Water Hyacinth: A Growing Problem

A Remote Sensing Analysis of Water Hyacinth Growth Across Kenya's Winam Gulf in Lake Victoria

INTRODUCTION

Lake Victoria is the second largest freshwater lake in the world whose shoreline is shared by Kenya, Uganda and Tanzania. Only a small section of the lake reaches into Kenya's western border, a nearly horizontal arm covering an area of approximately 4,128 km^2 or about six percent of the lake's total area, called Winam Gulf.

Lake Victoria is of great socio-economic value to its riparian states as the major source of freshwater for domestic, agricultural, and industrial purposes in the area. More than 40 million people rely on the lake's historically thriving fish stocks for food and livelihood. More than half of these dependents live below the international poverty index.

Rapid urbanization and economic development are key drivers of water pollution in Winam Gulf. Small outdated factories and water management systems pump raw, untreated effluent directly into Winam Gulf, saturating the lake with nutrients and degrading water quality.

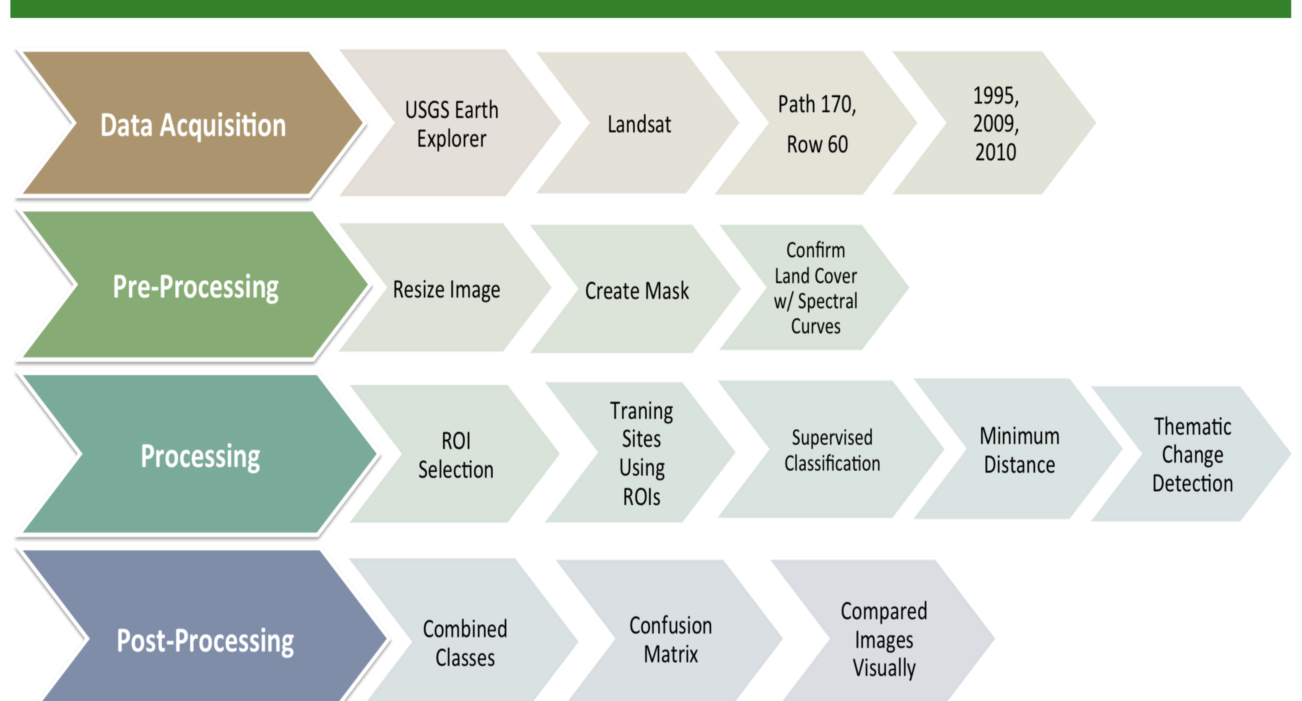
Common water hyacinth (*Eichornia crassipes Mart. solms*) is native to the Amazonian basin. Considered one of the most productive plants in the world, hyacinth takes over any ecosystem to which it's introduced, with vegetative doubling rates of one to two weeks. Its expansive, densely packed mats block sunlight from penetrating the water column to support other aquatic plants, causing them to die. Plant respiration and biomass decay result in oxygen depletion and fish kills, greatly limiting any other species' ability to survive. Hyacinth thrives in the nutrient-rich waters of Lake Victoria, covering massive expanses of coastline, and creating dense hyacinth-islands through the middle of the lake, blocking and re-routing transport routes on this valuable tri-country waterline.

This intense growth has greatly impacted biodiversity of the other plants and fish in Lake Victoria. Fishermen report dwindling catch and affected fishing areas due to thick growth. Boats become entrapped within the quick-growing weed.

Economic impacts of the weed have included the clogging of irrigation canals, choking off of navigational routes, smothering of rice paddies and increase in habit for disease-transmitting vectors, such as mosquitoes, and poisonous aquatic snakes.

This remote sensing analysis aims to determine the change in growth and distribution of water hyacinth across Winam Gulf, Kenya's portion of Lake Victoria, over a 15-year period, between 1995 and 2010.

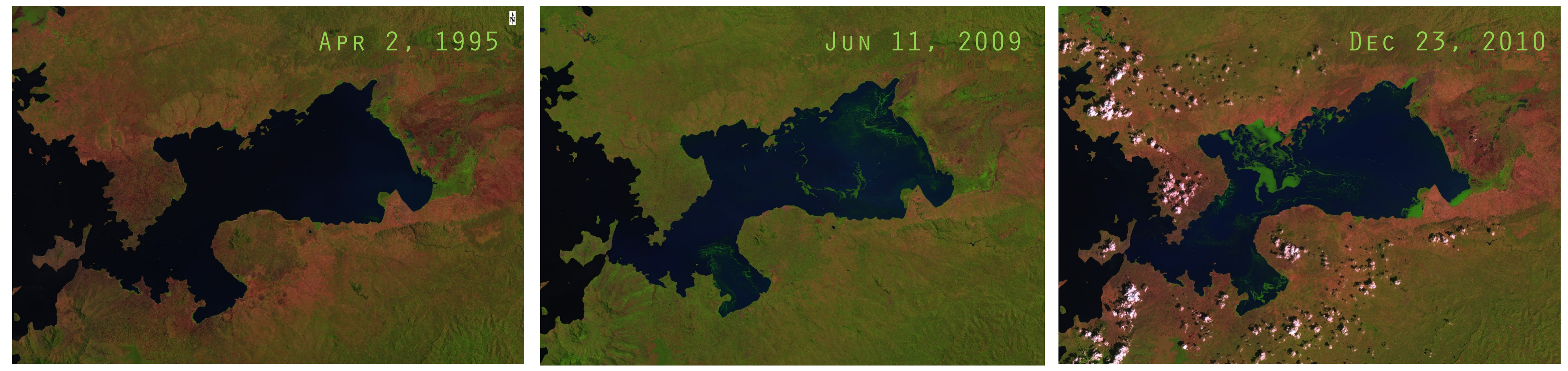
WORKFLOW



METHODS

Data Acquisition:

Images were acquired from USGS Earth Explorer using Tier 1 data from Landsat 5 (1995) and Landsat 7 (2009 and 2010) taken from Path 170, Row 60 on three separate dates within a 15-year timeframe. Raw images were resized to focus on the area of interest, Winam Gulf within Kenya's portion of Lake Victoria and shown in RGB: 5, 4, 3.

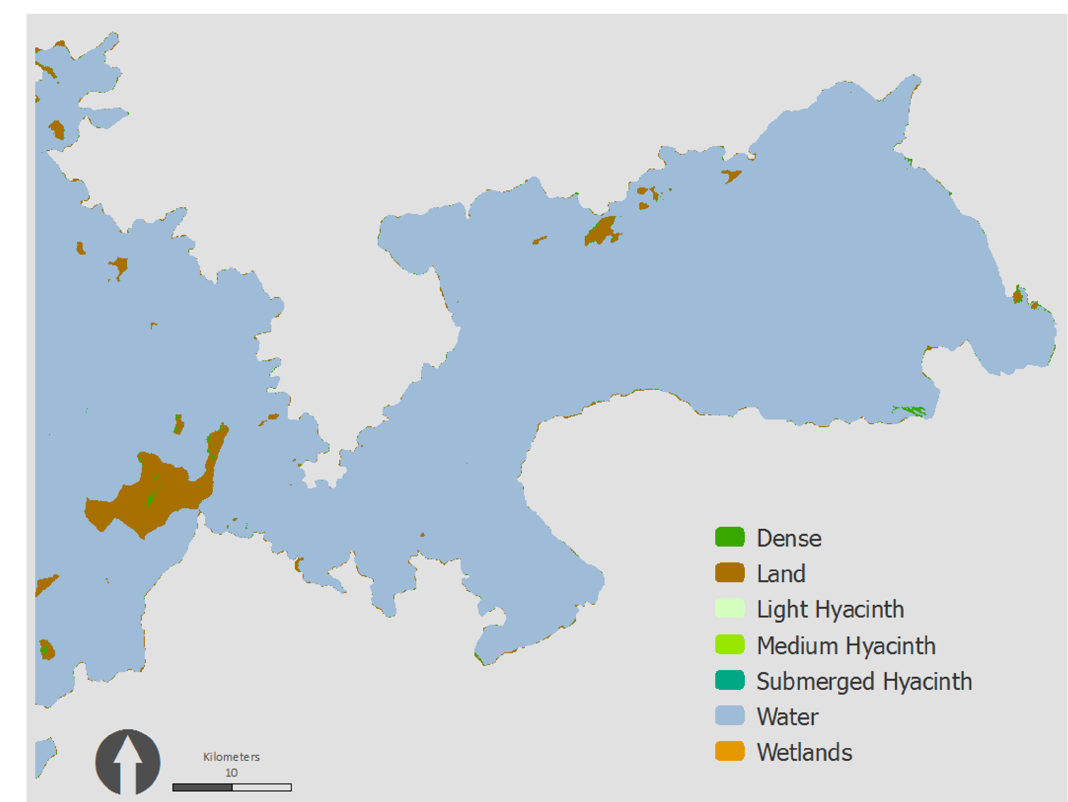


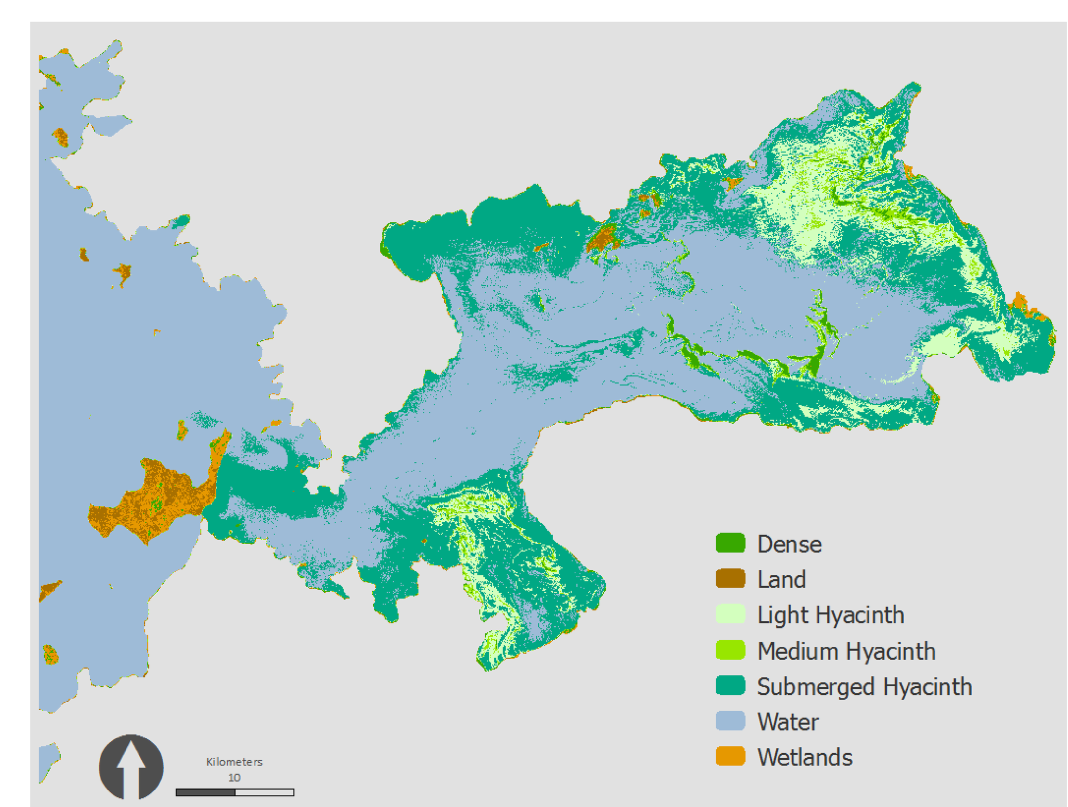
Supervised Classification:

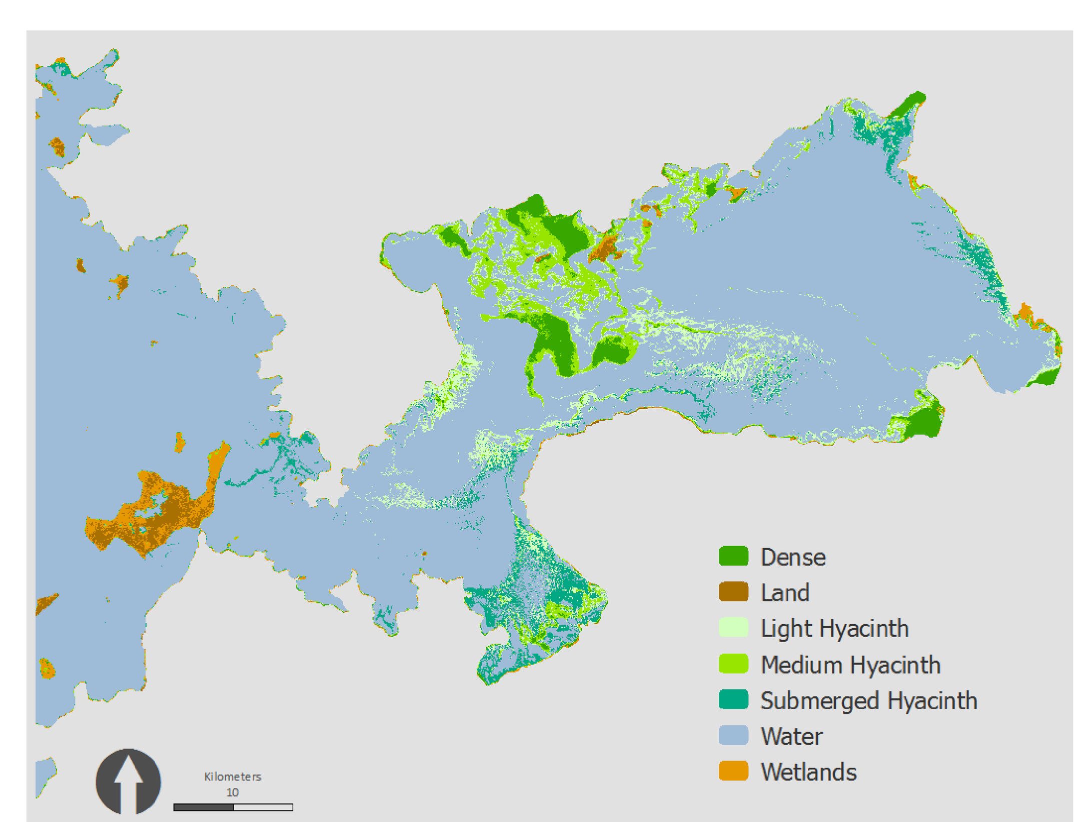
The minimum-distance classification assigns each pixel to a class based on their Euclidian distance to the mean spectral value of each class. In this method, the mean distance is calculated for every pixel in the image, and then it is assigned to the class of the closest spectral signature.

Using the same assortment of land cover types to create individual ROI sets for each image, this tool was applied to the 1995, 2009, and 2010 images. A land mask was created and used for each classification in order to remove land pixels from the analysis. For the 1995 image, which had a very small amount of homogeneously dense hyacinth, only three classes were created. They were water, land, and hyacinth. For both 2009 and 2010, which had significantly more variation and dispersal of hyacinth cover, classifications were created for each, which are detailed in the table to the right.

Once each image was accurately classified, they were visually analyzed and compared to each other to observe differences between them. Again, it was clear that the majority of hyacinth growth occurred between 1995 and 2009, and that hyacinth became much denser between 2009 and 2010.







RESULTS

The change between 1995 and 2009 is likely due to many of the causes of water quality degradation mentioned previously created by rapidly expanding human settlements. 1997 is cited as the worst year of water hyacinth density over Lake Victoria, but in that same year, several interventions were put into place to combat the spread. The interventions, such as weed-eating water beetles and chemical removal techniques, had varying reports of success and failure, but fall within a Landsat 5 data gap so could not be analyzed.

The slight decline between 2009 and 2010 could be due to seasonality on the lake. The June, 2009 image should have been in Kenya's dry season, yet it is the lushest and most vegetated image among the three. The converse is true for the December, 2010 image, which should appear densely vegetated, but instead appears dry. It's possible that these months fall on the edge of their respective seasons and the vegetation is catching up to their normal lushness. Drought may also be a contributing factor.

LIMITATIONS

- Anniversary images without significant cloud cover were not available within this range of dates
- Due to de-centralized data storage, Landsat 5 had a 5-year data gap in this area from 1995-2000, during which time many interventions were made to water hyacinth on the lake, the results of which are not available for remote sensing analysis
- Limited supporting data available for this area due to poor reporting by governmental agencies on the ground
- Limited knowledge of ENVI tools by analyst
- Limited time in which to conduct a meaningful analysis

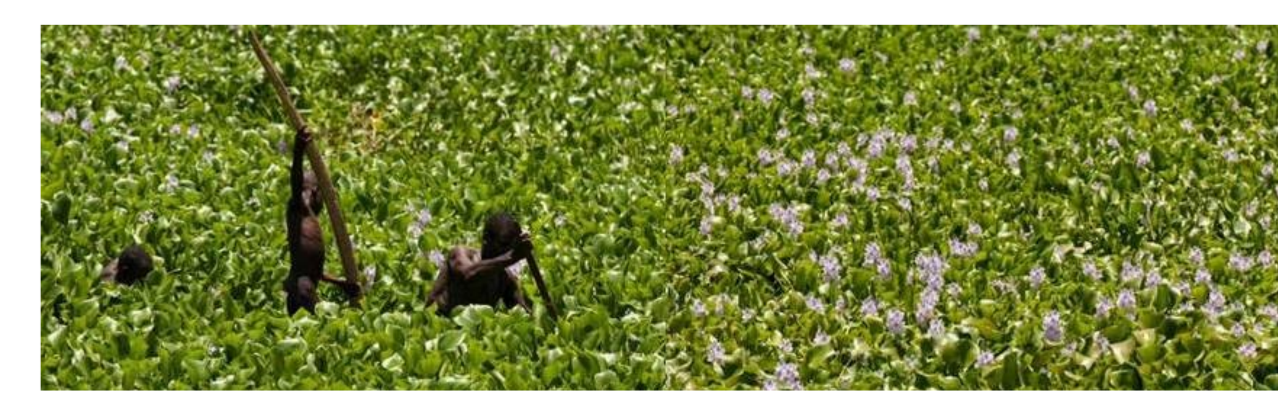
CLASSIFICATIONS

Classification	Description
Submerged Hyacinth	Translucent areas of wispy dark aqua-green in false-color composite
Light-Density Hyacinth	Opaque areas of hyacinth, but widely dispersed, not matted
Medium-Density Hyacinth	Wider-set areas of hyacinth interspersed with water, not densely matted
Dense Hyacinth	Densely-matted areas of hyacinth, shown as bright green in false-color
Land	Dry soil, mostly comprising islands within the gulf
Wetland	Land with high moisture content, identified by spectral curve
Water	Areas of open water with no evidence of hyacinth growth

CHANGE DETECTION

The Thematic Change Workflow was conducted to examine the change between 1995 and 2009, between 2009 and 2010, and finally between 1995 and 2010. The thematic change detection process identifies changes in pixel numbers for each classification compared to every other classification. The resulting images were classified into 81 different classes, as each class is analyzed individually against each other class. To better understand the change in hyacinth growth, the Combine Classes tool was used to combine classes of no change and those of change. Due to the shifting nature of the hyacinth in each image, the Thematic Change images were not very useful to the analysis, as the change between years reflected the classified hyacinth. Thematic Change Detection was useful in evaluating percent change, however. Change in hyacinth growth between years was:

Years	Change in Pixels	Percent Change
1995 — 2009	+ 829,926	+ 13,158 %
2009 — 2010	- 7,027	- 0.84 %
1995 — 2010	+ 822,899	+ 13,047 %



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