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# Urban Heat Island (UHI) Analysis in New York City Using Remote Sensing and GIS



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## SUMMARY/ABSTRACT

**Importance of the Study:** Urban Heat Islands (UHI) significantly impact urban climates by increasing local temperatures. These elevated temperatures can exacerbate heat-related illnesses, strain energy infrastructure due to increased air conditioning demand, and decrease overall livability. New York City, with its extensive concrete infrastructure and limited green spaces, represents a compelling case for analyzing and mitigating UHI effects.

### Objective of the Study:

- To analyze spatial and temporal variations of Urban Heat Island (UHI) intensity in New York City using remote sensing technologies.
- To assess the relationship between air temperature, vegetation cover (NDVI), and shape length of census tracts in influencing the UHI effect.
- To generate predictive models that explain spatial patterns in UHI behavior and offer a basis for future policy decisions.

### Methodology:

- Air temperature values were obtained from secondary data sources; no raw satellite images were downloaded or processed.
- NDVI data in raster format was extracted and processed using Zonal Statistics.
- Shape length of both NDVI zones and census tracts were calculated in ArcMap.
- Census 2020 data, shapefiles for NYC tracts, and other supporting vector layers were sourced from official open-access GIS platforms.
- All analysis was conducted using ArcMap software. Only Ordinary Least Squares (OLS) regression was performed to identify significant variables affecting UHI.

### Expected Outcome:

- Accurate identification of urban hotspots with high UHI intensity in NYC.
- Determination of the statistical correlation between vegetation coverage, geometric features, and air temperature variation.
- Development of maps and analytical outputs that can support sustainable city planning and green infrastructure strategies.

## 2. INTRODUCTION

**Importance of the Study:** Urban areas tend to be significantly warmer than their rural surroundings primarily due to anthropogenic heat emissions, the abundance of impervious surfaces, and limited vegetation cover. This phenomenon, known as the Urban Heat Island effect, can lead to increased energy usage, heightened risks to public health, and altered local climate patterns. NYC's extensive urban sprawl and population density make it highly

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susceptible to UHI impacts, particularly during heatwaves. Addressing UHI is crucial for climate adaptation, urban resilience, and public well-being.

### **Literature Review:**

1. Zhou et al. (2014) - Environmental Research Letters: Analyzed the spatial footprint of UHIs globally and proposed broad mitigation techniques.
2. Li et al. (2021) - Remote Sensing of Environment: Studied global city UHI intensities and their environmental drivers using high-resolution remote sensing data.
3. Chakraborty et al. (2022) - Nature Communications: Presented a comprehensive global UHI assessment with determinants like vegetation, surface materials, and urban form.
4. Ramamurthy & González (2020) - Environmental Research Letters: Developed a spatial exposure model to map UHI vulnerability across NYC neighborhoods.
5. Zhou, Wang & Cadenasso (2017) - Landscape Ecology: Investigated the impact of urban built environments on LST in Washington, DC, offering comparative insights for NYC.

### **Objectives:**

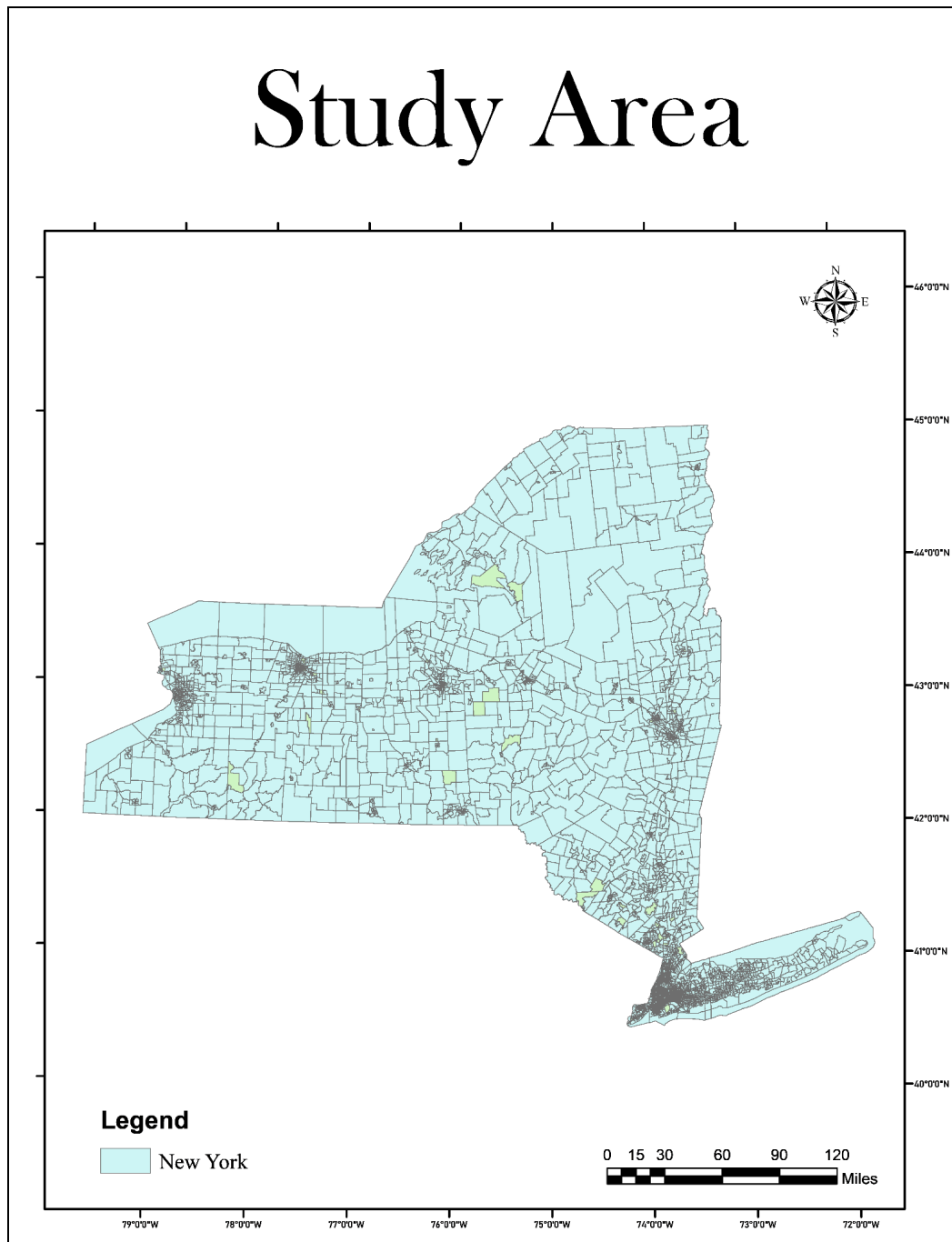
- To develop spatial models of UHI intensity in NYC using remote sensing data.
- To assess the influence of vegetation indices and population distribution on the occurrence and severity of UHI.
- To identify areas where mitigation strategies such as green roofs and increased tree cover can be most effective.

## **3. METHODOLOGY**

**a. Study Area:** New York City (NYC), one of the most densely populated and urbanized cities in the world, consists of five boroughs—Manhattan, Brooklyn, Queens, The Bronx, and Staten Island. It exhibits diverse land use types, varying degrees of impervious surfaces, and multiple microclimates that make it ideal for an in-depth UHI study.

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**b. Study Area Map:**

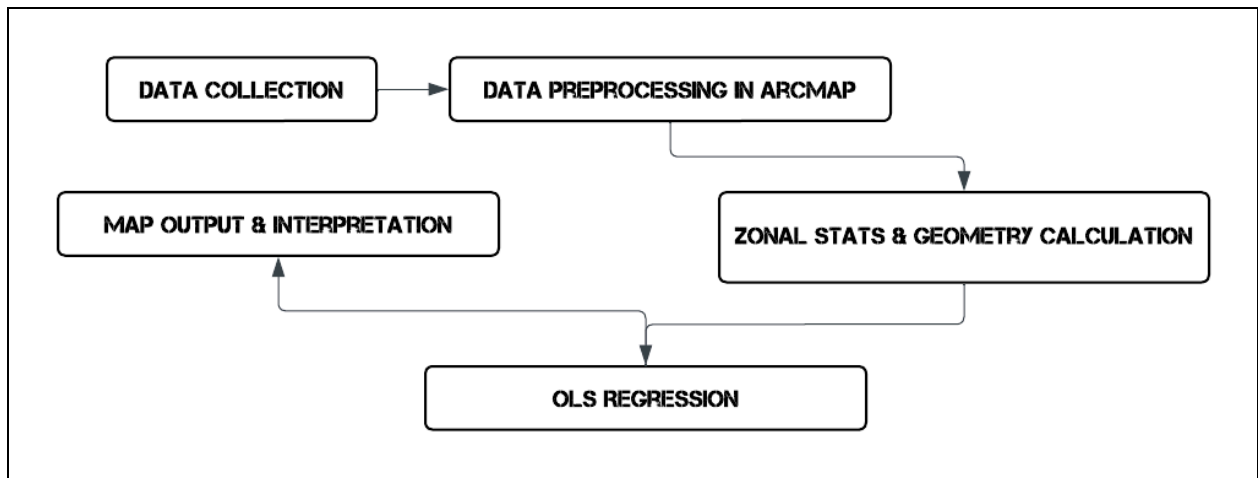


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### c. Descriptive Methods:

- Air temperature data was joined to spatial boundaries.
- NDVI was calculated from raster and summarized by census tract using zonal statistics.
- Shape length for each tract and NDVI boundary was calculated using ArcMap.
- These values were input into regression models to determine their influence on UHI intensity.

### d. Flow Chart:



### e. Explanation of Methods:

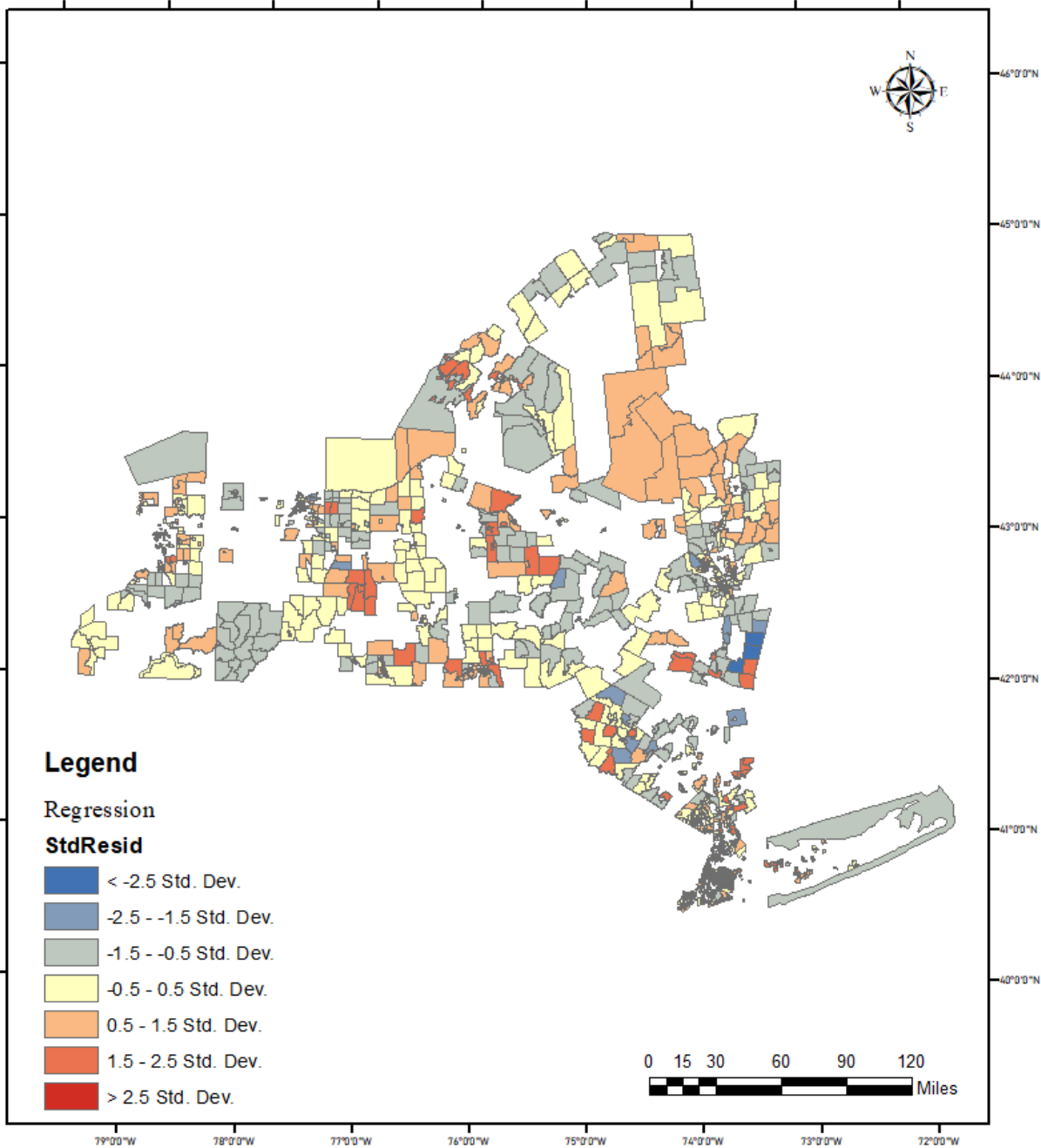
- Air Temperature: Data was obtained in processed format from reputable online sources; no direct satellite imagery was used or processed. The temperature data was spatially joined to NYC census tracts and analyzed using ArcMap.
- NDVI: Provided as a raster dataset, NDVI was extracted using zonal statistics and associated with NYC census tracts for spatial analysis.
- Shape Length: The geometric length of both NDVI regions and census tracts was computed using the "Calculate Geometry" function in ArcMap. This spatial characteristic was used as an independent variable.
- Population: US Census 2020 tract-level data was downloaded and processed to match spatial extents. Demographic layers were sourced from the US Census Bureau website and NYC Open Data portal.
- Shapefiles: Census tract boundary shapefiles were obtained from the US Census Bureau's TIGER/Line Shapefiles database.
- Analytical Techniques: Only Ordinary Least Squares (OLS) regression was applied using ArcMap to evaluate the statistical relationship between variables and assess spatial variation in UHI intensity.

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## 4. RESULTS & DISCUSSION

- **UHI Mapping:** Maps revealed high air temperature concentrations particularly in urban cores like Midtown Manhattan and Downtown Brooklyn, aligning with areas of high built-up density and low vegetation.
- **Regression Analysis:** Strong inverse relationships were identified between NDVI and air temperature values, confirming the cooling effect of green spaces. Shape length of census tracts also showed varying influence depending on tract geometry.
- **Population Influence:** Although not the main variable in the final model, demographic concentration correlated with denser, hotter zones in several boroughs.
- **OLS Interpretation:** The OLS model produced meaningful statistical results with interpretable coefficients. Residual analysis and R-squared values provided insights into the model's spatial accuracy.

# OLS Analysis New York



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## 5. REFERENCES

- Chakraborty, T., Lee, X., Ermida, S. L., & Shepherd, J. M. (2022). A global analysis of surface urban heat island intensity and its determinants. *Nature Communications*, 13(1), 1–11. <https://doi.org/10.1038/s41467-022-28652-9>
- Li, X., Zhou, Y., Yu, S., Zhao, K., & Strobl, J. (2021). Urban heat island intensity and its environmental determinants in global cities. *Remote Sensing of Environment*, 266, 112678. <https://doi.org/10.1016/j.rse.2021.112678>
- Ramamurthy, P., & González, J. E. (2020). Urban heat stress vulnerability in New York City: An assessment based on a spatially varying exposure model. *Environmental Research Letters*, 15(9), 094021. <https://doi.org/10.1088/1748-9326/ab93e7>
- Zhou, D., Zhao, S., Liu, S., & Zhang, L. (2014). The footprint of urban heat islands and their mitigation strategies. *Environmental Research Letters*, 9(6), 064003. <https://doi.org/10.1088/1748-9326/9/6/064003>
- Zhou, W., Wang, J., & Cadenasso, M. L. (2017). Effects of the urban built environment on land surface temperature in Washington, DC. *Landscape Ecology*, 32, 2131–2147. <https://doi.org/10.1007/s10980-017-0551-6>
- NASA EarthData. (n.d.). Retrieved from <https://earthdata.nasa.gov>
- US Census Bureau. (n.d.). Retrieved from <https://www.census.gov>
- NYC Open Data. (n.d.). Retrieved from <https://opendata.cityofnewyork.us>
- Copernicus Open Access Hub. (n.d.). Retrieved from <https://scihub.copernicus.eu>