**NASA DEVELOP National Program**

**Summer 2016 Project Proposal**

**University of Georgia**

**Costa Rica Water Resources**

Monitoring Drought and Water Balance in the Guanacaste Province to Enhance Decision Making and Response Planning in Costa Rica

**Project Overview**

***Objective:*** To enhance the understanding, capacity, and decision-making skills regarding water management using NASA Earth observations. Specifically, to use three different indices to monitor meteorological, hydrological and agricultural drought in Costa Rica to assist in management and mitigation efforts. The drought work will be expanded into the development and refinement of a comprehensive water budget analysis toolset.

***Community Concern:*** The Arenal Reservoir in Costa Rica’s Guanacaste Province is the country's largest lake and was built to transfer water from the Atlantic side of Costa Rica to the Pacific side while producing electricity during the process. This is an excellent example of how the country has adapted to climate change. That said, over the past four years’ drought has threatened the Guanacaste Province giving rise to questions about agricultural production and more effective water management practices in the region. In response, the government of Costa Rica has convened resources around a Guanacaste and North Pacific Water Program (PIAAG) in support of efforts that will enhance the country’s ability to effectively respond to the current situation as well as future water management issues

***National Application Areas Addressed:*** Water Resources, Agriculture

***Study Location:*** Costa Rica – specifically the Arenal-Tempisque watershed in Guanacaste Province

***Study Period:*** Jan 2000 to May 2016

***Advisors:*** Dr. Marguerite Madden (Department of Geography, University of Georgia), Dr. Adam Milewski (Department of Geology, University of Georgia), Dr. Angelica Gutierrez (NOAA)

***Source of Project Idea:*** This topic was highlighted as a priority by the Embassy of Costa Rica officials during multiple meetings with DEVELOP.Officials at the Embassy then connected DEVELOP with potential end-users in Costa Rica to refine exact objectives for the proposed project to align with the country’s efforts in the PIAAG.

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Ministry of Environment and Energy (MINAE): Water Directorate (DA-MINAE) | Vivian Gonzalez Jimenez, Project Engineer, Water Directorate of MINAE (DA-MINAE) | End User | No |
| National Service of Underground Water, Irrigation, and Drainage (SENARA) | Javier Artiñano Guzmán, Agronomist for the Arenal-Tempisque Irrigation District | End User | No |
| Embassy of Costa Rica to the United States | Alejandra Solano Cabalceta, Deputy Chief of Mission, Minister Counselor at the Embassy of Costa Rica | Collaborator | Yes |
| University of Costa Rica | Dr. Rafael Arce, Professor, Department of Geography | Collaborator | No |

***End-User Overview***

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

DA-MINAE is responsible for the management, conservation, and sustainable development of the environmental and natural resources of the country, and the Water Directorate is responsible for the management of water resources in the country. In support of this mission and in response to the ongoing drought in Guanacaste, DA-MINAE is managing the PIAAGwhich aims to coordinate all institutions focused on the water sector (e.g., research, infrastructure, water management) towards monitoring and mitigating the impacts of the drought on the country’s natural resources and peoples.

SENARA is responsible for agricultural water management and helps coordinate water usage with the agricultural agencies of Costa Rica. In an effort to increase efficiency in water usage, SENARA has begun to incorporate GIS into their decision support tools. Even though remote sensing is not currently being used, SENARA is aware of and interested in incorporating NASA Earth observations into their decision support tools. SENARA currently calculates certain parameters using in situ measurements and NASA Earth observations will allow more data over continuous areas. SENARA is involved in PIAAG with the development of irrigation projects and studying & management of underground water.

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

Previous discussions and collaboration between DA-MINAE, SENARA, and DEVELOP have concluded that incorporating NASA Earth observations into their decision-making process will help bolster water management as it will allow more continuous data than currently utilized. Successful implementation will have cascading benefits to local stakeholders, the agriculture industry, and environmental agencies.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

Embassy of Costa Rica – The Embassy of Costa Rica originally identified the topic of water management as it relates to the ongoing drought impacting large portions of Costa Rica, and that utilizing the DEVELOP partnership as a means to infuse freely-available NASA Earth observations into MINAE and SENARA’s efforts would be a highly beneficial collaboration at multiple levels. Officials at the Embassy have been and will continue to be a vital link between the DEVELOP team and end-users in Costa Rica.

University of Costa Rica – In an effort to broaden the capacity building associated with this project, DEVELOP sought to identify two Costa Rican participants sitting in Costa Rica to collaborate on this project with the rest of the DEVELOP project team at UGA. Dr. Rafael Arce is a professor in the Department of Geography and recruited applicants at the University of Costa Rica. The team will continue to engage with Dr. Arce as needed throughout this project.

***Boundary Organization Dissemination:***

Embassy of Costa Rica – Officials at the Embassy of Costa Rica will serve as the liaisons to organizations and decision makers throughout Costa Rica, and will ensure that the benefits of this work are widespread within the country. They will provide local policy makers with the end-products and results to aid management practices and resource allocation in Guanacaste Province.

***Project Communication & Transition Overview***

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

The DEVELOP project team – split between the University of Georgia and the University of Costa Rica – will communicate daily to ensure successful completion of the project’s objectives. The team will have weekly communication with the DA-MINAE and SENARA via Skype, and this communication will be supported by the Embassy of Costa Rica. If possible, DEVELOP participants in Costa Rica will meet with DA-MINAE and/or SENARA in-person during the term.

***Transition Approach:***

It has been requested by both DA-MINAE & SENARA to conduct an in-person handoff workshop of project results. This could be conducted by the UCR DEVELOP participants and supported by the DEVELOP UGA team, as well as the National Program Office. This plan is still tentative (31 May) but will be explored more during the summer term.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI/TIRS** | Surface reflectance | Landsat 8 OLI surface reflectance data will be used to derive vegetation indices, land cover classifications, and evapotranspiration. Vegetation indices will aid in finding areas of agriculture that are stressed. Land cover classifications will help identify agriculture fields. Evapotranspiration will be used as a SWAT input. |
| **SRTM-v2 C-Band** | Digital Elevation Models | SRTM-v2 C-Band Digital Elevation Models data will aid in identifying elevation and slope which will help determine areas suitable for rain-gages |
| **GPM IMERG** | Precipitation | GPM IMGER will provide precipitation data that will aid in identifying areas prone to droughts |
| **Aqua/Terra MODIS** | Temperature/Vegetation | Aqua/Terra MODIS will provide surface temperature and vegetation health data, as well as evapotranspiration as a SWAT input. |
| **TRMM PR** | Precipitation | TRMM PR will provide precipitation data that will aid in identifying areas prone to drought |

***Ancillary Datasets:***

Institute of Technology of Costa Rica – Costa Rica Digital Atlas – watersheds, roads, political boundaries, and census data

Climate Forecast System Reanalysis (CFSR) – weather parameter data sets – relative humidity, solar radiation, precipitation, temperature

***Models:***

Soil and Water Assessment Tool (SWAT) Model (POC: Dr. Adam Milewski, Department of Geology, University of Georgia)

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

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Meteorological Drought Time-Series | Allows project partners to identify severity of meteorological drought over time to help allocate resources to areas most affected by meteorological drought. | Using Aqua MODIS to calculate land surface temperature, Terra MODIS to calculate the Normalized Difference Vegetation Index, and TRMM PR and GPM IMGER for precipitation data to calculate which areas are being affected by meteorological drought. | N/A |
| Agricultural Drought Time-Series | Allows project partners to identify severity of agricultural drought over time to help allocate resources most affected by agricultural drought. | Using Aqua MODIS to calculate land surface temperature, Terra MODIS to calculate the Normalized Difference Vegetation Index, and TRMM PR and GPM IMGER for precipitation data to calculate which areas are being affected by agricultural drought. | N/A |
| Agricultural Drought Near Real-Time Monitoring | Allows project partners to monitor agricultural drought in near real-time. | Using Aqua MODIS to calculate land surface temperature, Terra MODIS to calculate the Normalized Difference Vegetation Index, and TRMM PR and GPM IMGER for precipitation data to calculate which areas are being affected by agricultural drought in near real-time. | N/A |
| Water Balance Assessment Toolset | Assess water balance metrics for the Arenal-Tempisque Irrigation District at the watershed and sub-basin levels. | The SWAT model will be run using NASA Earth observations (e.g., MODIS-derived evapotranspiration) and in situ datasets provided by the partners. | N/A |

***End-User Benefit:***

These end-products will benefit the end-user by enhancing their decision making process when allocating water resources. The end-products will also allow for enhanced management practices and placement for water reservoirs during flooding and drought conditions which will be beneficial in crop productivity. This will help partners ensure sustainable withdrawals and supply of freshwater to address water scarcity. These analyses will also inform goals related to improving water quality.

**Project Timeline & Previous Related Work**

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

***Multi-Term Objectives:***

* **Term 1 (Proposed Term):** 2016 Summer
  + Create a Meteorological Drought Index Time Series, a Hydrological Drought Index Time Series, an Agricultural Drought Index Time Series, and an Agricultural Drought Near Real-Time Monitoring Tool throughout Guanacaste.
* **Term 2:** 2016 Fall
  + The objectives for the second term of this project are to incorporate the results of Term 1 into a water budget analysis reflecting agricultural and meteorological conditions over the past fifteen years. If sufficient progress is made during 2016 Summer (Term 1), then work will begin on the water budget analysis work.

***Previous Related Terms:***

2015 Summer (GSFC/Wise) – Thailand Disasters

***Related DEVELOP Work:***

2015 Summer (UGA) – Costa Rica Water Resources II: Utilizing NASA Earth Observations to Develop a Comprehensive Water Budget for the Arenal-Tempisque Watershed of Costa Rica

2015 Summer (MSFC/Wise) - Thailand Agriculture: Monitoring Food Crop Health and Stress Due to Changing Climate for Enriched Agricultural Land Management

2015 Summer (GSFC/Wise) - Thailand Disasters: Monitoring Risk and Extent of Drought for Enhanced Decision Making and Resource Allocation in the Kingdom of Thailand

**Project Needs/Requests**

***Participants Requested:*** 5 (3 at UGA and 2 at UCR)

***Software & Scripting:***

ArcMap 10.3 – Raster Manipulation/Analysis, Image Enhancement, and Map Creation of Landsat 8 OLI/TIRS, SRTM-v2 C-Band, GPM IMGER, TRMM PR, and Aqua/Terra MODIS

ENVI 5.0 – Atmospheric Correction for Landsat 8 OLI/TIRS