# P2 : AI-BASED VEGETATION HEALTH & DENSITY MAPPING USING NDVI AND MACHINE LEARNING

# PROJECT REPORT

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**Institution: Delhi Technological University**
**Date of Submission : 18 Feb 2026**

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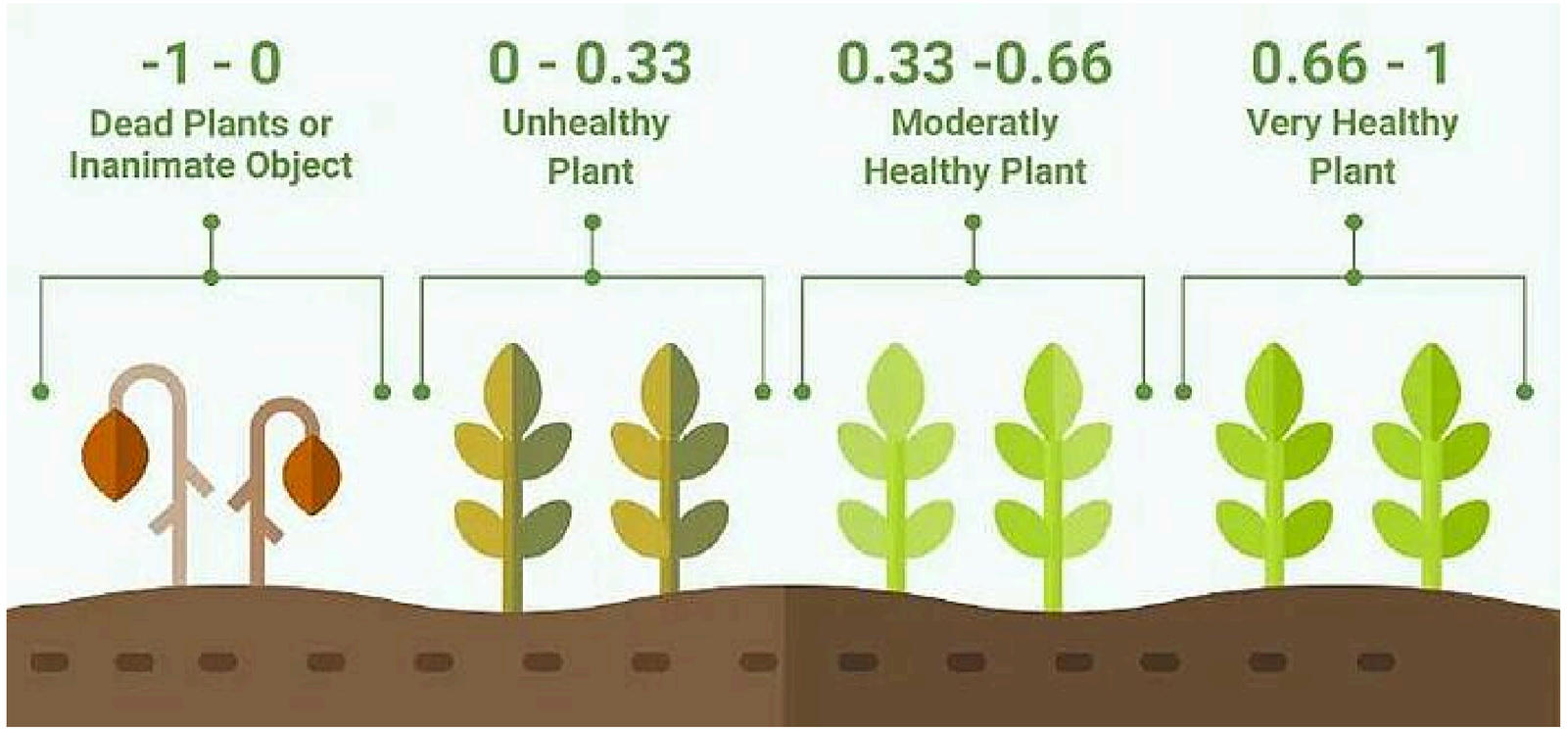
# Objectives

**To assess vegetation health, density, and spatial distribution using the Normalized Difference Vegetation Index (NDVI) integrated with Artificial Intelligence (AI) and Machine Learning (ML) techniques, enabling improved classification accuracy, automated vegetation zoning, and enhanced interpretation compared to conventional threshold-based NDVI analysis**




Source : https://www.cropin.com/blogs/ndvi-normalized-difference-vegetation-index/

# Study Area- Wayanad, Kerala, India

**The study area selected for the present analysis is Wayanad District, located in the northeastern part of Kerala, India. The district lies in the Western Ghats region and is characterized by undulating terrain, dense forest cover, and high ecological sensitivity.**

**The district boundary shapefile was obtained by extracting the Wayanad district from the India administrative boundary ZIP file downloaded from DIVA-GIS, and QGIS was used to prepare the final map layout."**

DIVA-GIS

DATA

« Documentation :: Contents :: Climate data »

## Data

Select and download free geographic (GIS) data for any country in the world<br>

Country

India

Subject

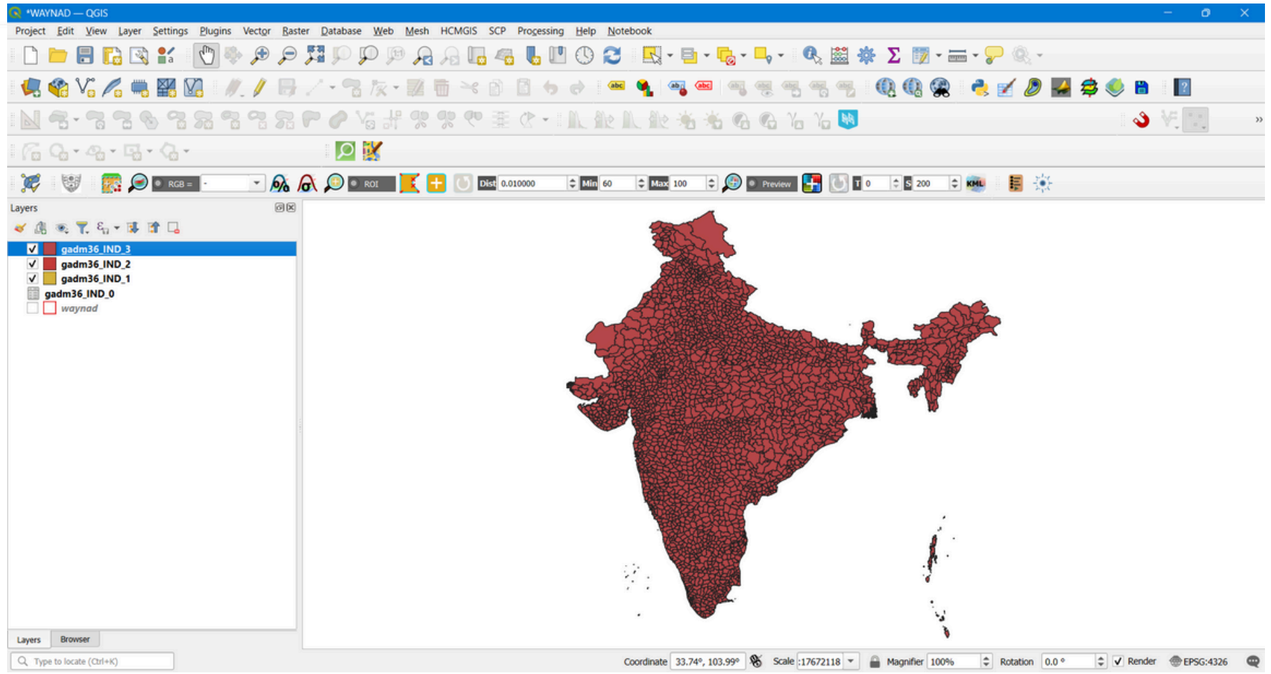
Administrative areas

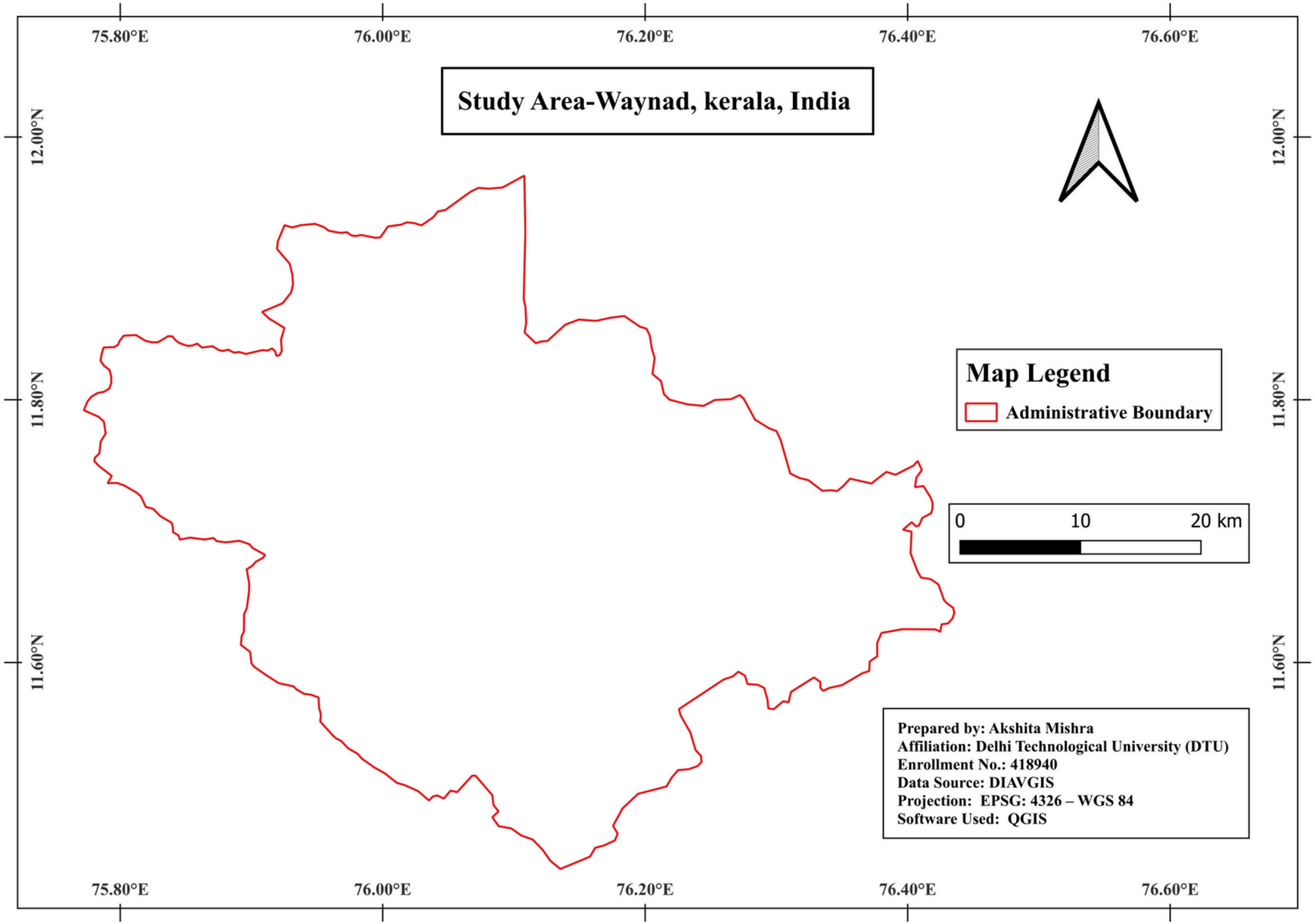
Format

Download IND_adm.zip

Sources

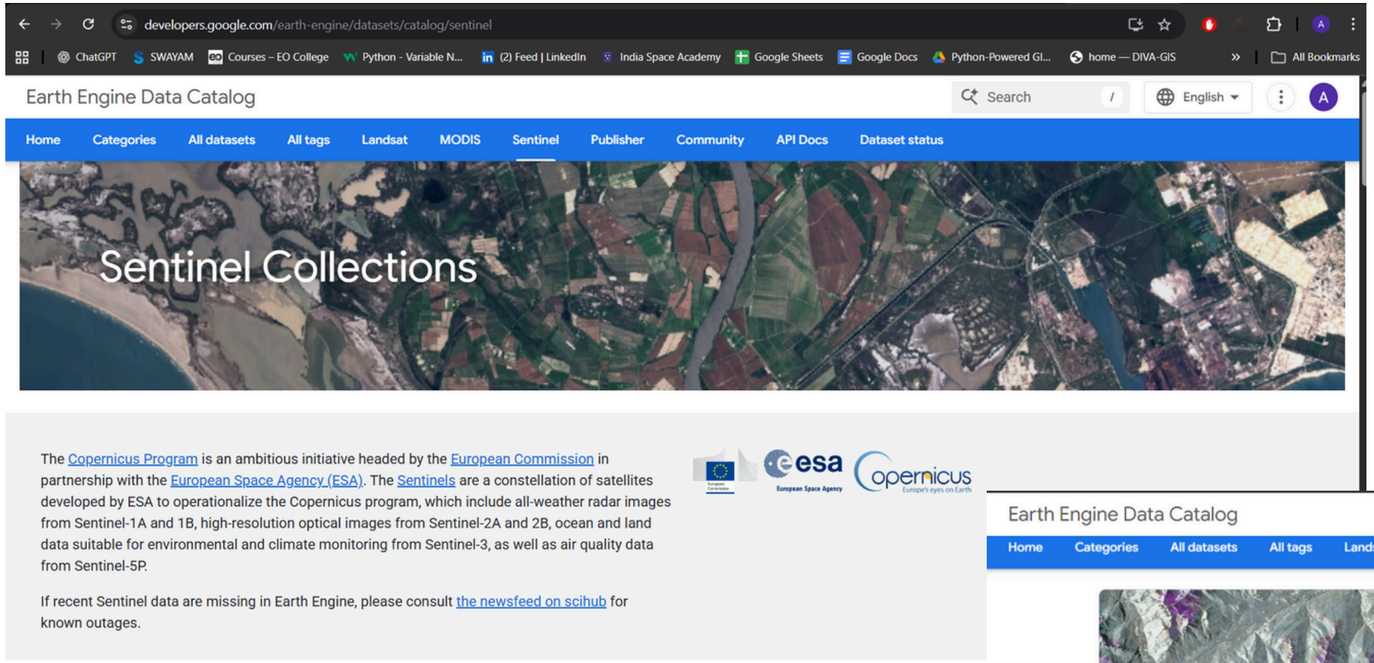
| Subject | Description | Source | Format | Resolution |
|---|---|---|---|---|
| Administrative areas (boundaries) | Country outlines and administrative subdivisions for all countries. The level of subdivisions that is available varies between countries | GADM | Vector (area) | - |





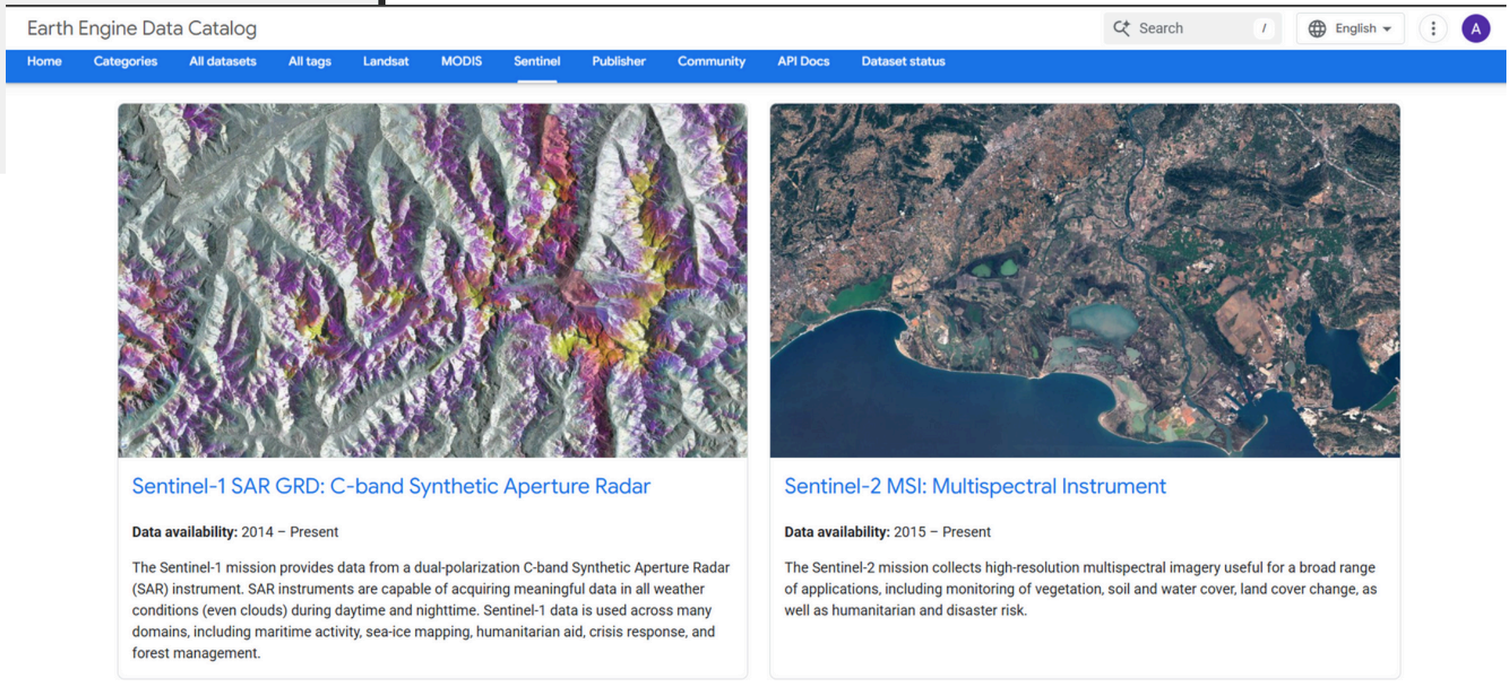

**The final map layout was prepared in QGIS by incorporating standard cartographic elements such as title, legend, scale bar, north arrow, and coordinate grid.**

# Data Set & Bands Used




| Dataset | Satellite | Bands Used | Spatial Resolution | Purpose |
|---|---|---|---|---|
| Sentinel-2 MSI | Sentinel-2 | Band 4 (Red)<br>Band 8 (NIR) | 10–20 m | NDVI computation |

**Sentinel-2 multispectral data were accessed from Google Earth Engine (GEE), and Bands 4 and 8 were used for NDVI calculation.**



# Methodology

Study Area & Data Sources

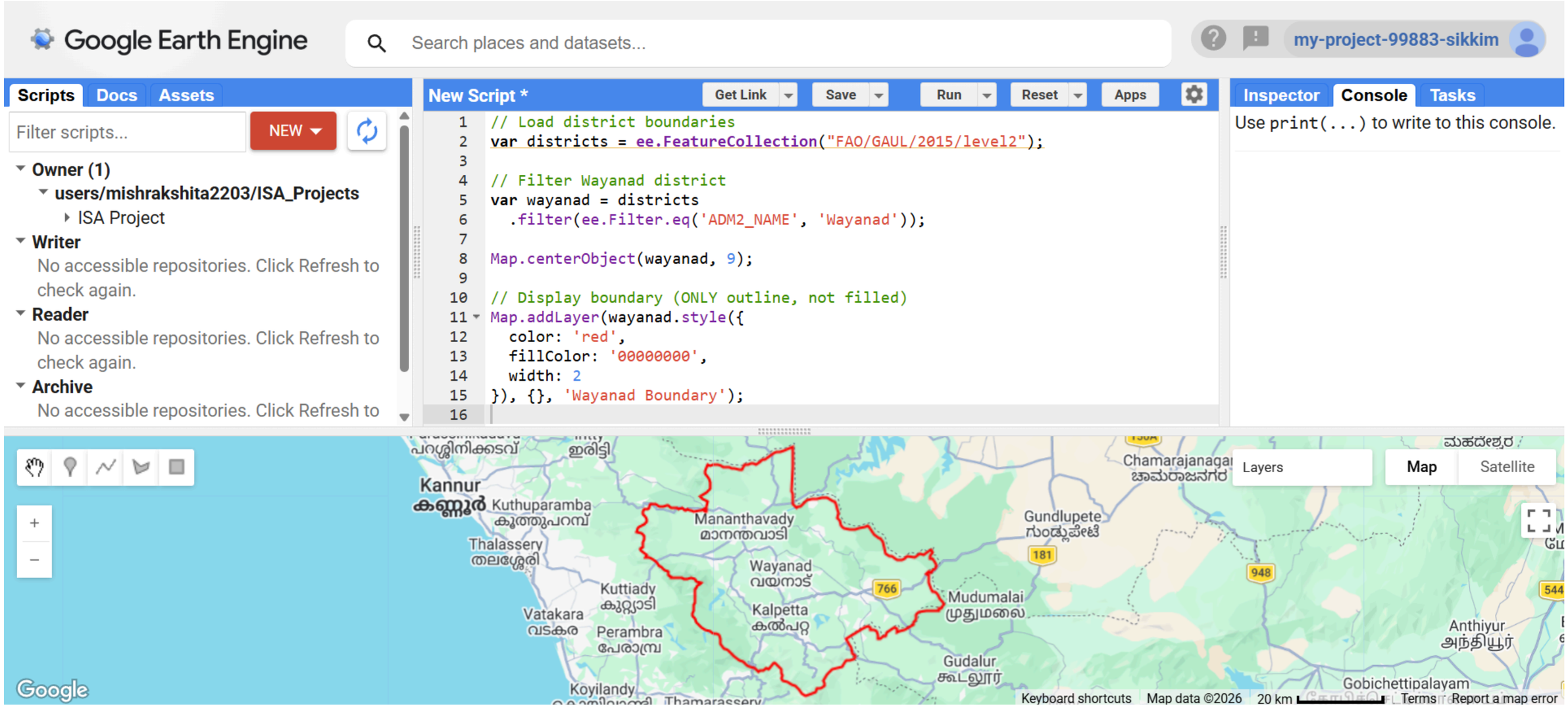
Satellite Data Pre-processing

Vegetation Indices Generation (NDVI)

AI-Assisted Vegetation Classification

Accuracy Assessment & Area Statistics

***STEP 1: Define Study Area (Wayanad Boundary)-*** *The study area boundary of Wayanad district, Kerala was extracted directly within Google Earth Engine using an administrative boundary FeatureCollection. The boundary was filtered using the district name attribute to isolate Wayanad. This approach ensures spatial accuracy and eliminates dependency on external shapefile uploads. The extracted boundary was visualized using a red outline to clearly demarcate the Area of Interest (AOI) without masking internal land cover details.*



***STEP 2: Selection of Season & Cloud-Free Sentinel-2 Imagery-*** *Sentinel-2 Surface Reflectance imagery was used due to its high spatial resolution (10 m) and suitability for vegetation analysis. The dataset was spatially filtered to the Wayanad district boundary and temporally filtered for the summer season (February–March 2023) to avoid monsoon-related cloud contamination. Images with cloud cover greater than 5% were excluded. A median composite was generated to further suppress residual cloud effects and clipped to the AOI for precise analysis.*

Google Earth Engine

Search places and datasets...

my-project-99883-sikkim

Scripts | Docs | Assets

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- Reader
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- Archive
  - No accessible repositories. Click Refresh to

New Script * | Get Link | Save | Run | Reset | Apps

```
// Display boundary (ONLY outline, not filled)
Map.addLayer(wayanad.style({
  color: 'red',
  fillColor: '00000000',
  width: 2
}), {}, 'Wayanad Boundary');

// Load Sentinel-2 Surface Reflectance data
var s2 = ee.ImageCollection('COPERNICUS/S2_SR_HARMONIZED')
  .filterBounds(wayanad)
  .filterDate('2023-02-01', '2023-03-31')
  .filter(ee.Filter.lt('CLOUDY_PIXEL_PERCENTAGE', 5))
  .median()
  .clip(wayanad);
```

Inspector | Console | Tasks

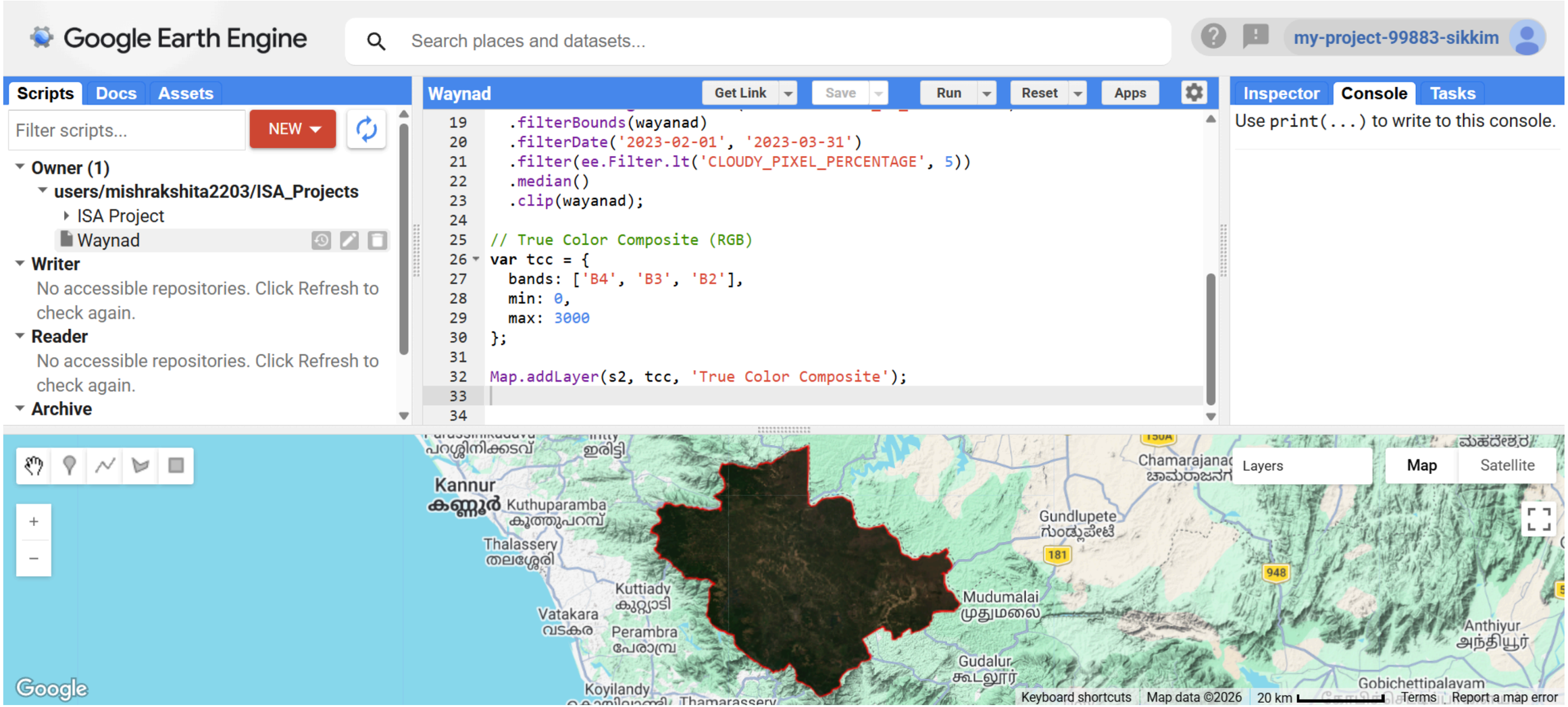
Use `print(...)` to write to this console.

***Why Summer Season Was Selected?***

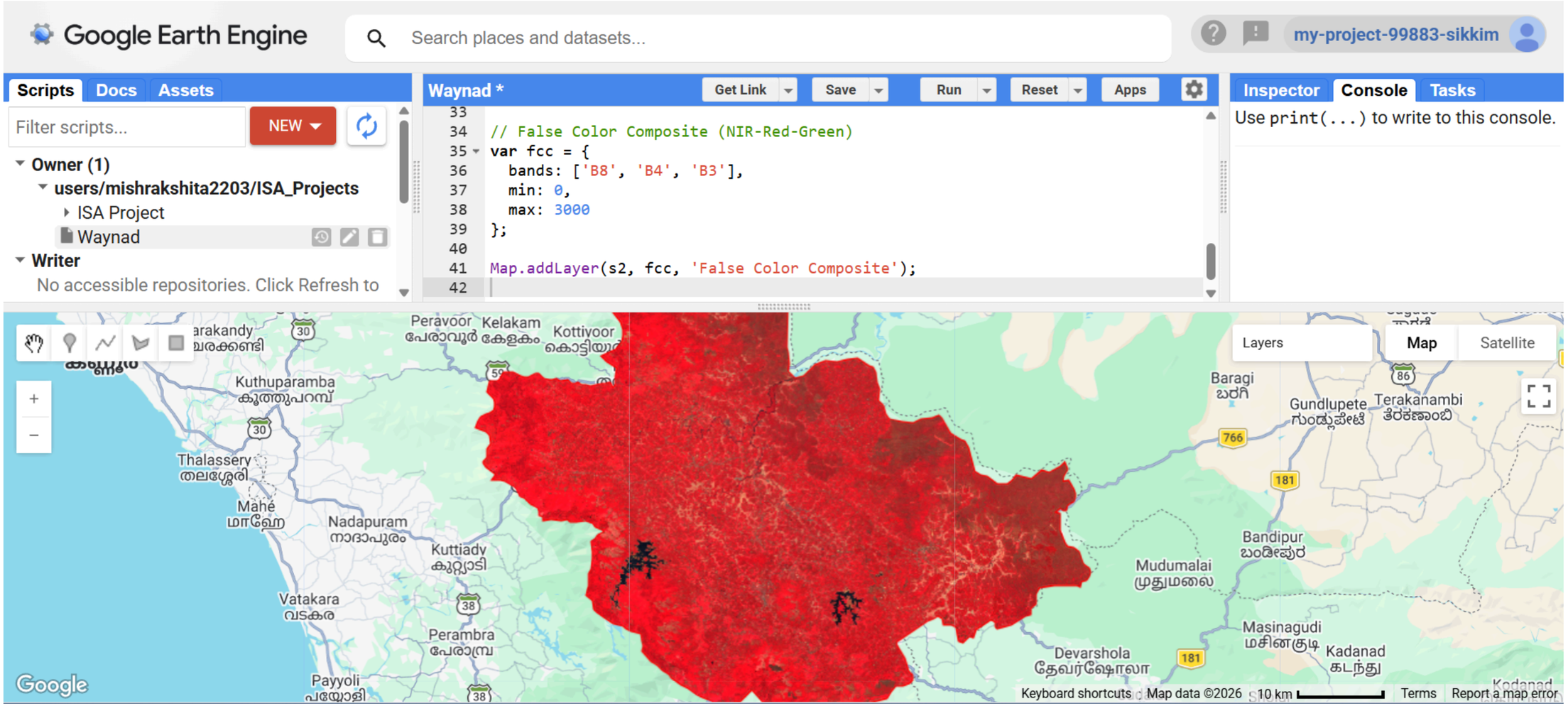
*The summer season was selected due to active agricultural conditions and minimal cloud cover compared to the monsoon period. These factors ensure clearer satellite imagery and more reliable NDVI values for accurate vegetation analysis.*

***Selected period: February–March 2023***

***STEP 3: Pre-Processing – True Color Composite (TCC)-*** *A TCC was generated using Sentinel-2 bands Red (B4), Green (B3), and Blue (B2) to simulate natural color visualization. This step aids in visual verification of land cover, identification of vegetation, water bodies, and built-up areas, and serves as a reference for validating subsequent vegetation indices and classifications.*



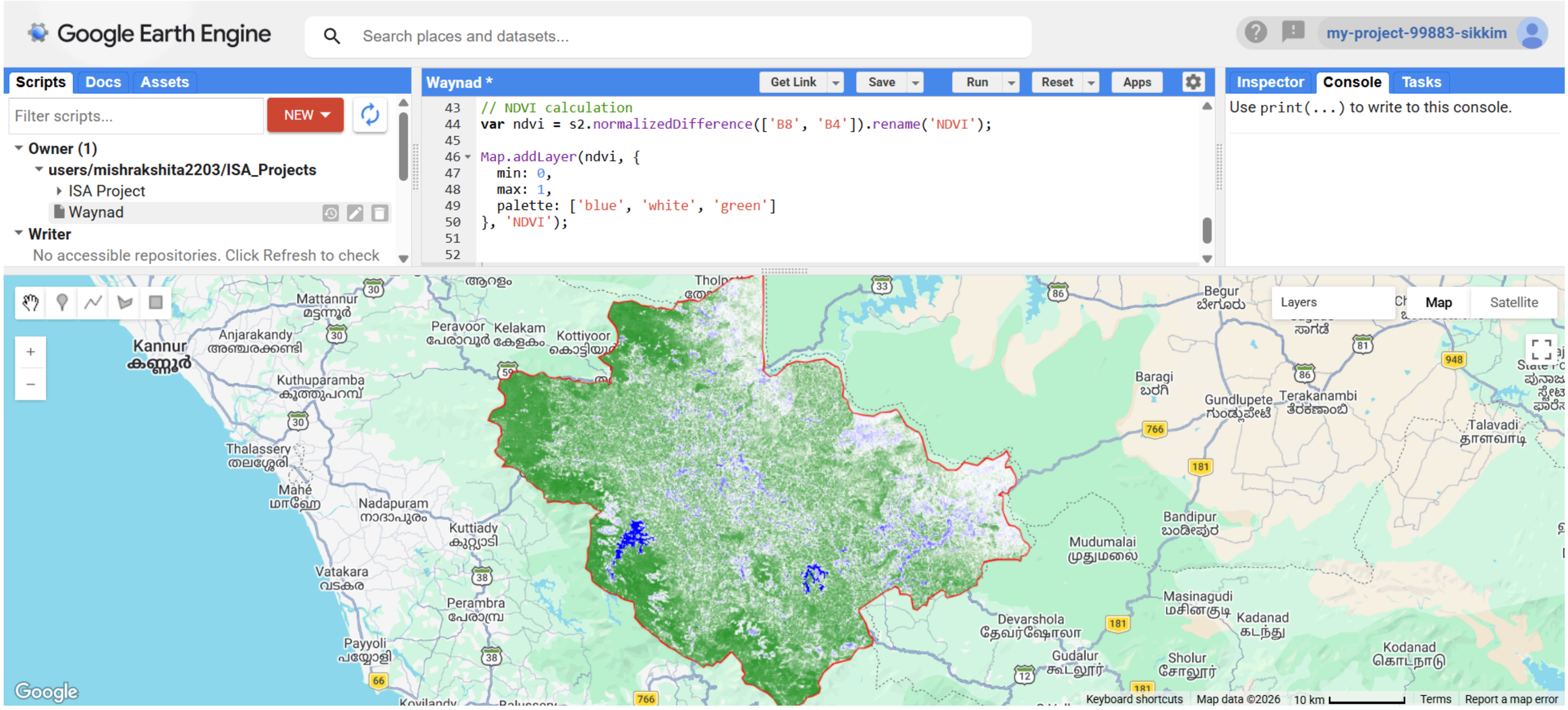
***STEP 4: False Color Composite (FCC)-*** *A False Color Composite (FCC) was created using Near Infrared (B8), Red (B4), and Green (B3) bands. Vegetation appears in shades of red due to high reflectance in the NIR region, making FCC highly effective for distinguishing vegetation density and health. This visual enhancement supports interpretation prior to NDVI computation.*



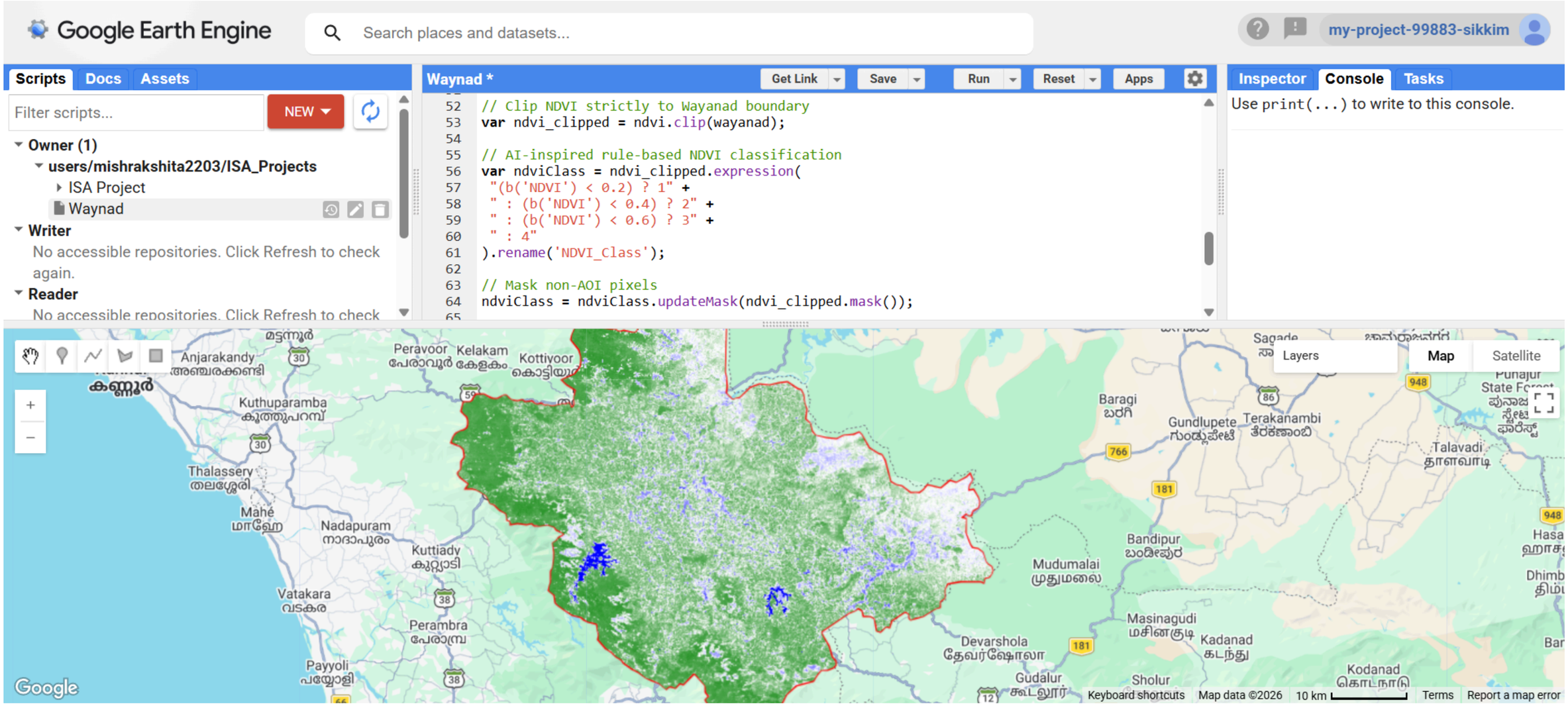
***STEP 5: NDVI Calculation-*** *The Normalized Difference Vegetation Index (NDVI) was computed using the standard formula*

**NDVI = (NIR - Red) / (NIR + Red)**

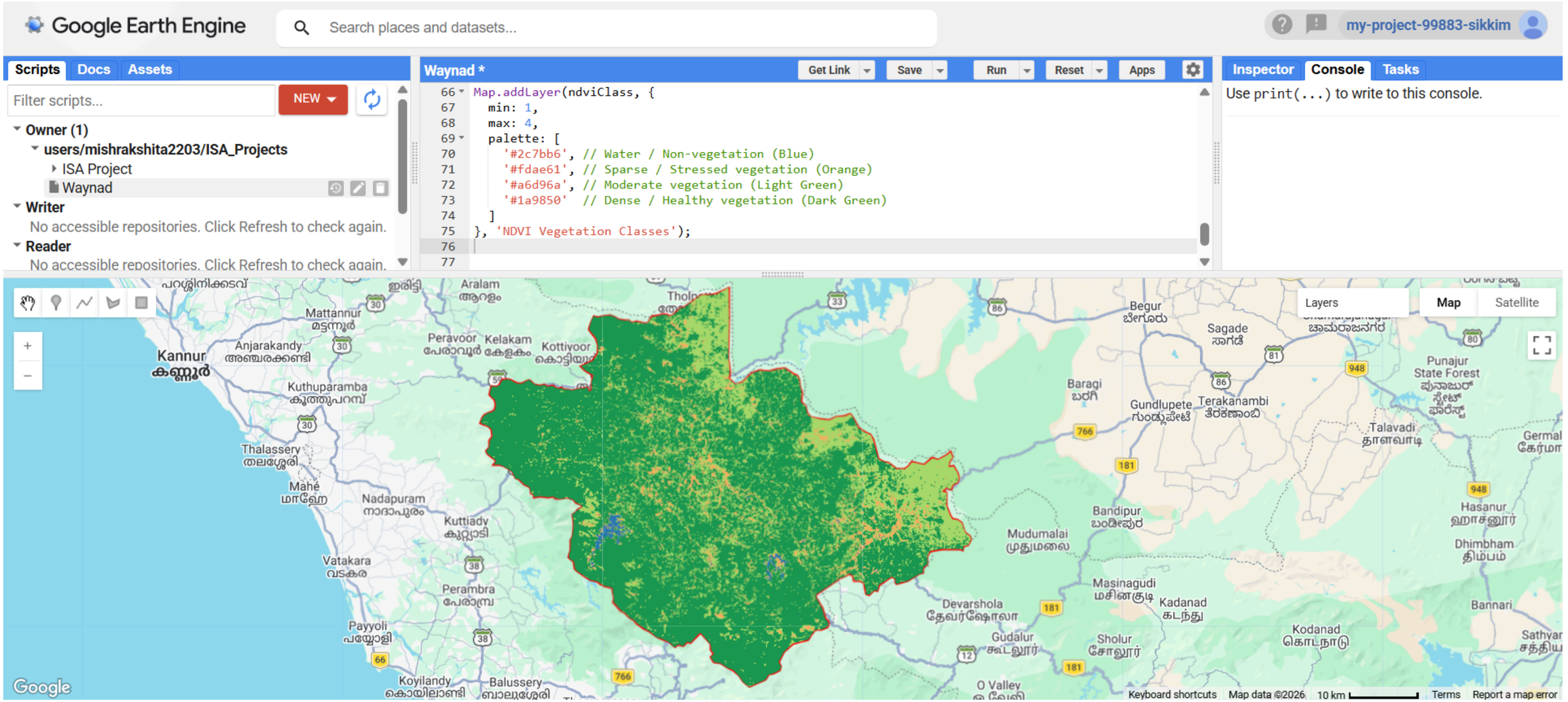
*where Band 8 (NIR) and Band 4 (Red) of Sentinel-2 were used. NDVI values range from –1 to +1, with higher values indicating healthier and denser vegetation. The resulting NDVI raster provides a continuous representation of vegetation vigor across the study area.*



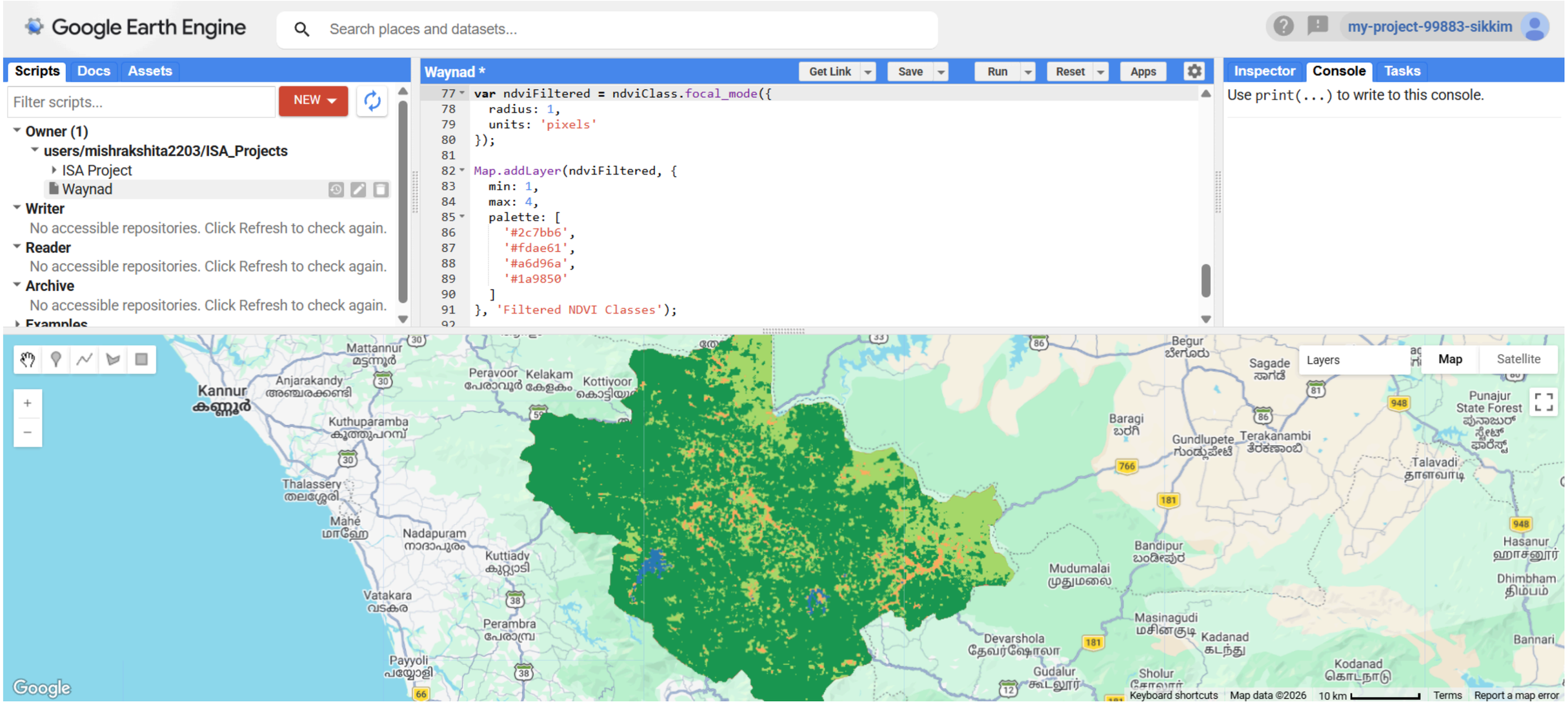
***STEP 6: AI-Inspired NDVI Classification (Adaptive Vegetation Zoning)-*** *The NDVI raster was clipped to the Wayanad district boundary prior to classification to avoid background misclassification. An AI-inspired rule-based logic was applied to adaptively group NDVI values into four vegetation health categories. Masking was applied to remove null pixels outside the study area, ensuring spatial precision.*



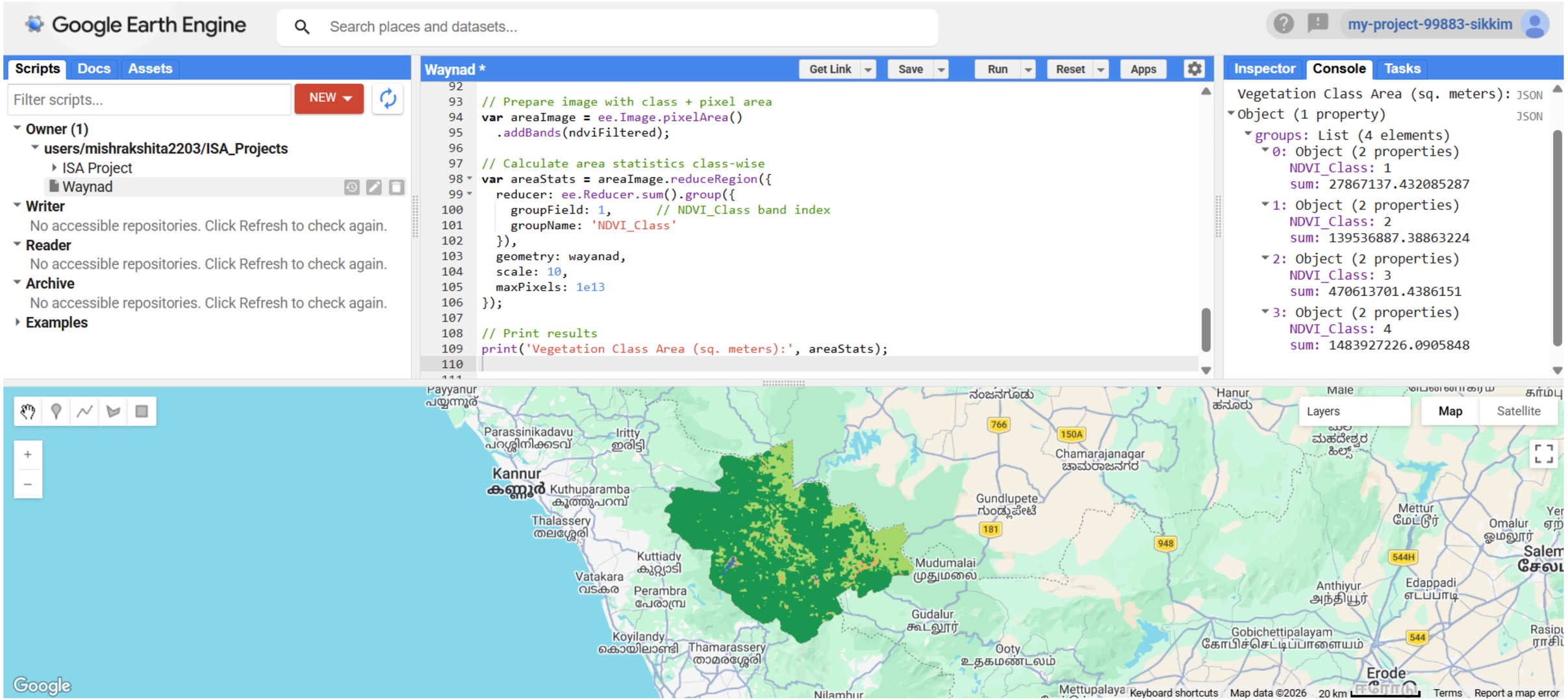
***STEP 7: Improved Color Coding for Vegetation Classes-*** *A scientifically standardized color palette was applied to represent vegetation health classes. Blue represents water and non-vegetated areas, orange indicates sparse or stressed vegetation, while light and dark green represent moderate to dense vegetation respectively. This color scheme improves visual clarity and interpretability of vegetation patterns.*



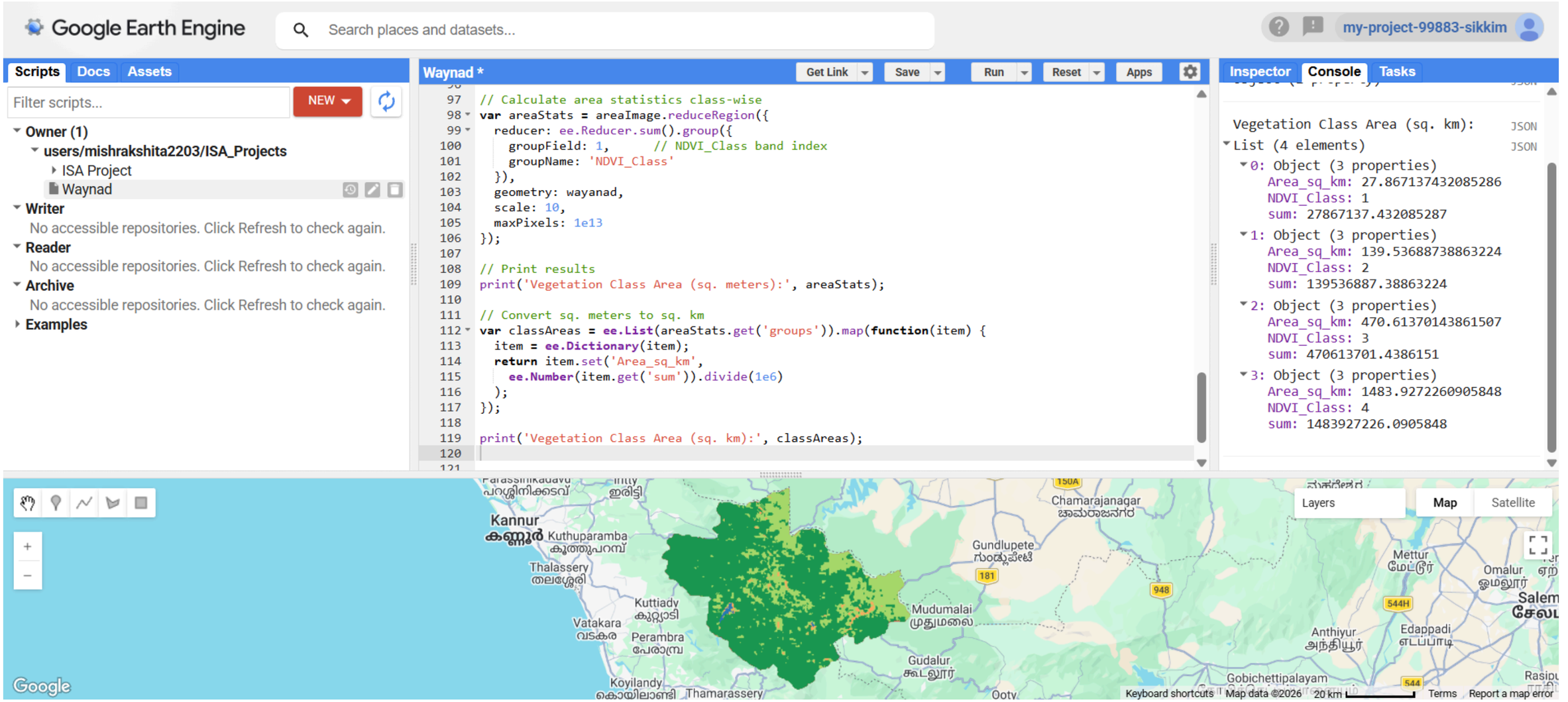
***STEP 8: Post-Classification Noise Reduction-*** *A focal mode filter was applied to the classified NDVI raster to reduce salt-and-pepper noise caused by mixed pixels. This spatial refinement simulates AI-based post-processing and improves class continuity, resulting in a smoother and more realistic vegetation map.*



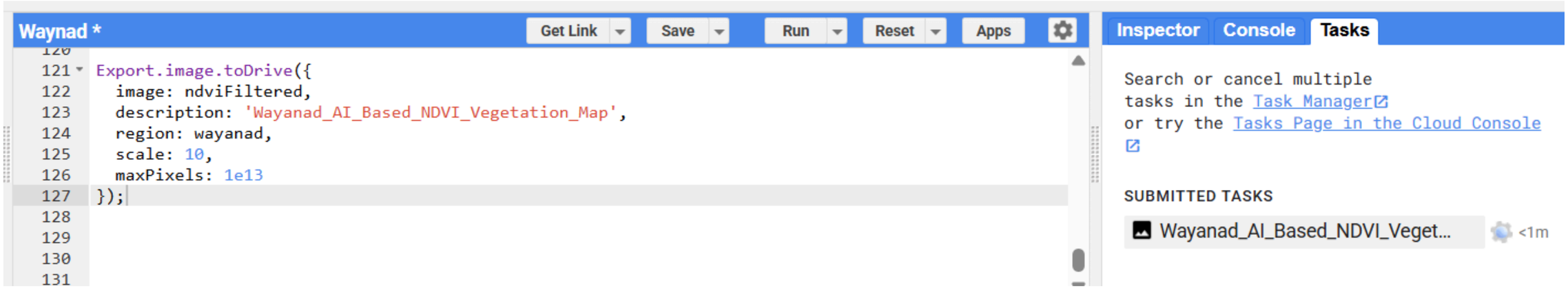
***STEP 9: Area Statistics for Vegetation Health Classes-*** *Area statistics were computed for each vegetation health class by combining pixel-level area information with the classified NDVI raster. This quantitative analysis supports objective assessment of vegetation distribution across the study area.*



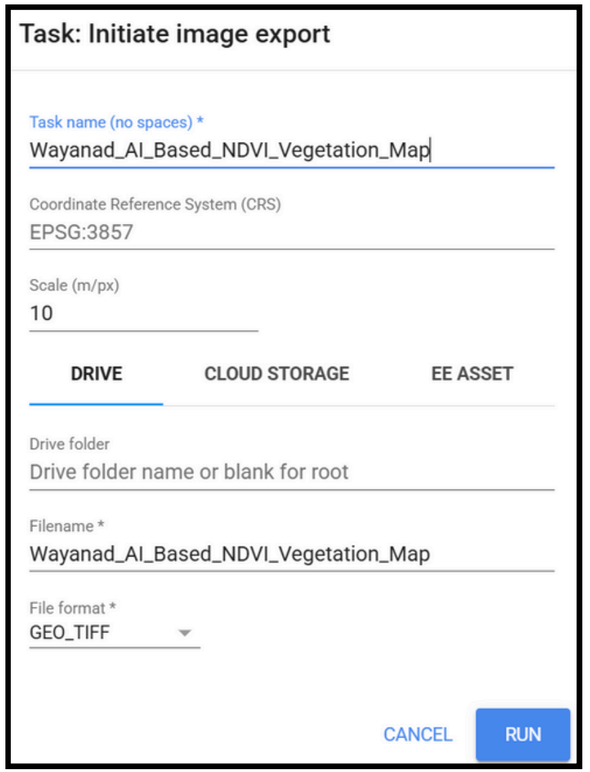
***STEP 10:*** *The calculated areas were further converted f**rom square meters to square kilometers** to facilitate easy interpretation and reporting in standard geographic units.*



***STEP 11: The final AI-assisted NDVI vegetation health and density map was exported from Google Earth Engine to Google Drive at a spatial resolution of 10 meters.***




*Exporting the processed output enables its integration with desktop GIS software such as QGIS for further spatial analysis, cartographic layout preparation, and inclusion in the final project report. This step ensures data reproducibility, long-term storage, and usability of results beyond the cloud-based processing environment.*

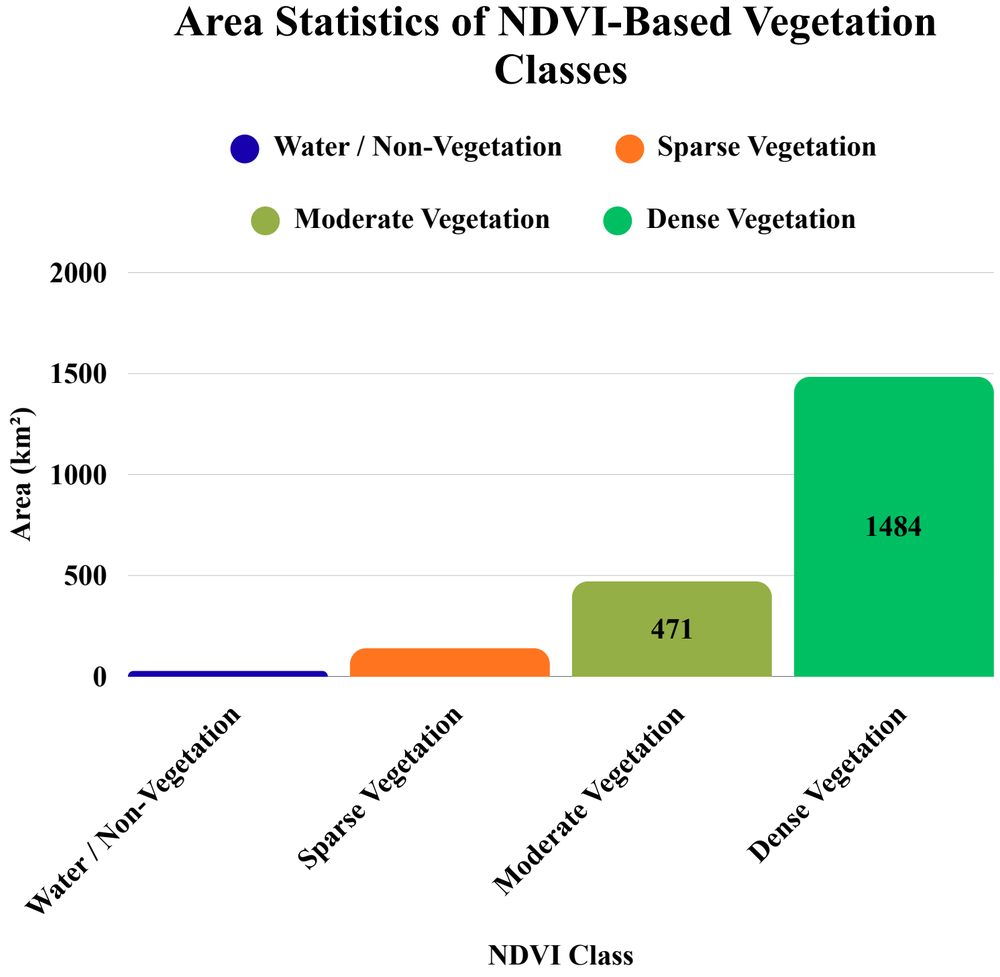


# Result

- *Continuous NDVI raster representing vegetation vigor*
- *AI-assisted classified vegetation health and density map*
- *Area statistics for each vegetation class*
- *Final cartographic layouts suitable for reporting and analysis*

**The AI-based NDVI analysis revealed that Wayanad district is predominantly covered by dense and healthy vegetation, particularly in forested and plantation regions such as Brahmagiri Wildlife Sanctuary, Wayanad Wildlife Sanctuary, and the forest belts around Thirunelli and Muthanga. These areas exhibit consistently high NDVI values, indicating dense canopy cover and healthy vegetation conditions.**

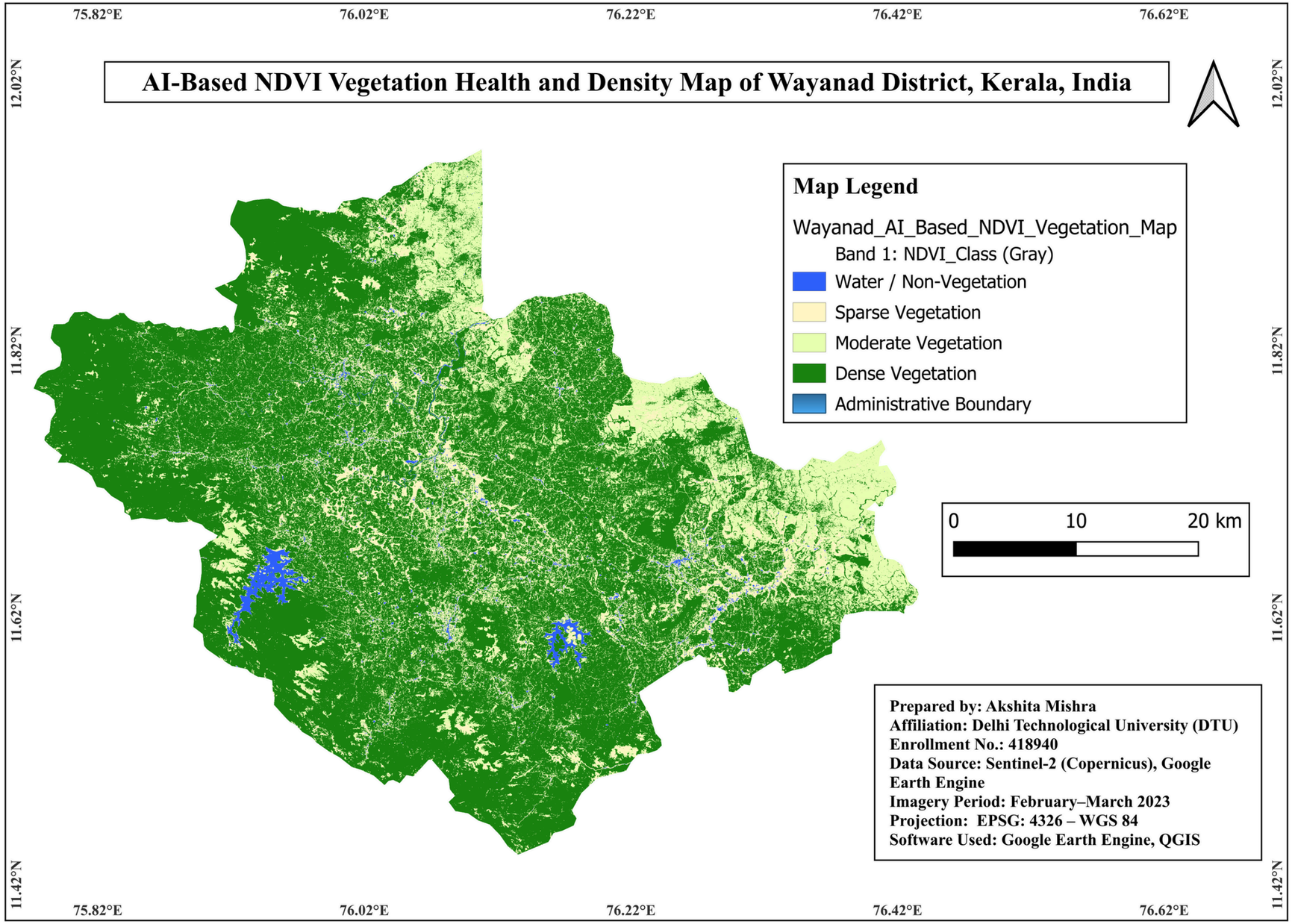
**Moderate vegetation was observed mainly in agricultural and mixed land-use zones, especially around Kalpetta, Mananthavady, and Sulthan Bathery, where plantation crops, croplands, and scattered settlements coexist. Sparse vegetation and non-vegetated regions were limited in extent and were primarily associated with urban settlements, road networks, water bodies, and exposed surfaces, particularly in localized pockets around town centers and river courses.**



# Conclusion

This study demonstrates the effectiveness of integrating Artificial Intelligence-inspired classification techniques with NDVI-based vegetation analysis using Google Earth Engine. The adaptive rule-based approach improved classification consistency and reduced noise compared to traditional fixed-threshold NDVI methods.

The results highlight the dominance of healthy vegetation in Wayanad district and confirm the suitability of cloud-based geospatial platforms for large-area environmental monitoring. Despite limitations related to seasonal variability and atmospheric effects, the methodology provides a reliable framework for vegetation assessment in agricultural, forest, and environmental applications.



# Limitations & Future Scope

## Limitations

- NDVI is sensitive to soil background and seasonal changes.
- Cloud shadows may still influence results despite filtering.
- Rule-based classification approximates AI but does not replace full ML models.

## Future Scope

- Integration of machine learning classifiers (Random Forest, SVM).
- Use of multi-temporal NDVI for seasonal trend analysis.
- Incorporation of additional indices such as EVI and SAVI.

# References


1. Cropin. (n.d.). Normalized Difference Vegetation Index (NDVI). Retrieved from https://www.cropin.com/blogs/ndvi-normalized-difference-vegetation-index/
2. Google Earth Engine. (2023). NDVI calculation tutorial. https://developers.google.com/earth-engine/tutorials/tutorial_api_06
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