Analyzing change in land-use/land-cover of Wayanad and Nilgiri

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Certificate of Originality

The work embodied in this report entitled **"Analyzing the change in land-use/land-cover of Wayanad and Nilgiri"** has been carried out by **Abhishek Bharadwaj**, **Arpita Kesharwani**, **Deepanshu Mishra**, **Kritika Verma** and **Siddhartha Mahajan** for the paper **"An Introduction to GIS and GPS"**. We declare that the work and language included in this project report is free from any kind of plagiarism.

(Name and Signature)

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This report analyzes change in the distribution of the geographical area in the district of Wayanad and Nilgiri from the year 2015 to 2022 using ArcGIS by ESRI

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1 Introduction

1.1 Background and Context

The districts of Wayanad and Nilgiri have recently went through efforts to increase the protected area contained in them. Unable to go to the sites to check if these efforts worked or not, we turned to remote sensing.

Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation. We can use this remote sensing to analyse the change in land use and land cover of an area, over some time.

This will enable us to determine if the distribution of the geographical area is changing over the years,or not. We used remote sensing to study about the Wayanad district (11°44 N–11°97 N and 75°77 E–76°43 E) and Nilgiris district (11°30' N–11°15' N and 76°45' E–77°00' E).

1.2 Scope and Objectives

- Learn about remote sensing and its applications.
- Learn about different techniques and algorithms to analyze images and map data.
- Use ArcGIS to study the chosen area.
- Use supervised classification to classify an area as barren, green, waterbody or built up.
- Learn about manipulating the data from the satellite for the best results.

- Compare the data we get, to data already known in the literature.
- Figure out the change in land use and land cover and analyze the results.
- To enhance our skills in LaTeX.
- Learn how to collaborate better on group projects.

1.3 Achievements

- We were able to use images from Landsat-8 to get the ones we want by using Earth Explorer.
- We worked with algorithms and techniques to get the images ready for data classification.
- We learned to work with and about different bands and spectrum of light that the satellite data contains and which bands can be used for what.
- We recorded quite accurately the land use and land cover distribution in Wayanad and Nilgiri.
- We have enhanced our skills in LaTeX.
- We learnt how to collaborate better on group projects.
- We learnt a lot about GIS and GPS.

1.4 Literature Review

From a study of LULC of Wayanad from 2004-2018 we know that the built up area went way up, from 32 sq km in 2004 to 128 sq km in 2018 [1]. In an area so ecologically sensitive as Wayanad, this can be a problem.

From another study of LULC of Nilgiris from 1973-2004 we know that the built up area first increase from

1973-1991 but then decreased from 1991-2004. At the same time, the forest areas grew considerably while the plantation and barren areas went down [2].

2 Formulation of the Problem

2.1 Problem Statement

We worked on the following problem statements:

- Wayanad and Nilgiri have recently underwent efforts to increase the protected areas in them. Find out how the vegetation area changed over the years.
- Going to the sites and land surveying would take time and resources that we don't have. Find a remote way to accurately get the data.

2.2 Methodology

The following are the steps we took to get the land use and land cover of Wayanad and Nilgiri using ArcGIS [3] and a few other resources:

Data Collection

- First from the shape-file of all the districts of India, from DIVA-GIS, we clipped our focus-area, the districts of Wayanad and Nilgiri.
- Then from Earth Explorer, we found land-sat images of 2015 of our focus areas and chose the ones with the least cloud cover.

Image Pre-processing

- ArcGIS does geometric correction for us, matching the matrix of the images to the one of the district shape files, near perfectly.
- Then we used **composite bands** to combine the 7 bands found in Landsat 8 data.
- Then we used **histogram equalize** to increase the contrast of the images.
- We used **extract by mask** to correctly trim the images to our exact district area.
- Then we **mosaic** the images we had to use due to a larger study area. (2 in our case)

Image Enhancement

- As we had low resolution data, edge correction and sharpening was not needed.
- Then we took a **false color composite** of our images, changing the bands 2,3 and 4 to 5,4 and 3 for better differentiation between different land cover classes. The images of the raster pre-fcc and post-fcc can be seen in the Appendix 5

Data Training and Classification

- Then we pixel trained by choosing around a 100 pixels each of areas with water, barren land, built-up areas and areas with vegetation and used the Maximum Likelihood Classifier (explained below) which comes under supervised classification on this data.

- Then we added the shape-files for roads and railways to match the built-up area prediction well.
- We then found out the area of each class by using the no. of pixels it thinks are each class and multiplying them by the geographical size a pixel represents in this case (900 sq m).

  Analysis of change over time
  We repeated the experiment for year 2017, 2019 and 2022 and compared the results.

False Color Composite (FCC)

- A false color image is one in which the R,G, and B values do not correspond to the true colors of red, green and blue.
- In our False Colour Composites, blue is assigned to green radiations (0.5 to 0.6 µm), green is assigned to red radiations (0.6 to 0.7 µm) and red is assigned to Near Infrared radiation (0.7 to 0.8 µm) or band 2,3 and 4 (B-G-R) to band 5,4 and 3 (NIR-R-G).
- This false colour composite scheme allows vegetation to be detected readily in the image. vegetation appears in different shades of red depending on the types and conditions of the vegetation, since it has a high reflective-ness in the NIR band.

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Maximum Likelihood Classifier
The main idea of Maximum Likelihood Classification is to predict the class label y that maximizes the likelihood of our observed data x. We will consider x as

being a random vector and y as being a parameter (not random) on which the distribution of x depends. At first, we need to make an assumption about the distribution of x (usually a Gaussian distribution). Then, the learning of our data consists of the following:

- We split our data set into subsets corresponding to each label y.
- For each subset, we estimate the parameters of our assumed distribution for x using only the data inside that subset.

When making a prediction on a new data vector x:

- We evaluate the probability density function (PDF) of our assumed distribution using our estimated parameters for each label y.
- Return the label y for which the evaluated PDF had the maximum value.

For mathematical reasons, a multivariate normal distribution is applied as the probability density function. In the case of normal distributions, the likelihood can be expressed as follows.

$$f(x) = \frac{1}{\sqrt{(2\pi)^d \det \Sigma}} \cdot e^{-\frac{1}{2}(x-\mu)^T \Sigma^{-1}(x-\mu)}$$

where:

x = a column vector with data from one observation
d = dimension of x (x is a $d \times 1$ vector)
μ = mean of x (also $d \times 1$)
Σ = covariance matrix of x ($d \times d$)

3 Results and Discussion

3.1 Results

We got the following results:

- We got the raster of Wayanad and Nilgiri for 2015 after the data classification, as shown in Figure 1.

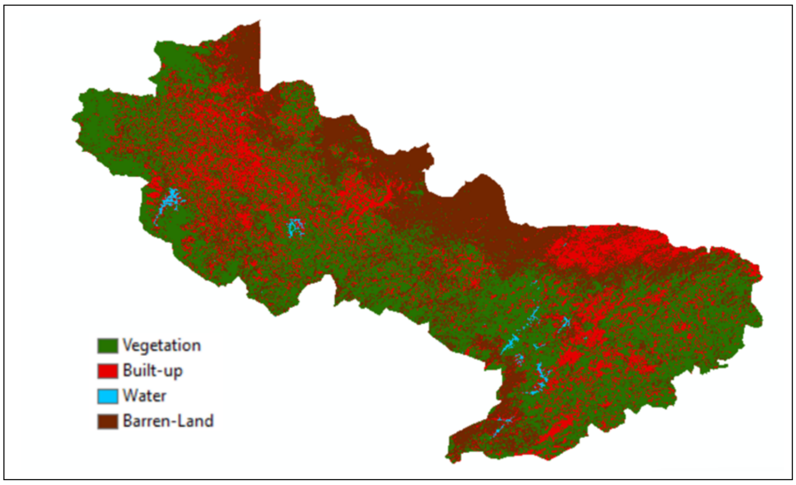

Figure 1: Map of Wayanad and Nilgiri with LULC classification (2015)

- The maximum likelihood classifier of this raster data for the year 2015 gave us the results as shown in Table 1.

LULC of Wayanad and Nilgiri for 2015		
Class	Count (in pixels)	Area (in sq. km)
Vegetation	2478320	2230
Built-up	1089120	980
Water	30029	27
Barren land	1588280	1429

Table 1: Predicted land use and land cover data of Wayanad and Nilgiri for 2015.

- We got the raster of Wayanad and Nilgiri for 2022 after the data classification, as shown in Figure 2.

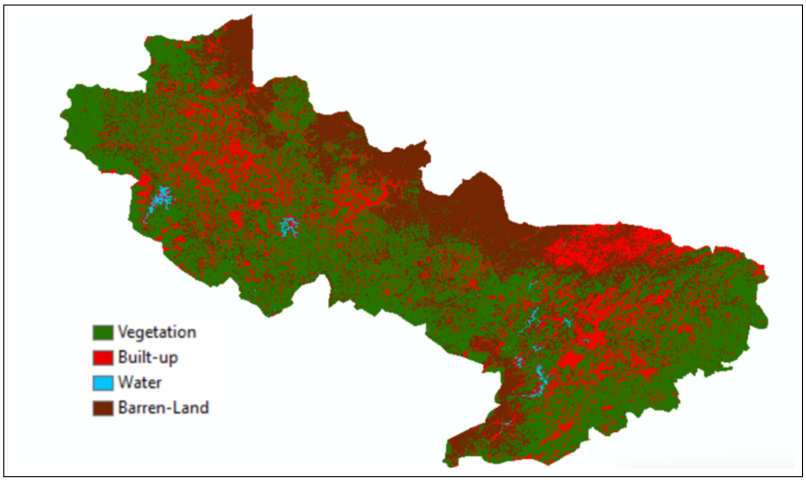

Figure 2: Map of Wayanad and Nilgiri with LULC classification (2022)

- The maximum likelihood classifier of this raster data for the year 2022 gave us the results as shown in Table 2.

LULC of Wayanad and Nilgiri for 2022		
Class	Count (in pixels)	Area (in sq. km)
Vegetation	2889620	2600
Built-up	916210	824
Water	24689	22
Barren land	1355230	1219

Table 2: Predicted land use and land cover data of Wayanad and Nilgiri for 2022.

3.2 Analyzing the results

By analyzing the results, we can say that:

- The area of vegetation went up between 2015 to 2022. These can be attributed to an expansion of forest area around the Nilgiri Biosphere Reserve and increased plantations in Wayanad.
- The built-up area in them went down, which can be

attributed to strict restriction in building construction in landslide prone areas of Wayanad [4] and removal of illegal resorts from protected areas in Nilgiri [5].

- The water area went down but that can be attributed to seasonal change or may be a result of a drought in 2016 [6].
- The barren area went down, mostly due to increased plantations in Wayanad and small land rejuvenation projects in Nilgiri.

3.3 Shortcomings

During our study we had the following possible shortcomings:

- We couldn't actually go the sites of Wayanad and Nilgiri and conduct a land survey there, therefore, had to rely on remotely sensed data.
- The reflectance of the sand in the river basins in Wayanad and Nilgiri match in a lot of spectral bands to the reflectance of the built-up area. The scatter plots of reflectance of classes in different bands can be found in the Appendix 5. This can be due to built-up areas using sand and sand like materials for construction. This may have created an error in the Maximum Likelihood Classification.
- The data available to us was of low resolution and hence might not have been very accurate.

3.4 Conclusion

By conducting our study and learning from available literature, we have come to the conclusions that:

- The districts of Wayanad and Nilgiri are ecologically sensitive areas as they contain a lot of endemic specias of flora and fauna.
- Due to urbanisation, deforestation and excessive plantations these areas have become highly unstable, suffer from droughts, landslides, desertification and floods throughout the year, and are on the **brink of ecological collapse** [7] [8].
- Major steps must be undertaken to save these areas.
- These steps should be taken at all levels be it administrative or personal.

  Nilgiri and Wayanad are home to countless animal and plant species which will face **dire** consequences if action is not taken soon.

4 References

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5 Appendix

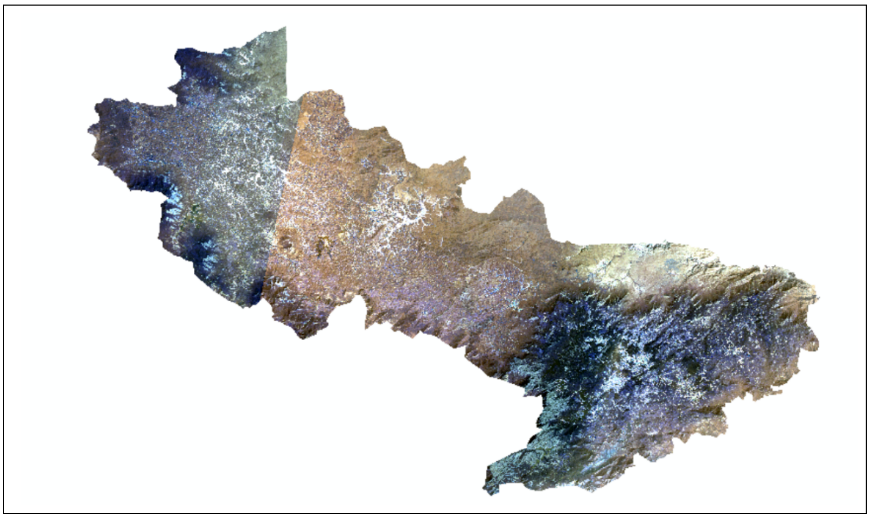

Figure 3: Map of Wayanad and Nilgiri in real color

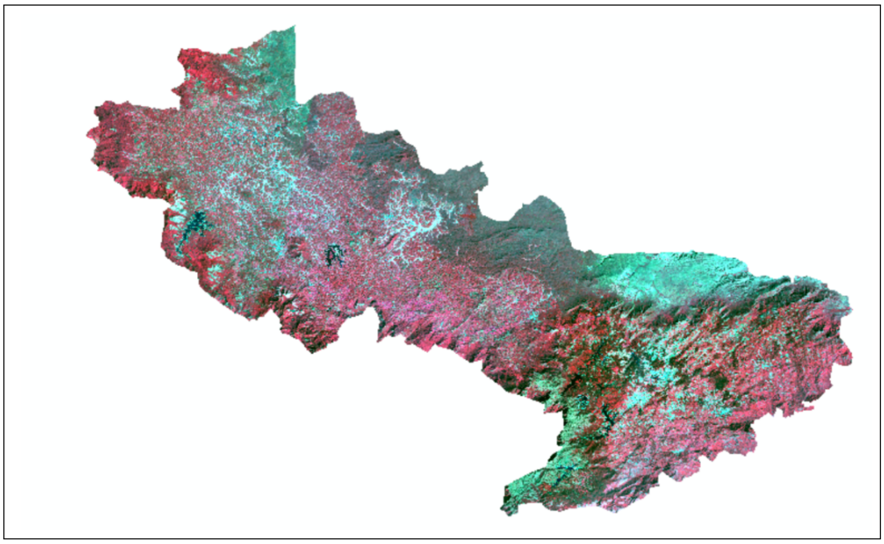

Figure 4: Map of Wayanad and Nilgiri in false color composite