Spatiotemporal modelling & automated *in-situ* sensors to monitor Harmful Algal Blooms(HABs)

Case Study-Lake Victoria

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Reg. No: ENC222-0149/2017

Introduction

- Toxic Cyanobacteria-rich Harmful Algal Blooms (CyanoHABs) , a phenomenon which turns water bodies **dark blue-green** due to eutrophication; potentially harming humans and animal, e.g., Unsightly nuisance, acute liver damage when ingested, irritation, massive fish deaths, etc.
  (Santoleri et al., 2003), WHO

- Hence, quantifying the spatial distributions of CyanoHABs in L. Victoria is of great significance, which requires high spatiotemporal resolution monitoring. (Sitoki et al., 2012)

- There however exists that niche to support the space observations with a near-real time geointelligent in-situ monitoring and reporting system.

Problem statement

- The rapidly escalating demographics along L. Victoria riparian reserves has negatively impacted water quality through deposits of agricultural, industrial runoff and sewer refuse eutrophicating the said region. (Burkholder et al., 2006; MOH)

- Deterioration in water quality initiates ecosystem conflicts, poor economic growth, reduced tourism, poor water quality furthermore baring achievement of SDG 6 & 14- Clean Water and Sanitation. (Hecky et al., 2010)

- Coupling wide spread spatiotemporal monitoring, and automated in-situ sensors will play a big deal in return. This would inform the Govt. and the general public the affected zones, calling for immediate remedy actions.

Justification

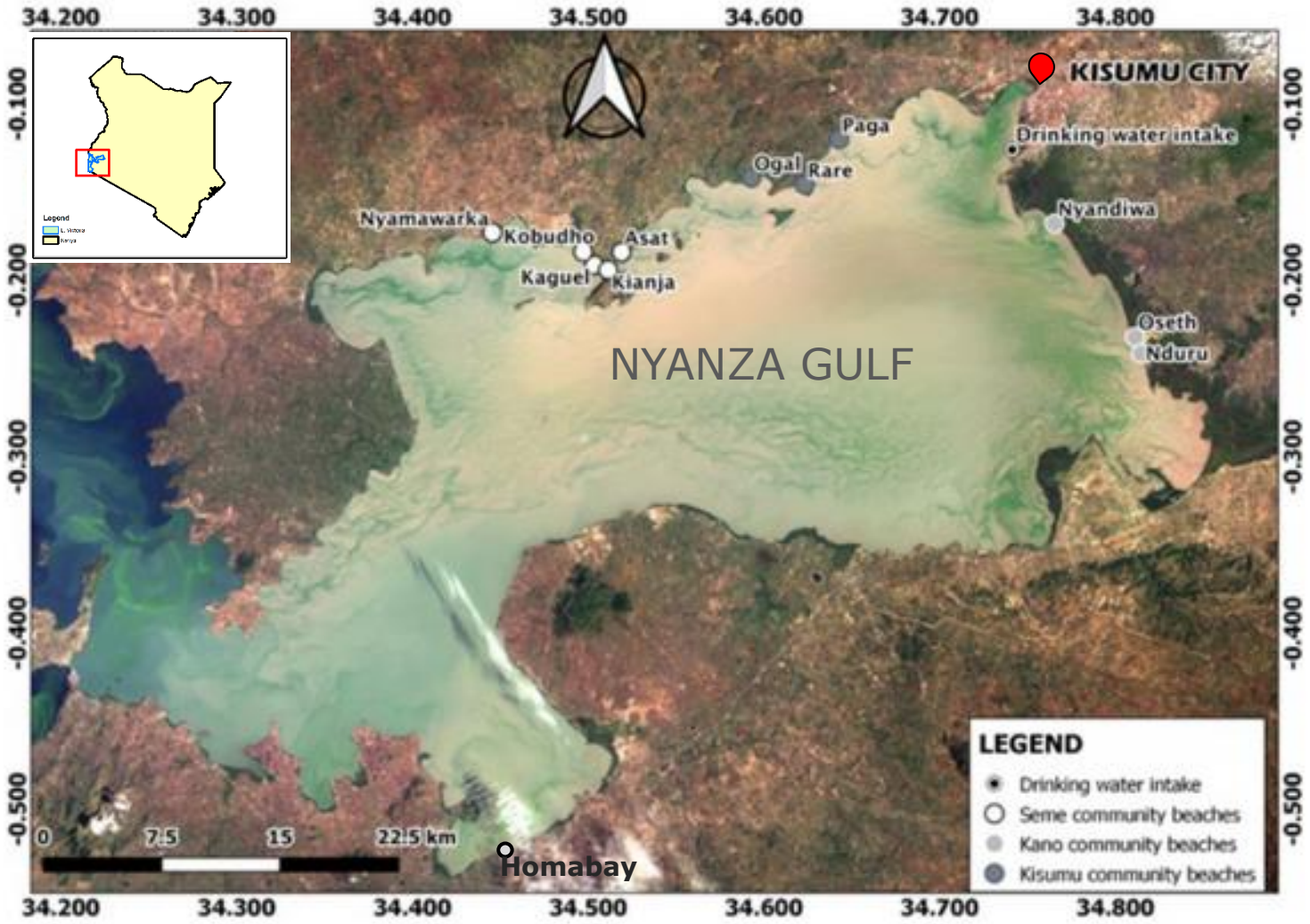
Image Sources: Standard Media KE, KMFRI, allAfricawaters

General and specific objectives

- To detect, monitor and report the occurrence of Harmful Algal Blooms(HABs) and Cyanobacteria in Lake Victoria.

  - To monitor chlorophyl-a(chl-a) concentration from L8 OLI images.
  - To monitor Lake Surface Water Temperature(LSWT) from L8 TIRS images as another HAB indicator in L. Victoria.
  - To develop automated Internet of Things (IoT) *in situ* sensors, Applicable in near real-time to monitor and report geo-tagged Water quality data.

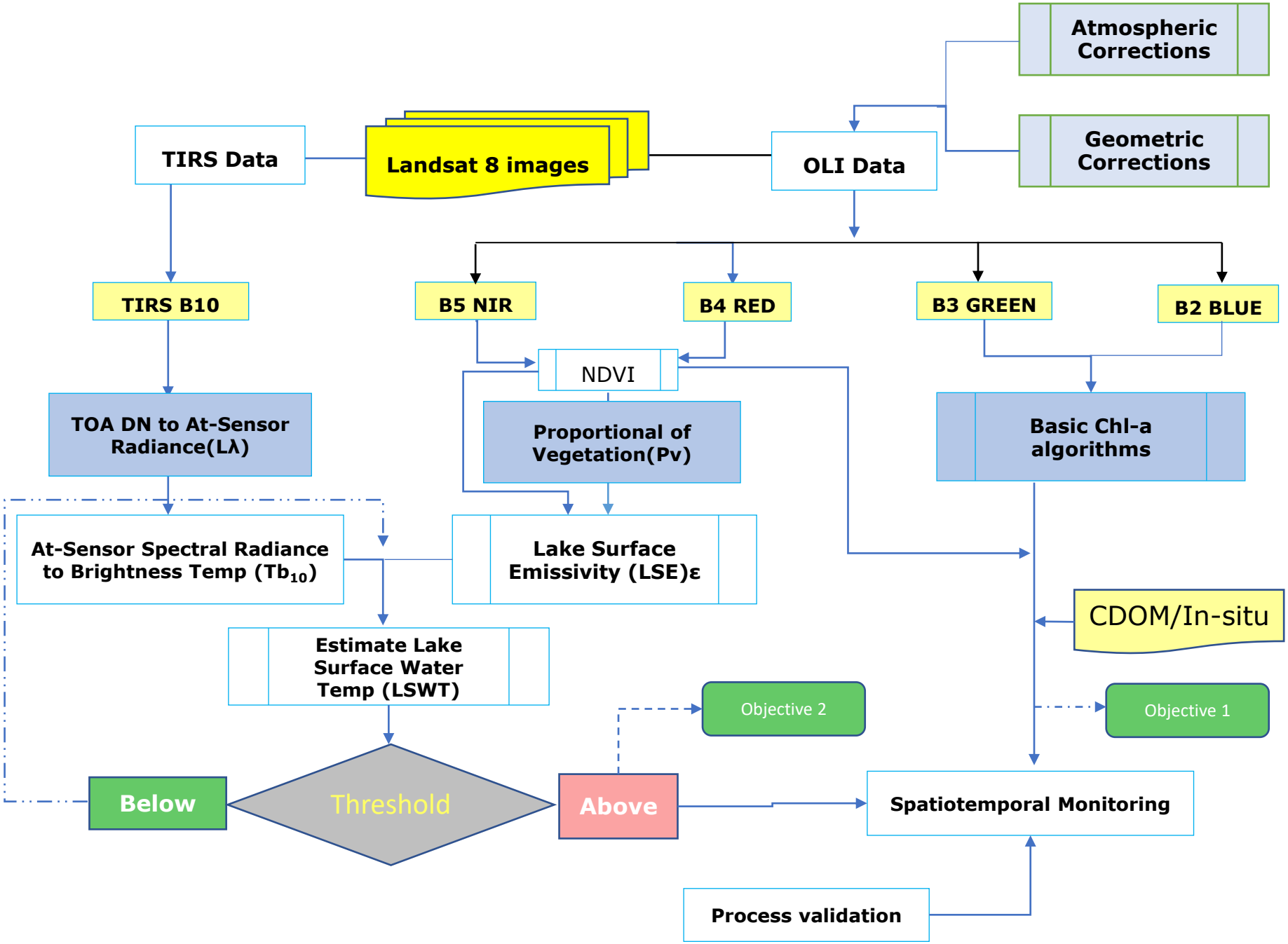
Study Area


34.200
34.300
34.400
34.500
34.600
34.700
34.800
-0.100
-0.200
-0.300
-0.400
-0.500
KISUMU CITY
Drinking water intake
Paga
Ogal
Rare
Nyandiwa
Nyamawarka
Kobudho
Asat
Kaguel
Kianja
Oseth
Nduru
NYANZA GULF
Homabay
0
7.5
15
22.5 km
LEGEND
Drinking water intake
Seme community beaches
Kano community beaches
Kisumu community beaches

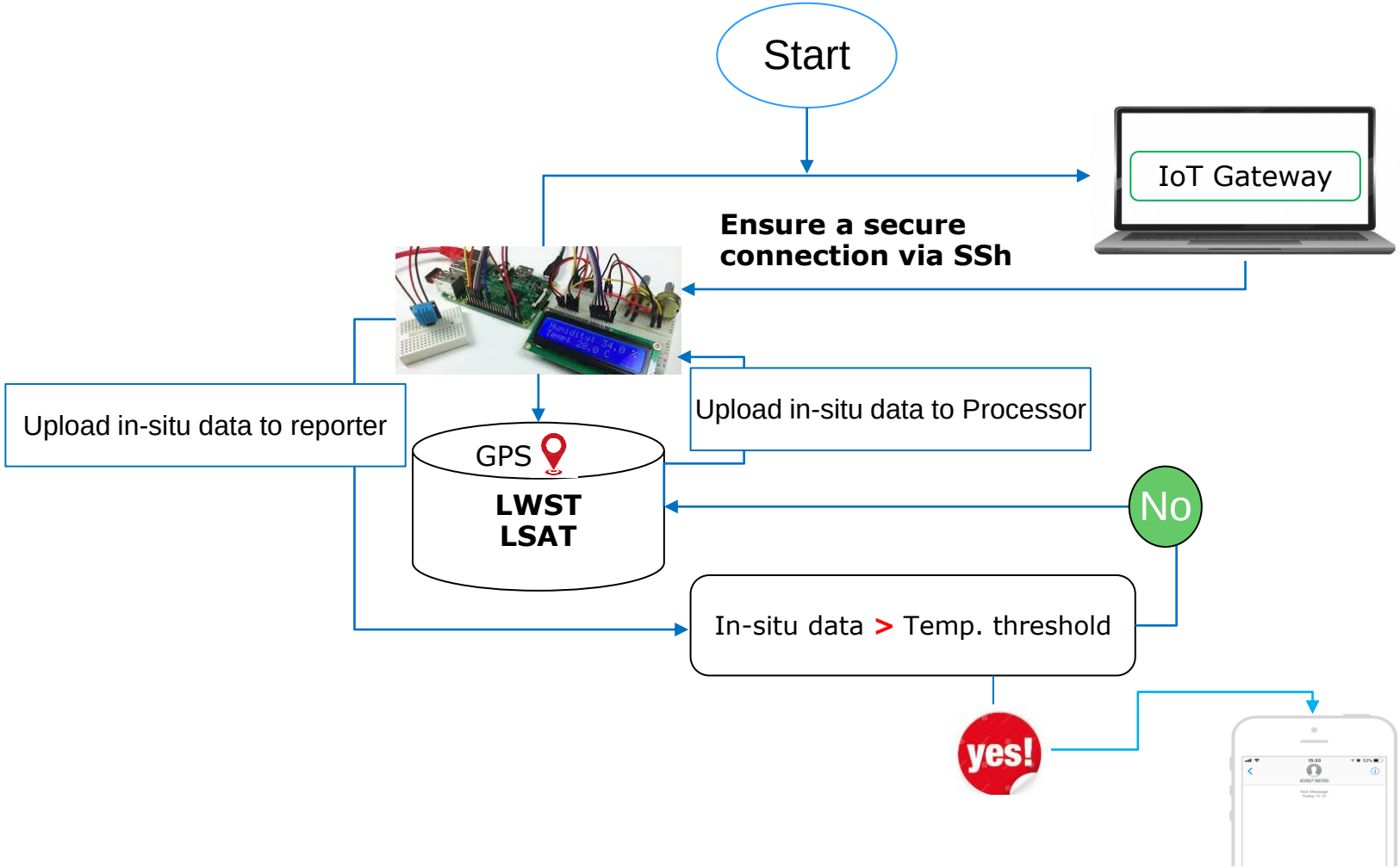
Overall Methodology : Data and Materials

Data Type	Source	Role/Use
Landsat 8 OLI (30m, 16 days)	Google Earth Engine (2015-2021)	Spatiotemporal HAB Monitoring
Landsat 8 TIR (100m, 16 days)	Google Earth Engine (2015-2021)	Lake Surface Water Temperature Monitoring(LSWT)
Meteorological Data	Kenya Marine & Fisheries Research Institute-KMFRI (2015-2021)	Water Quality assessment
Shapefiles	Geodatabase of Global Administrative areas-GADM	Delineate the Study area
In-Situ Data	In-situ Sensors 2021 Onwards	Continued In-Situ Algal Monitoring

Tool/Material	Role	Availability
Google Earth Engine (GEE)	Geocomputation & Processing	Freely Available
QGIS/ArcMap, R & Python	Further Analysis & Maps	Free
Microcontroller & Sensors	In-Situ data Monitoring	Local Purchase
KiCAD	Design the Schematics & basic Circuits	Free & Open source


Atmospheric Corrections
Geometric Corrections
TIRS Data
Landsat 8 images
OLI Data
TIRS B10
B5 NIR
B4 RED
B3 GREEN
B2 BLUE
NDVI
TOA DN to At-Sensor Radiance(Lλ)
Proportional of Vegetation(Pv)
Basic Chl-a algorithms
At-Sensor Spectral Radiance to Brightness Temp (Tb_{10})
Lake Surface Emissivity (LSE)ε
CDOM/In-situ
Estimate Lake Surface Water Temp (LSWT)
Objective 2
Objective 1
Below
Threshold
Above
Spatiotemporal Monitoring
Process validation

Overall methodology



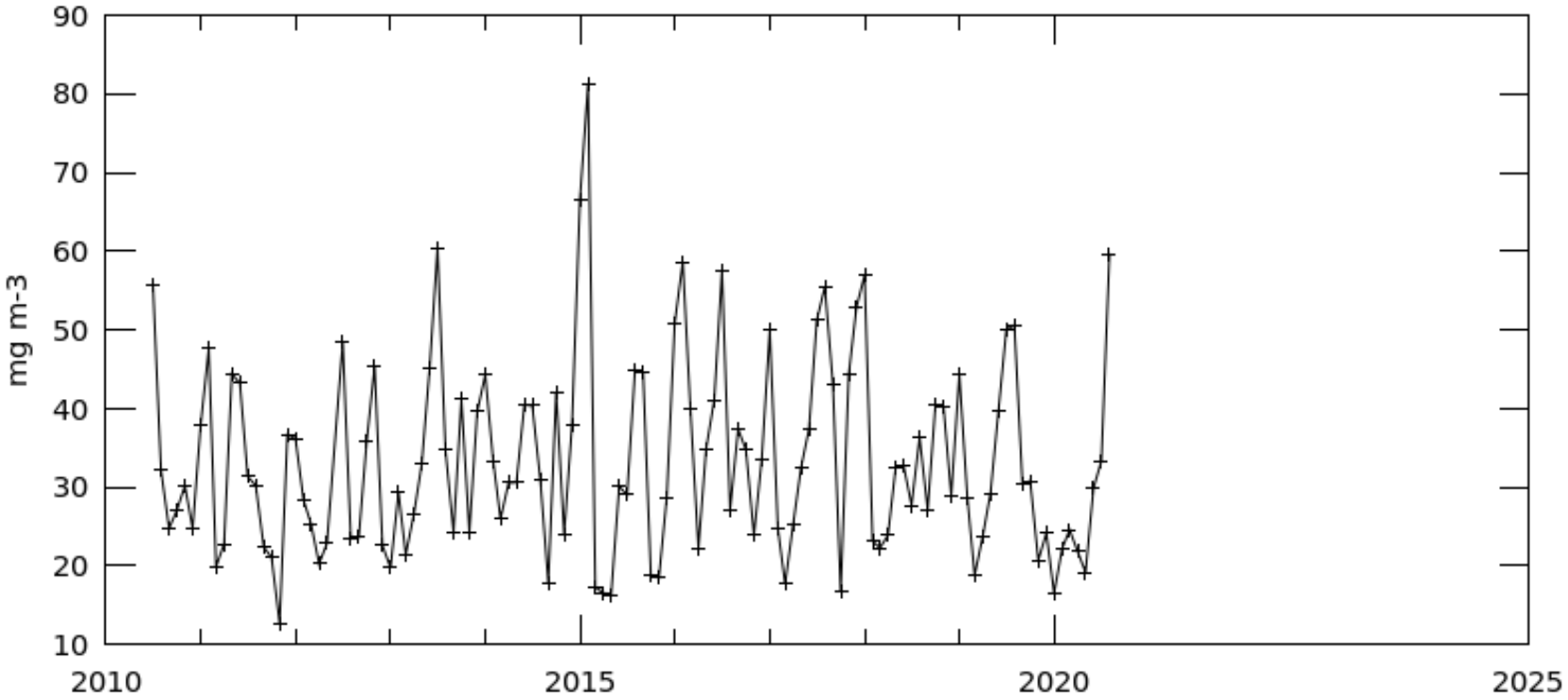
Expected Results

I. Chlorophyl-a Geographical Maps associating the occurrence of the Harmful Algal Blooms and Cyanobacteria.

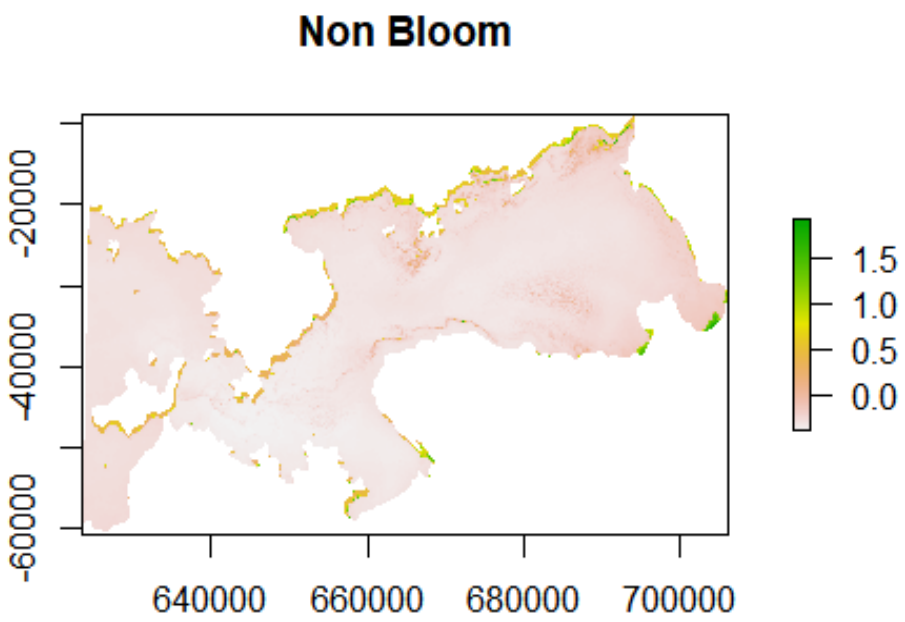
II. Lake Surface Water Temperature(LSWT) Maps associating the presence of HABs.

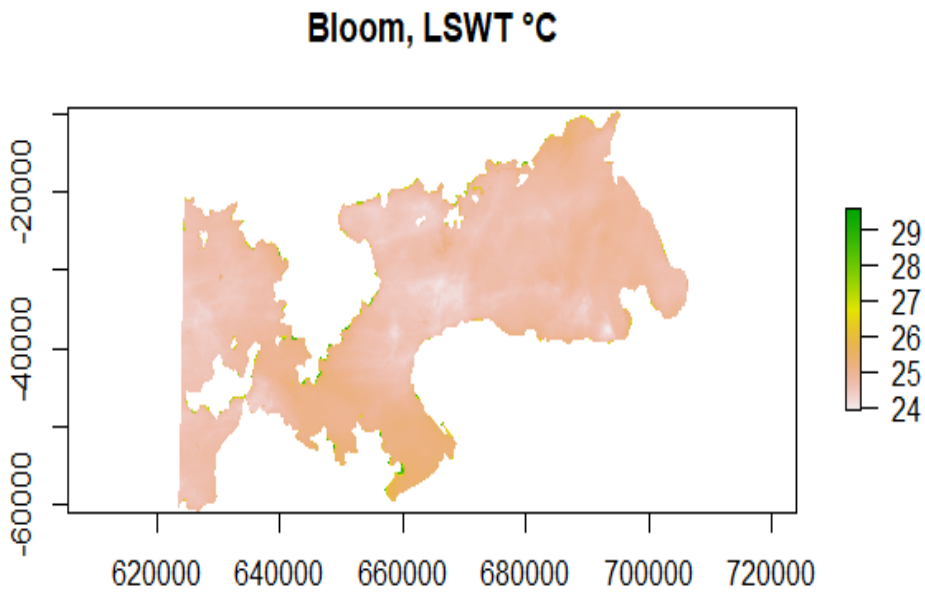
III. Autonomous system that monitors and reports geo-tagged water quality data in near-real time from the *in-situ* sensors.

SAMPLE RESULTS: Time series Average of Chl-a conc. monthly 4-Km MODIS L3m

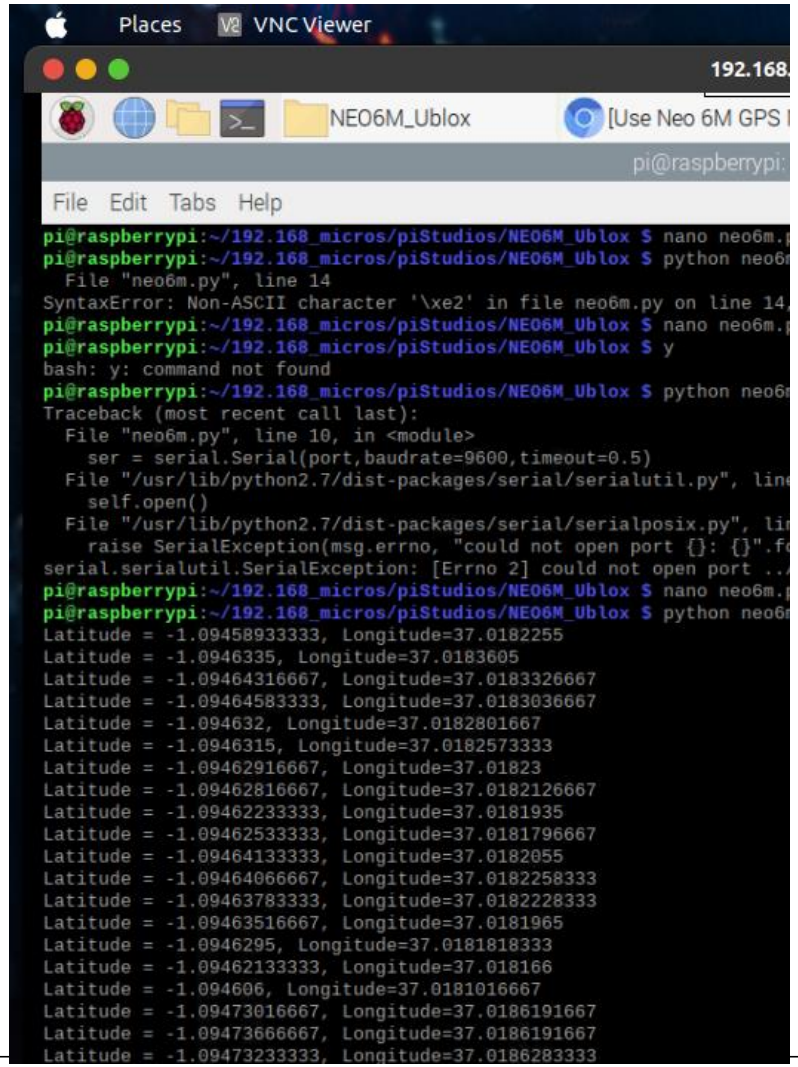


L8 2015: No Bloom Reported (cl-g map) Vs LSWT Map at Bloom Event.





Obtaining GPS Location, Water Temp and Relative Humidity from Sensors.




```
pi@raspi-53 ~/sensors/dht11 $ time sudo ./dht11 -r 10
1, humidity: 44.0 | temperature: 23.0
2, humidity: 43.0 | temperature: 23.0
3, humidity: 44.0 | temperature: 23.0
4, humidity: 44.0 | temperature: 23.0
5, humidity: 43.0 | temperature: 23.0
6, humidity: 43.0 | temperature: 23.0
7, humidity: 43.0 | temperature: 23.0
8, humidity: 43.0 | temperature: 23.0
9, humidity: 43.0 | temperature: 23.0
10, humidity: 43.0 | temperature: 23.0

real    0m11.710s
```

Project Timeline

	June - July	August	Sep	Oct	Nov	Dec
Chl-a	Literature Rev (Restructure)	Data Acquisition Preliminary results	Chl-a spatiotemporal Maps			
LSWT	Literature Rev (Restructure)		LSWT spatiotemporal Maps			
IoT	Literature Rev. Acquire all sensors	Unit tests	Long Range comm.		Full Data Acquisition and Dissemination	

Thank you for your attention! Questions?