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Application of Google Earth Engine and JavaScript API to Mapping Vegetation and Land Use Types in Nasarawa LGA

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ABSTRACT

BACKGROND: Nasarawa is a local government area (LGA) within Nasarawa state, north-central Nigeria characterized by solid mineral exploration and farming activities. It is known to have vast amount of water bodies that flows into the Benue River from the north. These events have great potential of altering the land use land cover (LULC) classification over time. This paper presents a comprehensive study on the application of Google Earth Engine (GEE) and JavaScript API for mapping vegetation and land use types in Nasarawa Local Government Area (LGA). Nasarawa LGA, located in Nigeria, represents a region with diverse ecosystems and land use patterns, making it an ideal case study for this research. ***AIM/OBJECTIVE(S):*** Aim of the paper is to develop a methodology for mapping vegetation and land use types in Nasarawa Local Government Area (LGA) using Google Earth Engine (GEE) and JavaScript API. The objective of this paper is to reliably map vegetation or forest cover and land uses by retrieving image collection from Sentinel constellation of satellites "Sentinel-2 Multispectral Instrument (Sentinel-2 MSI)" developed by European Space Agency (ESA) and to also use cloud-based remote sensing 'Google Earth Engine (GEE)' platform with the JavaScript application programming interface (API). ***METHODOLOGY:*** In this paper, vegetation and land use map of Nasarawa LGA was prepared using Sentinel-2 satellite data for both dry (November - April) and rainy (April - October) seasons of the year 2021 through 2022. Images mainly from '32PLQ' and '32NLP' granule or tile identifiers that covers the study area where used. Several earth engine JavaScript API were utilized to prepare the map, chart and calculate vegetation indexes. **RESEARCH FINDINGS:** Mapping results indicates Nasarawa LGA was 23.29% forested, 74.72% vegetated, 0.50% Built-up and 1.49% watered. The results provide valuable insights into the current vegetation and land use patterns in Nasarawa LGA, facilitating informed decision-making for land management, conservation efforts, and sustainable development. Furthermore, the methodology presented in this research serves as a valuable resource for researchers and practitioners seeking to employ GEE and JavaScript API in similar environmental mapping projects. ***CONCLUSION:*** The output of this study is invaluable for decision-makers at all level of government, environmental scientists, nature-related NGOs, farmers and agriculture investors. The application of GEE and JavaScript API has empowered us to contribute to the understanding of Nasarawa LGA's land cover dynamics.

Keywords: *sentinel satellite; google earth engine; vegetation mapping; land use mapping; JavaScript programming; application programming interface*

1.0 Introduction

Google Earth Engine (GEE) is a cloud-based platform that enables large-scale processing of satellite imagery to detect changes, map trends, and quantify differences on the earth's surface (Gandhi, 2021). GEE provides official client libraries to use the API from both JavaScript and Python. However, JavaScript API is the most mature and easiest to use (Gandhi, 2021). The GEE platform comes with a web-based Code Editor that allows you to start using the Earth Engine JavaScript API without any installation. The JavaScript API of Google Earth Engine allows for the development of interactive and flexible workflows, making it an ideal tool for mapping vegetation and land use types in Nasarawa LGA (Gorelick et al., 2017; Hansen et al., 2013). Remote sensing plays a crucial role in mapping vegetation and land use types. It involves the acquisition and analysis of data obtained from sensors mounted on satellites or aircraft. These sensors capture electromagnetic radiation reflected or emitted by the Earth's surface, allowing for the identification and characterization of different land cover types (Campbell, 2002; Jensen, 2005). Multispectral satellite imagery, which provides data in different spectral bands, is commonly used for land cover mapping (Cohen et al., 2010; Weng, 2012).

This paper uses multi-spectral images collected by the European Space Agency's Sentinel-2 satellite. Sentinel-2 is a wide-swath, high-resolution, multi-spectral imaging mission supporting Copernicus Land Monitoring studies, including the monitoring of vegetation, soil and water cover, as well as observation of inland waterways and coastal areas.

Vegetation type/land use mapping plays a pivotal role in enhancing our understanding of the natural and man-made environments by enabling us to quantify various vegetation types across local to global scales within a specific period. By acquiring current and accurate data on vegetation types, we can effectively initiate and implement vegetation protection and restoration programs. However, it is important to acknowledge that the conventional approach for collecting information on vegetation type/land use mapping is often associated with significant costs and time consumption (Bhatt, 2013). Hence, there is an imperative need to explore and embrace the potential of remote sensing and GIS-based holistic forest management and conservation strategies as an alternative approach. By harnessing the power of these advanced technologies, we can overcome the limitations of traditional methods and foster more efficient, cost-effective, and time-saving practices in the field of vegetation type/land use mapping. Such a shift towards remote sensing and GIS-based approaches not only empowers us to obtain timely and accurate data, but also facilitates the development and implementation of comprehensive strategies that encompass multiple aspects of forest management and conservation. Ultimately, embracing these innovative methodologies can contribute to the sustainable management and preservation of our valuable vegetation resources.

The focus of this paper is to map vegetation and land use types in Nasarawa Local Government Area (LGA) using Google Earth Engine and JavaScript API. Nasarawa LGA is located in Nigeria and encompasses diverse landscapes, including forests, croplands, grasslands, and urban areas. Accurate information on vegetation and land use types in this region is crucial for sustainable land management, conservation planning, and addressing environmental challenges and other risks that comes with such challenges. This introduction provides an overview of the importance of mapping vegetation and land use types and introduces the objectives and significance of the study. The subsequent sections will delve into the methodology, results, and discussion of the findings, providing insights into the mapping process and the implications for land management in Nasarawa LGA. This study could also be different from other studies in terms of location, types of vegetation cover, land use, tools, methodology and Analysis. Majority of the previous work covering this location was carried with Sentinel 1 and Sentinel 2 but for now we decided to use Google Earth Engine and Java script API to see whether there are differences and improvement. Our final analysis actually shows small level of differences from previous study carried out due to different tools used.

1.1 STUDY AREA

The study focused on Nasarawa Local Government Area (LGA) in Nasarawa state north-central region of Nigeria. Nasarawa LGA was chosen due to its diverse land cover types and the availability of satellite imagery for analysis. Mostly characterized by farming, fishing and mining activities, Nasarawa LGA is located at the Northern part of Benue River in north-central Nigeria. The geographical location of the Nasarawa LGA is between latitude 7˚N to 9˚N; and longitude 7˚E to 9˚E (see Figure 1).

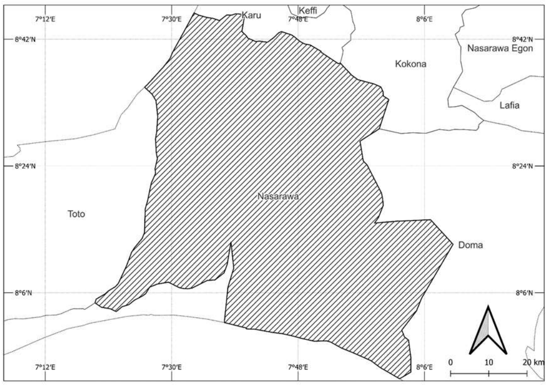

Figure 1: Map of study area (source: Department of Surveying and Geoinformatics Federal Polytechnic Nasarawa).

Nasarawa LGA holds substantial ecological and socio-economic importance. Its diverse ecosystems provide resources for agriculture, forestry, and wildlife conservation. Additionally, the region is home to a growing population with varying livelihoods, necessitating sustainable land management practices and environmental protection efforts. This study area serves as an ideal subject for the application of advanced geospatial technologies like Google Earth Engine and JavaScript API, enabling the accurate mapping of land cover and land use types, which, in turn, can inform decision-making for sustainable development, environmental conservation, and resource management in Nasarawa LGA.

2.0 DATA AND METHODOLOGY

The study mainly utilizes secondary data. The secondary data used is a high-resolution image of the study area from Harmonized Sentinel-2 Multi Spectral Instrument (MSI) to extract vegetation and other land use types. Table 1 below shows details of the bands from Sentinel-2.

The methodological approach adopted for the execution of this research is made up of three important steps namely; acquiring the images, pre-processing the images and image classification.

Name	Description	Resolution	Wavelength	Scale
B1	Aerosols	60 meters	443.9nm (S2A) / 442.3nm (S2B)	0.0001
B2	Blue	10 meters	496.6nm (S2A) / 492.1nm (S2B)	0.0001
B3	Green	10 meters	560nm (S2A) / 559nm (S2B)	0.0001
B4	Red	10 meters	664.5nm (S2A) / 665nm (S2B)	0.0001
B5	Red Edge 1	20 meters	703.9nm (S2A) / 703.8nm (S2B)	0.0001
B6	Red Edge 2	20 meters	740.2nm (S2A) / 739.1nm (S2B)	0.0001
B7	Red Edge 3	20 meters	782.5nm (S2A) / 779.7nm (S2B)	0.0001
B8	NIR	10 meters	835.1nm (S2A) / 833nm (S2B)	0.0001
B8A	Red Edge 4	20 meters	864.8nm (S2A) / 864nm (S2B)	0.0001
B9	Water vapor	60 meters	945nm (S2A) / 943.2nm (S2B)	0.0001
B10	Cirrus	60 meters	1373.5nm (S2A) / 1376.9nm (S2B)	0.0001
B11	SWIR 1	20 meters	1613.7nm (S2A) / 1610.4nm (S2B)	0.0001
B12	SWIR 2	20 meters	2202.4nm (S2A) / 2185.7nm (S2B)	0.0001
QA10	Always empty	10 meters		0
QA20	Always empty	20 meters		0
QA60	Cloud mask	60 meters		0

Table 1: Bands Table for Harmonized Sentinel-2 MSI: Multi Spectral Instrument, Level-1C (source: Earth Engine Data Catalog, 2023)

2.1 Acquiring the Image Tiles

The study area was cover by four tiles of Sentinel-2 satellite images, two each from '32PLQ' and '32NLP' granule or tile identifiers. Table 2 below shows the resulting images adopted from using the script in figure 2 to verify they fully covered the study area. We eventually found eight (8) granule or tile identifiers that covers the study are four each for both dry and wet/raining seasons as shown in table 2 below.

We also obtained and extracted a shapefile of Nasarawa LGA from Nasarawa Geographic Information Service (NAGIS), see figure 3. This makes is easier for the image clipping to our area of interest and the image mosaicking.

S/N	Season	Year	Granule/Tile ID
1.	Dry	2021	COPERNICUS/S2_SR/20221228T095421_20221228T100646_T32PLQ
			COPERNICUS/S2_SR/20221220T094319_20221220T095324_T32PLQ
			COPERNICUS/S2_SR/20221125T094331_20221125T095623_T32NLP
			COPERNICUS/S2_SR/20221228T095421_20221228T100646_T32NLP
2.	Rainy	2022	COPERNICUS/S2_SR/20220407T095029_20220407T100130_T32PLQ
			COPERNICUS/S2_SR/20220524T094029_20220524T095204_T32PLQ
			COPERNICUS/S2_SR/20220524T094029_20220524T095204_T32NLP
			COPERNICUS/S2_SR/20220914T094609_20220914T095925_T32NLP

Table 2: Image granule or tile identifiers for the study area

```
/**** GET IMAGE IDs FOR STUDY AREA ****/
// Define ROI point or import it...
var roi_geometry = ee.Geometry.Point([8.044, 8.178])

// Import the feature collection (that is a vector layer of ROI)
var NasLGA = ee.FeatureCollection('users/forum2k9/Nasarawa_LGA_SHP');

// Visualize the collection
Map.addLayer(NasLGA, {color: 'red'}, 'Nasarawa LGA');
Map.centerObject(NasLGA, 8);

// From Sentinel-2 surface reflectance image collection...
/* Filter for dry (November - April) and rainy (April - October) seasons
 in year 2022, also with least cloud cover */

var dataset = ee.ImageCollection('COPERNICUS/S2_SR')
  .filterDate('2022-04-01', '2022-10-31')
  .filterBounds(roi_geometry)
  .sort('CLOUD_COVERAGE_ASSESSMENT')
  .first();

print(dataset.id())


// To confirm the ID above... Read image by ID and add it to map...
var image = ee.Image("COPERNICUS/S2_SR/20220524T094029_20220524T095204_T32PLQ")

// (Optionally) Add them to map... (false-color bands combination)...
var VizMode = {bands:['B8','B4','B3'], min:0, max:3000}

Map.addLayer(image, VizMode, "Image 1", true);
```

Figure 2: JavaScript adopted to get image granule or tile identifiers for the study area

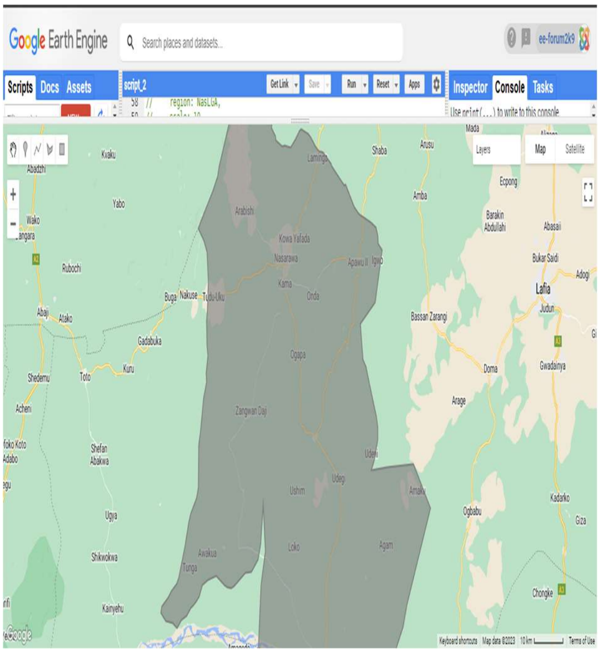

Figure 3: Shapefile of study area uploaded unto GEE

2.2 Image Pre-processing

The acquired Sentinel-2 satellite imagery underwent preprocessing steps, including geometric and radiometric corrections, atmospheric correction, and mosaicking. These processes ensure the data is accurately aligned and ready for analysis. Several pre-processing steps can be applied that aim at removing artefacts from the images that are not related to the actual reflectance of the land cover (e.g. sensor effects, atmospheric, and illumination conditions (Young et al. 2017).

2.2.1 Geometric and Radiometric Corrections

Radiometric correction is to avoid radiometric errors or distortions, while geometric correction is to remove geometric distortion. There are four main types of radiometric correction: radiometric calibration, atmospheric correction, topographic correction, and sensor normalization. They can be combined with geometric correction and image enhancement to produce better results.

```
// Define the study area
var studyArea = ee.Geometry.Rectangle([xmin, ymin, xmax, ymax]);

// Load a single Sentinel-2 image
var image = ee.Image('COPERNICUS/S2_SR/20220524T094029_20220524T095204_T32PLQ')
  .clip(studyArea)
  .select(['B2', 'B3', 'B4']); // Select relevant bands

// Define the control points for geometric correction
var controlPoints = [
  { "image": [x1, y1], "ground": [lon1, lat1] },
  { "image": [x2, y2], "ground": [lon2, lat2] },
  // Add more control points as needed
];

// Perform the geometric correction
var geometricallyCorrectedImage = ee.Image(image).geometricCorrection(controlPoints);

// Visualization parameters
var visParams = { min: 0, max: 3000, bands: ['B4', 'B3', 'B2'] };

// Display the geometrically corrected image
Map.addLayer(geometricallyCorrectedImage, visParams, 'Geometrically Corrected Image');

// -----------------------------------------------------

// Define the study area
var studyArea = ee.Geometry.Rectangle([xmin, ymin, xmax, ymax]);
```

```

// Load a single Sentinel-2 image
var image = ee.Image('COPERNICUS/S2_SR/20220524T094029_20220524T095204_T32PLQ')
  .clip(studyArea)
  .select(['B2', 'B3', 'B4', 'B8']); // Select relevant bands

// Function to apply atmospheric correction to a single image
var applyAtmosphericCorrection = function(image) {
  // Define atmospheric correction parameters
  var atmosphericParams = {
    aerosolModel: 'CARD',
    applyWaterVaporCorrection: true,
    applyOzoneCorrection: true,
    applyTcirrusCorrection: true,
    pModel: 'MS'
  };

  // Apply the atmospheric correction
  var correctedImage = image.divide(image.select('B8').divide(image.select('B4')).log()).multiply(atmosphericParams.pModel);

  // Return the atmospherically corrected image
  return correctedImage;
};

// Apply atmospheric correction to the image
var atmosphericallyCorrectedImage = applyAtmosphericCorrection(image);

// Visualization parameters
var visParams = { min: 0, max: 0.3, bands: ['B4', 'B3', 'B2'] };

// Display the atmospherically corrected image
Map.addLayer(atmosphericallyCorrectedImage, visParams, 'Atmospherically Corrected Image');

```

Figure 4: Function to apply geometric correction and radiometric correction on a single image.

2.2.2 Atmospheric Correction

The atmospheric correction of satellite imagery is considered fundamental in remote sensing applications, especially in the case of multi-temporal analysis (Belcore, 2020). The atmospheric correction removes the scattering effect of the Earth's atmosphere and it can be based on Radiative Transfer Models (Specific mathematical models that consider latitude, season and atmospheric conditions) or on Image-Based Correction Techniques (that estimate atmosphere scattering using information and data within the image).

```
// Function to apply atmospheric correction to a single image
var applyAtmosphericCorrection = function(image) {
  // Define atmospheric correction parameters
  var atmosphericParams = {
    'aerosolModel': 'AUTO',
    'platform': 'SENTINEL2',
    'utmZone': image.get('utm_zone'),
    'projection': image.select(0).projection(),
    'altitude': image.get('system:asset_size')[2]
  };

  // Apply atmospheric correction
  var correctedImage = ee.Algorithms.Sentinel2.ATCOR(
```

```
    image, // Input image
    atmosphericParams // Atmospheric correction parameters
  );

  // Return the corrected image
  return correctedImage;
};

// Apply atmospheric correction to the entire image collection
var correctedCollection = collection.map(applyAtmosphericCorrection);
```

Figure 5: Function to apply atmospheric correction on a single image.

2.2.3 Mosaicking

The four images acquired with least cloud cover for dry season (November - April) period where mosaicked, same for the rainy or wet (April - October) season for one year (2022 through 2023), see figures 6-8.

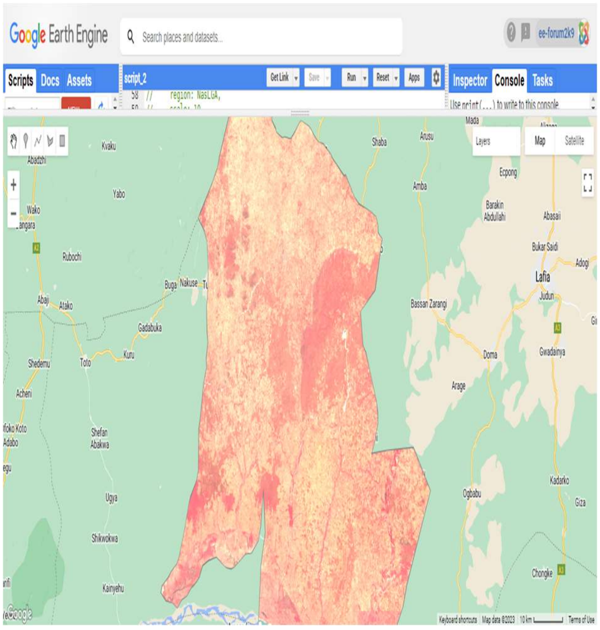

Figure 6: Mosaic and Clipped image for Dry season

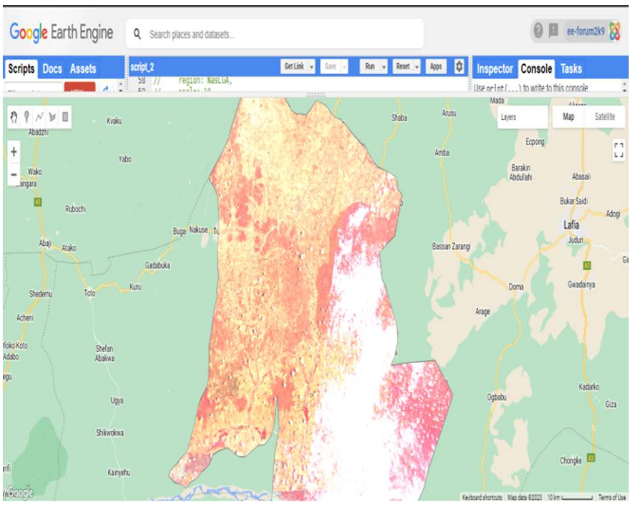

Figure 7: Mosaic and Clipped image for Raining season

```
/*
 *** MERGE THE IMAGES ***
This process will be repeated for both dry and rainy seasons.
*/

// Import the feature collection (that is a vector layer of ROI)
var NasLGA = ee.FeatureCollection('users/forum2k9/Nasarawa_LGA_SHP');
// Visualize the collection
Map.addLayer(NasLGA, {color: 'gray'}, 'Nasarawa LGA');
// Map.centerObject(NasLGA, 8);



// Read the images...
var dry_img1 = ee.Image("COPERNICUS/S2_SR/20221228T095421_20221228T100646_T32PLQ");
var dry_img2 = ee.Image("COPERNICUS/S2_SR/20221220T094319_20221220T095324_T32PLQ");
var dry_img3 = ee.Image("COPERNICUS/S2_SR/2022
```

```
1125T094331_20221125T095623_T32NLP");
var dry_img4 = ee.Image("COPERNICUS/S2_SR/20221228T095421_20221228T100646_T32NLP");

var wet_img1 = ee.Image("COPERNICUS/S2_SR/20220407T095029_20220407T100130_T32PLQ");
var wet_img2 = ee.Image("COPERNICUS/S2_SR/20220524T094029_20220524T095204_T32PLQ");
var wet_img3 = ee.Image("COPERNICUS/S2_SR/20220524T094029_20220524T095204_T32NLP");
var wet_img4 = ee.Image("COPERNICUS/S2_SR/20220914T094609_20220914T095925_T32NLP");


// Mosaic and Compose the mosaic to max value....
var dry_mosaic_img = ee.ImageCollection([dry_img1, dry_img2, dry_img3, dry_img4]);
var wet_mosaic_img = ee.ImageCollection([wet_img1, wet_img2, wet_img3, wet_img4]);

var dry_composite_img = dry_mosaic_img.max();
var wet_composite_img = wet_mosaic_img.max();

print(dry_composite_img);
print(wet_composite_img);


// Clip image to study area...
var clip_dry_img = dry_composite_img.clip(NasLGA)
var clip_wet_img = wet_composite_img.clip(NasLGA)


// (Optionally) Add them to map... True/False-colour rendering of the image
var TrueColorVizMode = {bands:['B4','B3','B2'], min:0, max:3000};
var FalseColorVizMode = {bands:['B8','B4','B3'], min:0, max:3000};

Map.addLayer(clip_dry_img, FalseColorVizMode, "Dry Season Image", false);
Map.addLayer(clip_wet_img, FalseColorVizMode, "Rainy Season Image", false);
Map.setCenter(8.044, 8.178, 8)

// We can export the image for use in other RS tools...
Export.image.toDrive({
  image: clip_wet_img.toUint16(),
  description: 'Rainy_Season_Image',
  folder: 'nas_gee_map',
  fileNamePrefix: 'nasarawa_gee',
  region: NasLGA,
  scale: 10,
  maxPixels: 1e9
});

Export.image.toDrive({
  image: clip_dry_img.toUint16(),
  description: 'Dry_Season_Image',
  folder: 'nas_gee_map',
  fileNamePrefix: 'nasarawa_gee',
  region: NasLGA,
  scale: 10,
  maxPixels: 1e9
});

/*
Use toUint16() to cast all bands to same unit to avoid error as described below
https://gis.stackexchange.com/questions/300344/exported-bands-must-have-compatible-data-types-found-inconsistent-types-uint16
*/
```

Figure 8: JavaScript to Mosaic the images and export to drive folder

In summary, calculating land use/land cover classifications using Google Earth Engine (GEE) involves a series of steps that leverage its cloud-based geospatial analysis capabilities. Here's a general outline of the methodology process:

a) Define region of interest (ROI)
b) Import and Preprocess Data
c) Training Data Collection (applicable only to supervised classification)
d) Classification Algorithm Selection
e) Train the Classifier (applicable only to supervised classification)
f) Classification of the Entire Image
g) Calculate Class Percentages

3.0 RESULTS AND DISCUSSION

3.1 Image Classification

Image classification is an important process in remote sensing where by land cover classes are assigned to image pixels. The classes we used in this paper include water (Snow and ice, Permanent water bodies, Herbaceous wetland), urban (built-up), forest (Tree cover) and agriculture (Shrubland, Grassland, Cropland, Bare / sparse vegetation, Mangroves, Moss and lichen). There are three common remote sensing classification methods: Unsupervised classification, Supervised classification and Object-based image analysis (OBIA). We utilized unsupervised classification technique which resulted in the tabulation and classification map below.

Major Land cover	Sub Land cover	Area (Ha)	Percentage
Forest	Tree cover	223,707	23.29%
Agriculture/vegetation	Shrubland	167,300	17.42%
	Grassland	149,309	15.55%
	Cropland	398,480	41.49%
	Mangroves	0	0.00%
	Moss and lichen	0	0.00%
	Bare / sparse vegetation	2,515	0.26%
Urban	Built-up	4,766	0.50%
Water	Snow and ice	0	0.00%
	Permanent water bodies	12,023	1.25%
	Herbaceous wetland	2,338	0.24%
Total		**960,438**	**100.00%**

Table 3: Land cover classification of Nasarawa LGA

The weather in Nasarawa LGA is tropical and of the dry grassland Savanna type (Olayemi I. K. et. al, 2014) with high temperature in many months of the year. The land cover in Nasarawa LGA is heterogeneous, encompassing various land use categories. Key land cover types include:

a) Forests and Woodlands: Nasarawa LGA boasts extensive forested areas, composed of both dense forests and open woodlands. These areas provide habitat for diverse flora and fauna and contribute to the region's biodiversity.
b) Agriculture: Cropland and agricultural activities are prevalent in

the low-lying areas, where fertile soils support the cultivation of crops such as cassava, yam, rice and cash crops like Sesame, soya beans, benniseed (Agidi et.al, 2017).

c) Grasslands and Pasture: Vast grassland areas are scattered throughout the landscape, serving as crucial grazing lands for livestock and supporting pastoral communities.

d) Urban and Built-up Areas: Urbanization has led to the development of towns, villages, and infrastructure in Nasarawa LGA.

e) Water Bodies: The region features several water bodies, notable River Benue to the southern region. These water bodies play a vital role in irrigation, fisheries, and water supply.

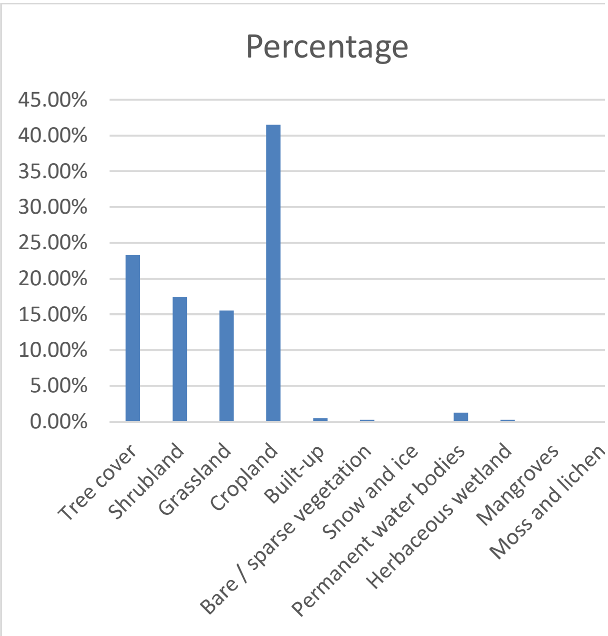

Figure 9: Bar chart showing percentages of the classification

The land cover maps revealed significant spatial variations in land use and vegetation across Nasarawa LGA. Forest and woodland cover were found to be concentrated in the central region, while cropland and agriculture predominated in northern and southern regions. Urban areas were primarily clustered around Nasarawa town and Maraba Udege, and grassland and pasture areas were widespread across Nasarawa LGA. Water bodies were accurately identified, including River Benue in the southern region.

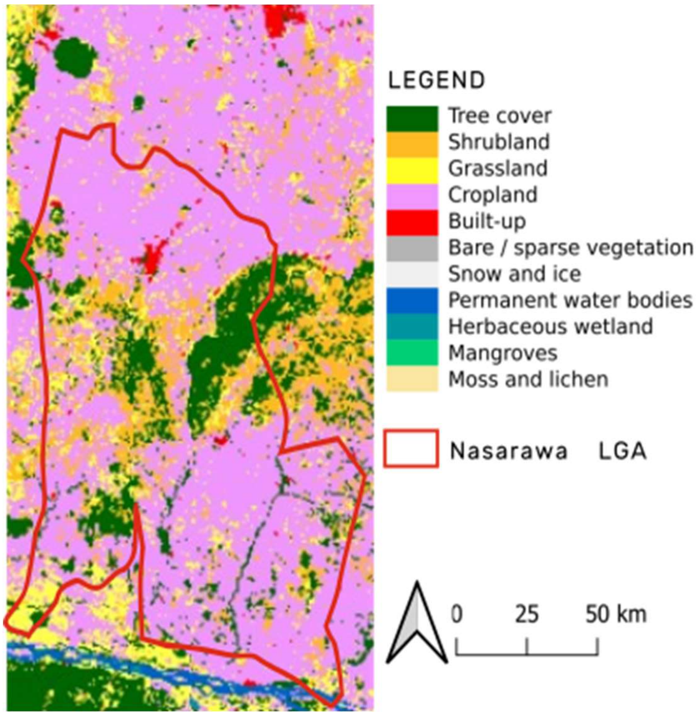

Figure 10: Classification map of Nasarawa LGA

3.2 Visualizing Band Combinations

We used different bands combination were used to visually investigate different land uses in the area. Table 3 shows sentinel-2 bands combinations we used as seen from figure 6 and 7 above uses 'false colour infrared' band combinations.

S/N	Description	Bands
1	Natural colour (True-colour)	B4, B3, B2
2	False colour infrared (False-colour)	B8, B4, B3
3	False colour urban	B12, B11, B4
4	Agriculture	B11, B8, B2

5	Atmospheric penetration	B12, B11, B8A
6	Healthy vegetation	B8, B11, B2
7	Land/Water	B8, B11, B4
8	Natural colours with atmospheric removal	B12, B8, B3
9	Shortwave infrared	B12, B8, B4
10	Vegetation analysis	B11, B8, B4

Table 4: Sentinel-2 Bands combinations for different visualization purposes

3.3 Calculating Vegetation Indices

There several spectral indices focused on understanding the vegetation. Vegetation index is a combination of spectral band

S/N	Vegetation index	Formula
1	Simple ratio (SR)	*SR=NIR/R*
2	Normalized difference vegetation index (NDVI)	*NDVI=(NIR–R)/(NIR+R)*
3	Perpendicular vegetation index (PVI)	*PVI=(NIR-aR-b)/(a2+1)1/2*
4	Soil adjusted vegetation index (SAVI)	*SAVI=(NIR–R)/(NIR+R+L)(1+L)*
5	Weighted difference vegetation index (WDVI)	*WDVI=NIR-aR*
6	Transformed soil adjusted vegetation index (TSAVI)	*TSAVI=a(NIR-aR-b)/(R+a(NIR-b)+X(1+a2))*
7	Modified soil adjusted vegetation index (MSAVI)	*MSAVI=(2NIR+1–((2NIR+1)2–8(NIR–R))1/2)/2*
8	Optimized soil adjusted vegetation index (OSAVI)	*OSAVI=(NIR–R)/(NIR+R+Y)*
9	Generalized soil adjusted vegetation index (GESAVI)	*GESAVI=(NIR–aR–b)/(R+Z)*
10	Atmospherically resistant vegetation index (ARVI)	*ARVI=(NIR-RB)/(NIR+RB), RB=R-γ(B–R)*
11	Modified normalized difference vegetation index (MNDVI)	*MNDVI=NDVI×(SWIRmax–SWIR)/(SWIRmax–SWIRmin)*
12	Enhanced vegetation index (EVI)	*EVI=2.5×((NIR–R)/(NIR+6R−7.5B+1))*
13	Reduced simple ratio (RSR)	*RSR=SR×(SWIRmax–SWIR)/(SWIRmax–SWIRmin)*
14	Moisture adjusted vegetation index (MAVI)	*MAVI=(NIR–R)/(NIR+R+SWIR)*

Table 5: List of vegetation indices used in remote sensing (adopted from Zhu G, et al., 2014)

```
1. //---------CALCULATION OF NDVI VALUES------------/
2. //NDVI:Normalized Difference Vegetation Index
3. var RED_BAND=clip_dry_img.select("B4")
4. var NIR_BAND=clip_dry_img.select("B8")
5. var NDVI = NIR_BAND.subtract(RED_BAND).divide(NIR_BAND.add(RED_BAND)).rename('NDVI');
6. print(NDVI, 'NDVI')
7. Map.addLayer(NDVI, {palette: ['blue', 'white', 'green'] }, "NDVI")
```

Figure 11: JavaScript to calculate Normalized Difference Vegetation Index (NDVI)

CONCLUSIONS

In this paper, we describe the step-by-step approach to data acquisition, pre-processing, and analysis using GEE and JavaScript API. We highlight the advantages of utilizing these tools, such as their scalability, accessibility, and the ability to integrate a variety of datasets. Moreover, we demonstrate the development of custom JavaScript scripts for image processing, classification, and visualization, ensuring the generation of accurate and detailed land cover maps.

The insights gained from this research can inform evidence-based decision-making, ultimately leading to more sustainable land use practices, environmental conservation, and improved quality of life for the communities within the region. As technology continues to evolve, this study represents a foundational step in ongoing efforts to monitor and safeguard the natural and cultural heritage of Nasarawa LGA for future generations.

While this study has provided a comprehensive assessment of Nasarawa's land cover, there are opportunities for further research and improvement. Incorporating temporal analysis, enhancing data continuity, and leveraging emerging machine learning techniques can enhance the accuracy and utility of future land cover mapping efforts.

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