

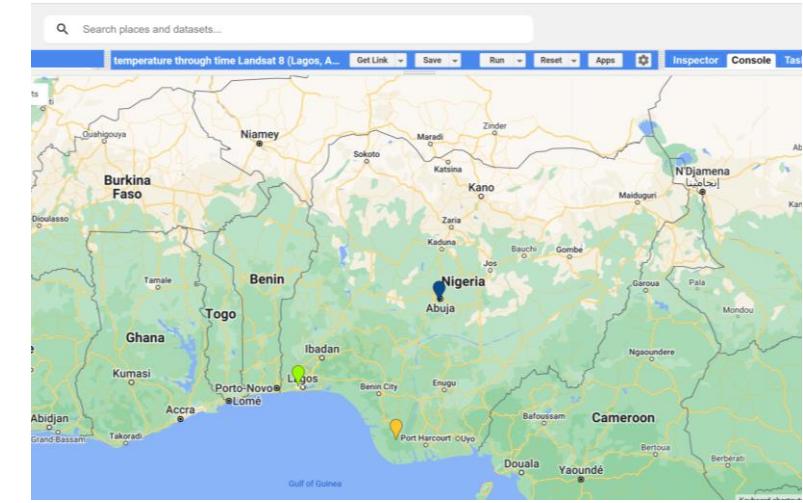
An aerial photograph showing a cluster of simple houses with corrugated metal roofs. The roofs are primarily red or brown, with some white-painted sections. The houses are surrounded by dense tropical vegetation, including palm trees and banana plants. The ground appears to be dirt or mud. The overall scene suggests a rural or semi-rural environment.

# Google Earth Engine

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(s1093361)

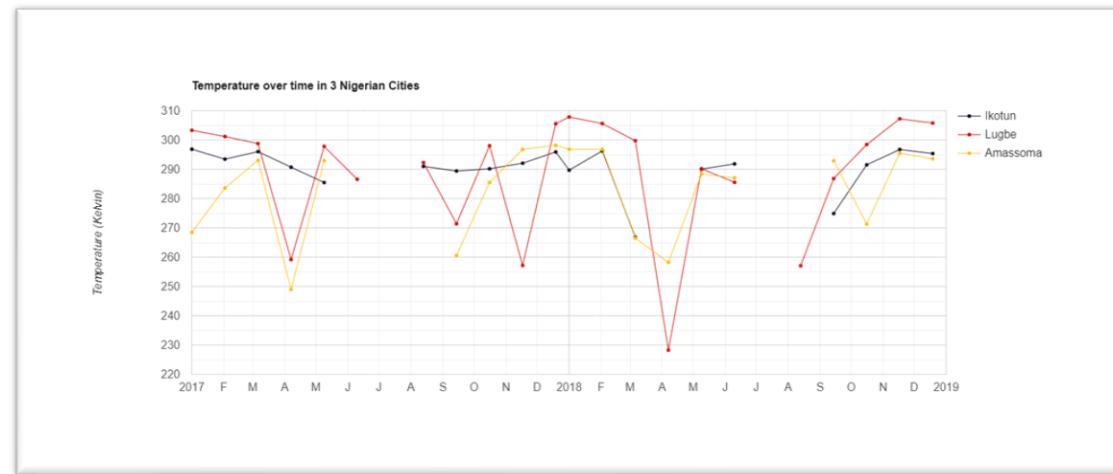
# Comparing Temperature Values from 3 Urban areas in different regions in Nigeria

- For this exercise, I decided to select typical urban settlements from the 3 different weather regions of Nigeria. Below is a brief introduction to the areas to give a bit of context.
- **Ikotun, Lagos State:** My home town in the heart of Lagos mainland, which is in the south western Nigeria, with one of the highest population densities in Nigeria.
- **Lugbe, Abuja:** In North Central Nigeria is one of the major residential areas in the Federal Capital Territory. Abuja's annual weather pattern is characterized by extremes (Cold and Hot).
- **Amassoma, Bayelsa:** Within the beautify Niger Delta, there exists one of the few mangrove rainforests in Nigeria. It is characterized by high temperature and humidity, and filled with settlements called creeks. Ammasoma is one such creek.



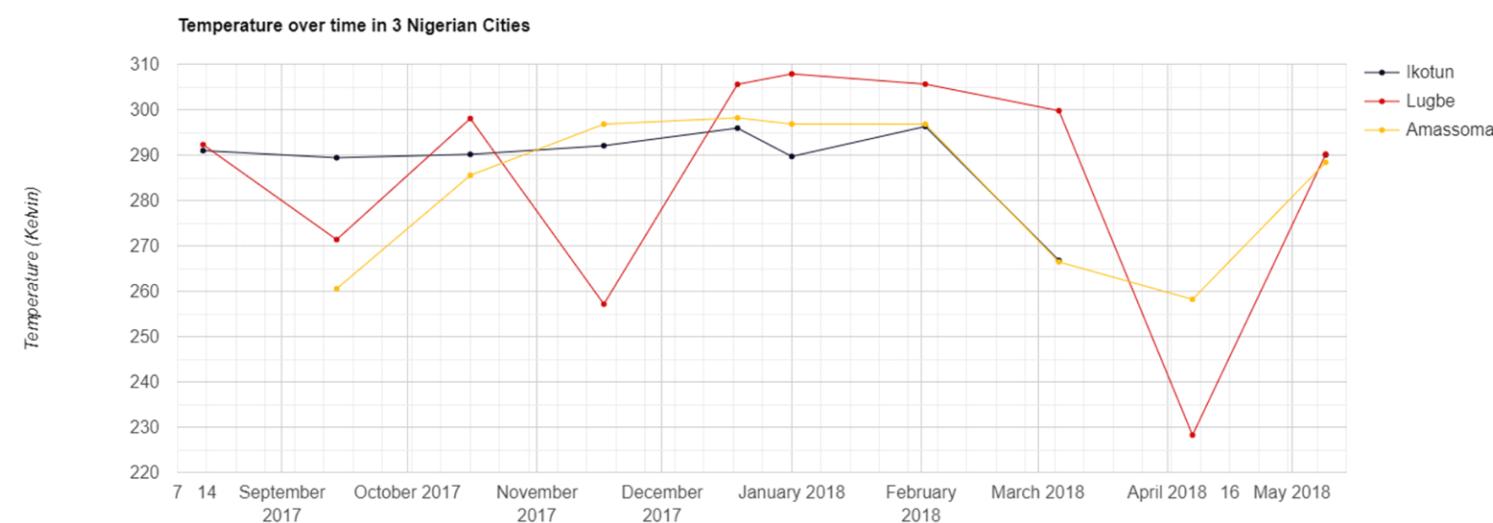
Ikotun, Lagos  
Lugbe, Abuja  
Amassoma, Bayelsa

```
temperature through time Landsat 8 (Lagos, Abuja, Bayelsa)
  * Imports (3 entries) ▾
    * var geometry: Feature 0 (Point, 1 property) ⓘ
    * var geometry2: Feature 0 (Point, 1 property) ⓘ
    * var geometry3: Feature 0 (Point, 1 property) ⓘ
  1 // Define a FeatureCollection: Ikotun, Lugebe, Amassoma
  2 var regions = ee.FeatureCollection([
  3   geometry,
  4   geometry2,
  5   geometry3
  6 ]);
  7
  8 // Load available Landsat 8 brightness temperature data for 1 year.
  9 var temp2017 = ee.ImageCollection('LANDSAT/LC08/C01/T1_3DAY_TOA')
 10   .filterDate('2017-08-13', '2018-06-10')
 11   .select(['B11']);
 12
 13 // Create a time series chart.
 14 var tempTimeSeries = ui.Chart.image.seriesByRegion(
 15   temp2017, regions, ee.Reducer.mean(), 'B11', 200, 'system:time_start', 'label'
 16   .setChartType('LineChart')
 17   .setOptions({
 18     title: 'Temperature over time in 3 Nigerian Cities',
 19     vAxis: {title: 'Temperature (Kelvin)'},
 20     lineWidth: 1,
 21     pointSize: 3,
 22     series: [
 23       0: {color: '#0371E'}, // red
 24       1: {color: "#00000"}, // green
 25       2: {color: '#FFBAA8'} // blue
 26     ]});
 27
 28 // Display.
 29 print(tempTimeSeries);
```



An earlier selection over a larger time span (Jan 2017 to Dec 2019) revealed a gap in image availability between June and August of both years.

# Code



# Resulting Chart

# NDVI Over 3 of Nigeria's Forrest Ecosystems

I decided to compare NDVI values over time for 3 of Nigeria's Forest Ecosystems.

**Omú Forest Reserve:** Located in South Western state of Ogun. Omú is one of Nigeria's most enduring forest conservation efforts.

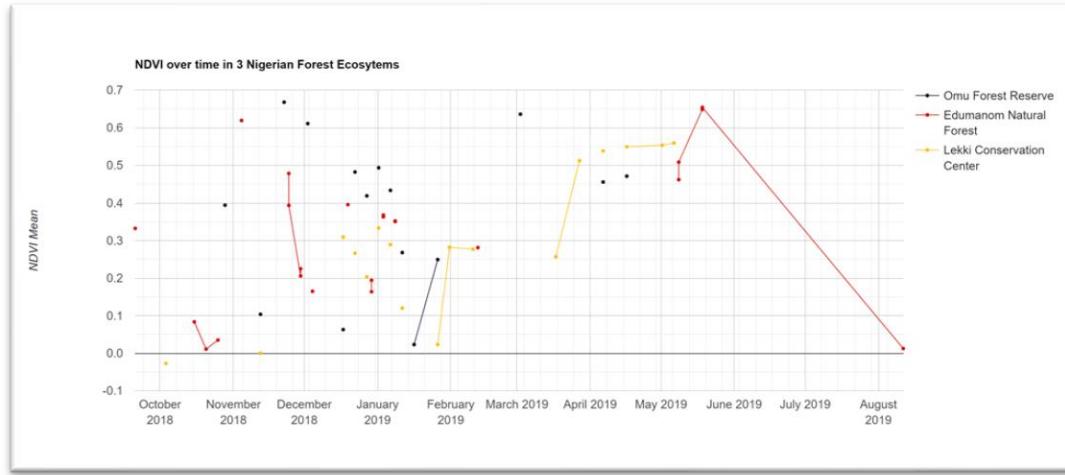
**Edumanom Natural Forest:** Is a mangrove forest conservation effort within the Niger Delta.

**Lekki Conservation Center:** is a relatively new effort to conserve a 78 hectare nature preserve at the heart of a very urbanized Lagos.

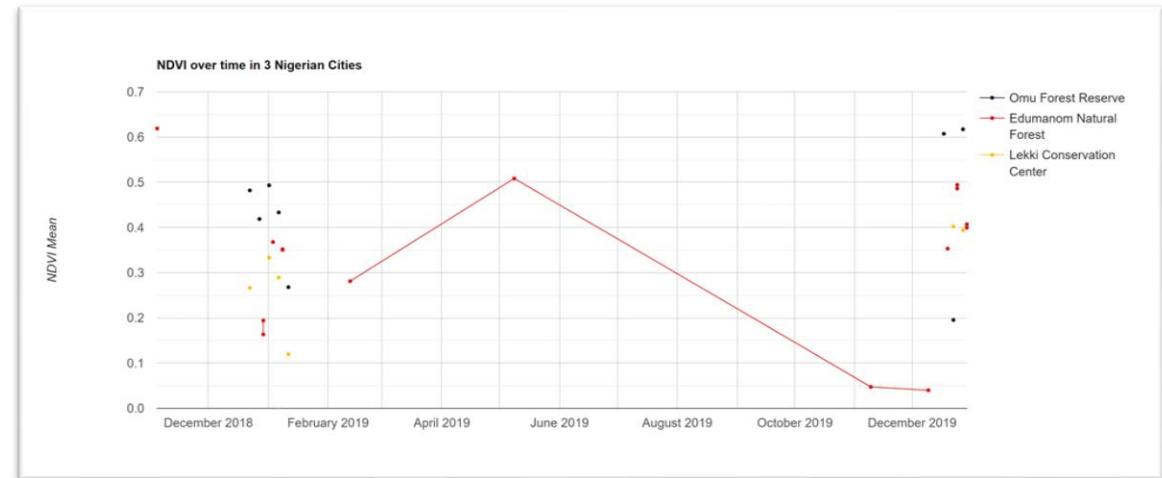
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NDVI(Sentinel-2).Regions_through_time *  
Get Link Save Run Reset Apps  
Imports (3 entries)  
+ var geometry: Feature (Point, 1 property)   
+ var geometry2: Feature (Point, 1 property)   
+ var geometry3: Feature (Point, 1 property)   
1 //Coordinates  
2 //Omú Forest Reserve, Bayelsa (4.41227803174266, 6.4268098861829)  
3 //Lekki Conservation Center (6.44014642054786, 3.5359872491276354)  
4 //Omú Forest Reserve (6.857734231168767, 4.356963668183962)  
5  
6 // TO COMPARE ndvi IN DIFFERENT REGIONS OVER TIME IN A CHART  
7  
8 // Define a FeatureCollection: Ammosuna in Bayelsa, Lekki in Lagos, Omú in Ogun  
9 var regions = ee.FeatureCollection([  
10   geometry,  
11   geometry2,  
12   geometry3  
13 ]);  
14  
15 var lng = 4.356963668183962;  
16 var lat = 6.4268098861829;  
17 var point = ee.Geometry.Point(lng, lat); // Omú  
var aoi = point.buffer(1000); // Create an area (1km buffer around point)  
Map.setCenter(lng, lat, 15); // Center the map on this location, zoom level 10  
21  
22 // Download the Sentinel-2 imagery collection  
var s2 = ee.ImageCollection('COPERNICUS/S2')  
.filterDate('2018-09-01', '2019-12-31')  
.filterMetadata('CLOUDY_PIXEL_PERCENTAGE', 'less_than', 20)  
//.filterBounds(aoi);  
27  
28  
29 // Function to calculate and add an NDVI band  
30 var addNDVI = function(image) {  
31   return image.addBands(image.normalizedDifference(['B8', 'B4']));  
32 };  
33  
34 // Add NDVI band to image collection  
var s2 = s2.map(addNDVI);  
35  
36  
37 // Add NDVI band to image collection  
var s2 = s2.map(addNDVI);  
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```

# What I did differently!

From the previous chart, I noticed that I was getting significantly lower values for my NDVI for a forest. On closer inspection of the NDVI (after adding to map), I discovered significant cloud cover which impeded a proper estimation of NDVI. I therefore reduced the cloud cover specification to **20**.



Before (30% Cloud Cover)



After (20% Cloud Cover). Notice there are fewer images available to process

# Focusing on one forest at a time

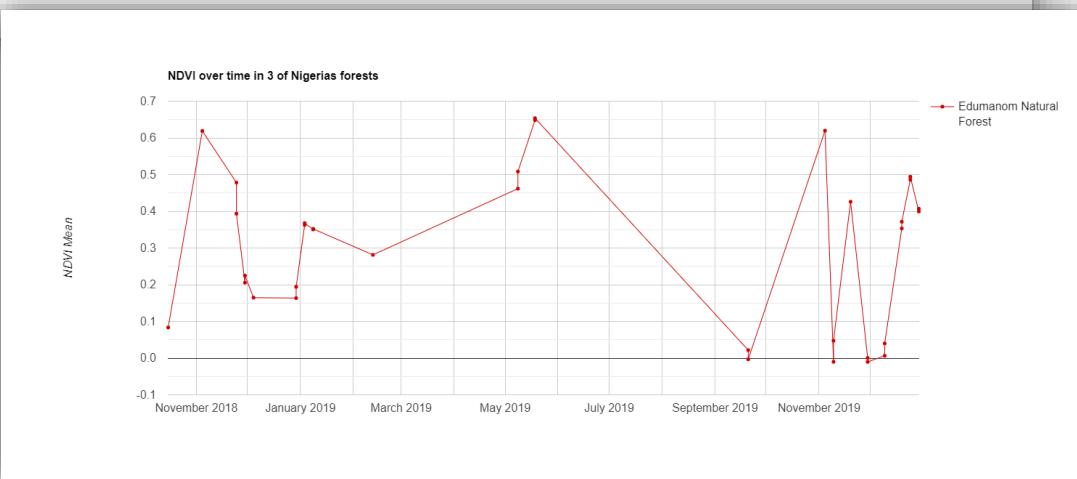
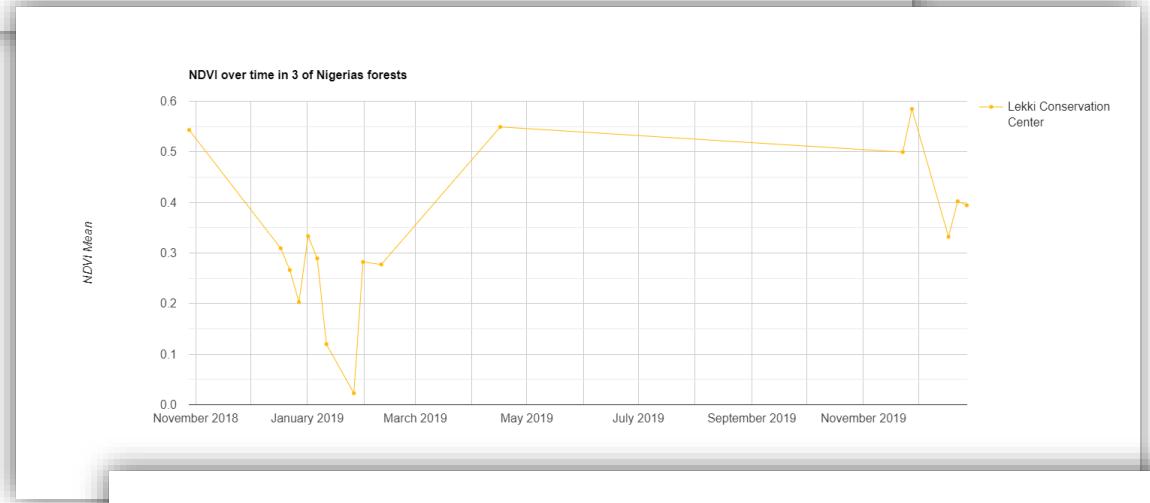
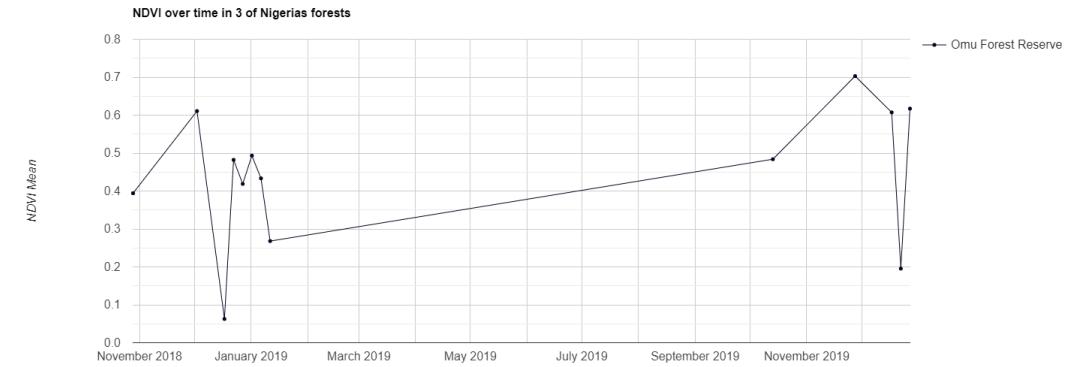
By setting an aoi (for each forest coordinates) and filtering the image collection by that, I focus the chart on each of the forests, so that I have a dedicated chart to each forest NDVI over time. This results in a less messy chart.

For each chart, the aoi coordinates correspond with the region.

The remaining code is the same for all, except the line color specification

```
NDVI(Sentinel-2)_Regions_through_time
Get Link Save Run Reset Apps
* Imports (3 entries)
  var geometry: Feature 0 (Point, 1 property)
  var geometry2: Feature 0 (Point, 1 property)
  var geometry3: Feature 0 (Point, 1 property)

1 //Coordinates
2 //Edumanom Natural Forest, Bayelsa (4.412270201574268, 6.42680908061829)
3 //Iledeki Conservation Center (6.440146643054786, 3.5359872491276354)
4 //Omù Forest Reserve (6.857734283160767, 4.356963608183962)
5
6 // TO COMPARE ndvi IN DIFFERENT REGIONS OVER TIME IN A CHART
7
8 //Define a FeatureCollection: Ammasoma in Bayelsa, Lekki in Lagos, Omù in Ogun
9+ var regions = ee.FeatureCollection([
10   //geometry,
11   //geometry2,
12   geometry3
13 ]);
14
15 // var lng = 4.356963608183962;
16 // var lat = 6.857734283160767;
17 // var point = ee.Geometry.Point(lng, lat); // Omù
18 // var aoi = point.buffer(1000); // Create an area (1km buffer around point)
19 // Map.setCenter(lng, lat, 15); // Center the map on this location, zoom level
20
21 // var lng = 6.42680908061829;
22 // var lat = 4.412270201574268;
23 // var point = ee.Geometry.Point(lng, lat); // Bayelsa
24 // var aoi = point.buffer(1000); // Create an area (1km buffer around point)
25 // Map.setCenter(lng, lat, 15); // Center the map on this location, zoom level
26
27 var lng = 3.5359872491276354;
28 var lat = 6.440146643054786;
29 var point = ee.Geometry.Point(lng, lat); // Lekki
30 var aoi = point.buffer(1000); // Create an area (1km buffer around point)
31 Map.setCenter(lng, lat, 15); // Center the map on this location, zoom level
32
33
34 // Download the Sentinel-2 imagery collection
var s2 = ee.ImageCollection('COPERNICUS/S2')
35 .filterDate('2018-09-01', '2019-12-29')
36 .filterMetadata('CLOUDY_PIXEL_PERCENTAGE', 'less_than', 20)
37 .filterBounds(aoi);
38
39
40
41 // Function to calculate and add an NDVI band
var addNDVI = function(image) {
42   return image.addBands(image.normalizedDifference(['B8', 'B4']));
43 }
44
45
46 // Add NDVI band to image collection
var s2 = s2.map(addNDVI);
47
48
49 // Extract NDVI band and create NDVI median composite image
var NDVI = s2.select(['nd']); // the newly added NDVI Band
50 var NDVImin = NDVI.min();
51 var NDVImax = NDVI.max();
52
53
54
55 // Create a time series chart, using Mean reducer
var tempTimeSeries = ui.Chart.image.seriesByRegion(
56   NDVI, regions, ee.Reducer.mean(), 'nd', 200, 'system:time_start', 'label')
57   .setChartType('LineChart')
58   .setOptions({
59     title: 'NDVI over time in 3 of Nigeria's forests',
60     vAxis: {title: 'NDVI Mean'},
61     lineWidth: 1,
62     pointSize: 3,
63     series: [
64       {0: {color: '#03071E'}, // ~ Xiketic
65        0: {color: '#000000'}, // ~ Rosso Corsa
66        0: {color: '#FFBA08'}} // ~ Selective Yellow
67    ]});
68
69
70 // Display the chart
print(tempTimeSeries);
71
```



# Surface Temp (Desert, Rainforest)

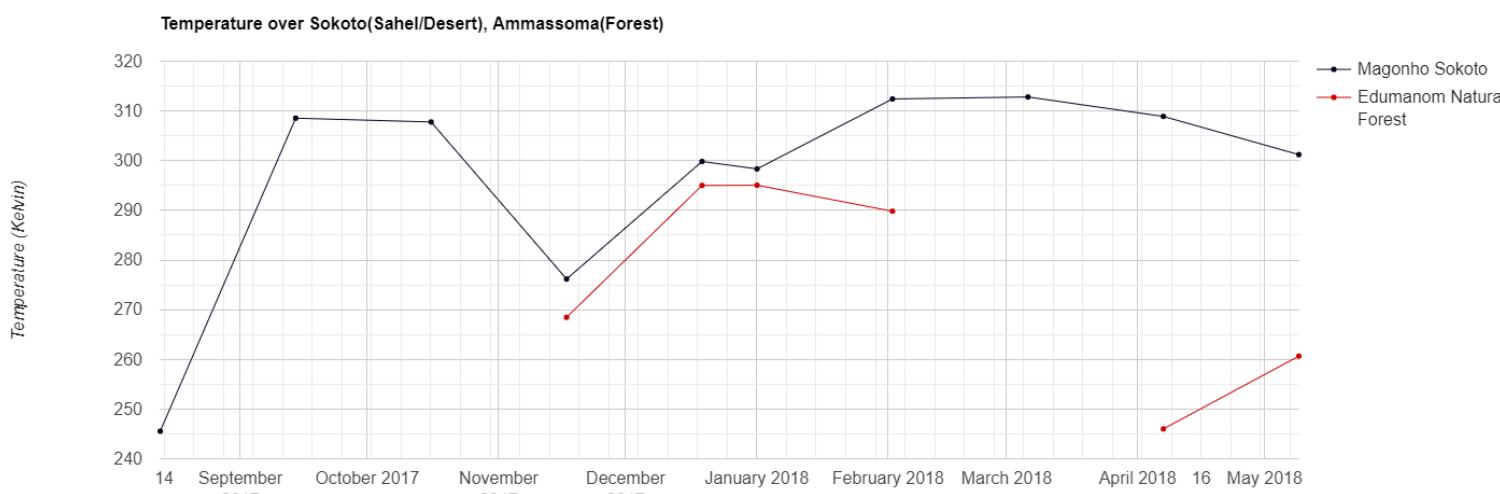
Lastly, I compared surface temperature between 2 different land use types (Savanna/Desert type) and (Mangrove Rainforest).

It is important to note that although there is significant temperature variation between the two, with the Desert type temperature being higher (characterized by sharp contrasts), temperatures in mangrove is high as well, compounded by the unusually high humidity.

```
temperature through time Landsat 8 (Desert, Rainforest)
Get Link Save Run Reset Apps
Imports (2 entries)
var geometry: Feature 0 (Point, 1 property)
var geometry2: Feature 0 (Point, 1 property)

// Define a FeatureCollection: Ammassoma, Sokoto
var regions = ee.FeatureCollection([
  geometry,
  geometry2,
]);
// Load available Landsat 8 brightness temperature data for 1 year.
var temps2017 = ee.ImageCollection('LANDSAT/LC08/C01/T1_32DAY_TOA')
  .filterDate('2017-08-13', '2018-06-10')
  .select('B11');

// Create a time series chart.
var tempTimeSeries = ui.Chart.image.seriesByRegion(
  temps2017, regions, ee.Reducer.mean(), 'B11', 200, 'system:time_start', 'label')
  .setChartType('LineChart')
  .setOptions({
    title: 'Temperature over Sokoto(Sahel/Desert), Ammassoma(Forest)',
    vAxis: {title: 'Temperature (Kelvin)'},
    lineWidth: 1,
    pointSize: 3,
    series: [
      0: {color: '#03071E'}, // ~ Xiketic
      1: {color: '#D00000'}, // ~ Rosso Corsa
    ]);
// Display.
print(tempTimeSeries);
```



There are many missing values for Edumanom Natural Forest. This may be due to there being significantly fewer TOA cloud-free composites for the area than for Sokoto.

An aerial photograph of a rural area. A paved road runs diagonally from the bottom left towards the top right. Several smaller paths or tracks branch off from the main road. The land is divided into various agricultural fields, some with dark, plowed soil and others with green crops. Power lines with utility poles are visible across the scene. The lighting suggests it's either early morning or late afternoon, casting long shadows.

# EO Browser

Opeyemi Kazeem-Jimoh  
(s1093361)

# Script Used : Historic NDVI Changes with Landsat 4-5TM and Landsat 8

- This script was developed by Monja B. Šebela @ Sinergise, to show how NDVI values have changes over a span of years. It does not refer to change in cropping cycles (hence it is important to compare images within the same time of year for the different years you analyse), rather the potential long term de-vegetation and revegetation of land.
- The script uses **data-fusion** technique, by analytically comparing historic Landsat 4-5 Level 2 imagery with contemporary Landsat 8-9 Level 2 imagery.
- Vegetation reduction (pink) could be indicative of urban growth, or deforestation, and an increase (green) may imply agricultural land expansion, or reforestation.
- In my example, I applied this script to the city of **Salzburg, Austria** and **Ikorodu, Nigeria** with significantly different results.
  - While I found less significant changes in the vegetative cover of Salzburg, which could be indicative of little to no changes in the land use over the years (Salzburg being an ancient city has seen most of its urban growth even before remote sensing became a thing), the situation is significantly different for Ikorodu, which over the past 30 years (1984 - 2021), has seen significant de-vegetation, and surprisingly revegetation in some parts.

# Script Used : Historic NDVI Changes with Landsat 4-5TM and Landsat 8

How it works:

NDVI is calculated for both collections, and returned in RGB to display changes. In the output, the recent Landsat 8 NDVI is displayed in the green channel, and the historic Landsat 4-5 TM NDVI in both red and blue channels.

The resulting RGB image shows green, where vegetation cover was high on a more recent image and low on an older one, thus indicating vegetation cover increase. Pink color indicates high vegetation cover on the older date and low on a newer one, thus indicating reduction in vegetation cover.

# The script

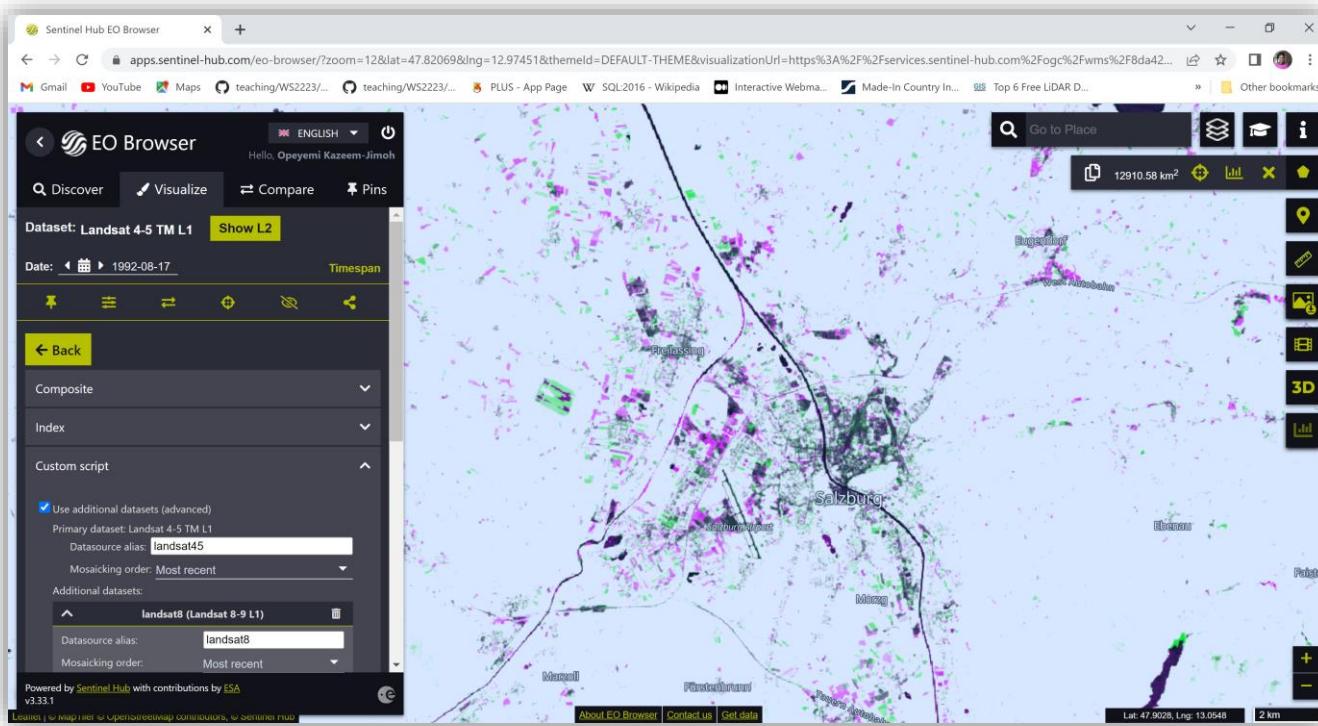
*The first part of the script sets up the samples list for both datasets (Landsat 4-5 and Landsat 8).*

```
function setup() {  
    return {  
        input: [  
            {datasource: "landsat45", bands:["B04",  
"B03","dataMask"], mosaicking: "ORBIT"},  
            {datasource: "landsat8", bands:["B05",  
"B04","B03","dataMask"], mosaicking: "ORBIT"}  
        ],  
        output: [  
            { id: "default", bands: 3, sampleType:  
SampleType.AUTO }  
        ]  
    };  
}
```

*The second part calculates the NDVI for both current and historic datasets individually, the outputs RGB values with the historic NDVI in R and the newer one in Green and Blue.*

```
function evaluatePixel(samples, inputData,  
inputMetadata, customData, outputMetadata) {  
    var L8 = samples.landsat8[0]  
    var L45 = samples.landsat45[0]  
    let oldNDVI = (L45.B04 - L45.B03) / (L45.B04 + L45.B03)  
    let newNDVI = (L8.B05 - L8.B04) / (L8.B05 + L8.B04)  
  
    let val = [2*oldNDVI, 2*newNDVI, 2*oldNDVI];  
    return {  
        default: val  
    }  
}
```

# Salzburg

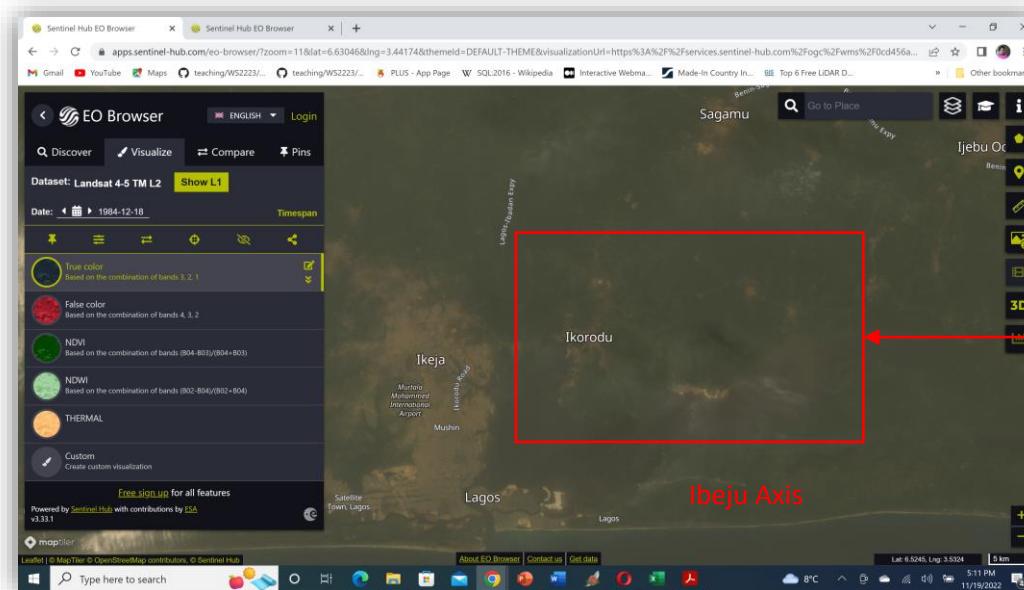


Salzburg from 1992-08-17 to 2022-08-04 shows areas where the vegetative cover has reduced. Although this does not happen on as large a scale as Ikorodu for example, mainly because the city structure has been established long before remote sensing became a thing, it indicates that many vegetative parcels of land have since become repurposed.

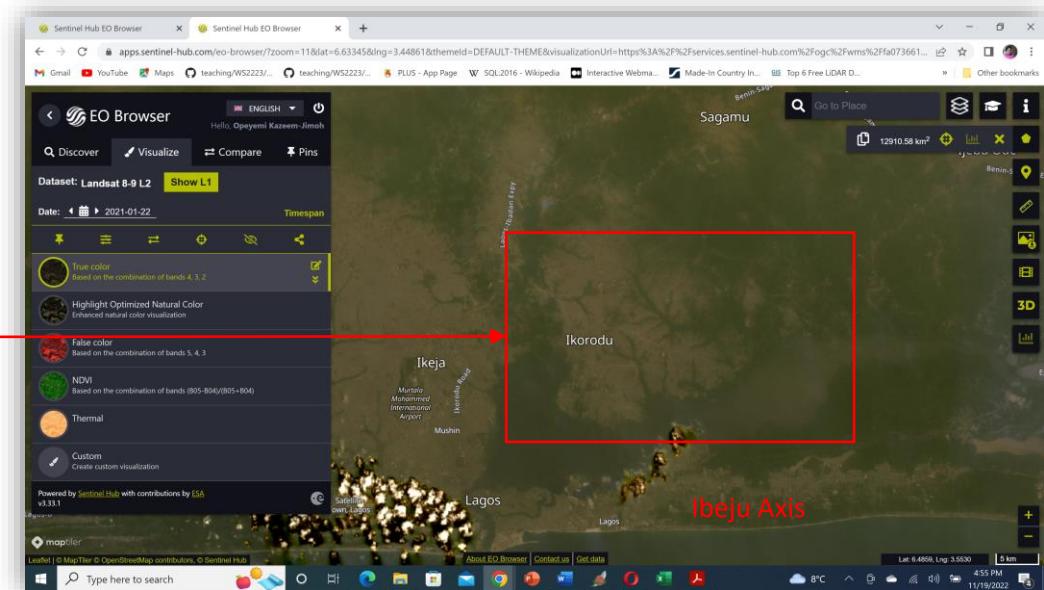
Overall, there is a higher degree of de-vegetation than re-vegetation.

# Ikorodu, Lagos

- Ikorodu is a metropolitan city in the heart of Lagos Mainland, and has seen significant growth and urbanization in the past 30 years. This coupled with the fact that I grew up here prompted me to run this analysis, mainly to see how the urban center has grown over time.
- Ibeju's growth happened in the past 10 years mainly, but this is also captured here.

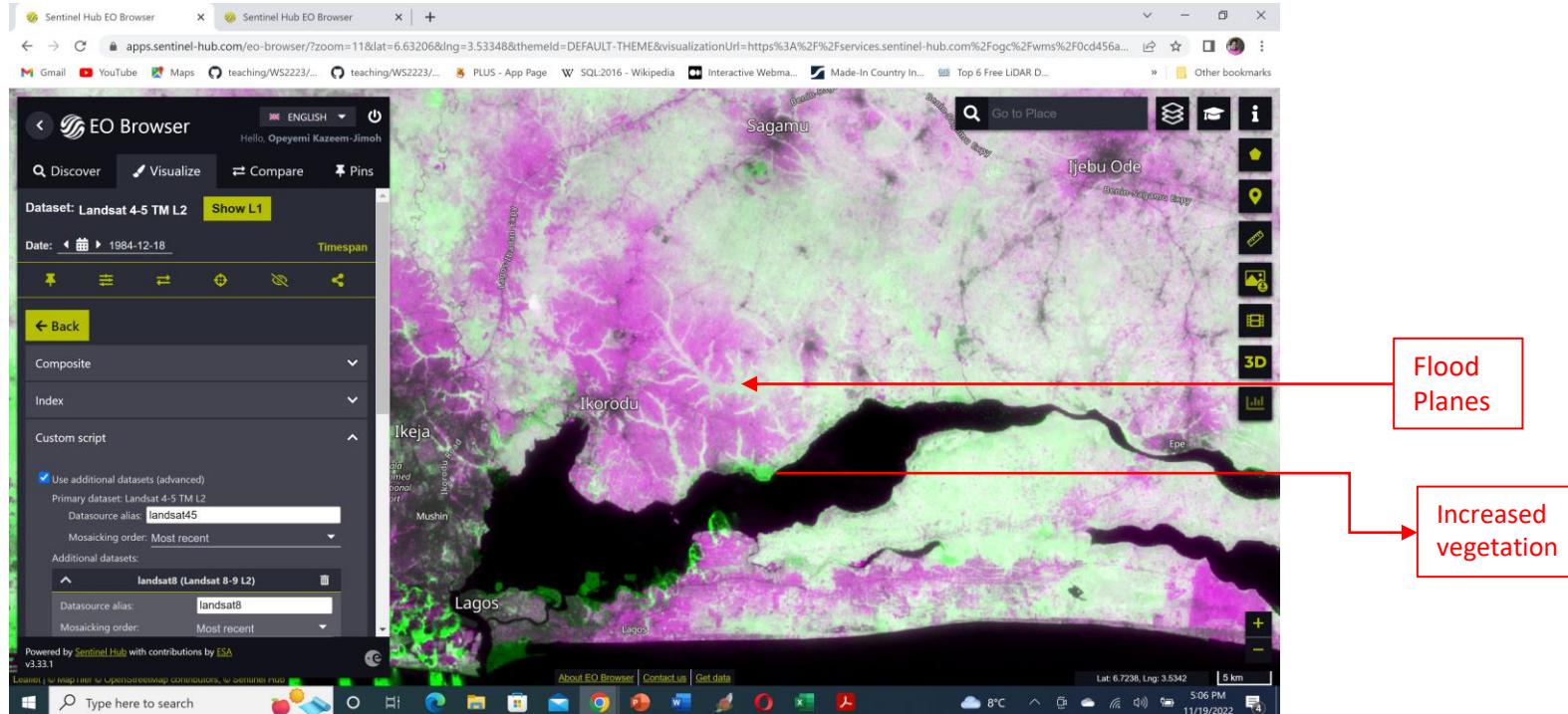


Landsat 4-5 Level 2  
Imagery of Ikorodu  
(date: 1984-12-18)



Landsat 8-9 Level 2  
Imagery of Ikorodu  
(date: 2021-01-22)

# Ikorodu Result



Ikorodu and Ibeju clearly show significant reduction in vegetation over time. Like I said in the previous slide, this can be alluded to widespread human settlement and growth in the urban area. The places that remain relatively unchanged are the lowland flood planes.

Something I find particularly curious is the increased vegetation in the south eastern tip of Ikorodu. On closer inspection it looks like reforestation from bare/sandy land and not agricultural land expansion, which I find peculiar, because this would mean that the area was abandoned and reclaimed by nature, something that is not common in that part of the world, for its lack of conservation prowess. Unfortunately I could not find any historical records to explain this, as at the time of submission.

Overall, there is a higher degree of de-vegetation than re-vegetation.

# What I did differently;

- Although the [example](#) uses Landsat 4-5 and Landsat 8 TM Level 1 imagery, I used Leve 2 of both because I realize that it give more accurate values and is less affected by shadows as the imagery is much sharper.
- Also, I have noticed that clouds cause false estimates, therefore, it is pertinent that cloud free imagery is use.

