**Hampton Roads Urban Development II**

*Assessing Urban Tree Canopy and Impervious Surface Distribution to Inform Urban Planning in Hampton, Virginia*

**VPS Title:** Watershed Woes: Remote Sensing of Impervious Surface and Tree Canopy Cover in Hampton, VA

**Project Team**

***Project Team:***

Stephanie Kealy (Project Lead)

Sophie Barrowman

Paige Haley

Alina Schulz

***Advisors & Mentors:***

Dr. Kenton Ross (NASA Langley Research Center)

***Past Contributors:***

Eric Deutsch

Holly Gould

Shaifali Prajapati

Danielle Ruffe

**Project Overview**

***Project Synopsis:*** The City of Hampton is an urban low-lying coastal community increasingly at risk of recurring flooding. This project used NASA Earth observations to map current percentages of and changes in tree canopy cover and impervious surfaces in the region. These maps help identify potentially vulnerable areas within the City of Hampton. This project incorporated risk-communication to residents to facilitate the City of Hampton’s goal of using a place-based, holistic approach to resilience in the face of increasing watershed risks.

***Abstract:***

Hampton Roads’ 1.6 million residents thrive on bustling military, harbor, and environmental industries. The region’s stakeholders identified an increasing flood and water quality risk due to urbanization, a changing climate, and sea-level rise. These hazards threaten not only the livelihood of Hampton Roads residents but also the well-being of the entire country as several key federal facilities exist in the region. Impervious surface cover and urban tree canopy cover are two known variables that influence flood risk. Using Landsat 5 Thematic Mapper and Landsat 8 Operational Land Imager, the team created maps of impervious surface and tree canopy cover change from 2000 to 2019 for the City of Hampton. These maps supported City of Hampton officials in directing resiliency efforts towards areas of greatest vulnerability within their municipality. Additionally, the team used the Impervious Surface Analysis Tool (ISAT) to illustrate how changes in impervious surface coverage impact local water quality and how different land management scenarios might alter these consequences. The team’s methodology will allow city officials to create updated impervious surface and tree canopy cover maps any time new imagery becomes available. Moreover, the team supported the city officials’ goals of using a place-based approach by demonstrating how the methodology can be applied to the smaller Newmarket Creek watershed in order to empower residents as active custodians of the environment.

***Keywords:***remote sensing, impervious surface, tree canopy, resiliency, watershed, Landsat, urban development, ISAT

***National Application Areas Addressed:*** Urban Development, Water Resources, Disasters

***Study Location:*** Newmarket Creek Watershed and the surrounding municipality of Hampton, VA

***Study Period:*** January 2000 to June 2019

***Community Concerns:***

* As a low-lying coastal community, Hampton, VA, is at risk of increased flooding frequency and intensity due to increasing global temperatures and sea level rise.
* Hampton urbanization causes decreased tree canopy cover and increased impervious surface cover, both of which exacerbate flood risk.
* Increased flooding creates problems for Hampton residents and businesses, such as higher flood insurance rates, increased repetitive loss from water damage, and decreased access to roadways and other infrastructure.

***Project Objectives:***

* Map the current distribution of impervious surfaces and tree cover as well as land cover change from 2000 to 2019
* Identify areas within the study area that are most susceptible to flooding
* Empower Hampton Roads residents and city officials to work together in combatting local environmental problems by demonstrating the utility of freely available NASA Earth observation data

***Previous Term:*** 2018 Fall (LaRC) – Hampton Roads Urban Development

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Hampton** | Bruce Sturk, Director of Federal Facilities Support; Lucy Stoll, Senior City Planner; David Imburgia, Environmental & Sustainability Manager; Allan Lambert, GIS Manager | End User | Yes |
| **Waggonner & Ball Architecture/Environment** | Janice Barnes, Principal | Collaborator | No |

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

Officials from the City of Hampton and architectural consultants from Waggonner & Ball collaborated to compose *Resilient Hampton*. This document assesses how water forces impact the area, provides a plan for dealing with those forces, establishes values by which to plan, and promotes a place-based theme to guide all resiliency efforts. The *Resilient Hampton* document aims to serve as a best practices guide for other coastal regions that experience similar challenges. To test their approach, they designated the Newmarket Creek watershed as a pilot study area while introducing new land management practices. City GIS officials currently obtain impervious surface and tree cover data by hand-digitizing imagery as necessary. Challenges include limited knowledge of remote sensing and a lack of state or federal guidelines for urban water risk adaptation strategies.

***Project Benefit to End User:***

Tree canopy and impervious surface cover affect an area’s risk of experiencing flood events. The team created maps of these parameters that give the partners the ability to apply NASA Earth observations at nested scales of analysis depending on their needs. The Impervious Surface Analysis Tool (ISAT) output demonstrates the impact of impervious surface cover on local water quality and will give the partners the opportunity to visualize areas exposed to flood risk based on different management scenarios. The team’s efforts will enhance the City’s capacity to approach resiliency on a municipal level and will develop the residents’ capacities to adopt parcel-level responsibility. End users appreciated data sourced from an objective, nationally recognized organization outside of their community. This framework can be shared with other urban management groups.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 8 OLI** | Surface reflectance | Surface reflectance data were used to create the percent impervious and percent tree canopy products. |
| **Landsat 5 TM** | Surface reflectance | Surface reflectance data were used to create the percent impervious and percent tree canopy products. |

***Ancillary Datasets:***

* City of Hampton 6-inch and 3-inch resolution commercial imagery – used to define impervious surfaces and urban tree locations
* City of Hampton maps & shapefiles – used to define the bounds of the study and overlay areas of interest onto the results of the project
* Chesapeake Conservancy Land Use Data Project classification product – used for calibration of the team’s regression model and input for ISAT
* US Census Bureau Population Density Dataset – used as an input for ISAT
* USGS National Land Cover Dataset (NLCD) Imperviousness product – used as an input for ISAT

***Software & Scripting:***

* Google Earth Engine API – used to pre-process Landsat data
* ERDAS IMAGINE – used for image processing
* Esri ArcMap and ArcGIS Pro – used for end product generation and running the Impervious Surface Analysis Tool (ISAT) to calculate impervious surface area and categorize results to represent good, fair, and poor water quality

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Percent Impervious Surface Maps** | Landsat 8 OLI | The partner will use these maps to understand the current spatial distribution of impervious surfaces, which city officials can use to analyze hydrology across the city and make decisions about urban planning. | I |
| **Impervious Surface Change Maps** | Landsat 5 TM  Landsat 8 OLI | The partner will use these to visualize changes in impervious surface distribution between 2000 and 2019. | I |
| **Percent Urban Canopy Maps** | Landsat 8 OLI | The partner will use these maps to understand the current spatial distribution of trees and vegetation, which city officials can use to analyze hydrology across the city and make decisions about urban planning. | I |
| **Urban Canopy Change Maps** | Landsat 5 TM  Landsat 8 OLI | The partner will use these to visualize changes in urban tree canopy distribution between 2000 and 2019. | I |
| **Project Methodology Tutorial** | Landsat 5 TM  Landsat 8 OLI | Partners will familiarize themselves with our methodology to enhance their existing capacities to use Earth observations and reproduce the process for analysis in other areas of interest. | I |

**Project Handoff Package**

***Transition Plan:*** Because the City of Hampton is a local partner, the team was able to handoff the project materials in person during Week 10 of the term. This handoff was between the members of the NASA DEVELOP project team and the City officials. A community outreach event organized by the partners was scheduled for fall 2019 during which the team was given an opportunity to present the results and distribute brochures.

***Team POC:*** Stephanie Kealy, stephkealy@gmail.com

***Partner POC:*** Bruce Sturk, bsturk@hampton.gov

***Handoff Package:***

* Percent Impervious Surface Maps
* Impervious Surface Change Maps
* Percent Urban Canopy Maps
* Urban Canopy Change Maps
* Project Methodology Tutorial
* Technical Paper
* Brochure for a community engagement event hosted by the City of Hampton
* Project Video
* Geodatabase of all maps (percent impervious, percent urban canopy, impervious surface change, and urban canopy change) for the City’s own analysis and distribution
* Study Area Shapefiles (watershed and city boundaries)

**References**

Hampton VA Community Development. (n.d.). *Resilient Hampton*. Retrieved June 25, 2019, from https://hampton.gov/3459/Resilient-Hampton

Waggonner & Ball Architecture/Environment. (2018). *Living with water Hampton: A holistic approach to addressing sea level rise and resiliency.* Retrieved from https://hampton.gov/DocumentCenter/View/20644/ Resilient-Hampton-Phase-I-Report?bidId=