Evolving Canopies

Tracking Climate Change Transformation in India's Forests

Concept Note

Satellite data reveals that Earth has undergone significant greening, with croplands in India emerging as one of the most pronounced greening hotspots (Chen et al., 2019). Green revolution in India has been influenced by changing climate patterns and increased human interventions. However, the expansion of agriculture has put pressure on India's forest cover, leading to deforestation for land clearance and agricultural expansion. Currently, forests in India cover only 21.71% of the country's total geographical area (FSI, 2021). This figure falls short of the target set by the National Forest Policy of India in 1988, which aimed to achieve 33% forest and tree cover across the nation. Therefore, real-time monitoring of forest dynamics is crucial for assessing the impact of human activities, such as deforestation, and for guiding conservation efforts aimed at preserving and restoring forest ecosystems.

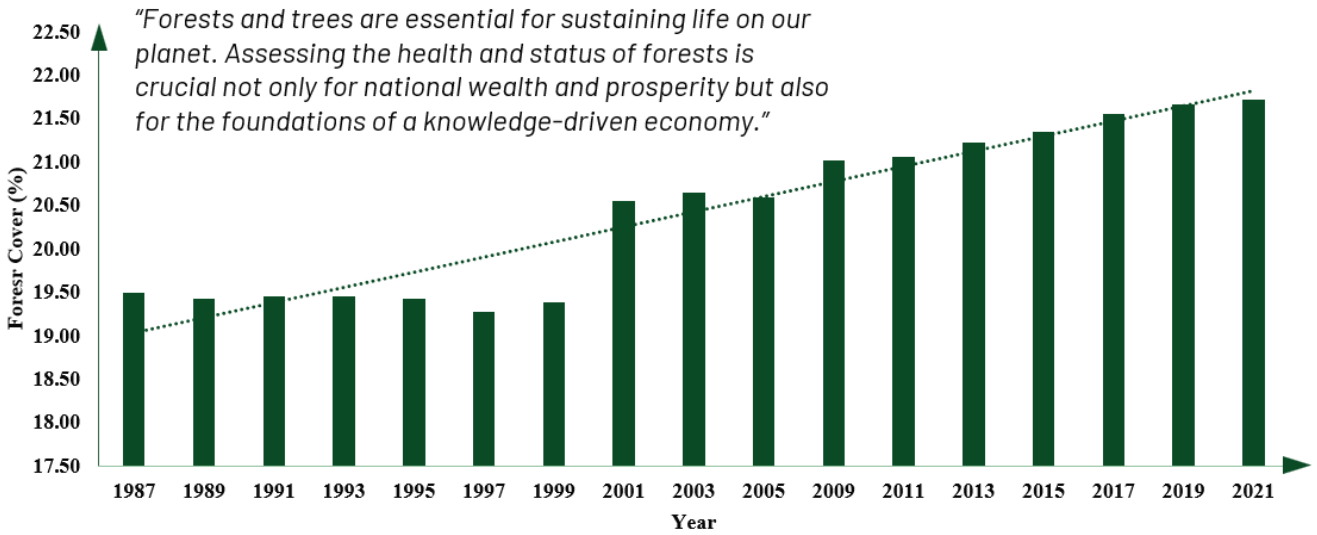

Figure 1 Forest Cover of India

Our work addresses three crucial aspects of forest cover dynamics: long-term change, near-real-time monitoring, and future climate projections. First, we aim to gather comprehensive data on the historical changes in forest cover through the analysis of land use statistics reports. This will provide valuable insights into the trends and patterns of forest dynamics over an extended period. Secondly, we aim to establish a system for monitoring forest areas in near real-time, which will enable us to track changes in forest cover, detect disturbances such as deforestation or forest degradation promptly, and assess the effectiveness of conservation measures. Lastly, we will explore the relationship between climate change variables and forest cover dynamics, projecting how this relationship may evolve under future climate scenarios.

Overall, our work aims to be a pivotal resource in the fight against climate change, offering data-driven insights and fostering informed decision-making for the conservation of India's invaluable forest ecosystems.

Problem Statement

Forests serve as crucial carbon sinks in combating climate change, necessitating the monitoring of forest cover change for environmental health assessment, biodiversity conservation, and climate change impact understanding. In India, the Forest Survey of India releases forest-related statistics biannually, with forest cover maps and associated geospatial data available for purchase. However, these maps are updated only every two years, limiting insights into local processes. Additionally, the Indian Meteorological Department (IMD) provides meteorological data for administrative regions rather than ecological regions, hindering the tracking of climate change impacts. To address these challenges, we propose developing a web-GIS portal providing long-term forest cover dynamics data, near-real-time monitoring of major forest areas, and future climate change projections.

The objectives of our study include:

- To generate long-term annual forest cover data of India.
- To create recent land-use statistics over the National Parks of India.
- To monitor major forest areas situated within the National Parks in near-real-time using satellite-based data.
- Projecting the vulnerability of major forest areas to climate change under future emission scenarios.

Our Product

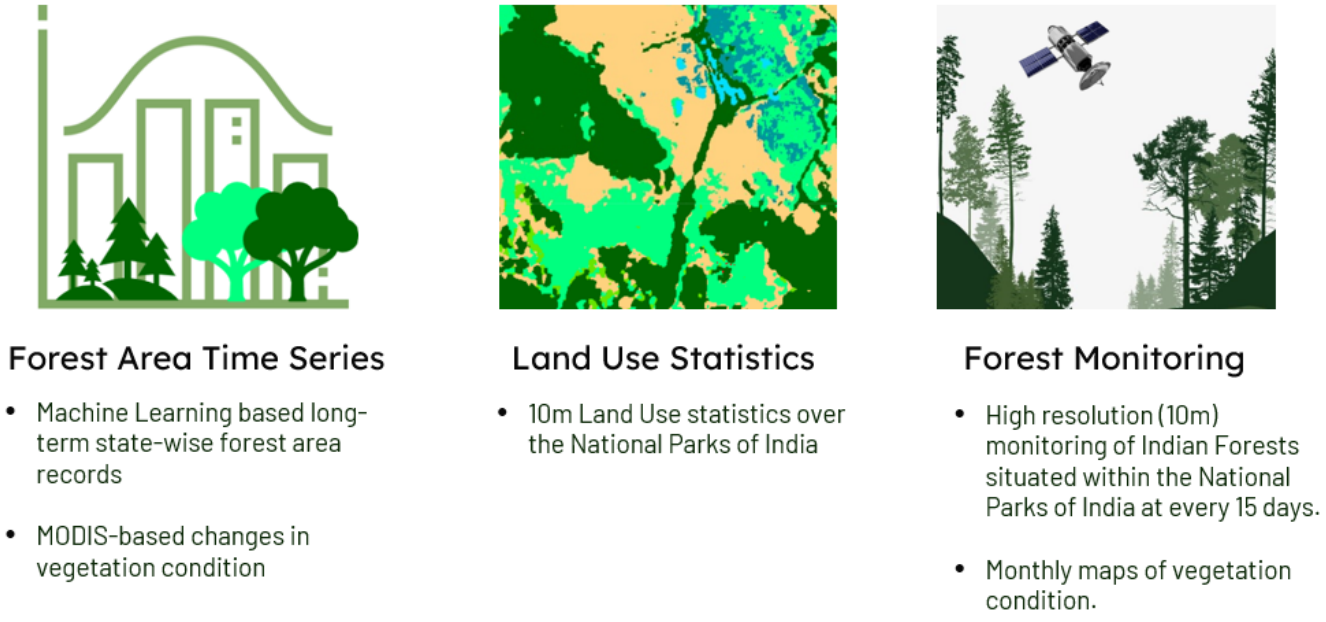

Figure 2 Products of Evolving Canopies

Main Website: https://sites.google.com/iitgn.ac.in/evolvingcanopies-iitgn/home

Forest Area Time Series: https://akankshayadaw.users.earthengine.app/view/timeseriesforest

Land Use Statistics: https://akankshayadaw.users.earthengine.app/view/lulcnp

Forest Monitoring: https://akankshayadaw.users.earthengine.app/view/forestdynamics

Future Projections: https://sites.google.com/iitgn.ac.in/evolvingcanopies-iitgn/future-projections

Data & Scripts

We have employed Google Earth Engine to develop web-GIS portals for our products. Additionally, all analyses have been conducted using Google Earth Engine, and the scripts for these analyses are provided below.

- **Codes to generate ML-based time series of Forest Areas**

Training Data

https://code.earthengine.google.com/c644730af80701bbb93177911e87059c

Yearly Input Data Generation for Classification

https://code.earthengine.google.com/d9934cdf4a4639c71328cfd565e7e986

Image Classification

https://code.earthengine.google.com/e598c9f1f3b4f475900bd3c4ce535a66?noload=1 (2000 to 2002)

https://code.earthengine.google.com/52156d62e497c11d40cd2b5778e07102?noload=1 (2003 to 2023)

Validation Data (From the reports of the Forest Survey of India)

https://docs.google.com/spreadsheets/d/1XTk9SkLRqJsEbYCO5I46sCmKLg4FEjVj/edit?usp=sharing&ouid=107404248034822461863&rtpof=true&sd=true

- **Codes to generate web-GIS portals**

Forest Area Time Series: https://code.earthengine.google.com/b912010bad9ce4b55fbaef5920bb5aea

Land Use Statistics: https://code.earthengine.google.com/e0d60109ec30a26479e36d4c6de354d8

Forest Monitoring: https://code.earthengine.google.com/5254dddf56531adbe47e768fcc347d9e

- **Data for future projections**

We used bias-corrected precipitation data from the BCC-CSM2-MR Global Climate Model (GCM), which is generated under the Coupled Model Intercomparison Project (CMIP)-6 project. For more information, please read Chuphal and Mishra (2023).

Methodology

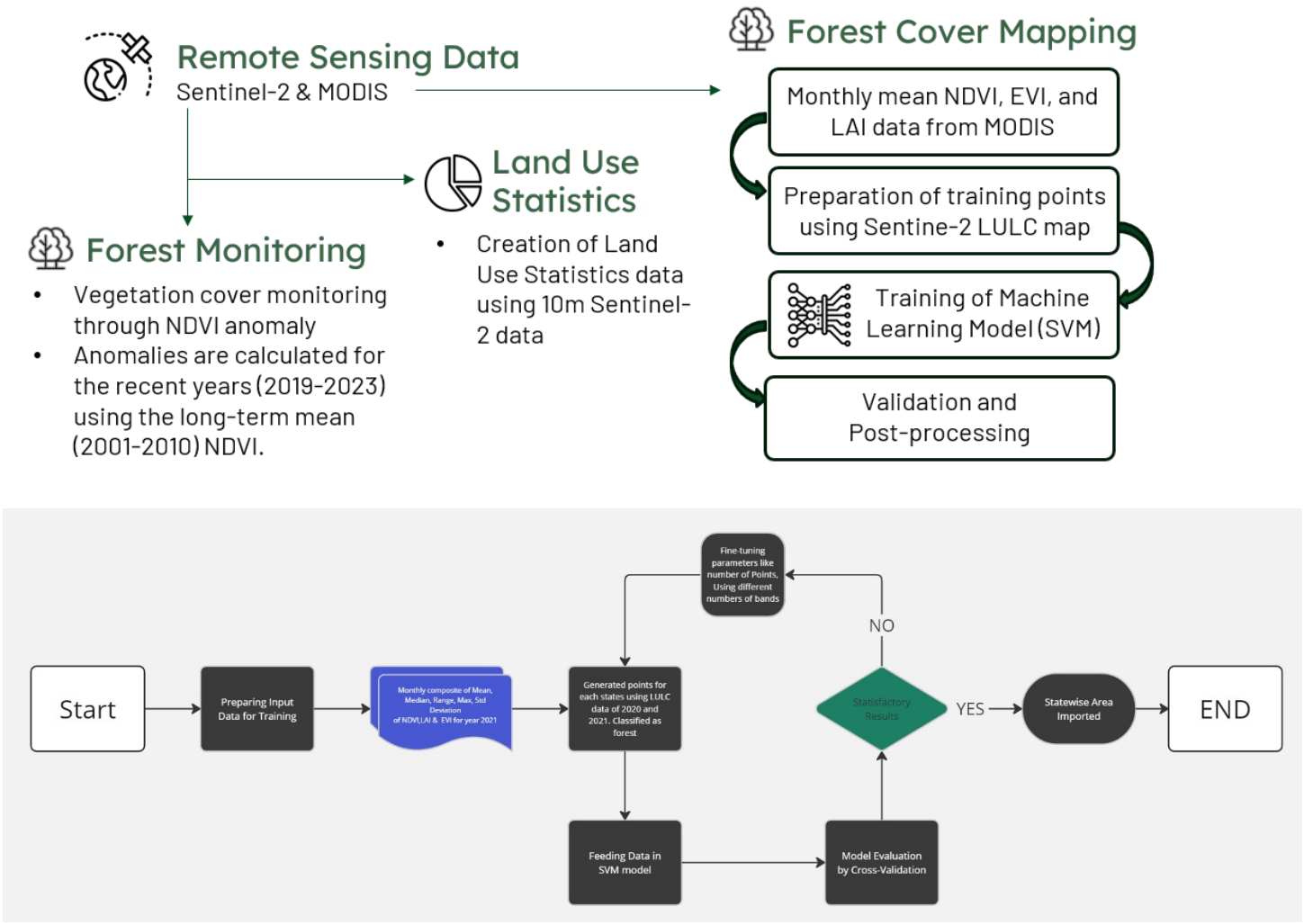

Figure 3 Methodology

Our Team

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Acknowledgement

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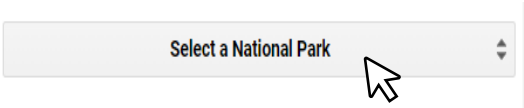
USER MANUAL FOR FOREST DYNAMICS

Forest Dynamics allows users to view and analyse Sentinel-2 satellite data. Users can select a national park and retrieve the Normalized Difference Vegetation Index (NDVI) for the last 15 days or view monthly NDVI data along with anomalies for a selected year and month. The application provides a split-window view for comparative analysis.

1.Select a National Park

In the sidebar to the left, user will find a dropdown menu labeled "Select National Park".



Click on the dropdown to view a list of available national parks and select the desired national park from the list.

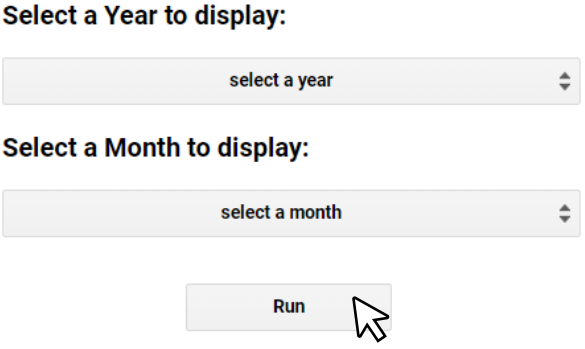
2. For Present Analysis:

Click on the "NDVI For last 15 Days" button to retrieve real-time NDVI data for the last 15 days.

Viewing Results: The main content area will display the NDVI map for the selected national park. The data is updated in real-time and shows the vegetation index for the past 15 days.

3.Long Term Analysis (2019-present)

Select Timeframe: In the sidebar, select the "Year" and "Month" dropdown menus.



Generate Analysis: Click on the "Run" button.

Viewing Results: The main content area will display two maps side by side:

Monthly NDVI Map: Shows the vegetation index for the selected month.

Anomaly Map: Shows the deviation from the average NDVI for that month.

Split-Window Functionality

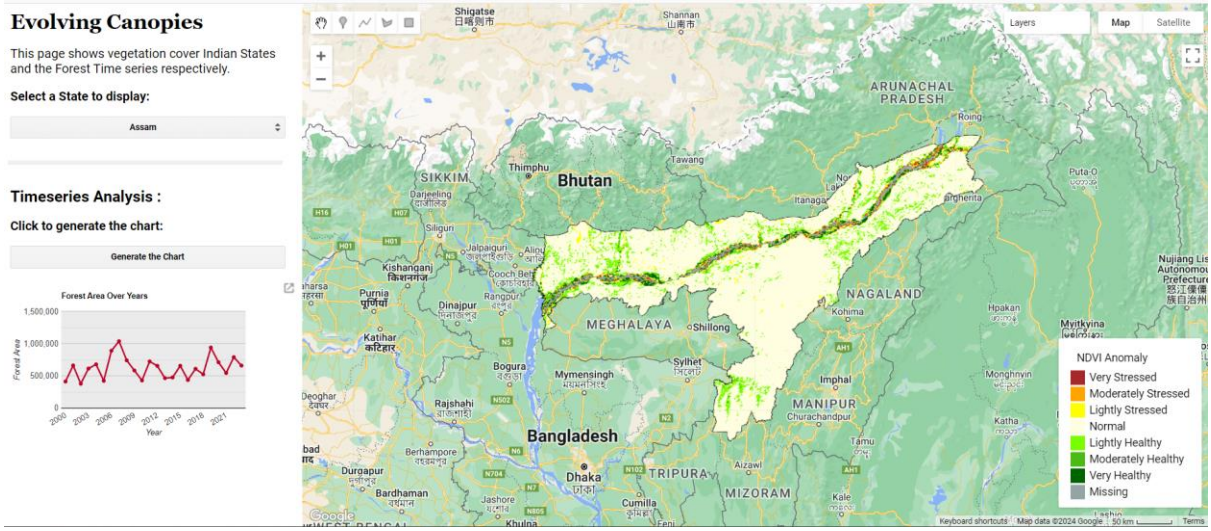
The split-window functionality allows users to compare the monthly NDVI and anomaly maps side by side.

- After selecting the year and month, the main content area will automatically switch to a split-window view.
- Use the slider in the middle to adjust the view of the maps. User can zoom in and out of each map individually.

USER MANUAL FOR EVOLVING CANOPIES

Evolving Canopies is designed to analyse and display the Normalized Difference Vegetation Index (NDVI) anomaly using MODIS data. This tool compares the mean NDVI values from 2019 to 2023 with the base values from 2001 to 2011. Additionally, it provides an overview of forest area variation across different states from 2000 to 2023.

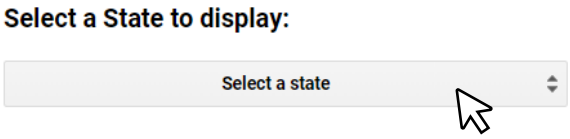
The web app interface:



1.Select the State

In the sidebar to the left, user will find a dropdown menu labeled "Select a state".

Click on the dropdown to view a list of available state and select the desired state from the list.

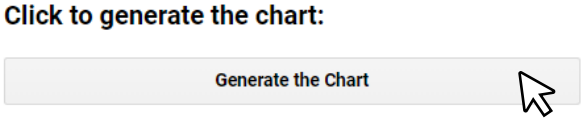


Viewing Results: The main content area will display the NDVI anomaly map for the selected state.

Anomaly Map: Shows the deviation from the average NDVI for period 2019 to 2023.

2.Timeseries Analysis (2019-present)

Generate Analysis: Click on the "Generate the chart" button.

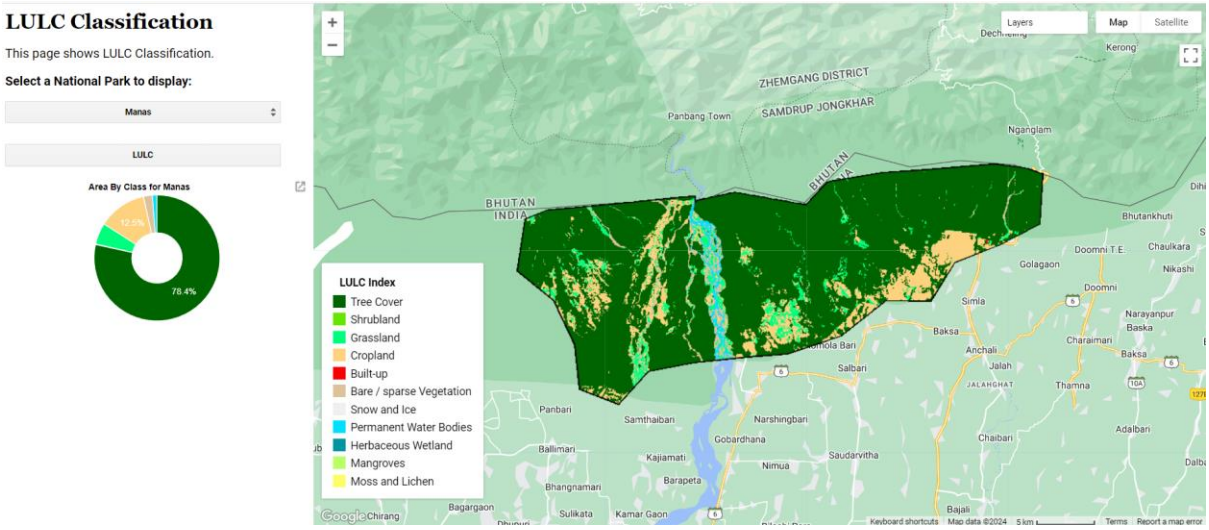


Viewing Results: The chart displays the area in selected state across the year from 2000 to 2023.

USER MANUAL FOR LULC CLASSIFICATION

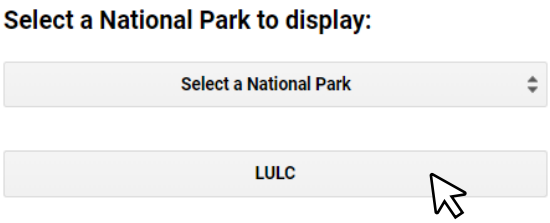
Forest Dynamics allows users to view and analyse Sentinel-2 satellite data. Users can select a national park and retrieve the Normalized Difference Vegetation Index (NDVI) for the last 15 days or view monthly NDVI data along with anomalies for a selected year and month. The application provides a split-window view for comparative analysis.

The web app interface:



1.Select a National Park

In the sidebar to the left, user will find a dropdown menu labeled "Select National Park".



Click on the dropdown to view a list of available national parks and select the desired national park from the list.

2.Click on LULC

Viewing Results: The main content area will display the landcover classification for the national park.