ANALYSING NDVI FOR INDIA

CS 341
GeoInformatics Project
Mentor:
Dr. Subhajit Bandhopadhyay

Presented by:
Tridib Nandi (202151174)
Shruti Gupta (202151151)

Group Name : TerraTech
Members : Tridib Nandi (202151174), Shruti Gupta (202151151)
Project 1 : Analysing NDVI for India
Duration : 30/11/2023 – 18/12/2023

Objectives:

Our objective was to write GEE code to calculate and analyze NDVI for India.
In this project, we wrote code to analyze the *Normalized Difference Vegetation Index* (NDVI) for India using Google Earth Engine (GEE). NDVI is a valuable indicator of vegetation health and can provide insights into land cover changes, agriculture, and environmental conditions.

Interpretation and Analysis:

The analysis of India's Normalized Difference Vegetation Index (NDVI) during the summer and monsoon seasons of 2022 is the primary focus of the Google Earth Engine (GEE) code. The production of time-series charts for the summer and monsoon seasons facilitates temporal analysis. These graphs provide a dynamic picture of vegetation changes by showing how NDVI values have changed over time. Patterns like the beginning of greenness, agricultural cycles, and reactions to environmental stress can be seen in the temporal trends of the NDVI. The temporal dynamics are represented more accurately in the time-series charts due to the lower scale used, which reduces the possibility of pixel count inaccuracies.

It turns out that the NDVI across India ranged from 0.078 to 0.397 during the monsoon season and from 0.106 to 0.343 during the summer. During the monsoon season, the maximum and minimum NDVI were recorded in September and July, respectively. The NDVI trend indicates a slight variation in the growth of vegetation around its mean value. The end of April and the beginning of May show a greater NDVI (0.343), whereas June shows a comparatively lower NDVI (0.106), indicating a decline in the patterns of vegetation development.

A high NDVI denotes a climate that is more conducive to photosynthesis, whereas a low NDVI could be the result of any natural disaster and related human activity like industry, urbanization, etc. The inter annual variation of NDVI is noteworthy due to their similar pattern, and strong association. The dynamic characteristics of soil moisture and precipitation are linked to agricultural productivity and natural vegetation growth, as is the fluctuation of the NDVI. During the monsoon, the NDVI displays somewhat higher values, which are linked to higher seasonal land surface temperatures. The increase in surface water irrigation during the monsoon may be the cause of the high NDVI rating. Nevertheless, given the variations in average NDVI throughout all seasons, the NDVI standard deviation was found to be somewhat substantial, highlighting the necessity of long-term studies to comprehend the variations brought on by certain meteorological factors.

In India, the summer months begin in April and last until the end of June. In contrast, the rainy season begins in July and ends in the first week of October. The months of July and August see the most precipitation, and the south-west monsoon winds that originate in the Indian Ocean may have a significant impact on this by transporting air masses that are driven by moisture. A slightly elevated NDVI is noted in high altitude regions, primarily as a result of increased microbial activity, metabolic reactions, and nitrogen availability. The biochemical and microbiological processes are crucial for soil fertility, which supports plant growth. Previous research has shown that a decrease in photosynthesis occurs during exceptionally rainy seasons, which is attributed to a reduction in solar energy availability. It has been noted that the NDVI is also dependent on the land cover (forest, agricultural, grassland, and urban areas), the local elevation, and the meteorological factors (temperature, rainfall, humidity, and soil moisture). In order to influence the rate of evaporation (water from the soil) and evapotranspiration (water from leaves) in crops and plants, soil moisture is essential to the life cycle of plants. Due to the usual meteorological conditions throughout the Indian Subcontinent region, as compared to other continents, higher values of NDVI were reported during monsoon seasons. Due to the availability of an energy source, photosynthesis is encouraged by two factors (Soil Moisture and Land Surface Temperature). The plant can create the most sugar from the available carbon dioxide and water, which further boosts the plant's metabolism and helps it reach a healthy NDVI. On the other hand, June's pre-monsoon season record lowest average NDVI as a result of greater land surface temperature and decreased soil moisture. These conditions cause the pre-monsoon evaporation and evapotranspiration rates from soil and plant leaves, respectively, to increase, which inhibits the growth of trees and plants.

Significant ramifications for Indian agriculture and environmental monitoring result from the insights gained from the NDVI research conducted throughout the summer and monsoon seasons. The data can be used by agricultural stakeholders to monitor the effects of weather on vegetation, evaluate crop health, and optimise planting and harvesting schedules. Researchers studying the environment can learn more about how ecosystem dynamics, seasonal variations, and changes in land cover affect biodiversity.

Challenges (Team faced):

Error in Map (Too Many Pixels):

Issue: The error indicated too many pixels in the region when calculating the mean NDVI.

Solution: Reduced the scale when calculating the time-series chart to aggregate pixels and lower the pixel count.

Error in Export (Payload Size Exceeds Limit):

Issue: The payload size for export to Google Drive exceeded the limit.

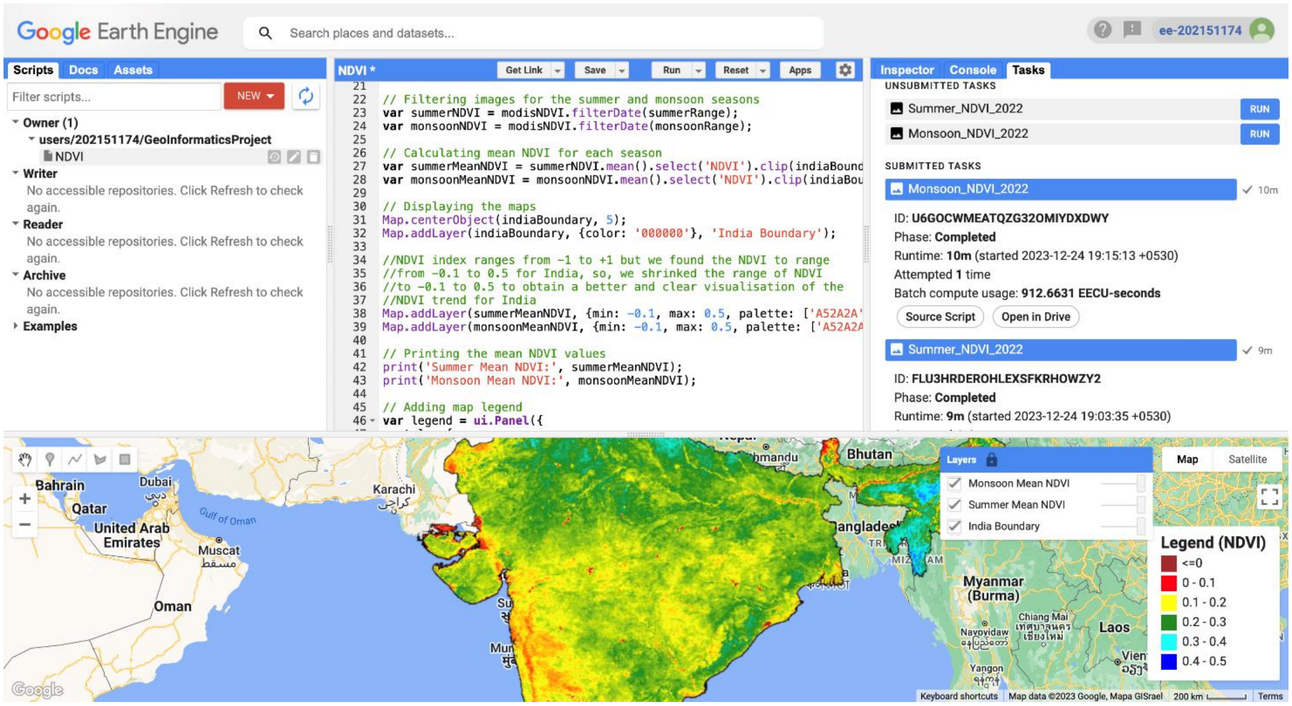
Solutions:

- Reduce the Area of Interest (AOI) or select a smaller region within India.
- Reduce the spatial resolution (scale) when exporting to reduce the amount of data.
- Split the export into smaller time intervals if covering a long period.
- Use Google Cloud Storage (GCS) instead of Google Drive for larger exports.

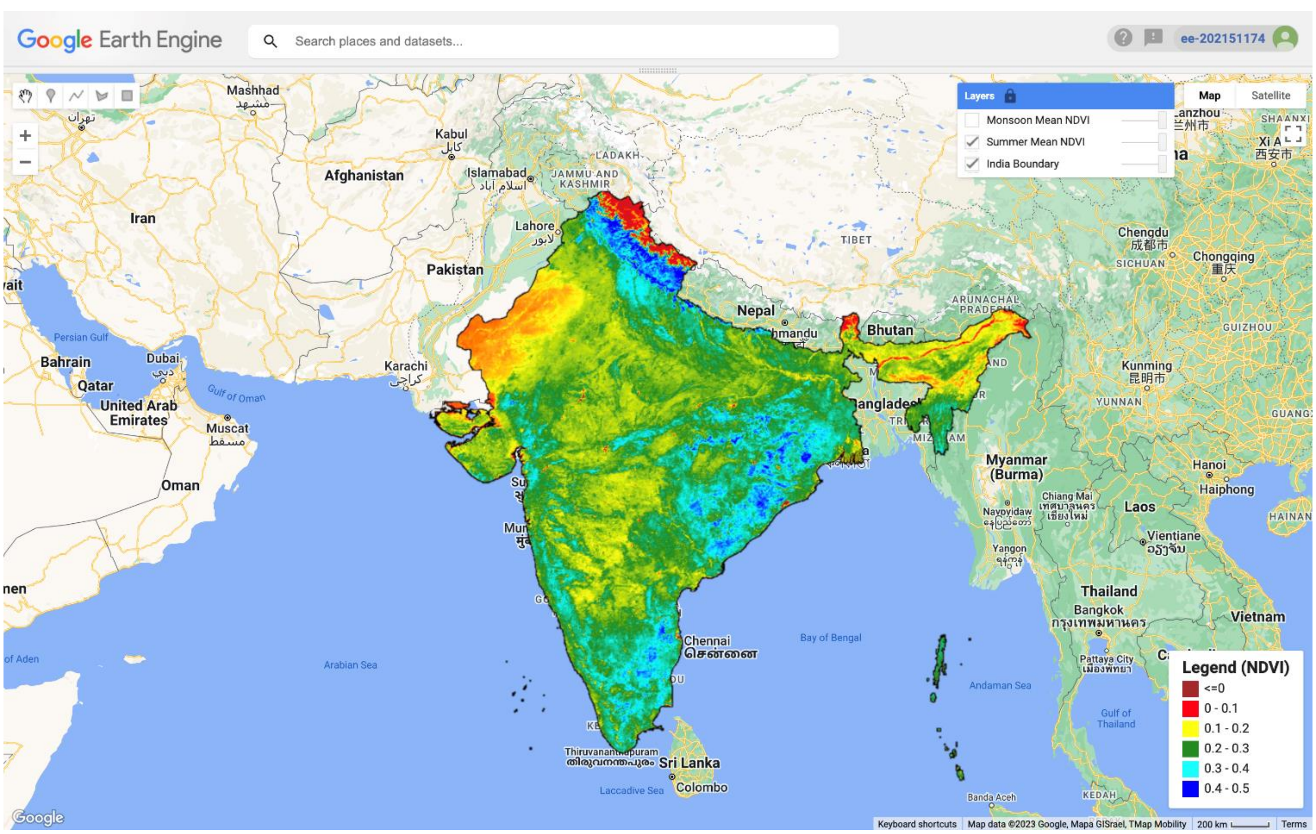
The following error message appeared when we attempted to export the NDVI pattern to Google drive: "Request payload size exceeds the limit: 10485760 bytes" because of the limits of the standard version of GEE. Thus, we attempted to extract the NDVI pattern for a more limited area, which is the state of Kerala. The link to Kerala's NDVI trends for the summer and monsoon seasons is provided below.

https://drive.google.com/drive/folders/1J_ca5u9Fe5hq28OCSFntkRtMoJrUviw5?usp=sharing

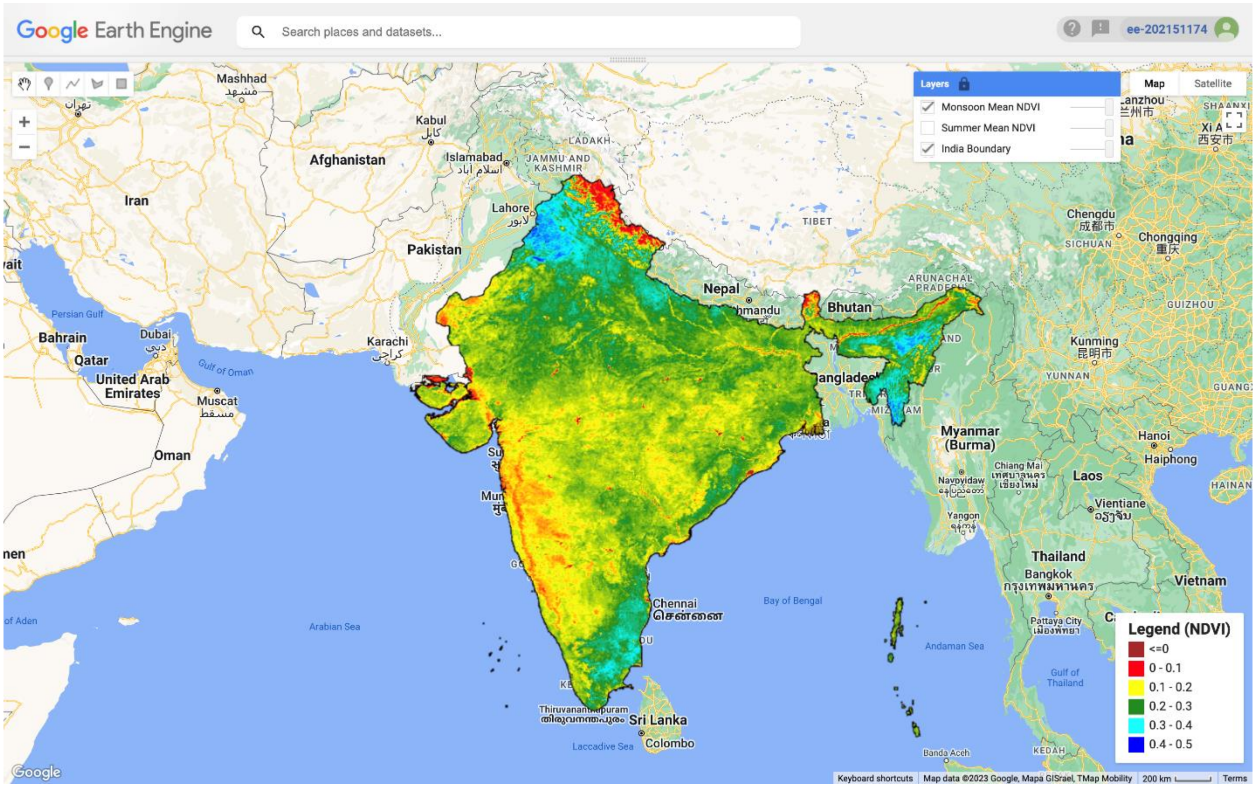
GEE Screenshot:



For Summer:



For Monsoon:



CODE:

```
// Defining the FAO/GAUL/2015/level0 dataset for India boundary
var indiaBoundary =
ee.FeatureCollection('FAO/GAUL/2015/level0').filter(ee.Filter.eq('ADM0_NAME',
'India'));
// Defining the MODIS MOD09GA dataset for NDVI
var modis = ee.ImageCollection('MODIS/061/MOD09GA')
  .filterBounds(indiaBoundary)
  .select(['sur_refl_b01', 'sur_refl_b02']);

// Function to calculate NDVI
var calculateNDVI = function(image) {
  var ndvi = image.normalizedDifference(['sur_refl_b02',
'sur_refl_b01']).rename('NDVI');
  return image.addBands(ndvi);
};
```

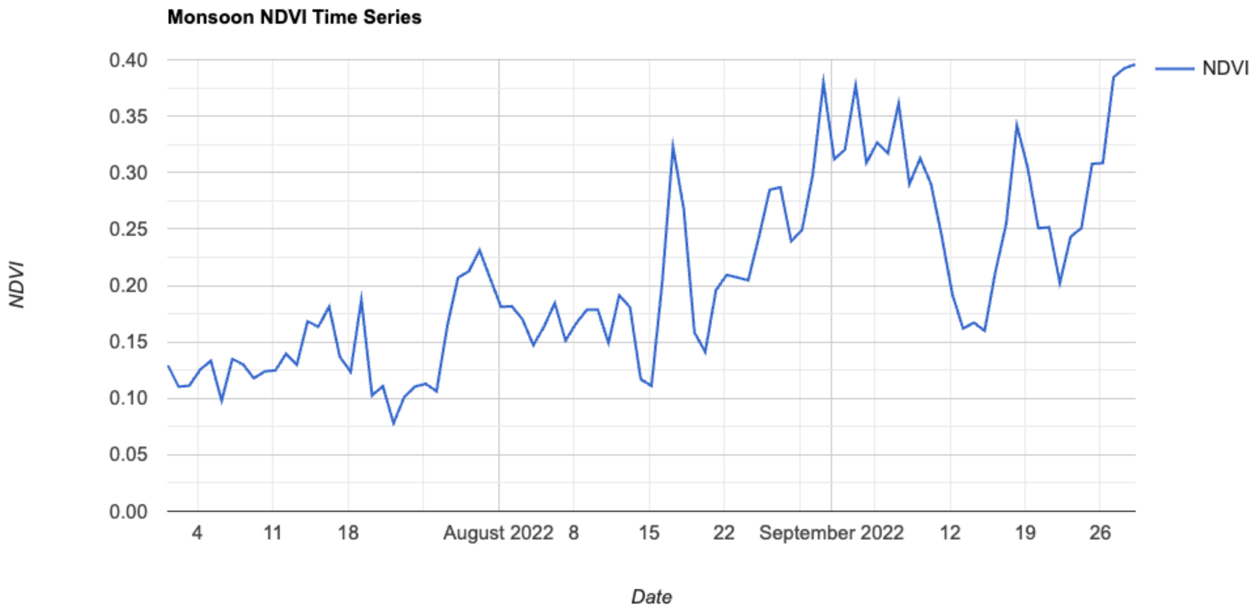
```
// Mapping the NDVI calculation function over the MODIS dataset
var modisNDVI = modis.map(calculateNDVI);

// Defining time ranges for the summer and monsoon seasons in 2022
var summerRange = ee.DateRange('2022-04-01', '2022-06-30');
var monsoonRange = ee.DateRange('2022-07-01', '2022-09-30');

// Filtering images for the summer and monsoon seasons
var summerNDVI = modisNDVI.filterDate(summerRange);
var monsoonNDVI = modisNDVI.filterDate(monsoonRange);

// Calculating mean NDVI for each season
var summerMeanNDVI = summerNDVI.mean().select('NDVI').clip(indiaBoundary);
var monsoonMeanNDVI = monsoonNDVI.mean().select('NDVI').clip(indiaBoundary);

// Displaying the maps
Map.centerObject(indiaBoundary, 5);
Map.addLayer(indiaBoundary, {color: '000000'}, 'India Boundary');

//NDVI index ranges from -1 to +1 but we found the NDVI to range
//from -0.1 to 0.5 for India, so, we shrinked the range of NDVI
//to -0.1 to 0.5 to obtain a better and clear visualisation of the
//NDVI trend for India
Map.addLayer(summerMeanNDVI, {min: -0.1, max: 0.5, palette: ['A52A2A', 'FF0000',
'FFFF00', '228B22', '00FFFF', '0000FF']}, 'Summer Mean NDVI');
Map.addLayer(monsoonMeanNDVI, {min: -0.1, max: 0.5, palette: ['A52A2A', 'FF0000',
'FFFF00', '228B22', '00FFFF', '0000FF']}, 'Monsoon Mean NDVI');

// Printing the mean NDVI values
print('Summer Mean NDVI:', summerMeanNDVI);
print('Monsoon Mean NDVI:', monsoonMeanNDVI);

// Adding map legend
var legend = ui.Panel({
  style: {
    position: 'bottom-right',
    padding: '8px 15px'
  }
});
var legend2 = ui.Label({
  value: 'Legend (NDVI)',
  style: {
    fontWeight: 'bold',
    fontSize: '18px',
    margin: '0 0 4px 0',
    padding: '0'
```

```
    }
});

legend.add(legend2);

// Creating the content of the legend
var content = function(color, label) {

      // Creating the color boxes
      var box = ui.Label({
        style: {
          backgroundColor: '#' + color,

          // Setting box height and width
          padding: '9px',
          margin: '0 0 4px 0'
        }
      });

      // Creating the labels
      var labels = ui.Label({
        value: label,
        style: {margin: '0 0 4px 6px'}
      });

      return ui.Panel({
        widgets: [box, labels],
        layout: ui.Panel.Layout.Flow('horizontal')
      });
};
//  Setting legend colors
var classcolor = ['A52A2A', 'FF0000', 'FFFF00', '228B22', '00FFFF', '0000FF'];

// Setting legend labels
var labelName = ['<=0', '0 - 0.1', '0.1 - 0.2', '0.2 - 0.3', '0.3 - 0.4', '0.4 -
0.5'];
// Combining legend colour and labels
for (var i = 0; i < 6; i++) {
  legend.add(content(classcolor[i], labelName[i]));
  }

// Adding legend to the map
Map.add(legend);
// Creating a time-series chart for NDVI with a lower scale
var chartSummer = ui.Chart.image.series({
  imageCollection: summerNDVI.select('NDVI'),
```

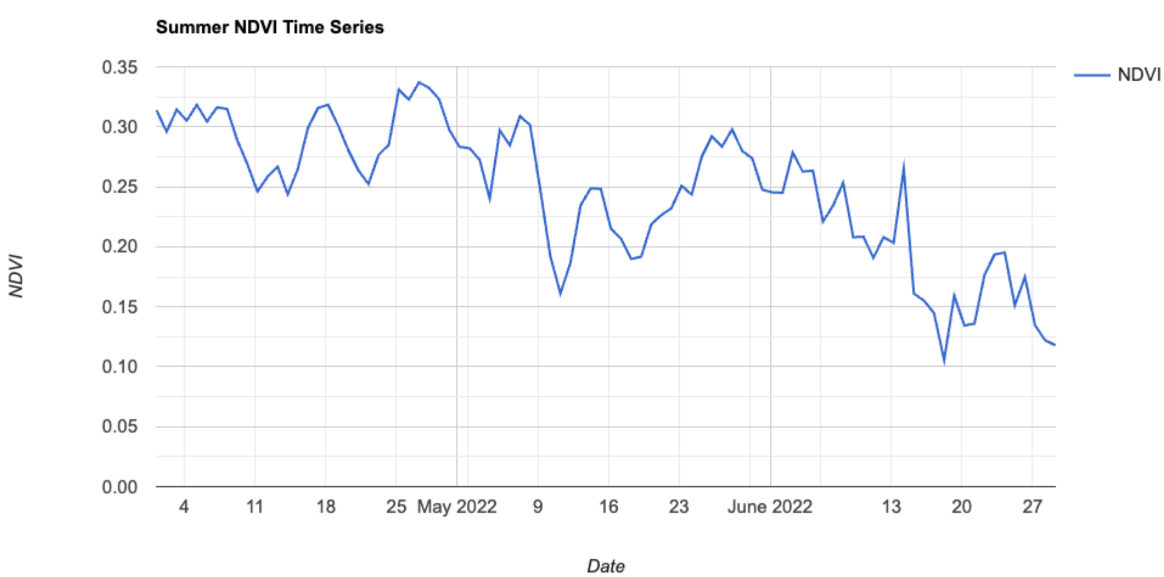
```
  region: indiaBoundary,
  reducer: ee.Reducer.mean(),
  scale: 4000, // Using a lower scale
  xProperty: 'system:time_start'
}).setOptions({
  title: 'Summer NDVI Time Series',
  vAxis: {title: 'NDVI'},
  hAxis: {title: 'Date'},
});
var chartMonsoon = ui.Chart.image.series({
  imageCollection: monsoonNDVI.select('NDVI'),
  region: indiaBoundary,
  reducer: ee.Reducer.mean(),
  scale: 4000, // Using a lower scale
  xProperty: 'system:time_start'
}).setOptions({
  title: 'Monsoon NDVI Time Series',
  vAxis: {title: 'NDVI'},
  hAxis: {title: 'Date'},
});

// Displaying the charts
print(chartSummer);
print(chartMonsoon);

// Exporting the final NDVI images to Google Drive
Export.image.toDrive({
  image: summerMeanNDVI,
  description: 'Summer_NDVI_2022',
  scale: 5000,
  region: indiaBoundary,
  folder: 'NDVI_Export',
  crs: 'EPSG:4326'
});

Export.image.toDrive({
  image: monsoonMeanNDVI,
  description: 'Monsoon_NDVI_2022',
  scale: 5000,
  region: indiaBoundary,
  folder: 'NDVI_Export',
  crs: 'EPSG:4326'
});
```

Time – Series Graphs:

Monsoon NDVI Time Series:



Summer NDVI Time Series:



Conclusion:

In conclusion, the analysis of Normalized Difference Vegetation Index (NDVI) trends in India provides valuable insights into the dynamic relationship between vegetation health and environmental factors. The exploration encompasses both the summer and monsoon seasons, revealing nuanced patterns and variations in vegetation development. The findings contribute to our understanding of the ecological dynamics within India and offer a foundation for further research and applications. The key observations from the analysis include the seasonal fluctuation of NDVI values, with higher values during the monsoon season and variations in different regions of India. The temporal trends highlight the influence of meteorological factors, such as precipitation and soil moisture, on vegetation dynamics. The integration of NDVI with land cover classification, biodiversity assessment, and climate change impact analysis presents opportunities for a more comprehensive understanding of India's ecosystems.

Moreover, the analysis serves as a foundation for ongoing and future research initiatives aimed at monitoring and mitigating the impacts of climate change, enhancing biodiversity conservation efforts, and promoting sustainable land use practices. By combining remote sensing technologies with interdisciplinary approaches, the work contributes to the broader goals of achieving environmental sustainability, resilience, and a harmonious coexistence between society and the Earth's ecosystems.

In summary, the NDVI analysis in India not only provides valuable information about vegetation dynamics but also lays the groundwork for holistic and sustainable approaches to environmental management, fostering a deeper connection between Earth, environment, and society.

New ideas to extend the work:

1. Land Cover Classification:

To classify different forms of land cover, including forests, agricultural, urban areas, and water bodies, more sophisticated classification algorithms can be implemented. A more thorough understanding of land use changes and how they affect ecosystems can be gained from this information.

2. Urban Planning and Green Infrastructure:

We can evaluate urban green areas and vegetation cover using NDVI analysis. We can then, utilize the findings to improve urban quality of life, encourage green infrastructure, and guide urban planning initiatives while reducing the impact of the urban heat island.

3. Climate Change Impact Analysis:

In order to identify possible effects of climate change on vegetation patterns, we can examine long-term NDVI trends. We can also, examine the effects of temperature changes, precipitation patterns, and extreme weather events on ecosystem resilience and NDVI values.

4. Precision Agriculture:

By giving farmers information on crop health, development stages, and regions that need attention, NDVI data can be used to precision farm. This can improve agricultural sustainability, reduce environmental impact, and maximize resource usage.

5. Natural Disaster Monitoring and Resilience:

We can investigate how NDVI data can contribute to monitoring and assessing the impact of natural disasters, such as floods, wildfires, and cyclones. We can use this information to enhance disaster resilience strategies and response planning.

By expanding the scope of NDVI analysis and integrating it with other datasets and technologies, the extended work can offer valuable insights for sustainable decision-making, resource management, and environmental conservation on local, regional, and global scales.

References:

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