**Chesapeake Bay Agriculture Forecasting**

*Applying NASA Earth Observations to Monitor Marsh Migration in Maryland’s Coastal Croplands*

**Project Team**

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**Project Overview**

***Synopsis:*** Climate change has induced global sea level rise around the world which damages coastal crops due to saltwater intrusion – an issue often difficult to recognize on the ground. Farmland in Maryland’s Chesapeake Bay has been fraught with inhospitable soil conditions and a decrease in crop yields that threaten the established way of life of Bay farmers. To address this problem, the project team used NASA Earth observations to create and forecast maps of marsh migration which assisted the Eastern Shore Land Conservancy (ESLC) and Maryland Department of Planning in their efforts to adapt to the impacts of saltwater intrusion.

***Abstract:*** The Chesapeake Bay boasts some of the nation’s oldest farms which have continually served the greater Maryland community for centuries. Rising sea levels induced by global climate change threaten these critical coastal croplands via saltwater intrusion (SWI). The effects of SWI are widespread yet enigmatic, as crops and forests seemingly die with no apparent cause. Local farmers now face decreasing crop yields and unfavorable soil conditions that disrupt their established livelihoods. The project team partnered with the Eastern Shore Land Conservancy (ESLC) who collaborates with farmers to understand how the region may be affected by climate change, and with the Maryland Department of Planning who informs state and local policy to adapt to SWI. In response to this problem, the team applied NASA Earth observation data, which included measurements from Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI). The team created land use land cover maps of cropland and marsh migration in the Chesapeake Bay from 2001 to 2021 and forecasted maps to 2040. The project team discovered that 60,000 acres of farmland in the study area has already been lost to marsh migration since 2001, with another 58,000 acres projected to be lost within the next twenty years. These maps will inform the ESLC and the Maryland Department of Planning of vulnerable regions in the bay to aid farmers in planning for saltwater intrusion and salinization.

***Key Terms:***

Saltwater intrusion, wetlands, land cover change, land use change, cropland loss, change modeling

***National Application Area Addressed:*** Agriculture

***Study Location:*** Chesapeake Bay, MD

***Study Period:*** June 2001 – September 2021, Forecasting to 2040

***Community Concerns:***

* Sea level in the Chesapeake Bay is rising three times faster than the global average, resulting in coastal impacts from saltwater intrusion. These impacts include marsh migration and loss of croplands, leading to an increase in economic challenges for farmers and landowners.
* Cropland loss and diminished agricultural productivity due to saltwater intrusion leads to a decrease in the ecosystem services known to be offered by Chesapeake Bay's agricultural lands such as nature reserves, food, fiber, and essential habitat for local wildlife populations.

***Project Objectives:***

* Create a time series of past land use land cover (LULC) maps to display land cover dynamics within coastal marsh and croplands
* Forecast LULC changes through 2040 with a 5-year interval
* Communicate results effectively through animated maps, static scenes, and written presentations of findings to increase scientific understanding and bring more attention to the issue of saltwater intrusion

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Eastern Shore Land Conservancy** | Larisa Prezioso, Restoration Specialist | End User |
| **Maryland Department of Planning** | Jason Dubow, Resource Conservation and Management; Deborah Herr Cornwell, Resource Conservation Planner | Collaborator |

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

Saltwater intrusion presents no easy mitigation, yet the project partners are taking initiatives to conserve the land for those who depend on the Chesapeake’s shores of Maryland. The ESLC oversees the preservation and conservation of the Chesapeake Bay. They work with farmers to make informed decisions about agricultural development that will conserve natural features while promoting sustainable farming practices. In addition to conservation, adaptation is also an important aspect of the issue. The Maryland Department of Planning uses land use and cover information to provide thorough and integrated planning for the optimal use of Maryland’s land. NASA Earth observations are currently unused with regard to their decision making. The current methods employed by the partners are limited to point data, field observation, and drone footage of affected areas. The results from this project could improve knowledge of the extent of saltwater intrusion and in turn, enhance the ability of the ESLC and the Maryland Department of Planning to identify priority areas for agricultural planning.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 5 TM** | Top of atmosphere reflectance | Landsat 5 TM data were used as an input for LULC classification maps from 2001 through 2011, forecasted LULC maps to 2040, and change detection within coastal croplands. |
| **Landsat 8 OLI** | Top of atmosphere reflectance | Landsat 8 OLI data were used as an input for LULC classification maps from 2013 through 2021, forecasted LULC maps to 2040, and change detection within coastal croplands. |

***Ancillary Datasets:***

* Eyes on the Bay Water Quality and Assessment Data (Maryland Department of Natural Resources) – point data for creating maps of salinity in the Chesapeake Bay
* NOAA Digital Elevation Model (DEM) – elevation data product used as an input for transition sub-model to predict changes in landcovers
* NOAA Mean Higher High-Water Datum (MHHW) – sea level elevation standard (based on measurements from one full tidal cycle, 1983 to 2001) the average of the highest high-water marks observed is used to ensure proper sea level height in mapping applications
* NOAA Coastal Change Analysis Program (C-CAP) – coastal area land cover dataset (2001, 2006, 2011, and 2016) integrated into synthesized land cover map focusing on marshes
* USGS National Land Cover Database (NLCD) – National land cover and land use dataset (2001, 2006, 2011, and 2016) integrated into synthesized land cover map focusing on urban development and deforestation
* USDA Cropland Data Layer (CDL) – crop specific land cover dataset (2002, 2011, and 2021) integrated into synthesized land cover map focusing on agricultural sector
* USDA National Agriculture Imagery Program (NAIP) – High resolution aerial imagery used to create true color composite images as a reference for LULC maps

***Software & Scripting:***

* Google Earth Engine – Acquisition, preprocessing, mapping, and classification of Landsat 5 TM and Landsat 8 OLI datasets using NAIP for map accuracy testing data
* Esri ArcGIS Pro 2.9.3 – Processing and analyzing spatial data, producing maps, and validating outputs from Google Earth Engine
* TerrSet Geospatial Monitoring and Modeling System 18.2 – Performing LULC change analysis, quantifying LULC changes, and producing the forecasted LULC maps

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **LULC Time Series Maps (yearly from 2001 to 2021)** | Landsat 5 TMLandsat 8 OLI | Unified LULC time series maps provide details on land cover dynamics within coastal croplands. These maps will allow partners to measure the scope and extent of cropland loss. | I |
| **Forecasted LULC Maps (2025, 2030, 2035, 2040)** | Landsat 5 TMLandsat 8 OLI | Forecasted LULC maps predict land cover changes into the future. Partners can use these maps to emphasize areas that are at high risk of cropland loss due to marsh migration. | I |
| **Marsh Migration Maps (yearly from 2001 to 2021, forecasted for 2025, 2030, 2035, and 2040)** | Landsat 5 TMLandsat 8 OLI | Maps demonstrate the regions where marsh habitat has changed over time and where marshes can potentially migrate in the next 20 years. These maps will allow partners to assess how marshland has historically impacted the farmland and how it might affect the landscape in the future.  | I |
| **Maps of Agriculture to Wetland transition (yearly from 2001 to 2021, forecasted for 2025, 2030, 2035, and 2040)** | Landsat 5 TMLandsat 8 OLI | Maps emphasize the observed transitions between agriculture and wetland land cover classes. Partners can use these to highlight potential areas of transition in future. | I |
| **True Color Composites** | Landsat 5 TMLandsat 8 OLI | True color imagery provides a reference for LULC maps to provide details and information on specific classes. These maps can also be used to assess accuracy of land cover classifications. | I |

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

The analyses presented in this project will aid the end users with their decision-making process regarding conservation of farmland in the Chesapeake Bay and allow these organizations to adapt their planning efforts against saltwater intrusion. The LULC and marsh migration time series maps can provide greater understanding of the scope and distribution of saltwater intrusion impacts on the eastern shore while forecasted LULC maps can identify vulnerable regions that require immediate intervention. These products will enable partners and community members to anticipate the impact of marsh migration through a better understanding of agricultural and coastal change.

**References**

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