FLOOD RISK MAPPING AND SOCIO-SPATIAL VULNERABILITY ASSESSMENT

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MUSA 6950

STUDY OVERVIEW & OBJECTIVE

With the intensification of climate change and urbanization, urban flooding possesses a growing threat for cities globally, especially those located in proximity to hydrological sources.

- Climate change drives not only rising temperatures but also increased evaporation, precipitation, and extreme weather, impacting natural and societal systems.
- Rapid urbanization, inadequate drainage, and the spread of impervious surfaces heighten the risk of flooding in cities.
- Marginalized communities are disproportionately exposed to flood risks, making it essential to consider land use and social equity in building climate-resilient cities.

This study aims to evaluate the general relationship between land use and flood hazards in selected [coastal] cities and assessing whether certain sociodemographic groups are more vulnerable to these risks.

STUDY SITES

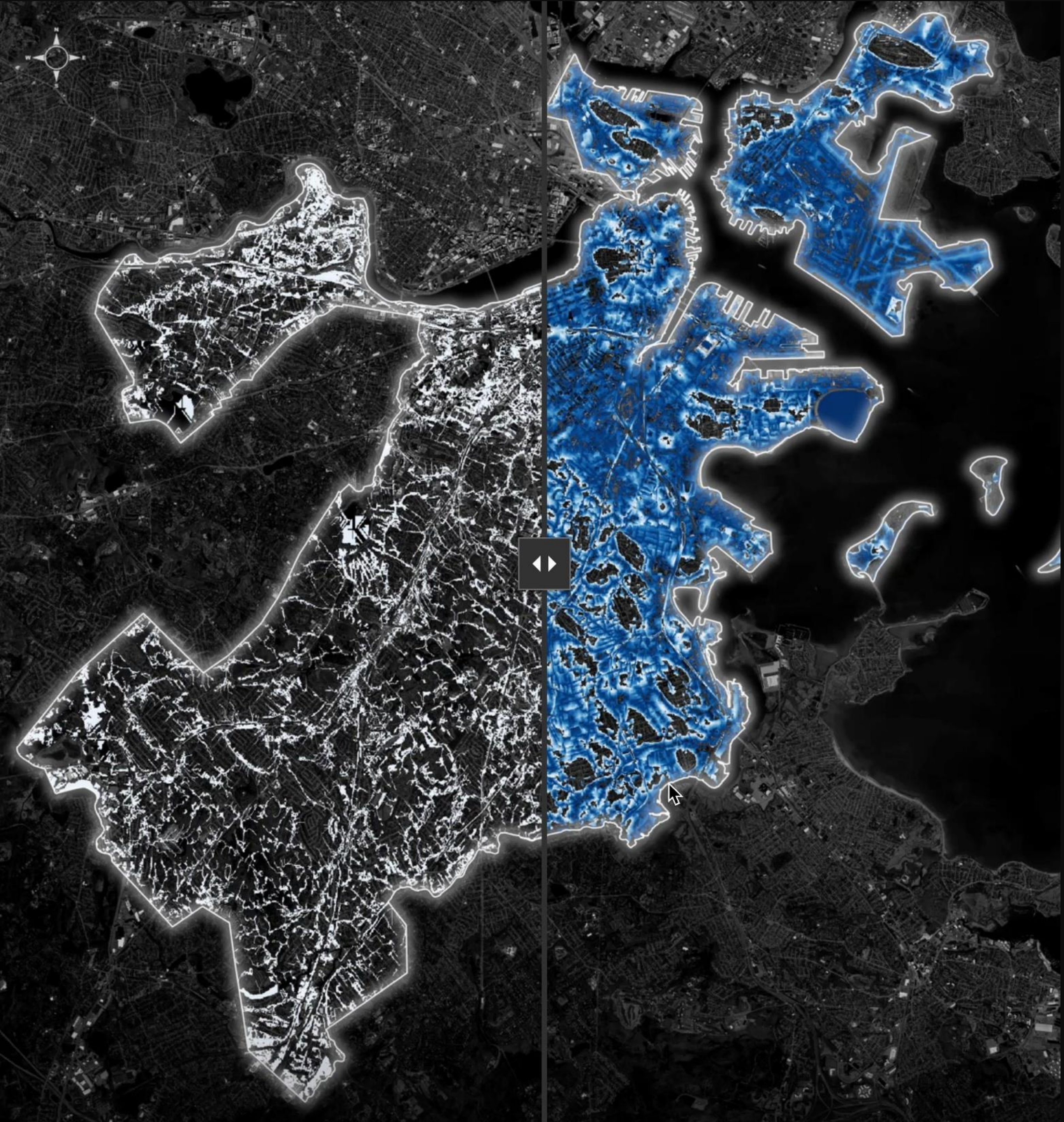
Boston, MA

Providence, RI

METHODOLOGY

- **Retrieve tiles and preform hydrological analysis**
  - Flow Accumulation + Direction, HAND Model, Inundation
- **Analyze land use**
  - % of land use flooded
- **Analyze demographics**
  - % of predominant race block groups flooded

```
from pysheds.grid import Grid

base_name = os.path.splitext(os.path.basename(input_tile))[0]

hand_output = os.path.join(output_dir, f"hand_{base_name}.tif")
acc_output = os.path.join(output_dir, f"flow_accum_{base_name}.tif")
fdir_output = os.path.join(output_dir, f"flow_dir_{base_name}.tif")

dirmap = (64, 128, 1, 2, 4, 8, 16, 32)

try:
with rio.open(input_tile) as dataset:
if dataset.count == 0:
print("Input raster has no bands. Skipping.")
else:
print(f"Processing: {input_tile}")

grid = Grid.from_raster(input_tile)
dem = grid.read_raster(input_tile)

pit_filled_dem = grid.fill_pits(dem)
flooded_dem = grid.fill_depressions(pit_filled_dem)
inflated_dem = grid.resolve_flats(flooded_dem)

fdir = grid.flowdir(inflated_dem, dirmap=dirmap)
acc = grid.accumulation(fdir, dirmap=dirmap)

hand = grid.compute_hand(fdir, dem, acc > 100)

meta = dataset.meta.copy()
meta.update(dtype=rio.float32, compress='lzw', count=1, nodata=np.nan)

with rio.open(hand_output, 'w', **meta) as dst:
dst.write(hand.astype(np.float32), 1)
print(f"HAND written to: {hand_output}")

with rio.open(acc_output, 'w', **meta) as dst:
dst.write(acc.astype(np.float32), 1)
```



Boston

INUNDATION

0.5 Meter Threshold:

24.50% INUNDATED

5 Meter Threshold:

64.69% INUNDATED

Providence

INUNDATION

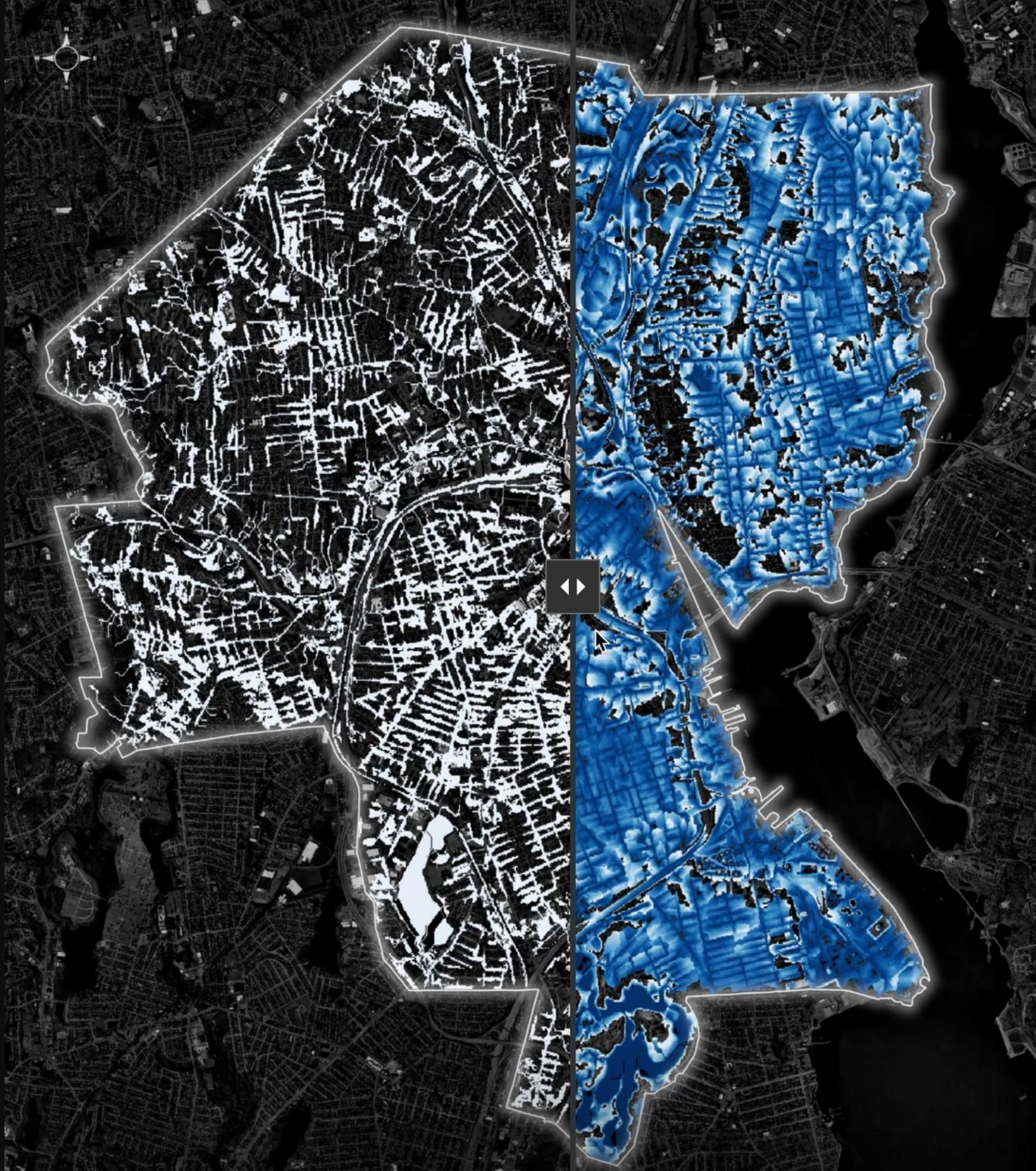
0.5 Meter Threshold:

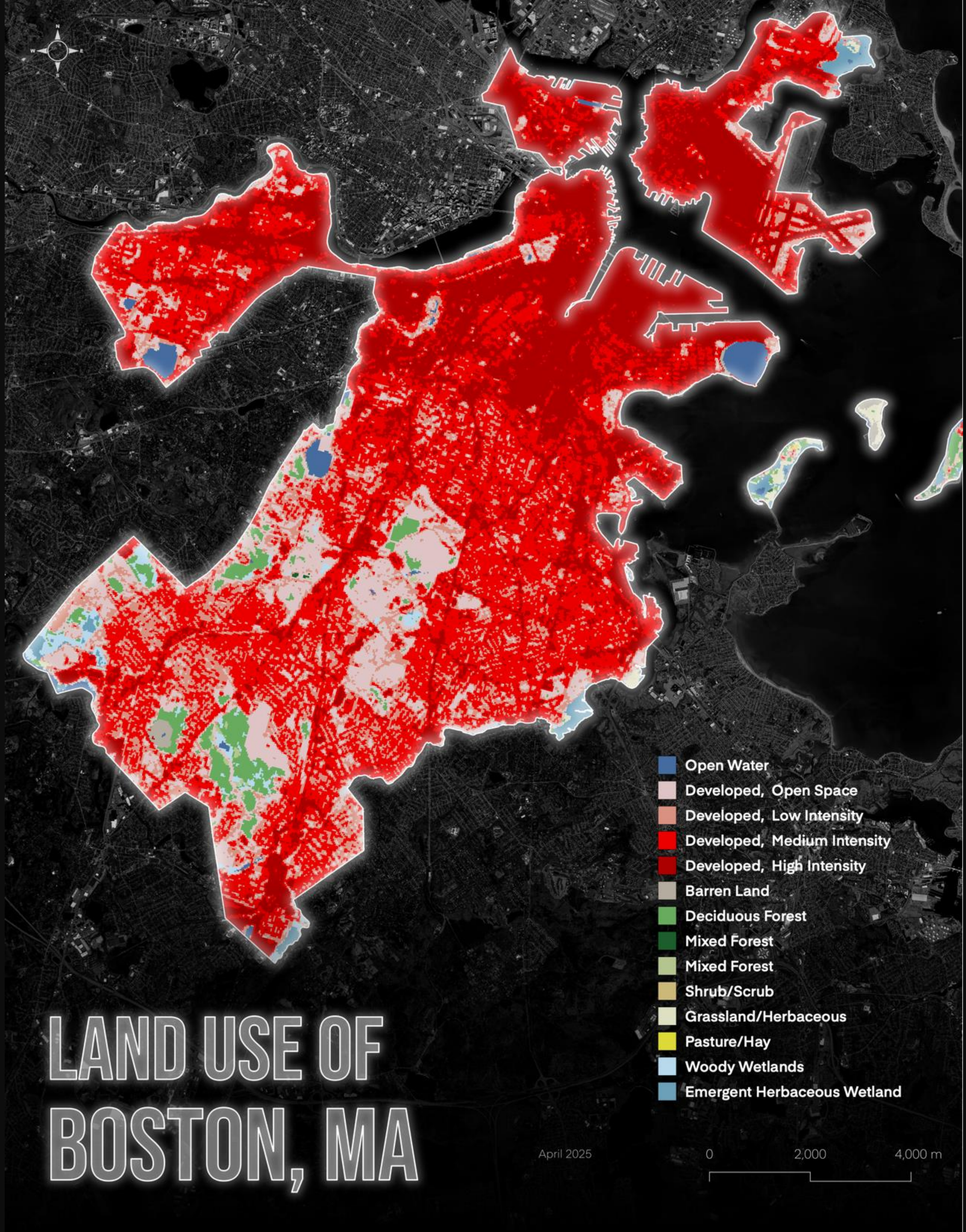
24.78% INUNDATED

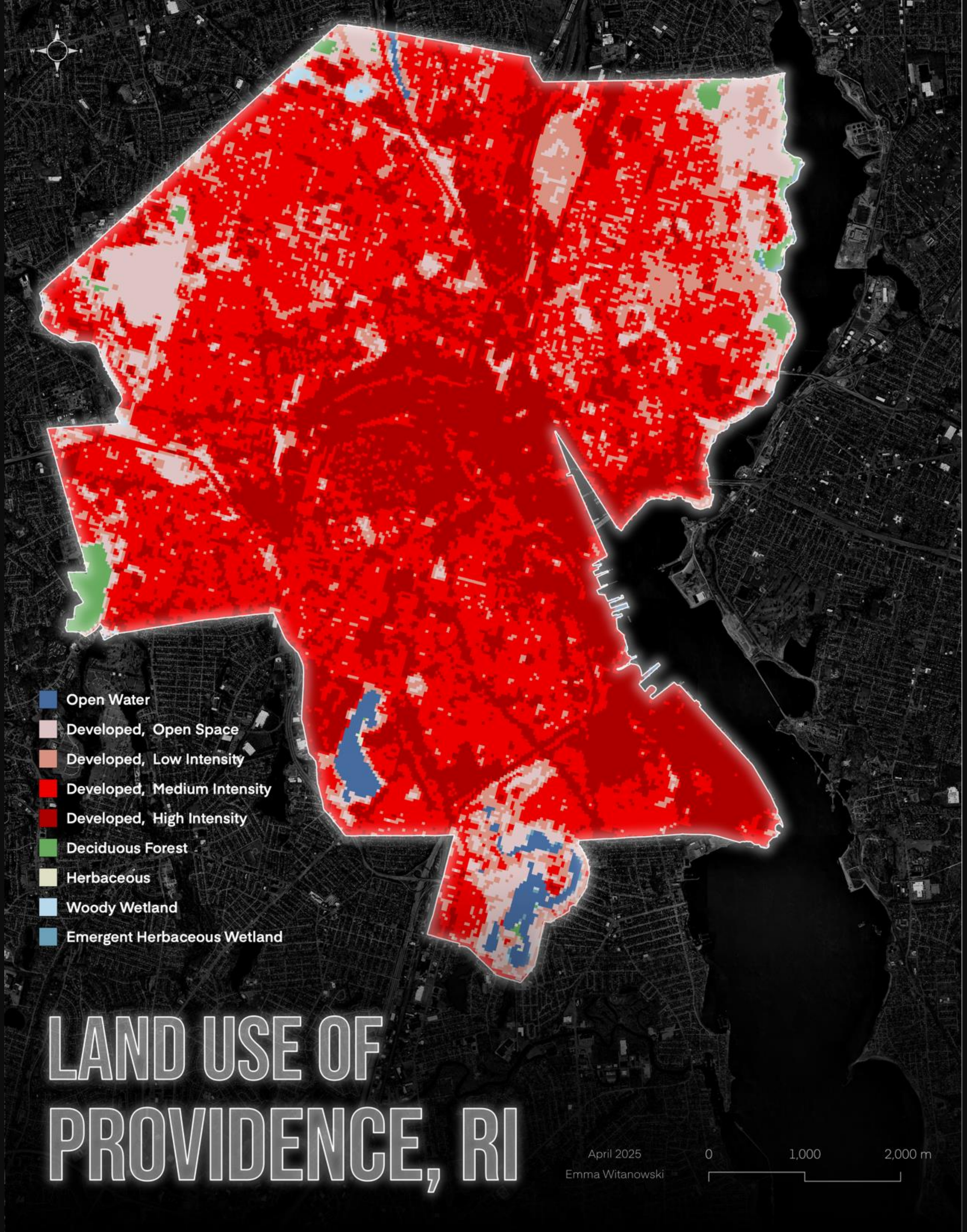
↓

5 Meter Threshold:

74.23% INUNDATED



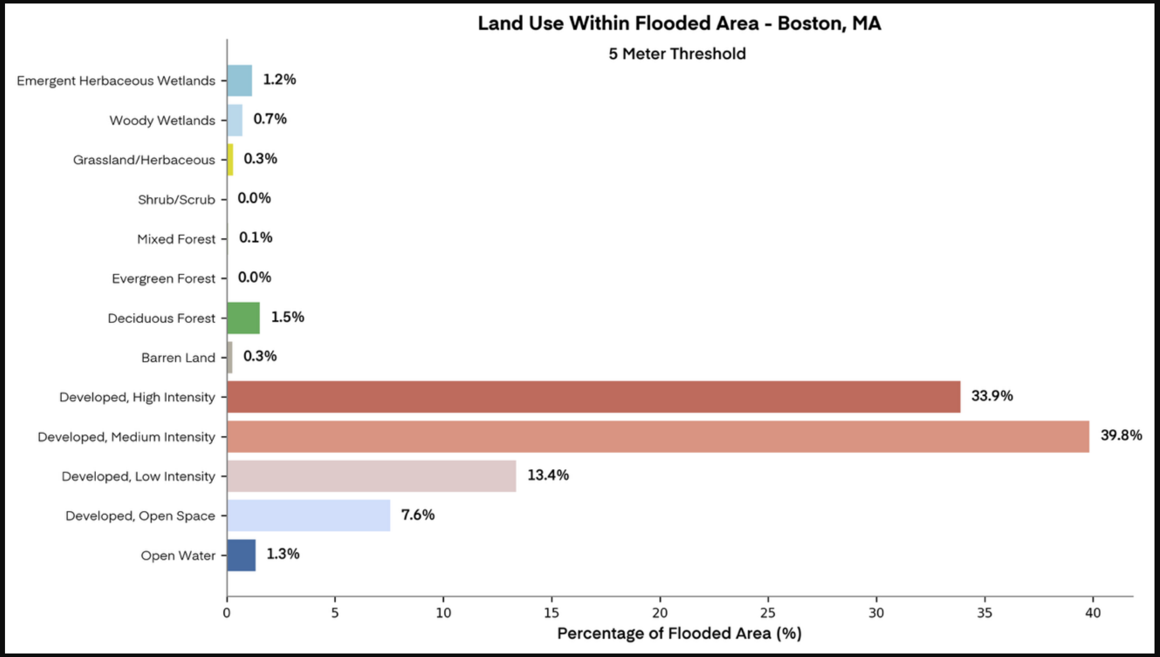

Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land
Deciduous Forest
Mixed Forest
Mixed Forest
Shrub/Scrub
Grassland/Herbaceous
Pasture/Hay
Woody Wetlands
Emergent Herbaceous Wetland
LAND USE OF
BOSTON, MA
April 2025
0
2,000
4,000 m

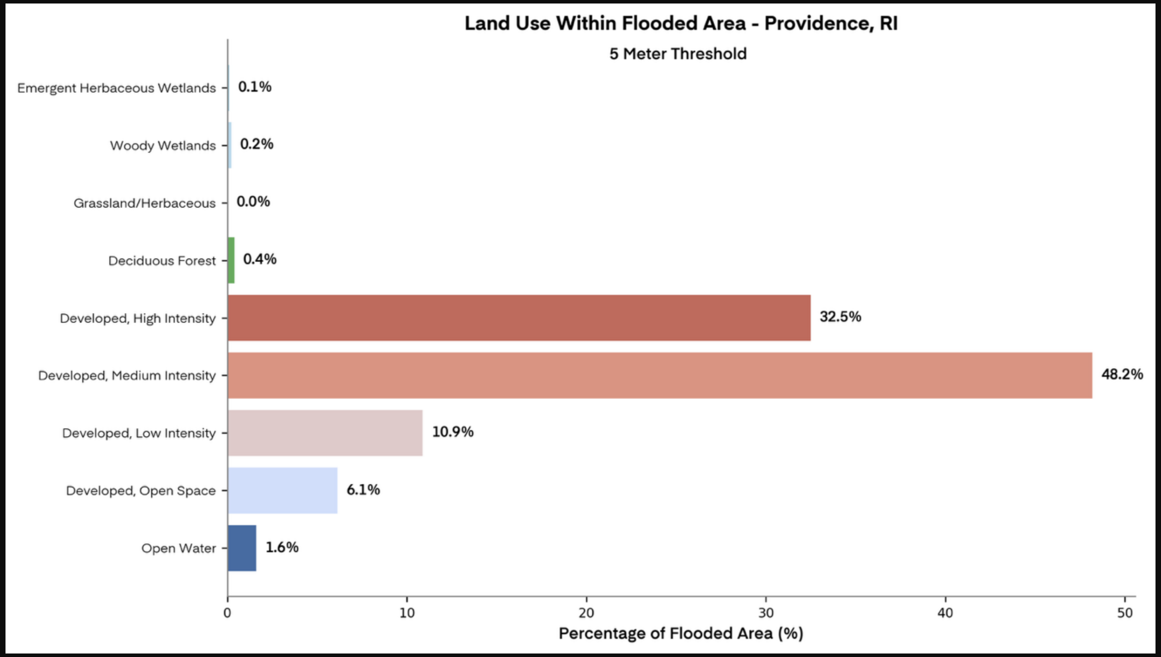

Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Deciduous Forest
Herbaceous
Woody Wetland
Emergent Herbaceous Wetland
LAND USE OF
PROVIDENCE, RI
April 2025
Emma Witanowski
0
1,000
2,000 m

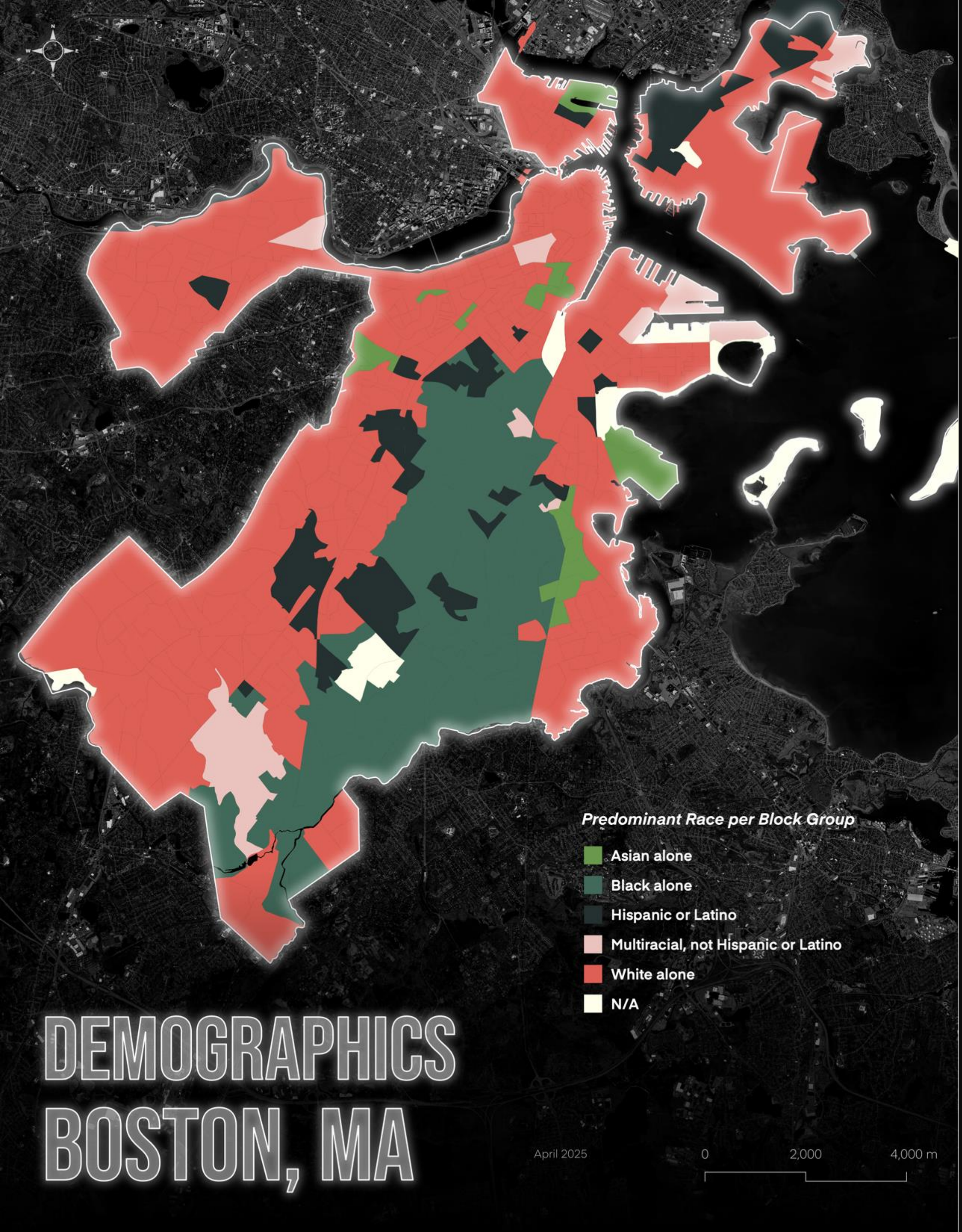
Boston & Providence

LAND USE

For both cities, '**Developed Land**' consistently constituted a greater portion of inundated land for all thresholds







Boston

VULNERABILITY

0.5 Meter Threshold

Race Group	Percent of Flooded Area
White, alone	57.87%
Hispanic or Latino	7.53%
Multiracial, not Hispanic or Latino	5.21%
Asian, alone	3.78%
Black, alone	17.95%

5 Meter Threshold

Race Group	Percent of Flooded Area
White, alone	56.35%
Hispanic or Latino	8.28%
Multiracial, not Hispanic or Latino	4.34%
Asian, alone	3.48%
Black, alone	22.84%

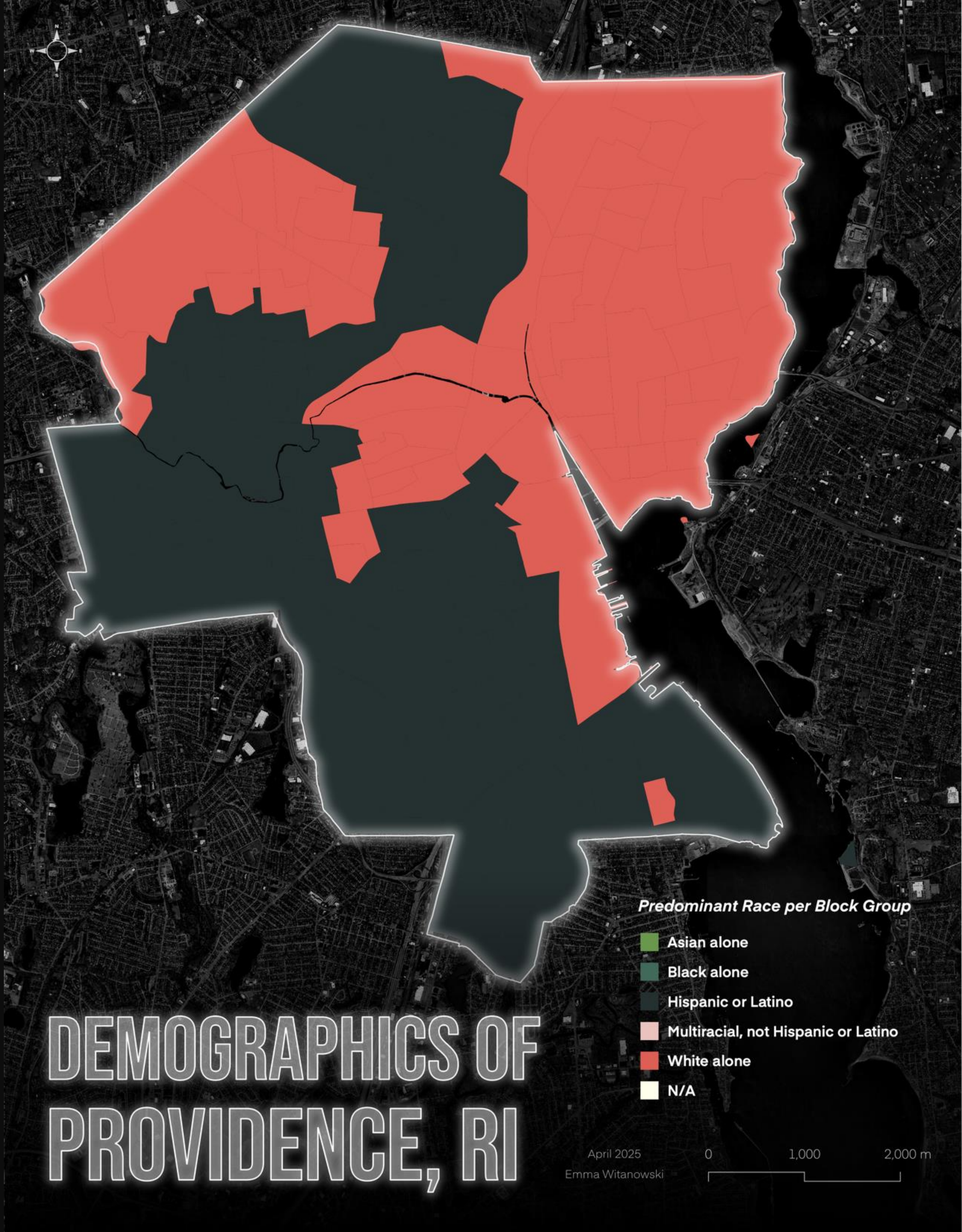
Providence
VULNERABILITY

0.5 Meter Threshold

Race Group	Percent of Flooded Area
White, alone	39.02%
Hispanic or Latino	60.22%

5 Meter Threshold

Race Group	Percent of Flooded Area
White, alone	43.13%
Hispanic or Latino	56.48%



CONCLUSION

Development alone (like building cities, adding roads, houses, etc.) **does not "cause" flooding** in the sense of generating storms, rain, or sea level rise.

- **Increases vulnerability** and severity of impacts

Local **topography** plays a crucial role in flood risk.

Racial disparities in flood vulnerability were **evident in Boston but not in Providence**, suggesting that the relationship between race and flood risk is shaped by local patterns of segregation, development, and infrastructure investment.

Future resilience efforts should prioritize equitable adaptation, integrating land use planning, green infrastructure, and community-driven strategies to reduce both physical and social vulnerabilities to flooding.

Future Research

- Testing accuracy of models & improving quality
- Checking trends of racial disparities in different cities
- Expanding so other sociodemographic factors (i.e., poverty, ownership, income)