Report on Land Cover Change Detection in Kisumu

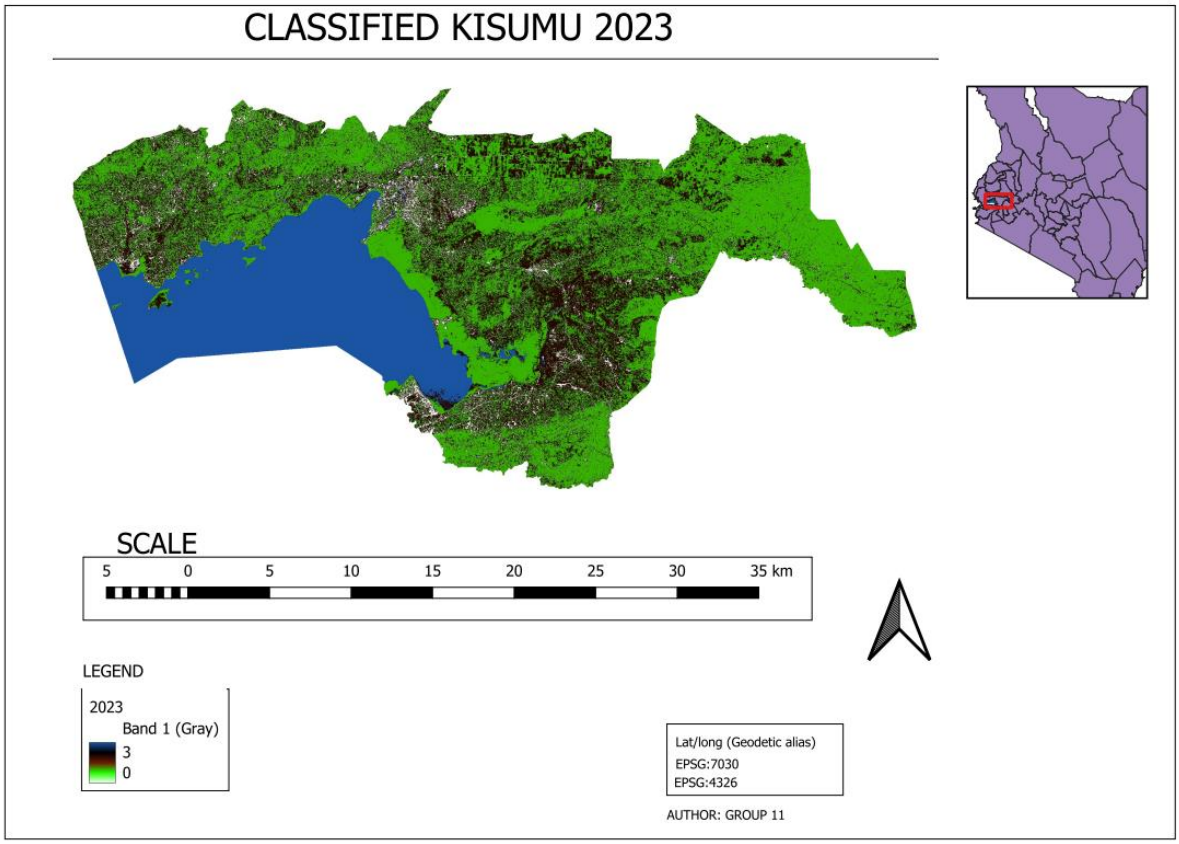
1. Introduction

This project aims to analyze land cover changes in Kisumu, Kenya, by comparing satellite imagery from different years.

Utilizing the Google Earth Engine (GEE) platform, we examine land cover changes between 2020 and 2024.

The primary goal is to identify shifts in land cover types, such as vegetation, water bodies, built-up areas, and bare land, while enhancing the analysis through NDVI application and accuracy assessment.

2. Study area



3. Objectives

To classify land cover types using Sentinel-2 satellite imagery.

To determine the areas of each land cover classes.

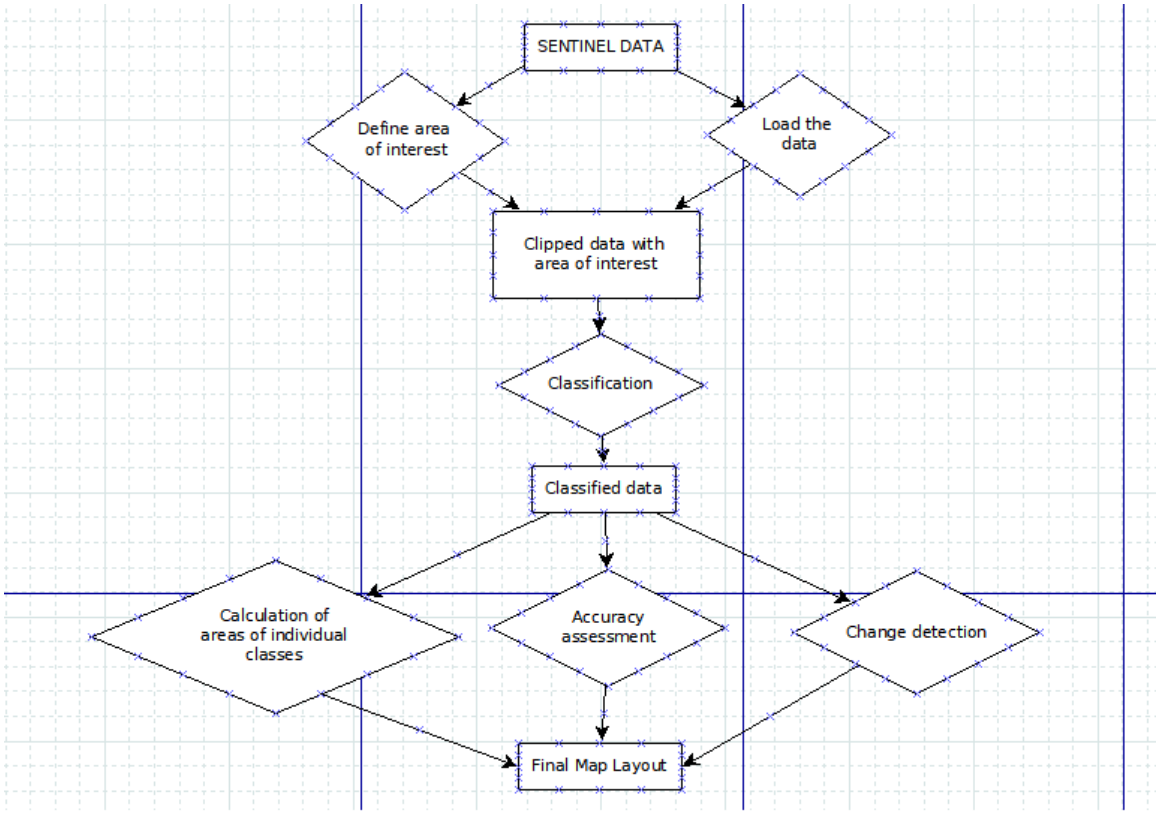
To assess changes in land cover between 2020 and 2024.

To evaluate the accuracy of the classification results.

To apply NDVI for enhanced vegetation analysis.

To visualize changes and provide a comprehensive overview of land cover transformations in Kisumu.

4. Methodology



a. Data Sources

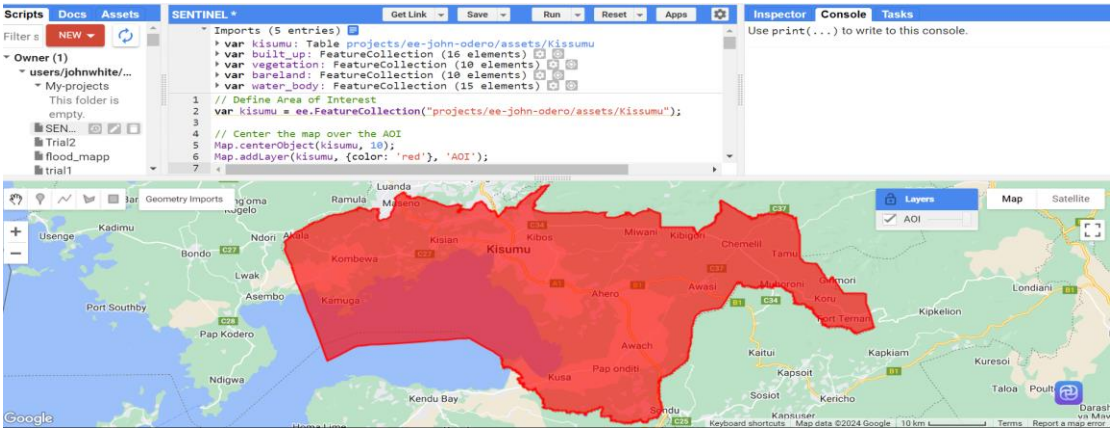
Satellite Imagery: Sentinel-2 Level-2A data (which provides surface reflectance) was used for the analysis. The imagery was filtered based on the area of interest and cloud coverage.

Ground Truth Data: Ground-truth data for training the classification algorithm was collected from existing feature collections of built-up areas, vegetation, bare land, and water bodies.

b. Data Processing Steps

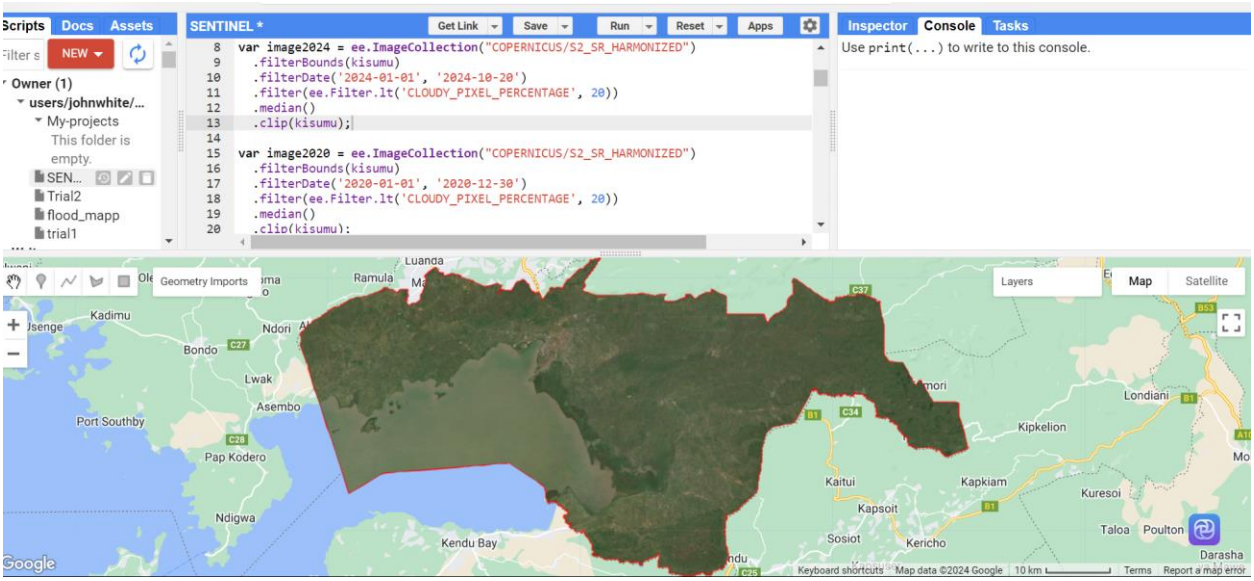
i. Define Area of Interest (AOI):

A feature collection representing Kisumu was created as the area of analysis.



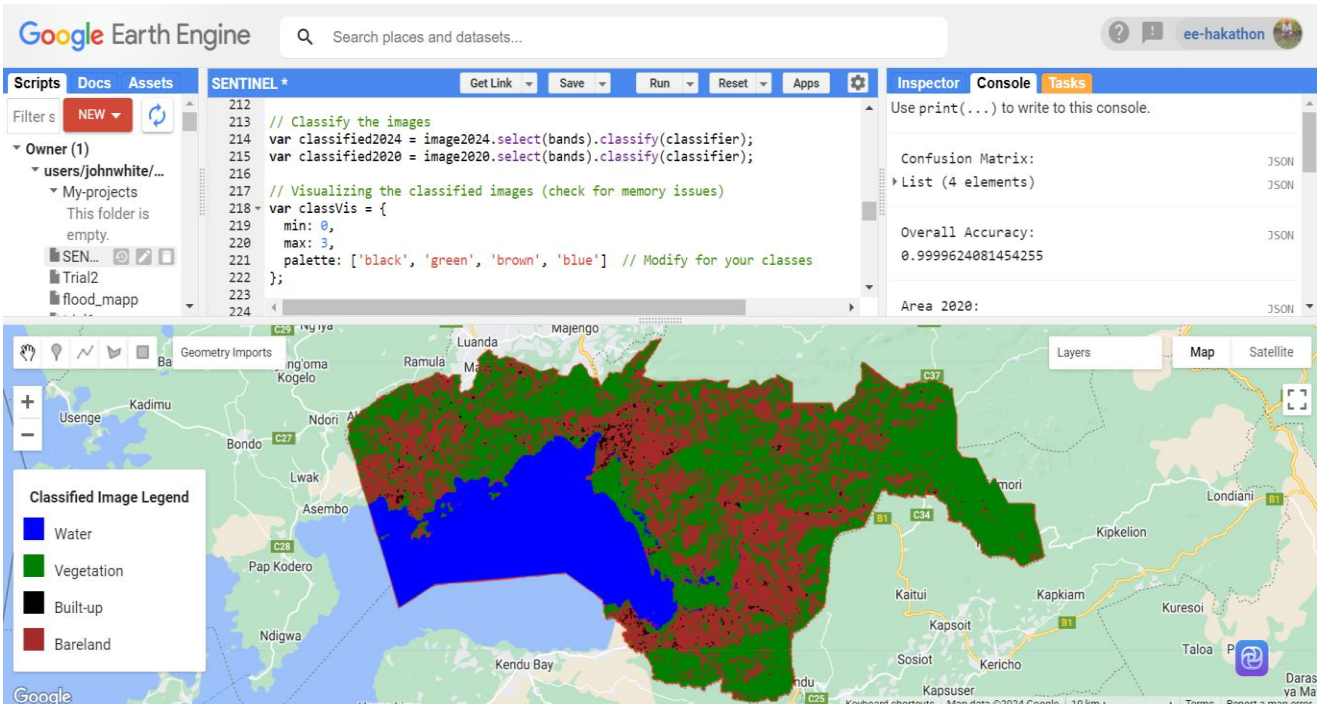
ii. Load Sentinel-2 Data:

Data for the periods from January to October 2024 and the entirety of 2020 were obtained, with an emphasis on minimizing cloud coverage (less than 20%).

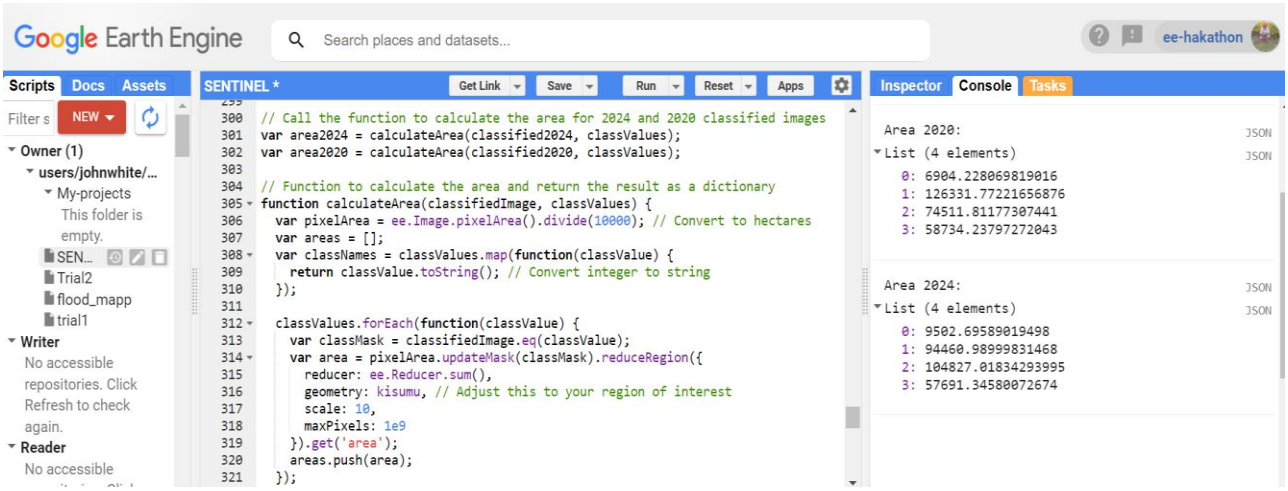


iii. Image Classification:

A Random Forest classifier was trained using sample data representing different land cover classes. The classifier was applied to both 2020 and 2024 images to produce classified land cover maps.



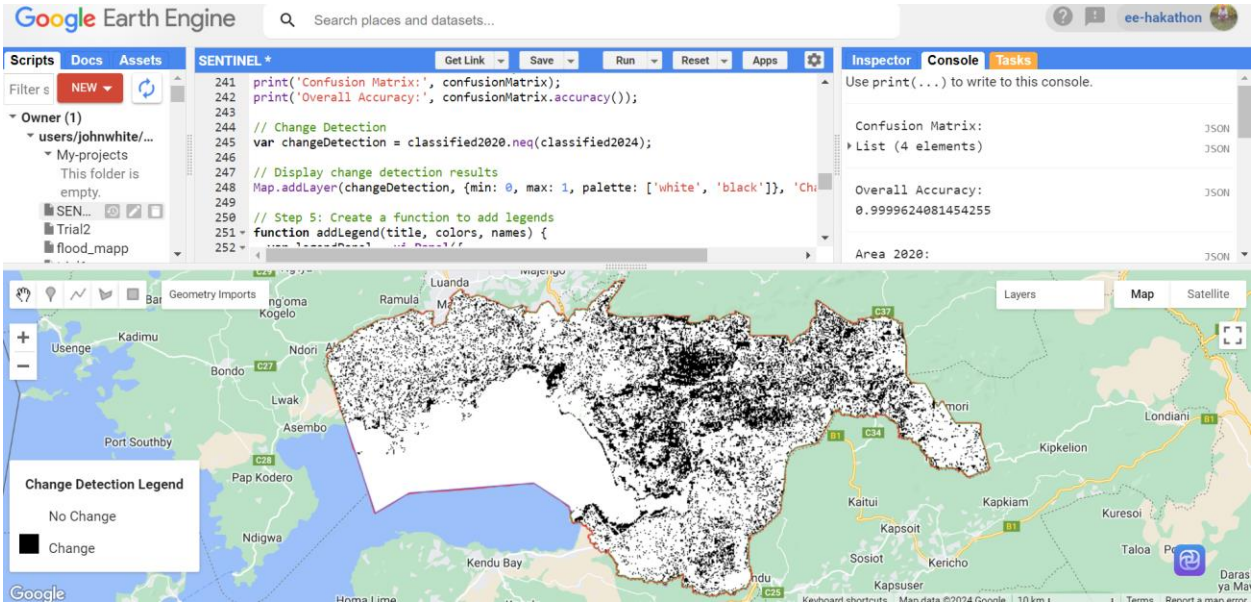
Areas of individual classes were then calculated still by Google Earth Engine and the results were as follows;



	2020_Area	2024_Area
Built_up	6904.2281	9502.6959
Vegetation	126331.7722	94460.9900
Bareland	74511.8118	104827.0183
water_body	58734.2379	57691.3458

iv. Change Detection:

Change detection was conducted by subtracting the classified image of 2020 from the classified image of 2024. A histogram summarizing the counts of each land cover type was generated.



v. Normalized Difference Vegetation Index (NDVI) Application:

NDVI was calculated for both years using the formula:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

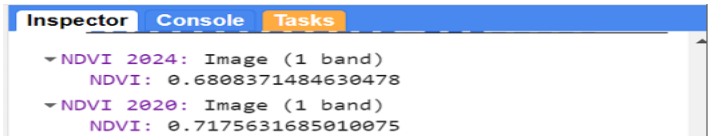
Which is equivalent to;

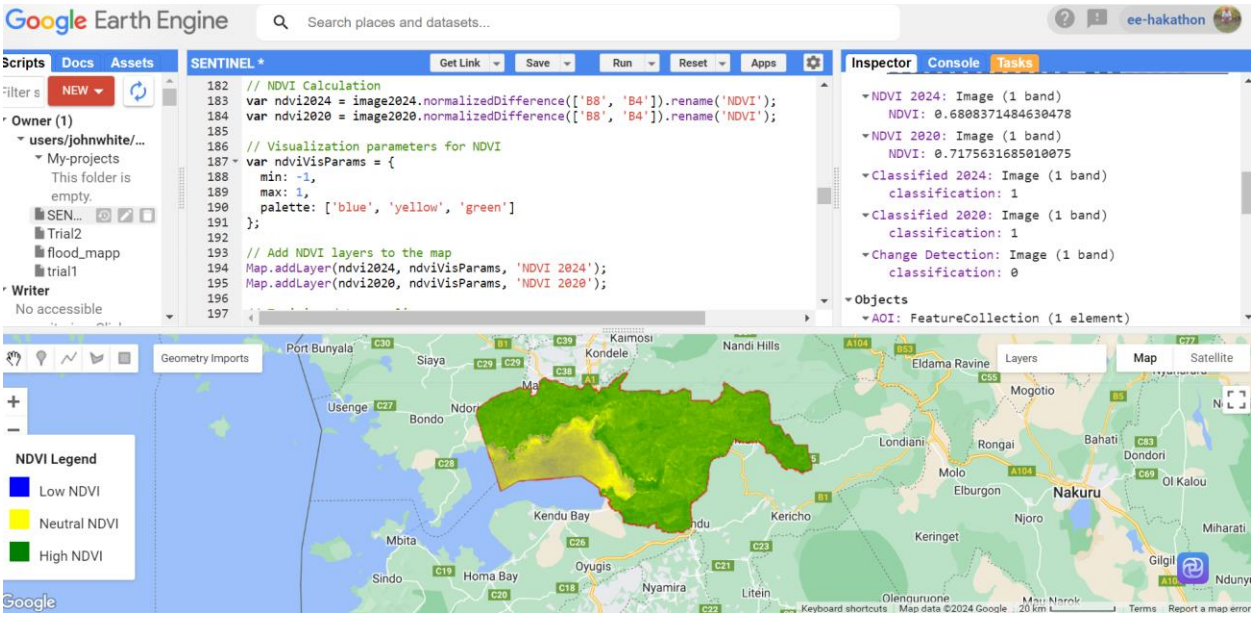
```
// NDVI Calculation
var ndvi2024 = image2024.normalizedDifference(['B8', 'B4']).rename('NDVI');
var ndvi2020 = image2020.normalizedDifference(['B8', 'B4']).rename('NDVI');

// Visualization parameters for NDVI
var ndviVisParams = {
  min: -1,
  max: 1,
  palette: ['blue', 'yellow', 'green']
};

// Add NDVI layers to the map
Map.addLayer(ndvi2024, ndviVisParams, 'NDVI 2024');
Map.addLayer(ndvi2020, ndviVisParams, 'NDVI 2020');
```

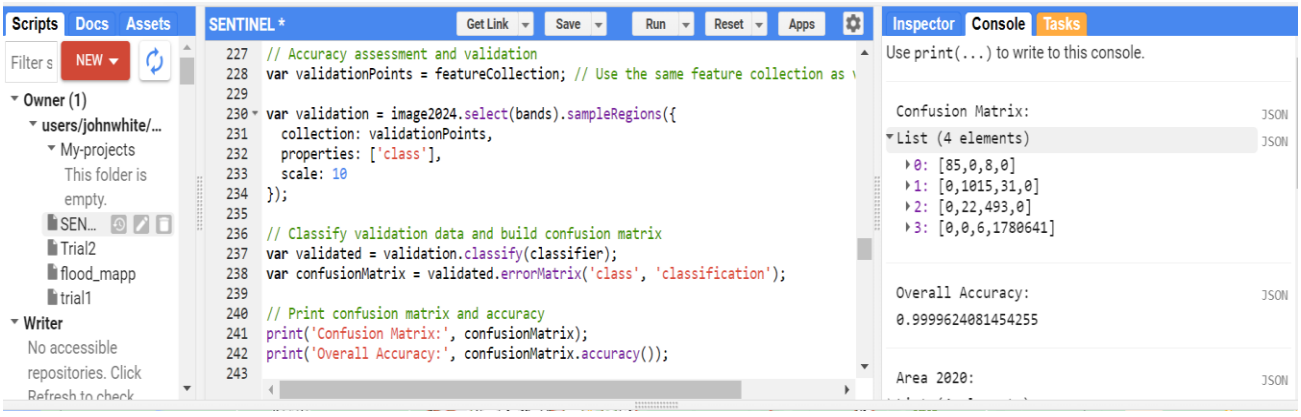
NDVI values provided additional insight into the health and density of vegetation in the study area.





vi. Accuracy assessment

The classification accuracy was assessed using the confusion matrix method. A set of validation points collected from known ground truth locations was compared against the classified maps to determine overall accuracy.

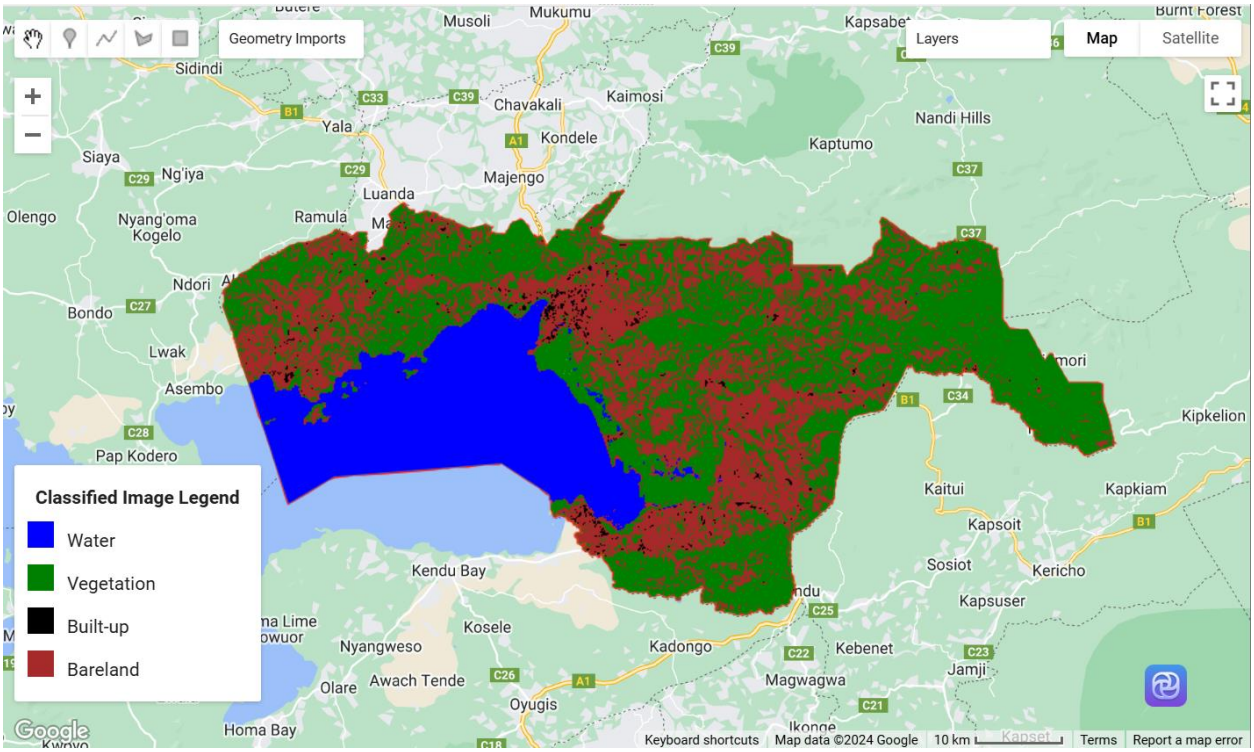


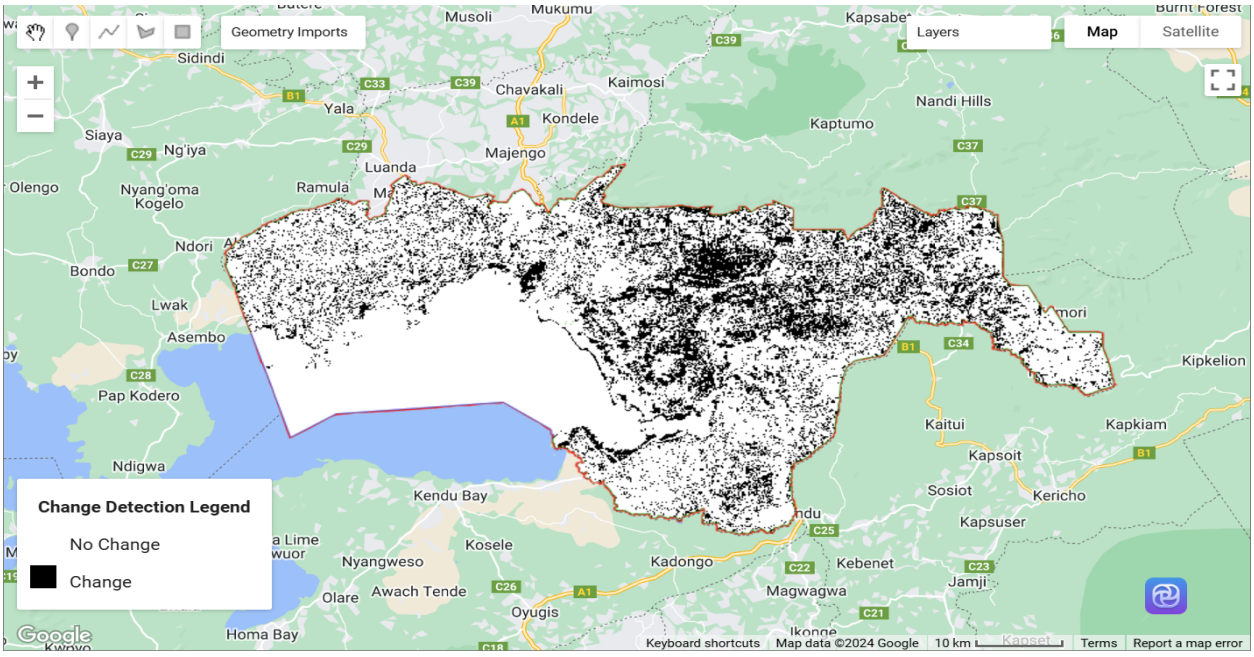
vii. Map Layout Creation:

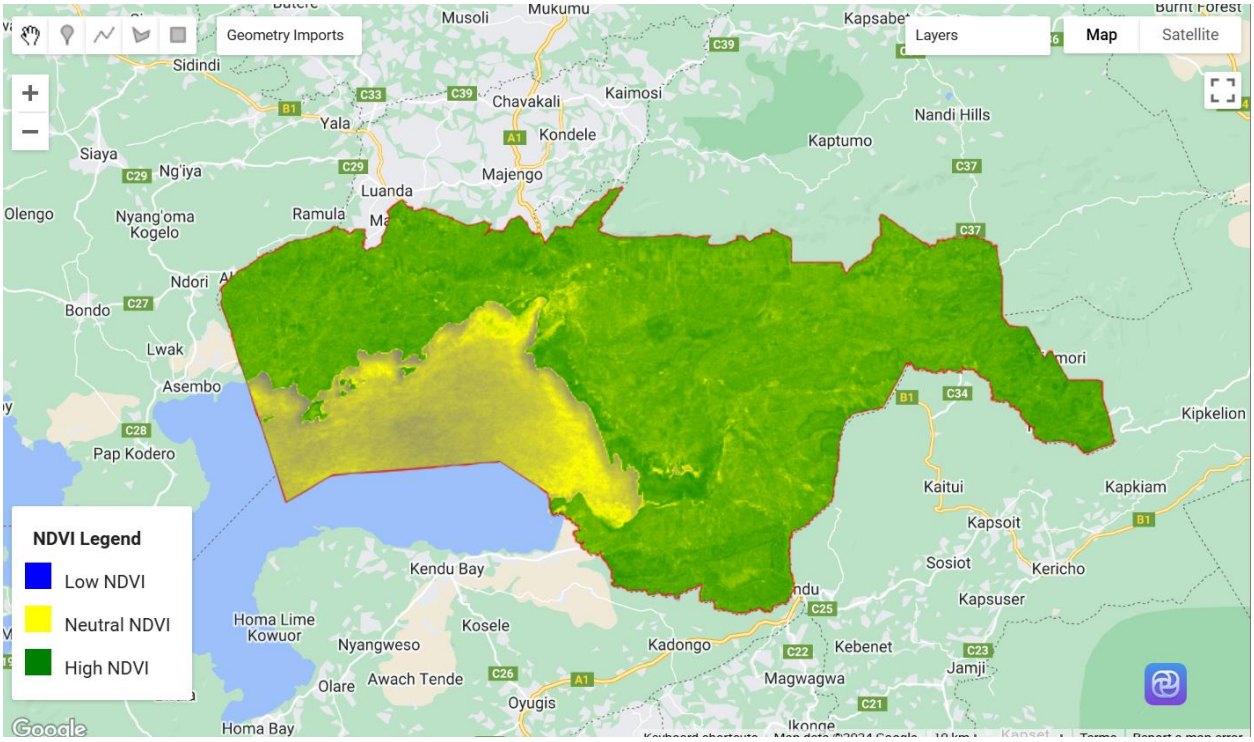
A comprehensive map layout was created using ArcMap software, incorporating various elements such as legends, scale bars, north arrows, and informative titles. The layout visually represented the land cover classes for enhanced analysis.

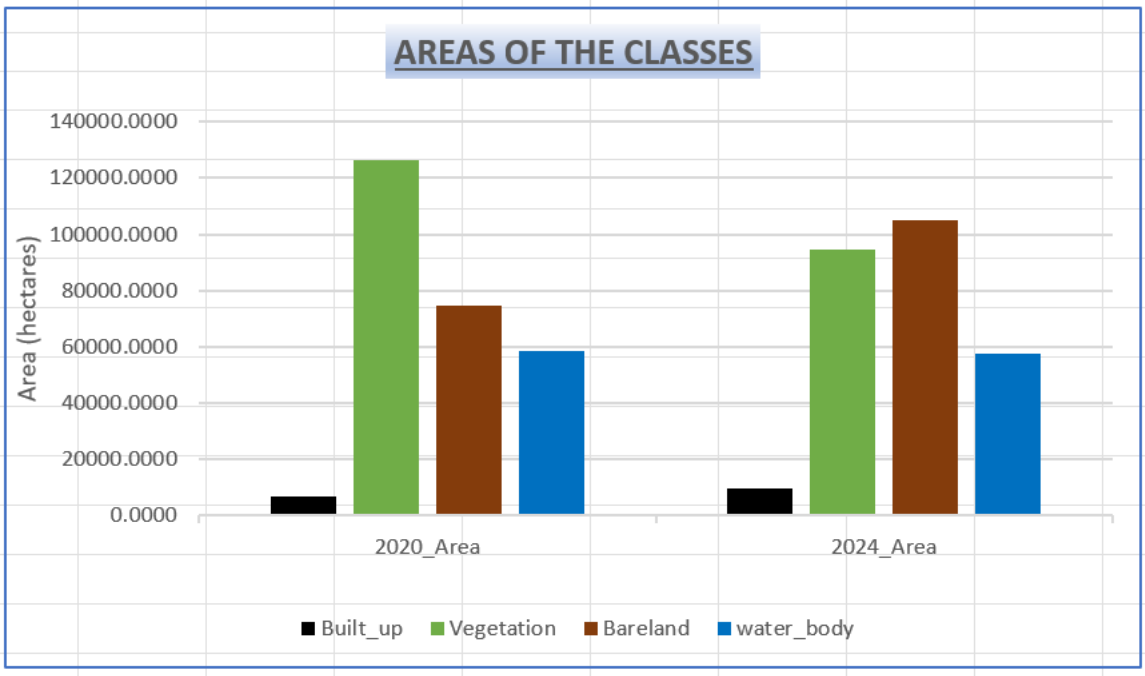
viii. Visualization

Classified images and change detection results were visualized on the GEE map interface. Bar charts depicting the number of pixels classified into each land cover type was generated.









c. Tools Used

Google Earth Engine (GEE): For processing satellite imagery, carrying out land cover classifications, change detection and calculating NDVI.

ArcMap Software: For creating detailed map layouts and static visual representations.

JavaScript API: The GEE JavaScript API was leveraged for scripting and processing.

Visualization Panel: GEE's UI features were utilized to create interactive maps and charts.

5. Results
    a. Classifications and NDVI

The classified land cover maps indicated distinct regions characterized by water, vegetation, built-up areas, and bare land for both years. The NDVI analysis also revealed areas of healthy vegetation, with NDVI values supporting the classification results.

    b. Change Detection

The analysis of changes between 2020 and 2024 revealed significant findings:

An increase in built-up areas, indicative of urban growth.

Mixed trends in vegetation cover, highlighting both conservation efforts and areas affected by urban sprawl.

Water bodies showed stability, with local conditions validating satellite-derived data.

Conclusion

The land cover change detection analysis in Kisumu from 2020 to 2024 revealed significant urban expansion, with an increase in built-up areas, a sign of urban growth in the region. While some vegetation areas showed positive trends due to conservation efforts, others indicated losses attributed to development pressures. Water bodies remained largely stable, aligning with local environmental observations, thus reinforcing the reliability of the satellite-derived insights.

Recommendations

- Urban Planning and Policy Development: The observed urban expansion calls for effective urban planning and policies that integrate environmental sustainability to minimize the impact on vegetation and biodiversity.
- Conservation Efforts: Areas where vegetation has declined should be prioritized for conservation programs to mitigate habitat loss and support biodiversity.