Sea Level Rise and Urban Infrastructure

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Sea level rise

- IPCC: 0.38 to 0.77 meters of global mean SLR by 2100
  - Projections exceed 2 m in worst-case scenarios
  - Depending on ice loss in Antarctica and Greenland
- Substantial land subsidence for many coastal cities
  - Worst-affected cities mostly in Asia
  - Sinking between 5 and 15 mm per year

This paper

- Exposure of urban infrastructure to SLR up to 5 meters
- SUDS: Sea level rise and Urban infrastructure Data Set
  - New global data covering 11,422 cities, 3.7 billion people
- Implications for urban inequality and urban adaptation

Frontier spatial data

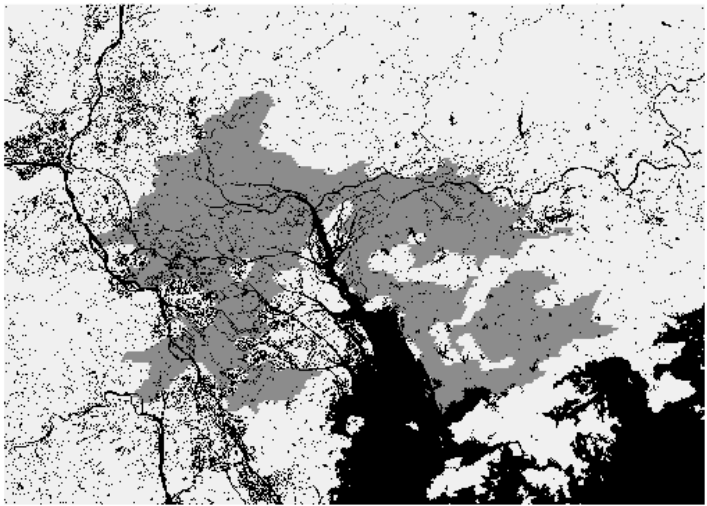
- Harmonized at 30-meter resolution

- City boundaries: GHS-UCDB
- Coastal terrain: DeltaDTM
- Infrastructure: OSM, GRIP
- Night lights: VIIRS

Inundation

- Elevation data from DeltaDTM
  - Copernicus satellite-derived elevation data
  - With forests and buildings removed
- Simple physical model of sea level rise
  - Elevation + hydrologic connectivity
  - (Below sea level + in the ocean's path)

1. Guangzhou



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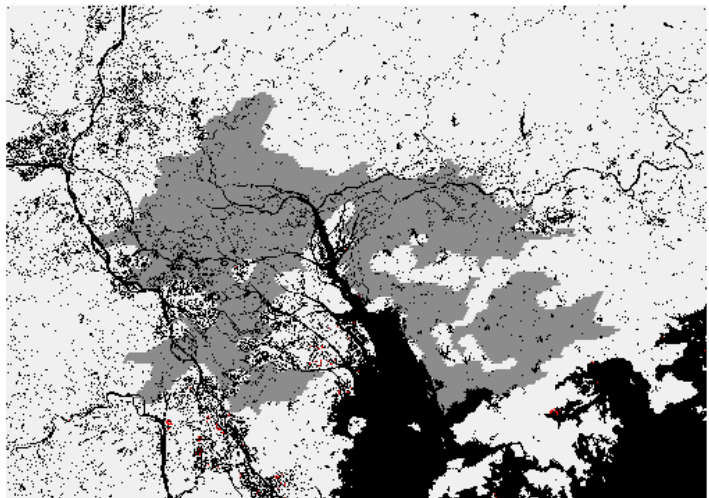

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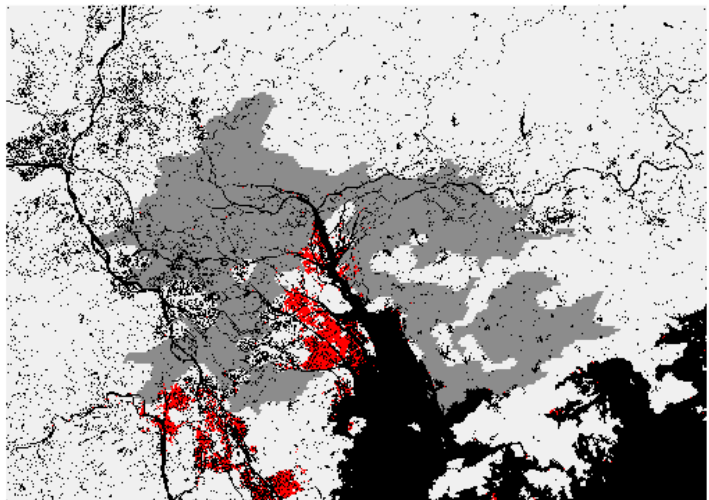

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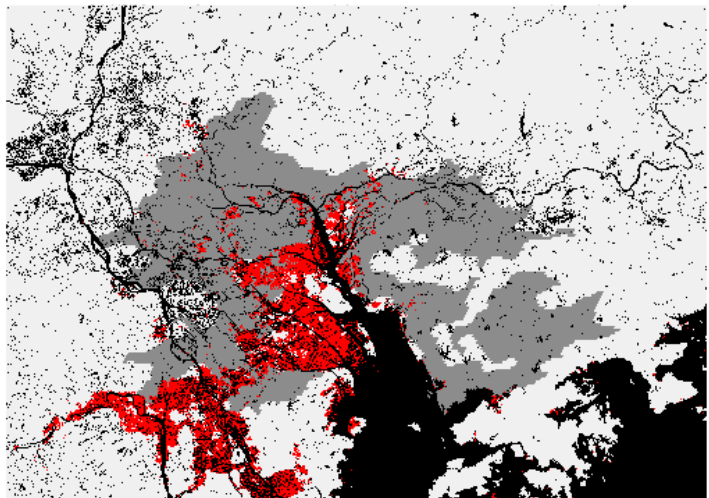

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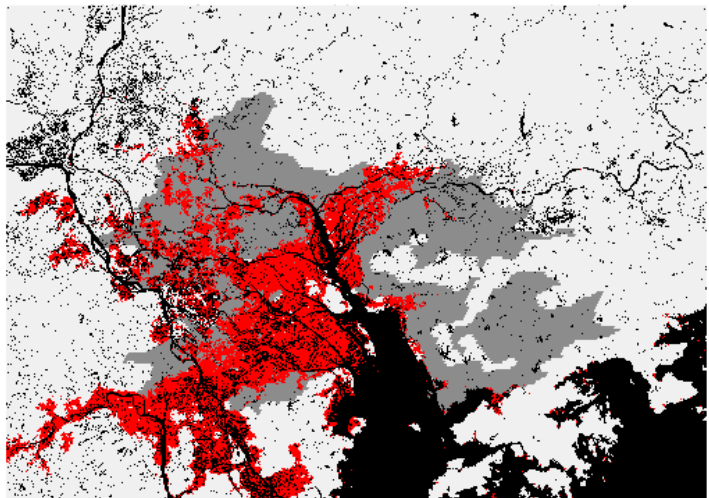

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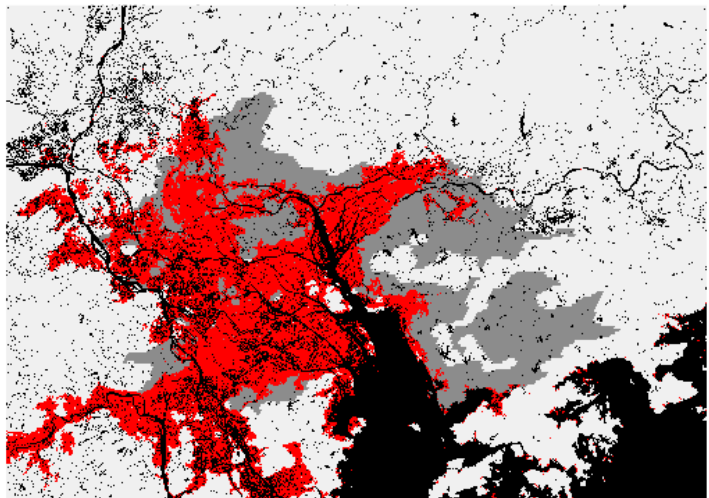

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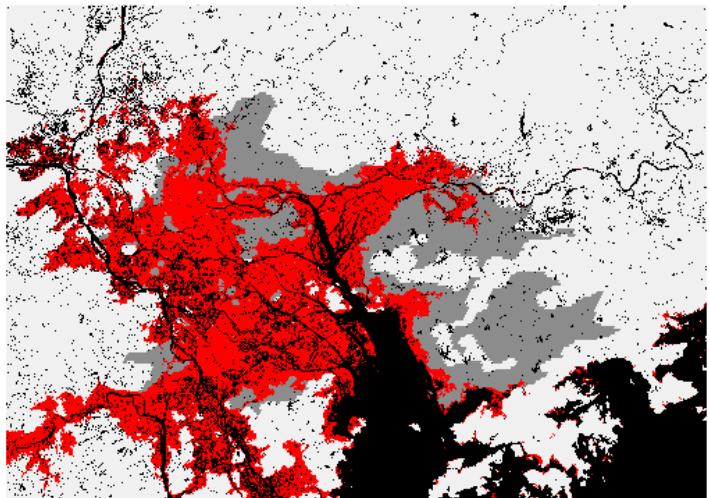

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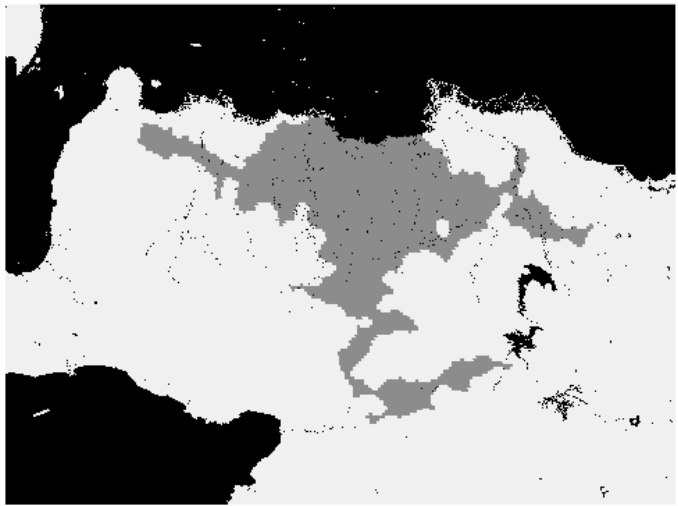

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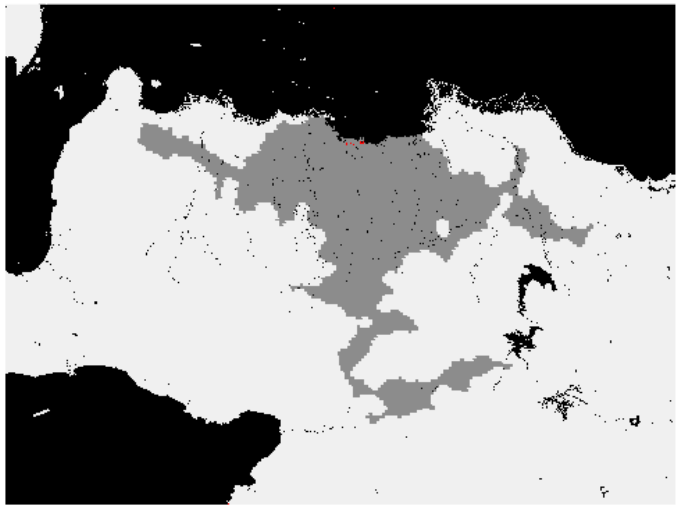

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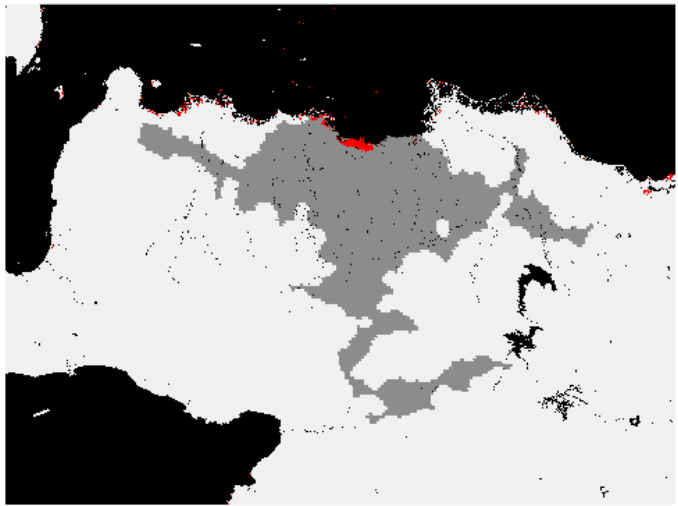

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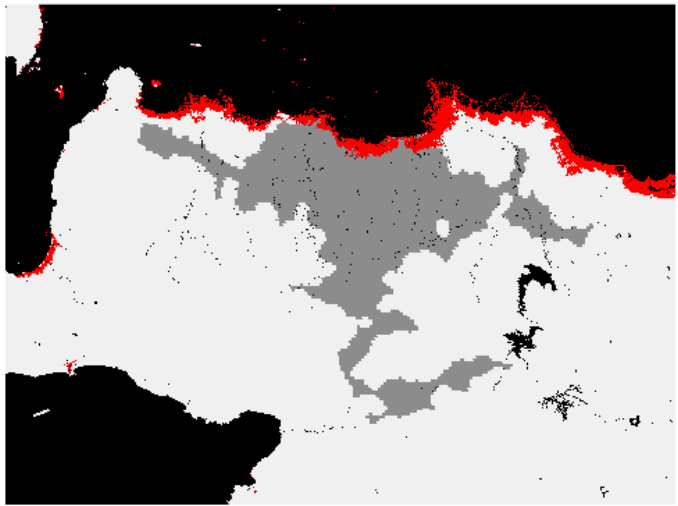

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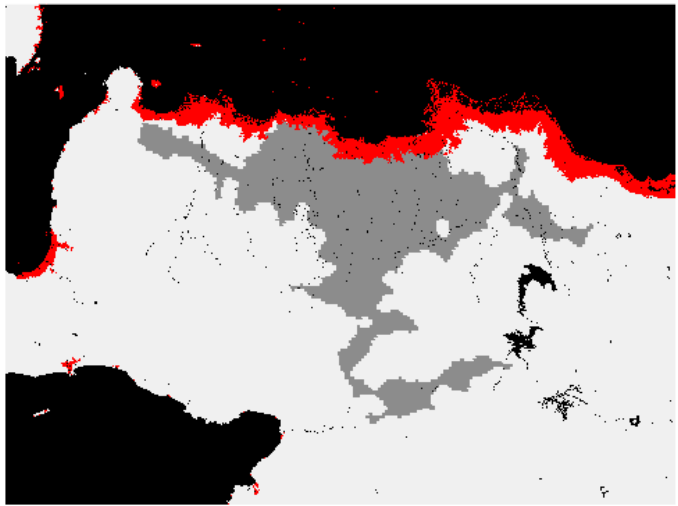

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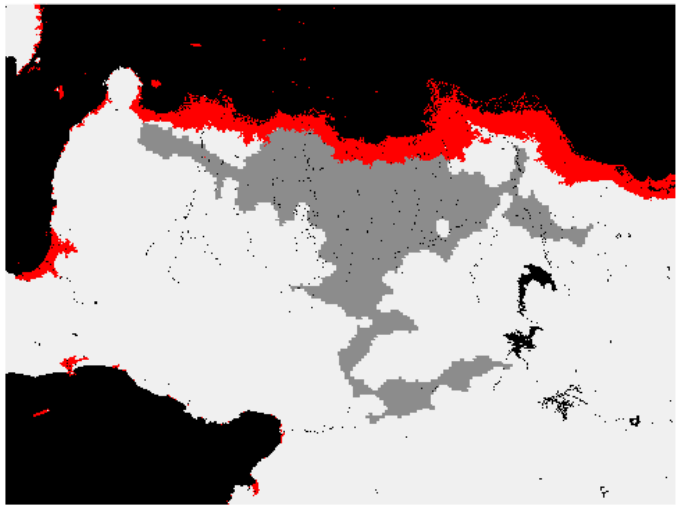

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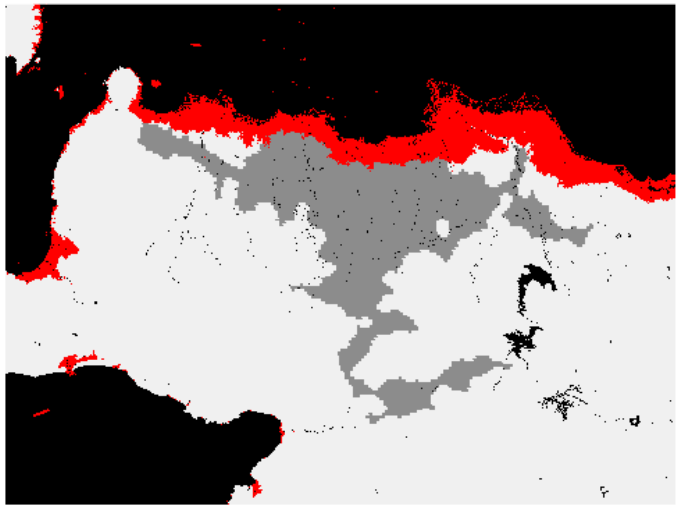

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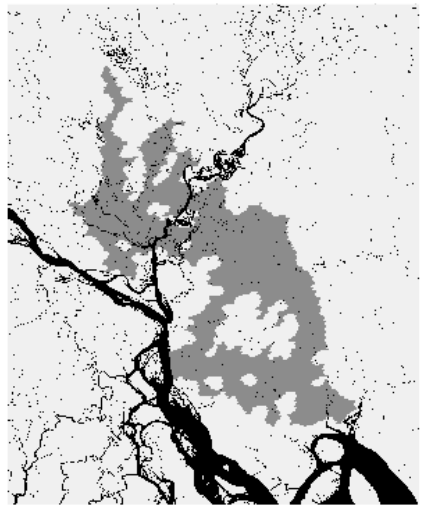

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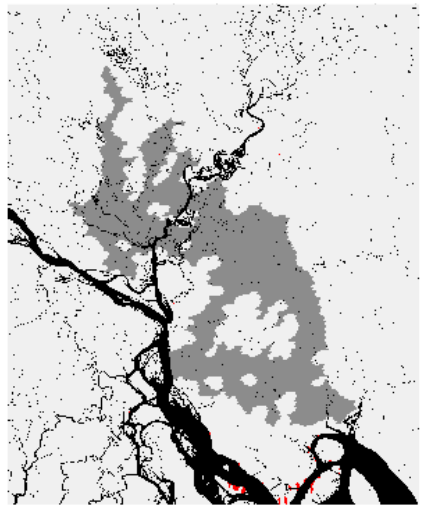

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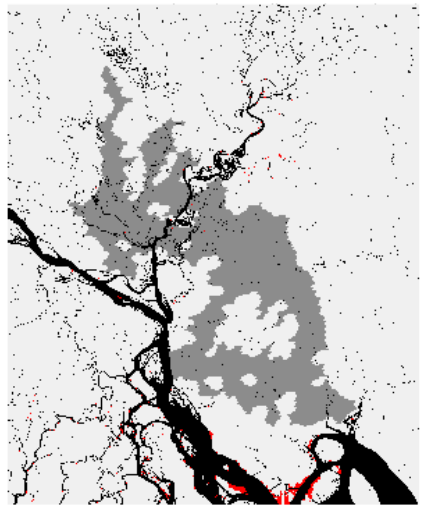

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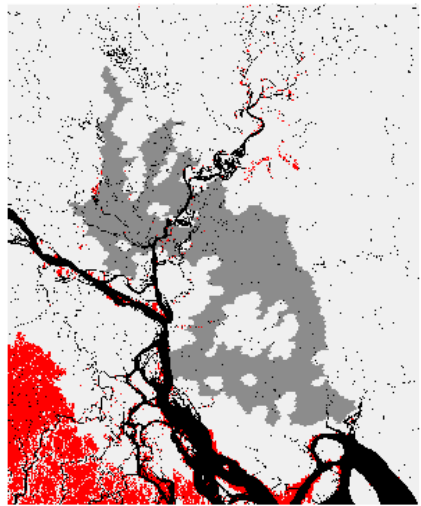

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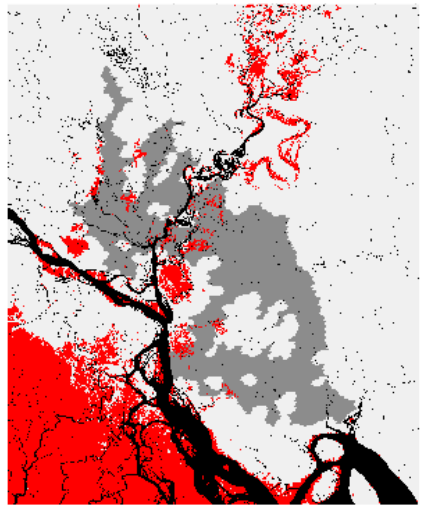

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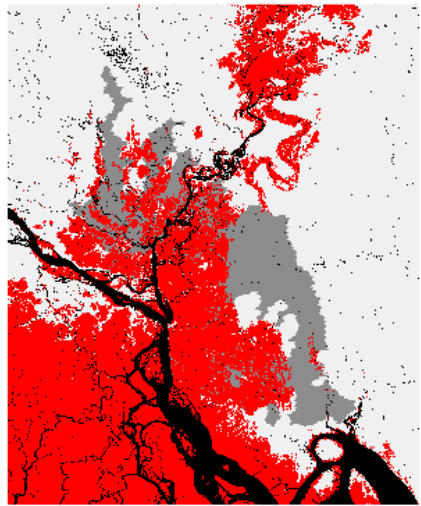

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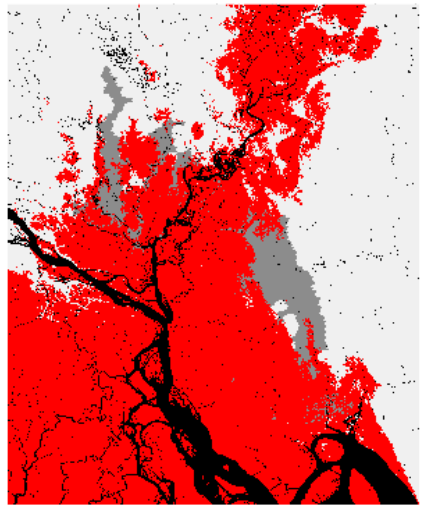

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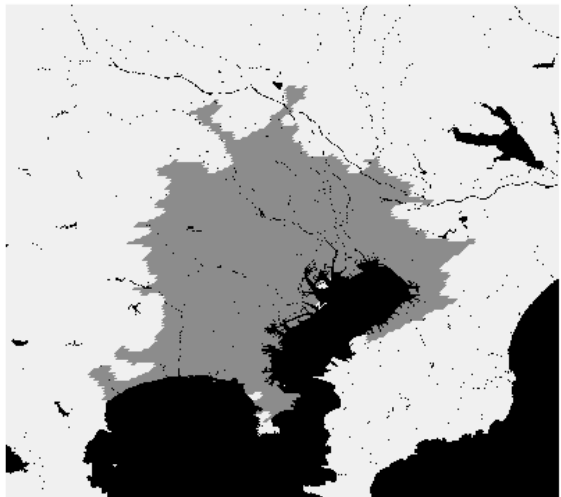

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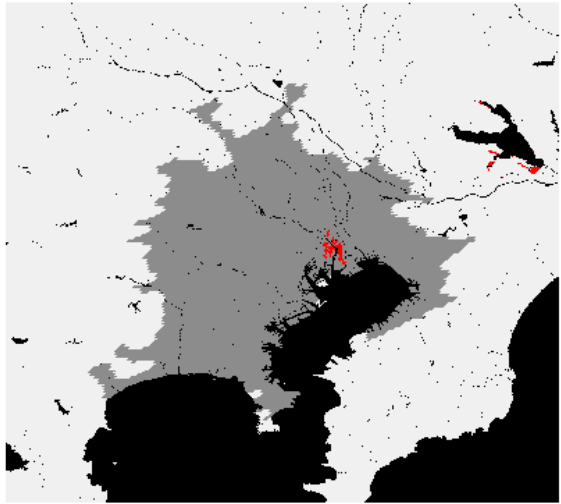

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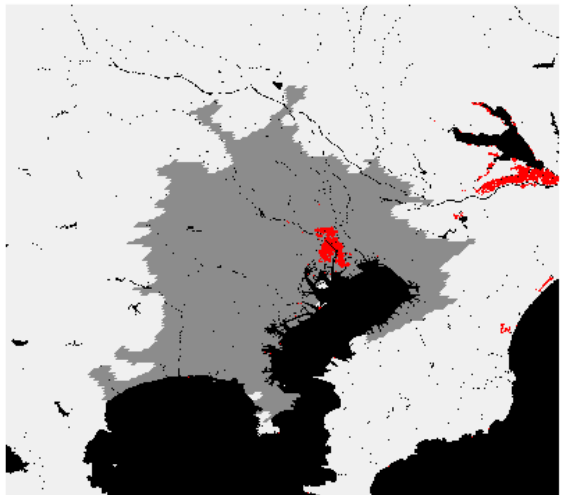

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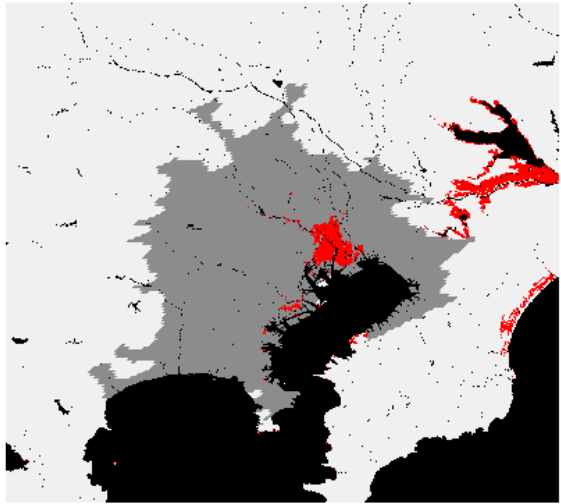

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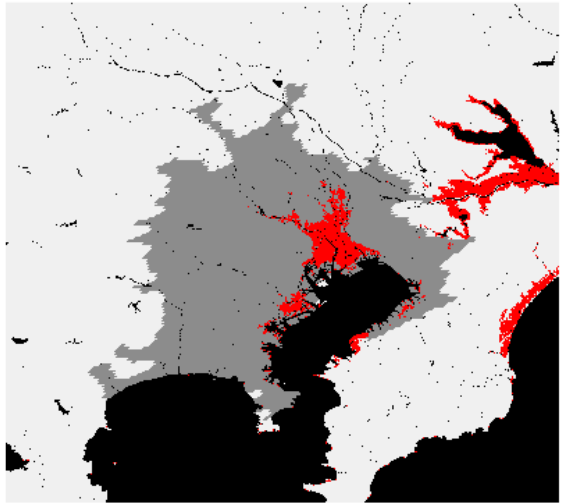

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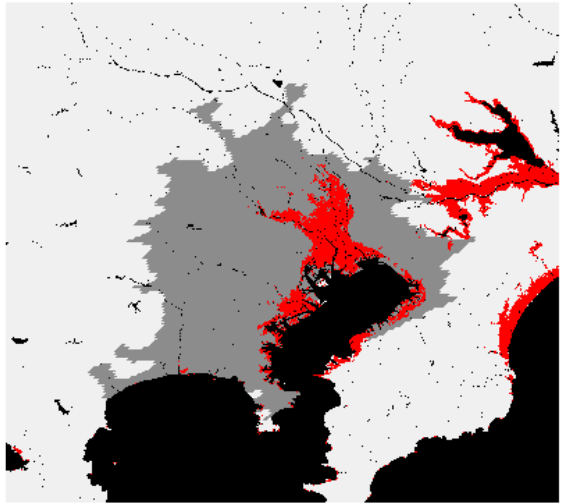

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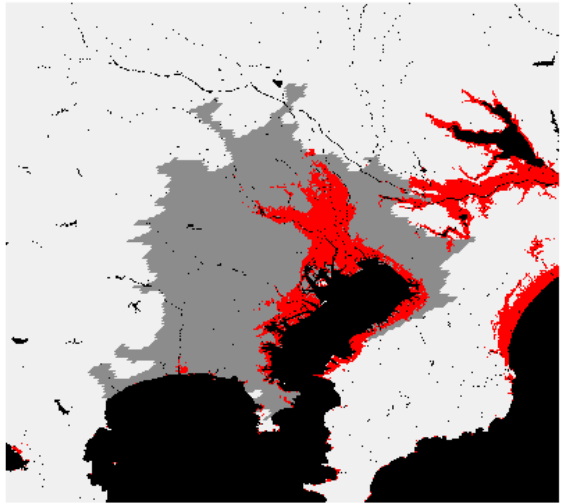

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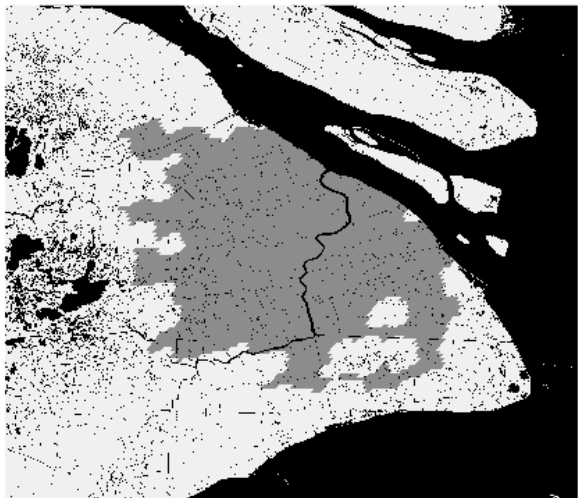

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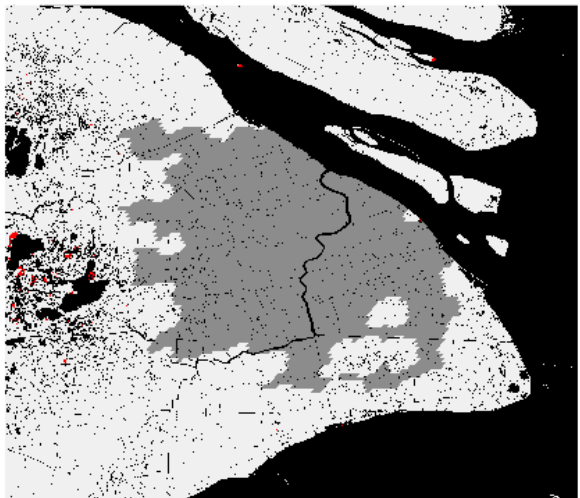

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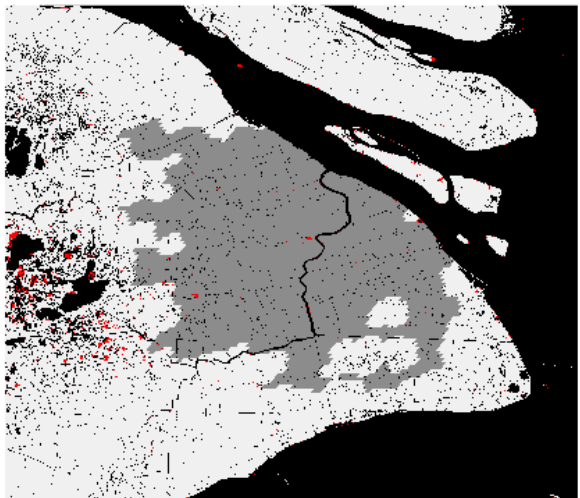

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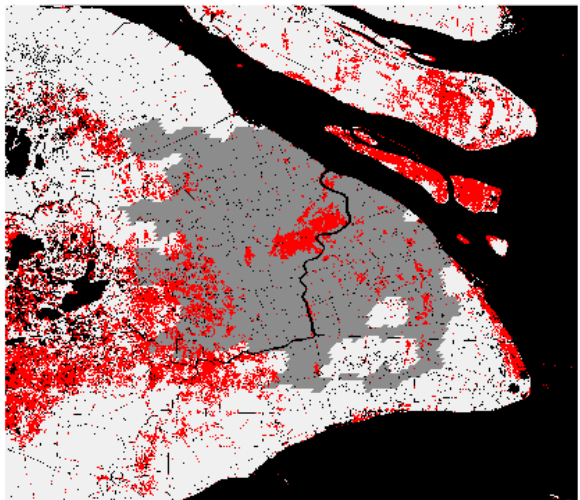

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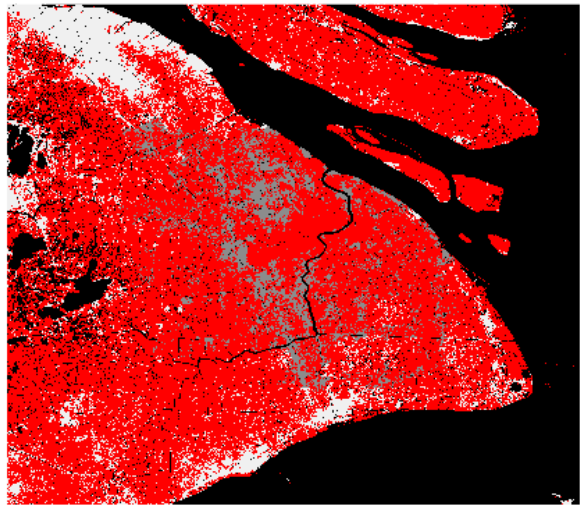

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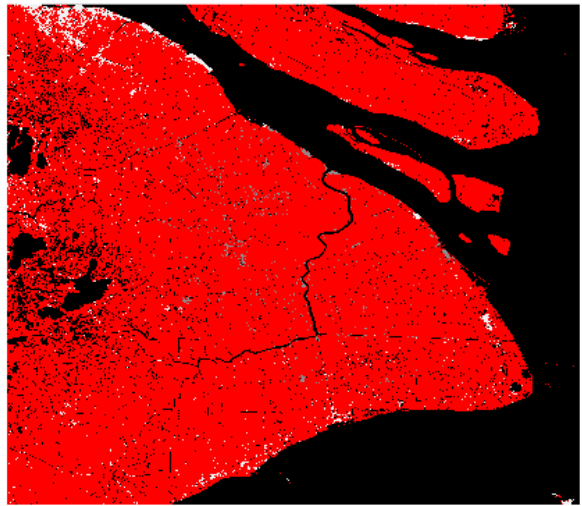

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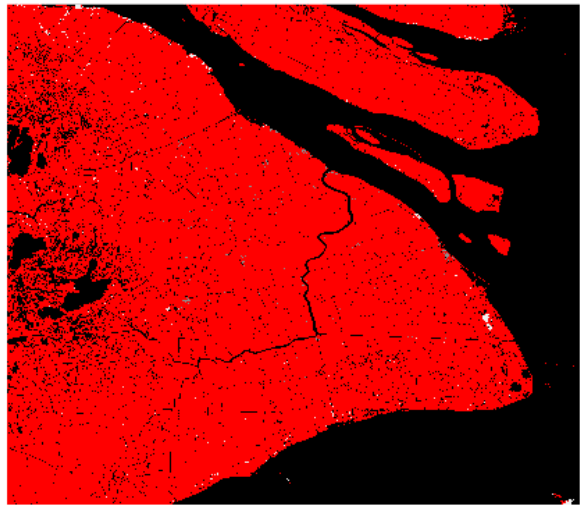


Infrastructure

1. Education: schools, kindergartens, colleges, universities (OSM)
2. Health: hospitals, clinics, doctors, dentists, pharmacies (OSM)
3. Transport: highways, primary roads, secondary roads, tertiary roads (GRIP)

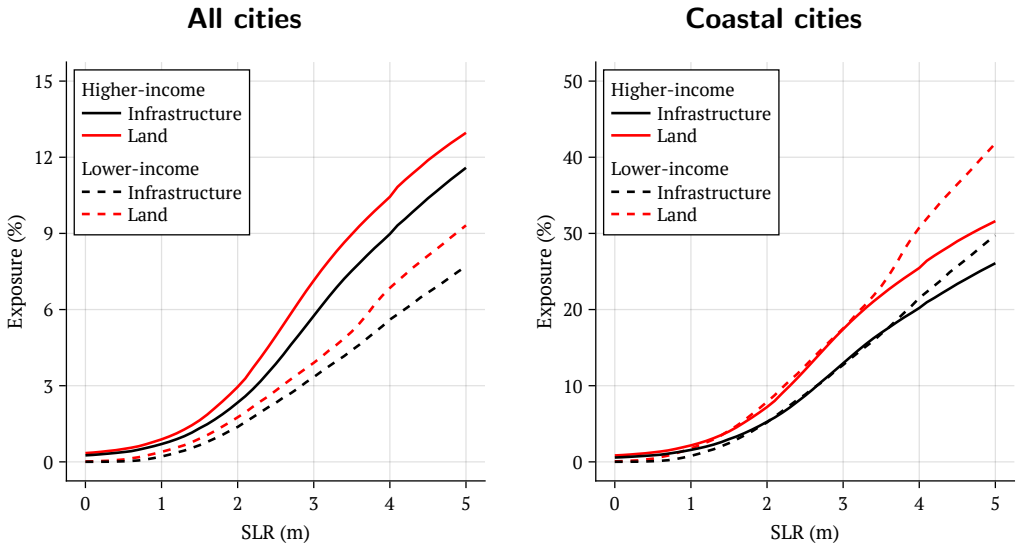
Exposure

- What percentage of urban infrastructure faces inundation?
  - Overlaying city boundaries, infrastructure, and inundation
  - Weighting by population density
- Ignoring current and future defense
  - Interpretation: land and infrastructure “at risk”

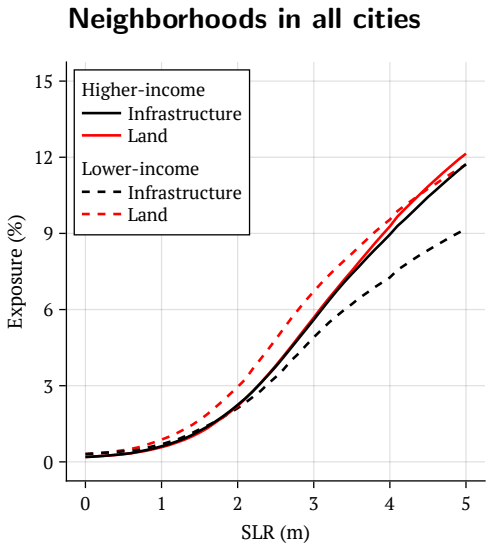
Asian cities are highly exposed

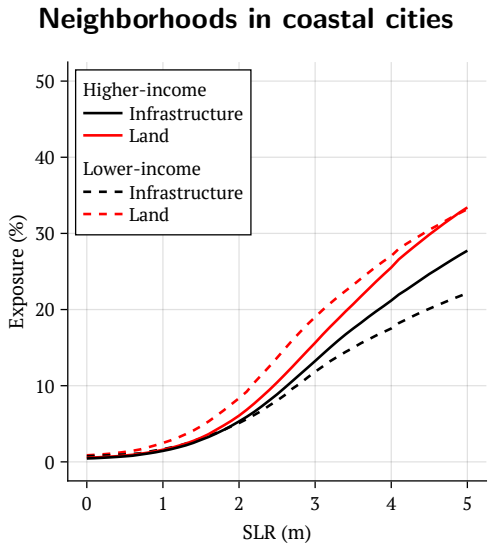
	SLR of 1 m		SLR of 2 m		SLR of 3 m	
Rank	City	%	City	%	City	%
1	Osaka	4.8	Bangkok	55.5	Bangkok	94.4
2	Jakarta	2.2	Shanghai	19.0	Shanghai	80.2
3	Tokyo	2.2	Manila	11.8	Suzhou	31.3
4	Lagos	1.7	Osaka	9.9	Lagos	25.7
5	Mumbai	1.1	Jakarta	9.5	Manila	21.3
6	Manila	1.0	Lagos	9.0	Ho Chi Minh City	20.9
7	New York City	0.4	Tokyo	5.4	Kolkata	20.1
8	Suzhou	0.2	Ho Chi Minh City	4.0	Jakarta	16.3
9	Bangkok	0.2	Kolkata	3.8	Osaka	15.7
10	Shanghai	0.2	New York City	2.7	Guangzhou	12.5

Poorer cities are less exposed



Poorer neighborhoods are less exposed





Exposure accelerates as SLR passes 1.5 m

- Below 1.5 m, slower pace and lower levels
  - At 1.5 m, mean exposure of 1.2% for all cities, 2.9% for coastal cities
- Above 1.5 m, faster pace and higher levels
  - At 5 m, mean exposure of 11.1% for all cities, 26.4% for coastal cities
- Global mean SLR likely to remain below 1.5 m by 2100
  - Scope for progress on land subsidence – especially in Asia

Sea Level Rise and Urban Inequality

- Will SLR exacerbate inequality in coastal cities?
  - The rich may adapt by moving to higher ground
  - Bidding up prices and pushing the poor elsewhere
- Simple quantitative model of spatial sorting
  - Estimated with granular data from Jakarta
  - Flood-prone megacity of 32 million
- Sea level rise may double inequality in flood exposure

Sea Level Rise and Urban Adaptation in Jakarta

- How does the proposed sea wall complicate long-run adaptation?
  - By crowding out private adaptation in other forms
- Dynamic spatial model of urban development and flooding
  - Lightweight dynamic estimation based on real estate price data
- Moral hazard generates coastal lock-in by delaying inland migration
  - Can reduce this friction with simultaneous investment inland

Summary

- New data set on sea level rise and urban infrastructure
  - https://allanhsiao.com/files/suds/data.zip
- Asian cities have big problems and global lessons
- How can cities adapt? How can governments help?