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WATERQ2: UNDERSTANDING WATER QUALITY & QUANTITY IN THE LIMPOPO BASIN

Quarterly Report, 01 July – 30 September 2021

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Milestone #24

DISCLAIMER: This work was supported by the United States Agency for International Development (USAID), Southern Africa Regional Mission, Fixed Amount Award 72067419FA00001. This work reflects the work of the authors and does not necessarily reflect the views of USAID or the United States Government.

WaterQ2: Understanding Water Quality and Quantity in the Limpopo Basin

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Project Information

Project Title Water Q2: Understanding Water Quality and Quantity in the Limpopo Basin
Geographic Locations Botswana, Mozambique, South Africa, and Zimbabwe
Award Number 72067419FA00001
Implementation Dates March 2019 to March 2022

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INTRODUCTION

The transboundary Limpopo River Basin crosses Botswana, Mozambique, South Africa, and Zimbabwe. At over 400,000 km², the Limpopo River Basin is home to 18 million people living in both rural and urban areas. Industries in the Basin include businesses in the urban areas and water-intensive uses such as agriculture and mining; industrial water use is growing rapidly. In addition to the human residents, the Basin contains some of the most biodiverse natural areas on the planet.

The rainfall in the Basin is heterogeneous with some sub-basins receiving less than 400 mm on average and other downstream sub-basins in Mozambique receiving over 750 mm annually. Even meteorological stations located in close proximity demonstrate substantial spatial variation within sub-basins. The Basin has experienced severe droughts in the last decade. In addition to the variation in the amount of rainfall, the timing, especially the start of the growing season, has varied significantly. However, there remain many questions about the reliability of rainfall data and other water measurements due in part to the infrequent calibration and validation of field site measurements. **The limited confidence in these data, combined with the substantial variation through time and space necessitates an integrated approach to improve data collection, validation, and overall Basin water resource management in the Basin.**

The goal of this project is to build resilience through the support of Basin stakeholders, including The Limpopo Watercourse Commission (LIMCOM), to improve governance around water resources management and water security in the Basin. A systems approach, such as integrated water resources management (IWRM) is needed to address such complex, large, and interrelated components of water resources. IWRM is recommended by the United States Agency for International Development (USAID) Water and Development Strategy Implementation Guide (2014). This context will be combined with data collection and validation, data sharing, and continuous evaluation of the interrelations that affect water resources.

This project will support water resources monitoring, and the development of methods for water quality and quantity measurement based on *in situ* sensors and satellite measurements. These **measurements** will enable characterization of water resource dynamics at the whole Basin scale and form the foundation for hydrologic **modeling** that can help estimate hard-to-measure parameters and also provide holistic assessments of Basin scale stocks and flows. To support data sharing, the project will use cloud-based, automated data collection and web-based **data sharing**.

The Development of local capacity to maintain water resources and make proactive, scientifically justified management decisions requires a substantial human capital resource that is currently lacking in the Basin. The project will provide training, workshops, and conferences will focus on integrated water resources management (IWRM) and environmental flow analysis.

The results of the water resources and biodiversity studies conducted will be compiled into a report for the Basin stakeholders. Continued high-quality data collection, training, and general logistics depends on dependable physical infrastructure. To support data collection efforts as well as training and collaboration the Limpopo Resilience Lab at the University of Venda will be established. The sustainability of lab activity will continue with the implementation of a small user fee beyond the duration of the project. Annual training workshops and conferences will be located at or nearby the Resilience Lab.

In this report, the collaborators, Duquesne University (Duquesne), University of Venda (Univen), and Rensselaer Polytechnic Institute (RPI) report their activities and progress in the second quarter (Q2) of project year 2021-22 (PY 2021-22).

PROJECT ADMINISTRATION

PROGRESS TOWARDS MILESTONES

Student research has continued during this quarter under the supervision of the PIs. The specific projects will be reported within the module which they support. Water resources monitoring will continue with remote sensing (satellites) and ground-based stations that are equipped with telemetry devices; however, not all instruments are compatible with telemetry or placed in an area that communications are available; these instruments require a physical connection for downloads and the project continues to lose data from those instruments.

The South African Department of Water and Sanitation requested that we offer the R training course again to their hydrologists. This course was delivered successfully and the upcoming stakeholder and training report will detail this training.

To support networking between basin scientists and the global academic community, the project plans to support, through sponsorship of side events and presentations, the Water and Health Conference at the University of North Carolina, Chapel Hill. This is presented by the Water Institute at UNC, led by Aaron Salzberg, formerly the *Special Coordinator for Water* at the United States Department of State. The conference is completely online 04-08 October 2021.

TRAVEL DISRUPTION

The COVID-19 pandemic has decimated our ability to travel both to and around the basin. During this quarter, the United States Department of State has placed every country in the basin under some sort of advisory or warning due to COVID and civil unrest. Specifically, the Department of State issued a “do not travel” warning for South Africa 06 July 2021 (Appendix A).

MODULE I: WATER MONITORING

HYDROMETEOROLOGICAL STATION NETWORK

Data from stations established in this project continue to be monitored remotely and by staff in South Africa. Data are now available through the project website and hosted on the Development Data Library, (DDL, data.usaid.gov). Data from telemetry sites were updated this quarter.

REMOTE SENSING RIVER GAGE

Researchers have been granted extended use from Planet Labs through the National Aeronautics and Space Administration’s (NASA) Commercial Smallsat Data Acquisition (CSDA) program. Previously, this project had access through Planet Labs’ Education and Research Program. These data are used in the ongoing research to develop river discharge records.

REMOTE SENSING WATER QUALITY

Researchers continue to develop remote sensing water quality with Landsat through Google Earth Engine. Calibration data were obtained through collaborations with the Department of Water and Sanitation, South Africa; the project plans to work with the scientists responsible for these data at the next travel opportunity.

GROUNDWATER MEASUREMENTS

Researchers are modeling groundwater recharge zones based on precipitation, river flow, and known geographical parameters throughout the region, especially in the Soutpansburg Mountains. Satellite-based measurements include water data from NASA's Gravity Recovery and Climate Experiment (GRACE). The data collected will aid in the development of a groundwater model of the Limpopo River Basin using HEC-HMS hydrologic modeling software. The developed model will identify key recharge zones for water resources in the Limpopo River Basin.

COASTAL WATER RESILIENCE

In previous stakeholder meetings, representatives from Mozambique have reported seawater intrusion to the Limpopo River. To estimate relative risk to near-coast freshwater resources, researchers are examining surface movement with differential interferometry from ESA's Sentinel-1 Synthetic Aperture Radar over Maputo, Xai Xai and Inhambane. Southern Mozambique is located on the African plate, southwest of the divergent East African rift zone (Figure 1). The examination of Xai-Xai has been largely successful with several regions that show sufficient signal coherence for analysis (Figure 2).

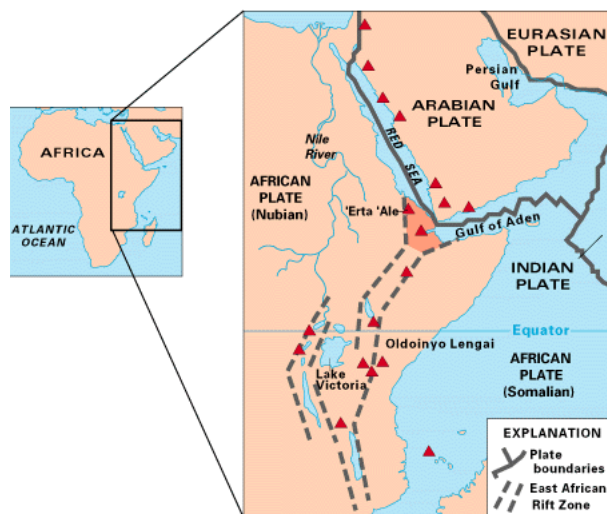


Figure 1: Map of the East African rift zone, image credit: United States Geological Survey, https://pubs.usgs.gov/gip/dynamic/East_Africa.html

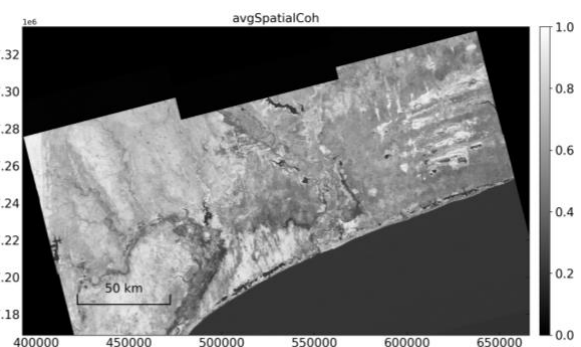


Figure 2: Spatial coherence map of coastal Mozambique.

RIVER HEALTH MONITORING

Researchers continue to monitor water quality in the Levhuvu River as it enters Kruger National Park. The samples were tested for fluoride, chloride, nitrate, nitrite, phosphate, and other ions by ion chromatography and trace metals by induced coupled plasma mass spectroscopy with microwave digestion. The ongoing sampling at these sites will support Mr. Hilton's thesis research.

MODULE 2: TRAINING, WORKSHOPS, AND CONFERENCES

R FOR DATA ANALYSIS

The project staff delivered a R Workshop for the Department of Water and Sanitation hydrology staff at their request in August 2021. Several participants continued to work with project staff to refine their own projects. Additional participants came from universities and the South African National Space Agency.

SCIENTIFIC CONFERENCE

PROJECT-SUPPORTED

The project sponsored events and presented at the technology showcase at the University of North Carolina's (UNC) Water Institute's Water and Health Conference, 04-08 October 2021. The project also supported additional participants. The conference was entirely remote. The Limpopo Resilience Lab presentation at the technology showcase can be viewed at the project website: www.duq.edu/limpopo, under conferences.

PROJECT PRESENTATIONS

Researchers will present their work at the following upcoming conferences:

International Conference on Transboundary Aquifers
06-09 December 2021
Paris, France (online conference)

American Geophysical Union Fall Meeting
13-17 December 2021
New Orleans, LA, USA (hybrid conference: online and in-person)

MODULE 3: BASIN-LEVEL REPORT

The WaterQ2 team has begun to prepare the draft report on water resources management based on our findings during the first year of the project. Currently, the report is being prepared in parallel with a draft of a manuscript that will be prepared for publication in a peer-reviewed journal.

MODULE 4: LIMPOPO RESILIENCE LAB

University of Venda is expanding their analytical water chemistry capabilities and computational resources. Quotes have been obtained for an ion chromatograph and several computer resources. The project is prioritizing and budgeting the Limpopo Resilience Lab expansion.

MONITORING AND EVALUATION

MODULES 1 AND 3: WATER MONITORING

There are four primary research activities that have continued in this quarter that are supported through this project. They all fall into USAID category, *Production Systems Research*, as they are a component of natural resources management. The research activities are:

- Remote sensing river gage (*Under field testing*)
- Remote sensing water quality (*Under field testing*)
- Remote sensing and models to estimate groundwater resources (*Under research*)
- Remote sensing to support coastal water resilience (*Under research*)

TABLE 1: MODULES 1&3 INDICATORS

| INDICATOR | DISAGGREGATION | CURRENT VALUE | PROJECT TOTAL |
|---|---|---------------|---------------|
| Number of technologies, practices, and approaches under various phases of research, development, and uptake as a result of USG assistance | Phase: Under research | 2 | 4 |
| | Under field testing | 2 | 2 |
| | Made available | 0 | 0 |
| | Demonstrated uptake | 0 | 0 |
| Number of peer-reviewed scientific publications resulting from USG support to research and implementation programs | None | 0 | 0 |
| Number of hectares of land under improved technologies or management practices with USG assistance | | 0 | 0 |
| Number of datasets shared, which were generated as a result of USG assistance | Downloads: Medike: 91 Mutale: 94 Mbahela: 76 Leshiba: 0 | 0 | 4 |

TECHNOLOGIES

Under research

- Groundwater resources with remote sensing and hydrologic models
- Relative risk for river seawater intrusion based on land subsidence, river discharge, and sea level rise

Under field testing

- Remote sensing of river discharge
- Remote sensing of water quality

PEER-REVIEWED PUBLICATIONS

No manuscripts have been submitted at this time; however, two are nearing submission:

- Remote sensing of river discharge for water resources management
- Remote sensing reveals synchrony in water quality and quantity in the Limpopo River Basin

HECTARES OF LAND UNDER IMPROVED TECHNOLOGIES OR MANAGEMENT PRACTICES

So far, the project has worked closely with the South African Department of Water and Sanitation and South African National Parks. The researchers hope that this engagement has assisted with technologies and management; however, it would be difficult to provide a specific area at this time.

DATASETS

The Leshiba dataset is currently being collected; however, it has not been uploaded due to COVID-19 travel restrictions.

MODULE 2. IWRM TRAINING, WORKSHOPS, AND CONFERENCES

Module 2 contains two primary components: convene stakeholder workshops and trainings; and convene future collaborators at conferences.

TABLE 2: MODULE 2 INDICATORS

| INDICATOR | DISAGGREGATION | CURRENT VALUE | | PROJECT TOTAL | |
|---|---------------------|---------------|--------|---------------|--------|
| | | Male | Female | Male | Female |
| Number of people trained in sustainable natural resources management and/or biodiversity conservation as a result of USG assistance | Sex | 7 | 5 | 45 | 23 |
| Number of water and sanitation sector institutions strengthened to manage water resources of improve water supply and sanitation services as a result of USG assistance | Institutional scale | 2 | | 4 | |

INSTITUTIONS

- South African Department of Water and Sanitation
- South African National Space Agency

Previous Institutions

- South African Weather Service
- South African National Parks

PROJECT PROGRESS

WORK PLAN PROGRESS

Table 3 outlines progress on work plan activities (outlined in the Mobilization Plan) and the ongoing research activities. As specified in the Project Description, the following activities were planned.

| TABLE 3: PROJECT ACTIVITIES | | | | | | | | | | | | | | |
|-----------------------------|---|------|-----------|---|----|------|---|---|---|---------------------|---|---|-----|--|
| # | ACTIVITY | 2019 | | | | 2020 | | | | 2021 | | | | |
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | |
| | Startup activities: Mobilization Plan, Staffing, EMMP | █ | | | | | | | | | | | | |
| 1 | Establish meteorological, river, and groundwater stations, <i>Water Monitoring and Algorithm Development Report</i> | | * | | | | * | | | | | | | |
| 1 | Groundwater measurements (ERT), to be included in <i>Water Monitoring Report</i> | | ** | | ** | | | █ | | | █ | | █ | |
| 1 | Develop satellite algorithms | █ | | | | | | | | | | | | |
| 1 | Develop hydrologic and water quality models | █ | | | | | | | | | | | | |
| 2 | Convene stakeholders in workshops | | █ | | | | █ | | | | | | *** | |
| 2 | Scientific conferences | | | | | **** | | █ | | | | ◆ | | |
| 2 | Training workshops | | █ | | █ | | | | † | | █ | | | |
| 3 | Publish and present basin report | | | | | | | | | ‡ | | | | |
| 4 | Launch Limpopo Resilience Lab | | | | | | | | | | | | | |
| | | █ | Completed | | | | | | █ | In-progress/planned | | | | |

Notes:

* Hydrometeorological stations have been installed; however, some stations were scheduled for installation but cancelled due to COVID-19 pandemic travel restrictions. It is unclear if the project will have time to establish these stations and may refocus these resources to Kruger National Park and the Soutpansburg Mountains.

** ERT measurements were delayed at first due to shipping delays with Tazmanian Logistics and then due to COVID-19 pandemic travel restrictions. Project staff is now making routine trips to Kruger National Park to collect data.

*** The stakeholder meeting for PY 2021-22 has been moved to January 2022 to showcase the results of the project and determine how best to integrate these results into water resources management.

**** The project convened a special side event at the Water Institute of Southern Africa conference. The conference was delayed due to COVID-19. The side event was a great success when the conference was held in December 2020.

❖ The PY 2021-22 conference was in conjunction with the University of North Carolina's Water Institute's *Water and Health Conference*, 04-08 October 2021.

‡ The basin report has been delayed.

MILESTONE PLAN

| TABLE 4: MILESTONE PLAN | | | | | | | | | | | | | |
|-------------------------|---|------|------|------|-----|------|---|---|-----|------|-----|-----|-----|
| # | MILESTONE | 2019 | | | | 2020 | | | | 2021 | | | |
| | Project year quarter | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | Mobilization Plan | Apr | | | | | | | | | | | |
| 2 | Environmental Mitigation and Monitoring Plan | Jun | | | | | | | | | | | |
| 3 | Quarterly Report | Jul | | | | | | | | | | | |
| 4 | Water Monitoring and Algorithm Development Report | | Dec* | | | | | | | | | | |
| 5 | Stakeholder Workshop Report | | Nov | | | | | | | | | | |
| 6 | Annual Work Plan | | Aug | | | | | | | | | | |
| 7 | Quarterly Report | | Dec* | | | | | | | | | | |
| 8 | Quarterly Report | | | Apr* | | | | | | | | | |
| 9 | Quarterly Report [^] | | | | Apr | | | | | | | | |
| 10 | LRL Website and Planning | | | | Apr | | | | | | | | |
| 11 | Scientific Conference | | | | | | | | Dec | | | | |
| 12 | Basin Report | | | | | Jul | | | | | | | |
| 13 | Quarterly Report | | | | | Jul | | | | | | | |
| 14 | Stakeholder Workshop Report | | | | | | | | | Sep | | | |
| 15 | Annual Work Plan | | | | | | | | Aug | | | | |
| 16 | Quarterly Report | | | | | | | | Oct | | | | |
| 17 | Quarterly Report | | | | | | | | | Jan | | | |
| 18 | Quarterly Report [^] | | | | | | | | | | Apr | | |
| 19 | Scientific Conference | | | | | | | | | | | Jul | |
| 20 | Quarterly Report | | | | | | | | | | | Jul | |
| 21 | Stakeholder Workshop Report | | | | | | | | | | | | Sep |

| | | |
|----|--------------------------------------|-----|
| 22 | Water Monitoring: Two manuscripts | Aug |
| 23 | Annual Work Plan | Aug |
| 24 | Quarterly Report | Sep |
| 25 | Quarterly Report | Jan |
| 26 | Basin Report | Mar |
| 27 | LRL Continuity Report | Mar |
| 28 | Quarterly Report | Apr |

Notes:

Shaded items are completed or pending approval.

Item 10 was delayed to collect more information and await publication of datasets on data.usaid.gov.

This report is upcoming.

Item 12, the draft of the basin report, was delayed to address comments from the thesis committee.

FINANCIAL

PRIME RECIPIENT

Duquesne University has used project funds for the expenditures in Table 5.

| TABLE 5: PROJECT EXPENDITURES | | |
|---------------------------------------|----------------|---------------|
| ITEM | Q2 EXPENDITURE | PROJECT TOTAL |
| Summer research salary for Dr. Kahler | \$0 | \$14,760.01 |
| GRA Stipend support | \$3,960.04 | \$82,865.90 |
| Tuition | \$0 | \$47,310.00 |
| Fringe | \$0 | \$2,940.44 |
| Equipment | \$0 | \$47,185.00 |
| Lab/Research Supplies | \$2,650.00 | \$18,401.56 |
| Travel | \$0 | \$25,837.30 |
| Subaward: Univen | \$48,274.04 | \$122,808.12 |
| Subaward: RPI | \$15,747.01 | \$234,234.60 |
| Indirect to Duquesne University | \$8,543.29 | \$92,034.20 |
| Total | \$79,174.38 | \$688,377.13 |

APPROVAL

This Quarterly Report has been received and approved by USAID. This satisfies the requirements set forth in the Milestone Plan, item #24: Completion of Quarterly Report (Q2).

Signature: _____

Name: _____
Agreement Officer's Representative

Date: _____

WaterQ2: Understanding Water Quality and Quantity in the Limpopo Basin