



8th
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When Waste Blocks the City: Quantifying the Social and Environmental Amplifiers of Urban Flood Impacts in Nairobi

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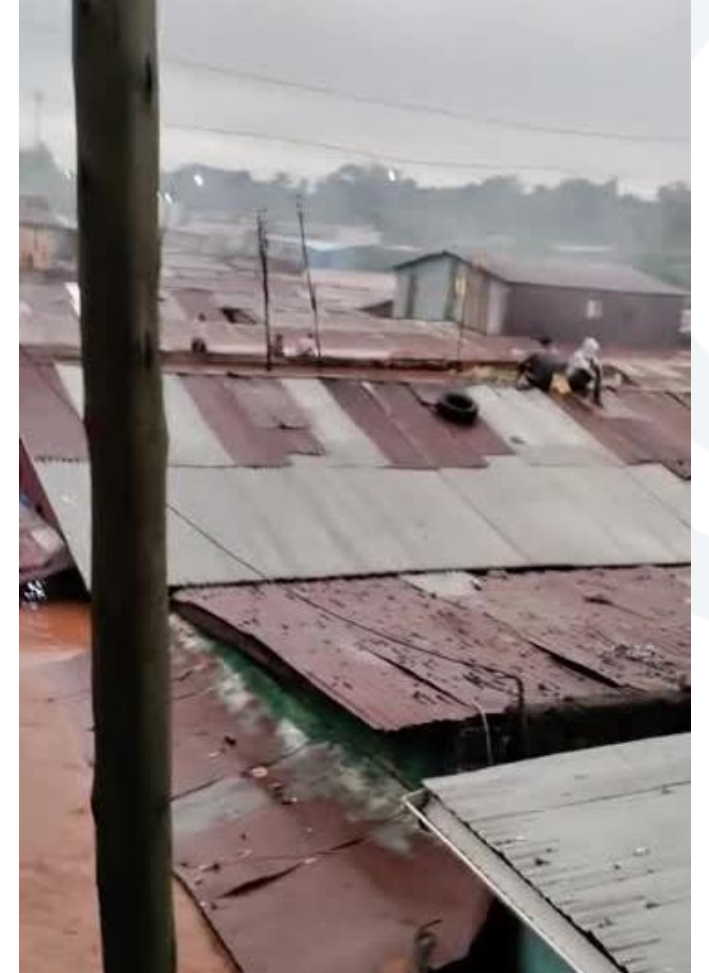
Background - Urban Flooding

Between 2000 and 2018, the number of people living in flood-exposed areas increased by more than 1/3 worldwide, with the fastest growth in **sub-Saharan Africa**, South and Southeast Asia, and Latin America

Tellman et al., 2021

Nairobi 2024

Deaths: 291 people,
Displaced: 278,000 residents



Background - Urban Flooding

- Urban flooding in sub-Saharan Africa is shaped not only by rainfall and topography but also by rapid, unplanned urbanisation and inadequate drainage infrastructure.

(Douglas et al., 2008)

- Low-income communities often occupy flood-prone zones, where limited services and infrastructural neglect intensify exposure.

Tellman et al., 2021

Blocked drainage
by waste

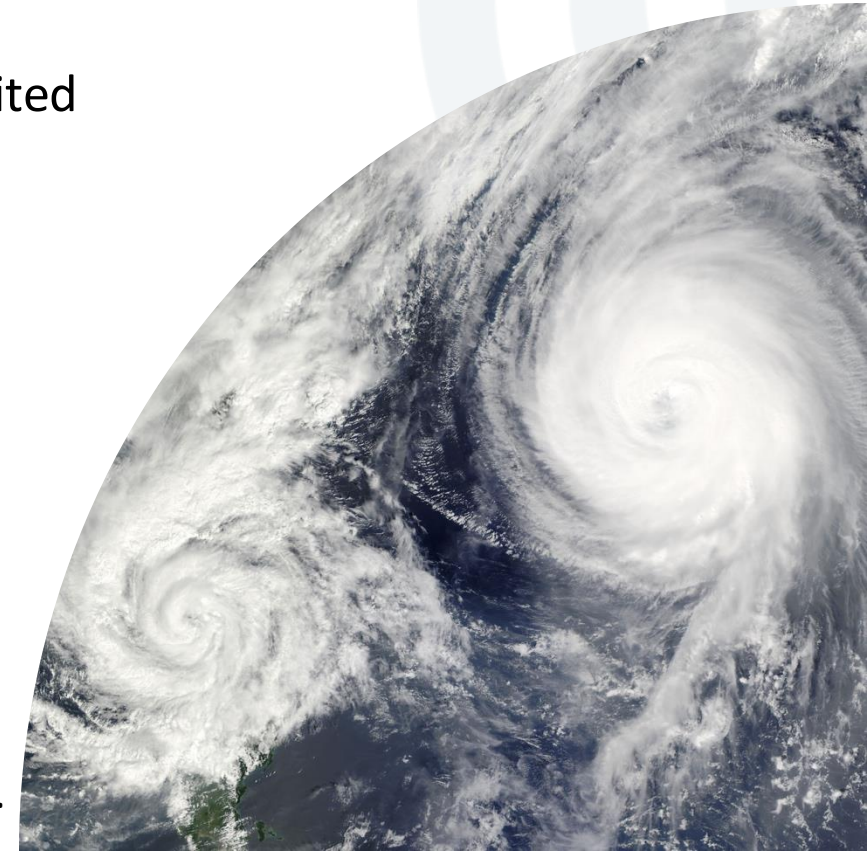
Nairobi, Kenya

Space4All project

IDEAMaps project

Other countries:

Pakistan, Cameroon, Indonesia, Malaysia etc.



Background - Urban Flooding



Aim

This study aims to evaluate how **environmental and social vulnerability** shape the **human impacts** of **urban flooding** in cities of the Global South.

Research Question

To what extent does **waste accumulation**, as an expression of environmental and infrastructural vulnerability, contribute to **population change** during a **urban flood**-related crisis in Nairobi, Kenya?

Hypotheses

- **H1. Flood intensity → human impact (main effect)**

Flood exposure should increase population change (i.e. more crisis impact).

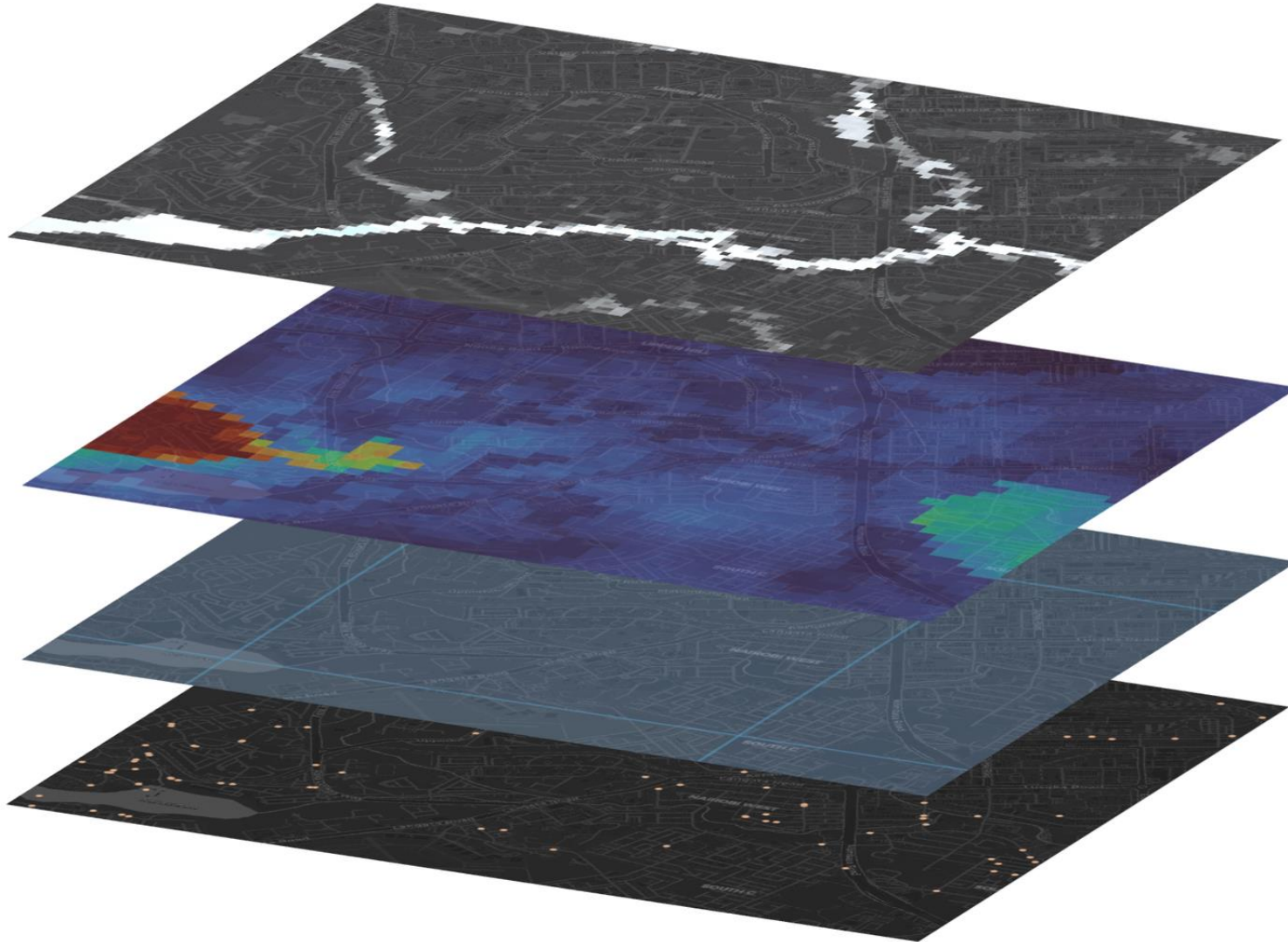
- **H2. Waste accumulation → human impact (independent effect)**

Areas with more waste should experience higher crisis population change, even when flood intensity is controlled.

- **H3. Interaction (waste × flood)**

Waste amplifies the effect of flood intensity, meaning that the impact of flooding on population change is stronger in waste-accumulated areas; indicating hazard amplification through infrastructural neglect.

Data Source



Simulated Flood:
Fast flood model, 30m, raster

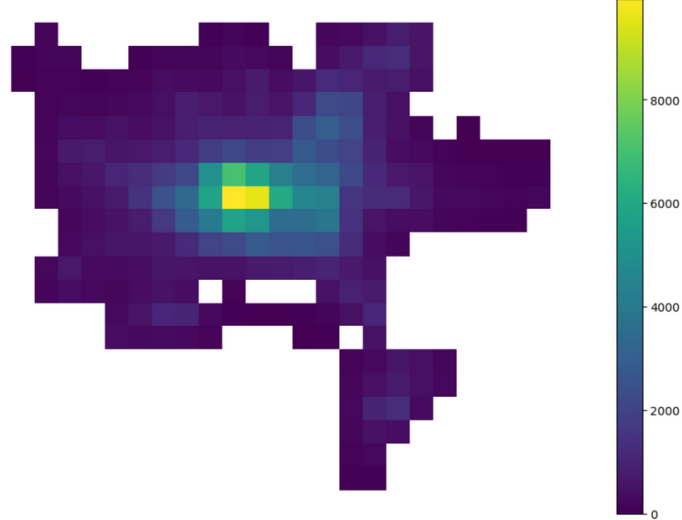
Population:
World Pop 2020, 100m, raster

Crisis population data:
Meta, 2.5km, vector grid

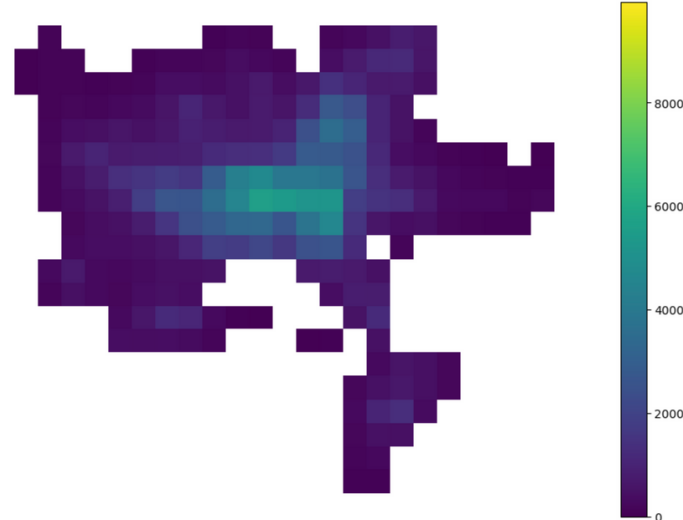
Waste accumulation map:
From Google street view, vector point

Data Source – Meta Population Distribution

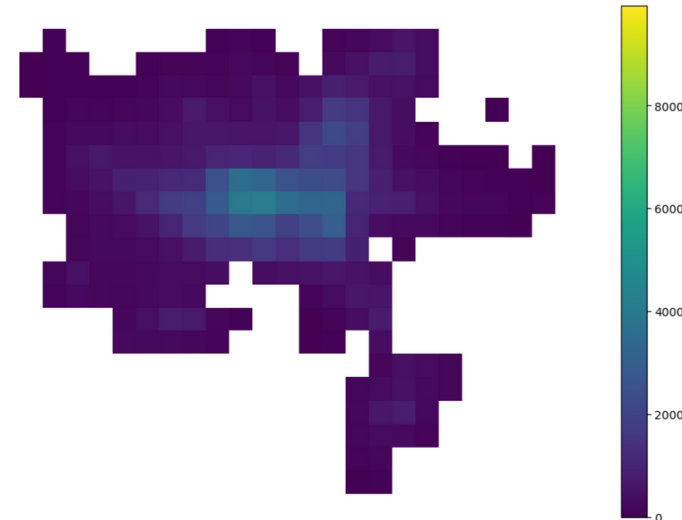
Baseline at 0h



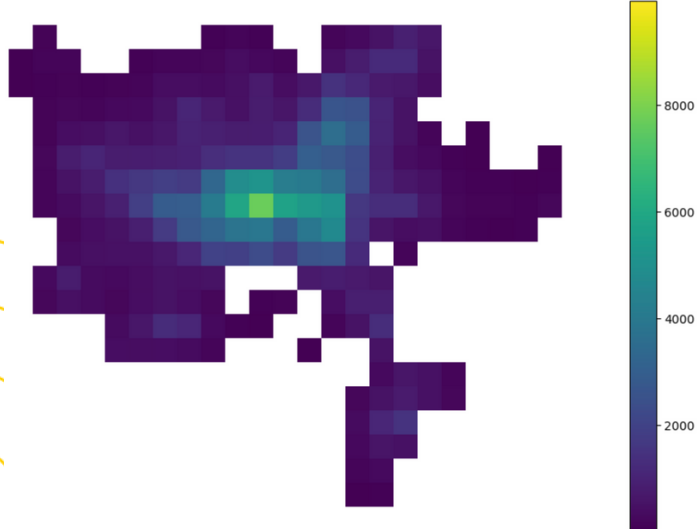
Baseline at 8h



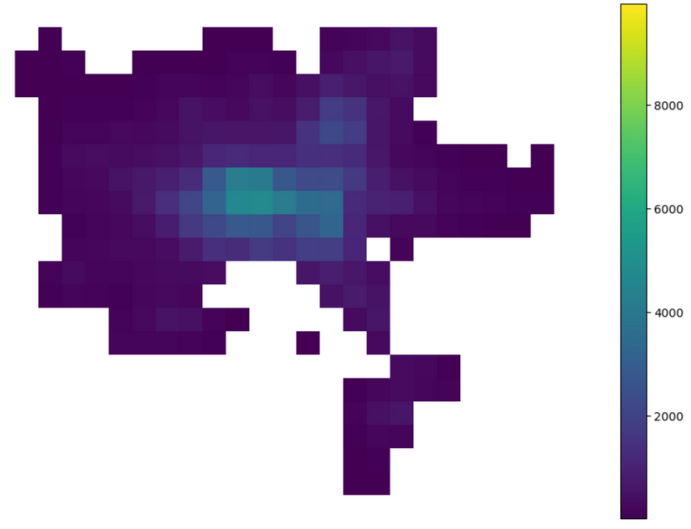
Baseline at 16h



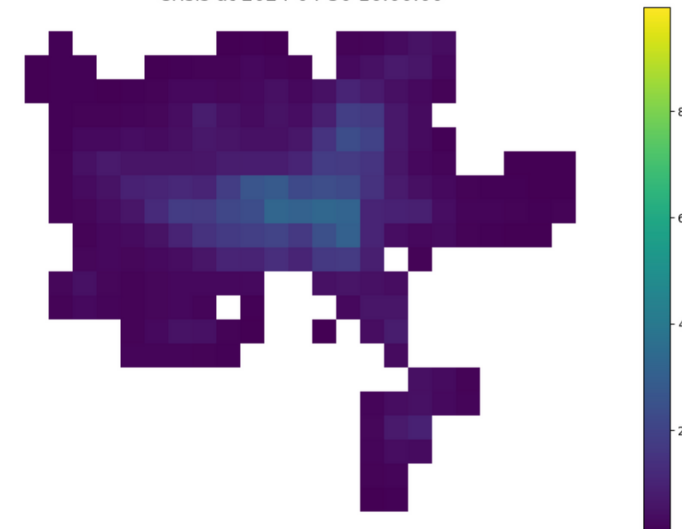
Crisis at 2024-05-01 00:00:00



Crisis at 2024-05-02 08:00:00

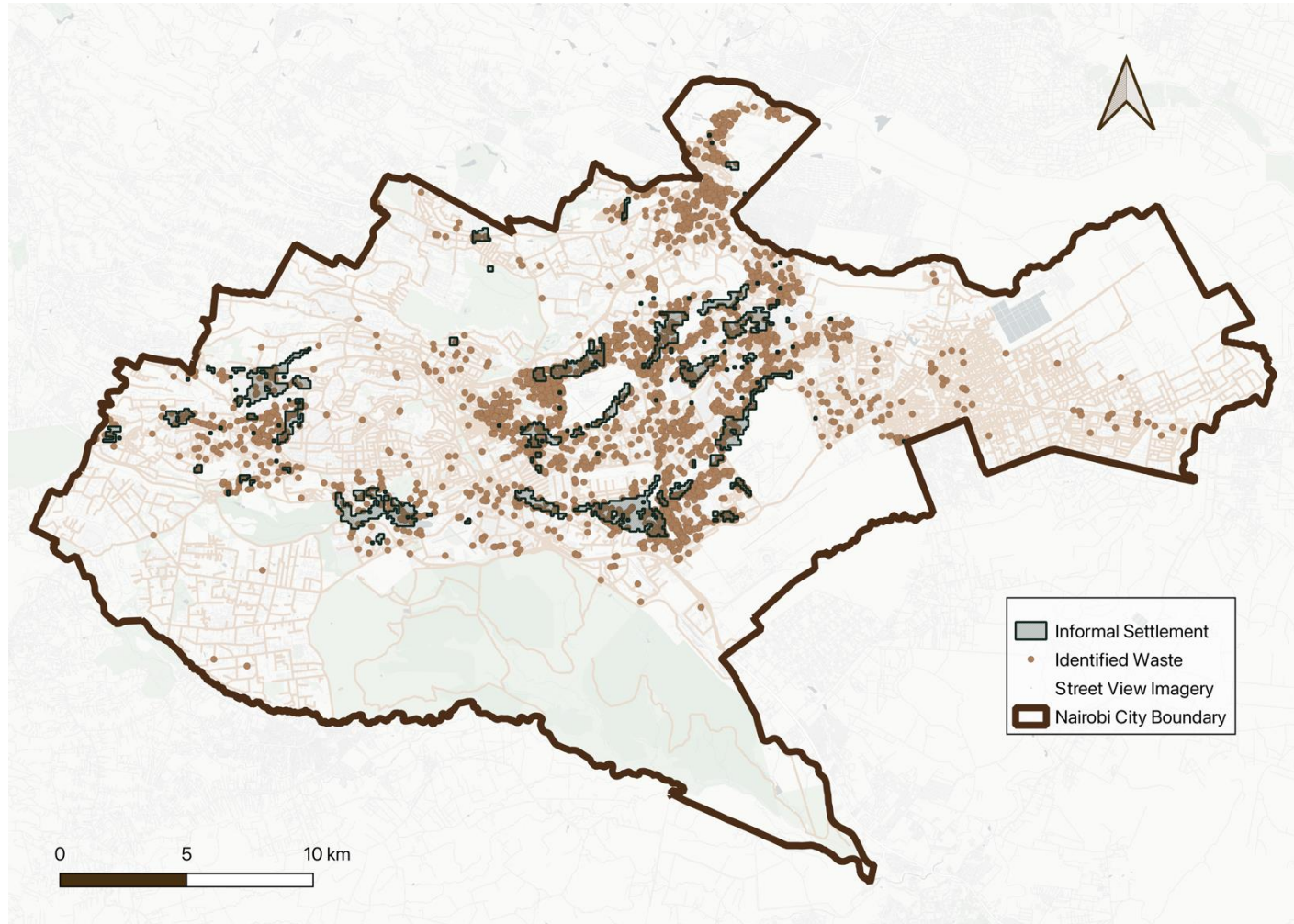


Crisis at 2024-04-30 16:00:00



; preserved.

Data Source – Waste Accumulation Map



Methodology - spatial lag model (SAR)

$$y = \alpha + \beta_1 \cdot \text{Flood} + \beta_2 \cdot \text{Near100} + \beta_3 \cdot (\text{Flood} \times \text{Near100}) + \beta_4 \cdot \text{Waste} + \gamma \cdot X + \rho \cdot W \cdot y + \varepsilon$$

- Dependent variable: crisis population change (Meta Crisis data).
- Independent variables:
 - Flood = simulated flood intensity
 - Near100 = location-based vulnerability indicator
 - Flood × Near100 = interaction term capturing amplification of flood effects
 - Waste = waste accumulation indicator
 - W·y = spatially lagged dependent variable (to account for spatial dependence)

Result - Key coefficients

Model N = 4 749; Spatial Lag (SAR, ML estimation)

Variable	Coefficient (β)	p-value	Interpretation
Flood intensity	26.92	< 0.001	Flooding is the dominant driver of crisis population change.
Near100 (proximity to waste)	-31.82	< 0.001	Baseline population change is lower near waste sites when floods are absent.
Flood \times Near100	+16.29	< 0.001	Flood impact is substantially stronger in waste-affected areas.
Waste accumulation (continuous)	+2.06	< 0.001	Independent positive effect: higher waste density increases crisis population change.
Spatial lag (ρ)	+0.52	< 0.001	Strong spillover: neighbouring displacement reinforces local impacts.

Result - Interpretation

- **Physical hazard:**

Simulated flood intensity is the strongest determinant of crisis population change ($\beta = 26.9$, $p < 0.001$). Areas experiencing more intense flooding show greater population movement during the crisis period.

- **Environmental vulnerability:**

Waste accumulation exerts an independent, positive effect ($\beta = 2.06$, $p < 0.001$), indicating that environmental neglect and poor waste management increase the scale of human disruption even under similar flood conditions.

- **Amplification effect:**

The interaction term ($\beta = 16.29$, $p < 0.001$) demonstrates that the impact of flooding is magnified in areas near visible waste accumulation. When flood intensity is high, proximity to waste increases crisis population change by roughly 60 % (from 26.9 to ≈ 43 units), confirming the role of waste as an amplifier of flood impacts.

- **Spatial spillover:**

The significant spatial lag ($p = 0.52$) suggests that population change patterns are spatially interdependent—areas experiencing severe crisis population change influence adjacent neighbourhoods, producing clusters of heightened impact.

Take Away

- **Flood intensity (simulated)** is the dominant driver of **Meta-user population change** in Nairobi.
- **Meta users near waste** sites show **lower baseline population**
 - likely reflecting **lower Meta app penetration in low-income neighbourhoods**.
- However, **waste** presence **amplifies** the impact of flooding when **floods are high**.
 - This indicates that **vulnerable**, lower-income groups face the most **extreme** flood impacts, combining physical exposure and social-environmental vulnerability (poor infrastructure, waste accumulation, public health threats)

Limitation

- **Data**
 - **Drainage** are covered or blocked by waste and difficult to **detect**
- **Modelling**
 - No **causal** inference;
 - Meta data have limited **penetration and representativeness** in cities of the Global South
 - **Alignment** of Spatial data across datasets may **introduce noise**.
 - **No longer-term or multi-event (longitudinal) changes** in flooding, waste patterns, or population dynamics tested.
- **Practical**
 - Cost - benefit analysis (maybe simulated?)



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