**Kenya Agriculture & Food Security**

*Utilizing NASA Earth Observations in the RHEAS Model to Enhance Drought Monitoring and Mitigation in Kenya*

**Project Team**

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**Project Overview**

***Project Synopsis:*** This project began a multi-term partnership with the Kenya National Drought Management Authority (NDMA), the Regional Centre for Mapping of Resources for Development (RCMRD), and NASA SERVIR to enhance capacity for developing early drought warning systems. Utilizing a suite of NASA Earth observations as inputs into the Regional Hydrologic Extremes Assessment System (RHEAS), the team developed multiple drought indices that will be incorporated into the Early Warning Bulletins currently produced by the NDMA in order to provide a more complex understanding of drought and increase capacity for forecasting.

***Abstract:***

Many regions of Kenya historically and regularly experience severe drought, necessitating a robust and well-informed response to drought events to protect agricultural production and minimize drought impact on food security. The National Drought Management Authority currently publishes monthly Early Warning Bulletins that depend on Moderate Resolution Imaging Spectroradiometer (MODIS) indices and are not sufficient in assessing current drought status nor predicting its trajectory. This project utilized Soil Moisture Active Passive (SMAP) L-band Radiometer, Aqua and Terra MODIS, and Global Precipitation Measurement Core Observatory (GPM) Dual-Frequency Precipitation Radar (DPR) data as inputs into the Regional Hydrologic Extremes Assessment System (RHEAS). This model supports an unlimited number of variables, as it relies on a land surface model that can be easily customized, allowing data from multiple resolutions to be used without the need for preprocessing. Using inputs from the Regional Centre for Mapping of Resources for Development, the team created multiple drought time series to better assist stakeholders in implementing drought mitigation and adaptation measures. Initial results showed that drought indices that cover a longer time period provided a clearer trend of drought conditions by county. The team also provided partners an initial analysis of the indices produced and a story map derived from the time series. Follow on work will validate these products and create training documents for end users.

***Keywords:***

RHEAS, remote sensing, SERVIR, Aqua, Terra, SMAP, GPM

***National Application Areas Addressed:*** Agriculture & Food Security, Water Resources

***Study Location:*** Kenya

***Study Period:*** January 2016 to April 2019

***Community Concerns:***

* Since 1960, the frequency and intensity of droughts have been increasing.
* Drought commonly plagues East Africa and can last for multiple years, leaving over 10 million people hungry.
* Crop and livestock production are extremely vulnerable to the impacts of drought.
* In Kenya, arid land comprises over 80 percent of the country and is home to 70 percent of its livestock.
* Agriculture comprises 25.9 percent of the Gross Domestic Product of Kenya; therefore, prolonged drought directly affects the national economy.

***Project Objectives:***

* Generate drought indices for the study area using RHEAS
* Create an assimilation framework matching outputs from the model to partner needs
* Compile an operating and procedure manual to assist second term team
* Present initial results to partners and solicit feedback for refinements to the model

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **National Drought Management Authority (Kenya)** | Nelson Mutanda, Drought Early Warning Officer | End User | Yes |
| **Regional Centre for Mapping of Resources for Development (RCMRD)** | Lilian Ndungu, SERVIR Eastern and Southern Africa Agriculture & Food Security Thematic Lead | Collaborator | Yes |
| **NASA SERVIR Science Coordination Office** | Dr. Lee Ellenburg, Food Security & Agriculture Thematic Service Area Lead | Collaborator | No |

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

The NDMA is mandated to ensure that drought does not lead to widespread famine and the impacts of changes in climate are sufficiently mitigated by establishing, institutionalizing, and coordinating structures for drought management. The NDMA manages a drought early warning system that provides timely and credible early warning information on drought risks using Moderate Resolution Imaging Spectroradiometer (MODIS) indices. As a result, it communicates the current drought status via published monthly bulletins that farmers and other stakeholders use to plan for and mitigate the impacts of drought on agriculture and food security. The five drought classifications used in Kenya are Normal, Alert, Alarm, Emergency, and Recovery. Drought status is determined by evaluating seven factors: rainfall, vegetation condition, livestock production, crop production, access to water, terms of trade, and health and nutrition. The NDMA conducts a variety of projects to alleviate the impact of drought, including distributing feed for livestock, providing school lunches, and buying livestock in counties experiencing extreme drought.

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

This project provided the NDMA with resources to help assimilate the existing RHEAS model into its current methodologies to enhance early warning for drought. RHEAS utilizes a land surface model that allows for unlimited variables, and end products derived from the model are easily customized and interfaced for use with the end user’s current systems. The integration of this new information into Early Warning Bulletins will improve agro-pastoral management practices. The story map we created will be used as an outreach tool to inform the public about drought and food security in Kenya.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **SMAP L-band Radiometer** | Soil moisture | This dataset was assimilated into the RHEAS model to evaluate soil conditions affecting agriculture through the Water Requirement Satisfaction Index (WRSI). |
| **Aqua MODIS** | Land surface temperature (LST) | This dataset was assimilated into the RHEAS system to determine the LST in drought-prone areas of Kenya. |
| **Terra MODIS** | LST | This dataset was assimilated into the RHEAS system to determine the LST in drought-prone areas of Kenya. |
| **GPM DPR** | Precipitation | This dataset was assimilated into the RHEAS system to determine precipitation levels in drought-prone areas of Kenya. |

***Ancillary Datasets:***

* Kenya National Drought Management Authority Drought Early Warning Bulletins – Contextualized RHEAS drought indices with qualitative and social data
* Climate Hazards Group Infrared Precipitation with Stations (CHIRPS) Precipitation Data – Assimilated into RHEAS for analysis of the Standardized Precipitation Evapotranspiration Index (SPEI) and the Potential Evapotranspiration (PET) Index
* National Centers for Environmental Prediction Temperature Data – Assimilated into RHEAS as a forcing dataset

***Modeling:***

* Regional Hydrologic Extremes Assessment System (RHEAS) (POC: Dr. Lee Ellenburg, NASA SERVIR) – Converted data inputs to standardized resolutions and created drought index outputs

***Software & Scripting:***

* Esri ArcMap 10.5 – Data analysis and map creation
* QGIS – Data analysis and map creation
* PostGIS – Stored and executed RHEAS inputs and outputs
* Python 2.7.12 – Used for data processing and analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **RHEAS Drought Indices** | SMAP L-band Radiometer  Aqua MODIS  Terra MODIS  GPM DPR | The end user can use the RHEAS Drought Indices to enhance the Early Warning Bulletins that it currently produces. In turn, this will improve efforts focused on drought response and recovery in the region. | II |
| **Drought Time Series** | SMAP L-band Radiometer  Aqua MODIS  Terra MODIS  GPM DPR | The time series visualizes the spatial and temporal distribution of drought to enhance the end user’s identification of counties with potential chronic food security issues. | II |
| **Evaluation of RHEAS Drought Indices in Kenya** | SMAP L-band Radiometer  Aqua MODIS  Terra MODIS  GPM DPR | The evaluation will guide the end user’s incorporation of RHEAS drought indices into its Early Warning Bulletins to assist stakeholders in implementing drought mitigation and adaptation measures. | II |
| **Drought in Kenya Story Map** | SMAP L-band Radiometer  Aqua MODIS  Terra MODIS  GPM DPR | The end user can use this end product to inform the general public about the issue of drought in Kenya, its impact on agriculture, and the utility of the RHEAS drought indices when used in conjunction with Early Warning Bulletins for improved drought monitoring. | II |

**Project Handoff Package**

***Transition Plan:*** All deliverables and end products were provided to partners via NASA Large File Transfer after approval from export control at the end of the term. Items listed in the Handoff Package below were limited to initial results for this term of the project; validation and final products will be shared following the second term. RHEAS was run on SERVIR’s cluster, Socrates, and RCMRD and NDMA had access to outputs hosted on this server. During week 10 of the project, the team conducted a handoff web conference during which the team presented initial results, addressed partner questions, and solicited feedback on adjustments to the model.

***Project Continuation Plan:*** All end products will be handed off to the next term along with the Poster and Technical Paper. The second term of this project will seek to validate the results of the first term and complete a detailed transfer of knowledge to the partners through comprehensive webinars or tutorials. The team, with the support of the NASA SERVIR Science Coordination Office, will conduct half-day webinars with partners to share framework and methodologies and address any concerns. Consistent partner interaction will culminate in the interactive handoff when validated results along with model operation instructions will be handed off to the project partners.

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***Handoff Package:***

* Drought in Kenya Story Map
* Drought Time Series
* Evaluation of RHEAS Drought Indices in Kenya
* Poster
* Presentation
* RHEAS Drought Indices
* Technical Paper

**References**

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