SILIGURI INSTITUTE OF TECHNOLOGY

Major Project: MCAN-482

STUDY OF URBANIZATION AND ITS EFFECT OVER SILIGURI USING SATELLITE IMAGERY

By

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Under the guidance of Prof. Dr. Tumpa Banerjee

Submitted to the Department of Master of Computer Application in partial fulfillment of the requirements for the award of the degree MCA.

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DECLARATION

This is to certify that Report entitled "**STUDY OF URBANIZATION AND ITS EFFECT OVER SILIGURI USING SATELLITE IMAGERY**" which is submitted by us in partial fulfillment of the requirement for the award of degree MCA at Siliguri Institute of Technology under Maulana Abul Kalam Azad University of Technology, West Bengal. We took the help of other materials in our dissertation which have been properly acknowledged. This report has not been submitted to any other Institute for the award of any other degree.

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CERTIFICATE

This is to certify that the project report entitled **STUDY OF URBANIZATION AND ITS EFFECT OVER SILIGURI USING SATELLITE IMAGERY** submitted to Department of MCA of Siliguri Institute of Technology in partial fulfilment of the requirement for the award of the degree of MCA during the academic year 2023-25, is a Bonafide record of the project work carried out by them under my guidance and supervision.

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Acknowledgment

We express our heartfelt gratitude to **Prof. Dr. Tumpa Banerjee**, our guide, for her invaluable support and guidance throughout this project. Her expertise and encouragement were key to its successful completion.

We also thank the faculty members and staff for their assistance, and our family and friends for their constant support and motivation.

This project would not have been possible without their contributions, and we are sincerely grateful to all.

Signature of all the group members with date

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1.

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Abstract

Siliguri, a fast-growing city in Northeast India, has seen major changes in its landscape over the last few years due to rapid urbanization. This project explores how urban growth has affected vegetation and water bodies in the region from 2020 to 2024. Using satellite images from Sentinel-2 and processing them through Google Earth Engine, we analyzed the land cover using key indices like NDVI (for vegetation), NDBI (for built-up areas), and MNDWI (for water bodies). We also used supervised classification with the Random Forest algorithm to map out changes more accurately.

Our findings show a clear increase in built-up areas, mainly around the city's edges, and a noticeable decrease in green cover. Water bodies have also slightly reduced. These changes raise concerns about the environmental impact of unchecked development. This study shows how freely available satellite data and cloud-based tools like GEE can help monitor such changes efficiently and support better planning for sustainable growth.

Introduction:

Urbanization is one of the defining trends of the 21st century, with cities around the world expanding at unprecedented rates. Driven by the migration of populations from rural to urban areas in pursuit of better employment opportunities, education, and living standards, the spatial footprint of cities is growing rapidly. This accelerated urban growth presents both significant opportunities and complex challenges for sustainable development. A thorough understanding of urban expansion dynamics is essential for effective resource management, infrastructure planning, and environmental preservation [1].

Siliguri, recognized as the gateway to Northeast India, is a rapidly developing city that has undergone substantial demographic and spatial growth over recent decades. This expansion is propelled by economic development, enhanced connectivity through road and rail networks, and increasing migration inflows. Consequently, land use patterns in Siliguri have transformed considerably, with agricultural lands and open spaces being converted into residential, commercial, and industrial areas. These changes directly affect the availability of critical natural resources such as water, green spaces, and air quality, underscoring the need for timely and precise monitoring.

Conventional methods for tracking urban growth primarily rely on ground surveys, physical inspections, and manual data collection. While these techniques can provide detailed local information, they are constrained by limitations in scale, cost, and time. These limitations often result in delays, data inconsistencies, and high demands on human resources, causing urban planners and policymakers to depend on outdated or incomplete datasets. This hampers proactive, data-driven decision-making critical for sustainable urban management. To address these challenges, this study proposes an automated approach leveraging remote sensing technology and cloud computing to monitor urban expansion in Siliguri. Google Earth Engine (GEE), a robust cloud-based platform, grants access to extensive archives of multi-spectral satellite imagery and powerful geospatial analysis tools. By integrating Artificial Intelligence (AI) and Machine Learning (ML) algorithms with these datasets, the system can efficiently classify land use and detect temporal changes, such as newly developed built-up areas and reductions in vegetation cover.

The automated monitoring system offers distinct advantages over traditional methodologies, including significant reductions in data collection time and effort, elimination of human bias, and near real-time monitoring capabilities. The continuous flow of updated information enables urban planners, environmental agencies, and government officials to better comprehend growth patterns, anticipate future expansion, and formulate policies that balance development with environmental sustainability.

Furthermore, consistent urbanization monitoring helps identify critical issues associated with unplanned growth, such as rising pollution levels, traffic congestion, water supply stress, sanitation challenges, and loss of green spaces. Early detection of such challenges facilitates timely mitigation strategies, infrastructure enhancement, and the promotion of healthier urban environments.

This study aims to develop and demonstrate a scalable, robust system for monitoring urban growth in Siliguri through satellite imagery and advanced computational techniques. The insights derived from this research will support efficient resource planning, sustainable urban development, and informed governance, ensuring that Siliguri's expansion aligns with both economic advancement and environmental well-being.

Related Work:

Earth observation data are extensively used for enhancing the life on the earth. It helps in the development of quality of living with the balance of environment preserving. Large amount of earth observation data is available for analyzing such as Landsat, Sentinel, MODIs or Sentinel providing several aspects of our earth. Many researchers and remote sensing team use these data tries to extract insight of the data and assist decision maker for planning better environment [2].

The authors [2] sentinel 2 dataset for detecting the changes in vegetation index in Romania's urban environment automatically. This paper analyses the degree of vegetation in urbanized area. Different method has been employed to monitor the vegetation and urban area and improve the accuracy and precision.

[3] proposed a CNN based architecture for performing water body segmentation from satellite imagery. Though satellite images are complex and contain many information which makes the detection of water body difficult., however it will be time and cost saving than physical survey.In a case study of Zafaraan Road at Red sea [4], Satellite images have been used to determine the flood affected area from the before and after flood images. Image difference feature (IDF) model proposed to detect flood area more than 98% accuracy which help will in recue process during and before environmental crisis.

Excessive growth of urbanization lead to the variations in land surface temperature with the conversion of green land to build-up area. [5] studied the transformational change in land area to identify the impact on rainfall variation in Kerala, India. It studied the imagery from four different years 2005, 2010, 2015 and 2020 to determine land use and land cover pattern for vegetation cover and built-up areas. This paper has shown a significant rise of temperature of 4.82 degree centigrade while the vegetation area reduced from 47.91% to 29.04% from 2005 to 2020.

Authors [6] explore the carbon capture and storage potentiality of trees and corresponding environment effect using Sentinel-2 dataset. A comparative study of Sentinel 2 and WorldView3 satellite images are used for to evaluate the NDVI index for street trees in Brussels and proved that Sentinel 2 is more effective in terms of accuracy and cost effective.

Material and Method:

Remote sensing is the science and technology of observing earth through the recording of earth's images to understand and analyses those images. A remote sensing platform gathers the reflected energy using its sensors and transmitted to the data for transmitting to the ground station (Figure 1). The ground station receives the signal from the remote sensing platform and process it to useable format. It makes the data error free and increase quality of the data and stored as the image for analysis.

Images of earth observation are derived from electromagnetic radiation in in a wide range of visible and invisible range. The radiation energy travels in space in the sinusoidal waves at the speed of light is known as Wavelength. A small range of wavelength of blue, green and red is visible to us, and it makes our earth looks beautiful (Figure 2).

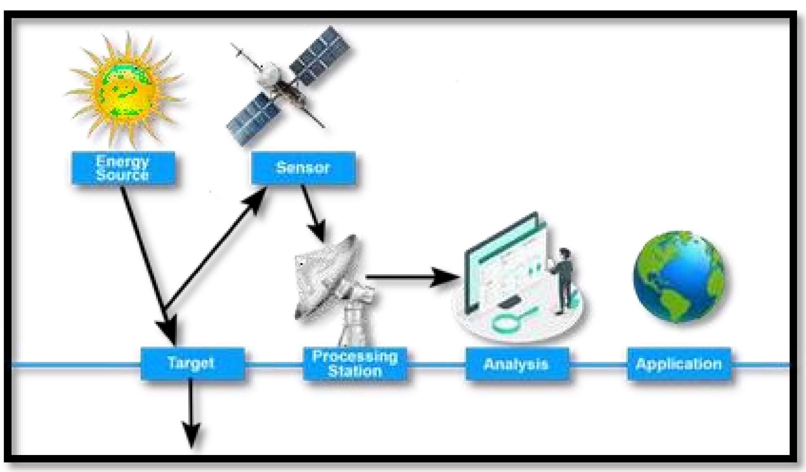

Figure 1 Remote Sensing Process

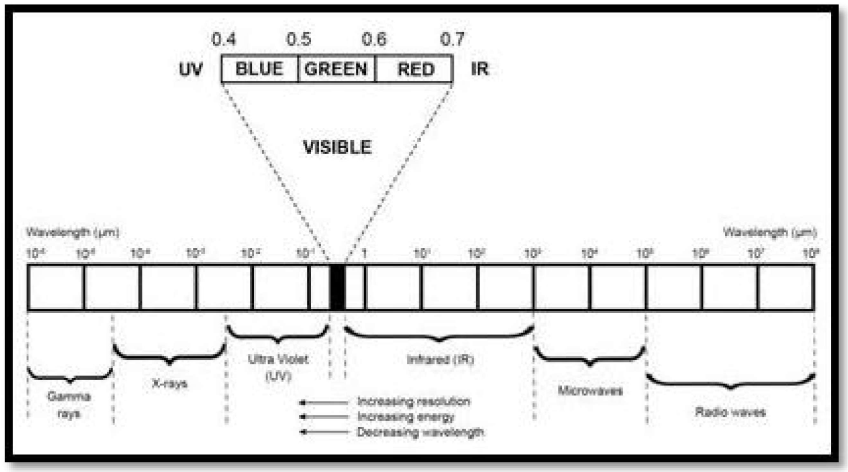

Figure 2 Range of Wavelength

Other wavelength ranges are not visible for human eye but can reveal the properties of earth surface materials. the presence of atmosphere between earth surface and sensors results challenges in satellite remote sensing mission. the effect of atmosphere is different for different wavelength. The figure (Figure 3) how shows the transmittance percent of the wavelength ranges.

With the right wavelength a satellite can detect water, vegetation, air quality etc. Understanding the transmittance of wavelength is important to analyze and determine the urbanization, vegetation and water bodies etc.

The sentinel is a fleet of European Space Agency (ESA) satellites designed to acquire measurements through multiple sensors with the objective of earth observation. Sentinel 2 is a polar orbiting,

multispectral high-resolution imaging mission for land monitoring to provide imagery of vegetation, soil and water cover, inland waterways, and coastal areas. We have used sentinel-2 image dataset for our work as it is useful for wide range of applications.

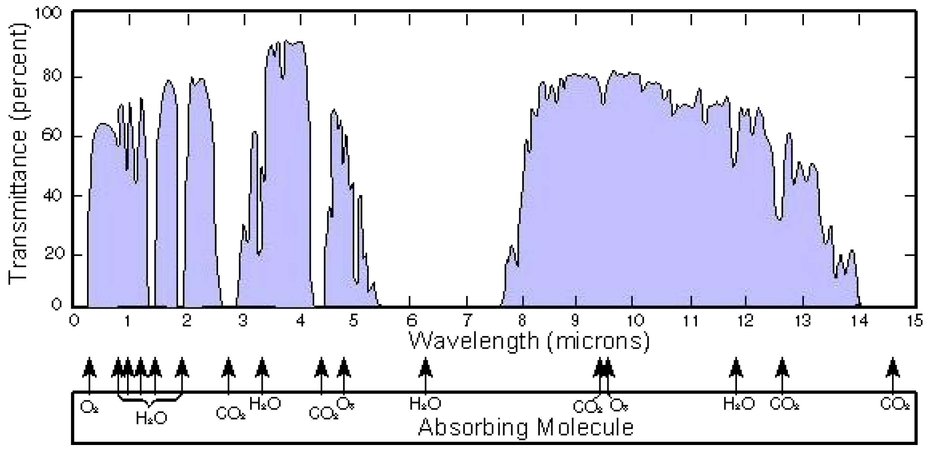

Figure 3 Transmitance Percent of different wavelength

Feature Detection:

We have used the Siliguri region for our study with the date from 2020 to 2025.

Vegetation index detection: Normalized Difference Vegetation Index (NDVI) approaches have been used for determining vegetation area from an image.

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

The NDVI is computed as the difference between near-infrared (NIR) and red (RED) reflectance divide by their sum and this ranges from -1 to 1. a healthy plant contains lots of chlorophyll and cell structure-actively absorbs red light and reflects NIR. Therefore, these two band NIR and RED are used for NDVI. The highest value of NDVI represent highest probability of vegetation present in our area. One threshold

value is used set for classifying the vegetation in our area of interest.The NDI utilize short wave infrared (SWIR2) band 12 and near infrared (NIR) to highlights the built-up areas.

$$NDBI = (SWIR - NIR) / (SWIR + NIR)$$

Implementation:

This project utilized several tools and platforms to detect land cover change effectively. The primary tool used was Google Earth Engine (GEE), a cloud-based geospatial analysis platform capable of processing large-scale satellite imagery. Sentinel-2 imagery, provided by the European Space Agency, served as the main dataset due to its high-resolution multispectral capabilities. The project was implemented using JavaScript within the GEE Code Editor, which offers an efficient way to access and manipulate geospatial data. Additional tools like QGIS were used to generate training data (shapefiles).

Google Earth Engine is a powerful platform for geospatial analysis and environmental monitoring. It offers access to a vast collection of satellite data, including Sentinel, Landsat, and MODIS, and processes them using Google's cloud infrastructure. This eliminates the need for high-performance local machines. GEE also features an interactive map interface for real-time visualization and supports JavaScript and Python APIs for flexible, scalable workflows. It is especially advantageous for academic and research use due to its no-cost access, ease of use, and active support community.

The implementation was carried out using JavaScript in the GEE Code Editor. This scripting language enabled interaction with the Earth Engine API to perform essential tasks such as data filtering, spectral index computation, supervised classification, and result visualization.

The workflow began by defining the area of interest (AOI), specifically focusing on the Siliguri region. Sentinel-2 images were filtered by cloud cover (less than 30%) and by date to extract scenes for the years 2020 and 2024. These images were further refined by selecting specific spectral bands and calculating the median composite for each year.

Spectral indices were then computed to enhance thematic features. NDVI was used to assess vegetation health, NDBI was applied to highlight urban or built-up areas, and MNDWI was used to identify water bodies. These indices provided a strong basis for distinguishing various land cover types.

RGB composites for both years were visualized using natural color bands to provide a reference view of land cover. Following this, labeled training data were created to represent different land cover classes, and the data were split into training and validation subsets. A Random Forest classifier, configured with 100 trees, was trained using the 2020 imagery and applied to classify land cover for both 2020 and 2024.

To assess the performance of the classification, a confusion matrix was generated from the validation dataset, and overall accuracy was computed. For change detection, NDVI images of both years were compared by subtracting the 2020 NDVI from that of 2024 to highlight areas of vegetation gain or loss. A threshold (NDVI < -0.2) was applied to extract regions with significant vegetation decline, and the area of vegetation loss was calculated in hectares using pixel-based area conversion.

Finally, urban growth was analyzed by isolating the urban class and computing its area for each year. These values were visualized in a comparative bar chart to illustrate the extent of urban expansion between 2020 and 2024.

Result and Discussion:

This section discusses the outcomes of urbanization, vegetation, and water body monitoring in Siliguri using Sentinel-2 satellite imagery and Google Earth Engine (GEE) over the period 2020–2025. The visual and quantitative analysis derived from spectral indices like NDVI, NDBI, and MNDWI highlights significant spatiotemporal transformations occurring in the region.

To compute these indices, a cloud-free image composite was generated for both 2020 and 2024 using Sentinel-2 imagery. A custom function was used in the GEE Code Editor to filter the imagery by date, cloud cover, and area of interest. The spectral indices were then computed to extract thematic features related to vegetation, built-up area, water bodies, and bare soil.

RGB Sentinel-2 Composite Depicting Siliguri's Land Cover in 2020

The RGB composite for the year 2020 offers a true-color representation of Siliguri, created using Sentinel-2 bands 4, 3, and 2, which correspond to red, green, and blue wavelengths respectively. This image was generated by filtering Sentinel-2 data to include only scenes with less than 30% cloud cover and spatially restricted to the geometry of Siliguri, as extracted using the UC_NM_MN attribute. A median composite was created from imagery between January 1, 2020, and January 1, 2021, to ensure a cloud-free and consistent visual output. In this composite, urban or built-up areas appear in shades of gray, vegetated regions show up in green, water bodies are seen as dark blue or black due to strong light absorption, and barren or sparsely vegetated land appears beige or light brown. This natural color image helps establish a visual baseline of the region's land cover and serves as a foundation for further analysis using spectral indices like NDVI, NDBI, and MNDWI, which were derived from the same dataset.

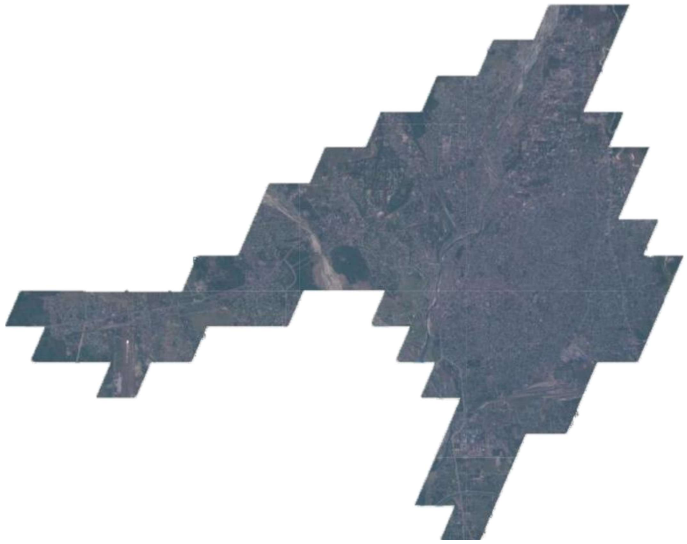

Figure 4 Composite of Siliguri in 2020 from Sentinel-2

RGB Sentinel-2 Composite Depicting Siliguri's Land Cover in 2024

The RGB composite for the year 2024 is generated using Sentinel-2 bands 4, 3, and 2, following the same approach as the 2020 composite. It reflects the current land cover of Siliguri by using median imagery from January 1, 2024, to January 1, 2025, filtered to include scenes with less than 30% cloud cover within the city's administrative boundary. Compared to 2020, the image visually highlights an increase in urban sprawl and building density, particularly around the city's edges and developing areas. Vegetation cover appears to have declined in certain zones, likely due to expansion and infrastructure development. Water bodies remain identifiable, though slight variations in their size and distribution are visible. This natural color view offers a clear visual context for evaluating land cover dynamics and supports the interpretation of classification and spectral index analyses.

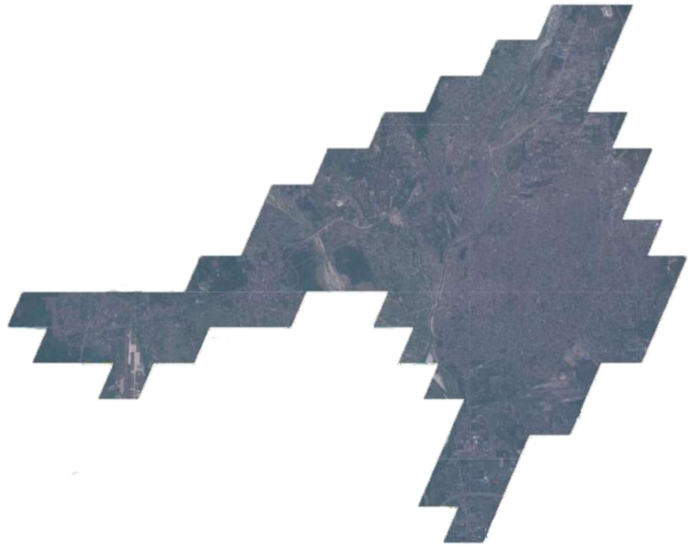

Figure 5 Composite of Siliguri in 2024 from Sentinel-2

Supervised Land Cover Classification of Siliguri (2020)

The land cover classification for Siliguri in 2020 was performed using a supervised approach within Google Earth Engine. Sentinel-2 imagery served as the input data, and training samples were prepared by merging ground control points representing four major land cover types: urban, vegetation, water, and barren land. A Random Forest classifier with 100 trees was trained on 60% of the labeled data and validated on the remaining 40%. The resulting map clearly distinguishes between urban areas (red), vegetation (green), water bodies (blue), and barren or sparsely covered land (orange yellow). Urban development is concentrated near the city center, while vegetation is more prevalent in the outer zones. Prominent water features such as the Mahananda River are accurately identified. This classified map forms the baseline for detecting land cover changes over time and provides critical input for accuracy assessment and future comparison

```
var training2020 = image2020.sampleRegions({
  collection: trainingGcp,
  properties: ['landcover'],
  scale: 10,
  tileScale: 16
});

var classifier2020 = ee.Classifier.smileRandomForest(100).train({
  features: training2020,
  classProperty: 'landcover',
  inputProperties: image2020.bandNames()
});
var classified2020 = image2020.classify(classifier2020);

Map.addLayer(classified2020.clip(geometry), classVis, 'Classified 2020');
```

Figure 6 Code snippet showing the supervised land cover classification of Siliguri in 2020 using Sentinel-2 imagery and a Random Forest classifier in Google Earth Engine.

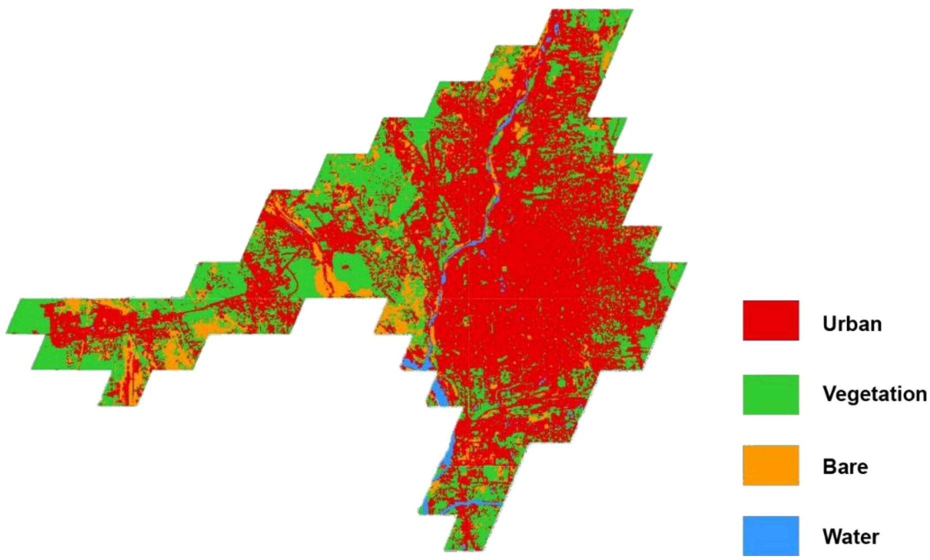

Figure 7 Supervised land cover classification map of Siliguri for 2020, generated using Sentinel-2 imagery and Random Forest classifier. The color scheme represents urban areas in red, barren land in orange, water bodies in blue, and vegetation in green.

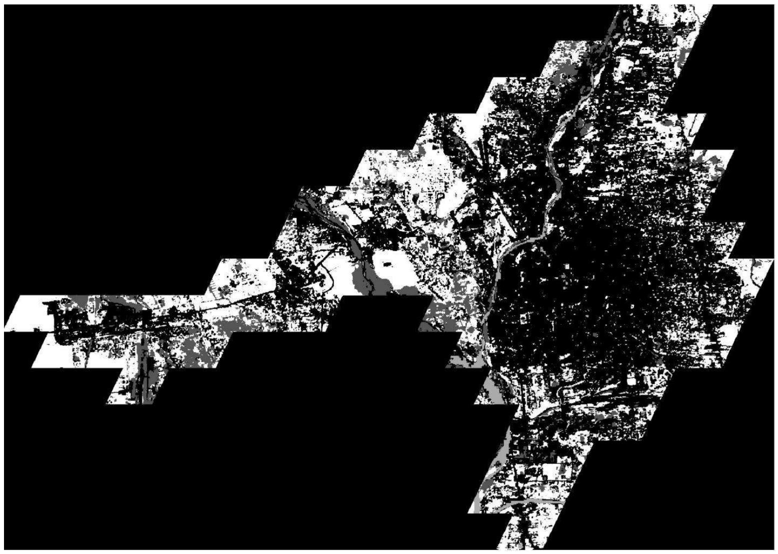

Figure 8 Supervised land cover classification map of Siliguri for 2020, generated using Sentinel-2 imagery and a Random Forest classifier in QGIS.

Supervised Land Cover Classification of Siliguri (2024)

The 2024 land cover classification for Siliguri was generated using a supervised approach implemented in Google Earth Engine, utilizing updated Sentinel-2 imagery. Training data consisted of ground control points representing the same four primary land cover categories as in 2020: urban, vegetation, water, and barren land. These samples were merged and used to train a Random Forest classifier with 100 trees, maintaining a 60% training and 40% validation split. The output classification map assigns urban areas in red, vegetation in green, water bodies in blue, and barren land in orange. A comparison with the 2020 map reveals a significant increase in built-up areas, particularly in the southern and central parts of the city, indicating urban expansion into previously vegetated zones. Vegetation cover has declined accordingly, while water bodies and barren regions appear in smaller, fragmented patches. This classified image supports temporal change analysis and contributes to understanding ongoing land transformation in the Siliguri region.

```
var training2020 = image2020.sampleRegions({
  collection: trainingGcp,
  properties: ['landcover'],
  scale: 10,
  tileScale: 16
});

var classifier2020 = ee.Classifier.smileRandomForest(100).train({
  features: training2020,
  classProperty: 'landcover',
  inputProperties: image2020.bandNames()
});
var classified2020 = image2020.classify(classifier2020);

Map.addLayer(classified2020.clip(geometry), classVis, 'Classified 2020');
```

Figure 9 Code snippet showing the supervised land cover classification of Siliguri in 2024 using Sentinel-2 imagery and a Random Forest classifier in Google Earth Engine.

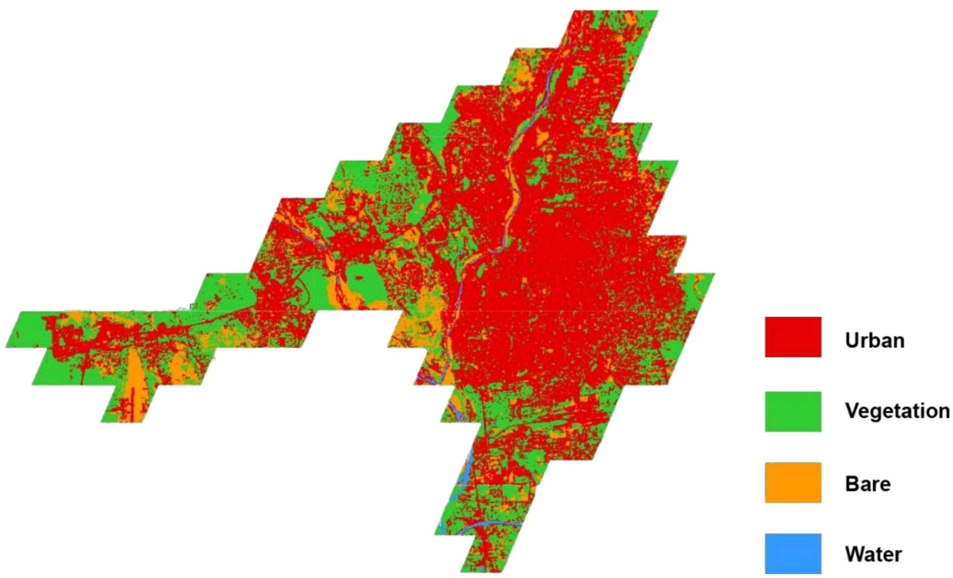

Figure 10 Supervised land cover classification map of Siliguri for 2024, generated using Sentinel-2 imagery and Random Forest classifier. The color scheme represents urban areas in red, barren land in orange, water bodies in blue, and vegetation in green.

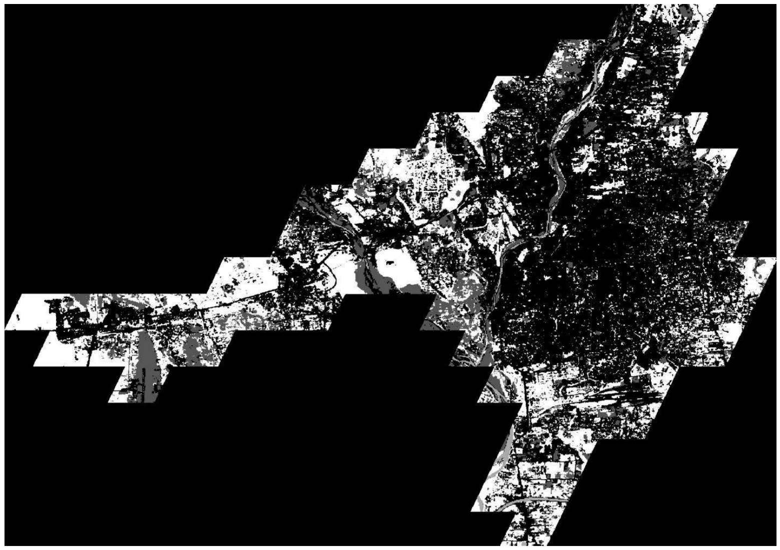

Figure 11 Supervised land cover classification map of Siliguri for 2024, generated using Sentinel-2 imagery and a Random Forest classifier in QGIS.

Mapping Urban Expansion through Supervised Classification-Based Class Difference (2020–2024)

This map visualizes the spatial extent of land cover changes in Siliguri between 2020 and 2024 using Sentinel-2 imagery within Google Earth Engine. The neq() function was employed to compare classified land cover maps from both years, identifying pixels where any category transition occurred. The output is a binary map, where red pixels (value = 1) represent locations of land cover change, and green pixels (value = 0) indicate areas that remained stable. To isolate only the changed regions, the selfMask() function was applied. While the map does not distinguish specific transitions, many of the changes correspond to urban expansion into formerly vegetated or open areas, especially in central and southern Siliguri. This pattern reflects growing development pressure and urban sprawl. The map provides a valuable tool for detecting dynamic land transformations and supports sustainable planning efforts by highlighting regions undergoing rapid urban growth.

```
var changeMap = classified2024.neq(classified2020).selfMask();
Map.addLayer(changeMap.clip(geometry), {palette: ['#dbdbdb']}, 'Change Map (Class Difference)');
```

Figure 12 Code snippet used in Google Earth Engine to detect land cover changes between 2020 and 2024.

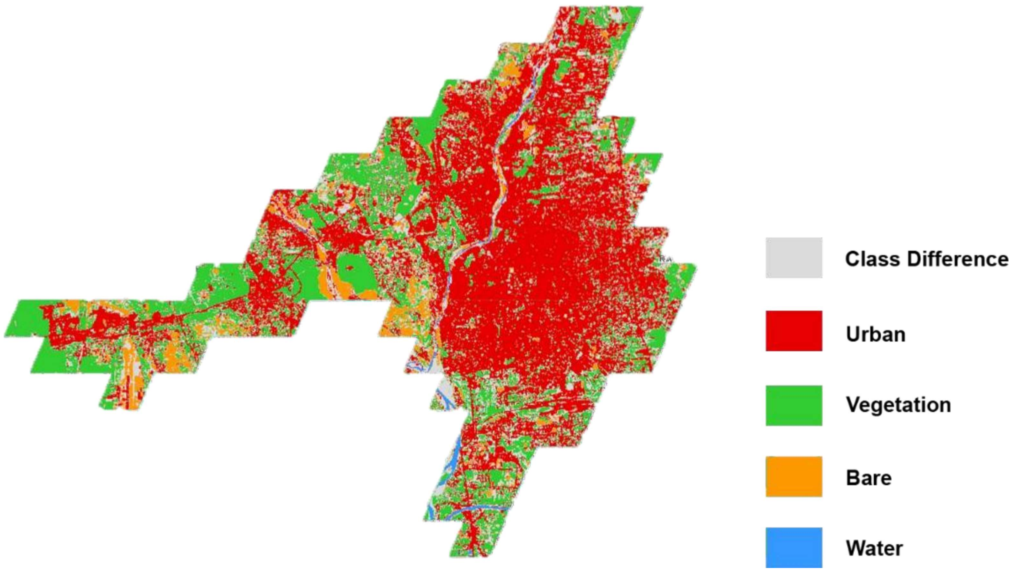

Figure 13 Land cover change detection map of Siliguri between 2020 and 2024, derived from supervised classification outputs using Sentinel-2 imagery in Google Earth Engine.

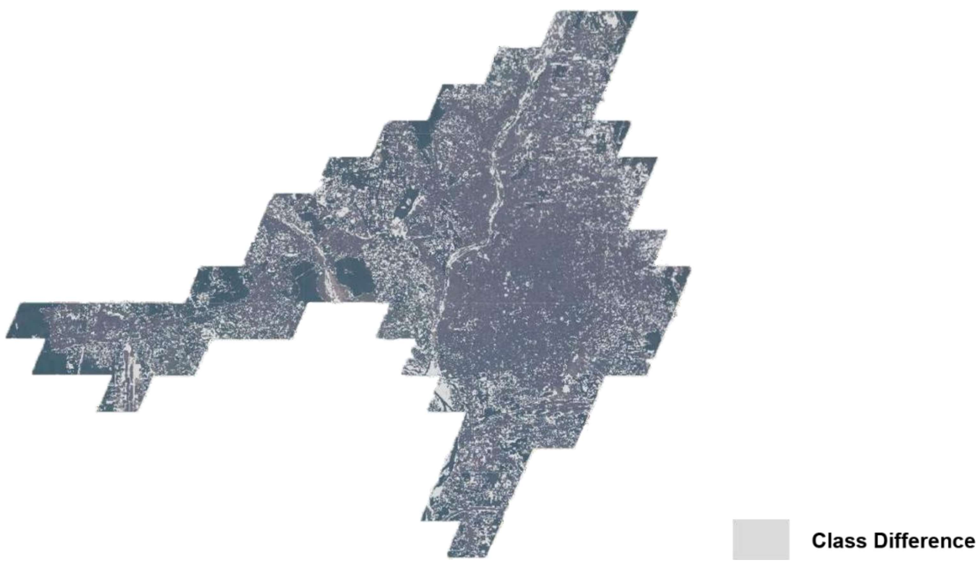

Figure 14 RGB Class difference overlay in 2024 true color composite of Siliguri derived from Sentinel-2 imagery.

Vegetation Gain and Loss (NDVI Change, 2020–2024)

This map visualizes the spatial changes in vegetation cover across Siliguri between 2020 and 2024 using the Normalized Difference Vegetation Index (NDVI) derived from Sentinel-2 imagery. By calculating the difference between NDVI values from 2024 and 2020, the map highlights areas of ecological transformation.

Red regions represent a decline in vegetation, often caused by urban development, deforestation, or other forms of land degradation. Green areas indicate an increase in vegetation, which may be attributed to reforestation efforts, seasonal agricultural expansion, or natural regrowth. Zones with minimal or no change in vegetation are displayed in yellow-beige tones, signifying relative stability in land cover.

This NDVI difference map serves as an essential tool for tracking vegetation dynamics, assessing environmental impacts, and informing green infrastructure planning and conservation strategies in rapidly urbanizing landscapes.

```
var ndviChange = image2024.select('ndvi').subtract(image2020.select('ndvi')).rename('NDVI_Change');
var ndviChangeVis = {min: -0.5, max: 0.5, palette: ['#d73027', '#ffffbf', '#1a9850']};
Map.addLayer(ndviChange.clip(geometry), ndviChangeVis, 'NDVI Change');
```

Figure 15 Code snippet used in Google Earth Engine to detect NDVI-based vegetation changes in Siliguri between 2020 and 2024

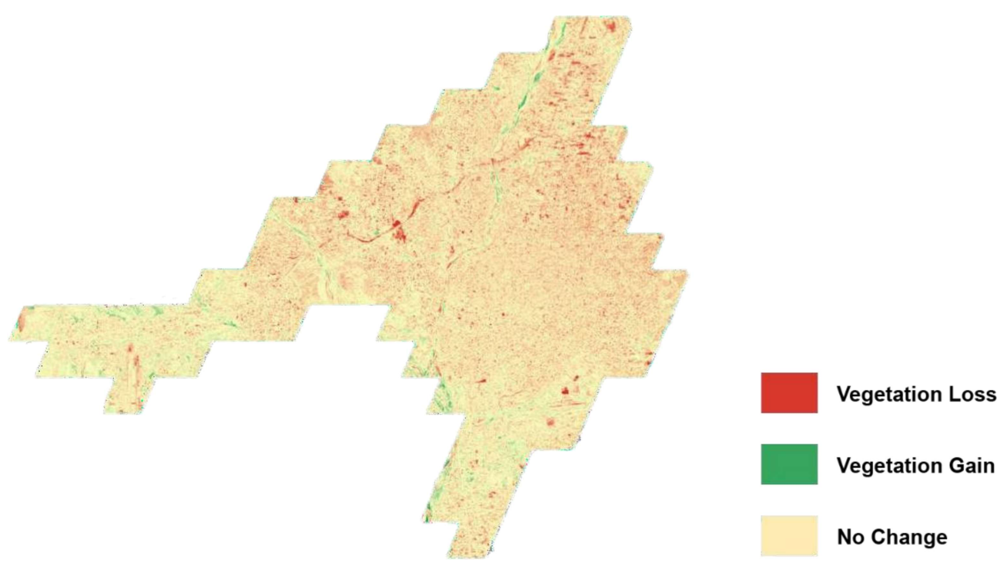

Figure 16 NDVI-based vegetation change map of Siliguri (2020–2024), derived from Sentinel-2 imagery. The red areas represent vegetation loss, the green areas indicate vegetation gain, and the beige tones show regions with little to no change

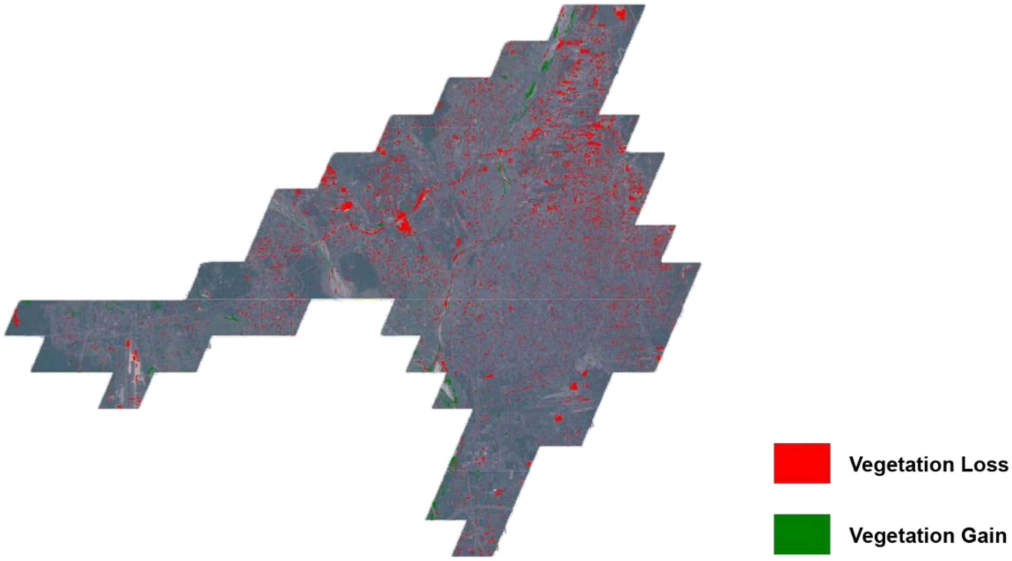

Figure 17 RGB composite map overlaid with vegetation gain and loss in Siliguri for 2024.

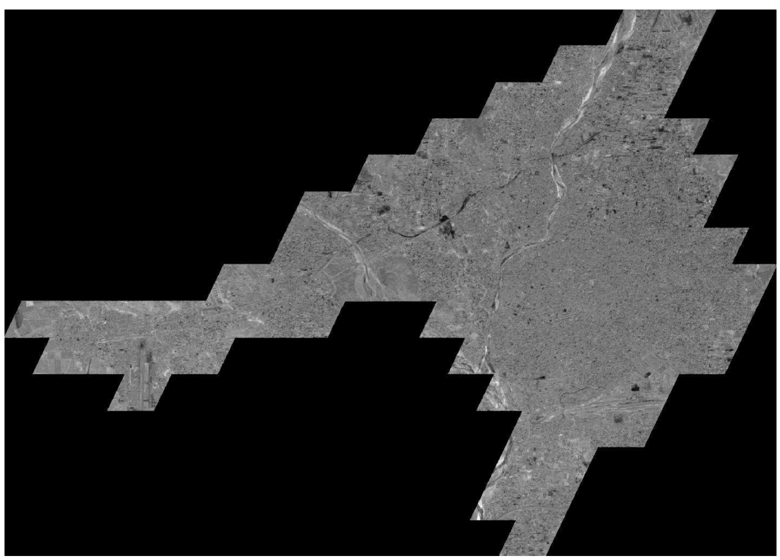

Figure 18 NDVI change map of Siliguri (2020–2024) generated in QGIS using processed Sentinel-2 imagery.

Mapping Vegetation Recovery in Siliguri Using RGB and NDVI Composite (2024)

This map displays the regions within Siliguri where vegetation has increased between 2020 and 2024, overlaid on the RGB composite of 2024. Areas highlighted in green indicate positive NDVI change, suggesting new or recovering vegetation, especially along riverbanks, forest edges, and peri-urban zones. The remaining areas are shown in natural RGB tones, indicating unchanged or non-vegetated zones. This visualization aids in assessing ecological restoration, urban greening efforts, and environmental resilience.

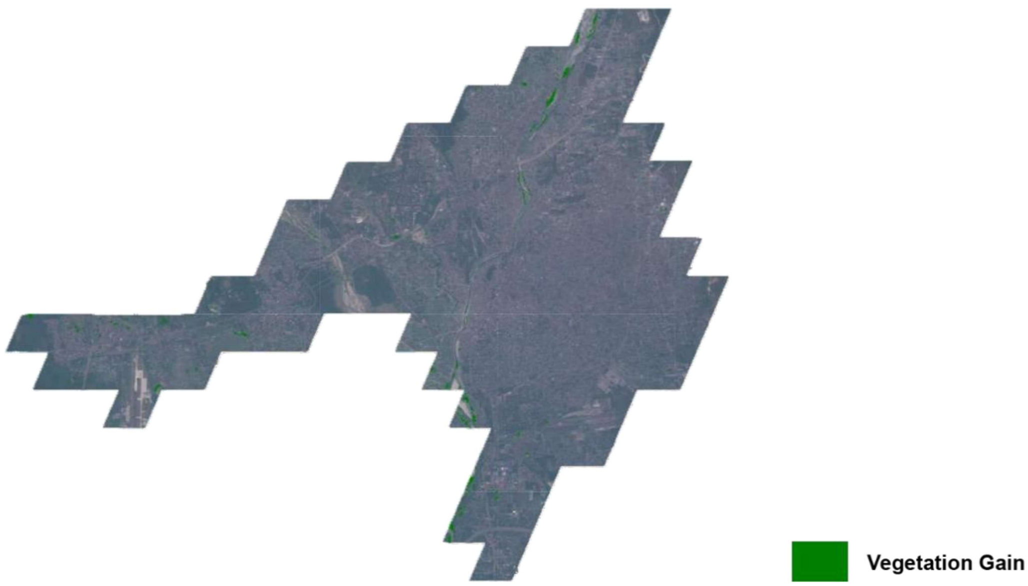

Figure 19 RGB composite map overlaid with vegetation gain in Siliguri for 2024.

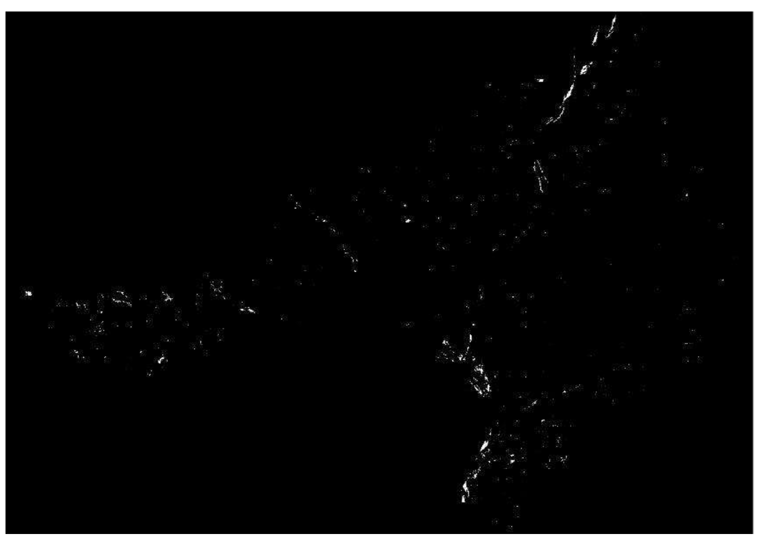

Figure 20 Vegetation gain overlay on RGB composite of Siliguri (2024), generated in QGIS using Sentinel-2 imagery.

Mapping Vegetation Loss in Siliguri Using RGB and NDVI Composite (2024)

This map visualizes vegetation loss across Siliguri by overlaying areas of significant NDVI decline (greater than 0.2) onto the 2024 RGB composite from Sentinel-2 imagery. Red-colored regions represent zones where vegetation health has deteriorated, often correlating with expanding urban infrastructure and construction activities. The RGB background provides a real-world visual context, allowing for quick identification of stressed or transformed landscapes. This map is a valuable tool for monitoring ecological degradation and guiding sustainable urban development.

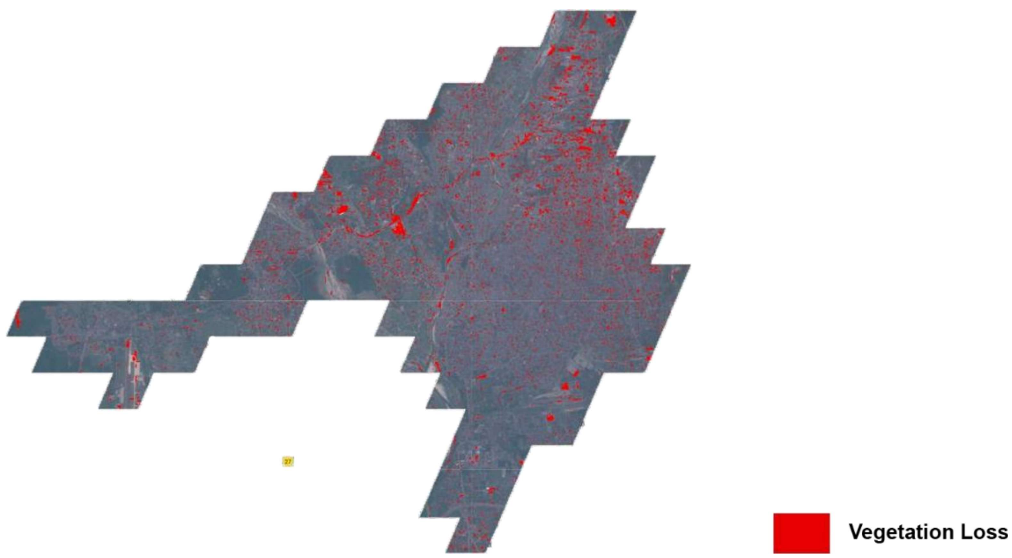

Figure 21 RGB composite map overlaid with vegetation Loss in Siliguri for 2024.

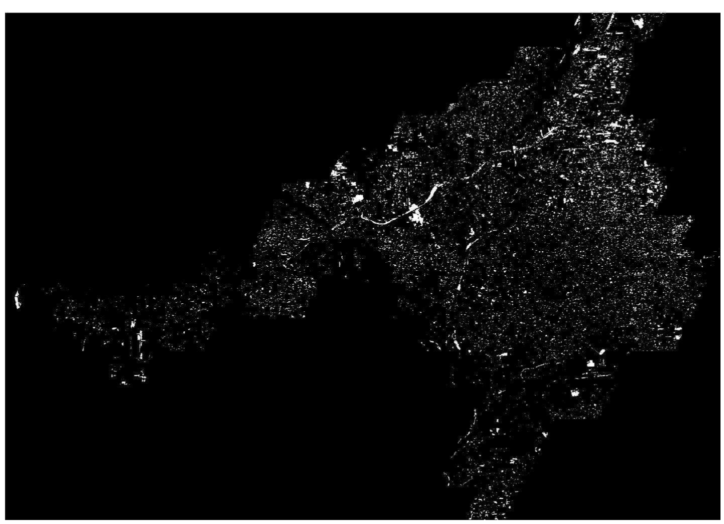

Figure 22: Vegetation gain overlay on RGB composite of Siliguri (2024), generated in QGIS using Sentinel-2 imagery.

Urbanization Monitoring:

Urbanization in Siliguri has shown a noticeable increase during the five-year period. Using indices such as NDBI and SWIR2–NIR combinations, built-up areas were clearly identified and extracted from satellite images. The classification maps revealed a consistent outward expansion of urban zones, particularly toward the eastern and northeastern parts of the city.

The availability of cloud-based computing through GEE allowed us to generate annual composite images that illustrate the growth of impervious surfaces. These visualizations support the observed trend of declining open and agricultural lands being converted into residential and commercial infrastructure. The densification of core urban regions is also evident, indicating both horizontal and vertical expansion.

Such rapid and often unplanned growth raises important concerns about urban sprawl, increased heat island effects, and the need for robust urban planning policies.

Vegetation Monitoring:

Vegetation cover was assessed using the Normalized Difference Vegetation Index (NDVI). The index effectively highlighted regions with healthy vegetation and detected changes over time. Areas with high NDVI values (typically > 0.4) were classified as dense vegetation, while areas with lower values indicated sparse or degraded green cover.

Between 2020 and 2025, a significant reduction in vegetative zones was observed, particularly in the city outskirts and peri-urban zones. Forest patches and agricultural fields adjacent to expanding urban areas have diminished, correlating with increasing built-up zones from urbanization analysis.

This decline in vegetation contributes to rising surface temperatures, reduced carbon capture capacity, and a loss of biodiversity. The findings stress the urgency of integrating green infrastructure and urban forestry into city planning.

Water Body Monitoring:

The Modified Normalized Difference Water Index (MNDWI) was employed to detect and analyze surface water bodies. Seasonal and annual fluctuations were accounted for by selecting images with minimal cloud cover and normalized acquisition dates.

Analysis revealed a slight reduction in water bodies, particularly small ponds and seasonal wetlands that have either dried up or been reclaimed for construction. Major water bodies remain intact but are under increasing stress from urban runoff and pollution.

The integration of water body data with urbanization trends emphasizes the need for water-sensitive urban design (WSUD) and conservation strategies to safeguard Siliguri's freshwater ecosystems.

Several thematic maps and time-series visualizations were generated using GEE, representing:

Annual urban spread from 2020 to 2025

NDVI-based vegetation loss maps

MNDWI maps highlighting shrinking water bodies

Change detection layers showing transitions from vegetation to built-up or from water bodies to land

These visual representations offer valuable insights for policymakers, urban planners, and environmental authorities. They also serve as a foundation for predictive modeling and simulation of future land-use scenarios.

Conclusion and Future Work:

This study showed that combining satellite images with cloud-based tools like Google Earth Engine is a great way to keep an eye on how land cover changes over time. Using Sentinel-2 images, we could map where green areas are disappearing and where the city is growing between 2020 and 2024. Bringing machine learning into the mix helped us get accurate classifications, and using NDVI made it easier to spot changes in vegetation.

Overall, this method works well for monitoring changes across a region and can easily be adapted to other places too. It offers useful information for planning cities in a way that's more sustainable and mindful of the environment.

Future Development

Looking ahead, we could make this even better by adding more indices and satellite data like ALOS or Landsat-8 to improve accuracy. It would also be helpful to look at seasonal changes throughout the year to understand how vegetation and water bodies shift over time.

Using object-based image analysis (OBIA) could give us more detailed results, especially in complex urban areas. Adding socio-economic data could also help us see how land cover changes relate to things like population growth or infrastructure projects.

Finally, automating the whole process and turning it into a web app would make it easy for city planners, researchers, and government officials to monitor land changes quickly and make smarter decisions.

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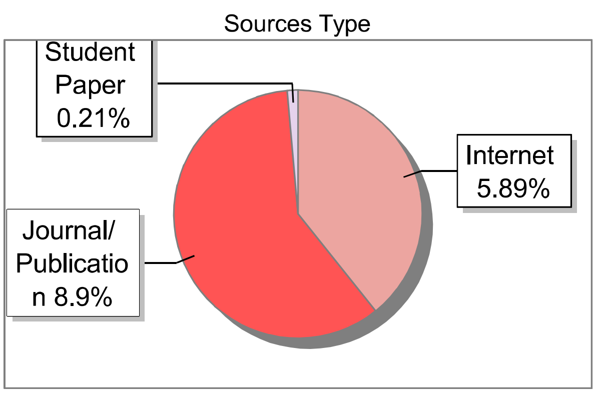

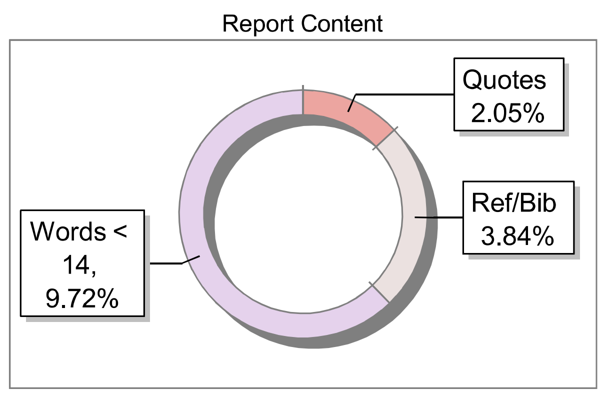

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