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UNIVERSITY  
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**Change Detection Analysis of Kasauli town, Solan, Himachal Pradesh,  
India**

**Course: Applied GIS Programming**

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## Introduction

The objective of this study is to detect change in the vegetation pattern of Kasauli town in Solan district of my home state Himachal Pradesh in India over the year of 2018, 2020 and 2022. This report focusses on using Python for change detection analysis using Normalized Difference Vegetation Index (NDVI).

The Normalized Difference Vegetation Index (NDVI) is an index which is used in remote sensing to assess as well as quantify the health and amount of vegetation present in an area. It provides information about the vegetation density and the health status of vegetation by measuring the difference between the reflectance of red and near-infrared light.

The mathematical expression for calculating NDVI is as follows:

$$\text{NDVI} = (\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red}) \text{ or } (\text{Band5} - \text{Band4}) / (\text{Band5} + \text{Band4})$$

NIR(Band5) represents the reflectance in the near-infrared portion and Red (Band4) represents the reflectance in the red band (visible portion) of the electromagnetic spectrum.

The range of NDVI value is from -1 to +1. The higher positive values denote dense as well as healthy vegetation whereas, lower values indicate sparse and stressed vegetation.

Trees of different species for instance, oak, pine, deodar cedar and scrub vegetation including Berberis and Rhododendron are found in Kasauli town. It has been observed that changes have occurred in the vegetation pattern and the health of the existing vegetation in the area of interest. Therefore, this study aims to report the change in vegetation pattern and health status in the time period of year 2018, 2020 and 2022.

## Materials

### Study Region

Kasauli (latitude 30.8986, longitude 76.9659) is a small town located in the Solan district of the state of Himachal Pradesh, India.

It is present in the Himalayan foothills. Kasauli has become a well-liked tourist destination thanks to its nice climate and stunning natural surroundings. The town has a historical feel to it and provides expansive views of the towering mountains that surround it. Its rugged terrain and peaceful environment make it the perfect retreat for nature lovers and people looking for a peaceful getaway.

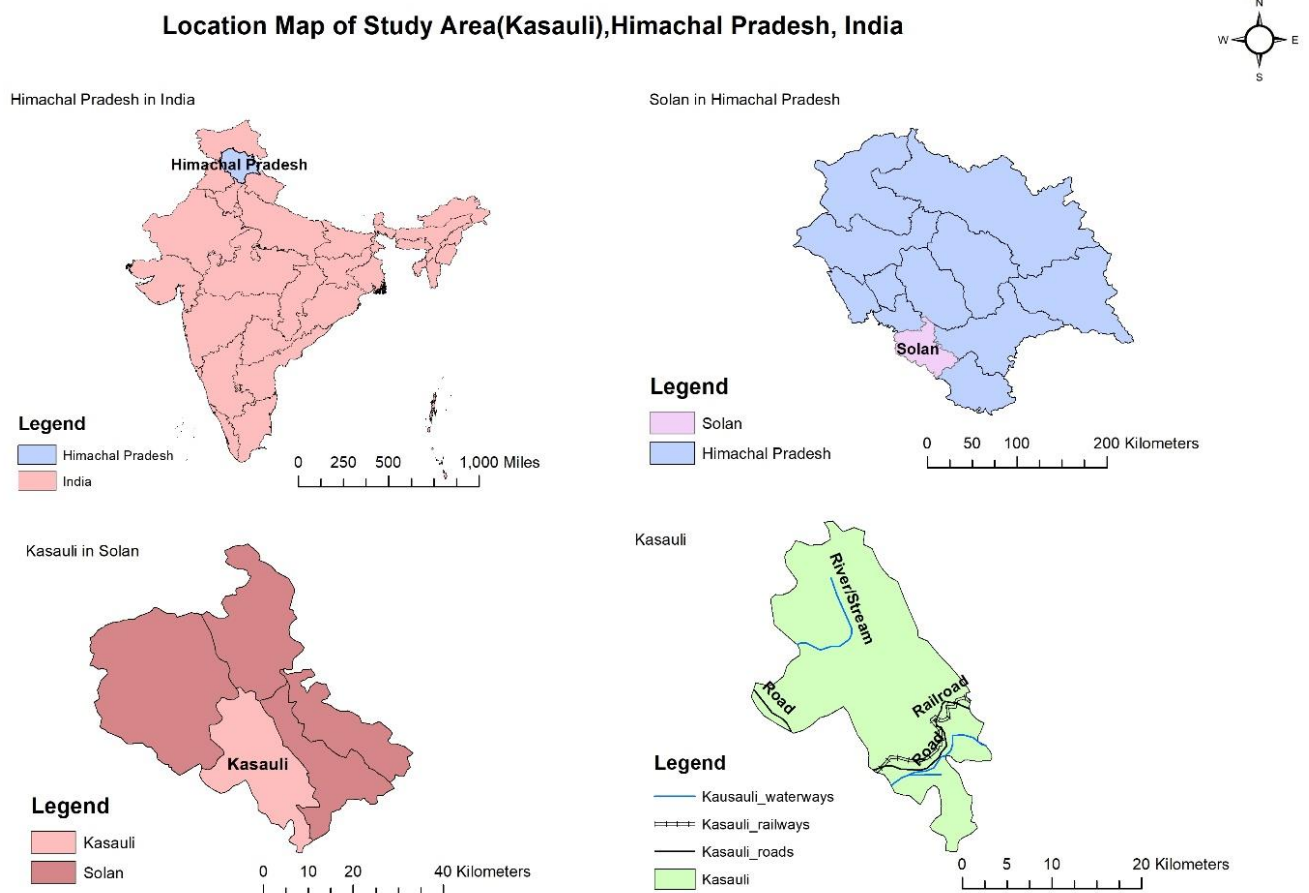


Fig. Location of Area of Interest (Kasauli)

## Data Acquisition

Data is collected from United States Geological Survey (USGS) Earth Explorer platform. From USGS Earth Explorer Platform, Landsat 8 satellite data is used for change detection analysis. Specifically, two bands namely Band 4 and Band 5 are utilized for calculating Normalized Difference Vegetation Index.

Band 4 represents red colour wavelength (0.64-0.67) micrometres and Band 5 represents near infrared wavelength (0.85-0.88) micrometres. Both bands have spatial resolution of 30 metres and have tiff file format.

The visible portion of the electromagnetic spectrum is captured by the red band (Band 4), which is then powerfully absorbed by the chlorophyll pigment found in healthy vegetation. Red band therefore counts the quantity of red light that is reflected.

The electromagnetic spectrum's near-infrared band (Band 5) collects light in this region, which is then highly reflected by the chlorophyll pigment found in healthy vegetation. Therefore, this band counts the amount of near-infrared light that is reflected.

NDVI represent the the contrast between the vegetation's absorption of red light and its reflection of near-infrared light, the NDVI is computed using these two bands.

## Method

Method involves the following steps:

### Data Processing

The satellite images were processed to remove the distortions and unwanted elements. Data processing include techniques of atmospheric correction and radiometric calibration to improve the accuracy and consistency of data which makes it suitable for analysis.

After processing of satellite images, they were clipped according to the area of interest (Kasauli) for calculating NDVI and carry out the analysis.

Installing and importing different packages: The following packages were utilized for calculating and plotting Normalized Difference Vegetation index.

- Geopandas - It is a customized Python library that provides significant capability for handling, manipulating, analyzing, and displaying geographical datasets. It is based on the pandas library. Geopandas offers users a comfortable and adaptable framework for dealing with geospatial data by utilizing the capabilities of pandas and other spatial libraries.
- PyProj- With the help of PyProj, a Python module, users can convert geographic coordinates between several coordinate reference systems (CRS) with ease. When working with spatial data, it is helpful since it makes coordinate transformations and conversions more efficient.
- Rasterio- It is an essential Python module made for raster data manipulation, including reading and processing satellite images. For image analysis, geographic operations, and

data extraction, its functionalities include opening, reading, writing, and processing raster datasets.

- Folium- It is a Python module that enables the production of highly customized and interactive maps. It improves the user experience by adding numerous map layers, markers, and interactive components to efficiently visualize geospatial data for users.
- Matplotlib.pyplot- It is a widely used plotting library in Python, which includes the pyplot module providing a MATLAB-like interface. This interface allows users to create various plots, charts, and visualizations, empowering them to effectively communicate insights from geospatial data.
- Numpy-The foundational Python library for scientific computing, NumPy, provides strong numerical and array operations. NumPy simplifies sophisticated geographic computations and analysis through the effective handling and computation of massive multidimensional arrays.
- EarthPy- It is a python library with broad features for handling, analyzing, and displaying raster and vector data. It is designed specifically for geospatial data in earth sciences. Professionals in earth science will find it intriguing because it has plotting and visualization features relevant to geographical data.
- os module- A variety of features for dealing with the operating system are available through the Python os module. It makes it possible to operate on files and directories, change environment variables, and run system commands. For managing geographical data files and interfacing with the operating system, the os module is crucial.
- Matplotlib.cm - A selection of color maps (cmaps) are offered by the Python matplotlib.cm module for use in Matplotlib-based visualizations. A color map allows you to express data using various color schemes by mapping values to colors.
- To give individual data points or locations in your plots different colors, you can utilize the several predefined color maps that are included with the cm module. These color maps are frequently used to visualize continuous data or create heatmaps, contour plots, scatter plots, and other visualizations.
- Matplotlib.patches - The Python matplotlib.patches package offers a number of classes for drawing and modifying various graphical objects, including rectangles, circles, polygons, and more. The Matplotlib library's plots and figures can be enhanced with graphical components by using these shapes, commonly referred to as patches. It is used for creating legends, drawing geometric shapes and adding shapes to plot elements.

### Importing Satellite Data

After processing of satellite data and installation as well as importing of required python packages then, Band 4 and Band 5 were imported into Jupyter notebook to calculate Normalized Difference Vegetation Index.

### Calculating NDVI

The mathematical expression for NDVI is as follows:

$$\text{NDVI} = (\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red}) \text{ or } (\text{Band5} - \text{Band4}) / (\text{Band5} + \text{Band4})$$

where NIR (Band 5) represents the reflectance in the near-infrared portion of electromagnetic spectrum and Red(Band 4) represents the reflectance in the red band(visible portion) of the electromagnetic spectrum.

### Visualization of NDVI Plots

Various python libraries such as matplotlib.pyplot , matplotlib.patches, matplotlib.cm were used for creating NDVI Plots of three years(2018,2020,2022).

### Visualization of Interactive map

An interactive map was created with the help of “Folium” module for visualizing the geographic location of our area of interest Kasauli (30.8986, 76.9659), Solan, Himachal Pradesh, India. Additionally, a red marker was added to highlight the location of interest.

### Change Detection

In change detection analysis, comparison was done between the calculated vegetation indices from the year 2018, 2020 and 2022 to find out the changes in vegetation cover over the specified time period.

## **Results**

The result of NDVI Plots of three years is given below:

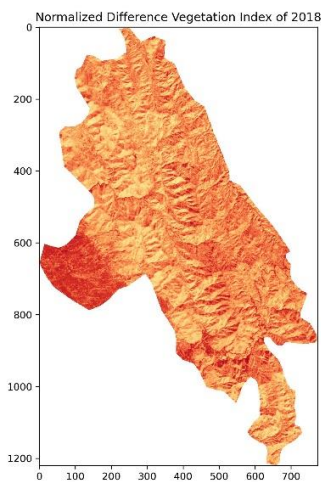


Fig1. NDVI of 2018

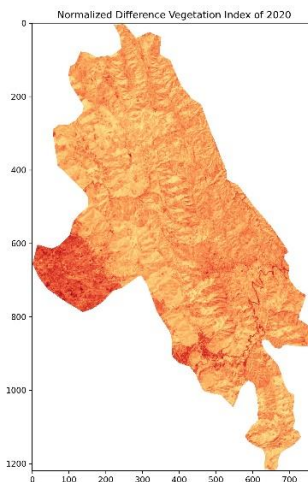


Fig 2. NDVI of 2020

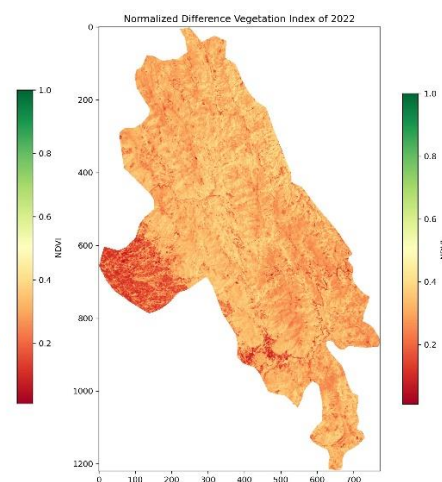


Fig3. NDVI of 2022

Dark red pixels showing NDVI value in the range of 0-0.2 represent either bare soil, water bodies or urban areas. NDVI value in the range of 0.2-0.4 indicate sparse or stressed vegetation. NDVI value in the range of 0.4-0.6 indicate moderate vegetation with comparatively better health conditions.

Therefore, it can be inferred that the year 2018 shows little or no vegetation cover, whereas, year 2020 shows sparse vegetation and year 2022 shows moderate vegetation cover with comparatively better health conditions. Therefore, over the specified time period from 2018 to 2022, the vegetation cover and the health of vegetation has improved in the area of interest.

## **Discussion**

The improvement in vegetation cover in Kasauli town over the time period from 2018 to 2022 can be attributed to the reason of increase in agricultural practices for sustaining increasing population of the town.

## **References**

<https://www.usgs.gov/landsat-missions/landsat-8>

<https://earthexplorer.usgs.gov/>

<https://gisgeography.com/ndvi-normalized-difference-vegetation-index/>

<https://forestecosyst.springeropen.com/articles/10.1186/s40663-015-0050-7>