Supplementary Material

S1. KII and casual mapping methods

Figure S1. Semi-Structured Interview Guide

Questions:

Role & Connection to Beira

1. Can you explain your connection and experience of Mozambique, specifically the Beira region?
    a. When?
    b. Specific to pre – or post Idai?

Major Socio-Economic Changes (2000-2019)

2. How has the socio-economic situation of Beira and the region changed over the past 20 years? (E.g demographics, land-use, governance)

Groups Most Affected (who/where/when)

3. Who do you think was most affected? Which groups, where, and when?

Key Drivers of Idai's Impacts

4. What do you think were the main socio-economic drivers of the impacts of Idai?
    a. For example: urban expansion, lack of awareness, no options for evacuation, poor quality housing, poor infrastructure and drainage.
    b.

Root Causes Behind Those Drivers (land-use change)

5. What factors or conditions lead to socio-economic changes that, according to you affected Idai's Impact?
    a. What factors do you think were driving the drivers?
    b. E.g. population growth, land-use changes.

Relative Importance of Exposure vs Vulnerability

6. To what extent do you believe the impacts were caused by the region's exposure and vulnerability?

Post-Idai Recovery

7. Do you have a perspective on the post – Idai situation. - What was the trend of reconstruction/ relocation?

8. Is there anything else you would like to add?

End of interview

- Thank them for their time and insights
- Explain the next steps, including how their inputs will contribute to the guidance document

Table S1. Thematic coding method to create the causal map.

Method Steps	Input	Output	Source
1. Semi-structured interviews	Semi-structured interview question framework: informed from literature	Transcribed interview recordings	(Galetta & Cross, 2013). (Moser & Korstiens, 2017).
2. Re-read interview transcriptions	Interview transcripts	Understanding of the data and interview	(Kenzie et al. 2024)
3. Qualitative analysis of interviews: a. Open Coding of the raw text to discover themes and select relevant 'data segments' b. Segments categorized into 'higher order' categories according to risk components described in Cardona et al., (2012) and Simpson et al. (2021).	Interview transcripts	Qualitatively coded quotations – based on grounded theory methodologies. Example of qualitative analysis shown in Appendix.	(Kim & Anderson, 2012) (Moser & Korstiens, 2017)
4. Transform variables and causal relationships into "words-and-arrow" diagrams: Create 'partial' or 'microstructure maps' of interview specific maps constructed from variables and causal relationships identified from Step 3.	Interview - coded quotations based on categories.	Micro-structure maps of identified key categorized variables and their interrelationships	(Newberry & Carhart, 2023) (Kim and Anderson, 2012) (Kenzie et al. 2024) (Hanf et al., 2025)
5. Add all variables and relationships into a causal mapping table (Excel)	Interview specific micro-structure maps	Table – detailing variables, links, description, category direction and quotation	(Kenzie et al., 2024)
6. Create causal map – upload table into visualisation software – (Kumu)	Causal mapping table	Overall causal map – in Kumu	(Kenzie et al., 2024)
7. Develop causal loop diagram	Identified key causal loop from causal map. Synthesized information	Causal Loop diagram of identified key drivers and their interactions	(Kim and Anderson, 2012)

Table S2. Example interview quotes and causal mapping method.

Example Quote	Interview Number	Category	Sub-Category	Description	Causal Map Variables
" And around Beira, it's very flat and there's lots of, river channels. Yeah. And so there was just mass flooding"	INT_02	Exposure	Physical Exposure	The geography of the region is highly exposed	Geography of Beira: Low elevation, proximity to the coast and river channels
"Beira is a low-lying city... with large parts of the city not served by drainage infrastructure."	INT_07	Exposure	Physical	Poor drainage systems in Beira	Inadequate Urban Drainage
""after Idai... people could still try to plant some fields... but then again there was a crop failure the next year."	INT_06	Response	Economic Vulnerability	Recurring flooding, preventing crop planting, hindering recovery	Crop Failure
""even when floods are not so severe, you still have damage to infrastructure because infrastructure in itself, it's usually poorly maintained."	INT_06	Vulnerability	Physical Vulnerability	Very poor infrastructure quality	Poor Infrastructure Quality
"about 90% of the infrastructure in Beira was affected by the cyclone. in terms of electricity, water access, all of that, it was broken down "	INT_03	Impact	Direct Impact	Direct impact in Beira from Idai	Extensive Infrastructure Damage
" if you live in rural Mozambique and you don't actually own the land and you live in a house that you made from pretty much, like, scavenged materials in the landscape, then you don't really have anything to your name. So you don't you don't easily have the ability to move into a city or to rent a place "	INT_02	Vulnerability	Social Vulnerability	Systemic poverty and land tenure ship leaves rural households with very few options	Insecure Land Tenure
"And the thing is that for Beira, a lot of the people living in Beira are involved in agriculture. They they do agriculture projects, and I don't quite remember the statistics, but a lot of the livelihoods are linked to agricultural activities"	INT_01	Vulnerability	Social Vulnerability	Dependence on urban based food systems	Reliance on urban agriculture
"Four or five years after the cyclone hit... some people still have open roofs or leaking roofs."	INT_04	Response / Indirect Impact	Response / Indirect Impact	Lack of reconstruction and slow response after the cyclone	Slow Reconstruction after Idai
"In the aftermath of Idai: in order to get something going, a lot of the young men went into charcoal burning. And charcoal burning involves depletion of the forest area and also some mangroves for fuel. So there was an influx of charcoal on the market, and even the price dropped. And when you are removing the vegetation cover, You are making the city more exposed to the severe impacts from cyclone. "	INT_03	Response / Indirect Impact	Response / Indirect Impact	Indirect impact of charcoal production and lack of alternatives	Environmental Degradation / Loss of forest cover
" The vulnerability of the people, you know, by virtue of being poor... makes the impacts of the cyclone much worse."	INT_05	Vulnerability	Economic Vulnerability	High economic vulnerabilities made the impacts much worse	High socio-economic vulnerabilities
"If it wipes people's farms out, that might lead them to harvest more charcoal to make up for the lost income."	INT-_08	Response/ Indirect Impact	Response / Indirect Impact	Feedback effect of losing crops to flooding impacts, results in even more deforestation	Charcoal Production
"This wasn't something it wasn't something they had experienced before, and they were totally unprepared To deal with the sort of impacts that occurred because a lot of people were affected. "	INT_03	Vulnerability	Social Vulnerability	Total lack of awareness and preparedness for the scale of the cyclone	Lack of preparedness

S2. Additional compound flood modelling information

Table S3. LULC reclassification and Manning values.

Lisboa et al., (2024) LULC Classes	Lisboa et al., (2024) LULC class description
Forest	1
Mangrove	2
Forestry Plantation	3
Cropland	4
Grassland	5
Wetland	6
Settlement	7
Other land	8

Reclassification

Reclassified Vito 2019 LULC Class	Reclassified Vito 2019 LULC class description	Assigned Mannings' N Value
114	Closed forest deciduous broad leaf	0.1
122	Open forest evergreen broadleaf	0.11
126	Open forest unknown	0.1
40	Cultivated and managed vegetation	0.037
30	Herbaceous vegetation	0.034
90	Herbaceous wetland	0.035
50	Built up	0.1
60	Bare/ Sparse	0.023

S3. Additional Results

The Figure S2 shows the discharge response difference between a large river (the Buzi river) and a smaller river located within the study region.

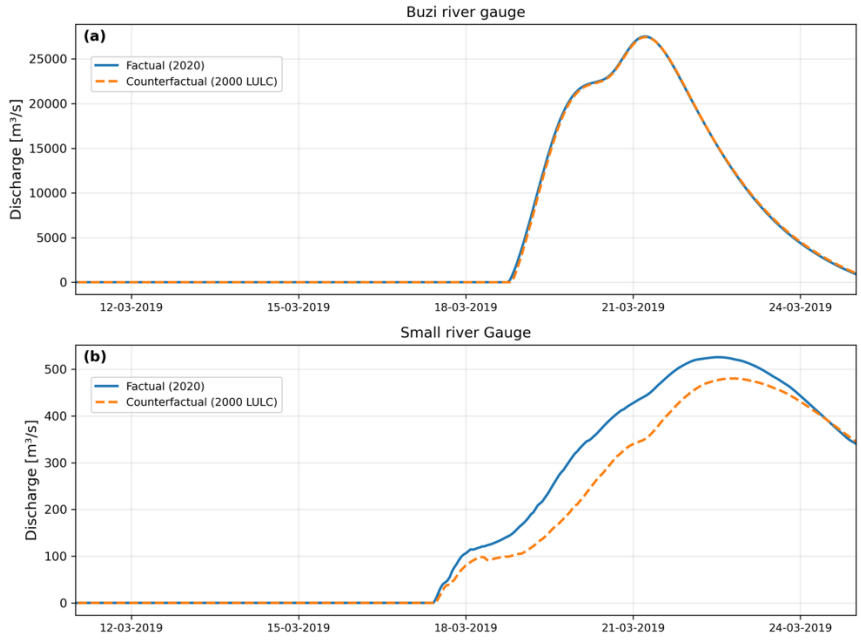

Figure S2. Discharge timeseries for two river gauges station showing the difference in discharge between the factual and counterfactual LULC scenario.

a) shows minimal difference in discharge over time for the Buzi River time gauge.

b) The discharge for the factual LULC scenario is greater, and peaks earlier for the small river.