Using Network Science and CDR's to evaluate access to critical facilities in Freetown, Sierra Leone

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Objective

1. Evaluate **accessibility** to Education and Health facilities taking into account the **demand or limited capacity** into these facilities

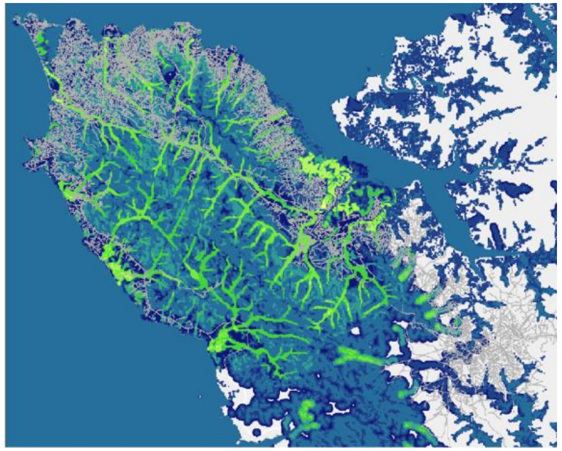
2. Explore **vulnerability** of neighborhoods and services both Seasonal disruptions and Major Hazards

3. Identify interventions to enhance the **resilience** of the urban mobility

“Resilience” has various meanings

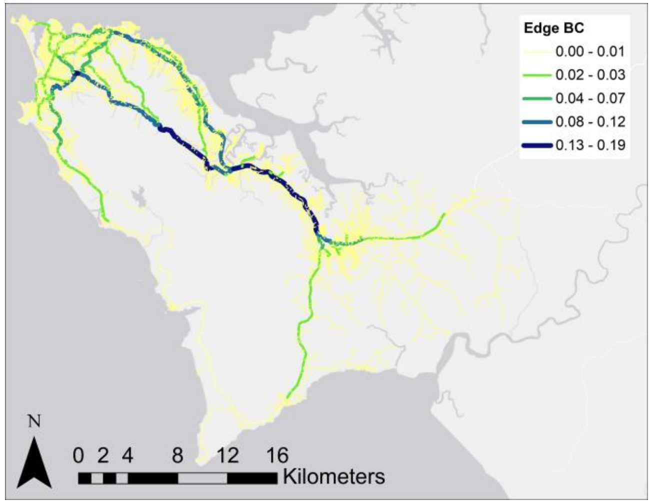
How systems resist, absorb, adapt, transform, and recover after stress or disasters.

We view “resilience” as the flipside of “vulnerability” to hazards



Vulnerability

Resilience



Diminishing vulnerability increases resilience

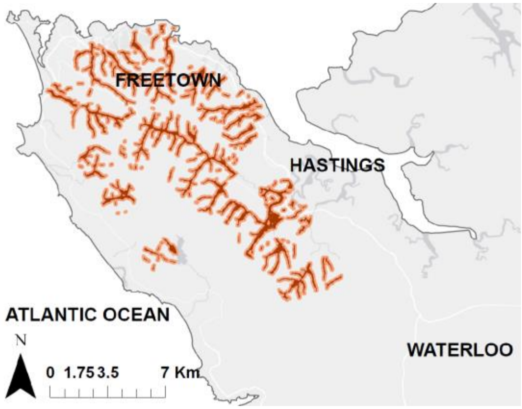
Part I

- Identify vulnerable and critical roads
- Simulate hazard scenarios and test road intervention sites

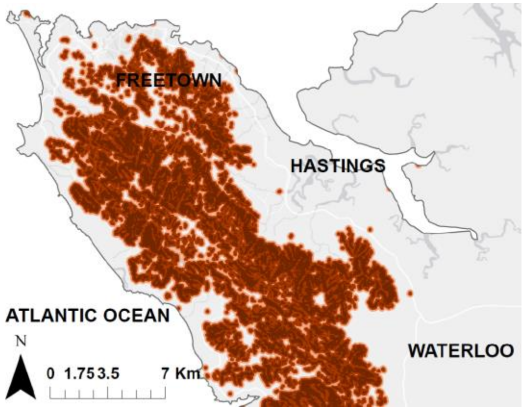
Estimating Risks

Geological Risk Factors

Mudslide

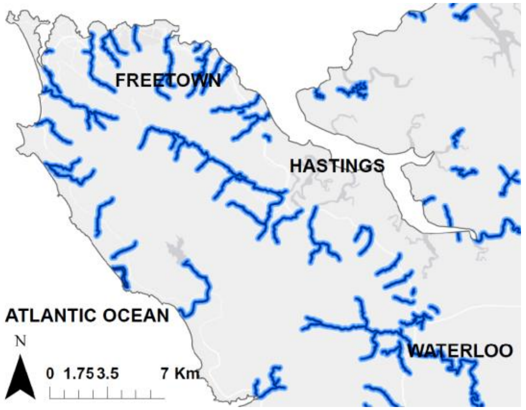


Landslide

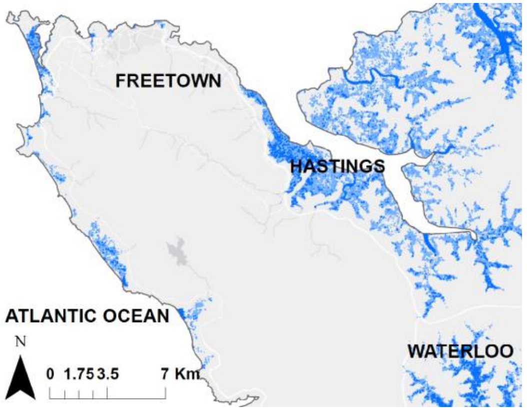


Hydrological Risk Factors

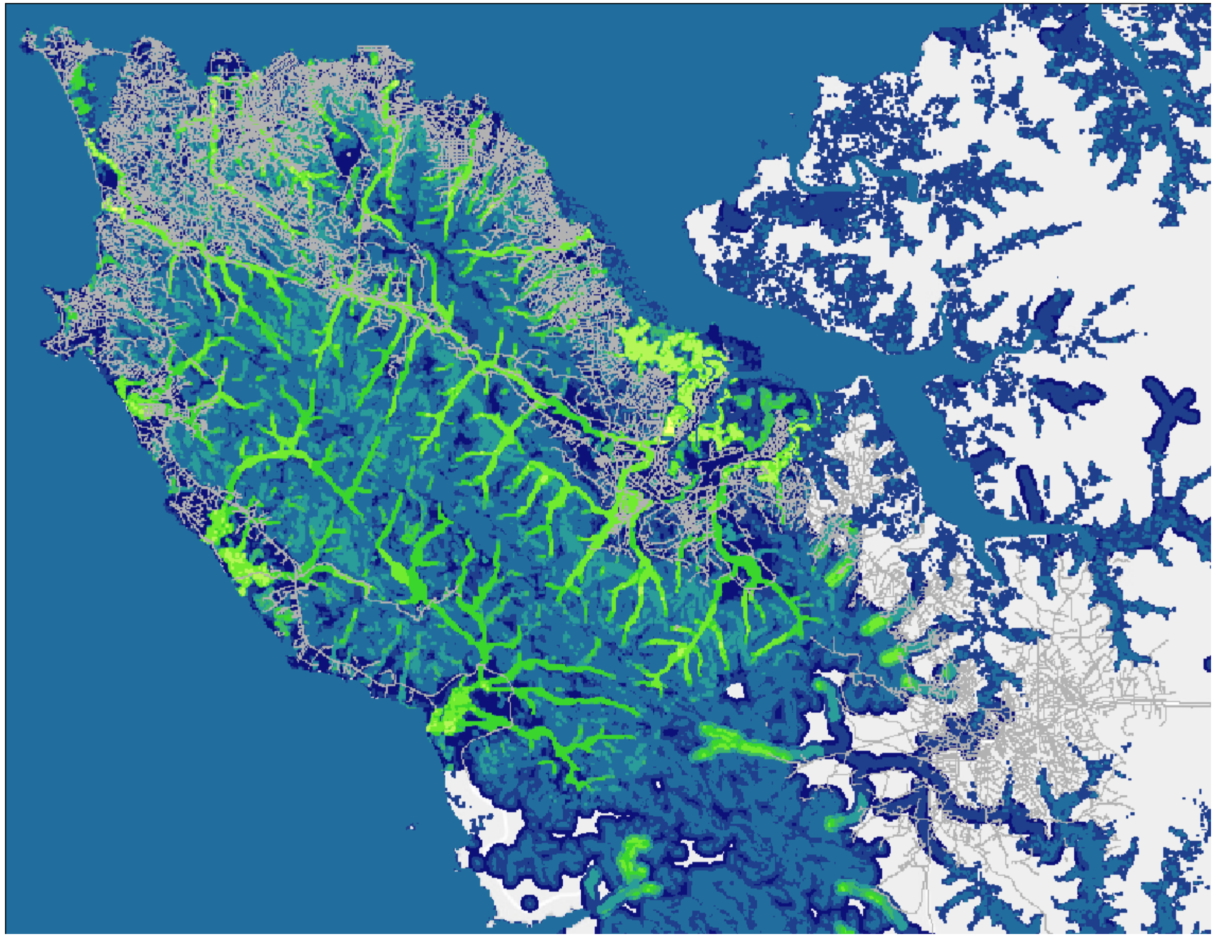
Riverine Flooding



Coastal Flooding



Input: Hydrological and Geological Risk Factors



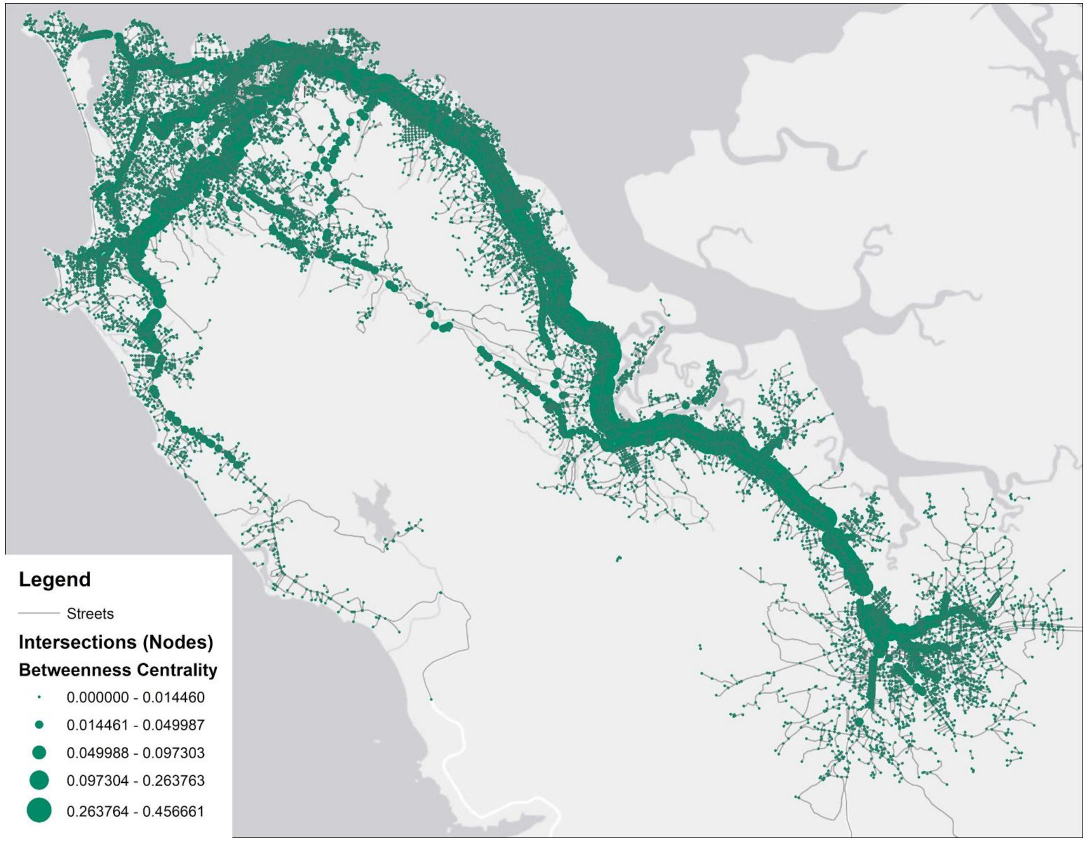
Output: Hazard for river flooding, landslides, mudslides, sea level rise, and storm surge

Network Science Analysis

KEY CONCEPT: BETWEENNESS CENTRALITY

Quantifies the number of times a node lies on any shortest paths in the graph, including every possible pair of origin and destination points. Its calculation is given by:

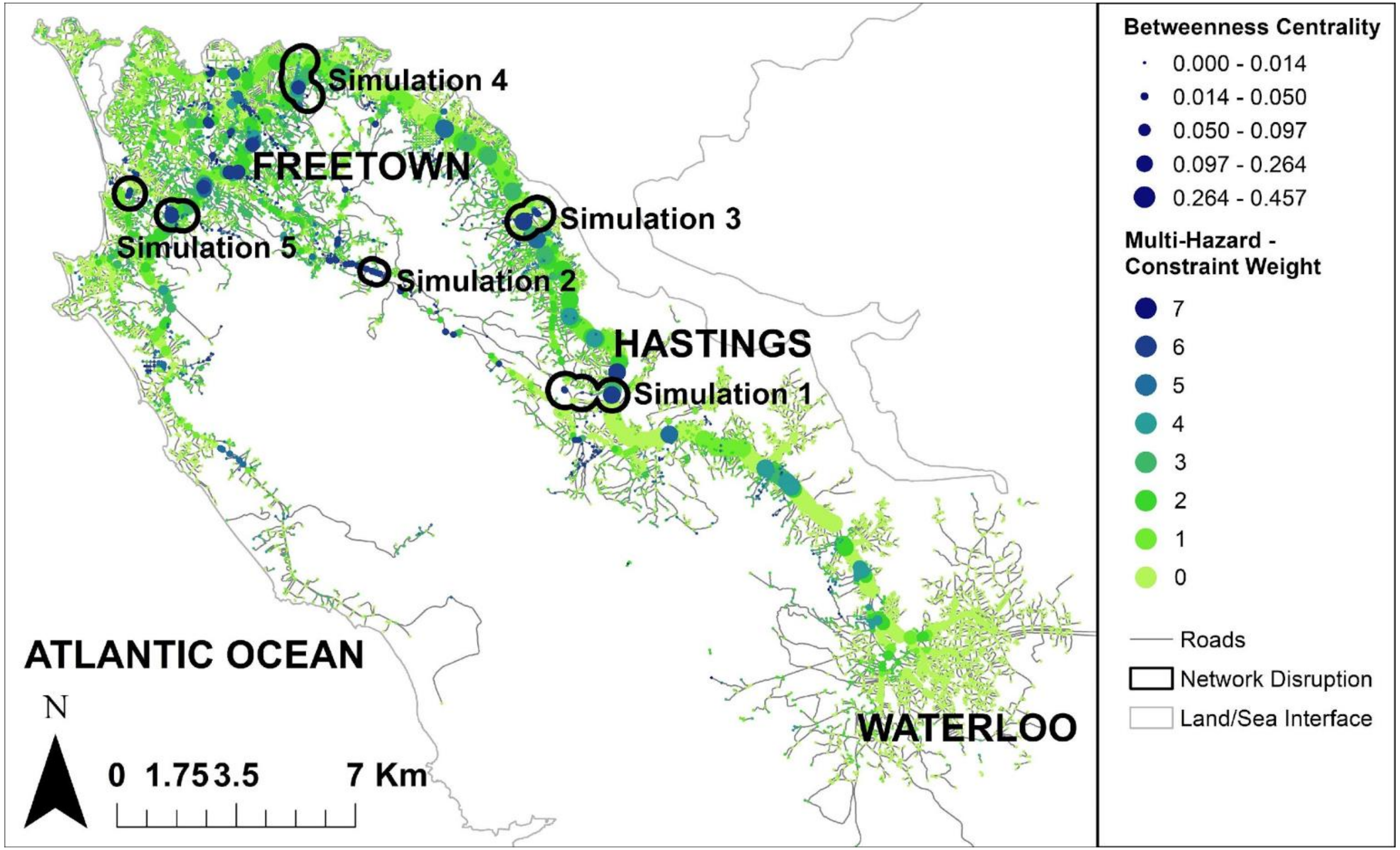
$$BC(v) = \sum_{i \neq v \neq j} \frac{\sigma_{ij}(v)}{\sigma_{ij}}$$



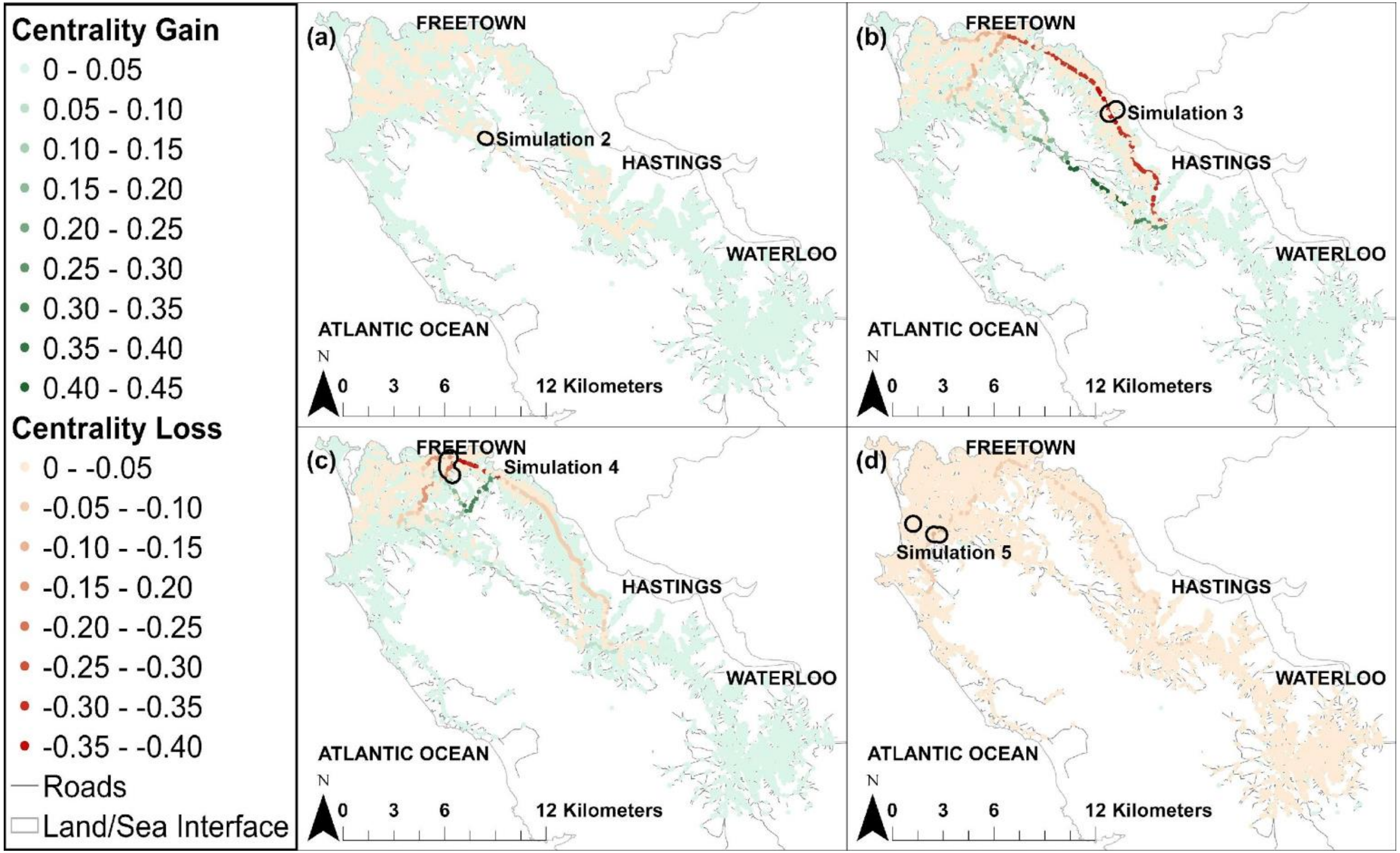
BC serves as a strong measure of how important each node is for all origin-destination node pairs within the transportation network

v is any node, *σ* is the total number of shortest paths between unordered node pairs *i* and *j*, and $\sigma_{ij}(v)$ is the number of those shortest paths which pass through *v*. It ranges from 0 to 1 in value.

Through matrix, we select scenarios



Estimated Changes in the Road Network

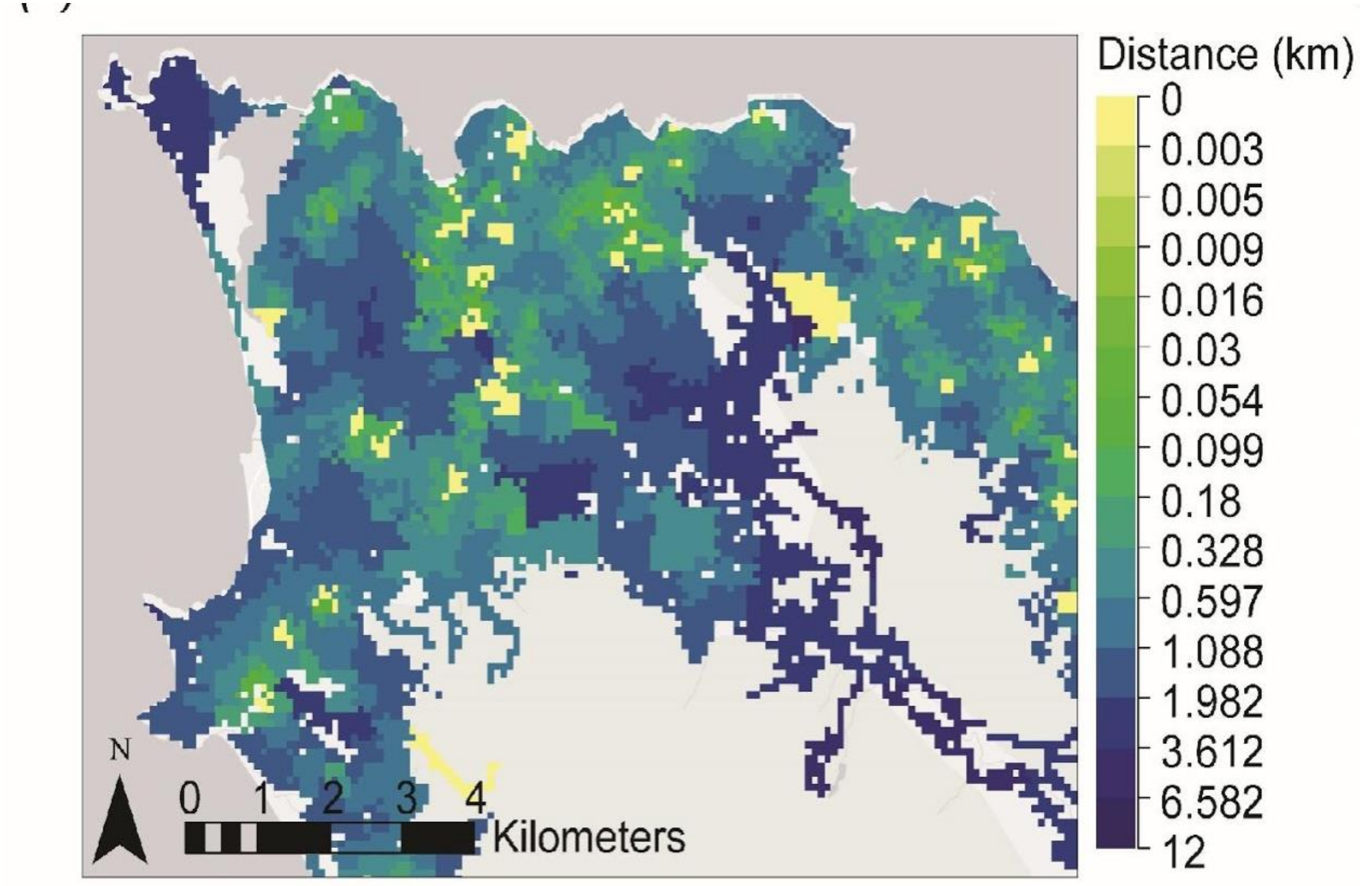


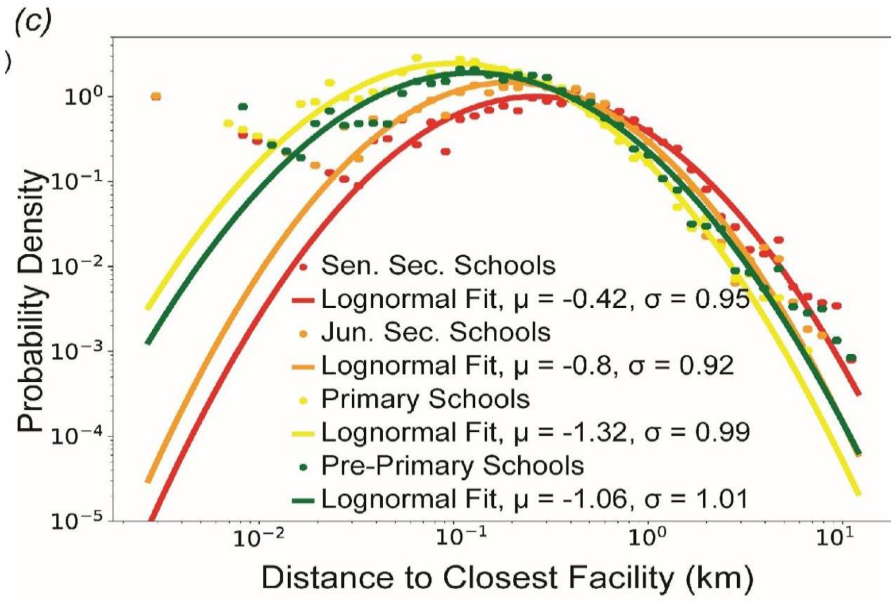
Part II

- Quantify Vulnerability as the Access to Key Facilities Service Area such as Schools and Health Centers

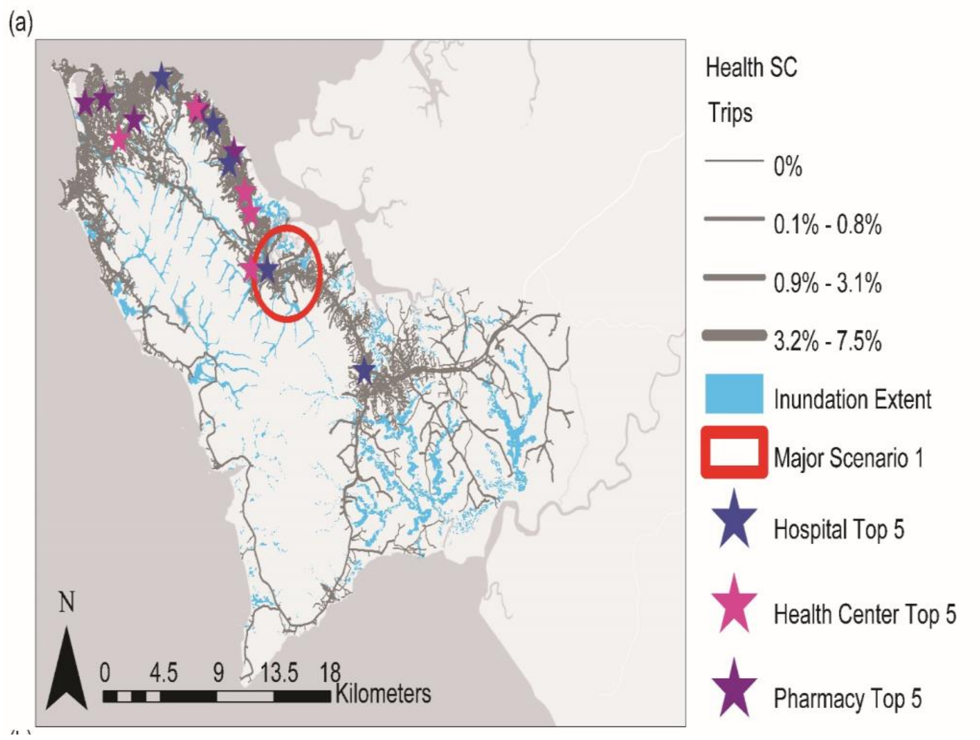
- Apply state of the art Climate Projection methods

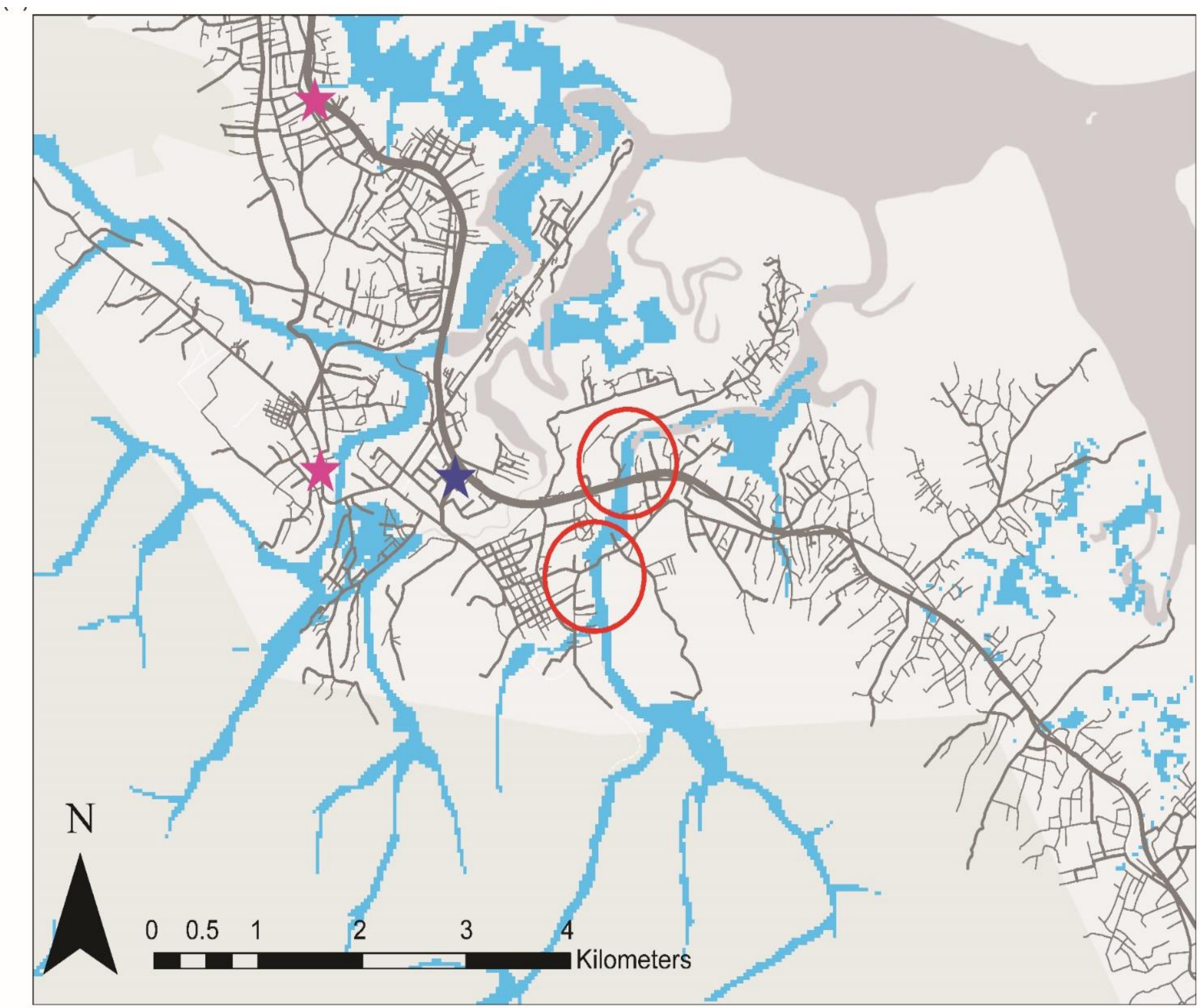
Accessibility via Road Network - Schools



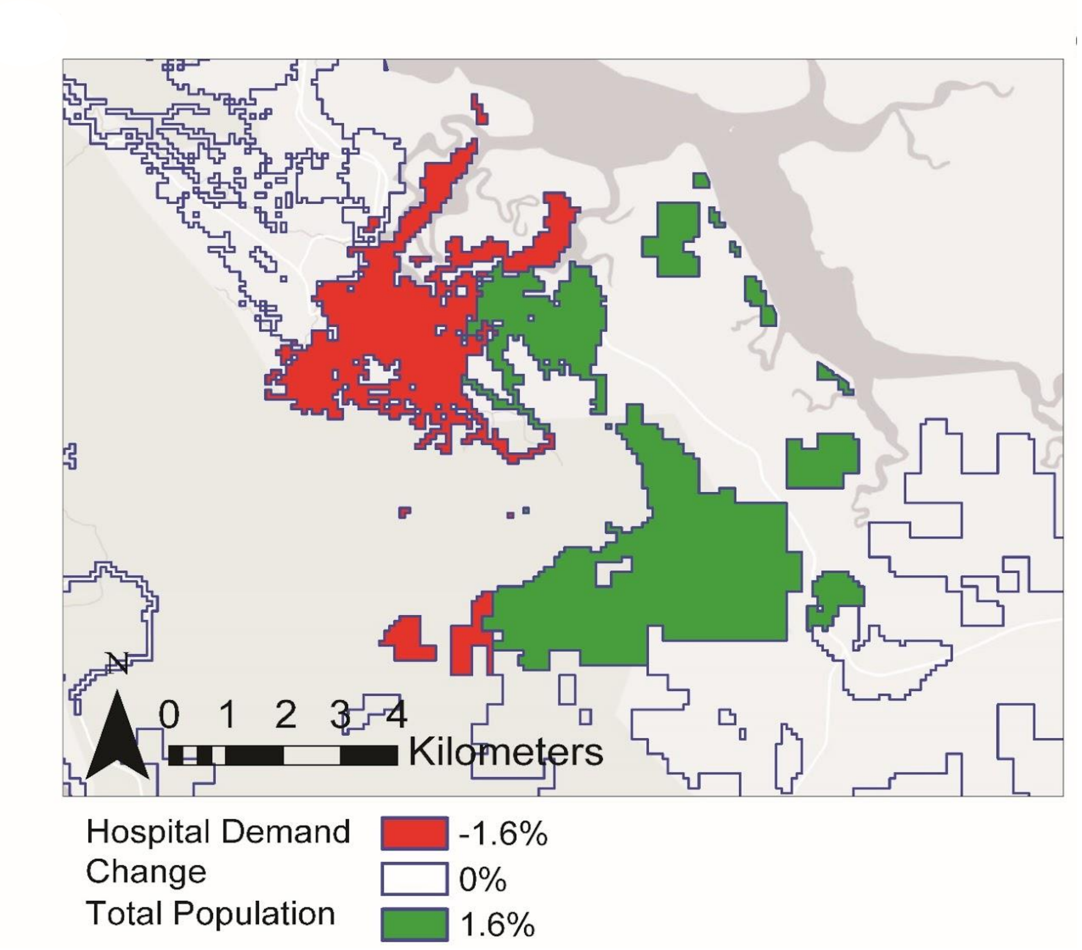


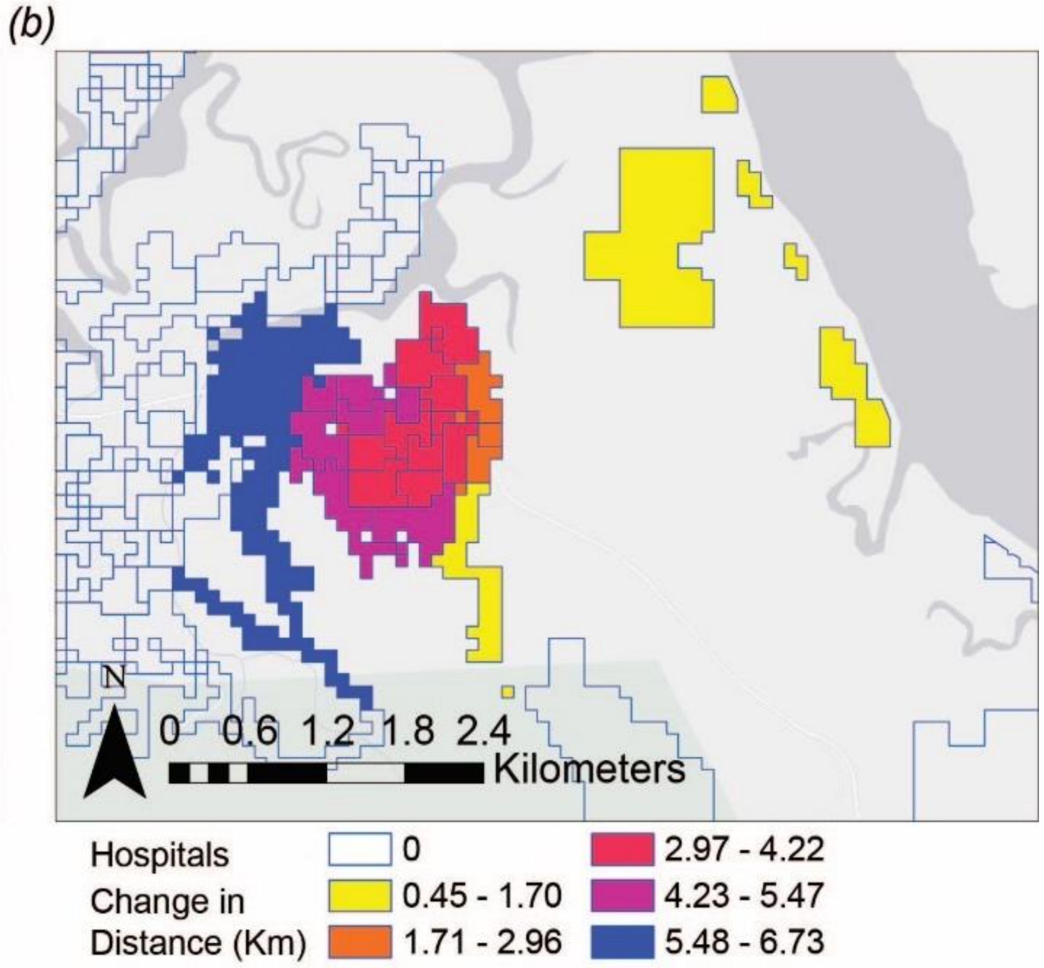
Scenario Analysis: Top Facility vs. Roads Affected





Demand and Accessibility Changes under Flooding Events



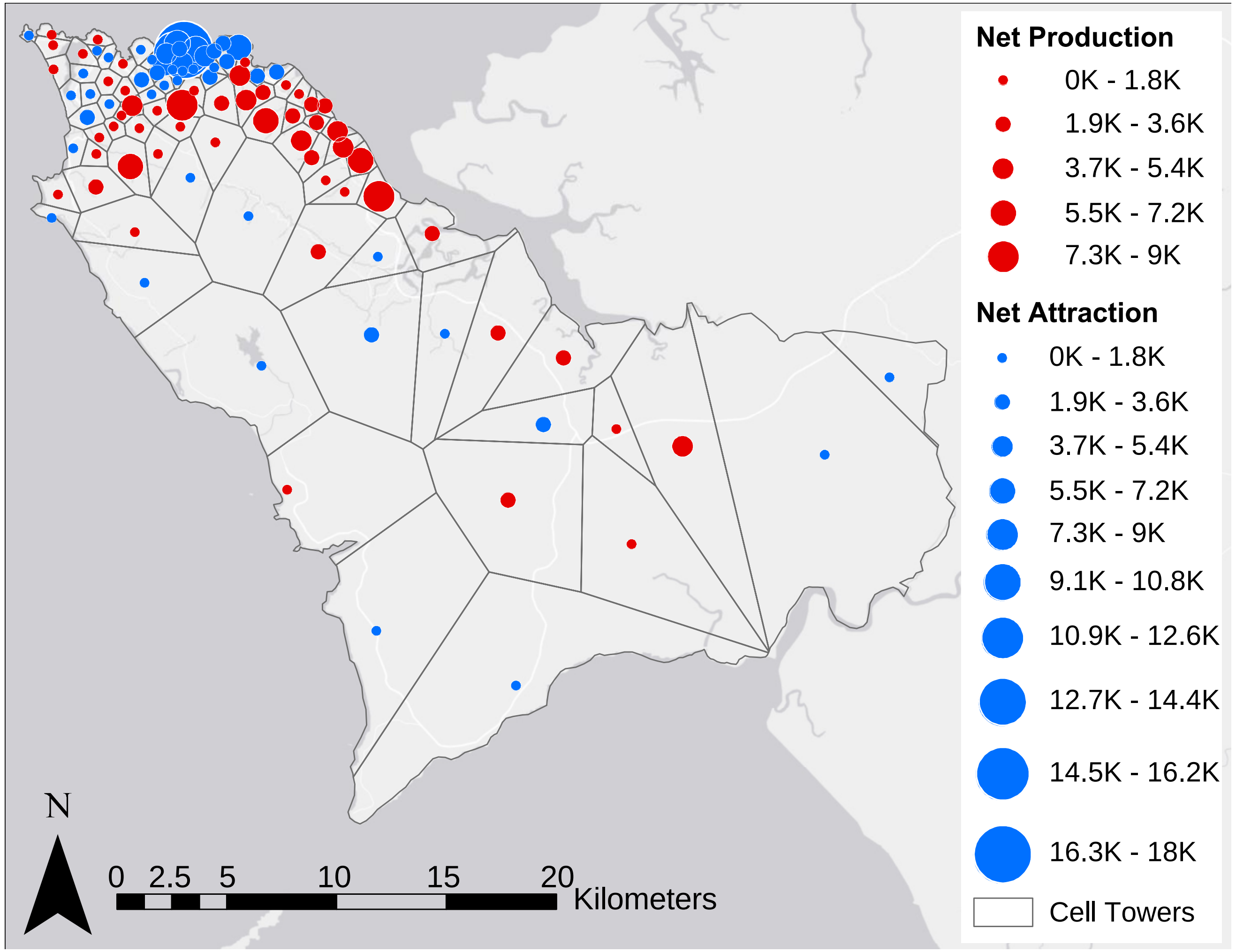


Part III

- Calculate trip demand informed by Call Detailed Records (CDRs)

- Focus vulnerability analysis on streets serving transit system

Call detailed records: Trip Production and Attraction



Within each of these regions, blue and red dots indicate the

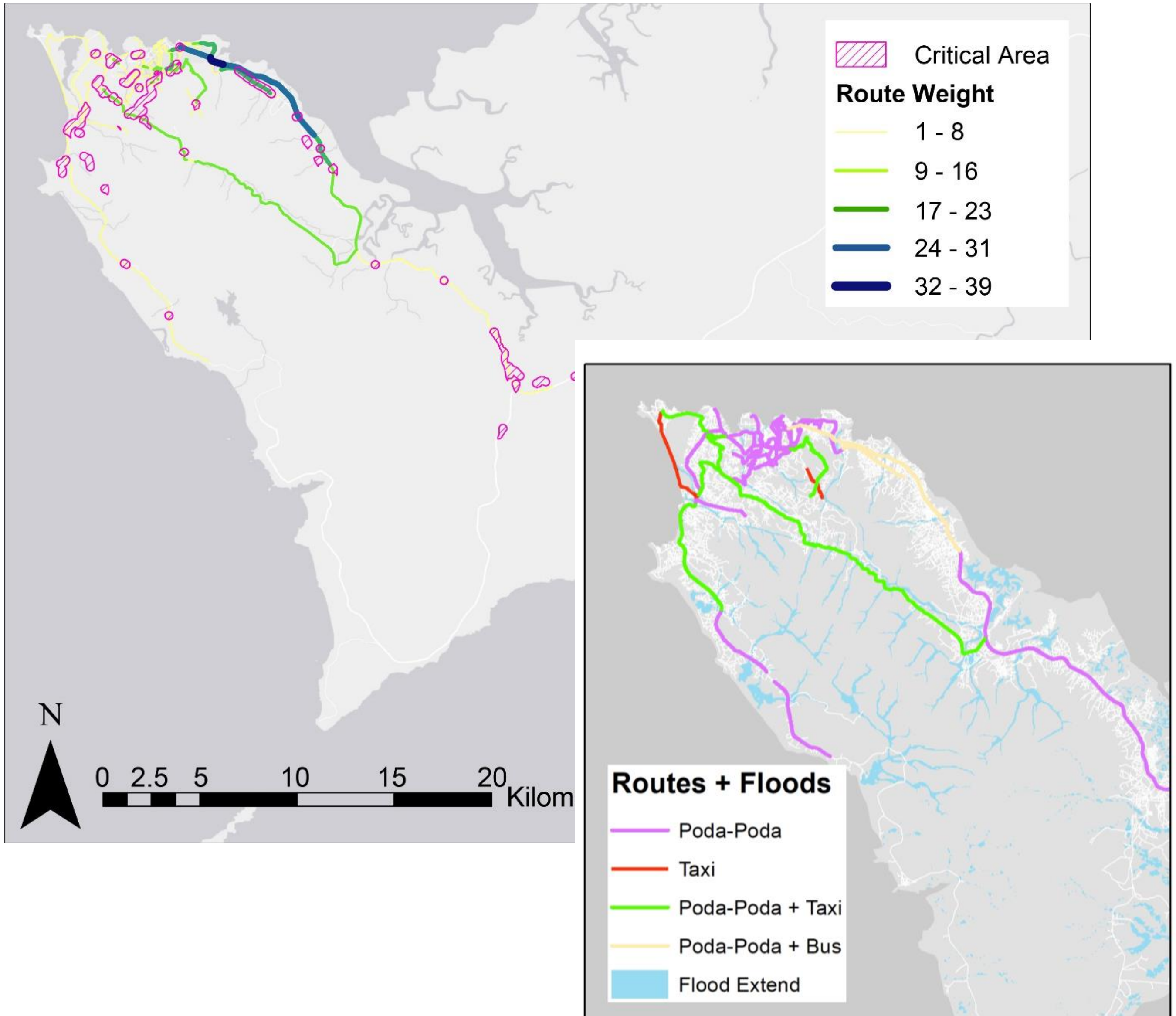
net attraction: (trips received - trips generated)

or

net production: (trips generated - trips received)

Using CDR-based OD matrix in the morning peak

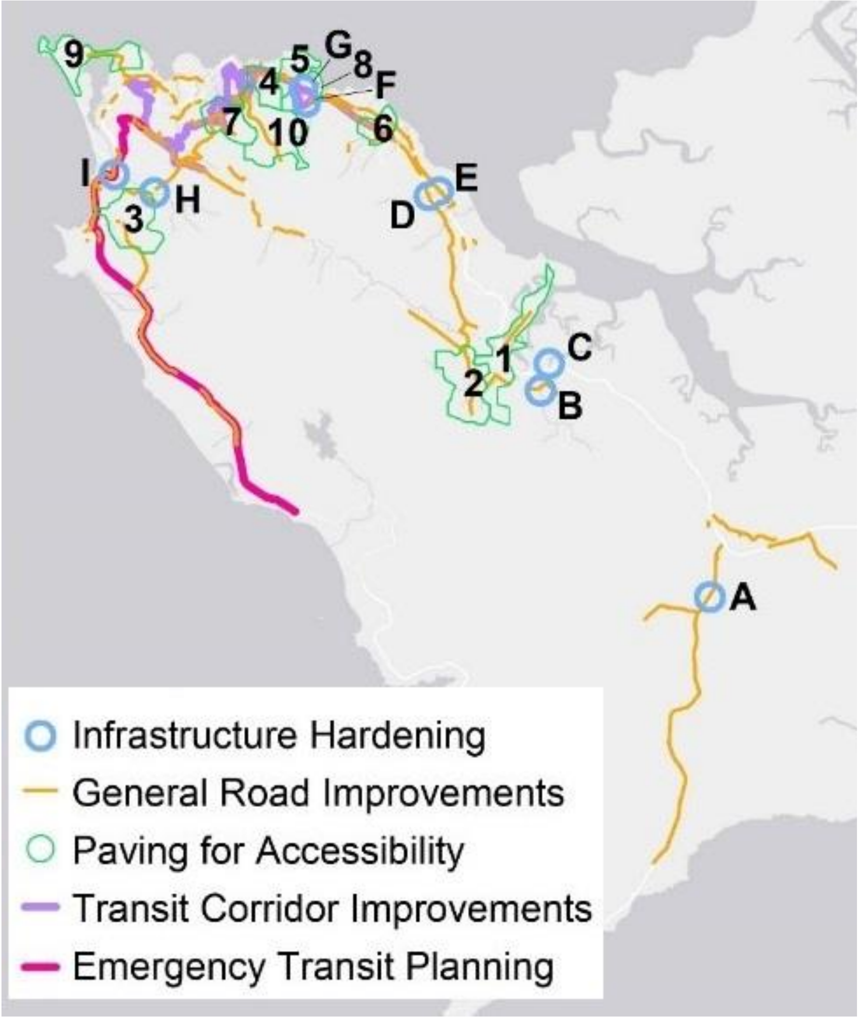
Flooding Scenario on Transit Routes



Transit corridor on Eastern Area shown as most critical in terms on enhancing climate resilience of Freetown urban mobility

Investment Recommendations

- **Infrastructure Hardening:** critical points vulnerable to disasters
- **Road Improvements:** road with high demand and serviceability
- **Paving For Accessibility:** neighbors with high flood exposure and low accessibility
- **Transit Corridor Improvement:** transit corridor with high flooding impact
- **Emergency Transit Planning: t**ransit corridor to become emergency routes



Conclusions and Discussion

- This methods has:
  - Identify needs for climate resilience on urban mobility
  - Determine accessibility constraints to critical social services
  - Incorporate real transport demands with CDR
  - Define priority for transit corridor improvements from resilience angle

- Future: Evaluate changes in CDR patterns during rainy season

Thank you very much for your attention!

Questions or Comments?

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