**NASA DEVELOP National Program**

NASA Marshall Space Flight Center

*Summer 2017*

**Short Title: Rwanda Ecological Forecasting**

**Subtitle:** Utilizing NASA Earth Observations to Classify Wetland Extent in Rwanda in Support of United Nations Sustainable Development Goals

**VPS Title:** Golly GEE Wetlands! Forecasting Wetland Extent in Rwanda

**Project Team**

**Project Team:**

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**Advisors & Mentors:**

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**Project Overview**

**80-100 Word Objectives Overview:**

This project created a time series of wetland extent in Rwanda over the past 10 years by working with NASA SERVIR and the GEO-Wetlands Initiative. Analyzing this time series allowed the team to identify where the development and destruction of wetlands is highest in this portion of the country. Using these results, a forecast model was developed depicting areas of wetlands that face a high risk for impact through the year 2030. This forecast model will allow the coordination of resource allocation efforts to prevent critical wetland destructions.

**Abstract:**

Balancing the demands of economic development and environmental protection is a challenge which requires policy-makers to be well informed about the extent and value of key natural ecosystems. Wetlands have long been known to regulate hydrological processes, reduce erosion and flooding, safeguard local biodiversity, mitigate changes in climate, and contribute to food security. Nonetheless, due to the coupled threat of increasing population and lack of land use classification, east African wetlands face eradication if a concerted effort to identify, map, and protect these areas is not rapidly undertaken. To advance the wetland conservation efforts of the Rwanda Environmental Management Authority (REMA) and the UN’s Sustainable Development Goals (SDG), a time series and land change extent model were generated to provide a baseline inventory of Rwandan wetlands and pinpoint critical areas that should be targeted for enhanced research and protection. Wetlands were identified by a supervised maximum likelihood classification conducted in Google Earth Engine API using Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI) data. The TerrSet Land Change Modeler software was used to generate a forecast of the land changes predicted to occur by the year 2030. These predictive models will optimize REMA’s conservation efforts of wetlands, and provide researchers with a replicable methodology that can be used to continue monitoring global wetland extent.

**Keywords:**

Landsat 5, Landsat 8, wetland, Rwanda, Land Change Modeler, classification, TerrSet, Google Earth Engine

**Partner Organizations:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Rwanda Environment Management Authority (REMA) | Marie-Laetitia Busokeye, Director of Research, Environmental Planning and Development  | End User | No |
| Regional Centre for Mapping of Resources for Development (RCMRD) | Dr. Robinson Mugo, Earth Observations Lead | End User | Yes |
| GEO-Wetlands Initiative  | Adrian Strauch, University Of Bonn, co-Lead; Lammert Hilarides, Wetl. Intern, co-Lead; Ania Grobicki, Ramsar Sec, co-Lead | Collaborator | No |
| NASA SERVIR Coordination Office at MSFC | Africa Flores, Eastern and Southern Africa Science Coordination Lead;Emily Adams, Eastern & Southern Africa Research Associate | Collaborator | No |

**Community Concerns:**

* Due to food scarcity within the country, 92,000 of the 165,000 hectares of wetlands have been converted to farmland in order to provide increased agricultural output; however, wetlands themselves support large fish habitats that many local communities depend on as a food source.
* A study conducted by the United Nations Environmental Program (UNEP) found that 47% of freshwater samples were pathogenic, meaning that there is a high likelihood that the freshwater used for drinking may be hazardous to human health in Rwanda.
* Wetlands are vital in regulating pollution within the water supply as they act as a natural water treatment and purification system. With increasing urbanization and industrial processes, toxins and chemicals are more likely to seep into the water supply further enforcing the need for wetlands.
* Human activities, such as farming and forest clearing, have led to increased erosion of soil. Without wetlands, less water is diverted into the water table leading to increased runoff which, combined with eroded soil, can lead to fatal mudslides and landslides.
* Wetlands serve as a buffer between water, such as rivers and lakes, and land, such as farmland or urban areas. This is especially important as water levels rise and threaten infrastructure.

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

In 2013, the Rwandan Ministry of Natural Resources released a five year strategic plan to develop the country’s economy while preserving environmental integrity. In addition to levying taxes on polluters, the government has plans to restore wetlands which have been repurposed for agricultural use or degraded to the point of low-productivity. The responsibilities for agricultural development reporting, wetland reclamation goals and best policy practices are not clearly defined, so a new policy will be required to provide a framework for conservation and appropriate utilization of wetlands.

**Decision Support Tools & Benefits:**

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| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software****Release** |
| Wetland Extent Time Series | Landsat 5 TM, Landsat 8 OLI | The project partners will use this time series to help understand the extent of the wetlands, quantify wetland extent for SDG indicator reporting, and potentially identify areas that require additional preservation practices. | N/A |
| Wetland Change Maps | Landsat 5 TM, Landsat 8 OLI | The Wetland Extent Time Series Maps will be used to calculate the change between years to help identify causation of wetland degradation. The partners will use these maps to influence wetland protection policy. | N/A |
| Wetland Prediction Map | Landsat 5 TM, Landsat 8 OLI | The Wetland Change Maps will be used to forecast future extent and highlight areas facing high likelihood of increased degradation through 2030. The map will allow partners to coordinate the allocation of resources to protect these areas. | N/A |
| Google Earth Engine Script  | Landsat 5 TM, Landsat 8 OLI | This script is an existing code than can be used for future use in identifying wetlands. The code included will allow for future analysis as the image repository stored on Google Earth Engine will be continuously updated with new data.  | N/A |

**Project Benefit to End User**:

Our products will provide useful information about the historical context of wetland extent throughout Rwanda. This context is critical in understanding the factors that are influencing the destruction of wetlands and the best methods that can be incorporated in mitigation and conservation efforts. The Wetland Change Map specifically will highlight the extent of wetlands in Rwanda. The map will illustrate how wetland extent has changed over the previous decade due to urban development or agricultural conversion. The Wetland Prediction Map will serve as a tool for project partners to predict where further degradation of wetlands in Rwanda is most likely. These products serve as the first step in understanding both where the problem areas are located and the factors causing the issues.

**Project Details**

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

**Study Area:** Rwanda

**Study Period:** January 2007 – June 2017; Forecasting to 2030

**Earth Observations & Parameters:**

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| Landsat 8 Operational Land Imager (OLI) | Surface Reflectance | Landsat 8 OLI Surface Reflectance will be used to classify wetlands in Rwanda. |
| Landsat 5 Thematic Mapper (TM) | Surface Reflectance | Landsat 5 TM Surface Reflectance will be used to classify wetlands in Rwanda. |

**Models Utilized:**

* TerrSet Land Change Modeler – land change forecast analysis

**Software Utilized:**

* Esri ArcGIS 10.4 – raster manipulation and analysis, image enhancement and map creation
* Google Earth Engine API – land classification of imagery

**Project Handoff Package**

**Transition Plan:**

For our local partner Africa Flores, from the NASA SERVIR Coordination Office, the hand-off will consist of an in-person meeting where a presentation will be given, and the time series maps, land change analysis, and forecasted extent maps will all be handed over on a flash drive. For our non-local partners, Robinson Mugo from RCMRD and Adrian Strauch from the GEO Wetlands Initiative, the handoff will be a teleconference or Google Hangout discussing some of the processes and conclusion that the team has drawn from the data for them, along with a shared Google Drive that contains all the maps and data processed.

*Project Continuation Plan*: The continuation of this project will focus on using Synthetic Aperture Radar (SAR) to more accurately map wetlands in Rwanda. During this term one of the major challenges was working with the cloud cover found over much of the wetlands in imagery acquired from the Landsat series. This was especially prominent during the rainy season. However, with SAR this will be mitigated as the SAR sensor can acquire data without regard to cloud cover.

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**Partner POC**: Adrian Strauch, adrian.strauch@uni-bonn.de

**Handoff Package:**

* Time Series Maps (January 2007 – June 2017) of wetland classification in Rwanda
* Land Change Analysis of how wetlands are changing year to year
* Land Modeler Forecast through 2030 depicting high risk areas of wetlands facing potential destruction through urban encroachment
* Final drafts of all deliverables
* Data and map documents
* Google Earth Engine script