International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 7 Issue 3, May-June 2023 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Evaluating Changes in Vegetation and Non-Vegetation Patterns of Lidder Valley, Kashmir, India by Using Remote Sensing and GIS

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ABSTRACT

The main goal of this study is to reveal the changes in the vegetation and non-vegetation land cover classes over the study region (Lidder Valley) from 1998 to 2020. Remote sensed data in the form of multi-spectral imagery was used to compute Normalized Difference Vegetation Indices. It provided the base for calculating changes in the land cover categories (Vegetation and non-vegetation). It has been analysed that a large area of the vegetation and non-vegetation classes of the study region had remained the same over 24 years, i.e., no change was noticed among them. About 06 % and 05% of the total area of the study region have witnessed afforestation and deforestation, respectively. Many studies have found that increasing horticultural area at the cost of agriculture is an important reason for increasing vegetation cover. In contrast, increasing population and tourism are the leading causes behind decreased vegetation cover. The large area under non-vegetation should be converted into vegetation other than horticulture because it has been found that increasing horticulture has created many problems in the region. Moreover, it is the need of the hour that government should restrict deforestation practices in the area.

KEYWORDS: *NDVI; Deforestation; Horticulture; Black carbon; Remote sensing*

DOI: https://doi.org/10.5281/zenodo.8241014

How to cite this paper*:* Azhar U Din Waza "Evaluating Changes in Vegetation and Non-Vegetation Patterns of Lidder Valley, Kashmir, India by Using Remote Sensing and GIS" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-7 | Issue-3, June 2023, pp.1361-1370, URL: www.ijtsrd.com/papers/ijtsrd59778.pdf

IJTSRD59778

1. INTRODUCTION

Remote sensing data of multi-spectral type constitutes a group of bands that generates a composite image and are used for interpretation and analysis. With the help of multi-spectral satellite imagery, the band composite, including the number of individual bands, can be transformed to produce more effective patterns and features. Transformation of the bands of satellite imagery has proved to be one of the common methods to create new images from two or more bands to extract information. The new images produced from this technique increase the representations of objects located on the earth, like vegetation. More than one hundred vegetation indices have been produced from the multi-spectral imageries [1]. Normalized Difference Vegetation Indices (NDVI) is also the band transformation, which involves dividing the difference between near-infrared (NIR) and red radiation by the sum of near-infrared and red radiation. The application of NDVI is fascinating because it delineates vegetation and areas of vegetative stress very quickly, which is vital in commercial agriculture and LULC research. The Pathfinder AVHRR Land Science Working Group gave the extraction of the NDVI data set at the global level great importance. NDVI has become one of the most prominent and well-known indices for vegetation assessment. The important reasons for its popularity are its long history, simplicity, and easy availability from multi-spectral satellite imagery [2]. In general, the main aim behind the incorporation of NDVI is to enhance the assessment of information regarding vegetation by utilizing remote sensing data. Many studies have examined that NDVI is adequate for distinguishing dense canopy forest, non-forest, savannah and agricultural lands [3].In addition to that, it can also be used to calculate Leaf area index (LAI) [4], the concentration of chlorophyll content in the leaves[5], biomass [6] productivity of plants [7]. Fractional vegetation cover (FCV) [8] and plant stress [9] .These calculations are generally generated by correlating of NDVI of remotely sensed data with the values obtained from the ground measurements of these variables [10]. Currently, remote sensing data can easily be accessed from different platforms and has a wide application in various sectors. Moreover, open access satellite data sources, especially MODIS, Sentinel, and Landsat. The spatial and temporal resolution of some commercial satellite imageries continuously increasing, e.g., Worldview has 31 cm resolution [11] which makes it the highest-resolution commercial satellite globally[1].

Change detection regarding the earth's surface features is pivotal because it helps us know about the interaction among the environment and anthropogenic activities, which is essential for enhancement and sustainable planning and development of the resources [12], [13]. Many researchers have found that land use land cover (LULC) have had several consequences on global biodiversity, soil and capability of biological systems to full fill the increasing demands of human beings. Dynamics in LULC have also increased the vulnerability of people and places to economic, climatic, social, and political distributions. Dynamics in the LULC changes result from global changes that the man is carrying out to fulfil their requirements for sustenance [14].

The factors responsible for dynamics in LULC may vary from region to region. However, dominant causes that may compel planners and the local population to change the land cover are increasing population, climate change, urbanization, and economic reasons [15].The key objective of this current research is to know the dynamics of vegetation and non-vegetation land cover classes and possible causes over the study area from 1998 to 2020 by incorporating Normalized Difference Vegetation Indices (NDVI) from the multi-spectral satellite imageries. Planners, policymakers and local people can use this study for sustainable management and development of the region's vegetation and non-vegetation areas.

2. Study area

Lidder Valley is named after the local Lidder, a right tributary of the Jhelum River in the district of Anantnag (J&K, India). It occupies one of the distinguished places among the valleys of Kashmir. It is located in the central mountain range of the Himalayas and stretches approximately 50 km from North to south. The valley has a diverse topography with an altitude of 1579-5308m, as shown in Figure 1, of the study area. The valley's main town is Pahalgam, one famous tourist attraction site of Kashmir and has several mesmerizing freshwater streams, pastures and scenic greenery. It is also the gateway to the sacred cave of Amarnath [16]. The valley has a sub-Mediterranean type of climate and receives its seventy per cent annual rainfall, mainly in winter and spring. Temperature variations indicated marked seasonality in its weather system, with a long cold season that lasts for about seven months and an abridged summer season. The valley also receives snowfall, especially from December to February and is mainly caused due to western disturbances [17]. The primary forest flora of the valley is deodar which is found at the altitude of 2000-2500 meters above sea level (ASL), Kail (Pinus walliachiana) (2000-2500m ASL), Fir (Abies pindrow) (2300-3600m ASL), Spruce (Picea smithiana) (2400-3600m ASL) etc.[2]. The valley's population in 1969 was just 69299 persons, which increased to 177361 persons in 2001 and further increased to 233664 persons in the census of 2011. The density population has increased from 59.77 persons / sq.km in 1969 to 201 persons /sq.km in 2011, an increase of 141.23 sq. km over 42 years. The total number of households in the area was just 28002, which increased to 1340361 households in 2011[3]. The main sources of the economy of the valley are agriculture, horticulture and tourism. The importance of horticulture has increased day by day because of its good economic returns [13].

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[1] https://worldview3.digitalglobe.com/

[2] https://jkforest.gov.in/

[3] https://censusindia.gov.in/census.website/

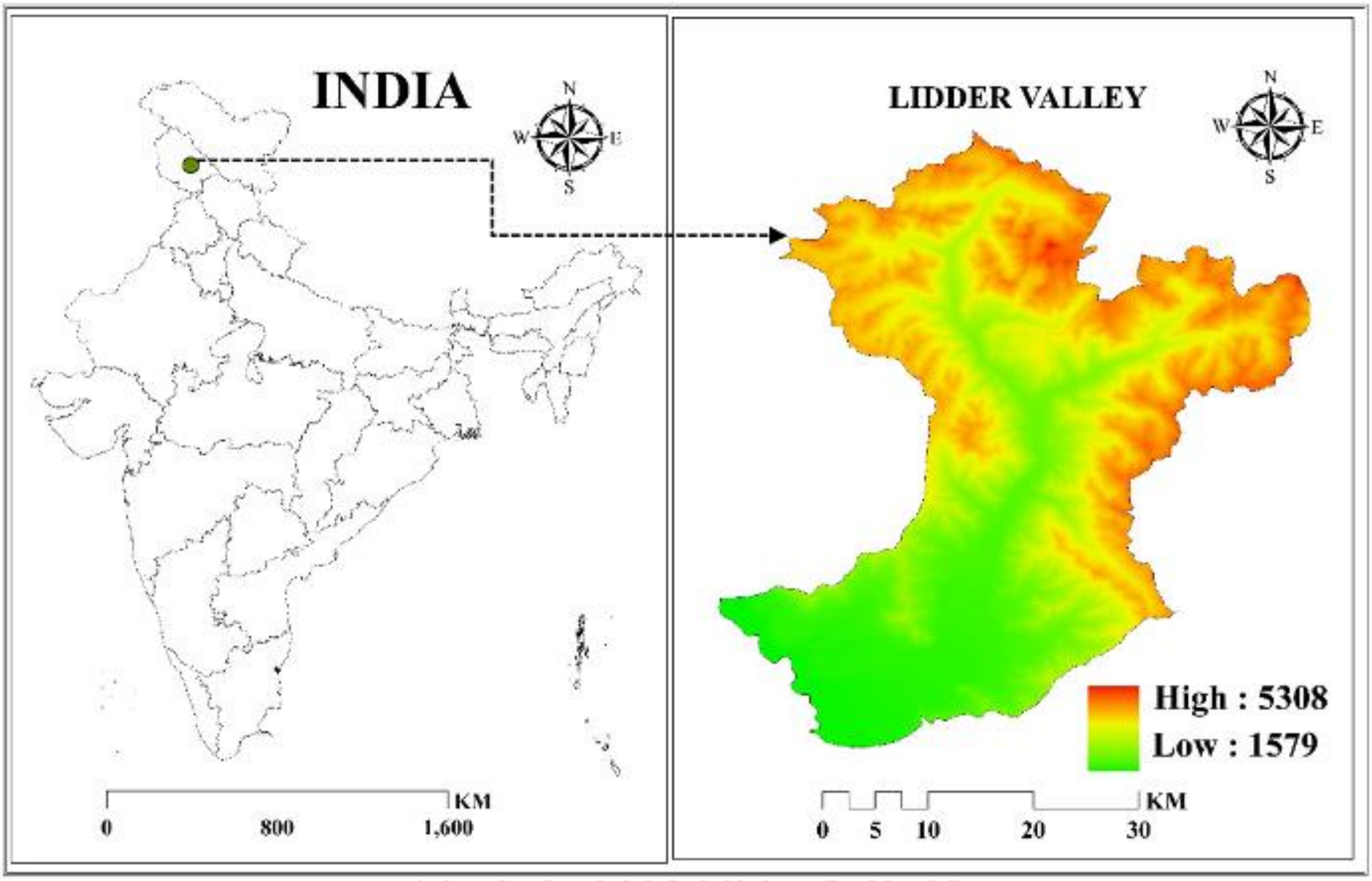


Figure 1, Location Map of the Study Area here.

3. Dataset and Methodology

This study used satellite imageries to assess the changes in the vegetation and non-vegetation patterns of the study area from 1998 to 2020 (refer, table 1). Band 3 and 4 of the Landsat 5 TM were incorporated to obtain the NDVI of the year 1998, and bands 4 and 5 of the Landsat 8 have been used to identify the NDVI of the year 2020 in Arc GIS 10.8.2. NDVI is used primarily to analyse the given area's greenness density. It calculates the difference of reflectance between the near-infrared (NIR) and the red band of the satellite imagery [18]. NDVI is mathematically calculated as follows:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

The value of the NDVI ranges from -1 to 1. The 1 represents the maximum level of greenness or highest vegetation cover [19]. The following formulas have been used to access the NDVI of the years 1998 and 2020.

Table 1, Datasets used to monitor the Vegetation and Non-Vegetation changes in the study region

Sn.no.	Satellite Imagery	Band used	Accusation Date	Spatial Resolution (m)	source
01.	Landsat 5_TM	3 and 4	17-04-1998	30	http://earthexplorer.usgs.gov/
02.	Landsat 8	4 and 5	28-05-2020	30	http://earthexplorer.usgs.gov/

$$1. \quad 1998\ NDVI = \frac{(Band\ 4 - Band\ 3)}{(Band\ 4 + Band\ 3)}$$

$$2. \quad 2020\ NDVI = \frac{(Band\ 5 - Band\ 4)}{(Band\ 5 + Band\ 4)}$$

After calculating the NDVI, reclassify command of spatial analyst tool of arc gis 10.8.2 was utilized to reclassify the old values of NDVI of both the years of 1998 (-0.26048 to 0.41846) and 2020 (-0.194922 to 0.998987) with the new values of -1(Non-vegetation) and 01 (Vegeataion) [20]. The format of the NDVI files were changed from raster (TIFF) to polygon (shp)for the area calculation in order to identify the changes in the vegetation from 1998 to 2020. Both the polygon shape files were interested in the geoprocessing tool of arc gis 10.8.2. Two more columns were added in the add field option of the attribute table (change and Area change). In the 'change'column 04, categories of vegetation classes have been generated using the field calculator: (non-vegetation to non-vegetation, non Vegetation to vegetation, Vegetation to non-vegetation and Vegetation to Vegetation). In the column of 'Area change' an area in sq. km was calculated for all 04 categories by incorporating the command geometry of the attribute table. In the symbology option of the arc gis 10.8.2, all 04 types were renamed from (non-vegeatation to non-vegetation) to (non-vegetation unchanged area), (non-vegetation to vegetation) to (afforestation), (vegetation to non-vegetation) to (deforestation) and (vegetation to vegetation) to (vegetation unchanged area). See flow chart.

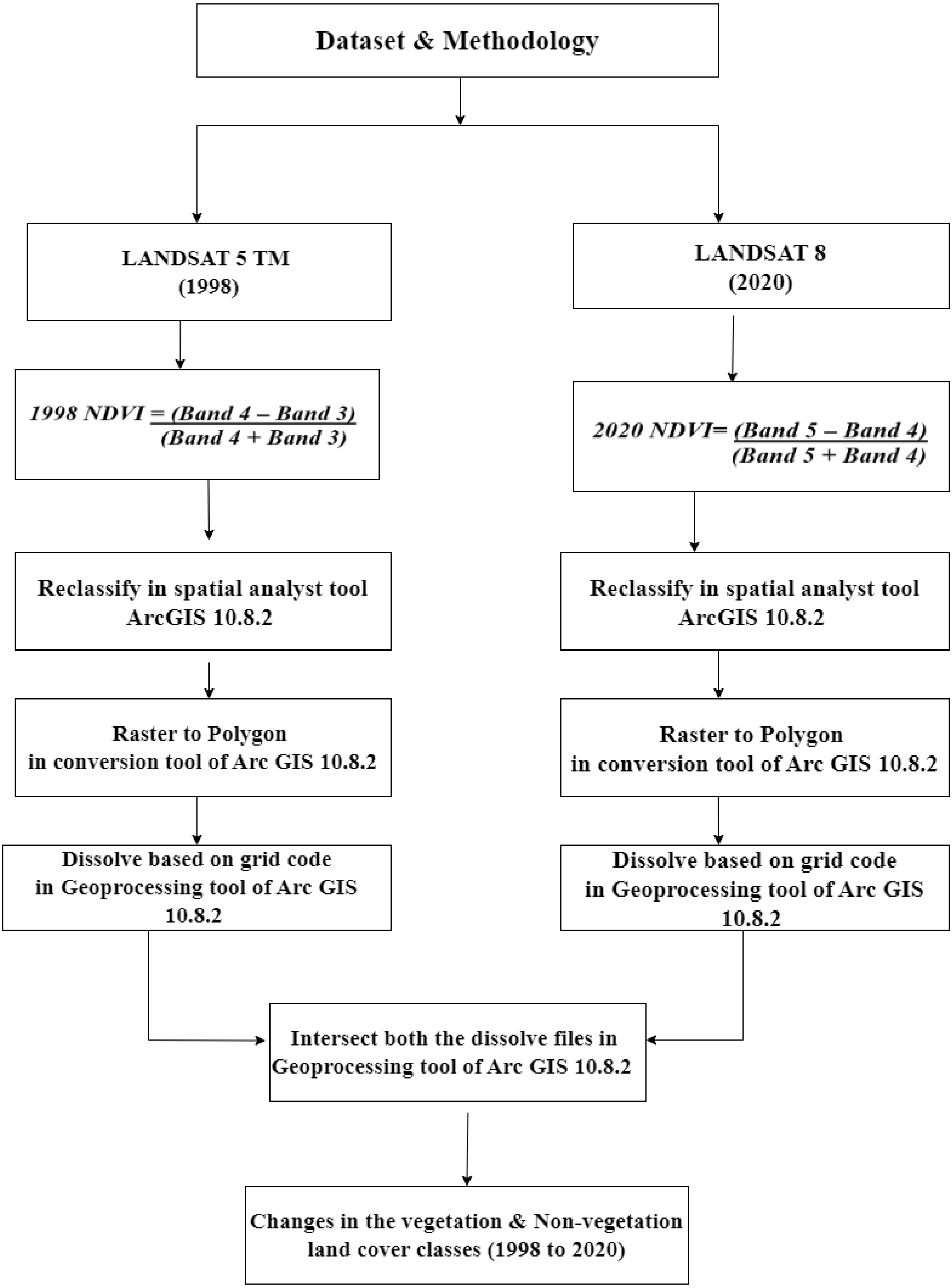


Figure 2, Flow chart of Dataset & Methodology

4. Accuracy Assessment

Accuracy assessment of LULC maps which is generated from the techniques of remote sensing, is not only required in analyzing the quality of maps, but it also has pivotal importance in comprehending the errors and their likely implications [21], [22]. The information from the error matrix has been incorporated in this study [23] and overall accuracy [24] was produced for the accuracy assessment. Another distinctive and more authentic method for checking the accuracy of LULC maps is the Kappa coefficient [24], [25] which is calculated as;

$$k = \frac{N \sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r} \left(X_{i+}.X_{+i}\right)}{N^2 - \sum_{i=1}^{r} \left(X_{i+}.X_{+i}\right)}$$

In the above formula, k is the kappa statistic; r refers to the number of rows in the confusion matrix; X_{ii} indicates the number of observations in row i and column i; X_{i+} is the total number of observations in column i; and N is the total number of observations included in the matrix [26].

Moreover, the producers and user accuracy of both the LULC classes of vegetation and non-vegetation were calculated. The producer accuracy computes the error of omission. It is calculated by dividing the number of pixels correctly classified in each LULC class (on the major diagonal) by the number of test pixels utilized for that land cover type (column total). While user accuracy calculates the error of commission. It is calculated by dividing the number of correctly classified pixels in each land class with the total number of pixels that were classified in that LULC type [16], [24]. In this study, sampling technique (a stratified random) was utilized to select sample points for accuracy assessment of the reclassified NDVI maps of 1998 and 2020. After google earth pro was used to verify sample points by considering their latitudes and longitudes, the overall accuracy of the 1998 NDVI reclassified map was 90%, and the user accuracy of vegetation was 92% and 88% for non-vegetation. The producer accuracy of vegetation and non-vegetation were 92% and 91 %, respectively. The kappa statistic of the 1998 NDVI reclassified map was 0.80. The overall accuracy of the 2020 NDVI reclassify map is 92%, the user accuracy of vegetation and non-vegetation classes were 100% and 84%, respectively, and the producer accuracy of vegetation was 86% and 100% accuracy of non-vegetation. The kappa statistic of the 2020 NDVI reclassified map was 0.84%. (Refer table 2).

Table 2 Accuracy Assessment and kappa coefficient of NDVI classified images (1998 & 2020)

Year	NDVI (Classified Image)	Class	Overall Accuracy	User Accuracy	Producer Accuracy	Overall, Kappa Statistics
1998	Landsat_TM	Vegetation	90%	92%	92%	0.80
		Non_Vegetation		88%	91%	
2020	Landsat_8	Vegetation	92%	100%	86%	0.84
		Non_Vegetation		84%	100%	

5. Result and Discussion

The maximum and the minimum NDVI in 1998 were 0.41 and -0.26, respectively as shown in Figure 3, while in 2020, 0.99 was the maximum and -0.19 was the minimum NDVI values, as shown in Figure 4. It represents that the vegetation cover has increased significantly over 22 years in the study area. The dark green colour is observed more in the NDVI map of 2020, which indicates the more significant area under vegetation, while the red and light yellow colour is more in the NDVI map of the year 1998, which highlights that the vegetation cover was comparatively low than in 2020. Table 2 shows the changes in vegetation in sq. km that is generated from the NDVI's of 1998 and 2020.

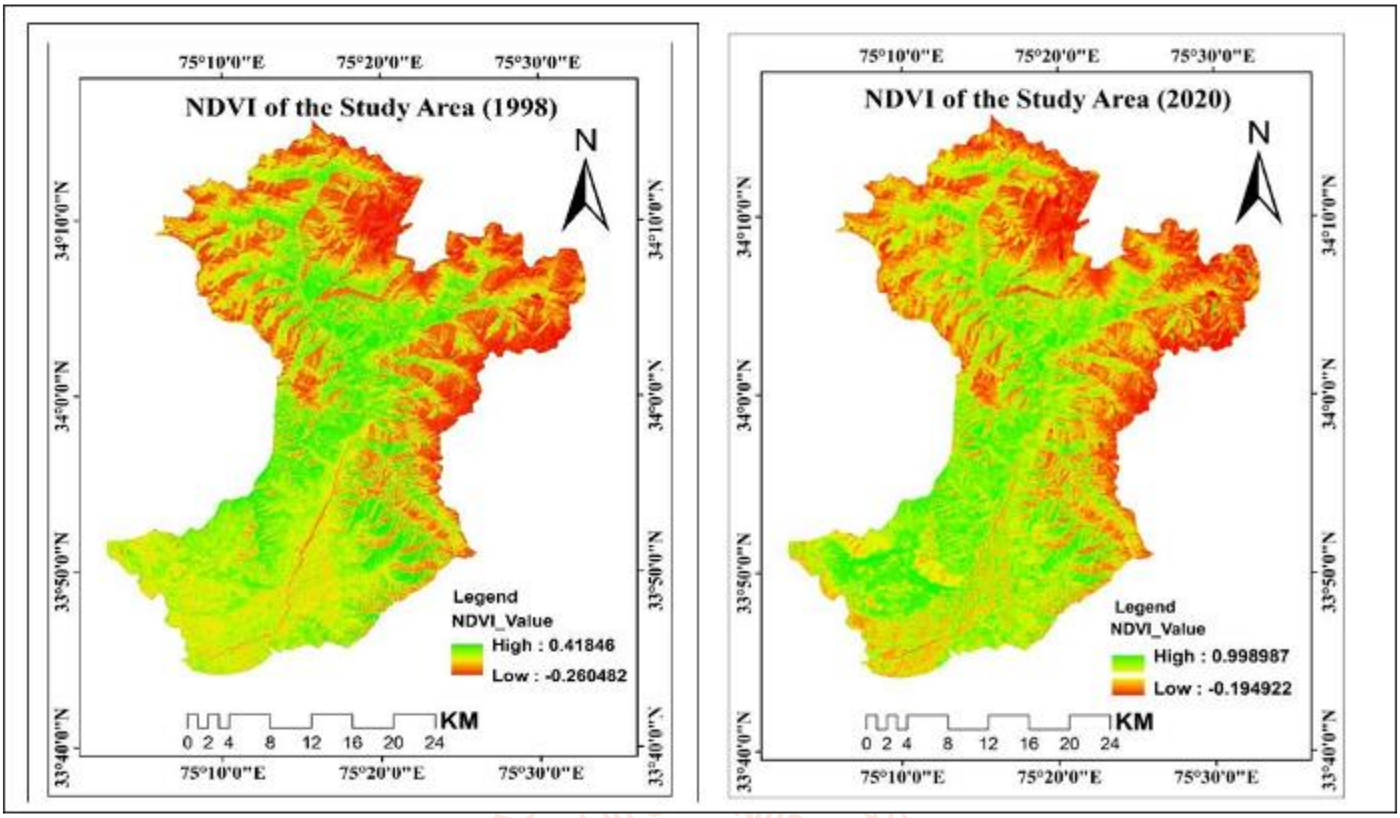
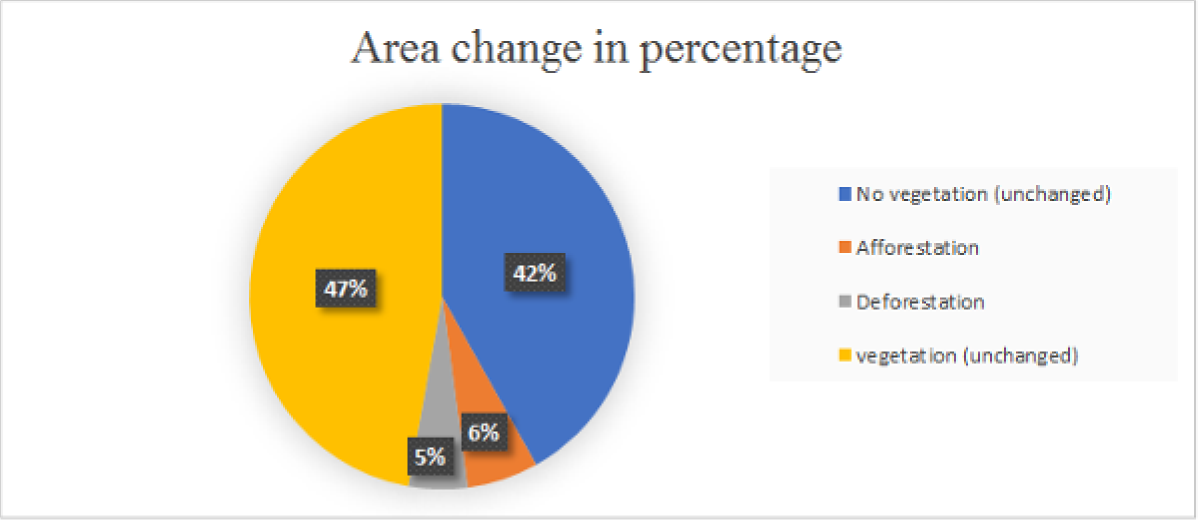


Figure 3 & 4 shows NDVI of 1998 and 2020 respectively

Table 3, Shows the changes in vegetation & non-vegetation (1998 to 2020)

LULC classes	Area change in sq. km
Non_vegetation (unchanged)	537.38
Afforestation	77.11
Deforestation	63.61
vegetation (unchanged)	605.20
Total	1283



Pie chart shows the changes in vegeatation cover (1998 to 2020) in %age

Table 3, and pie chart, show that from 1998 to 2020, about 537.38 sq. km (42%) of non-vegetation cover remained the same, i.e., no change has happened in this land category (refer figure 5). The afforestation area increased from 77.11 sq. km (06%) from 1998 to 2020 (see figure 6). During the same period, deforestation increased upto 63.61 (5%) sq. km (see figure,7) and about 605.20 (47%) sq. km of vegetation remained unchanged over 22 years (refer figure 5). The changes in the vegetation over these 22 years can be best visualized in Figure 8, which compares the changes in afforestation with the changes in deforestation of the study region.

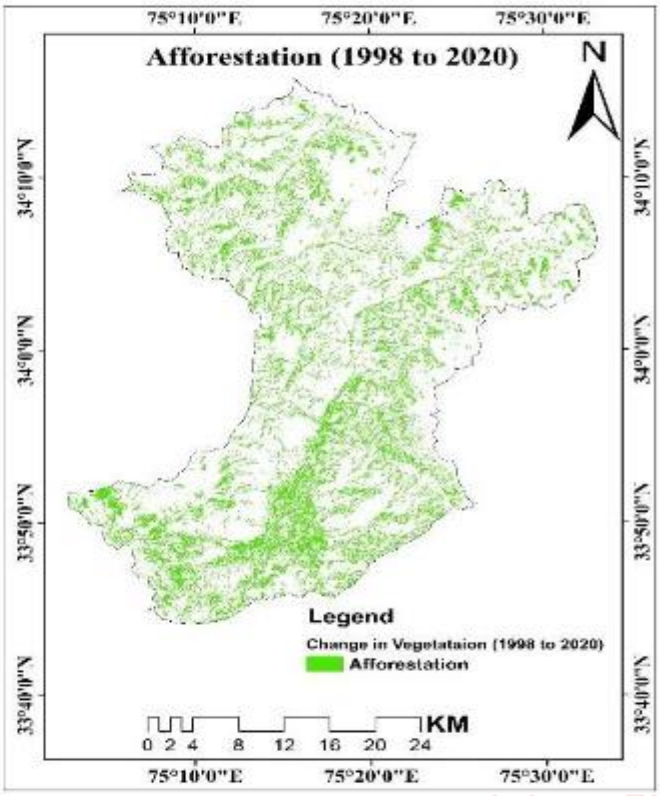


Figure 5, Changes in vegetation and non-vegetation (1998-2020)

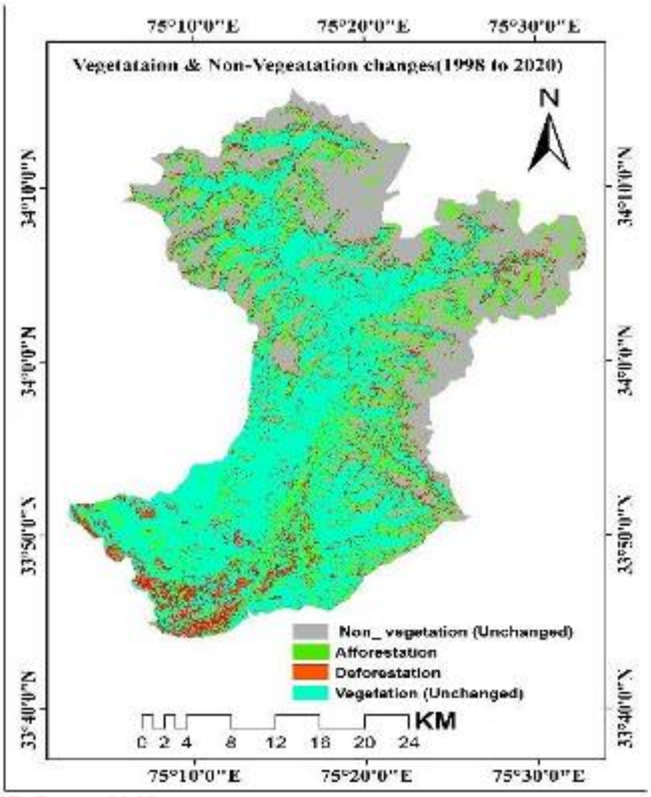


Figure 6, Shows Afforestation (1998-2020)

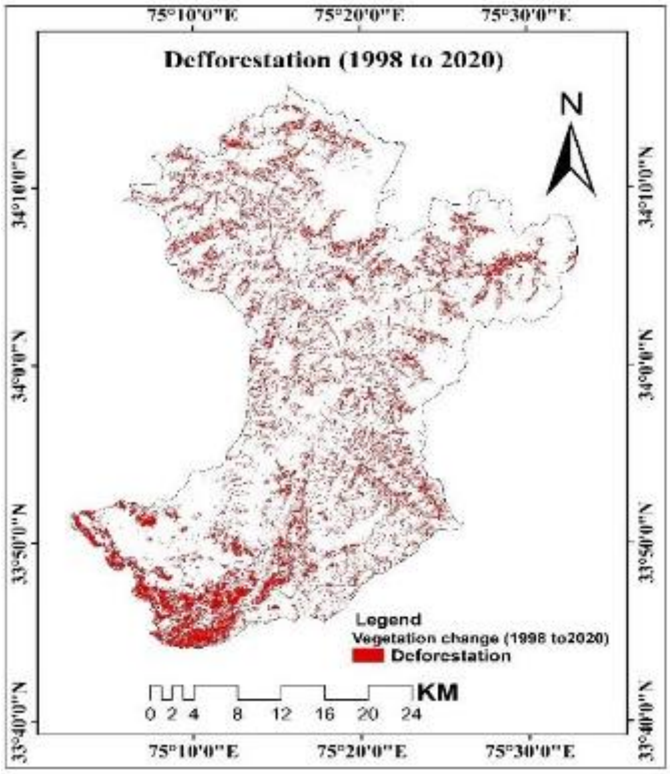


Figure 7, Shows Deforestation (1998_2020)

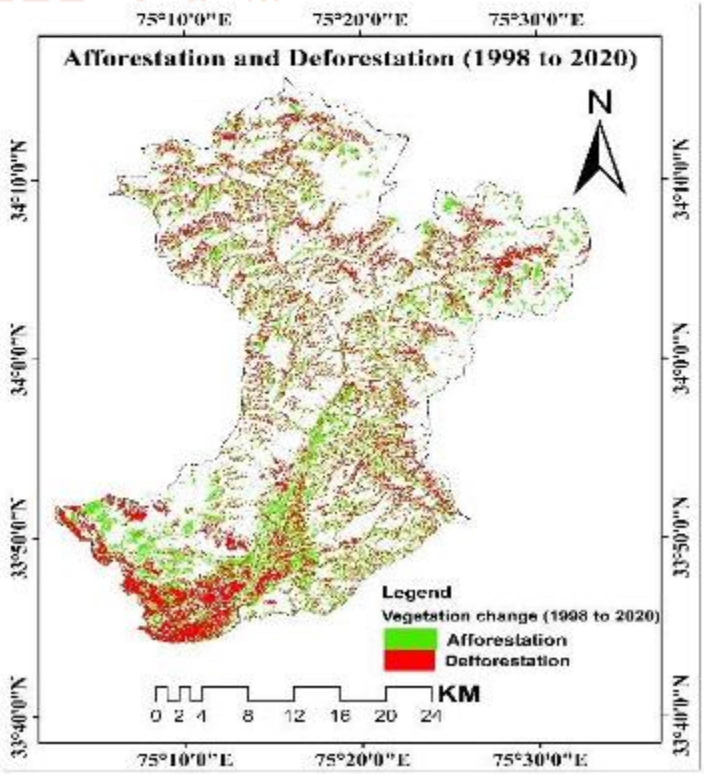


Figure 8, Shows the comparison between afforestation & deforestation (1998_2020)

The prime reason for the increase in the afforestation area is that the horticultural area in the region is increasing rapidly at the rate of 3 sq. km annually. At the same time, the agricultural land in the region has been reduced to a greater extent [13]. Figure 8, shows that afforestation has increased mainly over the plain areas of the study area from 1998 to 2020. However, increasing afforestation is one of the positive signs. However, it has increased the concentration of black carbon (BC) in the region and decadal, increasing from 10.5 mg/m2. The vital reason behind its increase is the biomass burning in winter months generated from the wastes of horticulture [27]. There is a decrease of 24 % in the snowfall of the study region with the changes in the unit degree in temperature and an increase in the amount of BC. Thus, an increase in the burning of biomass has not only impacted the glaciers of the area but is also a fundamental reason for worsening the quality of air [28]. Conversion of agricultural lands into horticultural has also created affected the food security of the region to the large extent. Besides that, it also affects the environment of the region, especially water and soil, as the usage of pesticides and insecticides is very high in the converted horticultural lands [27]. In addition to that, pesticides have also laid severe health problems like cancer, and eye and skin complications in the study region [29]. Important causes behind the region's deforestation are mainly an increase in the built-up area and population explosion [23]. In figure 7, the dark red colour in the plain areas of the study region indicates that most of the deforestation has occurred, and the dense vegetation has mainly been replaced by the built-up land use category. It has been found that over the past few decades, the Himalayan region witnessed drastic land use changes due to the high human population growth and an increase in the number of anthropogenic activities[30]. In the year 2025, the population of the study area is projected to be 1.28 million persons with 246.05 persons per sq. km, and this increase may limit the region's forest area to only 502.19 sq. km [17]. Socioeconomic changes play a vital role in the degradation of vegetation and landscape and is mainly a complex long-term process [31].Establishment of the modern economic system and the burden of rural subsistence and the migration of the population took huge cost of the forest resources of the Himalayan region and depleted them to a great extent [17]. Lidder Valley is a popular tourist spot in India, attracting over 50% of the tourists who visit Kashmir Valley annually. Between 1961 and 2007, the area witnessed an annual increase in tourism of 6.45%, and it is predicted to receive more than 1.5 million visitors by 2025. However, tourism is one of the significant contributors to the economy in the region. Nevertheless, the increasing flux of tourists led to the cutting down of trees for the construction of hostels, lodges and roads in the area [32].

About **605.20** sq. km of vegetation area has remained unchanged from **1998 to 2020**, which is a good indicator of the overall greenness of the study area. However, the expansion of built-up in the form of human settlements, roads and other commercial units can make it vulnerable to deforestation in the future. Thus, govt. and local people must take proper initiative to preserve this natural wealth. Nearly **537.38 sq.** km of the study area is under no vegetation cover, including bare surfaces, pastures and barren land. These lands should be converted into vegetation wherever it is possible so that the natural greenery of the study area will increase to a greater extent.

6. Conclusion

Remote sensing and GIS, together with satellite imageries, have brought the revolution in analyzing the LULC of any area. After analyzing the NDVI images of 1998 and 2020, we have found that most of the area under vegetation in the study region has remained unchanged. This is a good sign of the overall greenery of the region. The area under horticulture has increased in the region at the cost of agriculture fields due to its good economic benefits. However, we have found that many studies have concluded that this significant increase in this sector has hit the region's food security and created innumerable health and environmental problems in the study area. Several studies have found that increasing population, urbanization and tourism in the study region are the chief factors for deforestation. Efforts should be made that the large of the region which is currently under the non-vegetation should be brought under vegetation in consideration of sustainable plantation. Instead, horticultural crops have created several problems. Local people should prefer to plant agricultural crops and the trees like willow, chinar, deodar, fir, Spruce etc., because these trees can help regulate the area's natural ecosystem and provide quality wood for different things. Almost every study has its implication and limitation. The prime implication of this study is that it may help to the planners and local people before they are going to make any drastic change in the vegetation and non-vegetation cover of the study area. Major limitation of this work is that it is confined to a smaller area and the study only covers two decades and two years.

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