Assessing the Drivers of Urban Flood Vulnerability in Milwaukee using the Integrated Valuation of Ecosystem Services and Tradeoffs Urban Flood Risk Mitigation Model (InVEST)

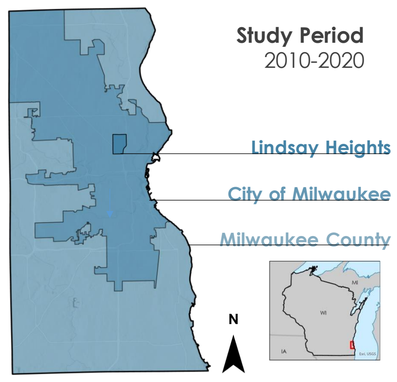
Abstract

Milwaukee County has experienced an increase in flooding due to climate change and urbanization. The frequency and severity of flooding vary spatially due to differences in land cover, surface permeability, and infrastructure. Marginalized communities tend to experience disproportionately high flooding and damage due to infrastructural inequalities and limited access to resources. To quantify these differences, we used the Natural Capital Project's Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Urban Flood Risk Mitigation Model to calculate and create maps of runoff retention, nominal flood depth, and economic damage to buildings in Milwaukee. Our model inputs included land cover, surface permeability, and rainfall. To inform our precipitation inputs, we used NASA's Integrated Multi-satellite Retrievals for Global Precipitation Measurement (GPM IMERG) and National Weather Service (NWS) data. We assessed the relationship between flood risk and social and environmental spatial data including redlining, racial demographics, greenspace, and community resilience. The data demonstrate that flood risk is higher in historically redlined neighborhoods, majority Hispanic and Black census block groups, areas that lack parks and trees, and areas of low community resilience as measured by the Census Bureau's Community Resilience Estimates (CRE). These findings will support our partners, Groundwork Milwaukee and Groundwork USA, in their efforts to promote the equitable distribution of resources and support environmental health in urban spaces. The end products of this project provide our partners with tools to assess urban flooding vulnerability, guide future intervention projects, quantify the effects of environmental injustice, and improve stakeholder access to data.

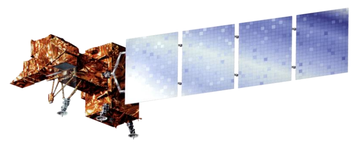
Objectives

- **Quantify** the spatial distribution of pluvial flood risk using the InVEST Urban Flood Risk Mitigation Model's runoff retention, nominal flood depth, and economic damage outputs.
- **Analyze** the relationship between flood risk and historic redlining, racial demographics, green spaces, and community resilience estimates.
- **Contextualize** the InVEST model's results using the CityCAT flood risk map, NDWI, and DEM-derived streams

Study Area



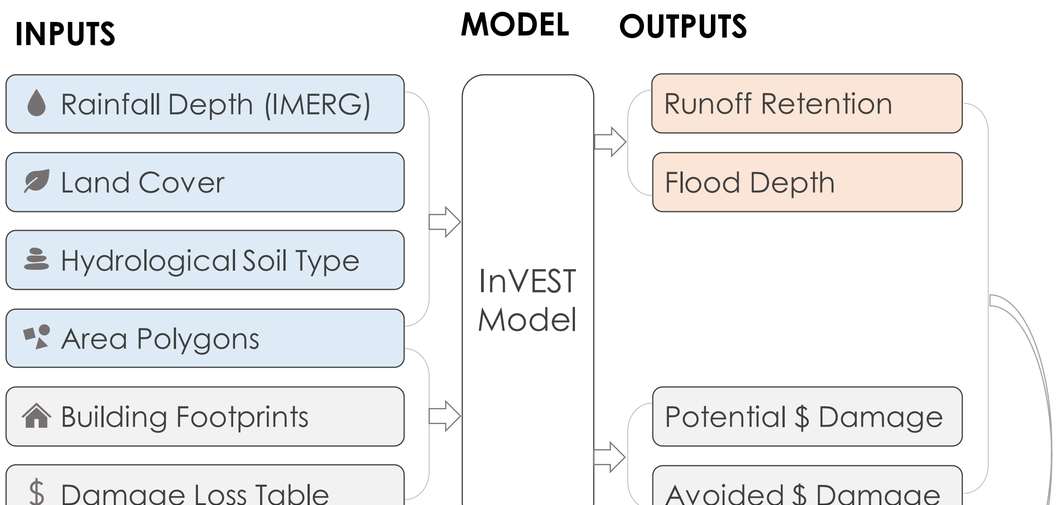
Earth Observations



Landsat 7 ETM+
NDWI

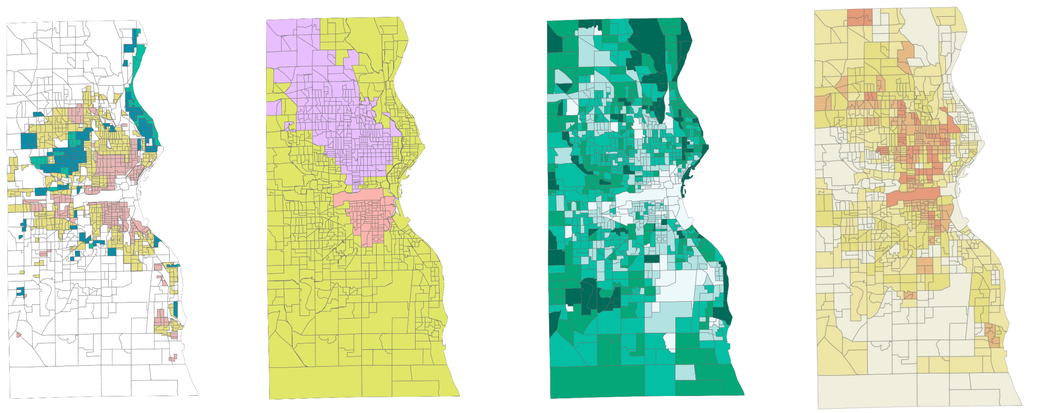
GPM IMERG
Rainfall Depth

Methodology

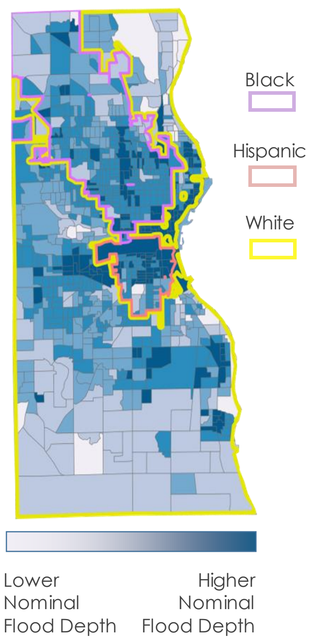


ENVIRONMENTAL JUSTICE GEOSPATIAL DATA ANALYSIS

Historic Redlining | Racial Demographics | Green Space | Community Resiliency

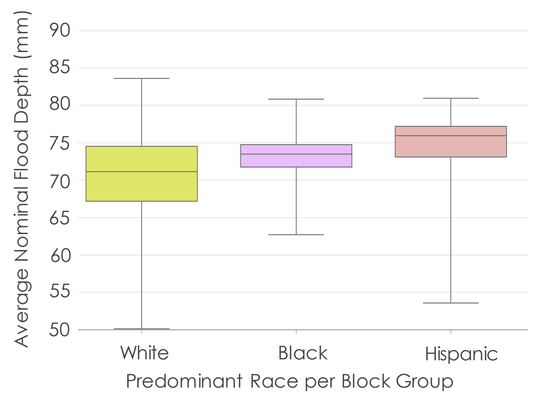


Results



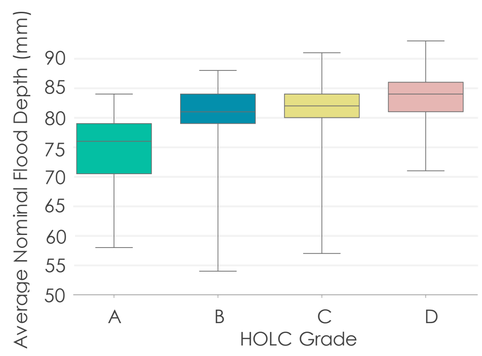
Race

Flood depth is 3.3% higher in predominantly Black census blocks and 6.8% higher in Hispanic census blocks than in predominantly White census blocks.

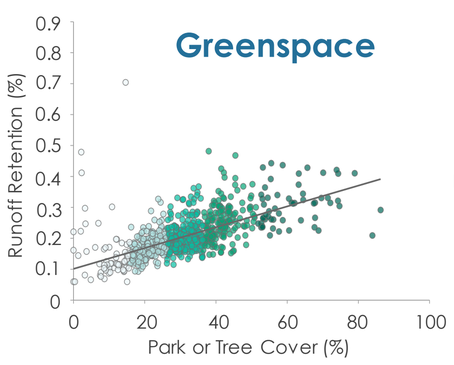


Redlining

D grade areas were predicted to have an average of 14% higher runoff and face 12% greater economic damage than those areas that had historically received an A grade.



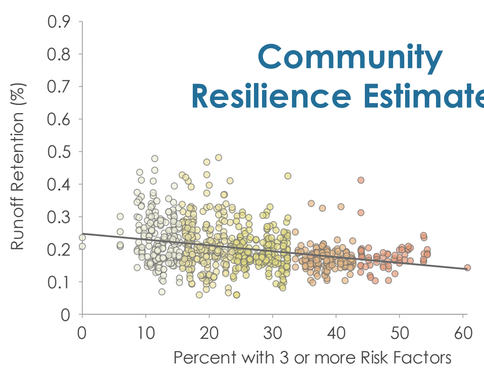
Greenspace



$R^2 = 0.4$

Average runoff retention was 67% higher in areas with parks or tree cover (30.44 m3) compared to areas without (18.26 m3).

Community Resilience Estimates



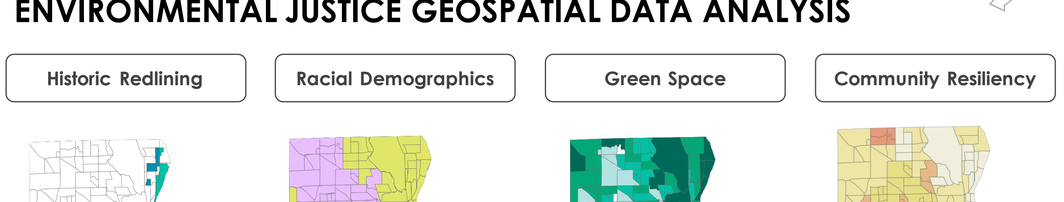
$R^2 = 0.11$

Runoff retention is slightly worse in areas of low community resiliency, compounding the dangers of a flood disaster.

Conclusions

- InVEST does not account for hydrologic flow, elevation, sewer infrastructure, riverine (fluvial flooding), or social vulnerability.
- InVEST corroborates the known phenomenon that flood risk disproportionally impacts marginalized groups due to decades of infrastructure disinvestment.
- InVEST is useful as a tool to evaluate community flood risk, but potentially challenging to implement.

Team Members



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Project Partners

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Urban Development Milwaukee

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