LASER PULSE

Long-term Assistance and SErvices for Research (LASER)
Partners for University-Led Solutions Engine (PULSE)

EAST AFRICA WATER SECURITY PROJECT
QUICK REFERENCE GUIDE

SUPPLEMENT TO AGREEMENT NO. AID-7200AA18CA00009
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ABOUT LASER PULSE

LASER (Long-term Assistance and SErvices for Research) PULSE (Partners for University-Led Solutions Engine) is a $70M program funded through USAID's Innovation, Technology, and Research Hub, that delivers research-driven solutions to field-sourced development challenges in USAID partner countries.

A consortium led by Purdue University, with core partners Catholic Relief Services, Indiana University, Makerere University, and the University of Notre Dame, implements the LASER PULSE program through a growing network of 3,000 researchers and development practitioners in 74 countries.

LASER PULSE collaborates with USAID missions, bureaus, and independent offices, and other local stakeholders to identify research needs for critical development challenges, and funds and strengthens the capacity of researcher-practitioner teams to co-design solutions that translate into policy and practice.

What is the LASER PULSE East Africa Water Security Project?

The LASER PULSE East Africa Water Security Project aims to provide water information, data access, and decision support to improve water resources (quantity, quality) management and, ultimately, water security in East Africa. Case studies are conducted in three key watersheds—Murchison Bay Watershed (Uganda); Simiyu River Watershed (Tanzania); and, Sasumua River Watershed (Kenya), representing a variety of landscapes and threats to water security—using a combination of existing climate data, recently developed rainfall data, and a modeling approach using the Soil and Water Assessment Tool (SWAT).

What Data Have We Collected, Processed, and Analyzed?

We have acquired, processed, and deployed a variety of data for use with water resources decision making and management, including: available observed water and climate data as shareable; continuous daily temperatures and rainfall amounts developed from climate reanalysis data; and, future climate datasets derived from Coupled Model Intercomparison Project Phase 6 (CMIP6) projections. We have established patterns and changes in daily, monthly, and seasonal rainfall, as well as annual and decadal temperatures from historical and future climate projections, and identified selected extremes. We have packaged these data and results into an interactive dashboard deployed with all our other data products.

What are the Key Takeaways from the Case Studies?

Sasumua River Watershed is projected to experience an increase in rainfall which would result in substantially higher flows into the Sasumua Reservoir, doubling the modern value within 70 years (based on the moderate climate scenario). The most effective management approach to reducing mean annual sediment, organic nitrogen, and organic phosphorous yields and NO_3 in runoff will involve combining multiple practices, with the most effective single practice being filter strips, based on the analysis.

Simiyu River Watershed is projected to experience increased surface runoff and water yield in response to changes in climate. The anticipated changes in land use will rapidly increase the amounts of Nitrogen pollutants in the basin.

Murchison Bay Watershed has been experiencing population increases over the past two decades which have led to dramatic land use changes, particularly in the development of built-up land. Scenario results indicate that these changes are responsible for higher stream flow rates and the growing prevalence of floods. Management practices to mitigate these effects on the hydrology of the watershed are highly recommended to reduce flood risks.

What Is included in This Quick Reference Guide?

This guide summarizes the data and modeling products that have resulted from the project, also specifying their purpose and how they may be accessed. The primary products include:

- Bias Corrected CFSR Climate Datasets
- Aggregated CMIP6 Climate Datasets
- Climate Scenario Exploration Dashboard
- Hydrologic Model Results of Watershed Case Studies

How Can the Information, Datasets, and Tools Be Used?

Products described herein, along with products accessible through companion resources provided, can be used to identify and address existing and anticipated water security challenges. The products are important in a variety of water resources applications including hydrologic and water quality modeling, and water resources decision making and management in general.

Bias Corrected CFSR Climate Datasets

Description

These datasets consist of continuous daily temperature and precipitation estimates for 12 locations from the Climate Forecast System Reanalysis (CFSR) global gridded products. The CFSR precipitation data has undergone bias correction as described in Garibay et al. (2021) to improve its similarity to station observations. Included in the datasets are observed data as available and shareable for the selected stations.

Locations:

- Kenya (Nairobi, Garissa, Moyale, Mombasa, Mandera);
- Tanzania (Mtwara, Mwanza, Tabora);
- Uganda (Arua, Jinja, Soroti, Entebbe);

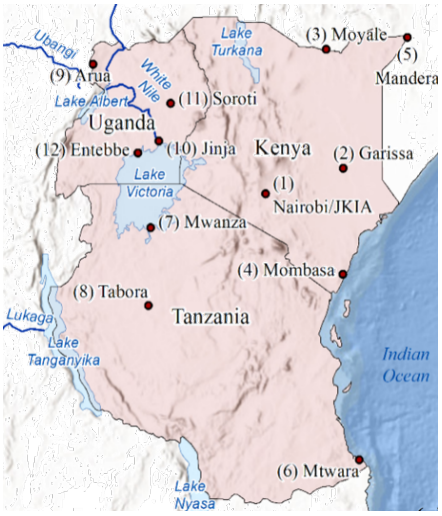


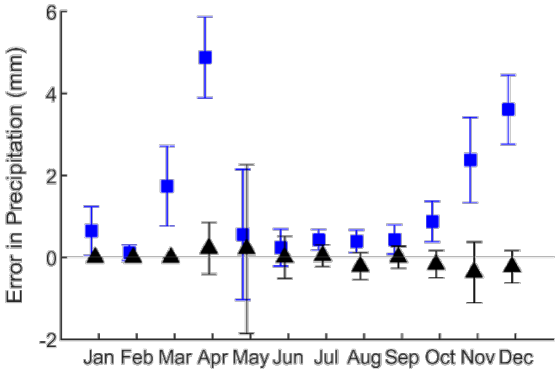
Figure 1. East Africa map showing country station locations.

Datasets are freely available for download from the Purdue University Research Repository at the following links:

- All 12 Stations (DOI:10.4231/2YMW-JY19)
- Kenyan Stations (DOI: 10.4231/QV4A-5J43)
- Tanzanian Stations (DOI:10.4231/2ARZ-BY05)
- Ugandan Stations (DOI:10.4231/6YK1-CQ13)

On the page, click Download Bundle (B), and a download of the zipped folder containing the files for the specified stations will begin.

Snapshot



Interpretation tips:
Target Value is 0mm Error in Precipitation.
Blue squares represent Original CFSR. Black Triangles represent Bias Corrected CFSR (this dataset).

Figure 2. Example of improvement in mean error for median daily rainfall in Mombasa, Kenya

Citation: Garibay, V.M., Gitau, M.W., Kiggundu, N., Moriasi, D. (2021) Evaluation of Reanalysis Precipitation Data and Potential Bias Correction Methods for use in Data-Scarce Areas. *Water Resource Management.* DOI: 10.1007/s11269-021-02804-8

Aggregated CMIP6 Climate Datasets

Description

These datasets are comprised of daily climate data as retrieved and reformatted from the most recent Coupled Model Intercomparison Project Phase 6 (CMIP6) model outputs. The datasets feature different scenarios are designed to capture a wide range of potential pathways that future development may take. More detail on these scenarios can be found in Riahi et al. (2016). The dataset locations consist of the same 12 station locations from the Bias Corrected CFSR Datasets as well as three additional locations corresponding to the Watershed Case Studies.

Datasets are freely available for download from the Purdue University Research Repository at the following links:

- Kenyan Stations (DOI:10.4231/G3T3-5287)
- Tanzanian Stations (DOI:10.4231/CDF2-2B03)
- Ugandan Stations (DOI: 0.4231/8QSZ-5V58)
- Sasumua Station (DOI:10.4231/DATG-PB58)
- Murchison Bay (DOI: 10.4231/1Q67-DZ61)
- Simiyu Station (DOI: 10.4231/ZYSE-P594)

On the page, click Download Bundle (B), and a download of the zipped folder containing the files for the specified stations will begin.

Snapshot

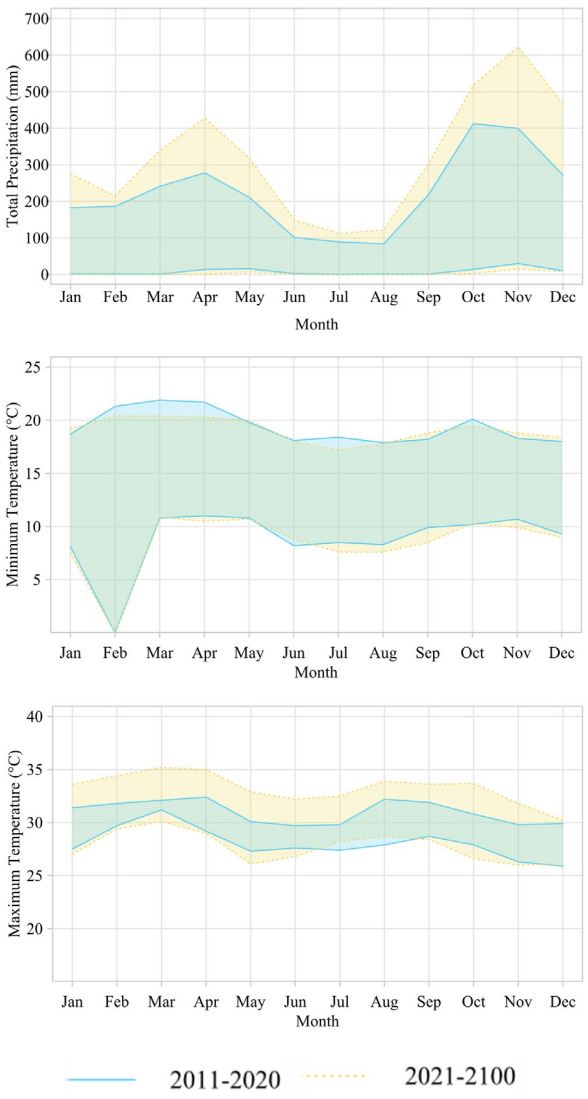


Figure 3: Example comparison of projected changes in precipitation and temperature, between the periods 2011-2020 and 2021-2100, using one climate scenario for one location.

Citation: Riahi, K., et al. (2016). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. Global Environmental Change, 42, 153–168. DOI: 10.1016/j.gloenvcha.2016.05.009

Climate Scenario Exploration Dashboard

Description

The Climate Dashboard can be used to review the annual precipitation totals and temperature extremes from the CMIP6 Datasets on an annual basis for four future development paths. The Dashboard also offers decadal summaries for visualization of long-term trends. The locations featured are the same 12 stations from the Bias Corrected Datasets as well as three additional locations corresponding to the Watershed Case Studies.

Snapshot

Figure 4: Example of decadal comparison of mean annual precipitation results from multiple models and a heatmap of total precipitation by season.

A full version of the dashboard is now available and is currently hosted at https://app.climate-dashboard.geddes.rcac.purdue.edu/.

Select a location from the links on the home page to review past and future climate trends based on a moderate climate scenario for the available models.

Adjust the sliders  at the base of the graphs to pinpoint a year range of interest

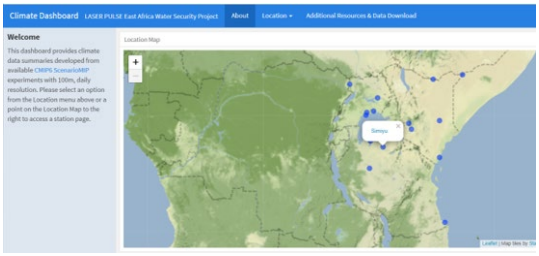


Figure 5: Screenshot of dashboard landing page.

For an in-depth view of the results for a single model, including the outlook based on other climate scenarios select the desired model from the row of buttons at the top of the page:

Hydrologic Model Results and Parameter Sets for Watershed Case Studies

Description

The Soil and Water Assessment Tool (SWAT) was set up and calibrated and validated for Murchison Bay, Sasumua River, and Simiyu River watersheds which are diverse in their characteristics and focal issues. The model results are used to investigate the effects of changes in land use, climate, and mitigation practices as relevant to each case study.

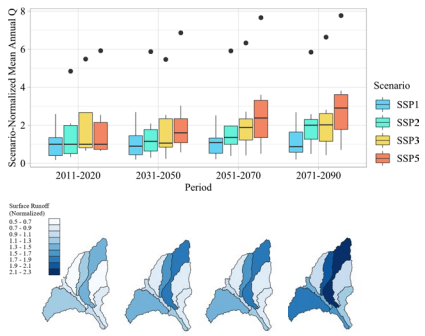


Figure 6: Examples of change over time for reservoir inflow and runoff levels by subbasin for Sasumua

Results

Sasumua River Watershed: Water flows are expected to more than double for three of four future scenarios compared to the baseline period (2011-2020). The single best management practice for reducing watershed sediment losses was found to be filter strips while a combination of riparian buffers, filter strips, terracing, field diversions, and water harvesting ponds (all suitable and practical management practices) would provide the best outcome.

Simiyu River Watershed: In comparison to the baseline period (1971-1999), precipitation has increased by 62% and is expected to more than double in the future (2030-2060). In response, increases are expected in overland flow and total water yield in all future climate scenarios, potentially leading to increased flooding. Sediment losses are expected to increase by more than 7% in response to land use changes occurring within the watershed.

Murchison Bay Watershed: Increases in stream flow, surface runoff, and some nutrients have occurred due to changing land use, which is attributable to increasing population growth within the watershed. These increases are projected to continue through 2040. Vegetative filter strips (2 m and 5 m) and retention ponds (20 m^3) could reduce sediment yield by 42%-70% and surface run off by 60%, respectively.

Gitau, M. W., Moriasi, D., Garibay, V., Kiggundu, N., Munishi, S. E. (2022). Modeling Products Snapshots: Model Results, Base Parameters, Scenario Evaluations. Sasumua River Watershed, Kenya; Simiyu River Watershed, Tanzania; Murchison Bay Watershed, Uganda. (publication in process)

Gitau, M. W., Moriasi, D., Garibay, V., Kiggundu, N., Munishi, S. E. (2022). SWAT+ and SWAT Model Parameters for: Sasumua River Watershed, Kenya; Simiyu River Watershed, Tanzania; and, Murchison Bay Watershed, Uganda. Purdue University Research Repository. doi:10.4231/CKJ4-8354

Historical climate and water data: Sasumua River Watershed (DOI: 10.4231/N75Q-ZW81); Simiyu River Watershed (DOI: 10.4231/FMF9-MF28); Murchison Bay Watershed (DOI: 10.4231/EB3J-CS77)