**NASA DEVELOP National Program**

****The University of Georgia

*Summer 2017*

**Short Title: Eastern India Ecological Forecasting III**

**Subtitle:** A Multi-Sensor Approach to Enhance the Prediction of Mangrove Biophysical Characteristics in Chilika Lagoon and Bhitarkanika Wildlife Sanctuary, Odisha, India

**VPS Title:** The Day After Tomorrow, Where Will the Mangroves Be?

**Project Team**

**Project Team:**

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**Project Overview**

**80-100 Word Objectives Overview:**

The objective of this project was to refine and implement a tool to predict biophysical characteristics of mangroves within Bhitarkanika Wildlife Sanctuary and Chilika Lagoon, using a suite of satellite data (Landsat 5 & 8, Terra, and Sentinel-1). This tool produces maps illustrating a long-term phenology in order to improve management and restoration efforts by the Department of Forest and Environment (DFE) in Odisha, India. Project partners received long-term, spatio-temporal estimations of mangrove physiological status. The results will increase understanding of long-term changes in mangrove cover and allow them to identify hotspots for early stages of mangrove degradation.

**Abstract:**

Across the globe, mangroves play a major role in coastal ecosystem processes mitigating erosion and serving as barriers against storm surges. India holds approximately 5% of the world’s mangroves, over half of which are along its east coast. Situated in the state of Odisha, Chilika Lagoon and Bhitarkanika Wildlife Sanctuary sustain mangrove sites of local importance in need of effective management. This study demonstrated the use of Terra, Landsat, and Sentinel-1 satellite data for spatio-temporal monitoring of mangrove health for both sites. Several indices including Normalized Difference Vegetation Index and Enhanced Vegetation Index, were examined to develop biophysical prediction tools and derive a 17-year time-series (2000 to 2016) of leaf chlorophyll (CHL), Leaf Area Index (LAI), and Gross Primary Productivity (GPP). Parallel to this assessment, a long-term (2000 to 2016) analysis of meteorological factors such as precipitation and temperature was completed to determine an association between these parameters. The correlation between meteorological parameters and mangrove biophysical characteristics enabled forecasting of mangrove health and productivity. A historical analysis of land cover maps was produced using Landsat 5 and 8 data to determine decadal changes in mangrove area estimates between 1995 and 2017. This analysis was used to predict land use-land cover change or fragmentation of Bhitarkanika mangroves. Based on IPCC data availability, the soft prediction map for 2050 showed the probability of mangrove risk to disturbance in the eastern part of Bhitarkanika. This study revealed the advantages of using a multi-sensor approach to monitor mangrove health and inform monitoring protocols.

**Keywords:**

MODIS, Landsat, Bhitarkanika, biophysical characteristics, mangrove degradation

**Partner Organization:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Government of Odisha, Department of Forest and Environment, Chilika Development Authority (India) | Dr. Gurdeep Rastogi, Senior Scientist, Wetland Research and Training Center | End User | No |

**Community Concerns:**

* Mangroves have been overexploited or converted to other forms of land use. It has been observed that mangrove vegetation in Odisha reduced from 234 km2 to 199.19 km2 during 1975 to 1993.
* There is growing concern for the effective management and conservation of these mangrove forests because they support families from 36 villages around the Odisha region that depend on mangrove resources for farmland, fishing and agriculture. Chilika Lagoon also provides food and livelihood 150,000 fishermen living in its 132 peripheral and island villages and is famous for prawn and crab fishing which maintains economic and cultural significance for the state.

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

Current assessments of Odisha coast mangrove forests conducted by the Chilika Development Authority (CDA) and DFE are limited to habitat delineation and documentation of change in areas using ground and aerial surveys. Most of the research funding from DFE and CDA are aimed at fisheries research which is the most important economic driver of the region. However, since mangrove habitats and fish production are deeply interlinked, project partners are interested in biophysical parameters that can inform early detection of mangrove stress to guide future restoration efforts.

**Decision Support Tools & Benefits:**

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software**  **Release** |
| Mangrove Biophysical Characteristics Forecast Models | Landsat 5 TM, Landsat 8 OLI, Terra MODIS | These models will be used by the partners for determining the regions that are most degraded or stressed, determining whether past restoration efforts have produced effective result, and prediction of the overall health of Odisha coast mangroves ecosystem. | N/A |
| Mangrove Extent Maps | Landsat 5 TM, Landsat 8 OLI, Sentinel-1 C-SAR | Extent maps will provide partners with information about areas transforming from mangrove to other land cover types, directly related to the Sustainable Development Goal indicators. | N/A |

**Project Benefit to End User**:

CDA will benefit from receiving an archive of a long-term spatio-temporal estimation of mangrove physiological status. The results of this project will allow them to identify ‘hotspots’ for early stages of mangrove degradation which can only be delineated by evaluating mangrove biophysical characteristics including distribution of chlorophyll content, leaf area index (a ratio of green foliage area vs. ground area), and aboveground biomass. The project partners will be able to continually monitor the effectiveness of a prior or ongoing restoration project using the models created by the DEVELOP team.

**Project Details**

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

**Study Area:** Bhitarkanika Wildlife Sanctuary and Chilika Lagoon, Odisha, India

**Study Period:** April 1995 – December 2016; Forecasting to 2050

**Earth Observations & Parameters:**

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| Terra MODIS | Leaf chlorophyll, leaf area index, and gross primary productivity | Biophyical models will be developed and tuned using MODIS based vegetation indices, and ultimately long-term data derived from the model will be used for forecasting of biophysical parameters. |
| Landsat 5 TM | Land use-land cover, leaf chlorophyll, leaf area index, and gross primary productivity | Mangrove extent maps will be created using Landsat 5 to achieve Sustainable Development Goal indicators. Additionally, biophysical parameters for small mangrove patch of Chilika will be derived. |
| Landsat 8 OLI | Land use-land cover, leaf chlorophyll, leaf area index, and gross primary productivity | Mangrove extent maps will be created using Landsat 8 to achieve Sustainable Development Goal indicators. Additionally, biophysical parameters for small mangrove patch of Chilika will be derived. |
| Sentinel-1 C-SAR | Leaf chlorophyll, leaf area index, and gross primary productivity | Comparison between Landsat 8 OLI and Sentinel-1 will be performed to estimate biophysical parameters for small mangrove patch of Chilika. |

**Ancillary Datasets Utilized:**

* Government of Odisha, India – land cover
* Chilika Development Authority data – mangrove patch location data
* GIOVANNI – meteorological parameters

**Models Utilized:**

* Guzman et al. 2015 Mangrove Chlorophyll Model

**Software Utilized:**

* Sentinel Application Platform (SNAP) – image processing and visualization
* Esri ArcGIS – study area shapefile creation by digitization
* Google Earth Engine API – data training and land cover classification
* TerrSet – land use-land cover change and forecasting
* Microsoft Excel – statistical analysis and forecasting
* R – statistical analysis

**Project Handoff Package**

**Transition Plan:**

The decision support tools will be handed off to the partner during a Skype call with the science advisor and team members. In this meeting, the team will discuss the project’s results, deliverables, tutorials, and additional resources with the partner at Chilika Development Authority.

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**Partner POC**: Gurdeep Rastogi, rastogigurdeep@gmail.com

**Handoff Package:**

* Final Draft Deliverables
* Project Video
* Mangrove Biophysical Characteristics Forecast Model
* Mangrove Extent Maps
* Methodology Tutorial