**Hawai‘i Island Disasters**

*Using NASA Earth Observations to Assess Coastal Flood Risk with Measures of Land Cover Change, Flood Extent, and Vulnerability for Adaptation and Mitigation Planning on Hawai‘i Island*

**Project Team**

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**Project Overview**

***Project Synopsis:***

The Hawai‘i Island Disasters project addressed the increasing risk of coastal threats and climate change to communities on Hawai‘i Island. Under the advisory of Arizona State University’s Center for Global Discovery and Conservation Science, the DEVELOP team partnered with the County of Hawai‘i to improve their geospatial capacity and create tools to assess flood risk and vulnerability using Hurricane Lane (2018) as a case study. The team developed a flexible framework utilizing NASA Earth observations to enable the County to visualize and quantify risk associated with various climate change hazards in the future.

***Abstract:***

As the County of Hawai‘i faces an increased risk of extreme flooding events, sea-level rise, and other hazards associated with climate change, the need for building geospatial capacity to make better-informed decisions is critical. The County of Hawai‘i and Arizona State University partnered with NASA DEVELOP to complete a macro-scale risk analysis for the island of Hawai‘i analyzing flooding, land cover, vulnerability, and exposure factors using Earth observations and socio-economic data. The team assessed the variation in urban coastal vulnerability around the entire island of Hawai‘i, using satellite imagery of coastal land cover typology from satellite products such as Landsat 8 Operational Land Imager (OLI), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Sentinel-1 Synthetic Aperture Radar (SAR). The team made a sharable geodatabase containing datasets modeling vulnerability to coastal flooding as well as the Hawai‘i Flood Risk Toolbox (HiFloRT) which contains multiple tools for the County to map land cover, extreme rainfall and flood extent across the Island. The end products will allow the County of Hawai‘i to establish a protocol and standard framework for the utilization of Earth observations in future planning.

***Key Terms:***

Remote sensing, flooding, Landsat 8 OLI, Landsat 7 ETM+, Sentinel-1 SAR, land cover, social vulnerability

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

***Study Location:*** Hawai‘i Island, HI

***Study Period:*** January 1981– September 2021

***Community Concerns:***

* Residents of Hawai‘i County are concerned about the threats that climate change-induced hazards such as sea-level rise, extreme storm events and flooding pose to coastal communities.
* The County of Hawai’i is actively working on climate mitigation strategies following the release of their Multi-Hazard Mitigation Plan, but determining precisely where to allocate limited resources is difficult based on existing global scenarios.
* Hawai'i Island holds many characteristics that make it difficult to assess shorelines properly. Specifically, its rocky shorelines, sheer size, and complex socio-ecological matrix of substrate types make it more difficult to capture spatial data for shorelines.
* The impacts of hazards such as flooding put marginalized communities at disproportionate risk. Such populations include native Hawaiians, the elderly, those with limited English proficiency and those living in poverty.
* Rapid increase in urban development along the coasts of the island poses additional threats to coastal communities. The County does not currently have a methodology to continually keep track of such development through consistently updated Earth observations.

***Project Objectives:***

* Build geospatial capacity within the County to use NASA Earth observation data
* Classify land cover across the island
* Create a framework and toolsfor the County to analyze disaster risk in the future
* Test frameworkutilizing Hurricane Lane as a case study
* Demonstrate an example of how our tools could be used to assess exposure and vulnerability variables in relation to flood
* Create a StoryMap for use as outreach and to communicate hazards of coastal flooding and risk identification methods

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **County of Hawai‘i** | Bethany Morrison, Planner, Planning Department; Kevin Sullivan, Planner, Planning Department; Erik Lash, GIS Program Manager | End User | Yes |
| **Arizona State University, School of Geographical Sciences and Urban Planning (SGSUP) and the Center for Global Discovery and Conservation Science (GDCS)** | Dr. Roberta Martin, Associate Professor (GDCS)  Dr. David Hondula, Associate Professor (SGSUP) | Collaborator | No |
| **University of Hawai‘i Hilo** | Dr. John Burns, Assistant Professor | Collaborator | No |

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

Hawai‘i County is the largest of the five counties within the state of Hawai‘i. The County of Hawai‘i currently relies on contractors for thorough hazard mitigation plans such as the Climate Adaption Plan, the Hazard Mitigation Plan, the Shoreline Setback and the Kīlauea Eruption Risk Vulnerability Assessment. Existing records of sea-level rise and flood extent are used in decision-making to assess areas at risk. The County’s collaboration with the University of Hawai‘i at Hilo has provided them with the capacity to use high-resolution coastal and riparian change data for two areas of interest (Kona and Honoli‘i). However, for making decisions and risk assessments, the County is looking to internally expand geospatial intelligence capacity to utilize NASA Earth observation data, which is free to access and more frequently updated. This will allow the County to make informed decisions and create policies based on more dynamic data.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Spectral indices of coastal land cover: NDVI, NDMI, NDWI, NDBI | A variety of spectral reflectance indices such as Normalized Difference Vegetation Index (NDVI), Normalized Difference Moisture Index (NDMI), Normalized Difference Wetness Index (NDWI) and Normalized Difference Built-up Index (NDBI) will be used to map land cover types in Hawai‘i Island at 30 m resolution. |
| **Landsat 7 ETM+** | Spectral indices of coastal land cover: NDVI, NDMI, NDWI, NDBI | A variety of spectral reflectance indices such as Normalized Difference Vegetation Index (NDVI), Normalized Difference Moisture Index (NDMI), Normalized Difference Wetness Index (NDWI) and Normalized Difference Built-up Index (NDBI) will be used to map land cover types in Hawai‘i Island at 30 m resolution. |
| **Sentinel-1 SAR** | Sentinel-1 SAR Ground Range Detected (GRD) Level 1 images | Sentinel-1 images were used in the HYDRAFloods toolbox to detect flooded areas and map flood extent following storms. |

***Ancillary Datasets:***

* Pacific Islands Ocean Observing System (PacIOOS), State of Hawai‘i Sea-Level Rise Passive Flooding Scenarios – Inundation maps of Hawai‘i Island for three scenarios of sea-level rise (1.1ft, 2.0 ft, 3.2 ft)
* US Census Bureau American Community Survey (ACS) 2019 – Population density and socioeconomic metrics
* GPWv411: UN-Adjusted Population Density (Gridded Population of the World Version 4.11) & Population Count 2020 – Population density and count
* State of Hawai'i Agricultural Land Use Baseline 2020 - Extract agriculture class for land cover map
* OpenStreetMap Foundation – Building footprint data used in exposure analysis
* Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) – Precipitation data
* Esri 2020 Land Cover - Cross-reference land cover classification training points for Landsat 8 OLI classifier
* NLCD 2001 Land Cover - Cross-reference land cover classification training points for Landsat 7 ETM+ classifier

***Software & Scripting:***

* ArcGIS Pro 2.8.2 – Overlay analysis of sea-level, flood extent, land cover classification, exposure variables and vulnerability factors for determination of risk zones
* QGIS 3.16.11 – Map visualization, processing, and creating web image
* Google Earth Engine - Data acquisition, image processing, and land cover classification
* ArcGIS Online – Development of a geodatabase for the County of Hawai‘i partners on a publicly accessible ArcGIS Online product, creating the StoryMap for public outreach

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **ArcGIS Online Geodatabase of Data Layers** | Landsat 8 OLI  Landsat 7 ETM+  Sentinel-1 SAR | This online geodatabase will serve as a repository of datasets for many decision-makers across different divisions of the County of Hawai‘i. The partners can then use this data in later analyses with disaster, vulnerability and exposure variables. | N/A |
| **Hawai'i Landcover Observations (HiLO) Tool** | Landsat 8 OLI  Landsat 7 ETM+ | This GEE program uses Earth observation data in order to classify land cover across the island from 1999 to the present year. The user will interact with a graphical user interface, allowing the County to extract land cover maps to analyze land cover change and urban expansion with little coding knowledge needed. | III |
| **HYDRAFloods Tool** | Sentinel-1 SAR | This Python API for GEE maps surface water, which will aid the County in mapping flood extent following heavy rain and storm. The user can define time-range, region of interest and flood sensitivity or buffers. | N/A |
| **Flood Proxy Precipitation Extent (FloPPE) Tool** | N/A | This GEE tool uses precipitation data to allow the user to find areas receiving extreme rainfall and determine these areas to have higher probability of flooding. | III |
| **Social Vulnerability Index** | N/A | This index uses census block group data to create four social indicators that when aggregated highlight to the end user where vulnerable populations are located. | N/A |
| **Usability Video** | Landsat 8 OLI  Landsat 7 ETM+  Sentinel-1 SAR | This video will walkthrough how the team conducted their methodology and will demonstrate how the County can use the tools and outputs produced by this project. | N/A |
| **StoryMap** | Contain maps and layers that are included within the geodatabase from the following satellites:  Landsat 8 OLI  Landsat 7 ETM+  Sentinel-1 SAR | The StoryMap can be used by the project partners to educate the public on the implications of climate change for the island as well as the risks and vulnerability associated with flooding. The StoryMap also explains and visualizes methods and results from the project to the public and references the satellites used for analysis. | N/A |

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

This project produced an initial flood assessment using Hurricane Lane as a case study and developed a framework and tools for the County to assess flood risk and other hazards in the future. The County will be able to utilize the tools to derive flood and extreme rainfall extents for past storm events and map land cover and change across the island. The County of Hawai‘i is in need of building geospatial intelligence capacity internally for facing complex issues (e.g. climate change, wildfires, flooding and coastal development). The creation of this geodatabase and framework will allow the County a pathway towards using NASA Earth observations to improve their data collection and allow for better-informed decisions in county policies.

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