**Kansas City Disasters**

*Assessing Environmental and Socioeconomic Factors of Urban Flood Vulnerability in Kansas City, Kansas*

**Project Team**

***Project Team:***

M. René Castillo (Project Lead)

Hadwynne Gross

Eric Sjöstedt

Raychell Velez

***Advisors & Mentors:***

Dr. Kenton Ross (NASA Langley Research Center)

***Team Contact:*** M. René Castillo, mcast.m.22@gmail.com

***Partner Contact:*** Reverend Adrianne Showalter Matlock, asmatlock@northeastkck.org

**Project Overview**

***Project Synopsis:***

Increasing severity and frequency of extreme weather events are key components of natural hazards that will reshape urban settings. The Kansas City Disasters project focused on identifying and assessing urban flooding events within Kansas City, Kansas. In collaboration with Groundwork USA and Groundwork Northeast Regional Group, the DEVELOP team created maps of runoff retention and potential economic damage using the InVEST Urban Flood Risk Mitigation Model. Local organizations will use these maps to support equitable resource distribution for flood mitigation, conduct local workshops, and engage in outreach for community resilience against flood hazards.

***Abstract:***

Pluvial flooding, over-saturated ground, and poor drainage systems disproportionately impact historically disinvested neighborhoods during extreme rainfall events independently of overflowing water bodies. These communities are impacted by physical and socioeconomic factors that make them vulnerable to flooding events, such as high concentration of impervious landcover, high precipitation rates, and a combined sewer system framework. Despite known vulnerability to environmental hazards, there is a lack of data supporting the potential pluvial street-level flooding events. The DEVELOP team investigated flooding events from June 2010 through June 2021 in Google Earth Engine (GEE) using NASA Earth observation products from the Global Precipitation Measure. Alongside the satellite imagery and ancillary datasets, the Natural Capital Project’s Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Urban Flood Risk Mitigation model was utilized to generate outputs of runoff retention and potential economic damage for risk mapping of Kansas City, Kansas to aid in identifying areas where future intervention is necessary. To provide further spatial detail, an Arc-Malstrøm model was used to produce spatially-explicit outputs of how pluvial flooding would accumulate across the surface elevation gradients. These resulting maps identify the most vulnerable neighborhoods throughout Kansas City, Kansas alongside potential economic damage from flooding. The resulting methodology and end products provide partners from Groundwork USA and Groundwork Northeast Revitalization Group (Groundwork NRG) with a detailed analysis of urban flood risk throughout Wyandotte County, Kansas, while simultaneously streamlining the methodology to provide neighborhood-scale vulnerability to Groundwork USA’s Climate Safe Neighborhoods project.

***Key Terms:***

InVEST Urban Flood Risk Mitigation model, Arc-Malstrøm model, urban flooding, socioeconomic vulnerability, GPM IMERG

***National Application Area Addressed:*** Disasters

***Study Location:*** Kansas City, Kansas

***Study Period:*** June 2010 – June 2021

***Community Concerns:***

* In Kansas City, Kansas, catastrophic flooding has recently occurred throughout the spring and summer months. Intense precipitation resulted in soil moisture saturation leading to runoff, exposure of raw sewage, and excessive property damage.
* Communities in Kansas City, Kansas, particularly those affected by neighborhood disinvestment and redlining, face higher levels of social vulnerability such as income disparities, education rates, and environmental health exposures.
* Urban flood risk mitigation methods can be time- and cost-intensive. Local communities lack access to geospatial methods to streamline this process.

***Project Objectives:***

* Generate precipitation runoff, runoff retention, and potential damage cost maps
* Detect and monitor socioeconomic and environmental factors of flood vulnerability
* Identify limitations and uncertainties of the InVEST Urban Flood Risk Mitigation model in identifying neighborhood-scale flood vulnerability

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Boundary Org** |
| **Groundwork USA, Groundwork Northeast Revitalization Group** | Jalisa Gilmore, Manager of Equity and Resilience Programs; Ben Carpenter, Climate Safe Neighborhoods Outreach Coordinator; Reverend Adrianne (Adri) Showalter-Matlock, Operations Director | End User | Yes |
| **Groundwork USA** | Cate Mingoya, National Director of Climate Resilience and Land Use; Lawrence Hoffman, Director of GIS | End User | Yes |

***Decision-Making Practices & Policies:***

Groundwork USA and Groundwork NRG’s Climate Safe Neighborhoods project communicates with local communities to gain insight on local hazards or environmental health concerns. This information is utilized for spatial data analysis to explore flood vulnerability, communicate findings back to local communities, and implement solutions. Wyandotte County, Kansas, does not possess policies to manage flood events; however, it has been updating the Flood Insurance Rate Maps (FIRM) in collaboration with the Federal Emergency Management Agency (FEMA). In 2020 the Environmental Protection Agency (EPA) and the U.S Department of Justice settled the filed 2013 lawsuit against the Unified Government of Wyandotte County and Kansas City, Kansas, to address unauthorized overflows of untreated raw sewage and reduce pollution levels in urban stormwater that violated the Clean Water Act. This resulted in the implementation of the Integrated Overflow Control Plan (IOCP) that split stormwater and sewage pipelines, costing over $600 million, with a completion date of 2044.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **GPM IMERG** | Precipitation | GPM IMERG rainfall data (10 km) were used to provide an average depth of rainfall input across study area for InVEST model. |

***Ancillary Datasets:***

* U.S. Census Bureau Block Group Shapefile, 2020 – Polygon layer of U.S. Census Block Groups for Wyandotte County, Kansas used for environmental justice analysis and InVEST model inputs
* American Community Survey Socioeconomic Data, 2020 – demographic and socioeconomic data at the U.S. Census Block Group level used for environmental justice analysis
* USGS NHDPlus (National Hydrography Dataset Plus) High Resolution (HR), 2018 – regional watershed boundary dataset containing HUC 8 and 12 watersheds for creating a delineated watershed polygon
* United States Department of Agriculture (USDA) Gridded Soil Survey Geographic (gSSURGO) Database, 2019 – soil type and drainage class for calculating curve numbers for the InVEST Urban Flood Risk Mitigation model
* United States Geological Survey (USGS) National Land Cover Database (NLCD), 2019 – land cover and land use data for input into the InVEST Urban Flood Risk Mitigation model
* United States Geological Survey (USGS) 3-DEM 10-meter (1/3 arc-second), 2020 – digital elevation model for input to watershed delineation and Arc-Malstrøm model
* Wyandotte County Unified Government Streams Layer, 2014 – stream location data for input into the Arc-Malstrøm model
* Wyandotte County Unified Government County Limits, 1988 – county shapefile data for input into the InVEST Urban Flood Risk Mitigation model
* Wyandotte County Unified Government Building Footprints, 2011 – local building footprint data for input into the InVEST Urban Flood Risk Mitigation model and the Arc-Malstrøm model

***Modeling:***

* Natural Capital Project InVEST Urban Flood Risk Mitigation model (Contact: Dr. Kenton Ross, NASA Langley Research Center) – Calculating precipitation runoff, runoff retention, and potential economic damage for Wyandotte County, Kansas
* Watershed Delineation Process – Producing a delineated watershed polygon for Wyandotte County, Kansas
* Arc-Malstrøm model – Producing pluvial flooding accumulation polygon and potential economic damage for Wyandotte County, Kansas

***Software & Scripting:***

* Google Earth Engine API – Acquiring Earth observation imagery
* Natural Capital Project InVEST 3.11.0 – Running the Urban Flood Risk Mitigation model
* Esri ArcGIS Pro 2.9.3 – Preparing data for the InVEST Urban Flood Mitigation model, running the Arc-Malstrøm model, and mapping environmental justice indices in Wyandotte County, Kansas

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Delineated**  **Watershed**  **Layer** | N/A | Ancillary datasets were used in the creation of the delineated watershed layer. The layer provides partners with a watershed boundary to analyze flood potential and flood risk in Kansas City, Kansas. | N/A |
| **Urban Flood Risk Mitigation Map Package** | GRM IMERG | Maps generated from the InVEST Urban Flood Risk Mitigation Model assists partners with identifying areas of high runoff retention and economic damage. These outputs inform partners where high flood vulnerability is occurring and where interventions should happen. | N/A |
| **Arc-Malstrøm Map Package** | N/A | Maps produced from the Arc-Malstrøm model provides partners spatially-explicit insight to pluvial flood pooling/inundation following surface elevation gradients. This output provides partners with a more accurate understanding of potential economic damage from flooding. | N/A |
| **Project Modeling Document** | N/A | A Microsoft word document that contains a brief background and step-by-step guide on how to produce the three models ran in this project. | N/A |

***Product Benefit to End User:***

The resulting maps of pluvial flooding will be used by Groundwork USA and Groundwork NRG to prioritize neighborhoods within Kansas City, Kansas, for flood mitigation efforts. This project explores the outputs of the InVEST Urban Flood Risk Mitigation model and Arc-Malstrøm model such as runoff retention and blue spots, which provides data for environmental-based tools that will be used by Groundwork USA and Groundwork NRG. The environmental justice maps will also allow for the access of neighborhood-scale pluvial flood vulnerability data useful for mitigation efforts and community development. These maps will be utilized in Groundwork NRG’s Climate Safe Neighborhood project to identify where intervention and mitigation efforts are most necessary. This methodology can be repeated for a continuation of updates that will inform decision-makers for future flood mitigation intervention efforts.

***Project Continuation Plan:***

The first term created a HUC 14/16 equivalent watershed layer that assisted in neighborhood-level analysis of flood modeling, assessing the socioeconomic implications of urban flood vulnerabilities in Kansas City, Kansas. This term handed off to our partners detailed InVEST and Arc-Malstrøm methodologies guide that improved the accuracy of the model as well as maps to support efforts in identifying areas for intervention.

The second term will focus on refining results from the InVEST and Arc-Malstrøm model. Inclusion of water quality analysis by the InVEST Urban Stormwater Retention model could provide greater insight to present issues of pollution and raw sewage exposure during flood events in Kansas City, KS.

**References**

Balstrøm, T., & Crawford, D. (2018). Arc-Malstrøm: A 1D hydrologic screening method for stormwater assessments based on geometric networks. *Computers & Geosciences*, 116, 64–73. <https://doi.org/10.1016/j.cageo.2018.04.010>

EPA. (2021). Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. *U.S. Environmental Protection Agency, EPA* 430-R-21-003. [www.epa.gov/cira/social-vulnerability-report](http://www.epa.gov/cira/social-vulnerability-report)

Hamel, P., Guerry, A. D., Polasky, S., Han, B., Douglass, J. A., Hamann, M., Janke, B., Kuiper, J. J., Levrel, H., Liu, H., Lonsdorf, E., McDonald, R. I., Nootenboom, C., Ouyang, Z., Remme, R. P., Sharp, R. P., Tardieu, L., Viguié, V., Xu, D., … Daily, G. C. (2021). Mapping the benefits of nature in cities with the InVEST software. *npj Urban Sustainability*, *1*, Article 25. <https://doi.org/10.1038/s42949-021-00027-9>

Hauth, L. D., & Carswell Jr., W. J. (1978). *Floods in Kansas City, Missouri and Kansas, September 12-13, 1977*. U.S. Geological Survey and the National Oceanic and Atmospheric Administration. <https://pubs.usgs.gov/pp/1169/report.pdf>

Tate, E., Rahman, M. A., Emrich, C. T., & Sampson, C. C. (2021). Flood exposure and social vulnerability in the United States. *Natural Hazards*, *106*(1), 435–457. <https://doi.org/10.1007/s11069-020-04470-2>