**NASA DEVELOP National Program**

**North Carolina – NCEI**

*Project Summary – Summer 2018*

**Central America Agriculture and Food Security**

*Utilizing NASA Earth Observations and NOAA Climate Data Records to Monitor Drought and Precipitation Patterns for Coffee Agriculture Management in Guatemala, Honduras, and El Salvador*

**VPS Title:** Deja Brew: Enhancing Climate Data Analysis for Central American Coffee Cultivators

**Project Team**

***Project Team*:**

Alexa Kennedy (Project Lead), alexaken@alumni.unc.edu

Danielle Curtis

Andrew Shannon

Meghan Russell

***Advisors & Mentors*:**

Michael Kruk (Earth Resources Technology, Inc.)

**Project Overview**

***Project Synopsis*:** Central America is one of the world’s largest coffee producers, with Honduras, Guatemala, and El Salvador making up half of Central America’s total export. The changing climate, such as increasing temperatures and extreme periods of rainfall and drought, poses threats to coffee crops in these countries. Using Terra Moderate Resolution Imaging Spectroradiometer (MODIS), NOAA Climate Data Records (CDR), and ancillary datasets, the team produced an El Niño-Southern Oscillation (ENSO) phase atlas and maps of Scaled Drought Condition Index (SDCI) to display large scale climate variables to assist with coffee crop management practices and policy decisions on coffee cultivation in a changing climate.

***Abstract*:**

In November of 2017, Guatemala, Honduras, and El Salvador produced over 12 million kg of coffee combined, accounting for half of Central America’s total output. However, in the last 20 years Central America has experienced crop declines between 50% and 90%, due largely to drought and irregular rainfall. These irregularities in the weather patterns have increased coffee crop vulnerability to diseases, such as coffee rust, as well as significantly decreased the productivity and overall quality of coffee crops. In particular, the 2015-2016 El Niño spurred a drought lasting for two years, the most severe drought in Central America in recent history. This project partnered with the United States Agency for International Development (USAID) Feed the Future Alliance for Resilient Coffee (ARC), International Center for Tropical Agriculture, and Conservation International to produce detailed analyses of precipitation anomalies for next generation coffee farmers, co-ops, and regional planners. The team created an atlas of El Niño-Southern Oscillation (ENSO) phases using the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), and a time-series analysis of the frequency and intensity of historical drought periods using the Scaled Drought Condition Index (SDCI). Analyses will be used to assist partners in early warning detection by observing anticipated rainfall conditions aiding in determining adaptive management options.

**Keywords:**

Scaled Drought Condition Index, MODIS, El Niño-Southern Oscillation coffee farming, drought monitoring, dry corridor

***National Application Area Addressed:*** Agriculture and Food Security

***Study Location:*** Guatemala, Honduras, El Salvador

***Study Period:*** January 1987- December 2017

***Community Concern:***

* Over the past eight years, Guatemala, Honduras, and El Salvador have been three of the largest coffee producing countries in Central America. Coffee agriculture is the primary source of income for approximately 110,00 families in Honduras, 95% of which represent smallholder farmers.
* Much of the coffee production lies within the Dry Corridor of Central America, which is an area prone to natural hazards and impacts from changes in climate.
* The primary coffee type grown for production in Central America, *Coffea Arabica,* is a particularly climate sensitive species. Higher temperatures, prolonged rainfall, and water stress from drought can be detrimental to this coffee plant’s maturation and harvesting.
* The ENSO phases influence seasonal rainfall and temperature and patterns of drought in Guatemala and Honduras.

***Project Objectives:***

* Compute the SDCI as a measure of regional trends in the magnitude and frequency of drought
* Quantify the influence of ENSO phases on seasonal precipitation anomalies based on historic satellite-derived rainfall data
* Contextualize the drought and precipitation findings in the geographic potential and limitation of coffee production regions
* Create an atlas of ENSO phase anomalies and drought index trends to communicate results to project partners
* Develop tutorials for regional agricultural extension workers to scale project methods in expanded regions of coffee production

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **USAID, Feed the Future Alliance for Resilient Coffee**  | Katherine Selengia, Program Manager, Climate Smart Coffee | End User | Yes |
| **International Center for Tropical Agriculture**  | Christian Bunn, Postdoctoral Fellow | Collaborator | No |
| **Conservation International** | Karyn Tabor, Director, Ecosystem Modeling and Early Warning Systems; Jenny Hewson, Senior Director, Habitat Monitoring and Climate Mitigation | Collaborator | Yes |

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

The Feed the Future Alliance for Resilient Coffee (ARC) currently leads a consortium of government, private, and NGO partners to mitigate the variety of climate related threats to coffee farmers by providing tools to decision-makers both locally and within the coffee industry. The ARC addresses the vulnerability of coffee crops to climate change by identifying farmers within a community and implementing “demo plots”, small-scale test beds for new technology, to determine the best planting techniques and crop practices. Based on “demo plot” results, a tool identifying these practices is then provided broadly across the co-ops and the region.

***Project Benefit to End User***:

The novel application of NASA Earth observations on coffee agriculture will not only inform coffee farmers and traders of the precipitation and drought conditions for a defined ENSO event, but will also be used as an early warning indicator for upcoming ENSO events. End users will gain actionable data to better inform adaptation options and decisions on coffee crop management practices on a local and regional scale. Climate data was used to assess which regions are most affected by changing climate regimes, which will be useful in conversations with coffee traders who are looking to expand their geographic region but have limited knowledge of Guatemala, Honduras, and El Salvador. This project will utilize open source platforms, including R-script and QGIS to enable the end user to disseminate the methodology and update results.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Terra MODIS** | Land Surface Temperature  | Land surface temperature data were used to develop a scaled drought condition index.  |
| **NOAA AVHRR** | Normalized Difference Vegetation Index (NDVI) | Satellite derived NDVI were used to develop a scaled drought condition index.  |

***Ancillary Datasets:***

Climate Hazards Group InfraRed Precipitation with Stations data (CHIRPS) – Precipitation data were used to

develop an El Niño-Southern Oscillation atlas and a scaled drought condition index.

***Software & Scripting:***

QGIS 3.0 – Raster manipulation and analysis

R- Raster manipulation and analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Scaled Drought Condition Index Analysis and Tutorial** | Terra MODIS, AVHRR  | The SDCI analysis will allow coffee cultivators to assess the vulnerability of their region to drought events and act accordingly to grow in less susceptible areas or take preventative measures. A tutorial detailing the code used to create SDCI maps will be provided so the end user can create future maps for analysis.  | III |
| **ENSO Atlas and Tutorial** | N/A | The ENSO atlas will provide static maps detailing historical precipitation levels associated with weak, neutral, and strong ENSO events thus allowing farmers to better prepare for future extreme drought and heavy precipitation events. A tutorial detailing the methods of the ENSO maps will also be released so that the partner may replicate results in the future. | III |

**Project Handoff Package**

**Transition Plan:**

Deliverables were handed off at the end of the term via video call. A presentation was prepared to highlight key findings and to show selected maps. The handoff package was emailed to the partners prior to the final video call.

*Software Release Plan*: The SDCI tutorial and ENSO Atlas tutorial utilize code falling under software release category III. As a result of this the code must pass through NASA’s software release process. The partner has been alerted to the fact that this process will cause a delay in code delivery. Once the code has successfully passed through the release process it will be handed off to the partner electronically in a functional form along with a README document detailing how to implement and update the code for future use. Alexa Kennedy will act as the software release person of contact and will maintain contact with the partners after the completion of the term until the code is successfully delivered.

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**Software Release POC**: Alexa Kennedy, alexaken@alumni.unc.edu

**Partner POC**: Katherine Selengia, katherine.selengia@hrnstiftung.org

**Collaborator POC I:** Christian Bunn, c.bunn@cgiar.org

**Collaborator POC II:** Karyn Tabor, ktabor@conservation.org

**Handoff Package:**

* SDCI maps and time series analysis of drought detailing changes in magnitude and frequency of drought events in the region
* ENSO Atlas comprised of static maps detailing precipitation associated with weak, neutral, and strong El Nino and La Nina events
* SDCI tutorial detailing code utilized to construct SDCI maps and steps taken to construct time series analysis
* ENSO atlas tutorial detailing code utilized to construct ENSO maps

**References:**

CIAT. 2017. Climate Smart coffee in Honduras. International Center for Tropical Agriculture (CIAT), Cali, Colombia.

Famine Early Warning Systems Networks (FEWS NET). Central America Special Report: The impact of coffee rust outbreak on the coffee sector in Central America. USAID. May 2016.

Rhee, J., Im, J., & Carbone, G. J. (2010). Monitoring agricultural drought for arid and humid regions using multi-sensor remote sensing data. *Remote Sensing of Environment,114*(12), 2875-2887. doi:10.1016/j.rse.2010.07.005

U.S. Agency for International Development (USAID). Climate Change Risk in Guatemala: Country Climate Risk Profile. Climate Change Adaptation, Thought Leadership and Assessments (ATLAS) Task Order No. AID-OAA-I-14-00013. April 2017.

U.S. Agency for International Development (USAID). Climate Change Risk in Honduras: Country Climate Risk Profile. Climate Change Adaptation, Thought Leadership and Assessments (ATLAS) Task Order No. AID-OAA-I-14-00013. March 2017.