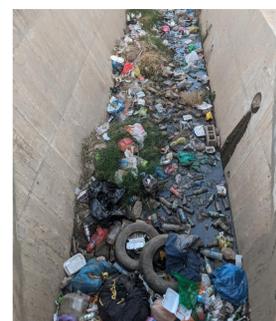
- Compared to an average 60% chance of flooding in 2016, households in 2022 had a 22-percentage-point reduction in flooding probability
- The drainage was not able to prevent flooding during periods of heavy rain
- 10% of households that experienced flooding report that their toilet overflows at least once during the season
- Flooding-related school absenteeism fell by half thanks to the drainage
- Physical features mediated household flooding: residences near impermeable surfaces were 22 percentage points more likely to flood; well-maintained drainage inside residential compounds was associated with a 90% lower flooding intensity

Figure 4. Map of garbage disposal and wealth distribution, 2022



There is a positive association between the percentage of neighborhoods that (A) pay for a formal garbage collection service, and (B) are in the top three wealth quintiles.

Figure 5. Clogged section of drainage, 2022



In one observed section of the drainage, a large amount of trash obstructs the flow of water.

Key findings: Research Question 2

- Several sections of the drainage were clogged by silt or garbage in 2022, while other sections were well-maintained
- Garbage collection services were costly (several times more than household per-capita water expenditures); 16-45% of surveyed areas dispose garbage informally
- Poorer households were nearly twice as likely to use informal means of disposal compared to richer households
- While Lusaka City Council took several steps to formalizing a garbage collection utility, this was not completed by 2022

CONCLUSIONS

- Large-scale gray infrastructure (i.e., concrete drainage) can reduce, but not eradicate flooding, with implications for water-borne disease transmission
- With climate change bringing increasingly erratic rainfall, ensuring that infrastructure can function in the most extreme weather events is critical
- Household-level factors mediating flooding indicate that green infrastructure (i.e., rain gardens) may complement gray infrastructure to improve drainage function
- To ensure sustainability, it is critical to allocate sufficient resources towards addressing the structural and behavioral factors that threaten infrastructure

Research Question 2:

What are the prospects for future functionality of the drainage?

Data:

- Surveyed households near the drainage about garbage disposal behaviors in 2022 (n = 1,019).
- No data on household garbage disposal behaviors available from 2016.
- Collected direct observations of drainage infrastructure

Analysis:

- Descriptive analysis of garbage disposal behaviors at the household and neighborhood-levels
- Linear probability model of garbage disposal methods used by households in different wealth classes