**NASA DEVELOP National Program**

**Fall 2016 Project Proposal**

**University of Georgia**

**Eastern India Ecological Forecasting**

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

**Project Overview**

***Objectives:*** To develop a mangrove biophysical characteristics prediction tool for Chilika Lagoon and Bhitarkanika Wildlife Sanctuary byusing moderate resolutionremote sensing reflectance data and to use the tool to derive a long-term phenology in order to improve management and restoration efforts by the Department of Forest and Environment in Odisha, India.

***Community Concern:*** Mangroves, one of the most productive ecosystems on Earth, play a major role in coastal ecosystem processes from mitigating erosion to acting as a barrier against tidal and storm surges associated with tropical cyclones. India has approximately 4,461 km2 of mangrove habitats- 57% of which are found in the Chilika Lagoon and Bhitarkanika Wildlife Sanctuary. There is growing concern for the effective management and conservation of these mangrove forests because they support families from 36 villages around the region. The mangrove forests also provide valuable services such as food, raw materials, and medicinal and ornamental resources. These two Ramsar sites (Chilika Lagoon and Bhitarkanika) in Odisha are located along the east coast of India and cover roughly 200 km2. With 71 species of mangroves and mangrove associates, this area supports the largest population of estuarine crocodiles in the country, along with lizards, both resident and migratory birds, and several rare and endangered mammals. Mangroves have been overexploited or converted to various other forms of land use including agriculture, aquaculture, salt ponds, terrestrial forestry, as well as urban and industrial developments. The encroachment of forestland, unauthorized aquaculture practices, grazing, and discharge of effluent are exerting pressure on mangrove forests and local biodiversity.

***National Application Area Addressed:*** Ecological Forecasting

***Study Location:*** Odisha, India.

***Study Period:*** January 2002to August 2016

***Advisor:*** Dr. Deepak Mishra, Department of Geography, University of Georgia

***Source of Project Idea:*** Communication between Dr. Mishra and Dr. Rastogi of the Chilika Development Authority (CDA) began in 2014 after the Category 5 hurricane, Phailin, devastated parts of Thailand, Myanmar, and India. Through their communication, the CDA has expressed interest in collaborating with United States partners.

**Partner Overview**

***Partner Organizations:***

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

***End-User Overview***

***End-User’s Current Decision Making Process:***

Current assessments of Odisha coast mangrove forests conducted by the 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 biophysical status of the mangrove habitats and fish production are deeply interlinked, research projects should focus beyond habitat delineation to monitoring and forecasting mangrove productivity trends.

***End-User’s Capacity to Use NASA Earth Observations:***

Chilika Development Authority, Odisha – CDA uses moderate resolution satellite data on a regular basis to map coastal habitats, land use/ land cover, etc. They mostly use Indian Remote Sensing (IRS) satellites such as OCM (IRS-P4) and ResourceSat for application development. They have GIS specialists in the agency who are capable of mapping. Biophysical parameter estimation using advanced remote sensing models and algorithms is not a part of their expertise. However, they have the basic geospatial skills to utilize the biophysical maps developed through this project to inform decision making. Additionally, this project is using NASA Earth Observations which would provide several advantages over IRS products such as high temporal and spatial resolution data, availability of surface reflectance products (no need for atmospheric correction), and open source software (NASA’s SeaDAS) for processing the satellite images.

Department of Forest and Environment, Odisha – CDA works closely with DFE in information dissemination and has similar capabilities to utilize remote sensing and GIS products.

***Project Communication & Transition Overview***

***In-Term Communication Plan:***

The team will send a weekly project update to the partners and have video conferences as needed to answer any questions the partner may have or ask questions to the partner. Although, the partners and end-users are well aware of the project’s goals and expected outcomes, the team will schedule a conference call with them before starting the work to discuss logistics and expectations. The primary point of contact for this communication will be the team lead and Dr. Rastogi.

***Transition Approach:***

The decision support tools will be handed off to the partner via a Skype call with all of the partners and team members. In this meeting, the team will discuss with the partners at CDA and DFE what the results are and explain any tutorials or additional resources to them.

**Letters of Support:** Chilika Development Authority, Dr. Gurdeep Rastogi, Senior Scientist, Wetland Research and Training Centre

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Terra/Aqua MODIS** | Canopy Chlorophyll, , Leaf Area Index, and Aboveground Biomass | Semi-empirical models using MODIS based vegetation indices and field data will be developed and tuned. |
| **Terra ASTER, MERIS and Sentinel-2** | Canopy Chlorophyll, Leaf Area Index, Aboveground Biomass | Semi-empirical models using ASTER, MERIS and Sentinel-2 based vegetation indices and field data will be developed and tuned. |
| **Landsat 5, 7, 8 TM, ETM+, OLI** | Canopy Chlorophyll, Leaf Area Index, Aboveground Biomass | Semi-empirical models using Landsat based vegetation indices and field data will be developed and tuned. |

***Ancillary Datasets:***

CDA – Top of Canopy (TOC) reflectance – calibrate and validate products

CDA – Canopy level chlorophyll content – calibrate and validate products

CDA – LAI readings – calibrate and validate products

CDA – Biomass measurements – calibrate and validate products

CDA – GPS locations– calibrate and validate products

***Modeling:***

Three-band model (POC: Dr. Anatoly Gitelson, University of Nebraska-Lincoln)

Visible Atmospheric Resistance Index (VARI) (POC: Dr. Anatoly Gitelson, University of Nebraska-Lincoln)

Wide Dynamic Range Vegetation Index (WDRVI) (POC: Dr. Anatoly Gitelson, University of Nebraska-Lincoln)

Weighted Difference Biophysical Model (WDBI) (POC: Dr. Deepak Mishra, University of Georgia)

***Software & Scripting:***

ENVI 5.0 – Developing vegetation indices (WDBI, VARI, WDRVI, Three-band)

R – Developing semi-empirical models and statistical analysis

ArcGIS – Map production

**Decision Support Tool & End-Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Mangrove Biophysical Characteristics Forecast Model | Prediction of the overall health of Odisha coast mangroves ecosystem.  Determination of the regions that are most degraded or stressed.  Determining whether past restoration efforts have produced effective result. | Models will be calibrated and validated to establish relationship between Landsat 30-m, MODIS 250-m, ASTER 15-m, MERIS and Sentinel-2 data and mangroves biophysical variables data (i.e., Chl content, LAI, and biomass). | 1 |
| Seasonal & Annual Time-series Mangrove Biophysical Characteristics Maps | Observing the phenological pattern change over a period of time.  Status of the restored region relative to non-restored region.  Determination of the potential causes of mangrove degradation. | After successful validation of forecast model, we will apply the model to available satelllite images covering the entire mangrove region and develop seasonal and annual composite of biophysical products. | 1 |

***End-User Benefit:***

CDA and DFE 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 Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2016 Fall (Start) to 2017 Spring (Completion)

***Multi-Term Objectives:***

* **Term 1 (Proposed Term):** Fall 2016 (UGA) – Eastern India Ecological Forecasting
  + Semi-empirical models will be developed, calibrated, validated, and tuned using Landsat, ASTER, and MODIS data to monitor mangrove biophysical parameters
* **Term 2:** Spring 2017 (UGA) – Eastern India Ecological Forecasting II
  + Models will be applied to predict the biophysical characteristics of mangrove habitats from 2002-2016. Map products and phenology charts will be developed and disseminated.

***Related DEVELOP Work:***

Summer 2016 (LaRC) – Everglades Ecological Forecasting: Improving the Capacity of the Everglades National Park to Monitor Mangrove Extent using NASA Earth Observations

Summer 2015 (LaRC) – North Carolina Ecological Forecasting: Evaluating the Application of NASA Earth Observations to Monitor Wetland Health in the Albemarle-Pamlico Watershed

Summer 2014 (JPL) – Coastal Colombia Ecological Forecasting: Mapping Mangrove Deforestation and Assessing Ecosystem Productivity in Colombia’s Coastal Wetlands

**Notes & References:**

***Notes:*** The proposed work is significant because it will allow us for the first time to use NASA satellite data to study the biophysical characteristics of mangrove forest in Odisha, India which in turn, has the potential of increasing our predictive capability with respect to carbon sequestration in these ecosystems. The result will be an efficient and non-destructive biophysical mapping protocol for emergent wetlands to be used in restoration decision making.

***References:***

Gitelson AA. 2004. Wide Dynamic Range Vegetation Index for Remote Quantification of Crop Biophysical Characteristics. Journal of Plant Physiology. Vol. 161: 165-173.

Gitelson A.A., Gritz, U. and Merzlyak M.N. 2003. Relationships between leaf chlorophyll content and spectral reflectance and algorithms for non-destructive chlorophyll assessment in higher plant leaves. Journal of Plant Physiology, 160, 271- 282.

Gitelson AA, Kaufman Y, and Merzlyak MN. 1996. Use of green channel in remote sensing of global vegetation from EOS-MODIS. Remote Sensing of Environment. 58: 289-298.