DAYANANDA SAGAR UNIVERSITY

KUDLU GATE, BANGALORE – 560068

Bachelor of Technology
in
COMPUTER SCIENCE AND ENGINEERING

Major Project Phase-II Report

Environmental Impact Analysis using Satellite Image Processing: A Case Study on Bangalore STRR Phase-1

Batch: 87

By

Varun P Shrivathsa – ENG20CS0402
Smriti Reddy U - ENG20CS0388
Girish Singh B S - ENG21CS3001

Under the Supervision:

Dr. Rajesh T M
Associate Professor and Dept. of CSE
&
Dr. P G Diwakar
ISRO Chair Professor, NIAS
&
Dr. Gopal Sharma R Joshi,
Project Coordinator and Professor of Practice at DSU

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING,
SCHOOL OF ENGINEERING
DAYANANDA SAGAR UNIVERSITY,
BANGALORE

(2023-2024)

Dayananda Sagar University
School of Engineering
Department of Computer Science & Engineering
Kudlu Gate, Bangalore – 560068, Karnataka, India

CERTIFICATE

This is to certify that the Major Project Phase-II Report work titled **"Environmental Impact Analysis using Satellite Image Processing: A Case Study on Bangalore STRR Phase-1"** is carried out by **Varun P Shrivathsa (ENG20CS0402), Smriti Reddy (ENG20CS0388) and Girish Singh BS (ENG21CS3001)** bonafide student of Bachelor of Technology in Computer Science and Engineering at the School of Engineering, Dayananda Sagar University, Bangalore in partial fulfillment for the award of degree in Bachelor of Technology in Computer Science and Engineering, during the year **2023-2024**.

Dr. Rajesh T M

Associate Professor
Dept. of CS&E,
School of Engineering
Dayananda Sagar University

Date:

Dr. Girisha G S

Chairperson
Dept. of CS&E
School of Engineering
Dayananda Sagar University

Date:

Dr. Udaya Kumar Reddy K R

Dean
School of Engineering
Dayananda Sagar University

Date:

Name of the Examiner **Signature of Examiner**

1.

2.

DECLARATION

We, **Varun P Shrivathsa (ENG20CS0402), Smriti Reddy (ENG20CS0388), and Girish Singh BS (ENG21CS3001**) are students of eighth semester B. Tech in Computer Science and Engineering, at School of Engineering, Dayananda Sagar University, hereby declare that the **Major Project Phase-II Report** titled "**Environmental Impact Analysis using Satellite Image Processing: A Case Study on Bangalore STRR Phase-1**" has been carried out by us and submitted in partial fulfilment for the award of degree in Bachelor of Technology in Computer Science and Engineering during the academic year 2023-2024.

Student	**Signature**
Name: Varun P Shrivathsa **USN: ENG20CS0402**	
Name: Smriti Reddy **USN: ENG20CS0388**	
Name: Girish Singh BS **USN: ENG21CS3001**	
Place: Bangalore **Date: 24/04/2024**	

ACKNOWLEDGEMENT

It is a great pleasure for us to acknowledge the assistance and support of many individuals who have been responsible for the successful completion of this project work.

First, we take this opportunity to express our sincere gratitude to the School of Engineering & Technology, Dayananda Sagar University for providing us with a great opportunity to pursue our bachelor's degree in this institution.

*We would like to thank **Dr. Udaya Kumar Reddy K R**, Dean, School of Engineering & Technology, Dayananda Sagar University for his constant encouragement and expert advice.*

*It is a matter of immense pleasure to express our sincere thanks **to Dr. Girisha G S**, Department Chairperson, Computer Science and Engineering, Dayananda Sagar University, for providing the right academic guidance that made our task possible.*

*We would like to thank our guide **Dr Rajesh T M**, Associate Professor, Dept. of Computer Science and Engineering, Dayananda Sagar University, for sparing his valuable time to extend help in every step of our project work, which paved the way for smooth progress and fruitful culmination of the project.*

*We deeply appreciate **Dr. P G Diwakar**, ISRO Chair Professor at NIAS, for being our guide. His expertise and guidance were crucial in shaping our project, enriching our understanding, and ensuring its success. Our sincere thanks also go to **Dr. Gopal Sharma R Joshi**, Professor of Practice at DSU, our project coordinator. His unwavering support and guidance were vital in steering our project to its successful completion through effective coordination and dedication.*

*We would like to thank our Project Coordinator **Dr. Meenakshi Malhotra** and **Prof. Mohammed Khurram J** as well as all the staff members of Computer Science and Engineering for their support.*

We are also grateful to our family and friends who provided us with every requirement throughout the course. We would like to thank one and all who directly or indirectly helped us in the Project work.

TABLE OF CONTENTS

Page

LIST OF ABBREVIATIONS 06
LIST OF FIGURES ………... 07
LIST OF TABLES. ………...09

ABSTRACT 10
CHAPTER 1 INTRODUCTION………..11
1.1 INTRODUCTION……......................................………............................11
1.2 OBJECTIVE…….. 12
1.3. SCOPE ……...13
CHAPTER 2 PROBLEM DEFINITION ………..14
CHAPTER 3 LITERATURE SURVEY………...16
CHAPTER 4 PROJECT DESCRIPTION..20
CHAPTER 5 REQUIREMENTS ....…24
CHAPTER 6 METHODOLOGY...25
CHAPTER 7 TESTING AND RESULTS …..29
8.1 RESULTS 29
8.2 DISCUSSION OF RESULTS 31
CHAPTER 8 CONCLUSION AND FUTURE WORK............ 54
8.1. CONCLUSION.. 54
CHAPTER 9 REFERENCES... 55

SAMPLE CODE 57
Funding and Published Paper details 61

LIST OF ABBREVIATIONS

LULC	Land Use/ Land Cover
STRR	Satellite Town Ring Road
NDVI	Normalized Difference Vegetation Index
NDSI	Normalized Difference Soil Index
QGIS	Quantum Geographic Information System

LIST OF FIGURES

Fig 1	Design Flowchart
Fig 2	USGS Sample Satellite Image
Fig 3	Spectral bands in Sentinel Data
Fig 4	5 Segments of STRR
Fig 5	ROI on LULC
Fig 6	Illustration of Buffers on Satellite data
Fig 7	Main Classes for LULC
Fig 8	Training using polygons in QGIS
Fig 9	Segment-1 Results
Fig 10	Segment 1 2015 v/s 2023
Fig 11	Analysis of LULC in Segment 1
Fig 12	Segment-2 Results
Fig 13	Segment 2 2015 v/s 2023
Fig 14	Analysis of LULC in Segment 2
Fig 15	Segment-3 Results
Fig 16	Segment 3 2015 v/s 2023
Fig 17	Analysis of LULC in Segment 3
Fig 18	Segment-4 Results
Fig 19	Segment 4 2015 v/s 2023
Fig 20	Analysis of LULC in Segment 4
Fig 21	Segment-5 Results
Fig 22	Segment 5 2015 v/s 2023
Fig 23	Analysis of LULC in Segment 5
Fig 24	DEM of entire STRR Road
Fig 25	DEM of Segment 1
Fig 26	DEM of Segment 2
Fig 27	DEM of Segment 3
Fig 28	DEM of Segment 4

Fig 29	DEM of Segment 5
Fig 30	Proposed Alternate route.
Fig 31	Aspect map
Fig 32	Slope Map
Fig 33	Hill shade map.
Fig 34	Pixel to Pixel comparison of LULC segment wise
Fig 35	Segment wise site visit pictures
Fig 36	Pseudocode of Maximum Likelihood Estimation
Fig 37	Code Snippet of Analysis graph generated

LIST OF TABLES

Table 1	Buffer wise Segment 1 before and after.
Table 2	Buffer wise Segment 2 before and after.
Table 3	Buffer wise Segment 3 before and after.
Table 4	Buffer wise Segment 4 before and after.
Table 5	Buffer wise Segment 5 before and after.
Table 6	Comprehensive pixel to pixel analysis.

Abstract

Our study is a thorough before-and-after analysis of land use and land cover (LULC) alterations in the area surrounding the construction of the Satellite Town Ring Road (STRR) Phase-1, focusing on the environmental implications associated with ongoing highway construction. The STRR Phase-1 is the focal point for our investigation, allowing us to gain insights into the transformation of the landscape. Our primary objective is to identify the significant changes that have transpired in the area since the initiation of construction activities. Through a comprehensive examination, we gather the impacts on LULC patterns, emphasizing the need for sustainable development practices. The study aspires to contribute valuable information that can guide future development endeavors in a manner that is environmentally responsible. By delving into the intricate dynamics of land use alterations, we seek to inform urban planners, policymakers, and stakeholders about the broader implications of highway construction on the environment. This research aligns with the goal of promoting sustainable urban development and underscores the importance of considering environmental factors in the planning and execution of infrastructure projects.

CHAPTER 1 INTRODUCTION

Highway construction plays a vital role in development, contributing to improved connectivity and economic growth. However, these constructions often bring about significant changes to the natural landscape. This study aims to comprehensively investigate Land Use and Land Cover (LULC) changes resulting from the construction of the Satellite Ring Road Phase-1. By understanding the nature and extent of alterations caused by these constructions, we can better address their environmental impact.

In this study, we will employ remote sensing techniques and supervised classification methods to analyze satellite imagery before and after the highway construction. The primary objectives of our investigation include evaluating forest clearance, assessing changes in water bodies, analyzing alterations in land use, investigating the impact on agriculture, and conducting a displacement analysis.

The process of highway construction almost always has diverse effects on the landscape, ranging from alterations in the distribution of vegetation to changes in water bodies and land use patterns. Through our upcoming study, we aspire to shed light on these transformations, providing valuable insights that can inform future construction practices and contribute to sustainable development. By anticipating and understanding these changes, we aim to pave the way for a balanced approach to infrastructure development—one that prioritizes progress while safeguarding the environment. This study, set to unfold in the coming months, endeavors to explore the multifaceted impacts of highway construction, laying the groundwork for informed decision-making and responsible development practices.

1.1. OBJECTIVE

The primary objective of this study is to comprehensively assess the socio-environmental impacts associated with the upcoming highway project. Specifically, our objectives are as follows:

1. **Agricultural Impact Assessment:** To quantify the extent of agricultural land affected by the project, assess potential crop yield losses, and evaluate the economic implications on local agriculture.
2. **Land Use Changes:** To measure and analyze changes in land use patterns resulting from the construction of the highway, considering implications for urban expansion, green spaces, and future land development.
3. **Forest Clearance Evaluation:** To determine the amount of forested land slated for clearance, assess ecological consequences, and propose strategies for mitigating deforestation effects.
4. **Water Body Assessment:** To identify the number of water bodies at risk of impact by the highway project and assess the environmental and human consequences related to these changes.

1.2. RESEARCH GAPS

- A potential research gap would be the assumption that all the changes surrounding the region of interest i.e., STRR phase - 1 were caused only by the construction and not any other activities in the area.
- Another potential research gap would be an error in classifying the displacement of people as a result of the highway while there might have been a different reason.
- A research gap may exist in the assumption that land use changes directly correlate with highway construction and overlook the dynamic nature of land use in response to various factors including economic and environmental trends.

1.3. SCOPE

The primary purpose of this project is to understand and study the changes happening to the land around the Satellite Town Ring Road (STRR) Phase-1 due to the construction of the highway. The target is to understand how the environment has been affected before and after the highway construction. The main goal is to figure out the impact of this construction on nature and to, in the future, find ways to build infrastructure in a sustainable manner.

1.4. SOCIAL/ENVIRONMENTAL IMPACTS

Social Impact:

- Construction of highways can sometimes lead to displacement of many communities. Our Impact Analysis will examine these social disruptions and their consequences.

Environmental Impact:

- Construction of highways can lead to a major loss of flora and fauna; our study can quantify and assess these impacts.
- Assessing land cover changes can provide insights on how much natural land has been converted into infrastructure. This can be crucial for sustainable land management and urban planning.

CHAPTER 2 PROBLEM DEFINITION

Problem: Highway construction often leads to deforestation, conversion of natural landscapes into impervious surfaces, and alterations in hydrological systems, which can result in adverse effects such as increased runoff, soil erosion, and habitat loss. Furthermore, these changes may impact local communities by affecting their access to resources, livelihoods, and overall quality of life.

Solution: To quantify the LULC changes in the areas that underwent highway construction. Our analysis will employ remote sensing techniques and supervised classification methods to perform the study in the STRR Phase-1 region - Bangalore. The results of this study will provide a valuable resource for urban planners, environmental managers, and policymakers involved in infrastructure development.

CHAPTER 3 LITERATURE REVIEW

1) Land classification analysis using geospatial techniques in Nanjangud Taluk of Karnataka State, India is crucial for determining spatial knowledge and its significance. Various image classification methods have been developed to generate standardized Land Use and Land Cover (LULC) maps, enabling analysis of ecological processes and human activities, and mapping land use/land cover changes at regional scales is essential for various applications including landslide prediction, erosion control, and land planning, among others.

2) Hadi, Prayoga & Wasanta, Tilaka & Santosa, Wimpy. (2021). The impact of road construction on land use change was investigated in this study. Roads play a pivotal role in fostering economic development, and this research aimed to analyze how the construction of new roads affects the rate of land use change, particularly focusing on building classifications. Findings revealed an accelerated growth in land use for building purposes following road construction compared to pre-construction periods.

3) Akyürek, D investigated land use and land cover changes (LULC) using multi-temporal satellite datasets in Istanbul New Airport's vicinity. Leveraging advanced space technologies such as remote sensing, the study aimed to monitor and assess environmental consequences resulting from LULC changes, particularly focusing on forest areas and water bodies. Supervised classification methods and spectral indices were applied to Landsat-8 and Sentinel 2A datasets to analyze total and annual changes during the airport's construction phase.

4) S. Feng et al., examined the environmental impacts of highway construction through a remote sensing approach. Highways serve crucial social and economic functions but can lead to various environmental consequences. The study revealed significant changes in land cover composition within certain buffers following highway construction, indicating the need for improved quantification and understanding of such disturbances and subsequent recovery processes.

5) Roy, Parth & Roy, Arijit. (2010). Land use and land cover changes have been extensively studied from a remote sensing and GIS perspective. Temporal information on land use and land cover dynamics aids in identifying areas undergoing change within a region, facilitating the quantification and prediction of various scenarios. The article provides an overview of current trends in LULC changes, supported by case studies employing geospatial modeling techniques.

6) Duarte, L., & Teodoro, A. explored the evolving landscape of QGIS, an open-source geospatial software, and its contribution to scientific development. QGIS, belonging to the Open-Source Geospatial Foundation (OSGeo), has witnessed a significant increase in publications and has positively impacted geographic information systems (GIS) knowledge and scientific production, as evidenced by strong correlations with code contributors and project income.

7) Khan, A., et al. utilized QGIS for open-source hydrological modeling in the Vishwamitri River Watershed, Gujarat, India. The study employed the Soil and Water Assessment Tool (SWAT) to simulate runoff, sediment yield, and water quality. Input data were prepared in UTM formats, and the SWAT model was successfully run for a 24-year period, providing valuable insights for watershed management.

8) Tefera, M., et al. assessed soil erosion risk using the Revised Universal Soil Loss Equation (RUSLE) in the Jhelum River watershed, Pakistan. The study revealed varying levels of erosion risk across the area, offering important guidelines for policymakers to enhance watershed management practices.

9**) Gebremeskel, G., et al. conducted mapping and monitoring of urban land use change in Addis Ababa, Ethiopia,** utilizing QGIS and Sentinel-2 data. The study proposed a novel approach combining Sentinel-2 and Landsat images for more accurate imperviousness mapping, enhancing the monitoring of urban areas and updating Copernicus Land services.

10) Said, M. S., explored the application of QGIS in participatory mapping and spatial planning for coastal communities in Zanzibar. The study highlighted the importance of integrating socio-economic factors into Marine Spatial Planning (MSP) frameworks, allowing for informed decision-making processes and the inclusion of coastal cultural values in planning efforts.

Reference Number	Technology Used	Results	Inference
[1]	The study uses IRS-1D LISS-III, to perform land classification analysis in Nanjangud Taluk of Karnataka, India.	The study classifies the land into three levels of detail: include agricultural land, built-up land, forest, water bodies, wastelands, and others	They identify specific cropping seasons and double-cropped areas. This information is valuable for environmental monitoring, land planning, and resource management, sustainable development, and ecosystem conservation.
[2]	They use geographic information systems (GIS) and satellite imagery from Google Earth to carry out LULC classification on 3 different ring roads.	Conversion of non-residential land into residential areas increased in all three cases.	After the operation of the new road, the increase in land use was significantly faster.

[3]	(LULC) changes in the vicinity of Istanbul Grand Airport (IGA). Using two satellite image datasets: Landsat-8 and Sentinel-2A. Spectral indices like NDVI, BI & NDSI are used.	The study's results show that the most significant change occurred in the vegetation cover, with large areas transitioning from "highly vegetated areas" to "construction areas."	The findings highlight the substantial negative impact on vegetation and coastal regions in the study area, emphasizing the ecological consequences of such large-scale infrastructure projects
[4]	BDACI-RS method with remote sensing to assess spatial and temporal environmental impacts before, during, and after Wujing Highway construction.	Model assesses highway's impact on environment using NDVI, NDMI, LST, terrain data. Poor quality increased during construction but improved after.	BDACI-RS assesses highway impacts, applicable to projects, and combines remote sensing and field data. Reveals post-construction recovery and uneven road impact distribution.
[5]	Agent-based model blends, Cellular Automata, factors like population, terrain, rainfall to predict land use dynamics in Goa.	Model forecasts 2027 land use trends in Goa, emphasizing dynamic categories, aiding informed decision-making on land use and cover.	Study demonstrates agent-based modeling's effectiveness in understanding land changes in Goa, stressing the role of human and environmental factors for sustainable land management.
[6]	QGIS	Identified Earth and Planetary Sciences, Environmental Science, and Computer Science as the most frequent fields using QGIS.	QGIS is a valuable open-source tool for scientific research, offering a powerful and accessible platform for geospatial analysis.

[7]	QGIS, SWAT model	Demonstrated the use of QGIS for setting up and running the SWAT model for hydrological simulations.	QGIS provides a user-friendly environment for open-source hydrological modeling, enabling researchers to conduct accurate and valuable simulations.
[8]	QGIS, RUSLE model	Identified areas of high erosion risk within the Gilgel Abay Watershed. Proposed soil conservation measures based on the model's outputs.	QGIS facilitates efficient and accurate soil erosion risk assessment through integrated use of geospatial data and erosion models.
[9]	QGIS, Sentinel-2 data	Utilized Sentinel-2 satellite imagery to map and analyze urban land use changes in Addis Ababa.	QGIS and Sentinel-2 data offer a cost-effective and efficient approach for mapping and monitoring urban land use change, providing valuable insights for urban planning and management.
[10]	QGIS	Employed QGIS as a tool for participatory mapping and spatial planning in coastal communities of Zanzibar.	QGIS empowers communities to participate in mapping and planning processes, promoting inclusive and sustainable development initiatives.

CHAPTER 4 DESIGN AND PROJECT DESCRIPTION

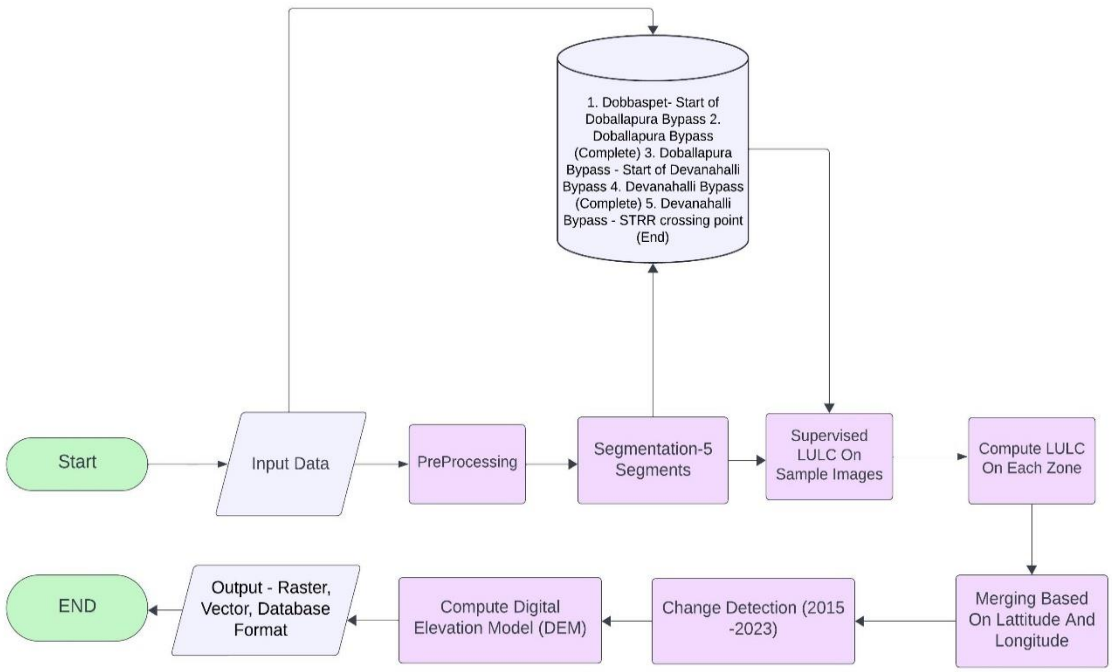


Fig 1. Design Flowchart

Data Collection:

Satellite images are being downloaded from multiple sources such as

1. USGS (United States Geological Survey)- Landsat 6-9 Satellites
2. Bhuvan (ISRO)- Resourcesat Satellites
3. Copernicus-Sentinel 1&2 Satellites
4. Resolution of data used ranges from 30m to 100m.

Pre-Processing: The Satellite data downloaded from various sources have Orthorectified images, here are the few examples of pre-processing the data

1.Conversion: Convert to a suitable format.

2. Calibration: Correct brightness and color.

3. Correction: Rectify geometric distortions.

4. Atmospheric Correction: Compensate for atmospheric effects.

5. Enhancement: Improve visual interpretation.

6. Subset and Resample: Focus on regions of interest, ensure consistent pixel size.

7. Normalization: Standardize pixel values.

8. Registration: Align images to a common coordinate system.

Segmentation:

STRR Phase-1 consisting of 80 km stretch is divided into 5 segments based on intersections-

1. Dobbaspet- Start of Doballapura Bypass
2. Doballapura Bypass (Complete)
3. Doballapura Bypass - Start of Devanahalli Bypass
4. Devanahalli Bypass (Complete)
5. Devanahalli Bypass - STRR crossing point (End)

Supervised LULC on Sample Images:

1. Load Image: Open your satellite image in QGIS.

2. Add Training Data: Use the 'Add Polygon Feature' tool to create training samples for each land cover class.

3. Attribute Data: Assign class labels to your training samples.

4. Train Classifier: Employ the 'Train Support Vector Machine' or another classification algorithm in the Processing Toolbox.

5. Classify Image: Apply the trained classifier to classify the entire image.

6. Evaluate and Refine: Assess accuracy, refine training data if needed.

7.Visualize and Export: Display the classified image in QGIS, assign colors for each class, and export the results.

Compute LULC On Each Zone:

These segments are divided into 3 buffer zones to analyze environmental impact, compute LULC for each buffer zone.

1. 0 - 200m
2. 200 - 500m
3. 500 - 1000m

Merging Based on Latitude and Longitude:

Merge spatial data based on latitude and longitude in QGIS, use the "Join attributes by location" tool from the Processing Toolbox. This tool combines data from two layers based on their spatial relationship, allowing you to merge information from different datasets. Ensure that the coordinate reference systems (CRS) match and review the attribute table of the merged layer for verification. Save the merged layer as a new file if you wish to retain the combined data for further analysis.

Comparison Of Before After Images:

Compare before-and-after satellite images in QGIS, overlay both images and adjust transparency for visual comparison. Use the 'Raster Calculator' to compute the pixel-wise difference and create a color composite image to highlight changes. Apply image enhancement techniques and symbology for improved visualization. Analyze the differences and document observed changes for reporting. Export the comparison image for further analysis or documentation purposes.

Output - Raster Vector or Database Format:

The output format for raster, vector, or database in QGIS depends on specific needs and the type of analysis:

1. Raster Format:

- Common raster formats include Geo TIFF, JPEG, PNG, and ERDAS Imagine.
- Choose Geo TIFF for maintaining georeferencing and spatial information.

2. Vector Format:

- Common vector formats include Shapefile, GeoJSON, and KML.
- Choose Shapefile for compatibility with many GIS applications.

3. Database Format:

- For spatial databases, popular formats include PostgreSQL/PostGIS, SQLite, and Spatialite.
- Choose PostgreSQL/PostGIS for a robust open-source spatial database system.

CHAPTER 5 REQUIREMENTS

Software Requirements:

- Modern multi-core processor (e.g., Intel Core i5)
- 4 GB RAM (8 GB recommended)
- Several gigabytes of free disk space
- Graphics card with OpenGL 3.3 support
- QGIS Software
- Semi-Automatic Classification Plugin
- USGS and Copernicus Satellite Images

Hardware Requirements:

- Python
- QGIS Software
- SCP and Semi-Automatic Classification Plugins
- Internet connection for online data access.
- Storage: Program requires about 100 MB of storage space.

CHAPTER 6 METHODOLOGY

1) Data Collection & Preprocessing:

- Satellite images are being downloaded from multiple sources such as
- USGS (United States Geological Survey)- Landsat 6-9 Satellites
- Bhuvan (ISRO)- Resourcesat Satellites
- Copernicus-Sentinel 1&2 Satellites
- Resolution of data used ranges from 30m to 100m.
- Landsat images consist of 11 spectral bands.

Fig 2. USGS Sample Satellite Image

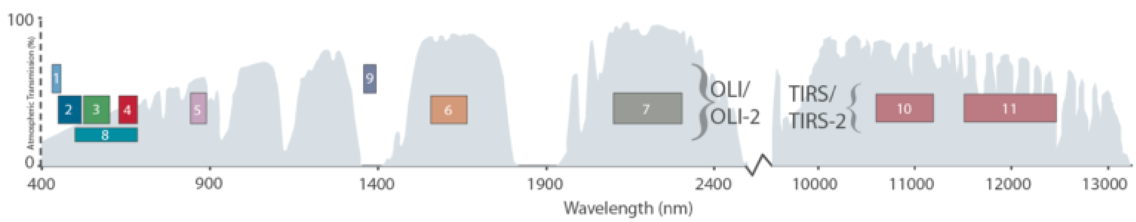


Fig 3. Spectral bands in Sentinel Data

2) Segmentation:

STRR Phase-1 consisting of 80 km stretch is divided into 5 segments based on intersections-

1. Dobbaspet- Start of Doddaballapura Bypass

2. Doddaballapura Bypass (Complete)

3.Doddaballapura Bypass - Start of Devanahalli Bypass

4. Devanahalli Bypass (Complete)

5. Devanahalli Bypass - STRR crossing point (End)

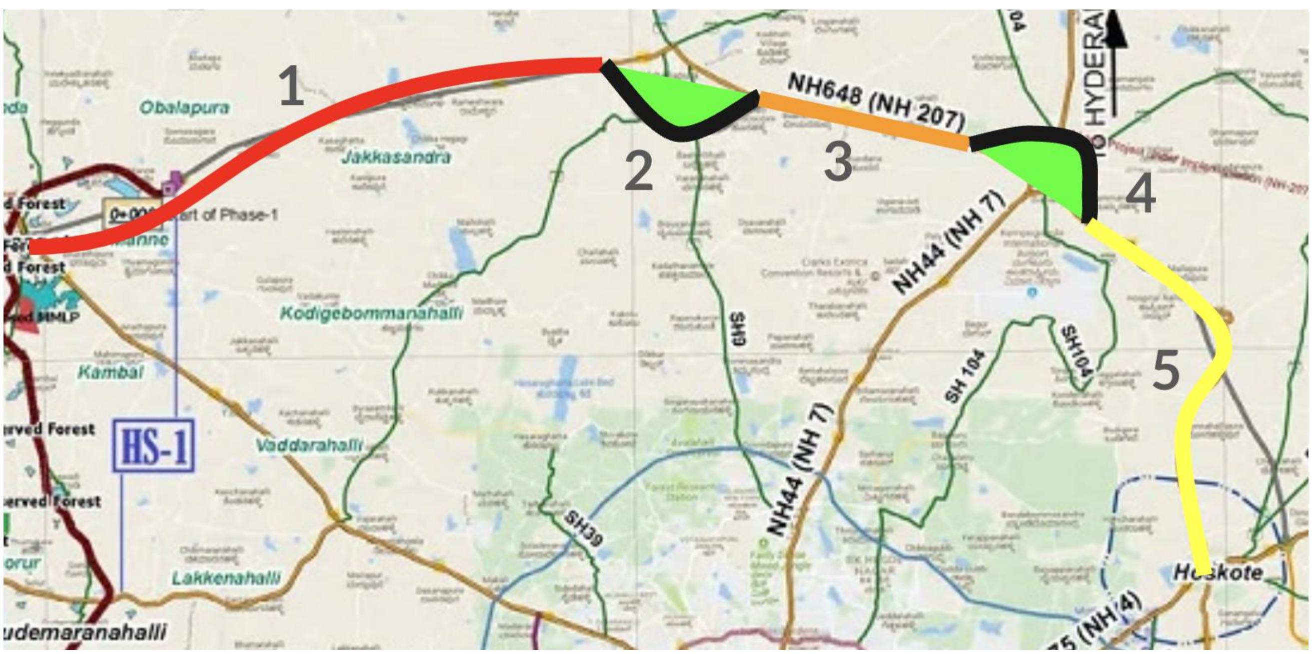


Fig 4. 5 Segments of STRR

3) Buffer Zones:

These segments are divided into 3 buffer zones to analyze environmental impact.

A. 200m

B. 500m

C. 1000m

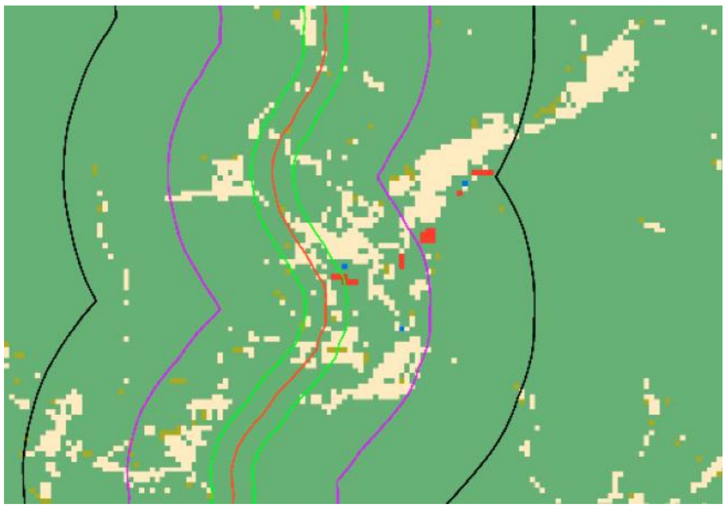


Fig 5. ROI on LULC

In the above image, the black line marks the 1000m buffer, purple marks 500 m and green marks the 200m buffer region.

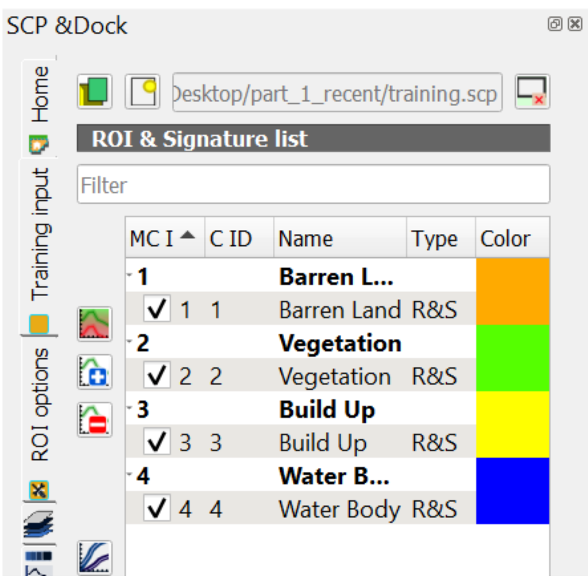
Fig 6. Illustration of Buffers on Satellite data

In the above image, the red line marks 1000m, yellow marks 500 m and green marks 200m on both sides of the bypass road.

4) Supervised LULC Land Use and Land Cover (LULC) classification of satellite images involves categorizing Earth's surface into different classes

- Urban (Build Up),
- Vegetation
- Barren land
- Waterbodies

Supervised training is done by selecting appropriate ROIs (Region of interest) using the Semi-Automatic Classification Plugin of QGIS.



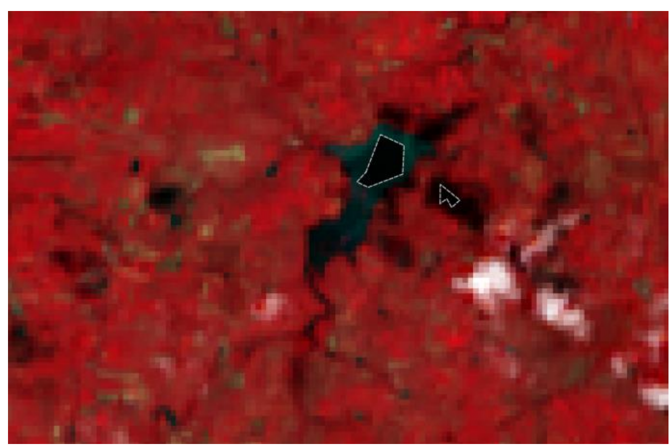


Fig 7. Main Classes for LULC

Fig 8. Training using polygons in QGIS.

CHAPTER 7 TESTING AND RESULTS

Segment -1

- Dobbaspet- Start of Doddaballapura Bypass
- Distance: 32 km
- This stretch consists of 4-lane highway.

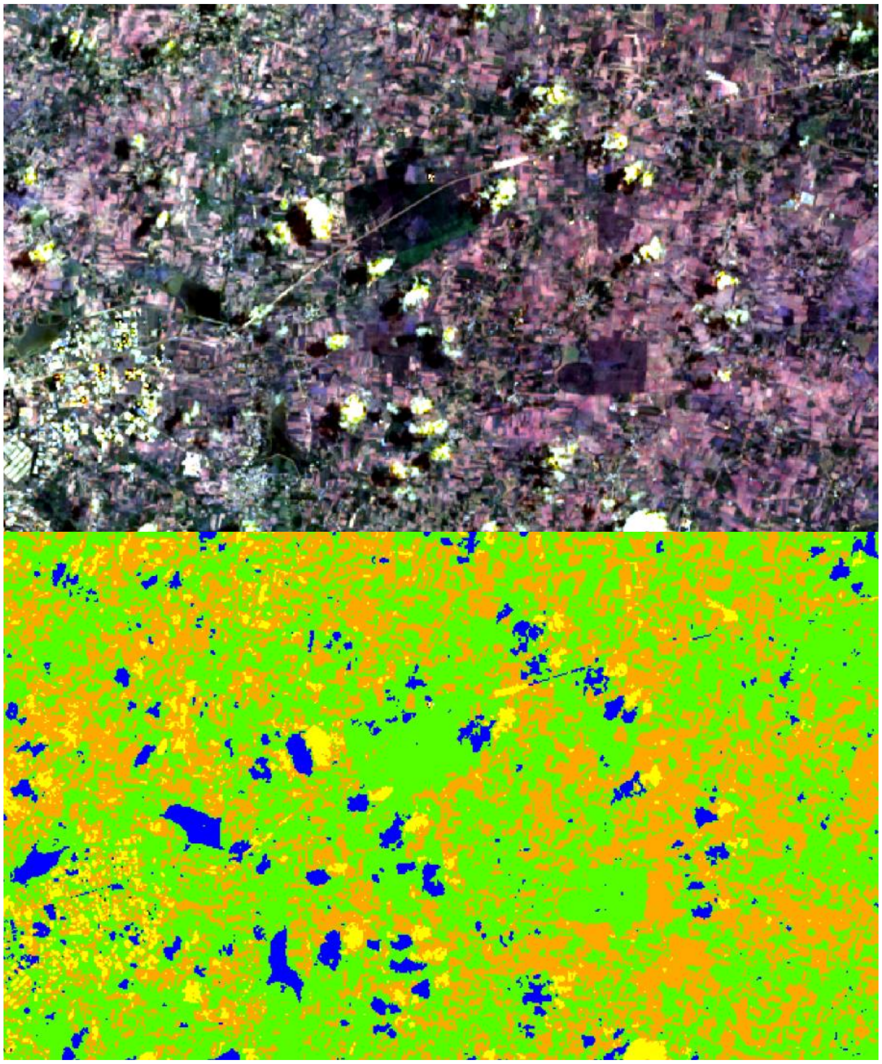


Fig 9. Segment-1 Results

We understand from the above LULC classfication that as the presence of orange color is evident it states that there is more barren land in that area and also large number of small waterbodies such as lakes and ponds.

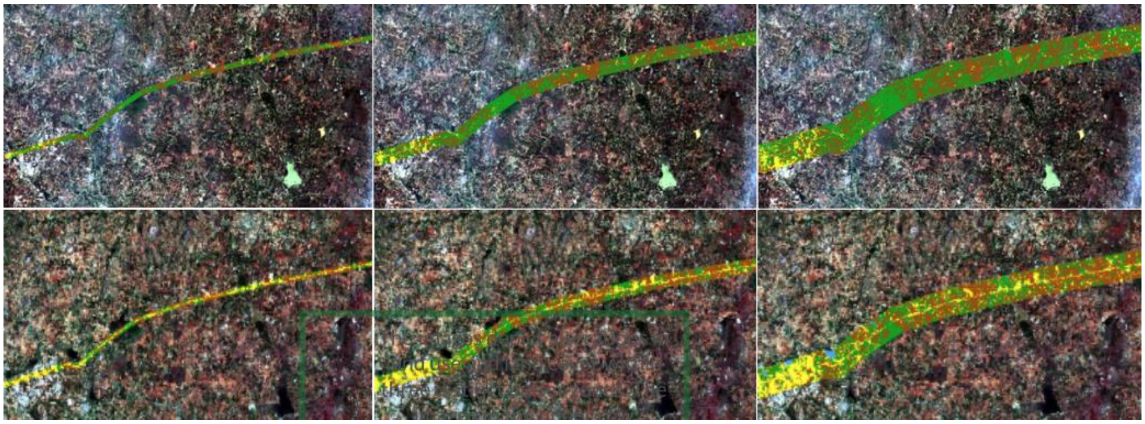


Figure 10 - Segment 1 2015 v/s 2023.

The images depict alterations in land use and land cover within three distinct buffer zones. The images in the upper row correspond to satellite images captured in the year 2015, while those in the lower row represent data from 2023.

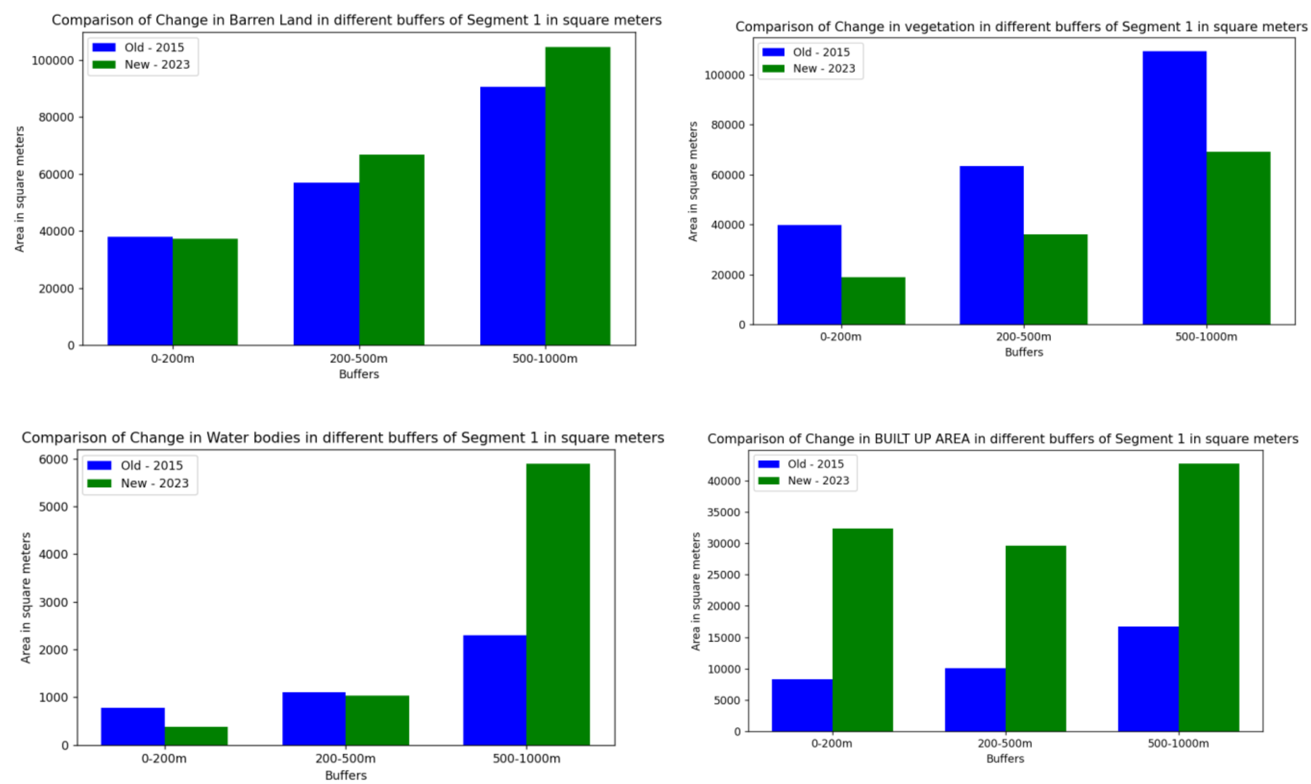


Figure 11. Analysis of LULC in Segment 1

The above image is a set of four graphs comparing changes in land use (barren land, vegetation, water bodies, and built-up area) across different buffer zones in Segment 1. Each graph shows data for two points in time: "Old-2015" and "New-2023". The X-axis is labeled "Buffers" and represents the distance from a central point in meters. The Y-axis is labeled "Area in square meters".

The top left graph shows the change in barren land. The area of barren land has decreased in all three buffer zones, with the greatest decrease occurring in the farthest zone (500-1000 meters).

The top right graph shows the change in vegetation. Vegetation area has increased in all three buffer zones, with the greatest increase in the farthest zone (500-1000 meters).

The bottom left graph shows the change in water bodies. Water body area appears to have decreased in all three buffer zones, with the greatest decrease in the closest zone (0-200 meters).

The bottom right graph shows the change in built-up area. Built-up area has increased in all three buffer zones, with the greatest increase in the closest zone (0-200 meters).

Segment -2

- Doddaballapura Bypass (Complete)
- Proposed Bypass: 15 km
- Construction of 4-lane bypass is underway.

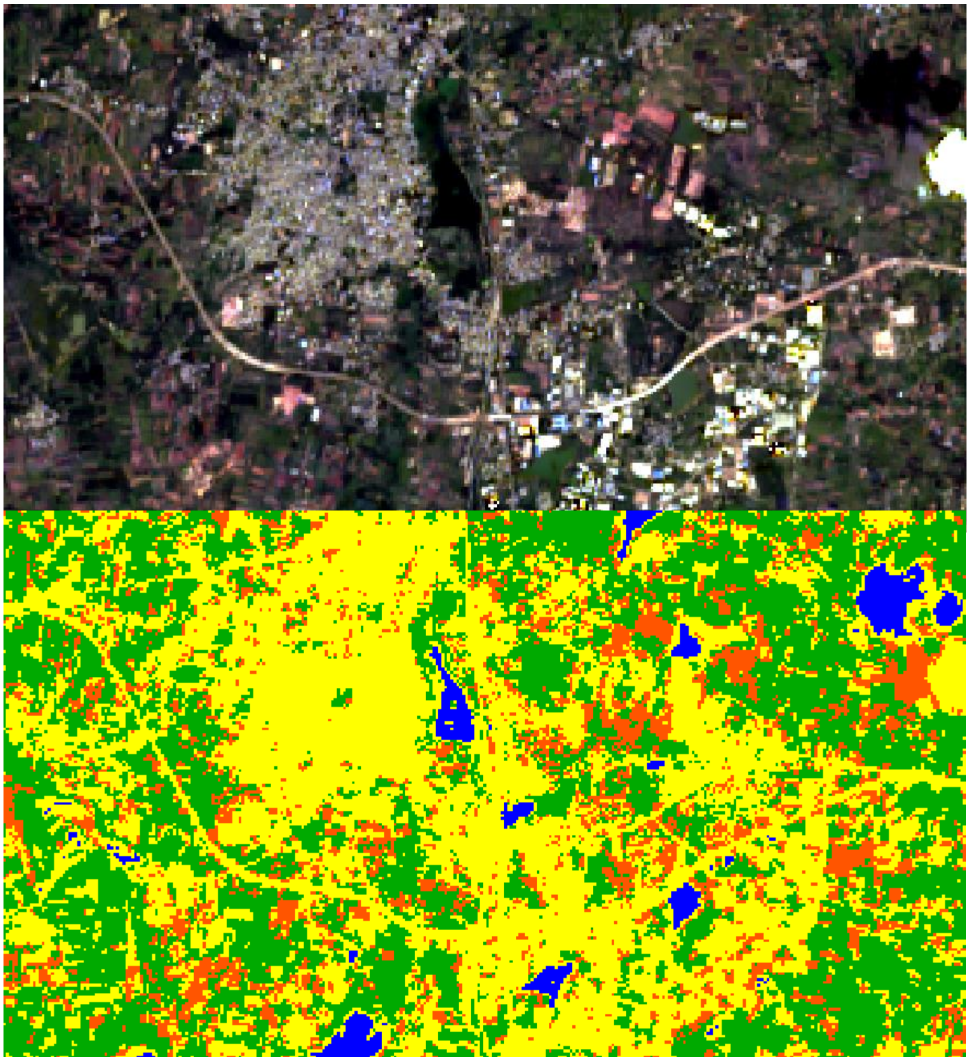


Fig 12. Segment-2 Results

We understand from the above LULC classfication that as this is a bypass road crossing the Doddaballapura city there is a huge presence of yellow color indicating built-up area and less of barren land.

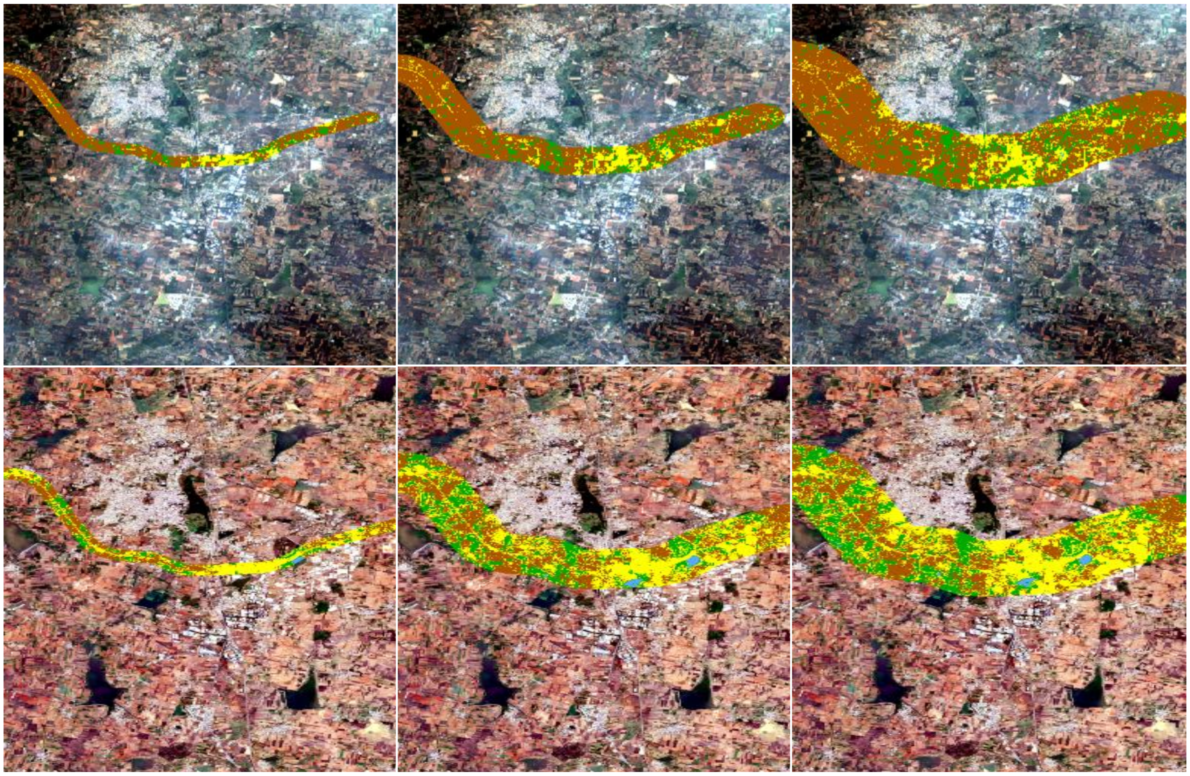
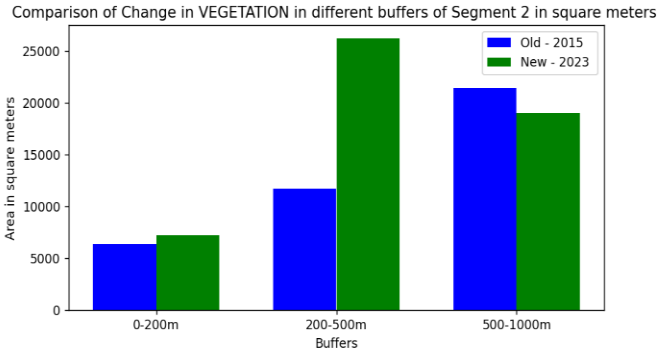


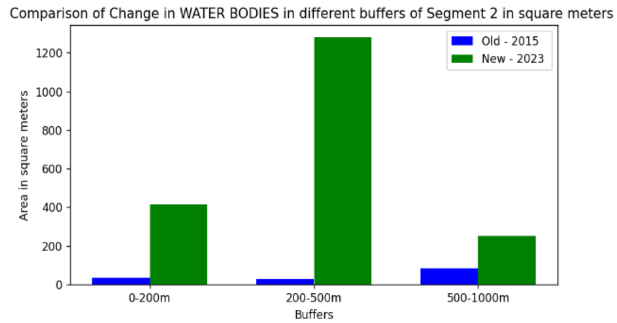
Figure 13. Segment 2 2015 v/s 2023

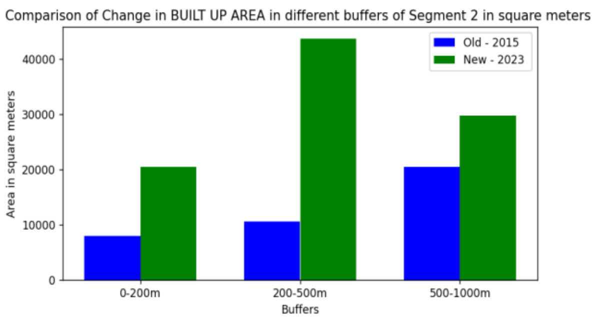
The images depict alterations in land use and land cover within three distinct buffer zones. The images in the upper row correspond to satellite images captured in the year 2015, while those in the lower row represent data from 2023.

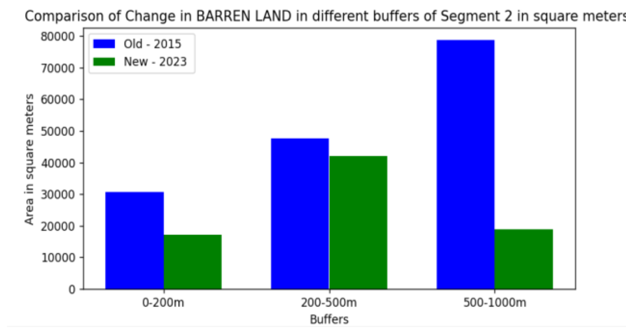
The below image is a set of four graphs depicting the change in land cover (vegetation, water bodies, built-up area, and barren land) in square meters across different buffer zones of Segment 2. Each graph compares data for two years: "Old-2015" and "New-2023". The X-axis labeled "Buffers" represents the distance from a central point in meters. The Y-axis labeled "Area in square meters" shows the extent of each land cover type.

Figure 14. Analysis of LULC in Segment 2









Top left: This graph shows the change in vegetation in Segment 2. The area of vegetation has increased in all three buffer zones, with the greatest increase in the farthest zone (500-1000 meters).

Top right: This graph shows the change in water bodies in Segment 2. There appears to be a decrease in water body area in all three buffer zones, with the most significant decrease in the closest zone (0-200 meters).

Bottom left: This graph shows the change in built-up area in Segment 2. The built-up area has increased in all three buffer zones, with the greatest increase in the closest zone (0-200 meters).

Bottom right: This graph shows the change in barren land in Segment 2. The area of barren land has decreased in all three buffer zones, with the greatest decrease in the farthest zone (500-1000 meters).

Segment-3

- Doddaballapura Bypass - Start of Devanahalli Bypass
- Distance: 12 km
- Road widening of National Highway 648

This particular classification results states that there is less vegetation in this area and more of built-up area with commerical or residential uses.

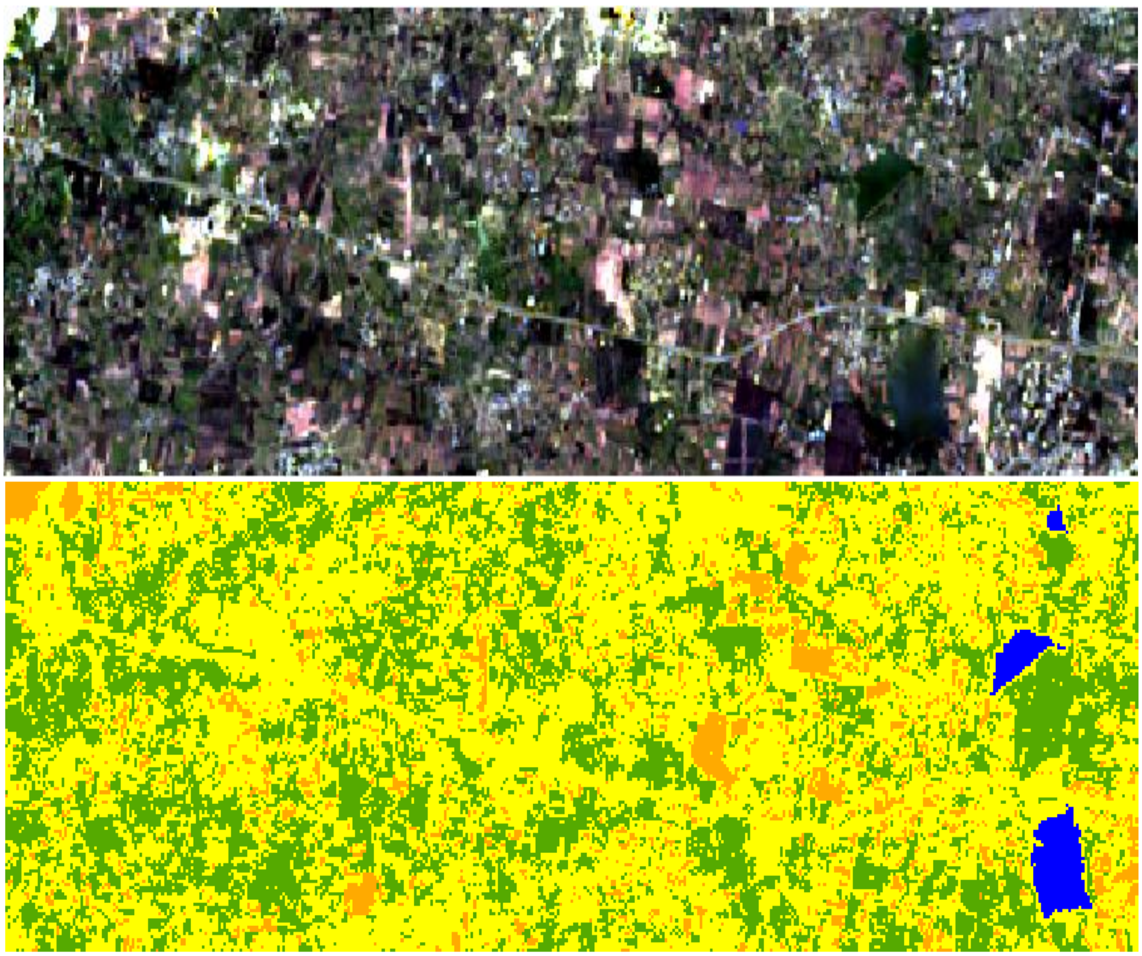


Fig 15. Segment-3 Results

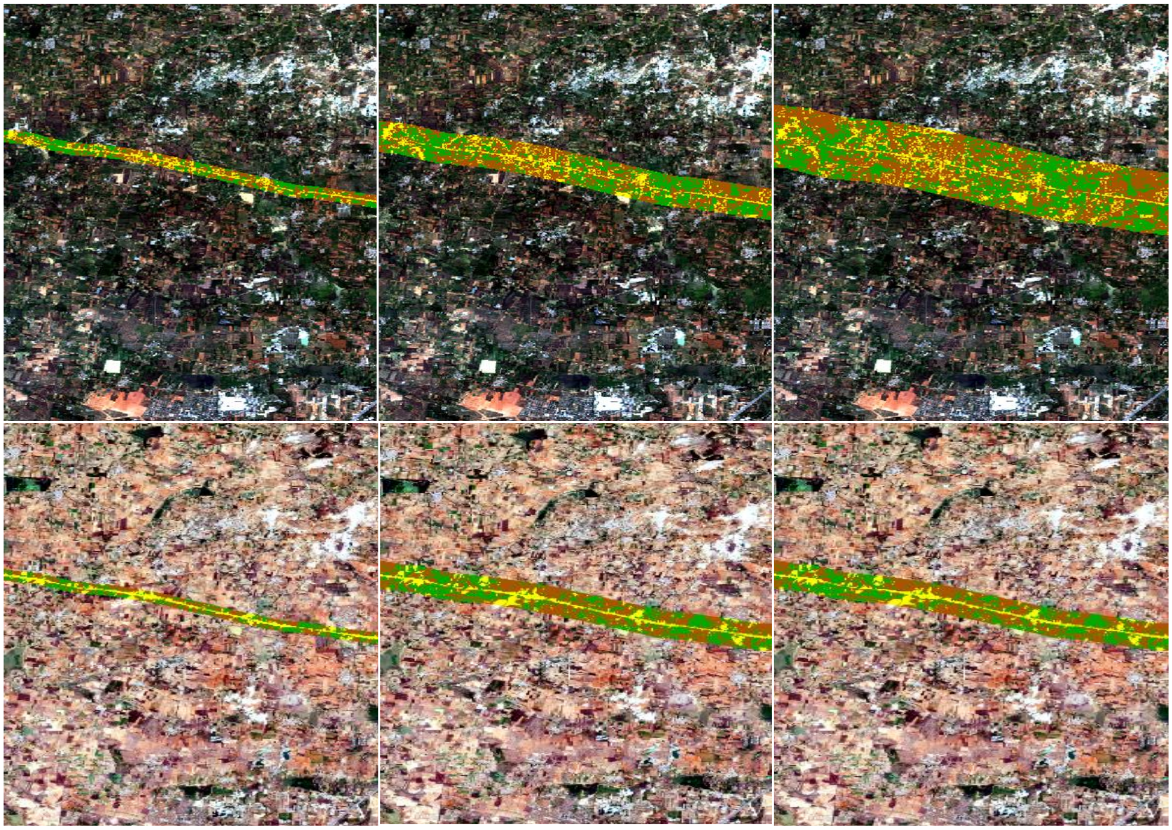


Figure 16. Segment 3 2015 v/s 2023

The images depict alterations in land use and land cover within three distinct buffer zones. The images in the upper row correspond to satellite images captured in the year 2015, while those in the lower row represent data from 2023.

The below image is a set of four charts titled "Comparison of Change in [Land Cover Type] in different buffers of Segment 3 in square meters". Each chart compares data for two years: "Old-2015" and "New-2023". The X-axis labeled "Buffers" represents the distance from a central point in meters (0-200m, 200-500m, and 500-1000m). The Y-axis labeled "Area in square meters" shows the extent of the specific land cover type.

Top left: This chart shows the change in vegetation in Segment 3. There seems to be a slight increase in vegetation in the farthest buffer zone (500-1000 meters) and a decrease in the closer zones (0-200 meters and 200-500 meters).

Top right: This chart shows the change in water bodies in Segment 3. Water body area appears to have decreased in all three buffer zones, with the greatest decrease in the closest zone (0-200 meters).

Bottom left: This chart shows the change in built-up area in Segment 3. The built-up area has increased in all three buffer zones, with the greatest increase in the closest zone (0-200 meters).

Bottom right: This chart shows the change in barren land in Segment 3. The area of barren land appears to have decreased in all three buffer zones, with the greatest decrease in the farthest zone (500-1000 meters).

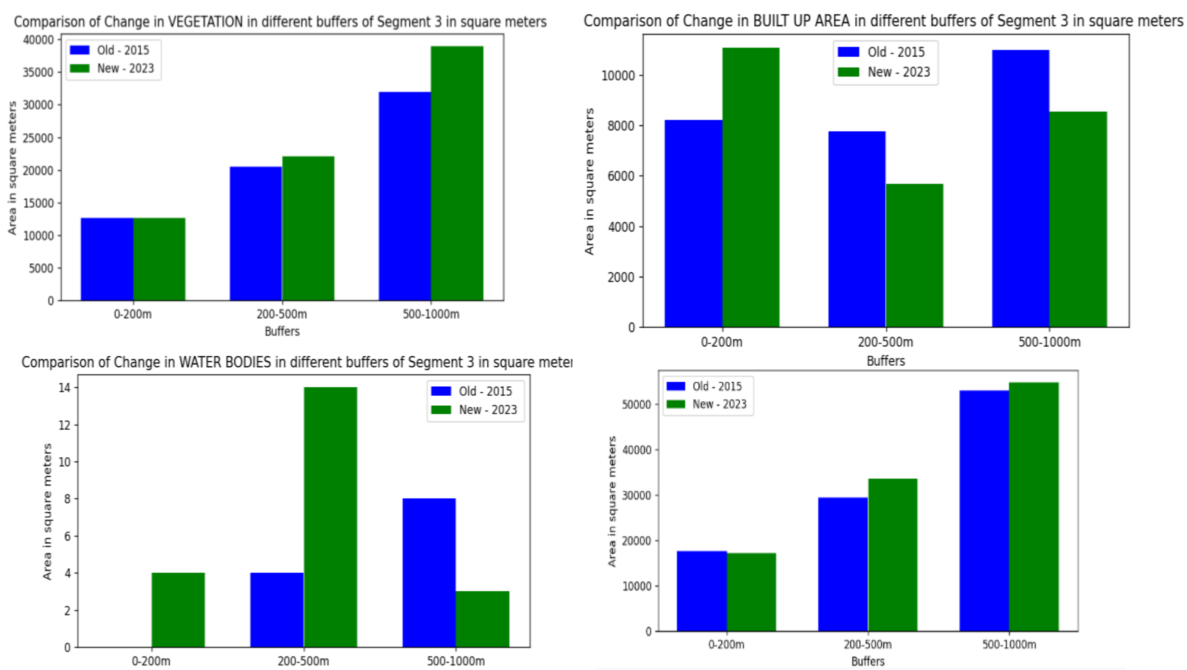


Figure 17. Analysis of LULC in Segment 3

Segment -4

- Devanahalli Bypass (Complete)
- Proposed Distance: 11 km
- Status: Land acquisition is complete but construction still underway.

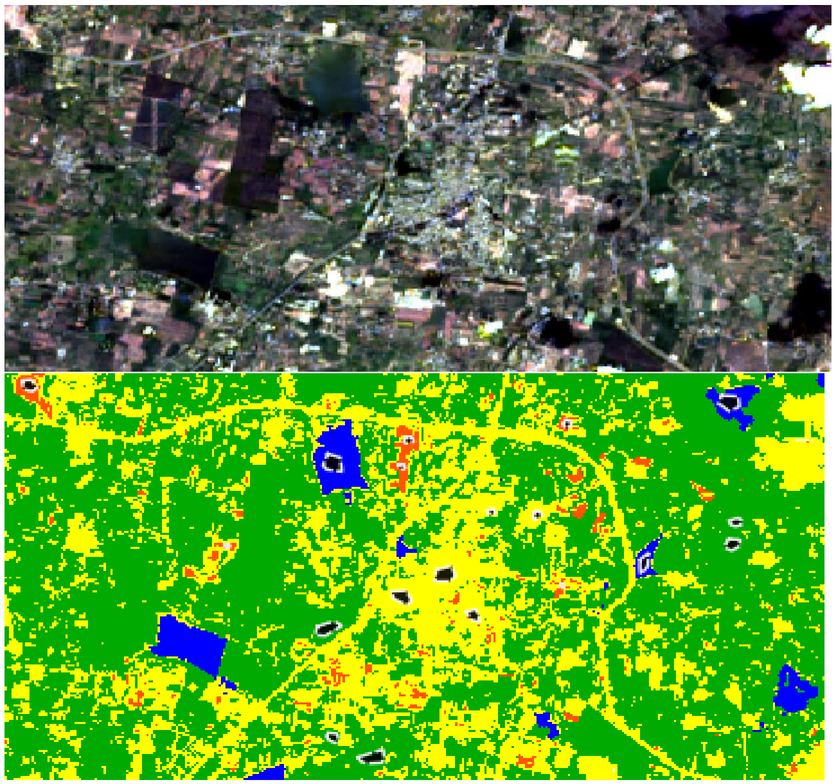


Fig 18. Segment-4 Results

We understand from the above LULC classfication the built-up is concentrated in the centre as it is the town of Devanahalli. By the vast presence of green color, we know that there is abundant vegetation in this area.

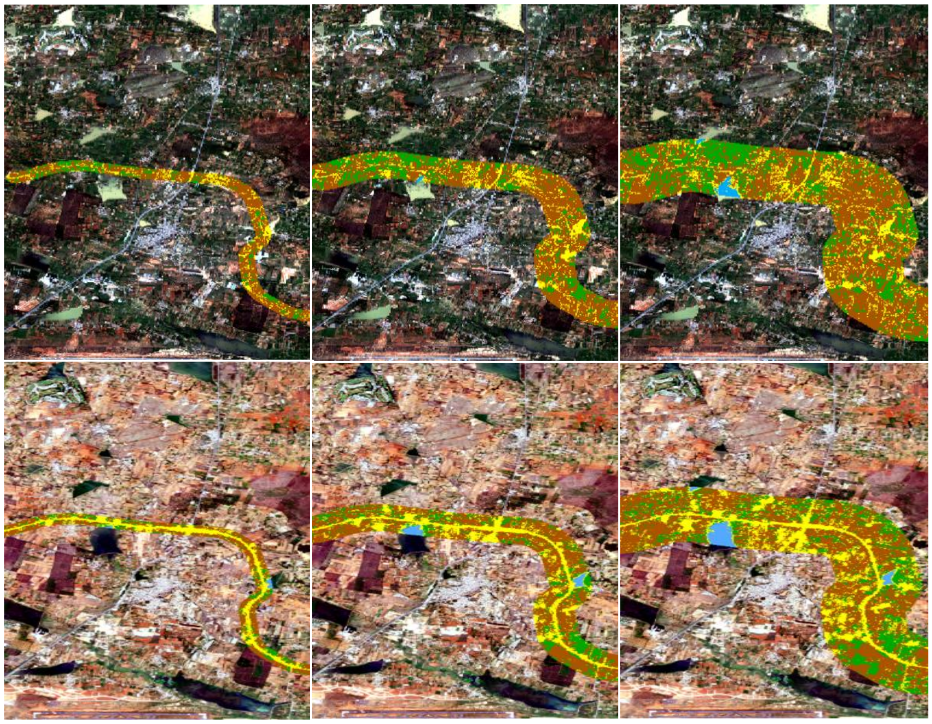


Figure 19. Segment 4 2015 v/s 2023

The images depict alterations in land use and land cover within three distinct buffer zones. The images in the upper row correspond to satellite images captured in the year 2015, while those in the lower row represent data from 2023.

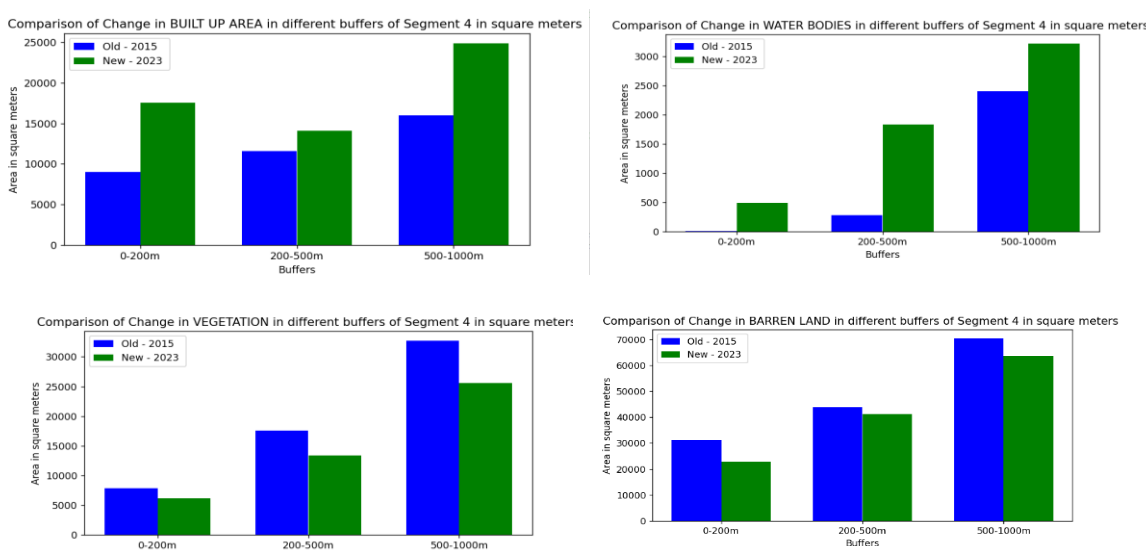


Figure 20. Analysis of LULC in Segment 4

The image is a set of four charts titled "Comparison of Change in [Land Cover Type] in different buffers of Segment 4 in square meters". Each chart compares data for two years: "Old-2007" and "New-2022". The X-axis labeled "Buffers" represents the distance from a central point in meters (0-200m, 200-500m, and 500-1000m). The Y-axis labeled "Area in square meters" shows the extent of the specific land cover type.

Top left: This chart shows the change in built-up area in Segment 4. The built-up area has increased in all three buffer zones, with the greatest increase in the closest zone (0-200 meters).

Top right: This chart shows the change in water bodies in Segment 4. Water body area appears to have decreased in all three buffer zones, with the greatest decrease in the closest zone (0-200 meters).

Bottom left: This chart shows the change in vegetation in Segment 4. There seems to be a decrease in vegetation in all three buffer zones, with the greatest decrease in the farthest zone (500-1000 meters).

Bottom right: This chart shows the change in barren land in Segment 4. The area of barren land appears to have increased in all three buffer zones, with the greatest increase in the farthest zone (500-1000 meters).

Segment -5

- Devanahalli Bypass - STRR crossing point (End)
- Distance: 25 km
- Final stretch of STRR Phase-1 Under construction

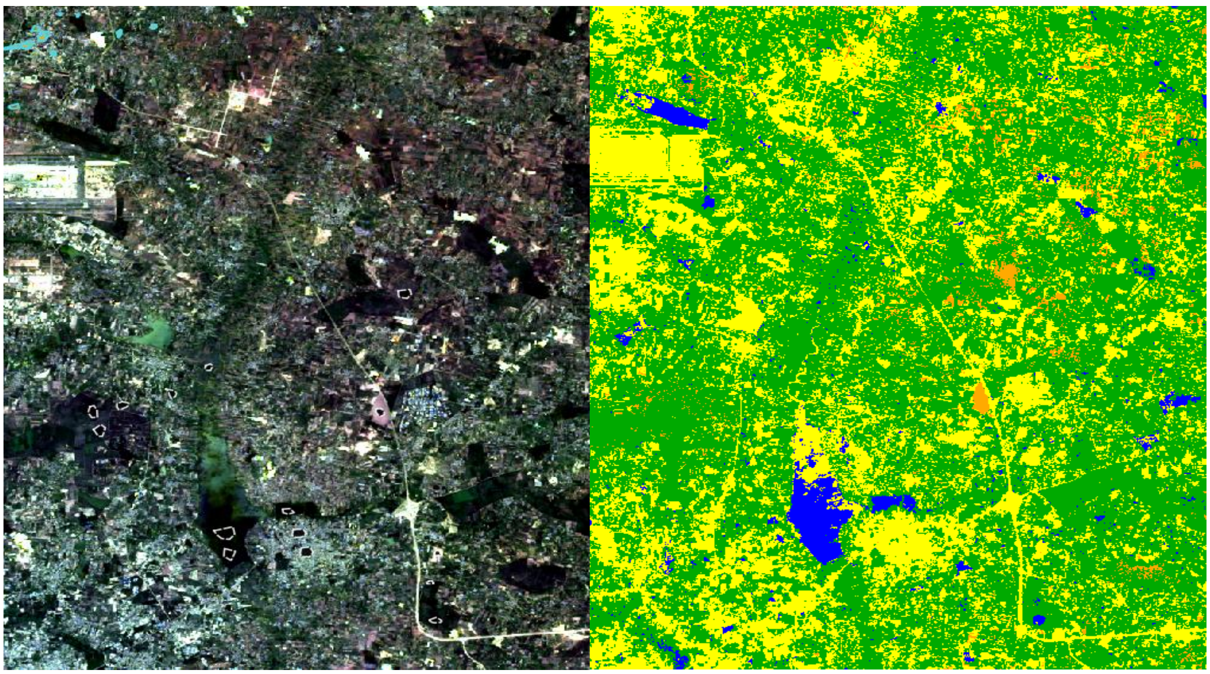


Fig 21. Segment-5 Results

We understand from the above LULC classfication that there are small patches of barren land, and it also indicates a presence of 2 huge lakes and multiple other small ponds in the area. This is also huge amount of built-up in the area due to the presence of Hoskote town and also the Bangalore International Airport.

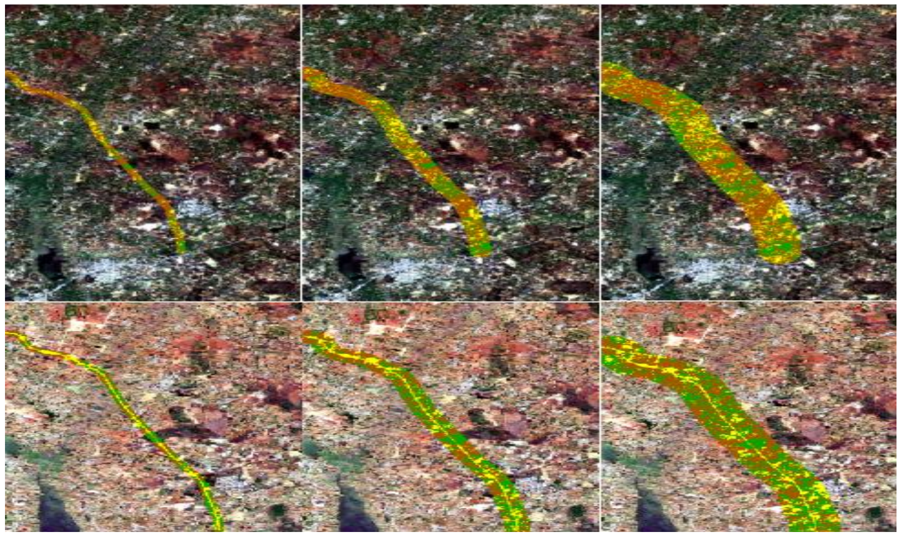


Figure 22. Segment 5 2015 v/s 2023

The images depict alterations in land use and land cover within three distinct buffer zones. The images in the upper row correspond to satellite images captured in the year 2015, while those in the lower row represent data from 2023.

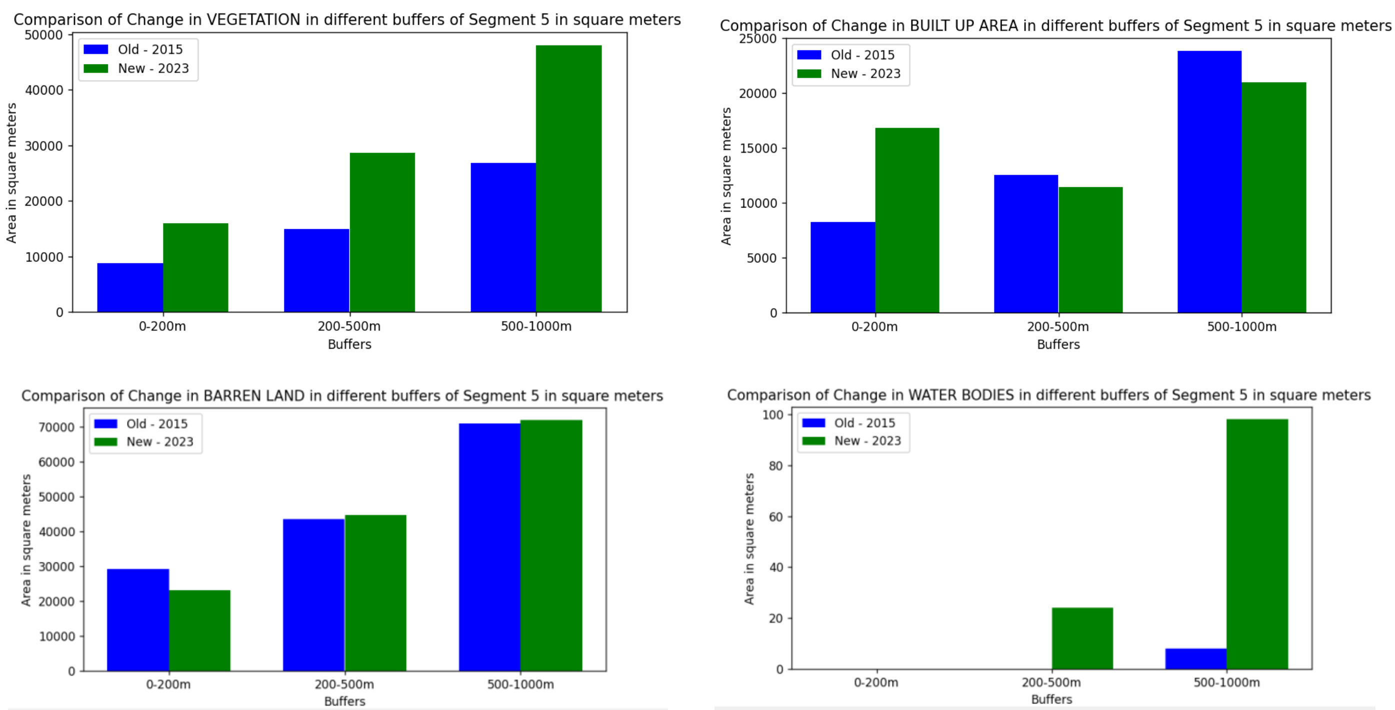


Figure 23. Analysis of LULC in Segment 5

The above image is a set of four charts titled "Comparison of Change in [Land Cover Type] in different buffers of Segment 5 in square meters". Each chart compares data for two years: "Old-2015" and "New-2023". The X-axis labeled "Buffers" represents the distance from a central point in meters (0-200m, 200-500m, and 500-1000m). The Y-axis labeled "Area in square meters" shows the extent of the specific land cover type.

- Top left: This chart shows the change in vegetation in Segment 5. There seems to be an increase in vegetation in the farthest buffer zone (500-1000 meters) and a decrease in the closer zones (0-200 meters and 200-500 meters).
- Top right: This chart shows the change in built-up area in Segment 5. The built-up area has increased in all three buffer zones, with the greatest increase in the closest zone (0-200 meters).
- Bottom left: This chart shows the change in barren land in Segment 5. The area of barren land appears to have decreased in all three buffer zones, with the greatest decrease in the farthest zone (500-1000 meters).
- Bottom right: This chart shows the change in water bodies in Segment 5. Water body area seems to have fluctuated the most, with a decrease in the closest zone (0-200 meters), an increase in the middle zone (200-500 meters) and a decrease in the farthest zone (500-1000 meters).

DEM - Digital Elevation Model

A Digital Elevation Model (DEM) is a visual representation of the bare ground (bare earth) topographic surface of the Earth excluding trees, buildings, and any other surface objects.

DEM can be used for:

- **Topographic Mapping**: DEMs are used to create detailed topographic maps that display the elevation contours of an area, helping in navigation, urban planning, and infrastructure development.
- **Terrain Analysis:** DEMs enable detailed analysis of terrain characteristics such as slope, aspect, and curvature. This information is valuable in landform classification, land cover mapping, and environmental modeling.

Digital Elevation Models (DEMs) play a crucial role in planning routes for highway construction by providing detailed information about the terrain and topography of the area. Here's how DEMs can be utilized in this process:

- **Terrain Analysis**: DEMs allow engineers and planners to analyze the terrain along potential highway routes. By examining elevation data, they can identify areas of steep slopes, rugged terrain, valleys, and ridges. This information helps in selecting the most feasible route that minimizes construction challenges and costs.
- **Slope Analysis:** DEMs provide slope information, which is essential for highway design. Steep slopes may require extensive earthwork, rock blasting, or other costly measures. By analyzing slope data from DEMs, planners can design the highway to minimize steep gradients, ensuring safer and more cost-effective construction.
- **Hydrological Considerations**: DEMs help identify drainage patterns, watershed boundaries, and watercourses along the proposed route. Understanding the hydrology of the area is critical for designing proper drainage systems, bridges, culverts, and erosion control measures. DEM-derived information assists in assessing flood risk and ensuring the highway's resilience to extreme weather events.
- **Alignment Optimization**: By integrating DEM data with other factors such as land use, environmental constraints, and socioeconomic considerations, planners can optimize the highway alignment to balance engineering requirements with environmental and social concerns. DEMs enable the evaluation of multiple alignment alternatives and the selection of the most suitable route based on various criteria.

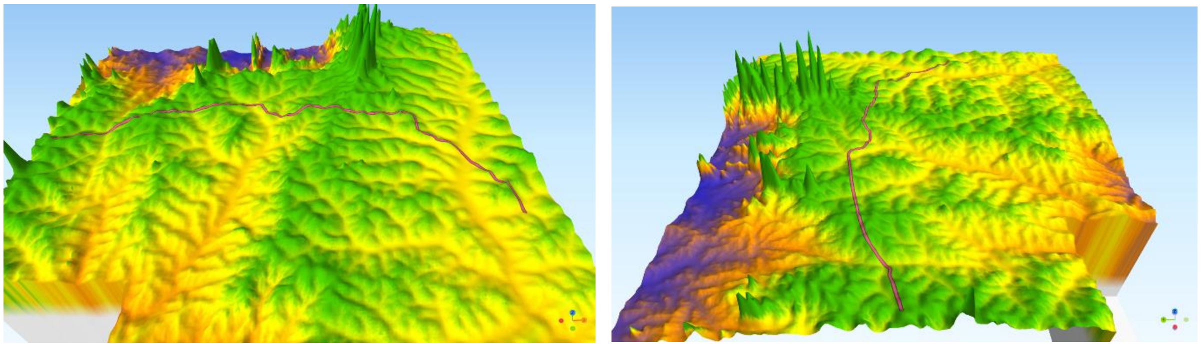


Figure 24. DEM of entire STRR Road

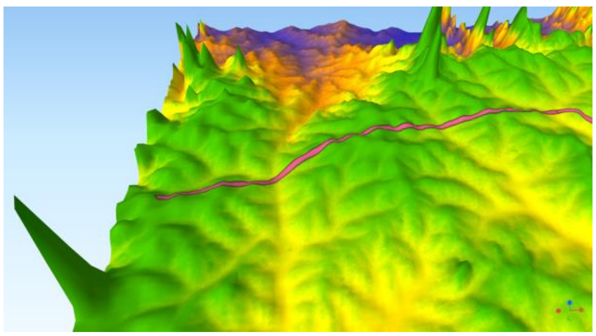


Figure 25. DEM of Segment 1

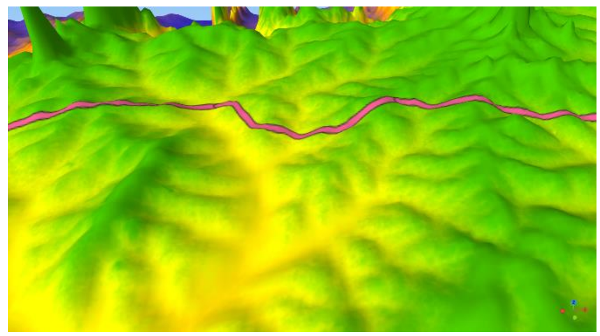


Figure 26. DEM of Segment 2

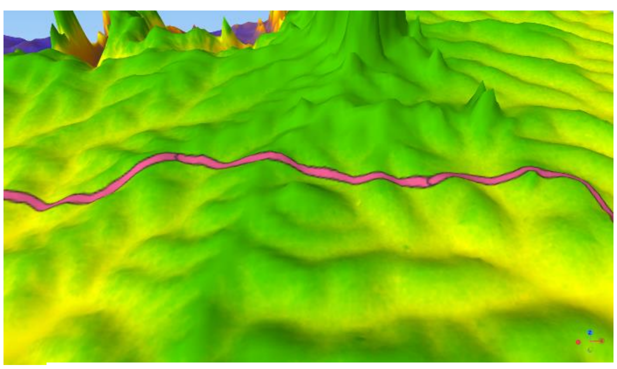


Figure 27. DEM of Segment 3

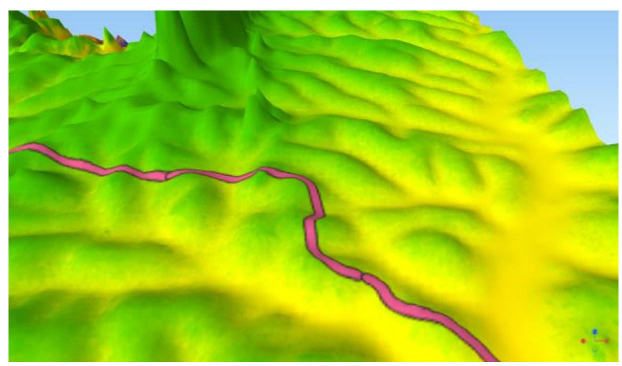


Figure 28. DEM of Segment 4

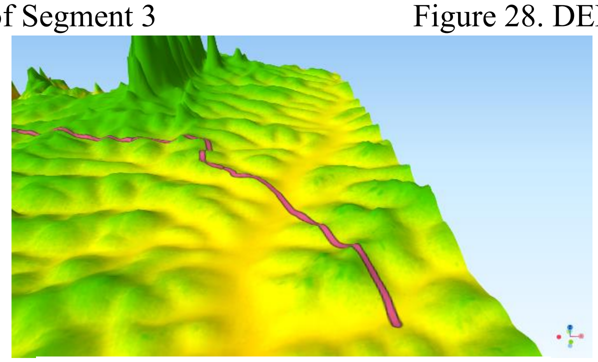


Figure 29. DEM of Segment 5

The above Digital Elevation Model (DEM) map offers a comprehensive representation of the topography encompassing the entirety of the STRR region. The map clearly shows different terrains and variations in altitude along the path of the highway. This information can play a crucial role in planning a route through the area.

Planning a route through areas with relatively similar terrain, as opposed to varying terrains, reduces the earthwork that needs to be performed for construction and also reduces the damage caused to the surrounding regions.

Below is our proposed alternate route that could have potentially reduced the damage to surrounding areas and also reduced the amount of earthwork i.e. moving or shaping large quantities of soil and rock that needed to be done.

The Line in red in the image is the actual road that has been constructed and the white line indicates an alternative route that could have been taken to avoid extra work and also lessen the damage.

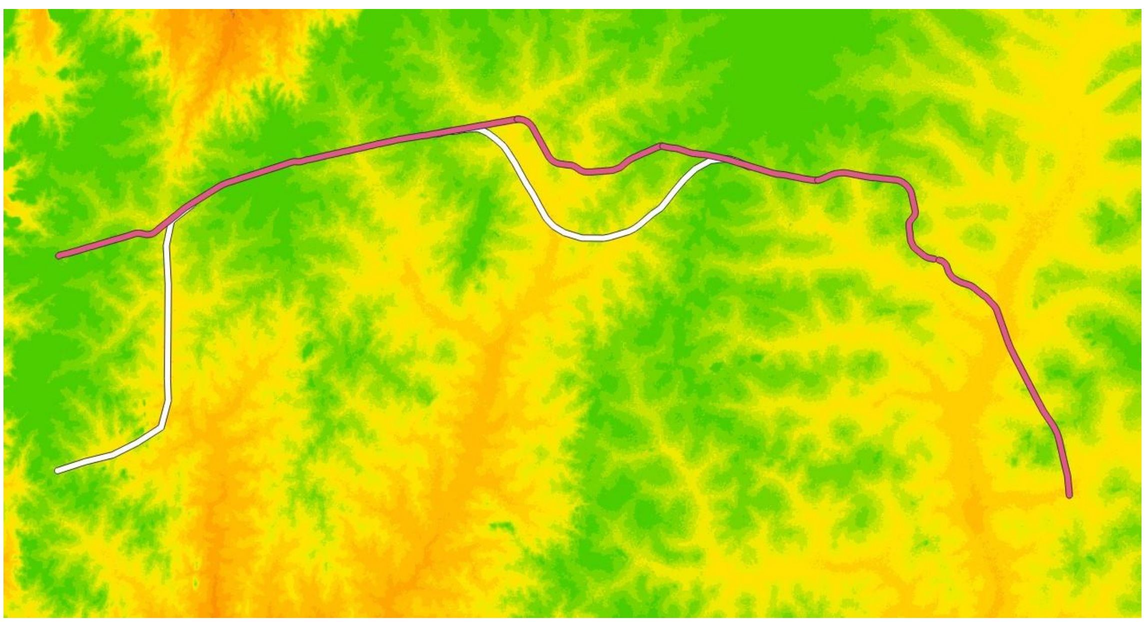


Figure 30. Proposed Alternate route.

Aspect Map: An Aspect Map is a type of thematic map commonly used in geography, geology, and environmental science to represent the orientation or direction of slopes on the Earth's surface. It provides information about the direction that each cell or pixel in a Digital Elevation Model (DEM) face.

In simple terms, an Aspect Map shows which way the slope of the terrain is facing. It divides the landscape into categories such as north-facing, south-facing, east-facing, and west-facing slopes. This information is valuable for various applications, including land use planning, agriculture, forestry, and environmental management.

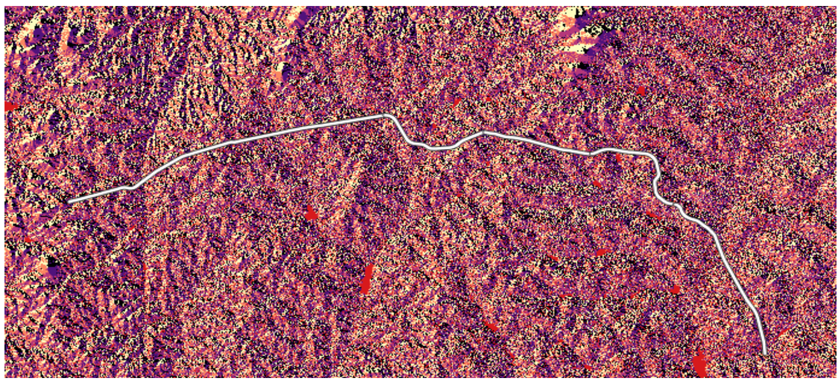


Figure 31. Aspect map

Slope map: A Slope Map is a type of thematic map that depicts the steepness or gradient of the terrain across a geographic area. It provides visual representation of how steep or gentle the slopes are in different parts of the landscape. Slope maps are typically derived from Digital Elevation Models (DEMs) or digital terrain models (DTMs), which contain elevation data for each point on the Earth's surface.

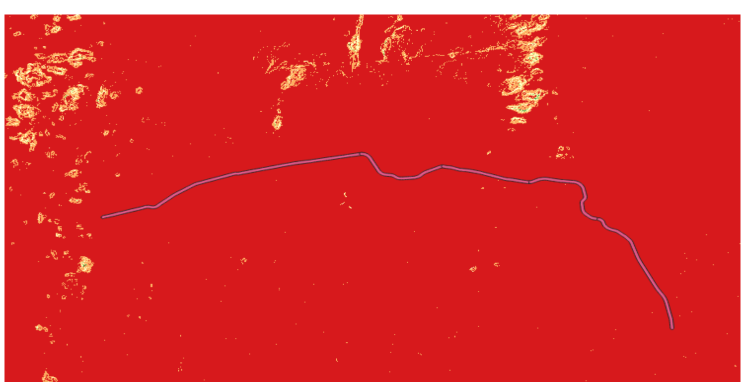


Figure 32. Slope Map

Hill shade map: A Hillshade Map is a type of thematic map that simulates the effects of terrain shading caused by sunlight on a three-dimensional landscape. It provides a visual representation of the terrain's surface by illuminating it as if it were illuminated by a light source from a specific direction.

Hillshade maps are typically created using Digital Elevation Models (DEMs), which contain elevation data for each point on the Earth's surface. By calculating the angle of incidence of sunlight and the slope of the terrain, hillshade maps simulate the shadows cast by elevated features such as hills, mountains, and valleys.

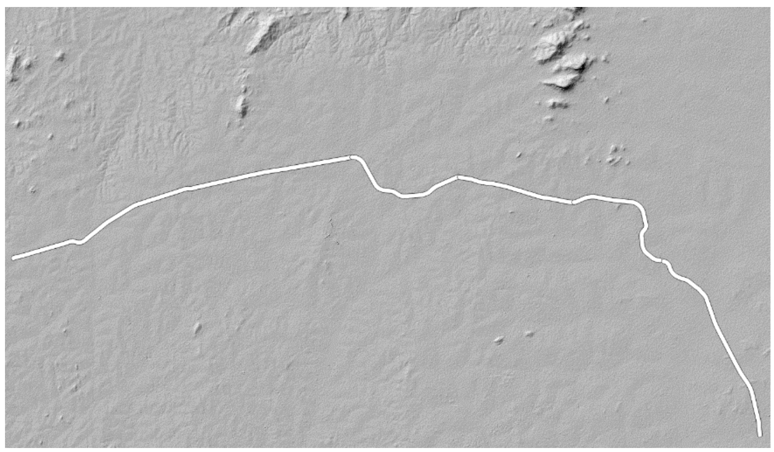


Figure 33. Hillshade map.

Comparative analysis:

SEGMENT 1=> DOBBASPET->DODDABALLAPURA BYPASS										
		0-200m			200-500m			500-1000m		
		PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS
VEGETATION	CLASS 1	39655	2.152075283	5759488.062	63322	3.048783303	9196880.672	109379	4.506844271	15886194.55
BARREN LAND	CLASS 2	38058	2.065406156	5527539.948	57110	2.74105849	8294650.44	90680	3.689443925	13170353.74
WATER BODIES	CLASS 3	777	0.042167759	112851.3989	1100	0.05263022	159763.8852	2294	0.095876306	333180.3206
BUILT UP AREA	CLASS 4	8292	0.450006512	1204329.215	10134	0.480599548	1471861.102	16723	0.676205368	2428846.775

SEGMENT 1=> DOBBASPET->DODDABALLAPURA BYPASS										
		0-200m			200-500m			500-1000m		
		PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS
VEGETATION	CLASS 1	18812	0.997984085	2652312.592	35974	1.727687557	5071990.92	69013	2.854328358	9730174.83
BARREN LAND	CLASS 2	37409	1.984562334	5274312.234	66819	3.200910303	9420841.754	104604	4.224527363	14748166.4
WATER BODIES	CLASS 3	380	0.020159151	53576.37598	1040	0.050487615	146630.0816	5901	0.259353234	831984.723
BUILT UP AREA	CLASS 4	32349	1.716127321	4560900.491	29608	1.36631049	4174445.631	42734	1.637562189	6025086.45

Table 1. Buffer wise Segment 1 before and after.

SEGMENT 2=> DODDABALLAPURA BYPASS (COMPLETE)										
		0-200m			200-500m			500-1000m		
		PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS
VEGETATION	CLASS 1	7213	2.007145918	721086.6062	26196	5.376613304	2618825.002	19001	2.945471457	1899537.863
BARREN LAND	CLASS 2	17203	4.787041623	1719791.056	42120	8.323998764	4210753.896	18784	2.282686393	1877844.283
WATER BODIES	CLASS 3	414	0.115202885	41387.75197	1280	0.259189887	127962.1317	251	0.008937769	25092.57426
BUILT UP AREA	CLASS 4	20480	5.69892533	2047394.107	43620	8.467884994	4360709.52	29728	4.32529149	2971920.509

SEGMENT 2=> DODDABALLAPURA BYPASS (COMPLETE)										
		0-200m			200-500m			500-1000m		
		PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS
VEGETATION	CLASS 1	6350	1.768900774	635126.5922	11695	2.45511608	1169733.149	21435	3.108004095	2143927.324
BARREN LAND	CLASS 2	30758	8.568165357	3076413.185	47671	9.790682957	4768050.359	78686	10.81973505	7870168.667
WATER BODIES	CLASS 3	34	0.00947128	3400.67782	28	0.005041829	2800.5582	83	0.01241554	8301.65467
BUILT UP AREA	CLASS 4	7951	2.214886623	795258.5094	10542	2.113999145	1054410.163	20503	2.91324921	2050708.743

Table 2. Buffer wise Segment 2 before and after.

SEGMENT 3=> DODDABALLAPURA BYPASS->DEVANAHALLI BYPASS										
		0-200m			200-500m			500-1000m		
		PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS
VEGETATION	CLASS 1	12645	5.011870742	1263886.468	20481	5.737704967	2047106.267	32004	5.481755021	3198847.173
BARREN LAND	CLASS 2	17565	6.961922466	1755647.75	29366	8.267454386	2935175.168	52988	9.671871961	5296229.034
WATER BODIES	CLASS 3	0	0	0	4	0.001298023	399.80592	8	0.001692549	799.61184
BUILT UP AREA	CLASS 4	8217	3.25682419	821301.313	7769	1.930723877	776523.0499	11008	1.539744144	1100265.894

SEGMENT 3=> DODDABALLAPURA BYPASS->DEVANAHALLI BYPASS										
		0-200m			200-500m			500-1000m		
		PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS
VEGETATION	CLASS 1	12642	4.702565171	1264046.113	22092	5.875716673	2208931.081	38926	6.650031905	3892126.165
BARREN LAND	CLASS 2	17167	6.385772527	1716491.031	33516	9.049796618	3351192.02	54662	9.20353908	5465534.616
WATER BODIES	CLASS 3	4	0.001487918	399.95131	14	0.003994004	1399.82958	3	-0.000570239	299.96348
BUILT UP AREA	CLASS 4	11082	4.12227711	1108065.102	5688	0.985046738	568730.7617	8557	0.81640005	855595.8382

Table 3. Buffer wise Segment 3 before and after.

SEGMENT 4=> DEVANAHALLI BYPASS (COMPLETE)										
		0-200m			200-500m			500-1000m		
		PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS
VEGETATION	CLASS 1	7869	1.68383887	787418.2565	17593	3.220915054	1760458.684	32685	4.828118099	3270652.651
BARREN LAND	CLASS 2	31214	6.679291713	3123455.77	43812	7.772992786	4384085.481	70261	9.866421154	7030727.426
WATER BODIES	CLASS 3	11	0.002353822	1100.72447	279	0.053508979	27918.37508	2401	0.394567292	240258.1311
BUILT UP AREA	CLASS 4	8985	1.92264484	899091.7568	11561	2.035138293	1156861.414	16014	2.161772496	1602454.69

SEGMENT 4=> DEVANAHALLI BYPASS (COMPLETE)										
		0-200m			200-500m			500-1000m		
		PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS
VEGETATION	CLASS 1	6135	1.369331003	613818.5242	13334	2.582890739	1334092.29	25564	3.9913812	2557727.262
BARREN LAND	CLASS 2	22845	5.099000288	2285686.094	41191	7.9003562	4121238.603	63639	9.521894719	6367204.085
WATER BODIES	CLASS 3	491	0.10959112	49125.49232	1832	0.361979639	183295.1159	3216	0.505481996	321766.9721
BUILT UP AREA	CLASS 4	17557	3.918719547	1756611.545	14129	2.513562445	1413633.566	24856	3.541452769	2486890.503

Table 4. Buffer wise Segment 4 before and after.

SEGMENT 5=> DEVANAHALLI BYPASS->HOSKOTE										
		0-200m			200-500m			500-1000m		
		PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS
VEGETATION	CLASS 1	8755	1.037325962	1389647.308	14925	1.575547294	2368987.558	26787	2.351712496	4251796.965
BARREN LAND	CLASS 2	29225	3.462690033	4638771.281	43456	4.556999203	6897602.902	70999	6.114530765	11269396.82
WATER BODIES	CLASS 3	0	0	0	0	0	0	8	0.000786983	1269.80908
BUILT UP AREA	CLASS 4	8263	0.979031916	1311554.05	12543	1.316721503	1990901.905	23813	2.093547543	3779745.441

SEGMENT 5=> DEVANAHALLI BYPASS->HOSKOTE										
		0-200m			200-500m			500-1000m		
		PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS	PIXEL SUM	PERCENTAGE %	AREA IN MS
VEGETATION	CLASS 1	15901	1.557567096	1590100	28621	2.530860932	2862100	47967	3.715951551	4796700
BARREN LAND	CLASS 2	23185	2.27106428	2318500	44776	3.969752781	4477600	71900	5.560892681	7190000
WATER BODIES	CLASS 3	0	0	0	24	0.002203905	2400	98	0.008090663	9800
BUILT UP AREA	CLASS 4	16838	1.649350026	1683800	11434	0.946850441	1143400	20960	1.558079668	2096000

Table 5. Buffer wise Segment 5 before and after.

Using the data that we collected from QGIS both segment wise and buffer wise, we performed a comprehensive pixel to pixel analysis to quantify the changes in Land Use and Land cover.

The below table (Table 6) shows the pixel-to-pixel comparison of the change in land use and land change in the area over the time period of 2015 to 2023. The column reference class depicts the classes in the year 2015 and the column Target class contains classes in the year 2023.

For example, in the first row of the table i.e., Segment-1, we can observe that 12247277m^2 of vegetation in 2015 remained as vegetation, 12052146 m^2 of vegetation has turned into barren land, has been converted to 799556 m^2 of vegetation has turned into water bodies and 5426440 m2 of vegetation has turned into Built-up area in 2023.

Similarly, the table contains the results for all 5 segments throughout the years.

		TARGET CLASS (2023)			
	REFERENCE CLASS (2015)	VEGETATION	BARREN LAND	WATER BODIES	BUILT UP AREA
SEGMENT -1	VEGETATION	12247277	12052146	799556	5426440
	BARREN LAND	4618424	16074322	124494	5763972
	WATER BODIES	110113	381520	20584	83043
	BUILT UP AREA	429597	851018	87273	3449754
SEGMENT -2	VEGETATION	1547042	797464	68579	1257627
	BARREN LAND	3328215	6258148	25692	5238649
	WATER BODIES	499	0	13995	0
	BUILT UP AREA	284715	573030	86174	2770880
SEGMENT -3	VEGETATION	2745967	3246324	699	515349
	BARREN LAND	3359968	5594984	0	1029400
	WATER BODIES	1199	0	0	0
	BUILT UP AREA	916655	918054	1399	861281
SEGMENT -4	VEGETATION	1539893	3124309	11505	938183
	BARREN LAND	2521799	8297075	90246	3096995
	WATER BODIES	400	0	261434	7203
	BUILT UP AREA	437425	1340090	190498	1609329

SEGMENT -5	VEGETATION	3195126	3739300	0	790597
	BARREN LAND	6957078	11742304	10344	3413267
	WATER BODIES	0	0	261	785
	BUILT UP AREA	1850009	2608135	5368	2212574

Table 6. Comprehensive pixel to pixel analysis.

Fig 34 shows the change in each segment either positively or negatively. The upwards arrow indicates an increase in the area of the class while a downward arrow indicates a decrease in the area of the class.

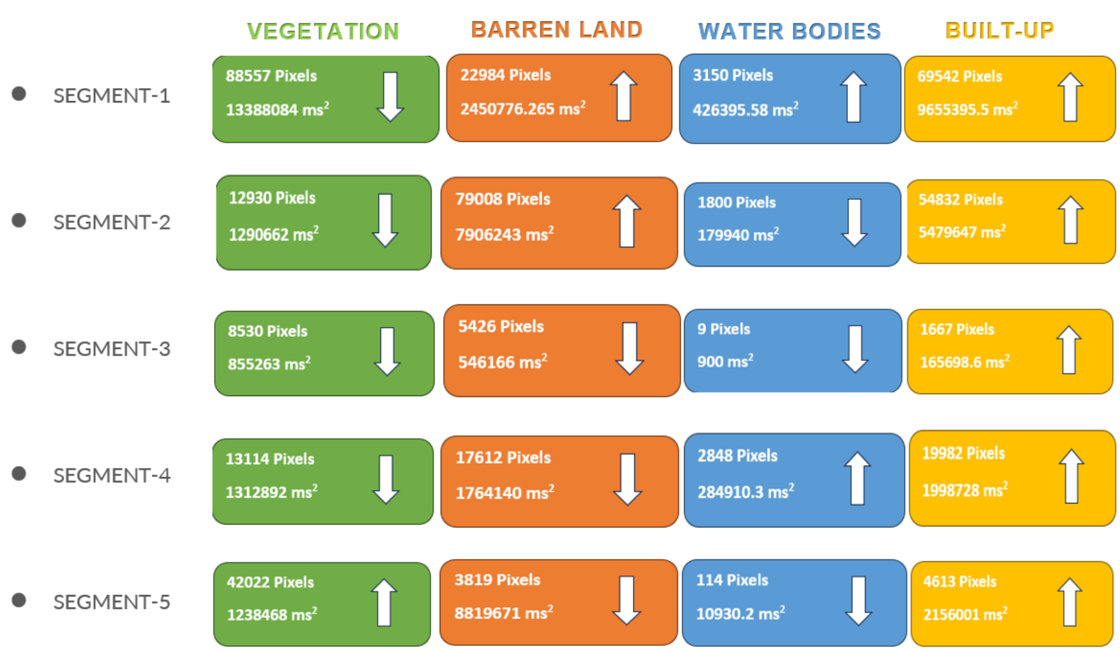


Figure 34. Pixel to Pixel comparison of LULC segment wise

SITE VISIT

Segment 1

Segment 2

Segment 3

Segment 4

Segment 5

Figure 35. Segment wise site visit pictures.

CHAPTER 8 CONCLUSION

8.1. Conclusion

Our assessment sheds light on the issues surrounding the displacement, agricultural vulnerability, land use shifts, forestry preservation, and water body alterations. It has become evident that the challenge lies not only in identifying these problems but also in crafting practical, sustainable solutions that can harmonize the project's undeniable benefits with the preservation of our environment, the well-being of our communities, and the sustainability of our agriculture.

Phase 1 of our project includes an LULC classification of the images of the area surrounding Bangalore STRR Phase - 1 of images from the year 2015 and 2023.

Phase 2 of our project includes a comparative analysis of the images of the area surrounding Bangalore STRR Phase - 1 prior and post-construction.

Phase 3 of our project includes mapping a DEM for our region of interest and plotting possible alternate routes that could have possible reduced the damage to surrounding regions and also reducing earthwork.

In summary, our study of the Bangalore Satellite Town Ring Road Phase 2 illuminates the multifaceted nature of the environmental impact associated with infrastructure development. It stresses on informed decision-making, emphasizing the need for sustainable urban planning, conservation efforts, and community engagement. As we move forward, it is our hope that this research will contribute to the creation of infrastructure that not only enhances connectivity and economic growth but also safeguards the environment for current and future generations.

CHAPTER 9 REFERENCES

[1] M.C. MANJUNATHA AND H.T. BASAVARAJAPPA, "LAND CLASSIFICATION ANALYSIS USING GEOSPATIAL APPROACH IN NANJANGUD TALUK OF KARNATAKA STATE, INDIA," IARJSET J. VOL. 8, ISSUE 6, JUNE 2021. DOI: 10.17148/IARJSET.2021.86108

[2] HADI, PRAYOGA & WASANTA, TILAKA & SANTOSA, WIMPY. (2021). LAND USE CHANGE DUE TO ROAD CONSTRUCTION. IOP CONFERENCE SERIES: EARTH AND ENVIRONMENTAL SCIENCE. 920. 012003. 10.1088/1755-1315/920/1/012003.

[3] AKYÜREK, D. & KOÇ, Ö & AKBABA, E. & SUNAR, FILIZ. (2018). LAND USE/LAND COVER CHANGE DETECTION USING MULTI–TEMPORAL SATELLITE DATASET: A CASE STUDY IN ISTANBUL NEW AIRPORT. ISPRS - INTERNATIONAL ARCHIVES OF THE PHOTOGRAMMETRY, REMOTE SENSING AND SPATIAL INFORMATION SCIENCES. XLII-3/W4.17-22. 10.5194/ISPRS-ARCHIVES-XLII-3-W4-17-2018.

[4] S. FENG ET AL., "QUANTIFICATION OF THE ENVIRONMENTAL IMPACTS OF HIGHWAY CONSTRUCTION USING REMOTE SENSING APPROACH," REMOTE SENSING, VOL. 13, NO. 7, P. 1340, APR. 2021, DOI: 10.3390/RS13071340.

[5] ROY, PARTH & ROY, ARIJIT. (2010). LAND USE AND LAND COVER CHANGE: A REMOTE SENSING & GIS PERSPECTIVE. JOURNAL OF THE INDIAN INSTITUTE OF SCIENCE. 90. 489-502.

[6] ROSAS-CHAVOYA M, GALLARDO-SALAZAR JL, LÓPEZ-SERRANO PM, ALCÁNTARA-CONCEPCIÓN PC, LEÓN-MIRANDA AK. QGIS A CONSTANTLY GROWING FREE AND OPEN-SOURCE GEOSPATIAL SOFTWARE CONTRIBUTING TO SCIENTIFIC DEVELOPMENT. CIG [INTERNET]. 2022 MAY 17 [CITED 2023 DEC. 7];48(1):197-213. AVAILABLE FROM: HTTPS://PUBLICACIONES.UNIRIOJA.ES/OJS/INDEX.PHP/CIG/ARTICLE/VIEW/5143

[7] PANCHOLI, VISHVAM & LODHA, PRADEEP & PRAKASH, INDRA. (2016). OPEN-SOURCE HYDROLOGICAL MODELING FOR VISHWAMITRI RIVER WATERSHED, WESTERN INDIA. IMPERIAL JOURNAL OF INTERDISCIPLINARY RESEARCH (IJIR). 2. 901-907.

[8] SPATIAL ASSESSMENT OF SOIL EROSION RISK USING RUSLE EMBEDDED IN GIS ENVIRONMENT: A CASE STUDY OF JHELUM RIVER WATERSHED *APPL. SCI.* 2023, *13*(6), 3775; HTTPS://DOI.ORG/10.3390/APP13063775

[9] LEFEBVRE, ANTOINE & SANNIER, CHRISTOPHE & CORPETTI, THOMAS. (2016). MONITORING URBAN AREAS WITH SENTINEL-2A DATA: APPLICATION TO THE UPDATE OF THE COPERNICUS HIGH RESOLUTION LAYER IMPERVIOUSNESS DEGREE. REMOTE SENSING. 8. 606. 10.3390/RS8070606.

[10] BLAKE, DENISE & AUGÉ, AMÉLIE & SHERREN, KATE. (2017). PARTICIPATORY MAPPING TO ELICIT CULTURAL COASTAL VALUES FOR MARINE SPATIAL PLANNING IN A REMOTE ARCHIPELAGO. OCEAN & COASTAL MANAGEMENT. 148. 195-203. 10.1016/J.OCECOAMAN.2017.08.010.

Sample Code

Inputs:

- Count rate reading $c_{i,t}$ of each detector, where $1 \leq i \leq M$ and $1 \leq t \leq T_W$
- Location (x_i, y_i) of each detector, where $1 \leq i \leq M$.
- Background radiation BG in counts per second (cps)
- Number of points (grids): N_X, N_Y, and N_I
- Parameter range: $[X_{\min}, X_{\max}]$, $[Y_{\min}, Y_{\max}]$, and $[I_{\min}, I_{\max}]$

Procedure: Searching for X_{ML}, Y_{ML}, and I_{ML} that maximizes the likelihood L

1. Initialize the likelihood $L_{\max}$ by an arbitrary low value (i.e., $L_{\max} = 0$)
2. For $m = 1 : N_X$
3.   For n = $1 : N_Y$
4.   For $p = 1 : N_I$
5. $X_m = X_{\min} + (m - 0.5)\frac{(X_{\max} - X_{\min})}{N_X}$
6. $Y_n = Y_{\min} + (n - 0.5)\frac{(Y_{\max} - Y_{\min})}{N_Y}$
7. $I_p = I_{\min} + (p - 0.5)\frac{(I_{\max} - I_{\min})}{N_I}$
8.   Initialize λ = [ ]
9.   For $i = 1{:}M$
10. $\lambda_i = \delta \cdot \frac{I_k}{(x_i - X_m)^2 + (y_i - Y_n)^2} + BG$
11.   Append the value of λ_i to the list λ
12.   end For
13. $L = \sum_{i=1}^{M} \sum_{t=1}^{T_W} \left(c_{i,t} \ln \lambda_i - \lambda_i\right)$ // Calculate the likelihood L
14.   if $L > L_{\max}$
15. $L_{\max} = L$
16. $X_{ML} = X_m$
17. $Y_{ML} = Y_n$
18. $I_{ML} = I_p$
19.   end if
20.   end For
21.   end For
22. end For

Output: Maximum likelihood estimates X_{ML}, Y_{ML}, and I_{ML}.

Figure 36. Pseudocode of Maximum Likelihood Estimation

Inputs:

Count rate readings (c_ {i, l}) of each detector, where i represents the detector number (1 to M) and l denotes the time interval (1 to T_W).

Location coordinates ((x_i, y_i)) of each detector.

Background radiation level (BG) in counts per second (cps).

Number of grid points across each dimension (X_N, Y_N, and N_I).

Parameter ranges: defined as intervals for X-dimension ([X_min, X_max]), Y-dimension ([Y_min, Y_max]), and intensity ([I_min, I_max]).

Procedure:

Initialization: Sets the maximum likelihood (L_max) to a low value (e.g., 0).

The algorithm iterates through each grid point defined by the number of points (N_X, N_Y, and N_I)

For each grid point, it calculates the corresponding X, Y, and intensity values.

An empty list (lambda) is initialized to store the calculated likelihoods for each detector at that grid point.

The algorithm loops through all detectors (i) and calculates the likelihood (lambda_i) based on the distance between the detector and the grid point, along with the background radiation. The likelihood is then appended to the list (lambda).

The overall likelihood (L) for the current grid point is calculated by summing the likelihoods (lambda_i) of all detectors.

If the current likelihood (L) is greater than the maximum likelihood (L_max) encountered so far:

Update L_max with the current L.

Store the current X, Y, and intensity values as the Maximum Likelihood estimates (X_ML, Y_ML, and I_ML).

The loop iterates through all grid points defined by the parameters.

Output:

The algorithm outputs the estimated maximum likelihood location (X_ML, Y_ML) and intensity (I_ML) of the source.

In essence, this algorithm efficiently searches a predefined grid of possible locations and intensities for a source that best explains the observed count rate readings from a network of detectors, considering background radiation. The location and intensity that maximize the likelihood function are considered the most probable source location and intensity.

```
import pandas as pd
import matplotlib.pyplot as plt

# Specify the path to your Excel file
path = "C:/Users/usmri/OneDrive/Desktop/graph_test.xlsx"

# Read the data from Sheet6 in the Excel file
data_sheet6 = pd.read_excel(path, sheet_name='OSeg2', header=1)

# Filter the data for the vegetation class in Sheet6
vegetation_data_sheet6 = data_sheet6[data_sheet6['Unnamed: 0'] == 'VEGETATION']

# Extract the 'AREA IN MS' values for each segment from Sheet6
segment_0_200m_sheet6 = vegetation_data_sheet6.iloc[0, 2]
segment_200_500m_sheet6 = vegetation_data_sheet6.iloc[0, 5]
segment_500_1000m_sheet6 = vegetation_data_sheet6.iloc[0, 8]

# Read the data from Sheet1 in the Excel file, skipping the first row which contains headers
data_sheet1 = pd.read_excel(path, sheet_name='NSeg2', header=1)

# Filter the data for the vegetation class in Sheet1
vegetation_data_sheet1 = data_sheet1[data_sheet1['Unnamed: 0'] == 'VEGETATION']

# Extract the 'AREA IN MS' values for each segment from Sheet1
segment_0_200m_sheet1 = vegetation_data_sheet1.iloc[0, 2]
segment_200_500m_sheet1 = vegetation_data_sheet1.iloc[0, 5]
segment_500_1000m_sheet1 = vegetation_data_sheet1.iloc[0, 8]

# Create a bar graph comparing values from Sheet1 and Sheet6
segments = ['0-200m', '200-500m', '500-1000m']
area_in_ms_values_sheet1 = [segment_0_200m_sheet1, segment_200_500m_sheet1, segment_500_1000m_sheet1]
area_in_ms_values_sheet6 = [segment_0_200m_sheet6, segment_200_500m_sheet6, segment_500_1000m_sheet6]

plt.figure(figsize=(8, 4))

plt.bar(index, area_in_ms_values_sheet6, bar_width, label='Old - 2015', color='blue')
plt.bar([i + bar_width for i in index], area_in_ms_values_sheet1, bar_width, label='New - 2023 ', color='green')

plt.xlabel('Buffers')
plt.ylabel('Area in square meters')
plt.title('Comparison of Change in VEGETATION in different buffers of Segment 2 in square meters ')
plt.xticks([i + bar_width/2 for i in index], segments)
plt.legend()

plt.show()
```

Figure 37. Code Snippet of Analysis graph generated.

The Python code reads data from an Excel file and creates a bar graph to compare vegetation area between two sheets.

1. Import libraries: Pandas for data manipulation and matplotlib for plotting.
2. Read data: Reads data from specific sheets ('OSeg2' and 'NSeg2') in the Excel file, focusing on rows with "VEGETATION" class.
3. Extract values: Extracts specific area values for different segments (0-200m, etc.) from both sheets.
4. Prepare data: Creates lists of segment names and area values for each sheet.
5. Create bar graph: Defines bar width and positions for data from both sheets.
6. Plot bars: Creates separate bars for each sheet data with labels and colors (blue for old, green for new).
7. Set labels & title: Defines labels for x-axis (buffers), y-axis (area), and a descriptive title for the graph.
8. Display graph: Shows the final bar graph comparing vegetation area between the two sheets.

A similar code extracts data of Barren Lands, Water Bodies and Built-Up area from the generated reports.

Project Proposal – KSCST

ಕರ್ನಾಟಕ ಸರ್ಕಾರ

KARNATAKA STATE COUNCIL FOR SCIENCE AND TECHNOLOGY

Indian Institute of Science campus, Bengaluru

Telephone: 080 -23600978, 23341652 || Email: spp@kscst.org.in
Website: www.kscst.org.in/spp.html or https://kscst.karnataka.gov.in/en

FORMAT FOR STUDENT PROJECT PROPOSAL FOR THE
47th SERIES OF STUDENT PROJECT PROGRAMME

(Handwritten proposals will not be accepted, please fill all the details in this MS word file, insert images / diagrams wherever necessary. Convert to pdf file, get it approved from the project guide / head of the department and principal of your institution. Keep ready the scanned pdf file of 1) Declaration and Endorsement 2) details of processing fees made and fill-up the Google Form.

https://forms.gle/mE8Q4pM2nwZQuHbi9

1.	**Name of the College: Dayananda Sagar University**
2.	**Project Title: Environmental Impact Analysis using Satellite Image Processing: A Case Study on Bangalore STRR Phase-1**
3.	**Branch: Computer Science and Engineering**
4.	**Theme (as per KSCST poster):** **(The project proposals shall mandatorily be from one of the broad themes / areas. Visit website www.kscst.org.in/spp.html)** **Pattern Recognition and Image Processing**
5.	**Name(s) of project guide(s):** 1. **Name: Dr. Rajesh TM** **Email id: rajesh-cse@dsu.edu.in** **Contact No.: 9591664668**
6.	**Name of Team Members (Strictly not more than four students in a batch):** *(Type names in Capital Letters as provided in your college)* (Please paste the latest passport size photograph adjacen respective names)  **Name: Varun P Shrivathsa** **USN No.: ENG20CS0402** **Email id: varunpshrivathsa@gmail.com** **Mobile No: 9535327087**  **Name: Smriti Reddy U** **USN No.: ENG20CS0388** **Email id: u.smritireddy@gmail.com** **Mobile No.: 7676850449**

KSCST: Student Project Programme: 47th series: 2023-2024 1

	Name: Girish Singh B S **USN No.: ENG21CS3001** **Email id: girishsingh209@gmail.com** **Mobile No.: 9741064475**
7.	**Team Leader of the Project:** **Name: Varun P Shrivathsa** **USN No.: ENG20CS0402** **Email id: varunpshrivathsa@gmail.com** **Mobile No.: 9535327087**
8.	**Processing Fee Details (Through Online Payment only):** (processing fee of Rs. 1000/-) **Please furnish the payment details in the format provided in the last page of the proposal.**
9.	**Date of commencement of the Project:** 12/12/2023
10.	**Probable date of completion of the project:** 12/06/2024
11.	**Scope / Objectives of the project:** The primary purpose of this project is to understand and study the changes happening to the land around the Satellite Town Ring Road (STRR) Phase-1 due to the construction of the highway. The target is to understand how the environment has been affected before and after the highway construction. The main goal is to figure out the impact of this construction on nature and to, in the future, find ways to build infrastructure in a sustainable manner.
12.	**Methodology:** 1) Data Collection: The initial phase involves gathering satellite imagery from diverse sources, including USGS Landsat, ISRO Resourcesat, and Copernicus Sentinel 12 satellites. This multipronged approach ensures a comprehensive dataset with resolutions ranging from 30m to 100m, capturing intricate details of the study area. The use of Landsat images, with their 11 spectral bands, enhances the richness of the acquired data. 2) Preprocessing: To prepare the raw satellite data for analysis, preprocessing steps are implemented. This includes conversion to a suitable format, calibration to correct brightness and color, correction to rectify geometric distortions, atmospheric correction to compensate for atmospheric effects, enhancement for improved visual interpretation, subset and resample to focus on regions of interest, normalization to standardize pixel values, and registration to align images to a common coordinate system. 3) Segmentation - 5 Segments: The study area, Bangalore Satellite Town Ring Road (STRR) Phase-1, is logically segmented into five distinct sections based on key intersections. This segmentation strategy allows for a more localized and detailed analysis of the highway's impact on different

KSCST: Student Project Programme: 47th series: 2023-2024 2

DAYANANDA SAGAR UNIVERSITY

SCHOOL OF ENGINEERING

(A State Private University under the Karnataka Act No.20 of 2013)

Approved by UGC & AICTE, New Delhi.

ENDORSEMENT

This is to certify that 1) Mr. Varun P Shrivathsa, 2) Ms. Smriti Reddy U, 3) Mr. Girish Singh BS, are bonafide students of the Department of Computer Science , in the degree program of our institution. If the project proposal submitted by these students under the 47th series of Student Project Programme is selected by KSCST, we will provide the requisite laboratory / Computer / infrastructure support in our college / Institution. Further we also take necessary steps to see that the project team will exhibit / demonstrate their project in the nodal centre and in the State Level Seminar and Exhibition (if selected). If the student team fails to send the completed project report or fails to attend the evaluation in nodal centre or fails to attend the State Level Seminar and Exhibition, the supported project amount will be returned to KSCST.

10/2/24

(Name & Signature of Project Guide with Seal)

Email id: rajesh-cse@dsu.edu.in

Contact No.: 9591664668

10/2/24

(Signature of HOD with Seal)

Email id: chairman-cse@dsuedu.in

Contact No.: 9880336008

Chairman / HOD
Computer Science Engg. Dept
Dayananda Sagar University
School of Engineering
Kudlu Gate, Hosur Main Road,
BANGALORE - 560 068

(Signature of the Principal with Seal)

DEAN - SCHOOL OF ENGINEERING
DAYANANDA SAGAR UNIVERSITY,
KUDLU GATE, HOSUR MAIN ROAD

Email id:dean-engg@dsu.edu.in

Contact No.:9980144184

Dayananda Sagar University, SOE, DSU
Bengaluru 560 114

APPROVED FOR SPONSORSHIP BY KSCST:

KARNATAKA STATE COUNCIL FOR SCIENCE AND TECHNOLOGY

Indian Institute of Science Campus, Bengaluru – 560 012

Website: www.kscst.org.in, https://kscst.karnataka.gov.in || Email: spp@kscst.org.in || Tel: 080-2334 1652,2334 8848/49/40

47th series of Student Project Programme (SPP): 2023-24

List of Student Project Proposals Approved for Sponsorship

402.	47S_BE_1252	ENVIRONMENTAL IMPACT ANALYSIS USING SATELLITE IMAGE PROCESSING: A CASE STUDY ON BANGALORE STRR PHASE-1	B.E.	COMPUTER SCIENCE AND ENGINEERING	Dr. RAJESH T. M.	Mr. VARUN P. SHRIVATHSA Ms. SMRITI REDDY U. Mr. GIRISH SINGH B. S.	3,500.00

Github Repository link:

https://github.com/Team-87-DSU/DSU-CSE-Major