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Land Use & Land Cover Change Detection and Analysis In Amaravati, A.P Using Google Earth Engine (GEE)

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Abstract
This study aims to create a detailed Land Use/Land Cover (LULC) map of Amaravati, the capital city of Andhra Pradesh, India, using Google Earth Engine (GEE). The research utilizes satellite imagery from Landsat 8, acquired from Google Earth Engine, to classify the LULC patterns in Amaravati Capital city. The classification is performed using a supervised machine learning algorithm, with training data collected from field observations and high resolution satellite imagery. The classified LULC map is then imported into QGIS for further analysis and visualization. The results show that the LULC map accurately captures the spatial distribution of different land use classes, including urban, agricultural, croplands, water bodies and barren lands. The study demonstrates the potential of Google Earth Engine for creating accurate and detailed LULC maps, which can be useful for urban planning, environmental monitoring, and sustainable development in Amaravati Capital city. The agricultural lands and crop land areas have decreased, indicating a shift towards urbanization and development. In this research study, we observed that, the last years from 2014-2024 , the data of year on year changes to 125.71% of water bodies are increased, 94.83% of Built-up area is increased, 74.82% of Barren land is increased, 73.45% of crop land is decreased, 29.32% of vegetation is decreased.

Key Words: *Google Earth Engine, QGIS, Urban Planning, Environmental Monitoring, Sustainable Development, Land Cover Classification, Geospatial Analysis.*

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1. INTRODUCTION

Land use and Land cover (LULC) change detection provides critical insights into the complex interplay between landscape patterns, processes, and environmental sustainability. The meteoric rise of urbanization, agricultural, deforestation, and infrastructure projects, has significantly transformed the urban landscape, leading to socio-economic and ecological transformations. Land Use and Land Cover (LULC) are Key elements in understanding the Earth's surface and application. Land cover represents the physical features found on the Earth's surface, including vegetation, bodies of water, constructed urban areas, and exposed soil. Land use defines human interaction with land, whether for agriculture, urban growth, or conservation efforts. LULC studies play a vital role in tracking environmental transformations, evaluating the effects of human actions, and strategizing for sustainable growth. Through the examination of LULC patterns, researchers can uncover trends like deforestation, urban expansion, or the spread of agricultural land, along with their effects on ecosystems and natural resources. Analyzing LULC patterns helps researchers detect trends like deforestation, urbanization, and agricultural growth, along with their effect on natural environments and essential materials. Such studies frequently utilize satellite imagery and GIS technologies to deliver precise and comprehensive analyses of land changes over time.

Amravati, situated in Andhra Pradesh, India, has been experiencing rapid urbanization and developmental changes. The study area includes various land types such as agricultural fields, urban zones, water bodies, and green spaces. Analyzing LULC patterns in this region is vital for understanding the effects of urban growth and planning sustainable strategies to manage its evolving landscape effectively. Over the years, urban expansion has led to a noticeable reduction in agricultural and vegetative areas, while urban and

wasteland categories have increased. Studies in this region often utilize satellite imagery, such as LANDSAT data, and GIS tools to monitor these changes. This study focuses on analyzing Land Use and Land Cover (LULC) changes in Amaravati over specific time intervals: 2013-2014, 2014-2015, 2017-2018, 2019-2020, 2021-2022, and 2023-2024. Utilizing satellite imagery and GIS tools, the project investigates shifts across five key land categories—water bodies, vegetation, croplands, barren lands, and built-up areas. The findings aim to provide valuable insights into urban growth, environmental transformations, and the impact of human activities in Amaravati.

Remote sensing is a revolutionary technology that gathers information about the Earth's surface without physical contact. By using sensors mounted on satellites, aircraft, or drones, it captures data such as electromagnetic radiation reflected or emitted by land, water, and vegetation. This information enables researchers to analyze land use and land cover patterns, assess changes over time, and develop insights into environmental dynamics. In a Google Earth Engine (GEE)-based project, remote sensing serves as the foundation for processing satellite imagery and conducting detailed spatial analyses, providing a comprehensive view of the evolving landscape.

1.1 Study Area

The study area i.e. Amaravati located on the central region of state of Andhra Pradesh, India and bounded by longitude 80°25”- 80°36” East and latitude 16°22”- 16°37” North and it covers a total area of 18336.09 hectares, there are 16 Mandals in this area and it is located in Guntur district along the southern banks of the Krishna River and it is a rapidly developing place in present times. The city’s land use/ land cover pattern includes urban/ built-up areas, water bodies, agricultural lands, barren lands and crop lands. The region has alluvial soil and black cotton soil, suitable for various crops, in this area rice, cotton, chili and peppers are major crops. and also the area is being developed as a smart city, with a focus on sustainable urban plan and green spaces.

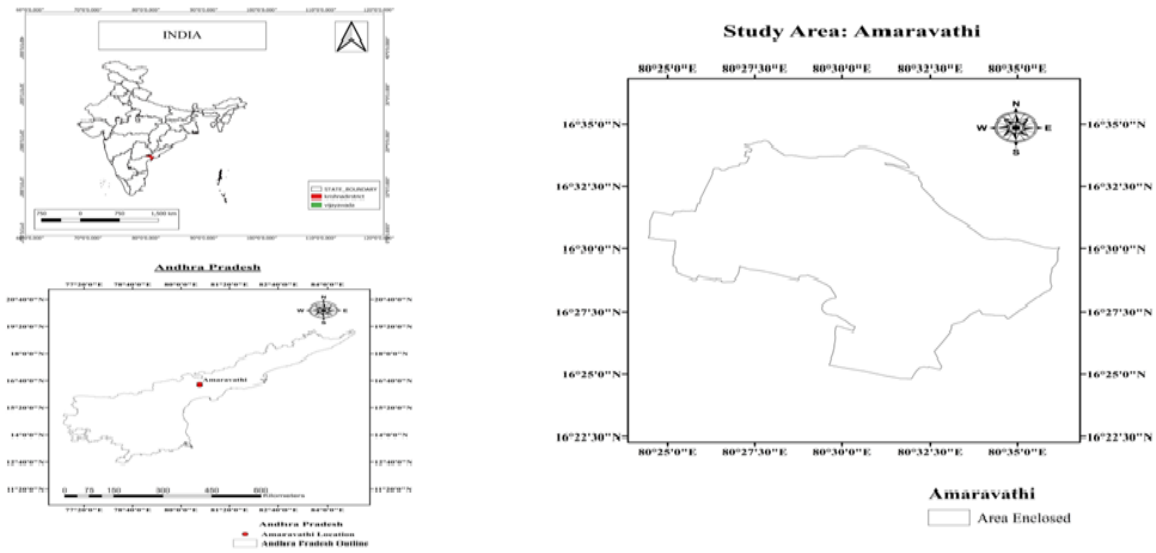


Figure 1: Study area

1.2 Objectives

1. To identify and analyze temporal changes in land use and land cover patterns in Amaravati capital region using satellite imagery.
2. Study temporal patterns in land use and cover to understand the modifications of urbanization and infrastructure development in Amaravati capital region.
3. Offer data-driven recommendations for regional planners and policymakers to balance development with environmental sustainability.
4. Improve the land use information through accessible visualization for the public.

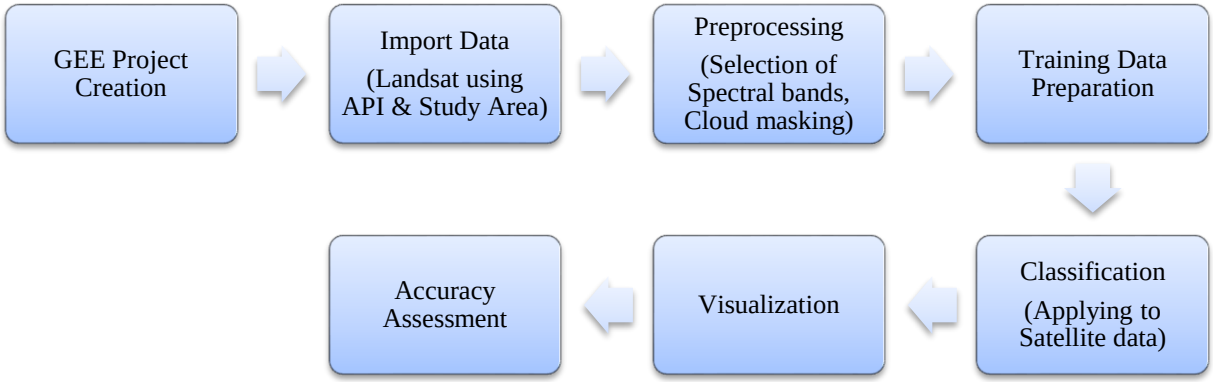
1.3 Scope of the Project

1. This study is limited to the geographic boundaries of the Amaravati capital region located in the state of Andhra Pradesh.

2. Examine satellite imagery to map Amaravati, Andhra Pradesh, focusing on urban areas, agricultural lands, Barren lands, and water bodies.
3. Distinguish and evaluate land use changes over time, such as urban development or loss of vegetation cover, to track Amaravati's growth and environmental conservation efforts.

2. METHODOLOGY

The methodology for this study involves analyzing Land Use and Land Cover (LULC) changes in Amaravati using Google Earth Engine (GEE) with the Random Forest classification method. The process begins with initializing a GEE project and importing Landsat satellite imagery along with boundary data for the study area. Pre-processing steps, such as spectral band selection and cloud masking, are applied to ensure high-quality data. Training datasets for five land categories - water bodies, vegetation, croplands, barren lands, and built-up areas are prepared to train the Random Forest classifier, a robust machine learning algorithm known for its accuracy and efficiency. The classifier is used to categorize the imagery, and the results are visualized to study spatial and temporal changes across different time intervals. To validate the classification, accuracy assessment techniques like Kappa coefficients and error matrices are employed. This methodology provides a reliable framework for understanding land dynamics and environmental changes over time.



Flow chart for LULC process

3. DATA COLLECTION

1. Landsat satellite imagery was acquired from the USGS Earth Explorer platform, which provides free access to remote sensing data.
2. The area of interest (AOI) was selected using coordinates, a shape file, or manually defining a region on the map.
3. The Landsat dataset was filtered based on key parameters such as acquisition date, cloud cover percentage, and sensor type to ensure optimal image selection.
4. The required bands (1 to 6) and the Metadata (MTL) file were chosen, as these are essential for further image processing and analysis.
5. The selected dataset was downloaded in Level-1 Geo TIFF format, which is radio metrically and geometrically corrected for analysis.
6. The downloaded file was in compressed (.zip) format, which was extracted to access the individual spectral bands and metadata for further processing.
7. Imagery was specifically acquired for the following time intervals: 2013-2014, 2014-2015, 2017-2018, 2019-2020, 2021-2022, and 2023-2024 for studying LULC changes in Amaravati.

4. ANALYSIS

1. **Preprocessing:**
   - Apply cloud masking to remove cloud-covered pixels.
   - Normalize spectral bands to improve classification accuracy.
2. **Classification:**
   - Use the Random Forest algorithm in GEE for LULC classification based on training data.
   - Categorize the imagery into five defined land categories.

3. **Temporal Analysis:**
    - Compare classified maps for the chosen years to identify spatial and temporal patterns of land use changes**.**
4. **Accuracy Assessment:**
    - Evaluate the classification results using Kappa coefficients and confusion matrices to ensure reliability**.**
5. **Change Detection:**
    - Quantify the transitions between land categories (e.g., croplands to built-up areas) over time.
    - Identify major trends such as urban expansion or reduction in vegetation**.**
6. **Visualization:**
    - Create maps and graphs in GEE or export the outputs to QGIS for professional layouts.

5. RESULTS

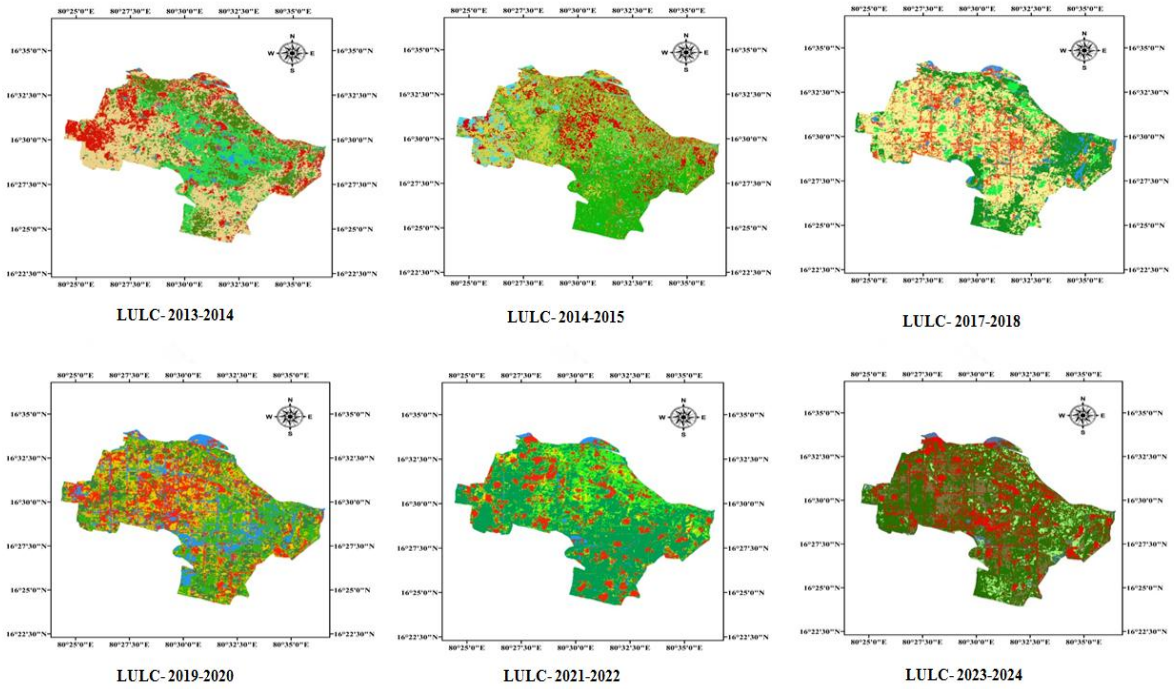
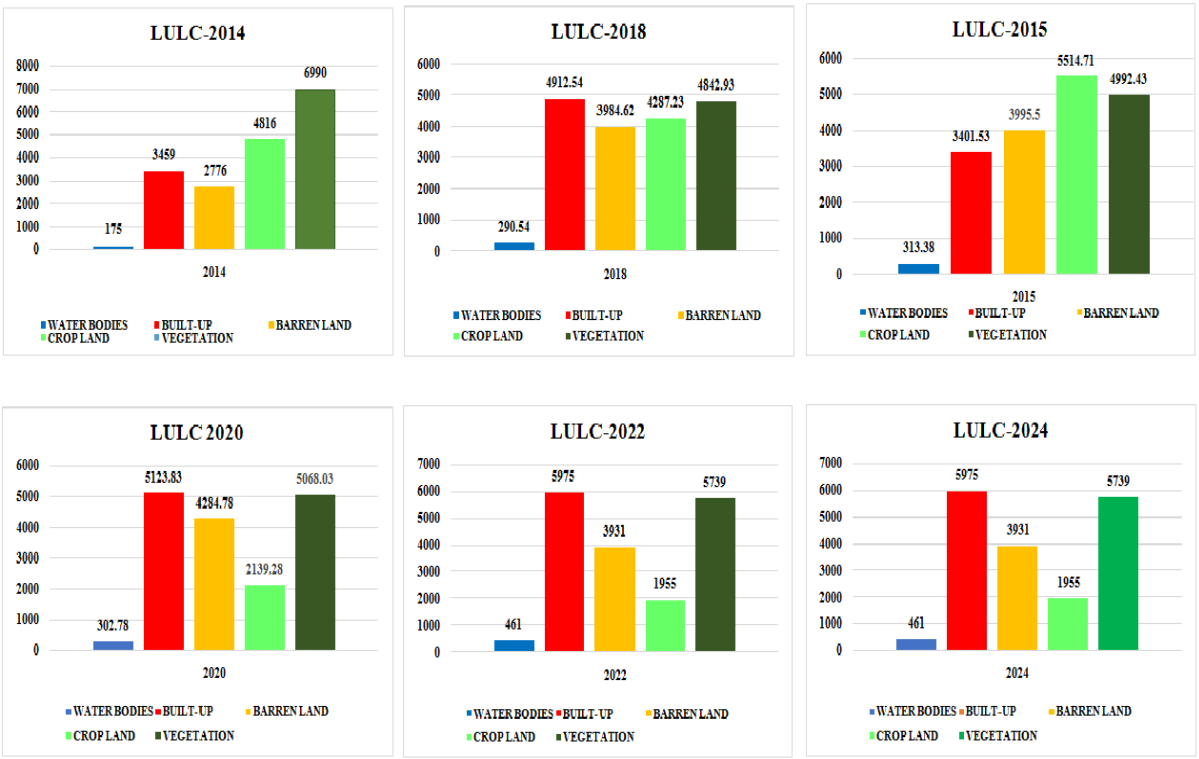
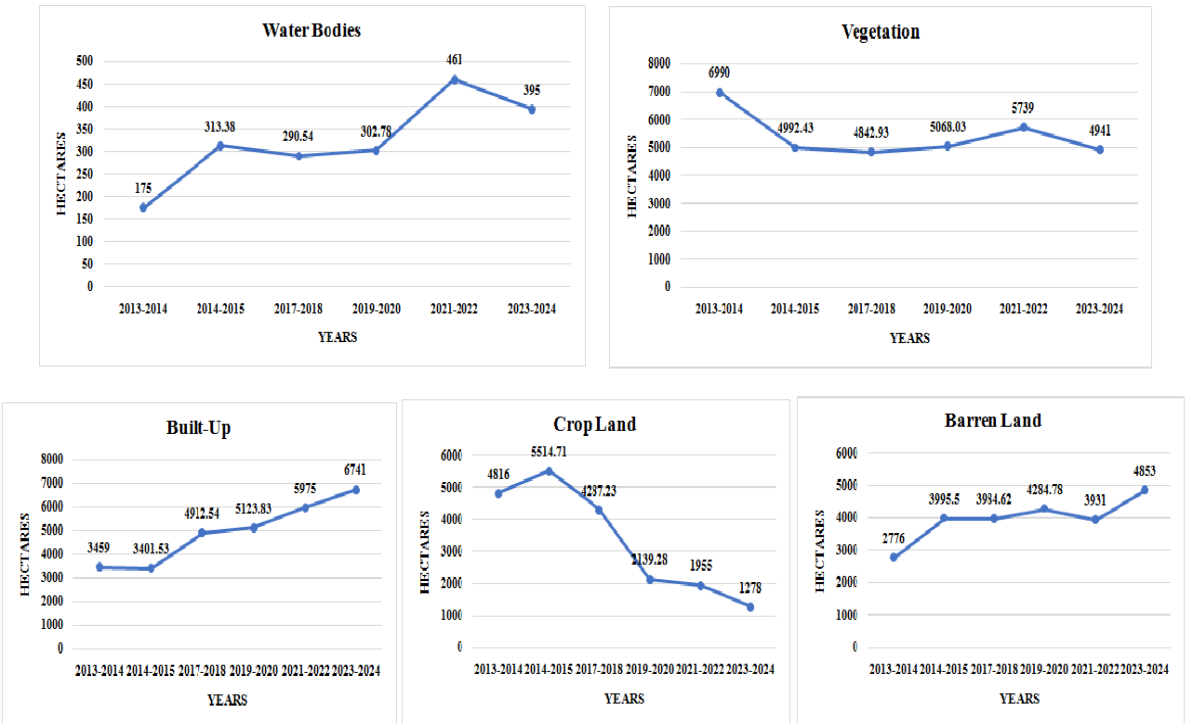


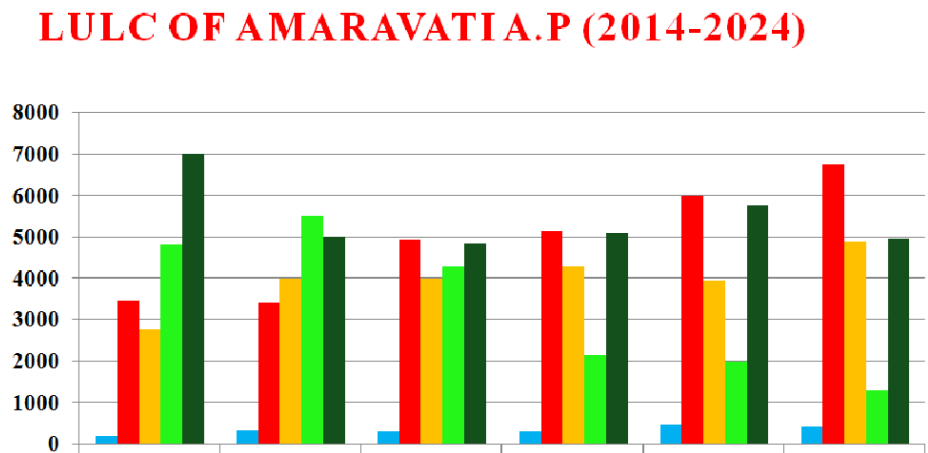
Figure 2: LULC of Amaravathi for various Years from 2014-2024



Graph 1: LULC of Amaravathi for various Years from 2014-2024



Graph 2: LULC of Amaravathi for various Years from 2014-2024



	2013-14	2014-15	2017-18	2019-20	2021-22	2023-24
water bodies	175	313.38	290.54	302.78	461	395
built-up	3459	3401.53	4912.54	5123.83	5975	6741
barren land	2776	3995.5	3984.62	4284.78	3931	4853
crop land	4816	5514.71	4287.23	2139.28	1955	1278
vegetation	6990	4992.43	4842.93	5068	5739	4941

Graph 3: LULC of Amaravathi for various Years from 2013-2024

6. CONCLUSIONS

1. The project, "Land Use/Land Cover Change Detection and Analysis in Amaravati using Google Earth Engine," focuses on monitoring and evaluating how land use and land cover have transformed over time in the Amaravati region. By leveraging Google Earth Engine's powerful processing capabilities, the project analyzes large satellite datasets to detect significant changes in vegetation, urban areas, water bodies, and other land cover types.
2. In 2013-2014, the area had a 175 hectares of Water bodies, 3459 hectares of built-up, 2776 hectares of barren land, 4816 hectares of crop land and 6990 hectares of vegetation. Overall the vegetation land dominated the landscape back then, while water was relatively limited.
3. In 2014-2015, the area had a 313.38 hectares of water bodies, 3401.53 hectares of built-up, 3995.5 hectares of barren land, 5514.71 hectares of crop lad and 4992.43 hectares of vegetation. The data source year on year changes, 79% of water bodies are increased, 1.66% of built-up is decreased, 43.9% of barren land is increased, 14.5% of crop land is increased, 28.6% of vegetation is decreased.
4. In 2017-2018, the area had a 290.54 hectares of water bodies, 4912.54 hectares of built-up, 3984.62 hectares of barren land, 4287.23 hectares of crop land and 4842.93 hectares of vegetation. The data source year on year changes, 7.3% of water bodies are decreased, 44.4% of built-up is increased, 0.27% of barren land is decreased, 22.3% of crop land is decreased, 3% of vegetation is decreased.
5. In 2019-2020, the area had a 302.78 hectares of water bodies, 5123.83 hectares of built-up, 4284.78 hectares of barren land, 2139.28 hectares of crop land and 5068.03% hectares of vegetation. The data source year on year changes, 4.2% of water bodies are increased, 4.3% of built-up is increased, 7.5% of barren land is increased, 50.1% of crop land is decreased, 4.65% of vegetation is increased.
6. In 2021-2022, the area had a 461 hectares of water bodies, 5975 hectares of built-up, 3931 hectares of barren land, 1955 hectares of crop land and 5739 hectares of vegetation. The data source year on year changes, 52.3% of water bodies are increased, 16.6% of built-up is increased, 8.3% of barren land is decreased, 8.6% of crop land is decreased, 13.2% of vegetation is increased.
7. In 2023-2024, the area had a 395 hectares of water bodies, 6741 hectares of built-up, 4853 hectares of barren land, 1278 hectares of crop land and 4941 hectares of vegetation. The data source year on year changes, 14.3% of water bodies are decreased, 12.8% of built-up is increased, 23.5% of barren land is increased, 34.6% of crop land is decreased, 13.9% of vegetation is decreased.
8. In last 2014-2024 , the data source year on year changes, 125.71% of water bodies are increased, 94.83% of Built-up area is increased, 74.82% of Barren land is increased, 73.45% of crop land is decreased, 29.32% of vegetation is decreased.

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