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Lake Victoria Water Resources

Spatio-Temporal Analysis of Lake Victoria Pollution and Algal Blooms Using NASA Earth Observations for Improved Water Management

 **Technical Report**

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# I. Abstract

[Placeholder - do not put anything here until the final draft submission. The abstract in the project summary is where the working draft of the abstract should “live”]

**Keywords**

Lake Victoria, Water Quality, Water Resources, Invasive Species, Remote Sensing

# II. Introduction

With a surface area of 68, 800 km2 in a catchment area of 194, 200km2 , Lake Victoria is the largest of Africa’s great lakes. The lake is shared between Kenya, Uganda, and Tanzania, and serves as the main reservoir of the Nile River. The drainage basin area is shared between Kenya, Uganda, Tanzania, Rwanda, and Burundi (Odada et al. 2006).

Millions of people depend directly on the lake for survival, utilizing it as a source of drinking water and food. Commercial fishing on the lake is also a vital part of the economy, as it provides a source of income for individuals and families (Kayombo and Jorgensen, 2006). Consequently, the water quality in Lake Victoria has rapidly degraded during the past century due to rising human activity. Sewage, industrial, and agricultural runoff have resulted in disturbances in the chemical balance of the lake. Excess nutrients in the water have caused eutrophication, a process which feeds rapid plant and algae growth while subsequently depleting the available oxygen in the water. Chemical runoff from herbicides and pesticides not only pose a threat to human health, but the deoxygenated water resulting from nutrient dumping activities also spells trouble for species living in the lake.

Once a thriving biodiversity hotspot, Lake Victoria has experienced a rapid decline in endemic fish species since the introduction of the invasive Nile Perch in the early 1960’s (Nkalubo et al. 2014). The introduction of the *Eichhornia crassipes*, or water hyacinth, has also had adverse impacts on the region by blocking boating access to the fishery and providing a breeding ground for disease carrying insects (Kayombo & Jorgensen 2006). Nutrient runoffs from increasing populations, agriculture, and industry in the region are also major contributors to hyacinth blooms (Kiage & Obuoyo 2011).

The funding required to research and improve the issues facing Lake Victoria is lacking and spotty between organizations who do not effectively communicate with one another. Despite the challenges that come with mitigating such a large body of water, several organizations have been making an effort to improve water quality, control invasive species, and facilitate collaboration on these issues among the nations which thrive off of Lake Victoria. SERVIR -The Regional Visualization and Monitoring System - is a joint venture between NASA and the US Agency for International Development (USAID), providing satellite-based Earth monitoring, imaging, and predictive models to help improve environmental decision-making among developing nations with hubs in Africa, the Hindu-Kush region of the Himalayas, and the lower Mekong River Basin in Southeast Asia. SERVIR - Africa, located in Kenya, has been collaborating with the Regional Centre for Mapping of Resources for Development (RCMRD) to monitor certain water quality parameters, as well as hyacinth extent, in Lake Victoria via satellite remote sensing techniques. Current efforts include mapping chlorophyll concentration, water surface temperature, and turbidity for Lake Victoria using the Moderate Resolution Imaging Spectrometer (MODIS) sensor on the Aqua satellite. In addition, preliminary efforts have been made to map the extent of the water hyacinth in the Winam Gulf in Kenya using Landsat imagery.

This project aimed to complement RCMRD and SERVIR’s efforts to gain a better understanding of the invasive water hyacinth. This was done by developing a water hyacinth detection algorithm using Landsat imagery to distinguish the water hyacinth from other algal growth in the lake. A Chlorophyll Extent Map was also developed to determine areas in need of mitigation and to prioritize study efforts. Collaboration with members from the SERVIR Coordination Office, the SERVIR Africa Team, and RCMRD was facilitated to reach this goal.

This project focused on the extent of the water hyacinth in Lake Victoria from August 2000 to the present. A subset of dates with known hyacinth presence during the study period was used to develop the detection algorithm. These dates were “\*TBD\*”.

This project addressed NASA’s national water resources application area by researching water quality and water hyacinth within the Winam Gulf in Lake Victoria. Monitoring the historical water quality of the lake achieved a better understanding of the degradation of the water quality and the growth of the water hyacinth.

# III. Methodology

**Data Acquisition** Landsat Surface Reflectance High Level GeoTIFF data products for Landsat 8 Operational Land Imager (OLI), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 4 and Landsat 5 Thematic Mapper (TM) were downloaded for WRS-2 path 170, row 60 from the United States Geological Survey (USGS) Earth Explorer website. Landsat 4-5 TM and Landsat 7 ETM+ imagery from this data product have had a MODIS atmospheric correction applied, in addition to a 6S radiative transfer model to generate top of atmosphere reflectance (TOA), surface reflectance, brightness temperature, and masks for clouds, cloud shadows, adjacent clouds, land, and water (USGS). Landsat 8 images from this data product were atmospherically corrected and converted to surface reflectance using the newly developed L8SR algorithm (USGS). Images with minimal cloud cover throughout the scene were selected to use.

● List dates downloaded and justification of why those dates were chosen...this can include rainfall patterns discovered through CHIRPS, seasonality, population, etc.

● Discuss data download of other datasets, TBD

**Data Processing**

To be determined.

**Data Analysis**

To be determined.

# IV. Results & Discussion

**Analysis of Results**

To be determined.

**Errors & Uncertainty**

Due to the climate over the Winam Gulf area of Kenya, cloud cover was a major issue with the Landsat imagery in this area. These factors decreased the number of usable Landsat images within the selected study period.

Due to the ever changing water levels at Lake Victoria, deriving an accurate shapefile of the lake was difficult. Throughout the study period, there were small gaps of spatial data along the coastline of the lake. This missing data could have water hyacinth and water quality values that may have been useful during the study.

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# Future Work

# As this project is proposed to last 2 terms, future work will include applying this algorithm to dates encompassing the entire study period.

# V. Conclusions

To be determined.

# VI. Acknowledgments

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# VII. References

Kayombo S. and Jorgensen SE (2006) Lake Victoria: experience and lessons learned brief. In: Lake Basin management initiative. http://www.ilec.or.jp/eg/lbmi/pdf/27\_Lake\_ Victoria\_27February2006.pdf. Accessed 25 Sept. 2015.

Kiage, Lawrence M., and Joyce Obuoyo. 2011. “The Potential Link Between El Nino and Water Hyacinth Blooms in Winam Gulf of Lake Victoria, East Africa: Evidence from Satellite Imagery.” Water Resources Management 25 (14): 3931–45. Web. 9 Sept. 2015.

Nkalubo, Winnie, Lauren Chapman, and Fredrick Muyodi. “Feeding Ecology of the Intensively Fished Nile Perch, Lates Niloticus, in Lake Victoria, Uganda.” Aquatic Ecosystem Health & Management 17.1 (2014): 62–69. Web. 2 Oct. 2015.

Odada, E., Daniel O. Olago, and W. Ochola. Environment for Development: An ecosystems assessment of lake Victoria basin environmental and socio-economic status, trends and human vulnerabilities. Kenya: United Nations Environment Programme (UNEP) and Pan African START Secretariat (PASS), 2006. Web. 2 Oct. 2015.

# VIII. Content Innovation

* Interactive Map Viewer
* TBD
* TBD

# IV. Appendices

TBD