A 30-Meter Resolution Urban Heat Vulnerability Index Incorporating Adaptive Capacity: Development and Application in New York City

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Background & Motivation

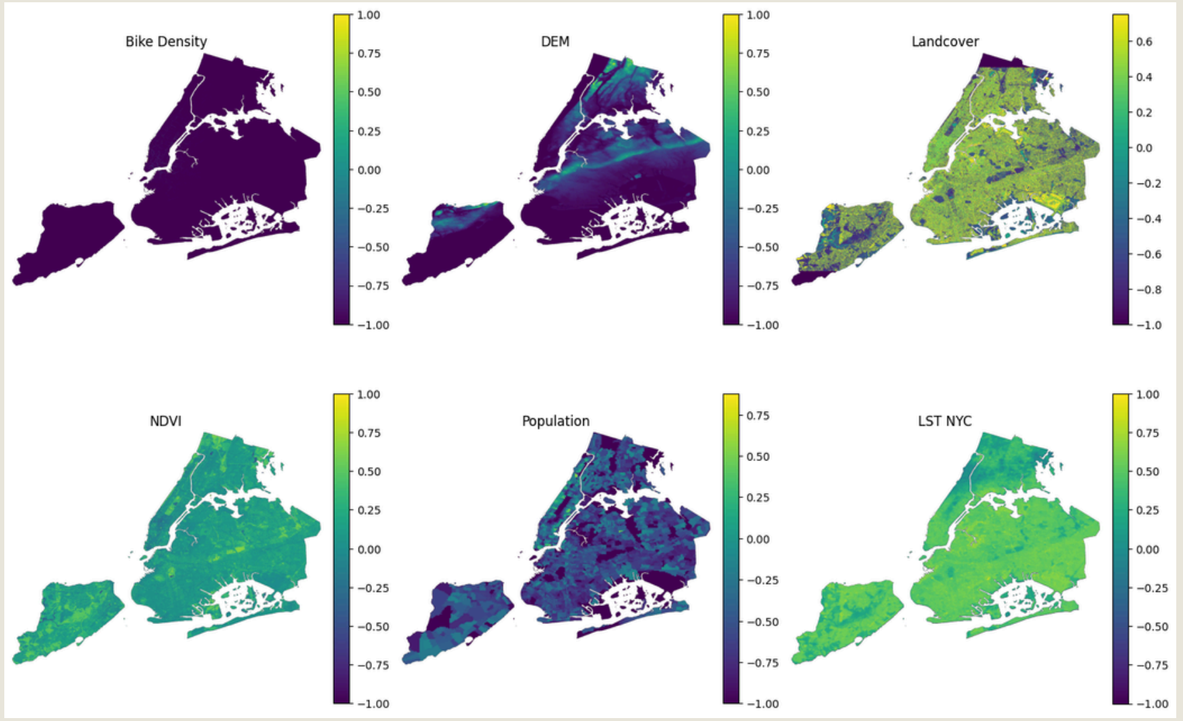
- Extreme heat is the top weather-related killer in cities, with rising risks due to climate change
- Hundreds of heat-related deaths occur annually in NYC, hitting vulnerable groups hardest
- Heat risk is uneven: low-income and minority neighborhoods often suffer greater heat exposure
- Heat vulnerability = Exposure + Sensitivity – Adaptive Capacity (conceptual framework)
- NYC's Health Dept. developed a neighborhood-level Heat Vulnerability Index (HVI) for planning
- But coarse community indices can mask block-level hotspots and micro-climate variations

Research Goal & Innovation

- **Objective**: Develop a high-resolution 30 m Urban Heat Vulnerability Index with Adaptive Capacity (UHVI-AC) for NYC
- **Innovation**: Integrate multi-source data (satellite, LiDAR, census, etc.) at the block level
- Captures intra-neighborhood variability that traditional coarse indices overlook
- Identifies “hidden” heat-vulnerable hotspots at fine scale for targeted intervention
- Advances urban heat resilience planning with a more granular, equity-focused approach

Study Area & Data Sources

- Study Area: New York City – complex urban form and microclimates across five boroughs
- 30 m grid across NYC used as analysis units, aligning with Landsat pixel size
- Multi-source data: high-resolution NAIP aerial imagery (land cover, NDVI), Landsat 8 thermal (LST), LiDAR (Landcover, DEM), population, and Citi Bike OD data
- All data layers reprojected and resampled to the common 30 m grid covering NYC

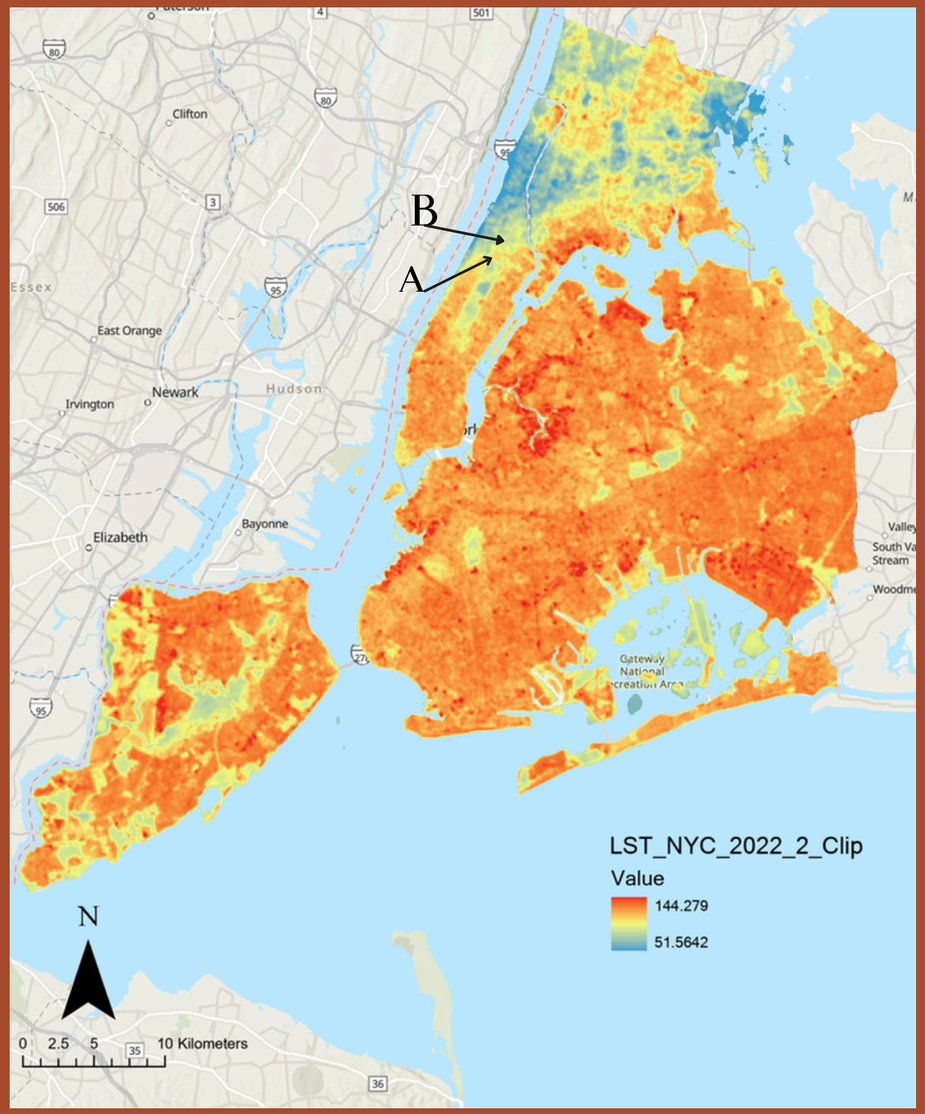


Methodology – Vulnerability Framework

- Adopted Exposure–Sensitivity–Adaptive Capacity framework for heat vulnerability
- Calculated UHVI-AC for each 30 m cell = (Exposure + Sensitivity) – Adaptive Capacity
- All variables normalized to -1 to 1 range to allow unbiased combination
- **Exposure**: intensity of heat hazard and likelihood of people exposed
- **Sensitivity**: population characteristics that heighten impact if exposed
- **Adaptive Capacity**: local features that reduce or cope with heat impact

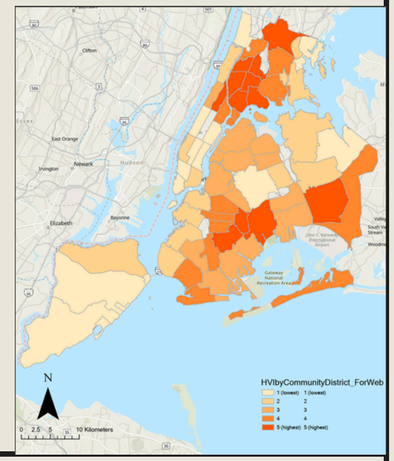
Methodology – UHVI_AC Formula & Weights

- Index components & weights: UHVI-AC combines multiple indicators with assigned weights
- Exposure (70% total): Land Surface Temp (25%), Impervious cover (20%), Low elevation (15%), Bike activity (10%)
- Sensitivity (20%): Population density (high = more people affected)
- **Adaptive Capacity (10%):** Vegetation greenness (NDVI) – high NDVI provides cooling
- **Sensitivity**: population characteristics that heighten impact if exposed
- Higher exposure/sensitivity raise the index, while higher adaptive capacity lowers it

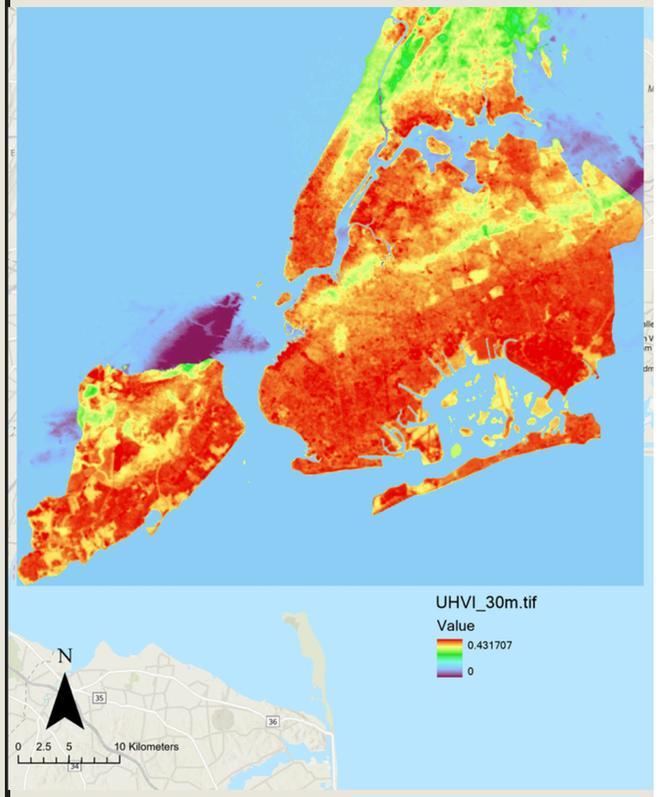


Why Block-Level Mapping Matters

- Hides Block Extremes → Treeless vs. shaded block = +6 ˚C Low vulnerability “cool islands” visible at large green spaces (e.g. Central Park stays blue amid surrounding heat)
- Loses 39 % Variance at census-tract scale
- Ignores Daily Mobility (sidewalks, bike lanes)
- Risk of Misallocation – cooling funds may miss true hotspots



Comparison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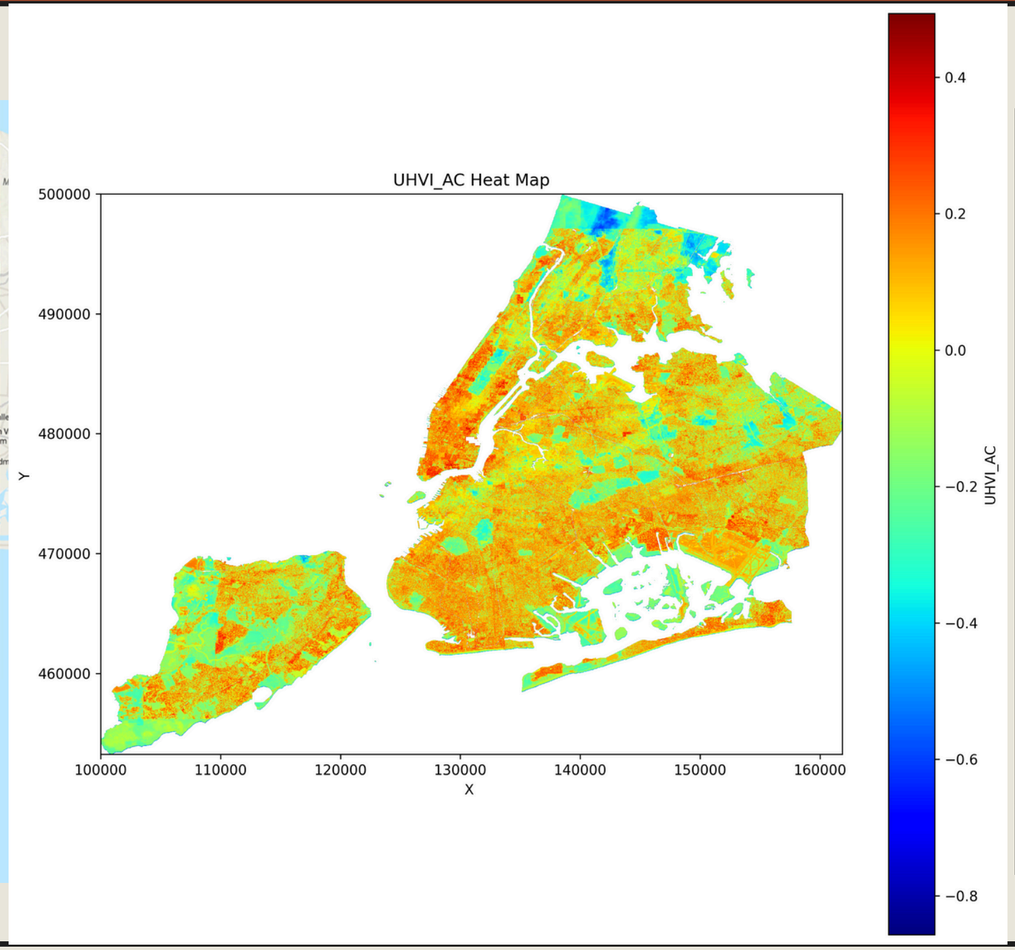
0
N
0 2.5 5 10 Kilometers


UHVI_AC Heat Map
500000
490000
480000
470000
460000
Y
100000
110000
120000
130000
140000
150000
160000
X
0.4
0.2
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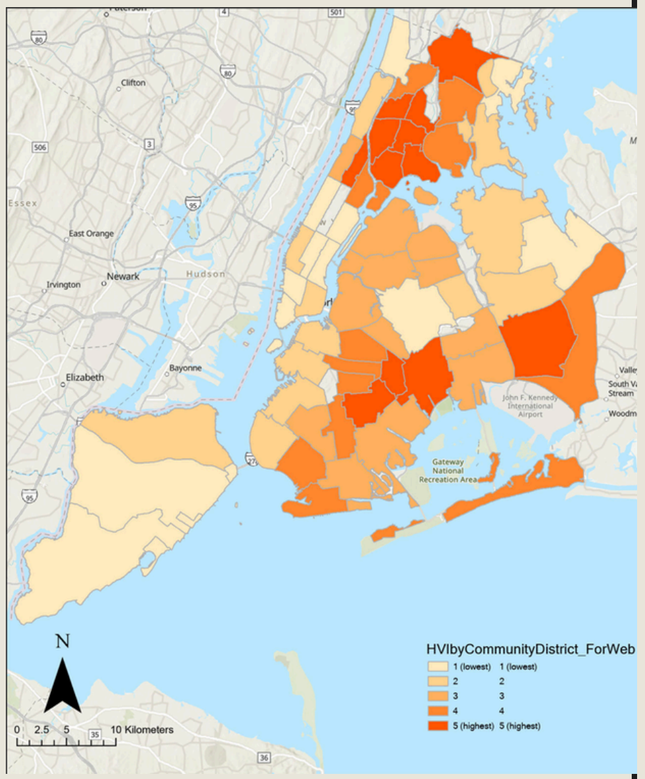
−0.2
−0.4
−0.6
−0.8
UHVI_AC


Clifton
East Orange
Irvington
Newark
Hudson
Elizabeth
Bayonne
John F. Kennedy International Airport
Gateway National Recreation Area
N
0 2.5 5 10 Kilometers
HVIbyCommunityDistrict_ForWeb
1 (lowest) 1 (lowest)
2 2
3 3
4 4
5 (highest) 5 (highest)

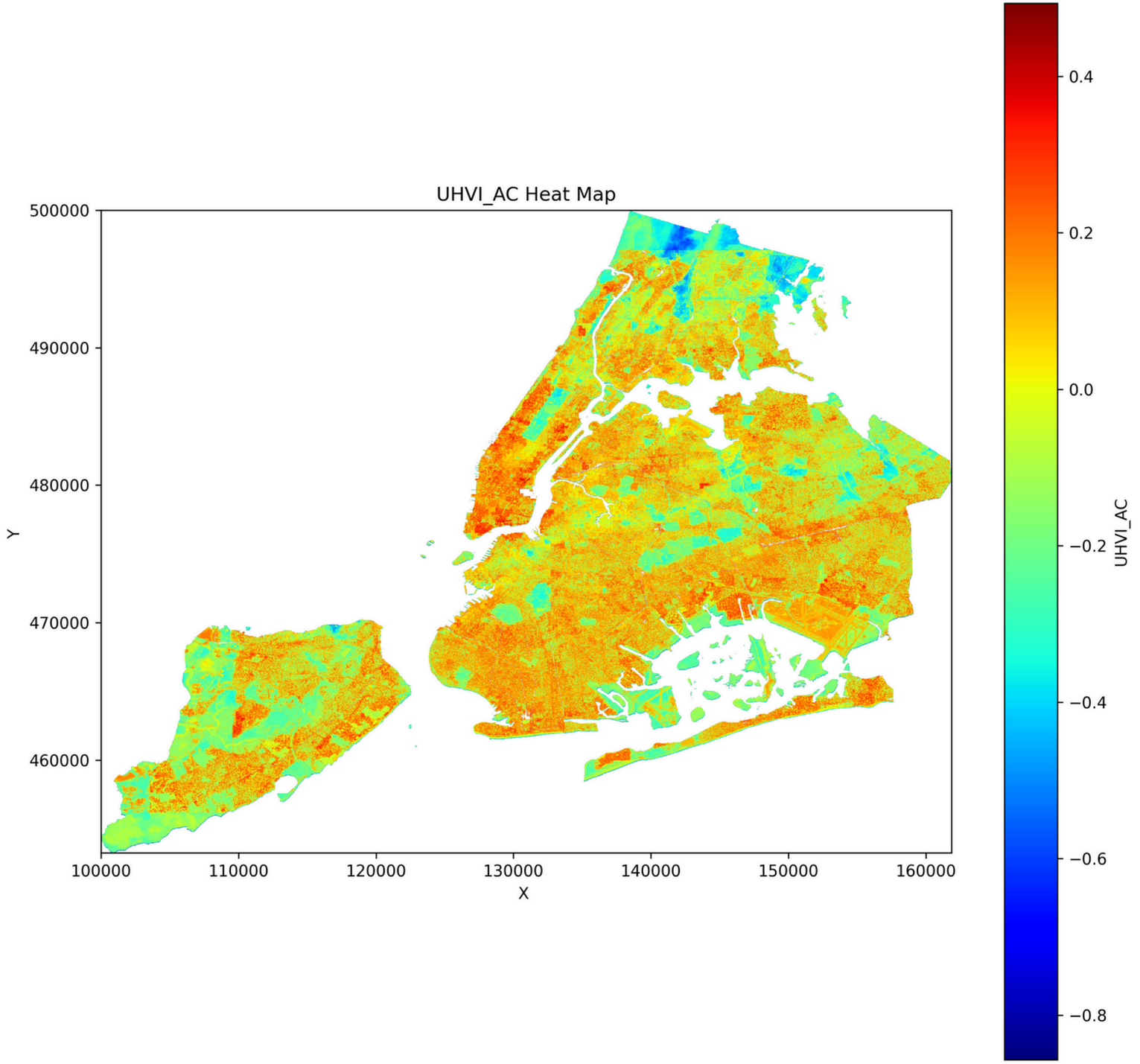
Policy Implications

- Targeted cooling interventions: Pinpoint specific hot blocks for trees, green roofs, cooling centers, etc.
- Resource prioritization: Direct heat-health resources (e.g. heat advisories, AC subsidies) to the most vulnerable blocks
- Urban planning integration: Incorporate fine-scale heat risk data into zoning, housing, and greening plans
- Environmental justice focus: Ensure adaptation efforts reach micro-neighborhoods historically overlooked

Conclusion

- Developed a novel 3**0 m UHVI-AC** for NYC, integrating exposure, population sensitivity, and adaptive greenness
- **Reveals hidden hotspots** at the block level that coarse neighborhood analyses could not resolve
- Demonstrates the value of **fine-grained vulnerability mapping** for urban heat risk and resilience
- Findings enable **more targeted and equitable heat adaptation** strategies in NYC
- Approach is **transferable**: can be applied to other cities for fine-scale climate vulnerability assessment

Thank You & Q&A


UHVI_AC Heat Map
500000
490000
480000
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460000
Y
100000
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X
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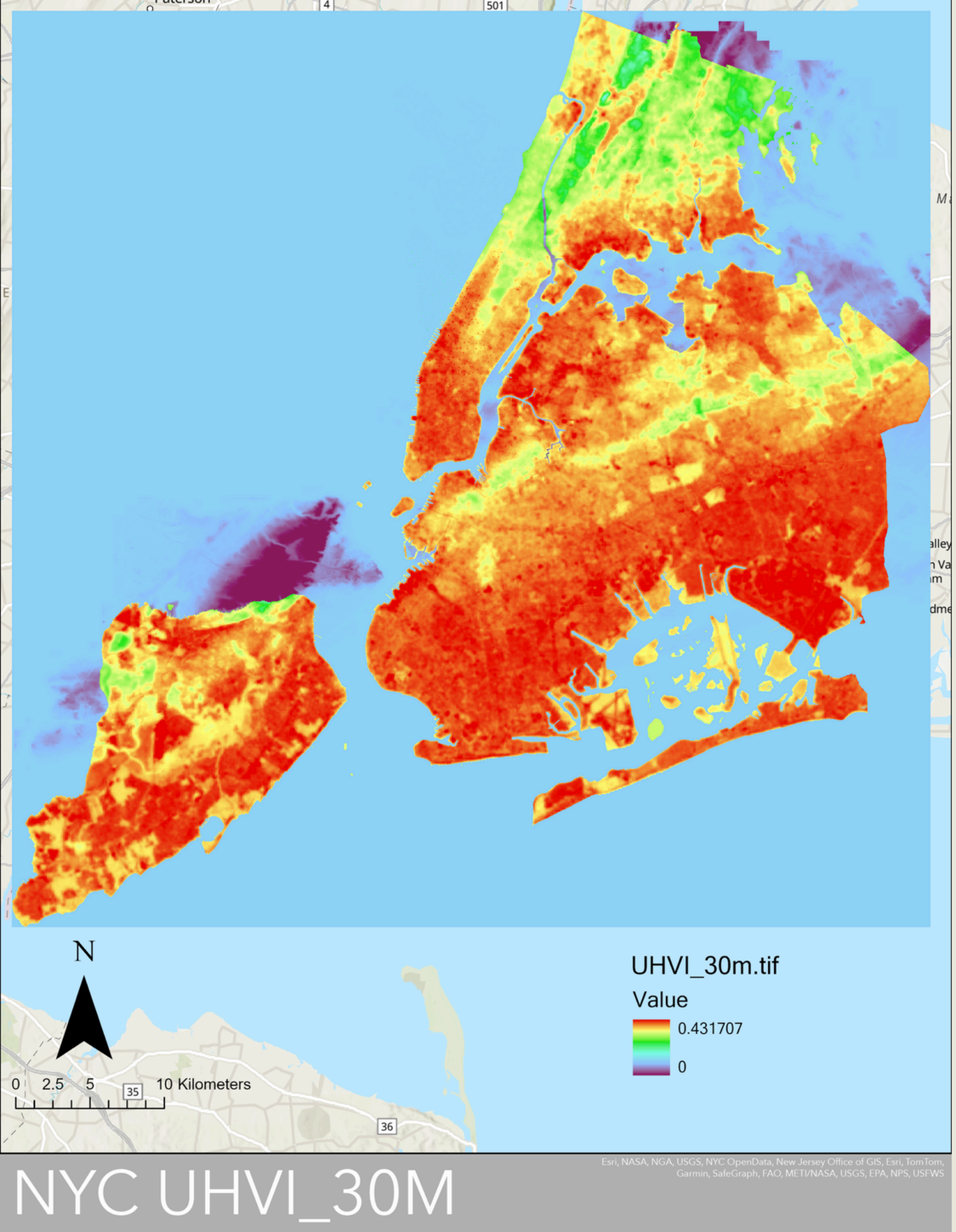
UHVI_AC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Value
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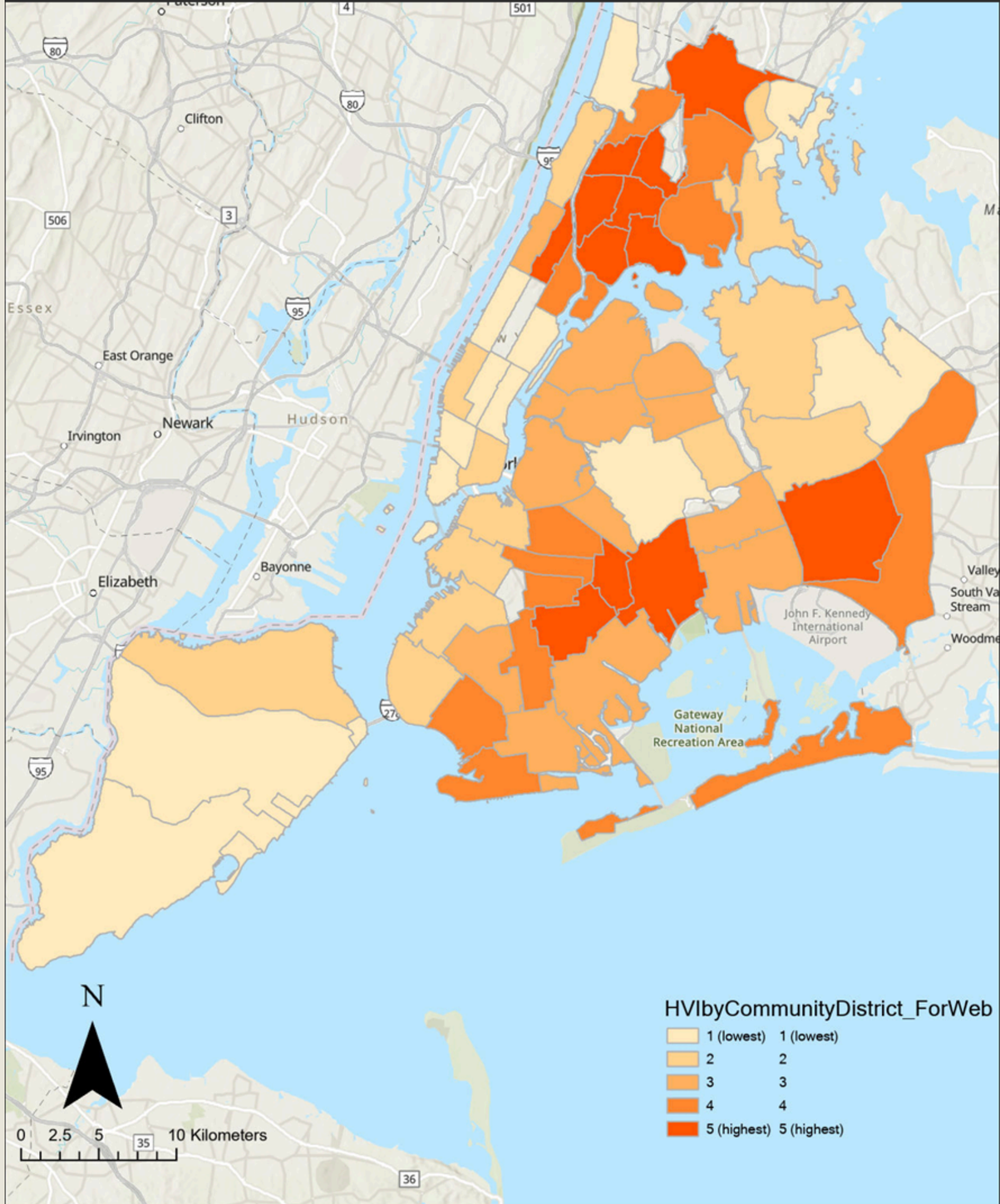
0 2.5 5 10 Kilometers
Esri, NASA, NGA, USGS, NYC OpenData, New Jersey Office of GIS, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS, USFWS

NYC UHVI_30M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Essex
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Hudson
Bayonne
Elizabeth
John F. Kennedy International Airport
Gateway National Recreation Area
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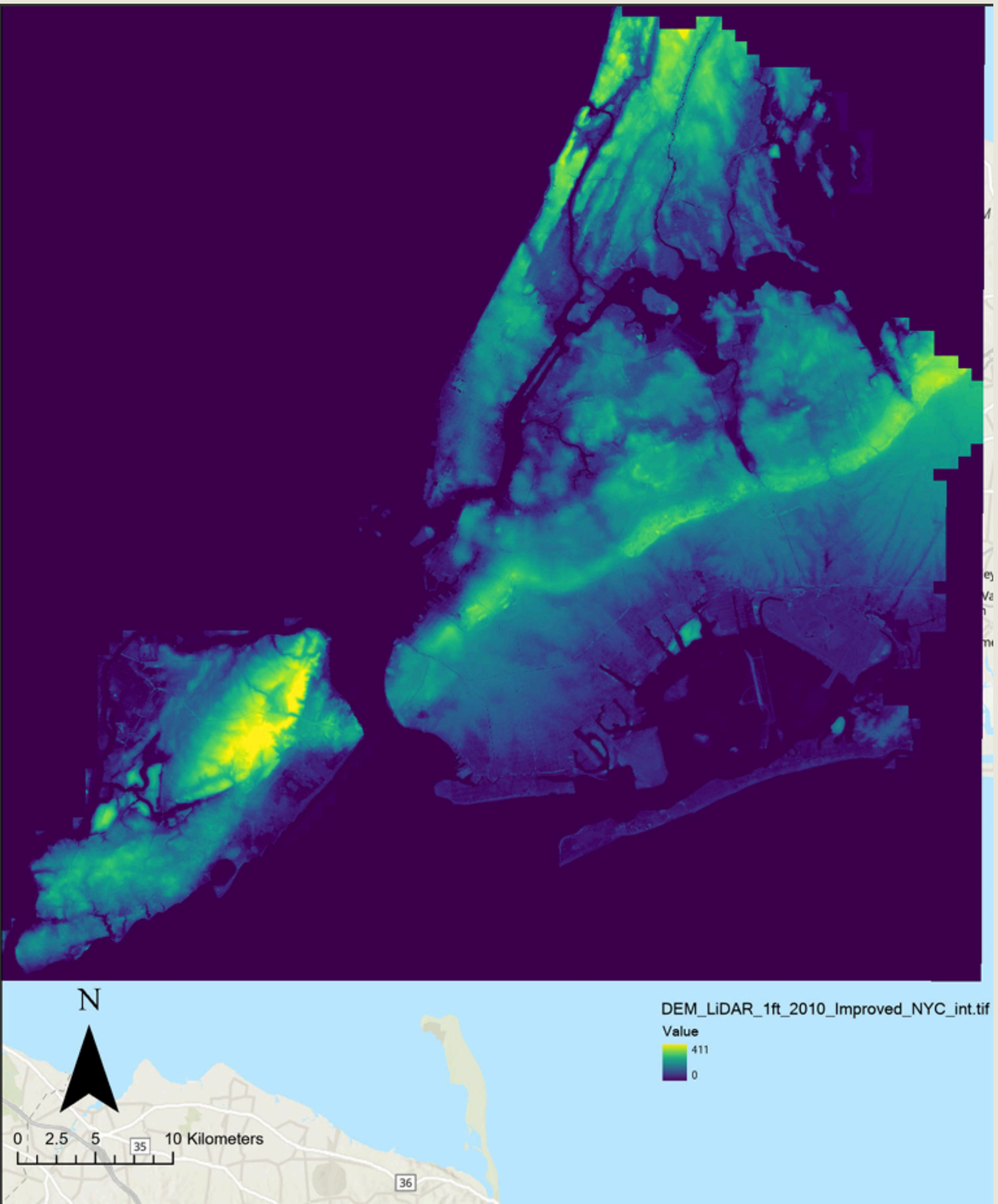
HVIbyCommunityDistrict_ForWeb
1 (lowest) 1 (lowest)
2 2
3 3
4 4
5 (highest) 5 (highest)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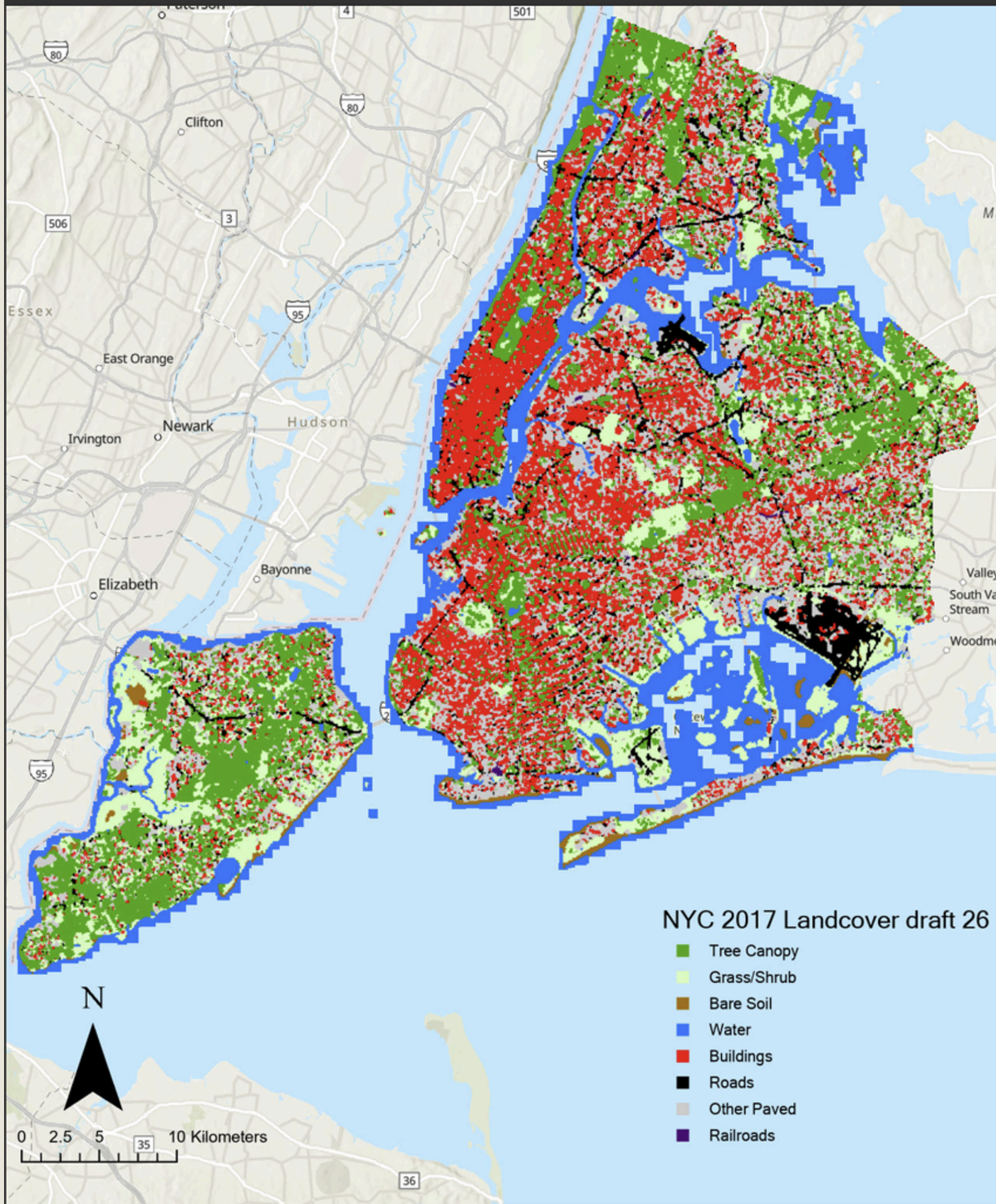
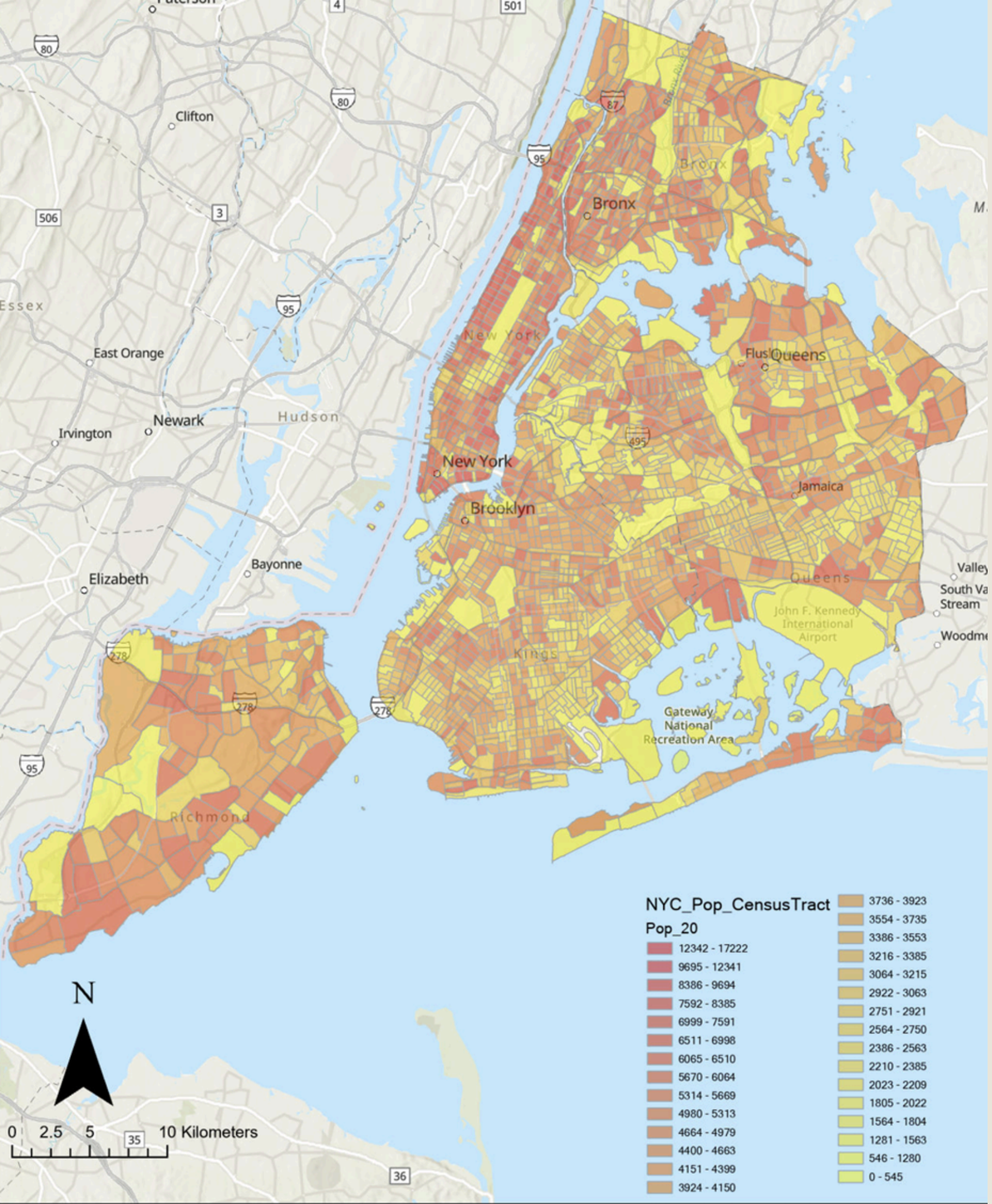

Clifton
Essex
East Orange
Irvington
Newark
Hudson
Elizabeth
Bayonne
N
0 2.5 5 10 Kilometers
NYC 2017 Landcover draft 26
Tree Canopy
Grass/Shrub
Bare Soil
Water
Buildings
Roads
Other Paved
Railroads


Clifton
Bronx
Essex
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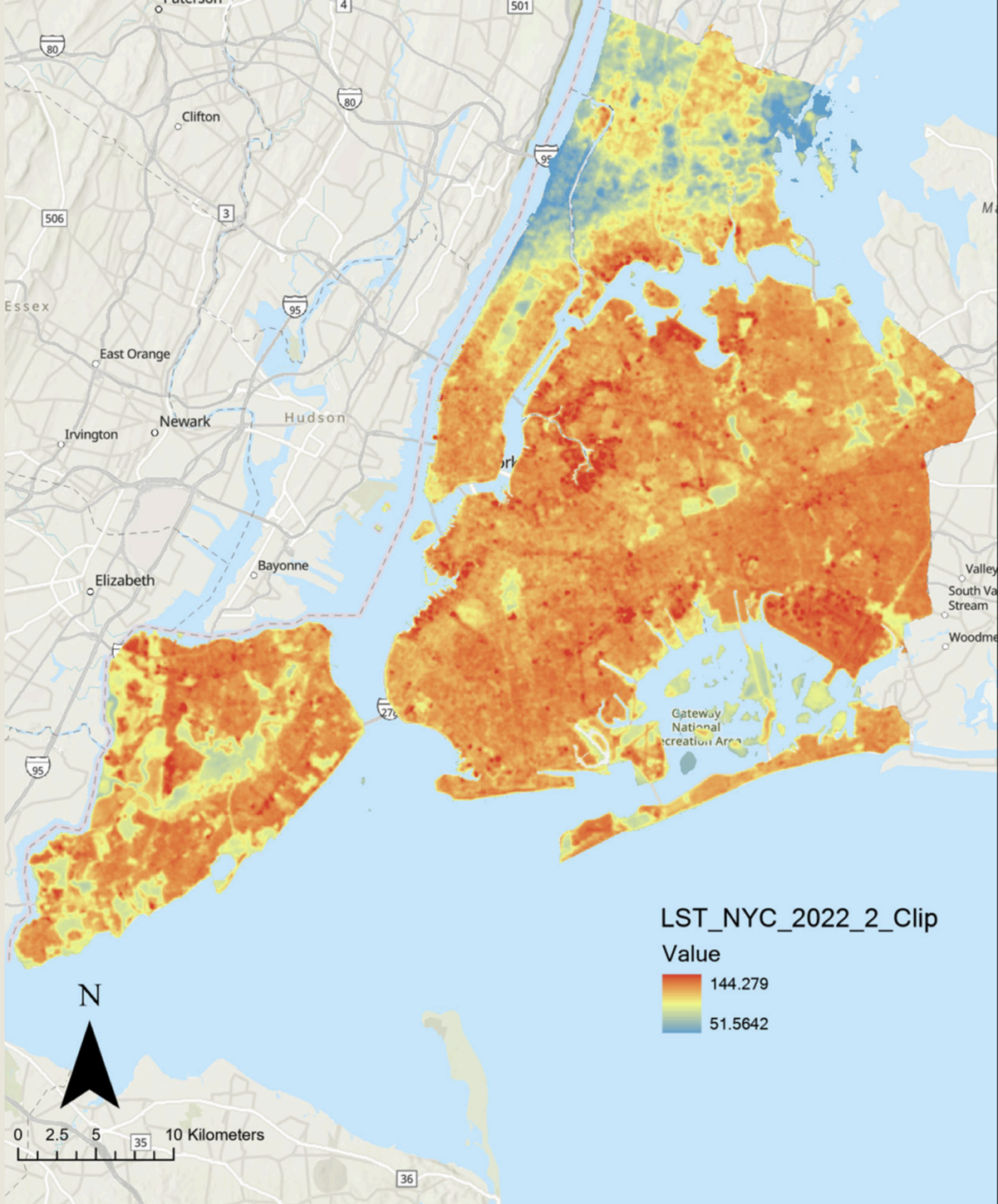
New York
Flushing
Queens
Jamaica
Brooklyn
Elizabeth
Bayonne
John F. Kennedy International Airport
Kings
Gateway National Recreation Area
Richmond
NYC_Pop_CensusTract
Pop_20
12342 - 17222
9695 - 12341
8386 - 9694
7592 - 8385
6999 - 7591
6511 - 6998
6065 - 6510
5670 - 6064
5314 - 5669
4980 - 5313
4664 - 4979
4400 - 4663
4151 - 4399
3924 - 4150
3736 - 3923
3554 - 3735
3386 - 3553
3216 - 3385
3064 - 3215
2922 - 3063
2751 - 2921
2564 - 2750
2386 - 2563
2210 - 2385
2023 - 2209
1805 - 2022
1564 - 1804
1281 - 1563
546 - 1280
0 - 545
N
0 2.5 5 10 Kilometers


Clifton
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East Orange
Newark
Hudson
Irvington
Elizabeth
Bayonne
Gateway National Recreation Area
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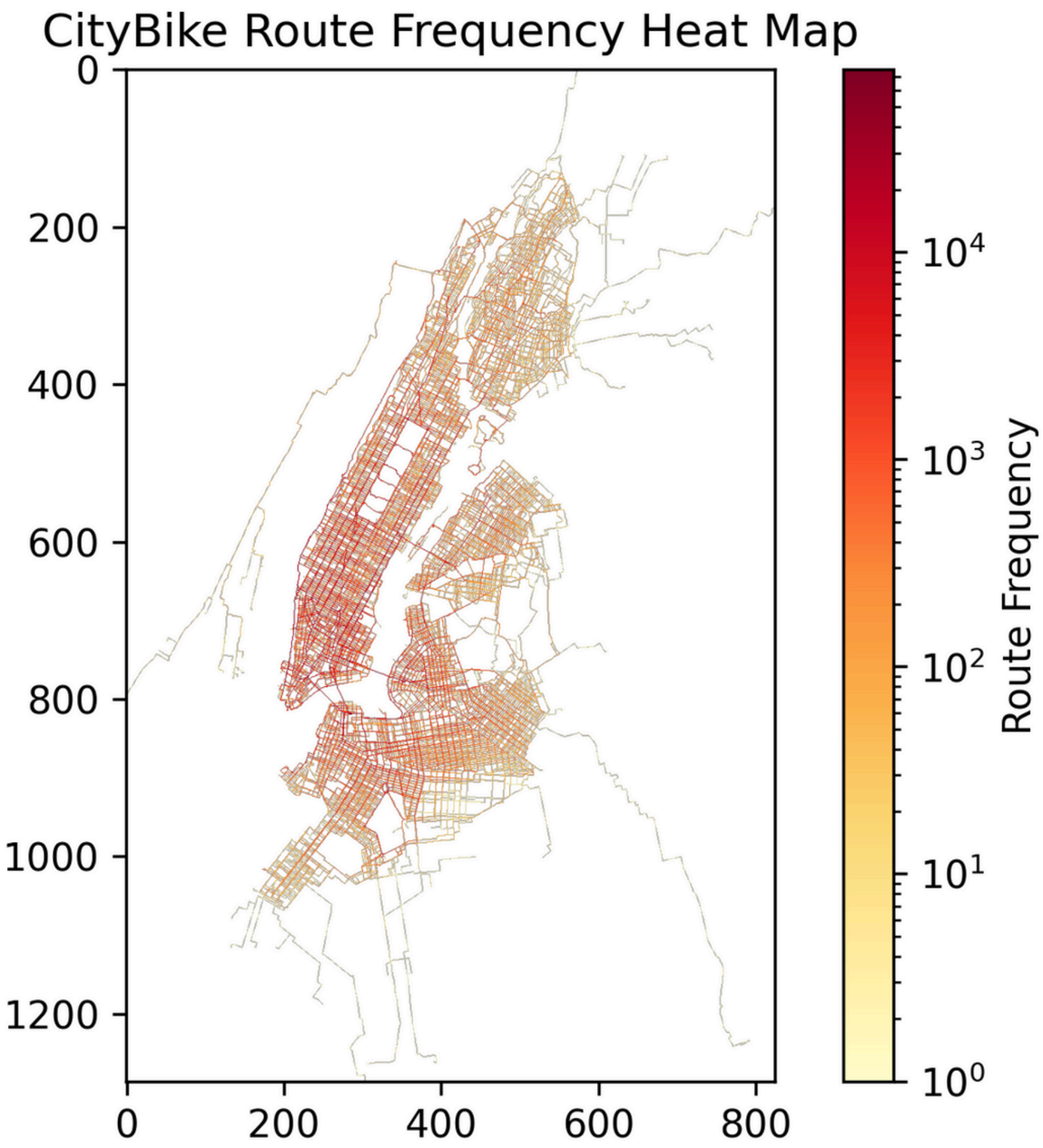
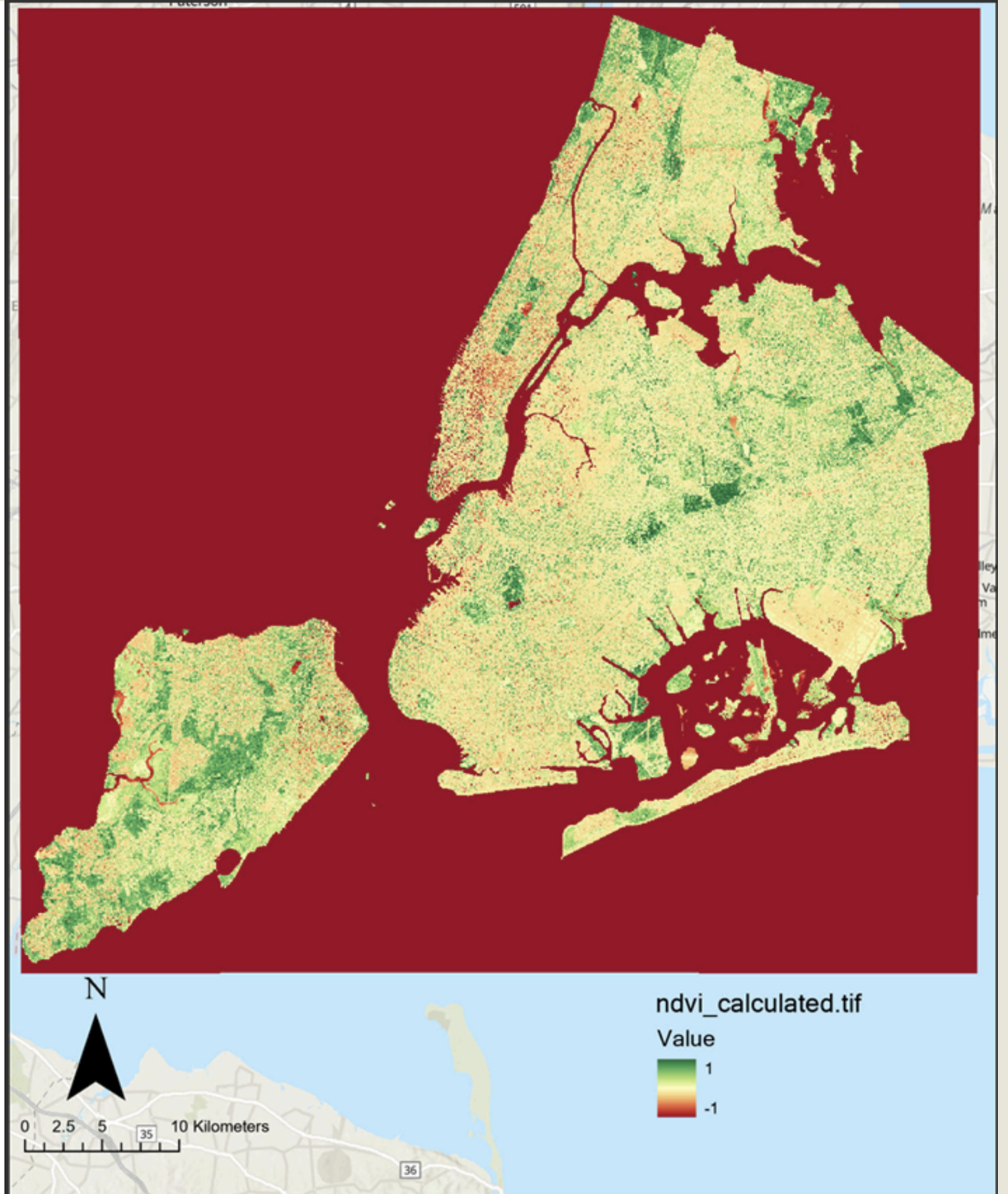

CityBike Route Frequency Heat Map
0
200
400
600
800
1000
1200
0
200
400
600
800
10^4
10^3
10^2
10^1
10^0
Route Frequency


N
0 2.5 5 10 Kilometers
35
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