**NASA DEVELOP National Program**



NASA Ames Research Center

*Summer 2017*

**Short Title: USVI Ecological Forecasting**

**Subtitle:** Using NASA Earth Observations to Monitor Land-use Change and Map At-risk Coastal Habitats in the U.S. Virgin Islands

**VPS Title:** Virgin Lands No More

**Project Team**

**Project Team:**

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**Project Overview**

**Objectives Overview:**

In the past fifty years, the total population of the U.S. Virgin Islands has more than tripled to approximately 105,000 people. This population increase has intensified coastal development. Rapid land use change and its associated impacts are placing pressure on the islands’ coastal environments, including mangroves, seagrasses, and coral reefs. We aim to define and predict future land use trends, as well as identify highly impacted sub-watershed areas. The results of our work will be used by the U.S. Virgin Islands Department of Planning and Natural Resources to help inform future management and planning decisions.

**Abstract**

The United States Virgin Islands (USVI) are home to an array of diverse and stunning habitats. The beauty of the islands has continued to attract visitors and residents, which overtime has increased human development and impact. The resulting land-use change increases sediment loads and the flow of pollutants into surrounding nearshore environments such as coral reefs, mangroves, and seagrass beds. Coral reefs, the most diverse marine habitats on Earth, are particularly susceptible to these inputs. Compounded with regional climate-related processes such as rising ocean temperatures and acidification, future land-use change poses a formidable threat to the marine environment. Without a healthy environment, the USVI economy also becomes endangered because it is heavily supported by tourism and recreation. In order to assess land-use change in the USVI, we utilized Landsat 5 TM, Landsat 8 OLI and TIRS, and Sentinel-2 MSI data to map land-use and analyze land cover change dating back to 1985. The produced maps were analyzed by watershed boundaries to identify high priority nearshore environments that are likely to be at risk to from growing development. Our work will provide the USVI Department of Planning and Natural Resources, Division of Coastal Zone Management (CZM) with a tool to better understand land-use trends, identify at-risk coastal habitats, and strengthen existing knowledge of the link between land-use and coastal ecosystem health.

**Keywords:**

Land use, Landsat, sedimentation, LU/LC, watersheds, United States Virgin Islands, nearshore ecosystems

**Partner Organizations:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| USVI Department of Planning and National Resources, Coastal Zone Management (CZM) | Jean-Pierre Oriol, Director;  Leslie Henderson, Coral Reef Initiative Coordinator, Pedro Nieves, Program Coordinator | End-User | Yes |
| University of the Virgin Islands (UVI) | Dr. Marilyn Brandt, Research Associate Professor  Dr. Tyler Smith, Research Associate Professor | Collaborator | No |
| College of Charleston (CofC) | Dr. Adem Ali, Assistant Professor | Collaborator | No |
| Kent State university (KSU) | Dr. Joseph D. Ortiz, Professor | Collaborator | No |

**Community Concerns:**

* The economy of the U.S. Virgin Islands is supported heavily by tourism, compromising about 35% of GDP and 27% of the USVI workforce. This industry is dependent on the condition of the natural environment which draws visitors and business.
* These natural environments that are critical to the territories economic success are susceptible to human-induced change. Concentrated and intense land-use by humans can cause sediment, nutrients and metals to flow from land into the ocean and subsequently harm the reef-building coral species that are the foundation of coral reef biodiversity.
* Climate change impacts such as increased storm intensity, ocean acidification and ocean warming impart additional stress on the delicate corals.
* Understanding land-use change within watersheds and the impact these changes have on the surrounding environment will inform future local management and spatial planning efforts to protect at-risk coastal areas.

**Current Decision Making Practices & Policies**:

In the current permit granting process, the Department of Planning and Coastal Zone Management (CZM) uses multiple tools. The department considers proximity to river or ocean, as well as soil type, slope and other nearby development. The CZM relies on remotely sensed data generated from partnerships with nonprofits or researchers. The division created a Local Action Strategy (LAS) initiative in 2005 that was designed to identify and implement priority actions focusing on the conservation of coral reefs with four committees assigned to recreational use, land based pollutants, fishing, and lack of awareness. The LAS was developed in conjunction under the USVI’s Management Priorities plan as an ongoing effort to equip place-based, local coral reef jurisdictions with strategic goals and objectives. Both documents operate as foundational guidelines for long term conservancy where actioned goals on land work to protect the coasts’ biological value.

**Decision Support Tools & Benefits:**

|  |  |  |  |
| --- | --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software**  **Release** |
| Land-use Map | Land cover classification performed using Landsat and Sentinel-2. | Identification of changes in land-use and land cover and intensity of human impacts on both terrestrial and nearshore marine habitats. This can be used for decision-making processes pertaining the evaluation of development permits at or near coastal areas. | II |
| Analysis of Land-use Change | Change detection analyzed using the Earth Trends module in TerrSet with Earth observations from Landsat and Sentinel-2. | Understanding of areas where largest and most rapid rates of change have occurred. This can be used for decision-making processes pertaining the evaluation of development permits at or near coastal areas. | I |
| Coastal Zone Risk Map | Analysis of EO-1, MODIS, Landsat, and Sentinel-2 will model coastal zones at high risk of impact due to land-use change on the islands. | Identification of nearshore habitats with high risk. This complements current NASA-funded efforts dedicated to study the present condition of coastal and marine ecosystems in the USVI. | I |

**Project Benefit to End-User**:

Our final product will provide CZM with resources for considering future developments in light of long-term land trends. The condition of the island’s coastal resources such as beaches, coral reefs, seagrass beds and mangroves is critical to sustain the territory’s tourism and overall economic success. Impacts to these resources are currently considered when making permitting decisions, but they are completed on a case-by-case basis without officially taking long-term effects and changes into account. Current zoning laws control what types of infrastructure can be developed on each land parcel, but comprehensive information to define overall development limitations and thresholds is lacking. Quantifications of current and historic land-use changes and identification of at-risk habitats produced from our project will facilitate permitting decisions made by the Department of Planning and Natural Resources, Coastal Zone Management so as not to disrupt the ecology that the island depends on economically.

**Project Details**

**Applied Sciences National Applications Addressed:** Ecological Forecasting

**Study Area:** U.S. Virgin Islands (VI)

**Study Period:** January 1985 – January 2025

**Earth Observations & Parameters:**

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| EO-1 Hyperion | Spectral vegetation indices | Mapping of the vegetation on the island to determine current land-use and land cover changes |
| Landsat 5 TM | Landcover | Time series analysis of land-use and land cover changes in the USVI |
| Landsat 7 ETM+ | Landcover | Time series analysis of land-use and land cover changes in the USVI |
| Landsat 8 OLI/TIRS | Landcover, Suspended Sediments | Time series analysis of land-use and land cover changes in the USVI, and to map at risk surrounding marine environments |
| Sentinel-2 MSI | Landcover | Time series analysis of land-use and land cover changes in the USVI |

**Ancillary Datasets Utilized:**

* Socioeconomic Data and Applications Center (SEDAC) – Gridded Population of the World (GPW) population density data for the USVI – trends in population density in the USVI to relate to land use changes through time.
* US Census Bureau – Population Data (1990, 2000, 2010) – Population density data by districts.
* NOAA Coastal Services Center Coastal (CSC) Change Analysis Program (C-CAP) – NOAA’s land use/land cover (LULCC) maps for 2002, 2003, 2005, 2007, and 2012 (depending on which island) – LULCC maps to compare to more recent LULCC map to be produced by the project.

**Software Utilized:**

* Google Earth Engine - image processing and land classification of Landsat imagery
* Esri ArcGIS – map creation

**Project Handoff Package**

**Transition Plan:**

This term the team will hand off a land-use map, analysis of land-use change, and a coastal zone risk map for the northern islands, St John and St Thomas, in the US Virgin Islands. In future terms this work will be expanded to St Croix. Additional analysis of coastal zone risk and coral reef health will also be included in future term hand-offs.

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**Software Release POC**: Jenna Williams, jenna.l.williams@nasa.gov

**Partner POC**: Jean-Pierre Oriol, jp.oriol@dpnr.vi.gov

**Handoff Package:**

* Land-use map
* Land-use change map
* Coastal zone risk map
* Google Earth Engine Code