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Assessment of Forest Fragmentation in District Shopian Using Multi-temporal Land Cover (A GIS Approach)

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Abstract Man has been using land since the beginning of human civilization. Over the time, growing population demanded more land which expanded its use, so forests that share their borders with built-up or agricultural land use are prone to further degradation than the forests that share their borders with non-forest, natural land cover e.g., wetland, water bodies, grassland etc. The increased use led to increase in the rate of degradation and fragmentation of forest land. Deforestation is the prime cause for the forest land fragmentation and dense forests are very sensitive to this phenomenon where roads are one of the major causes of fragmentation. The present study focusses on the land use dynamics and forest landscape fragmentation of Shopian district of hill state of Jammu and Kashmir from 1995 to 2015. The study is based on remotely sensed data using landscape fragmentation model in GIS. The analysis shows that agricultural and built-up land use has continued to increase at the cost of rich forest cover which has not only significantly decreased but is in the deplorable state. Forest land fragmentation analysis revealed the increase in deforestation and the degradation of the dense forest into small and isolated patches.

Keywords: *deforestation, forest land fragmentation, forest, GIS, land use*

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1. Introduction

Rapid urbanization and industrialization accompanied with other anthropogenic activities has resulted in significant land use/cover changes during the last century [10,18]. Land use/cover change results in to the reduction and division of any land area into two or more fragments which is termed as land fragmentation [3,4,23]. Such changes come at the cost of natural environment [6]. In the early days of settlement, much of the forested landscape was fragmented by land clearing for timber and agricultural [9]. However, this activity of clearing the forests was gradual but with the onset of urbanization and industrialization the rate of deforestation increased. Presently large areas under forests are being brought under deforestation due to increasing demand for land for expansion of settlements, building of roads for better connectivity [7], agriculture land and illegal logging [1].

The extensive degradation of forest land has produced a mosaic of natural and man-made ecosystem [21]. According to FAO, the global rate of deforestation is reported to be 0.7% per year from 1990 to 1995 [5]. The net rate of forest loss in the tropics is 21 m ha, which means that about 1.2% of all remaining tropical forests would be cleared annually [11]. Presently, 1.8% of the forest area is estimated to be degraded every year, the major cause being deforestation [19]. This phenomenon is prominent in developing countries [21] especially where already forest coverage is low. India also has a long history of deforestation (2 million hectares per decade) starting from the British period till the early years of independence 1880-1960 [20]. The British government policies were focussed on increasing revenue from timber exports as well as infrastructure development leading to large scale deforestation [12,20]. In the recent time the hilly states have also experienced increases in population and resultant land transformations where forest lands were the main sufferers. Presently India has estimated 17% of its land under forest cover. It stands tenth in the world in terms of forest cover (Roy and Roy, 2010) and at the same time its population has increased 6 folds (200 mi to 1200 mi) in 20th century [14,15].

The present study tries to measure the depletion in forest cover of Shopian district in the environmentally fragile hill state of Jammu and Kashmir. The district is observing widespread forest degradation. This degradation is mainly due to extensive agricultural reclamations and illegal timber trading [18]. The study uses remotely sensed data along with GIS techniques as these techniques have emerged as a powerful tool to closely map and monitor the forest cover of these areas economically, accurately and repetitively within a short period of time. The study tries to investigate land use/cover change and the degradation in forest cover using normalized differential vegetation index (NDVI). Further for forest land degradation, landscape fragmentation tool [13] has been used.

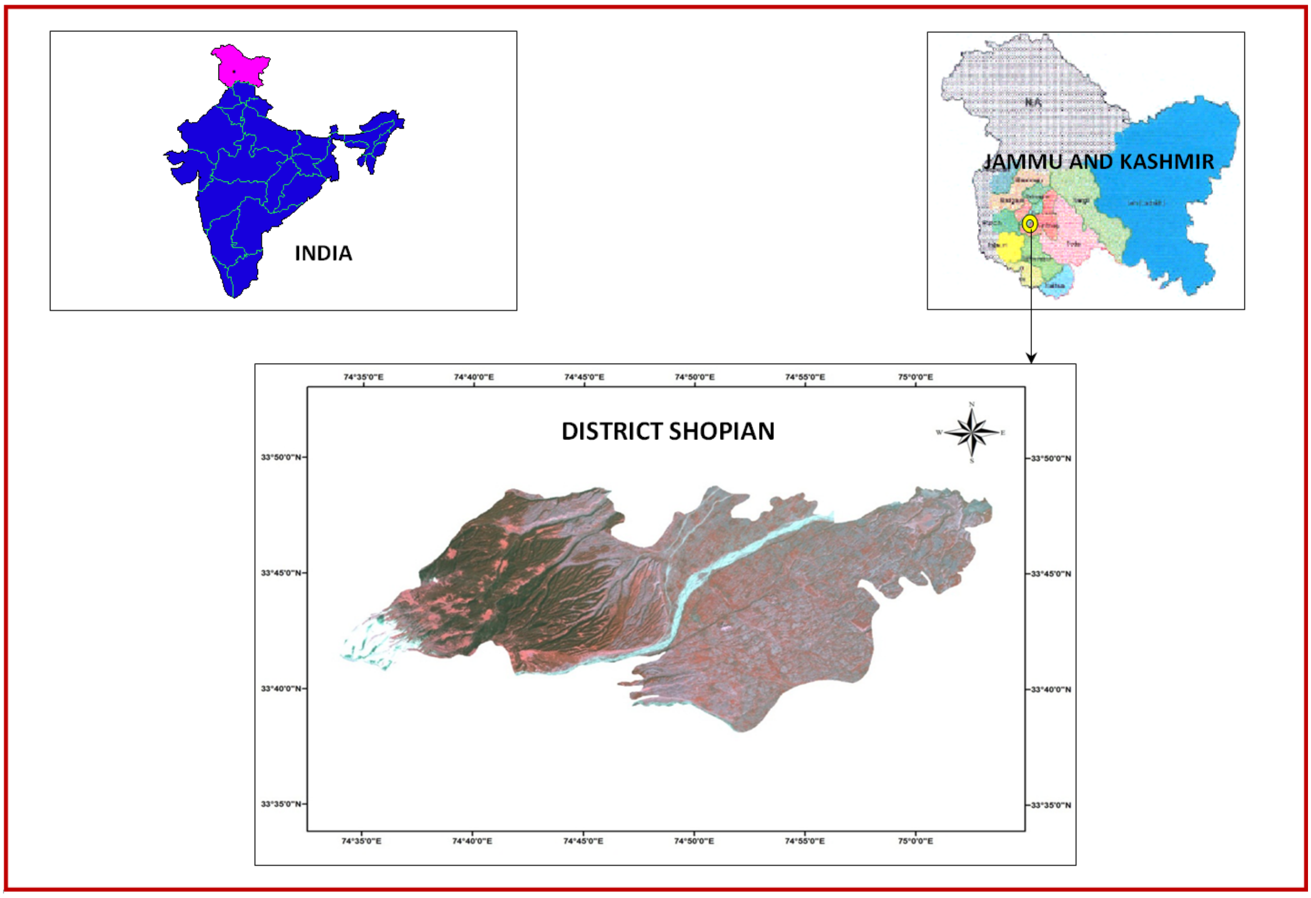

Figure 1.

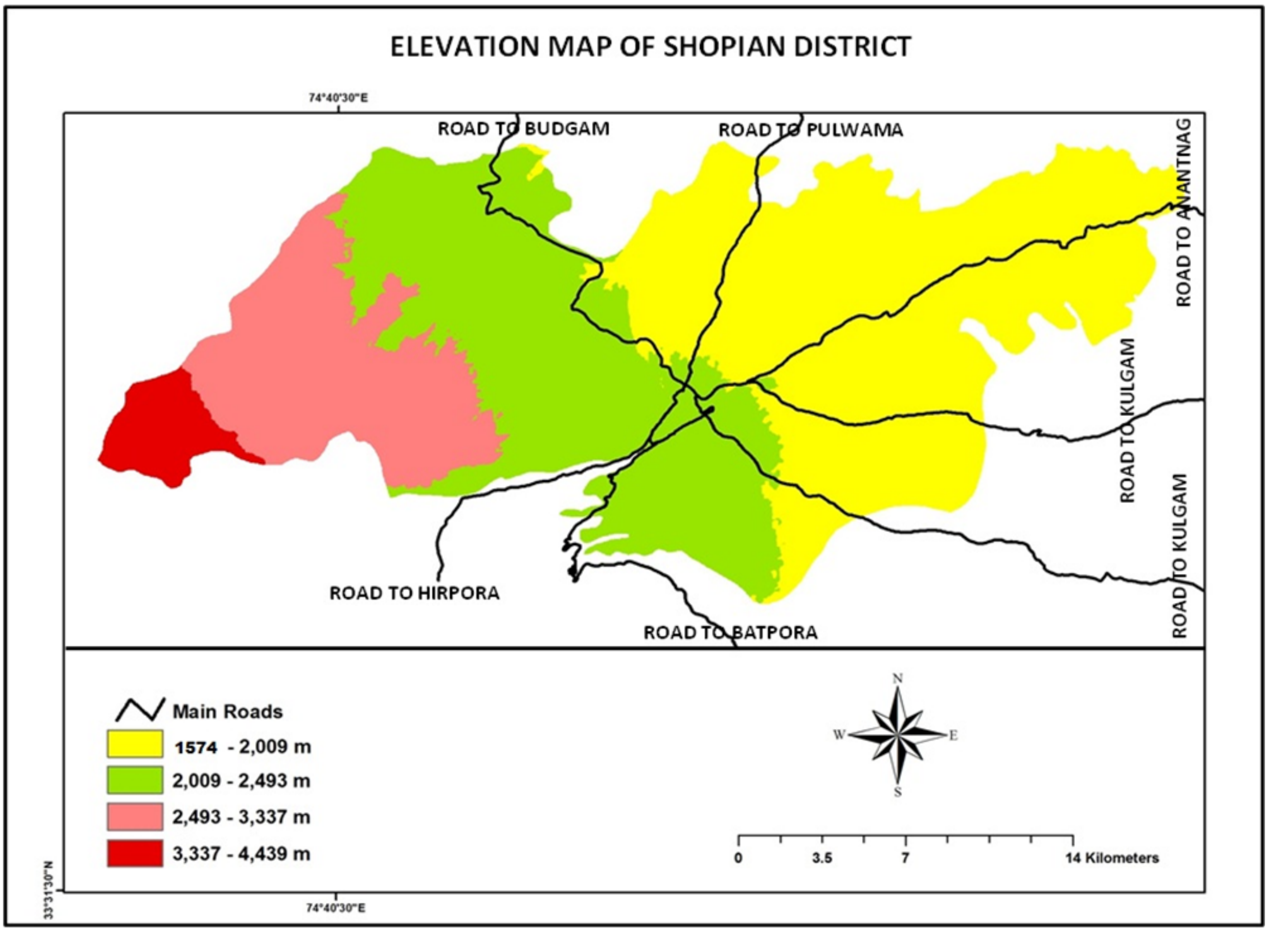

Figure 2.

2. Study Area

The Shopian District is located at 33°38'9.39" N to 33°48'48.4" N latitude to 74°34'0.811"E to 75°3'27.007"E longitude in the northern most state of India i.e., Jammu and Kashmir. The district got delineated in the year 2013 when it was carved out from district Pulwama. It lies in the southern area of the famous valley of Kashmir and is about 50 Kilometers away from Srinagar city (urban center and the summer capital of the state). It occupies a total area of 550 Sq.km. Shopian is located on the important tributary of Jhelum river namely Rambiara which dissects the district in north-east to south west direction (Figure 1). The general elevation of the district ranges from 1574 in the east to 4439 m in the west above mean sea level (Figure 2). The climate of the area is temperate type characterised with cool and wet rainy seasons (July to September) and cold and wet winter season (December to February). Shopian dominates the horticulture and agricultural production of the state. The western mountainous area is bestowed with the rich alpine forests. However due to anthropogenic activities the quality and quantity of this forest region has been deteriorated in the recent past.

Shopian forest area is rich in flora. Its diverse natural vegetation ranges from lush green grass belts called Margs to evergreen forests of coniferous on the mountain slopes. Such floral diversity is due to its ecology and climate. The region is characterised with widespread temperate forests dominated by coniferous vegetation and the commonly found tree species are *Cedrus deodara* (Deodar), *Pinus wallichiana* (Kail), *Abies pondrow* (Silver Fir), *Piecia simithiana* (Spruce) and *Taxus baccata* (Yew). There are also other broad leaved tree species like Maple, Ash, Horse chestnut, Bird cherry, Hazul nut, Willow, Walnut, Popular and Birch. The lower sloppy area of the Shopian forest area is rich in Kail forest. Some small patches of broad leaved deciduous species are also seen in the region. Altitude and aspect has a great role on the crop type. The crop varies according to its height and slope where the gentle sloppy areas in the east have a good crop and high reaches in the west have scanty crop due to the impact of adverse ecological factors.

3. Data Sets and Methodology

The study is mainly based on secondary sources of data; the data used for the preparation of previous date land use/land cover of the study area is Landsat-4 TM of 1995 satellite imagery. Similarly, the land use/land cover for the later date was carried out using IRS-1D LISS III 2015 satellite imagery (Table 1 and Figure 3).

3.1. Processing of Raster Data

Remotely sensed data was geo-referenced and cropped pertaining to the study area (Shopian District) in Earth Resource Data Analysis System (ERDAS) Imagine 2015 software. Geo-registration of remotely sensed data (LANDSAT-4 TM of 1995 and IRS-1D LISS III 2015) was done using ground control points collected from the field with the help of pre calibrated GPS (Global Positioning System). Landsat-4 data was resampled and the cell size was matched with the Liss III data. Also the help was taken from geo-referenced topographic maps published by the Survey of India of the series 43K/9, 43K/13, 43K/14, 43K/10 on a scale 1:50,000 were used. Image-to-image registration has been performed to bring the entire image in the same geometry using Universal Transverse Mercator (UTM) as its projection and WGS 84 as its datum with sub-pixel accuracy. Satellite imagery was stacked into different bands to produce a false color composite. The data pertained to the month of October 1995 and November 2015 which corresponds to Kharif season.

3.2. Processing of Vector Data

These images were digitized in GIS environment using ArcGIS 10 software using visual interpretation technique in the form of polygons representing different land use land cover categories. Reference to legacy data and other ancillary information has been used for precise interpretation of land use classes and delineation of the same. Land use/cover classification was based on National Remote Sensing Center (NRSC) classification (Level 1). The maps were put to further processing like area estimation, map composition and output generation. The data was classified into 11 broad land use/land cover classes spread over a total area of 550 Sq. Km of study area (Shopian district). Thematic accuracy assessment was done for the study area. All the Land Use Land Cover categories were numbered map-wise and sample chosen for field verification using the following Equation [8].

Table 1. Details of satellite data used in the study

S. No.	Data used	Path/Row	Date of Pass	Wave length width in µm/Band	Spatial resolution (meters)	Swath (km)	Purpose
1	LANDSAT-4 TM	92/46	10-10-1995	0.45-0.55 0.52-0.60 0.63-0.64 0.76-0.90 1.55-1.75 10.4-12.5 2.08-2.35	30	185	Land use and Land cover mapping
2	IRS-1D LISS-III	92/46	03-11-2015	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	23.5	142	Land use and Land cover mapping
4	Survey of India (SOI) toposheets of 1:50000 and 1:250000 scales	--	--	--	--	--	To Generate boundary and Base layer maps
5	Field visit data – captured using GPS	--	--	--	--	--	For geo-correcting and generating validation dataset

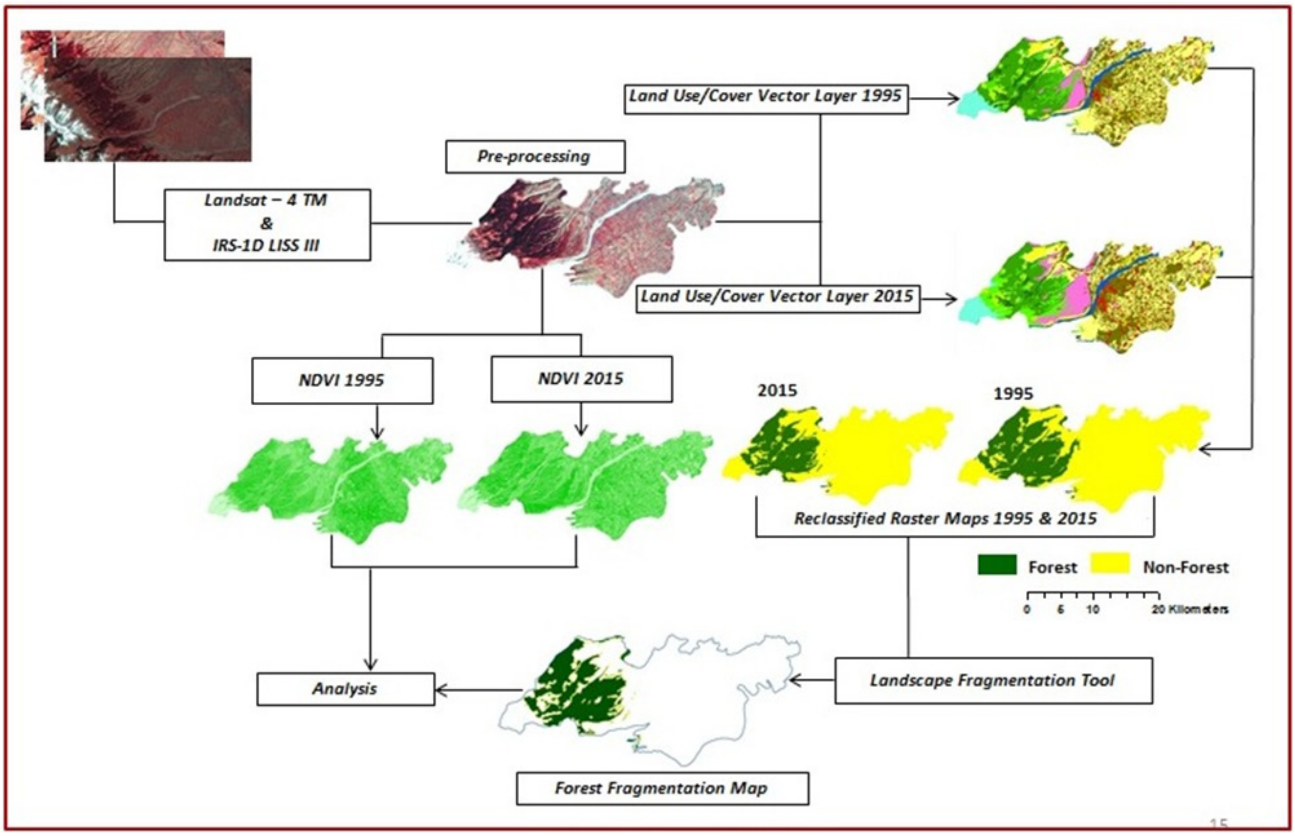

Figure 3. Methodology followed

3.3. NDVI Differencing

Differences in vegetation index was calculated using NDVI model of ERDAS Imagine software.

3.4. Landscape Fragmentation Tool

The study carried out qualitative analysis of forest degradation using landscape fragmentation tool (LFT v2.0) [22]. This model is used to map the types of fragmentation present in a land cover type of interest (i.e., Forest (Dense, Sparse and Scrub) in the present study). LFM is based on the study carried out by Parent [13]. This model works on ArcGIS 9.3 and requires raster land use/cover data that was reclassified into forest and non-forest covers [22].

4. Land Use/Cover Dynamics in Shopian District

The land use pattern of Shopian district is governed by its topography. There are steep variations in the general gradient of the predominantly land surface while moving from west to east starting from the hilly mountainous snow covered peaks to the low lying horticulture and agricultural fields. The district contributes significant share to the total agricultural and horticulture production of the state. Its forests are ecologically fragile areas comprising important forest compartment zones of the Himalayan Mountain Range. Due to increase in population and the negligence from the government authorities, widespread deforestation has taken place in this region remarkably by timber smugglers. The low gradient of slope helps in easy access to this forest region.

The entire Shopian district was classified into 11 land use/cover types based on their respective description (Table 2). These classes include; Forest (Dense), Forest (Sparse), Forest (Scrub), Agricultural land (Single Crop), Agricultural land (Double Crop), Built-up, Grassland, Wasteland, Snow/Glacial Area and Water bodies, covering the total area of 550 Sq. Km. Remote sensing, although challenged by the spatial and spectral heterogeneity of urban environments was used for the study as these sources are found to be an appropriate source of data to investigate such studies [2]. The study further carried out the change detection analysis by using the two time period data sets to find out the changes that have taken place between the year 1995 and 2015. The detailed land use/cover and change statistics is given in tables (Table 3 and Figure 4 and Figure 5).

The illustrations show significant changes in land use/cover prominently in forest area which is confined to Devi Pora forest block in the western hill area of the district. Forest (Dense) class has decreased from 23.46 Sq. Km (4.26%of the total study area) to 8.50 Sq. Km (1.54% of the study area) i.e., the decreased by -63.76% from the year 1995 to 2015. Similarly, Forest (Sparse) also decreased from 89.42 Sq. Km in the year 1995 to 73.69 Sq. Km in the year 2015 (decreased by -17.59 %) (Figure 6 and Figure 7). The decrease in the area under forest (dense) and forest (sparse) is attributed to the over exploitation of the forests by timber smugglers and local people whose growing number demands more food, fuel wood and timber. These forests are having the rich variety of tree species and wildlife habitat, so the decrease in its area has detrimental effect on region’s ecosystem. The decrease in the total area under dense and sparse forest led to the increase in the total area under Forest (Scrub) from 24.37

Sq. Km to 39.51 Sq. Km (increased by 62.12 %) during the study period.

Table 2. Description of land use/cover classes used for analysis of changes between 1995 and 2015

S. No	Land use/cover classes	Description
1	Agricultural Land (Single Crop)	Area under agricultural land cropped in Kharif season/ Rabi/ Zaid season.
2	Agricultural Land (Double Crop)	Area under agricultural land cropped in Kharif and Rabi season.
3	Plantation/Orchards	Area covered with agricultural plantation and horticulture plantation, mainly Apple, Peaches, Almonds and Walnuts etc.,
4	Built Up	Area under rural and urban settlement.
5	Forest (Dense)	Area under evergreen/semi evergreen-dense/closed forest.
6	Forest (Sparse)	Area under evergreen/semi evergreen-open forest.
7	Forest (Scrub)	Area under forest scrub land.
8	Grassland	Area covered with natural/semi natural grassland & grazing land-alpine/sub alpine
9	Snow/Glacial Area	Area under seasonal or permanent snow cover/glacial area
10	Wasteland	Area under wastelands-barren rocky/stony waste. Area under wastelands-gullied/ravinous land-deep ravinous Area under wastelands-gullied/ravinous land-gullied Area under wastelands-gullied/ravinous land-shallow ravinous. Area under wastelands-scrub land-dense scrub. Area under wastelands-scrub land-open scrub
11	Water bodies	Area covered by water bodies-lakes/ponds. Area covered by water bodies-reservoir/tanks. Area under water bodies-river/stream-dry. Area under water bodies-river/stream-perennial.

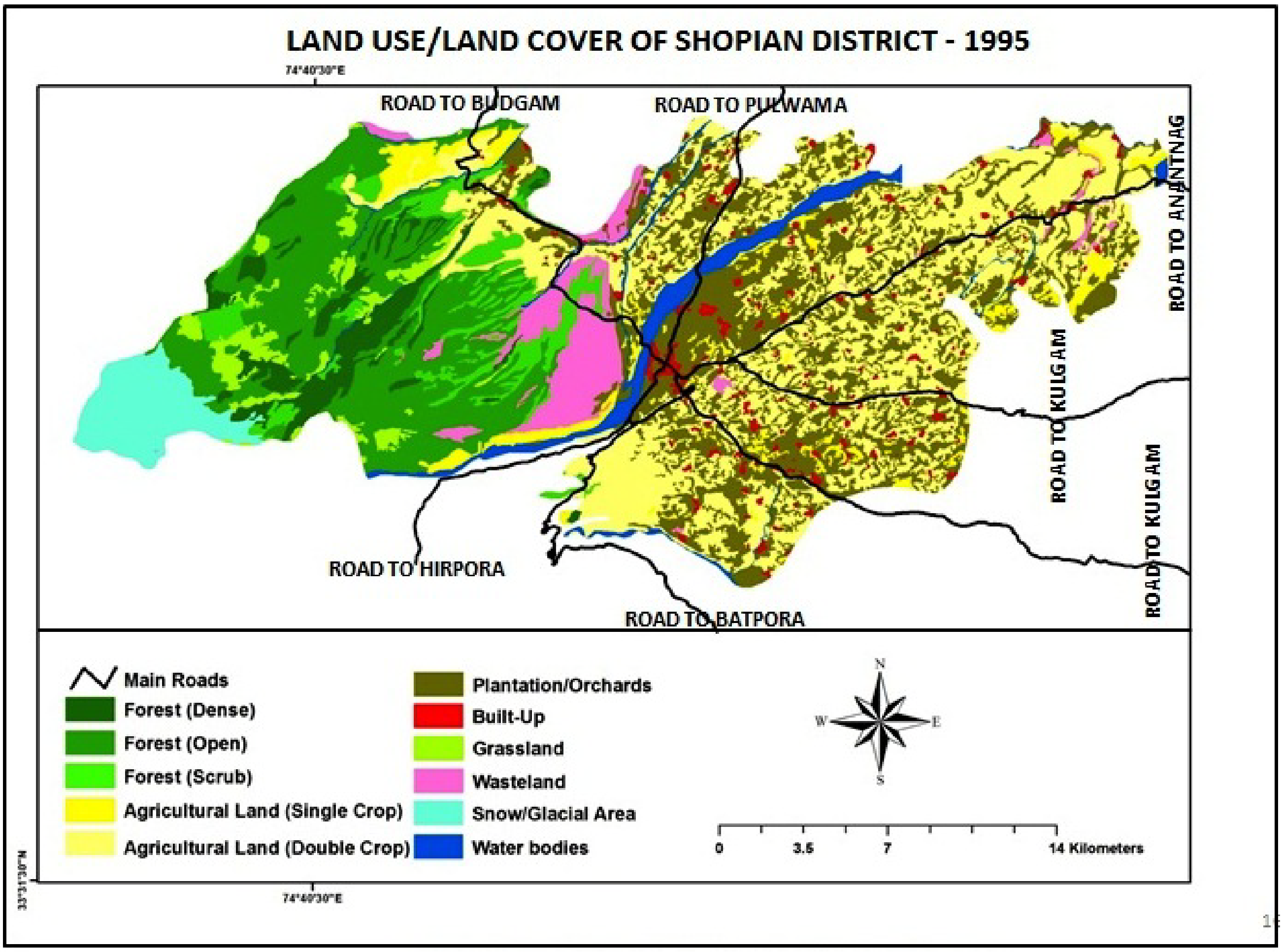

Figure 4. LAND USE LAND COVER OF SHOPIAN DISTRICT – 1995

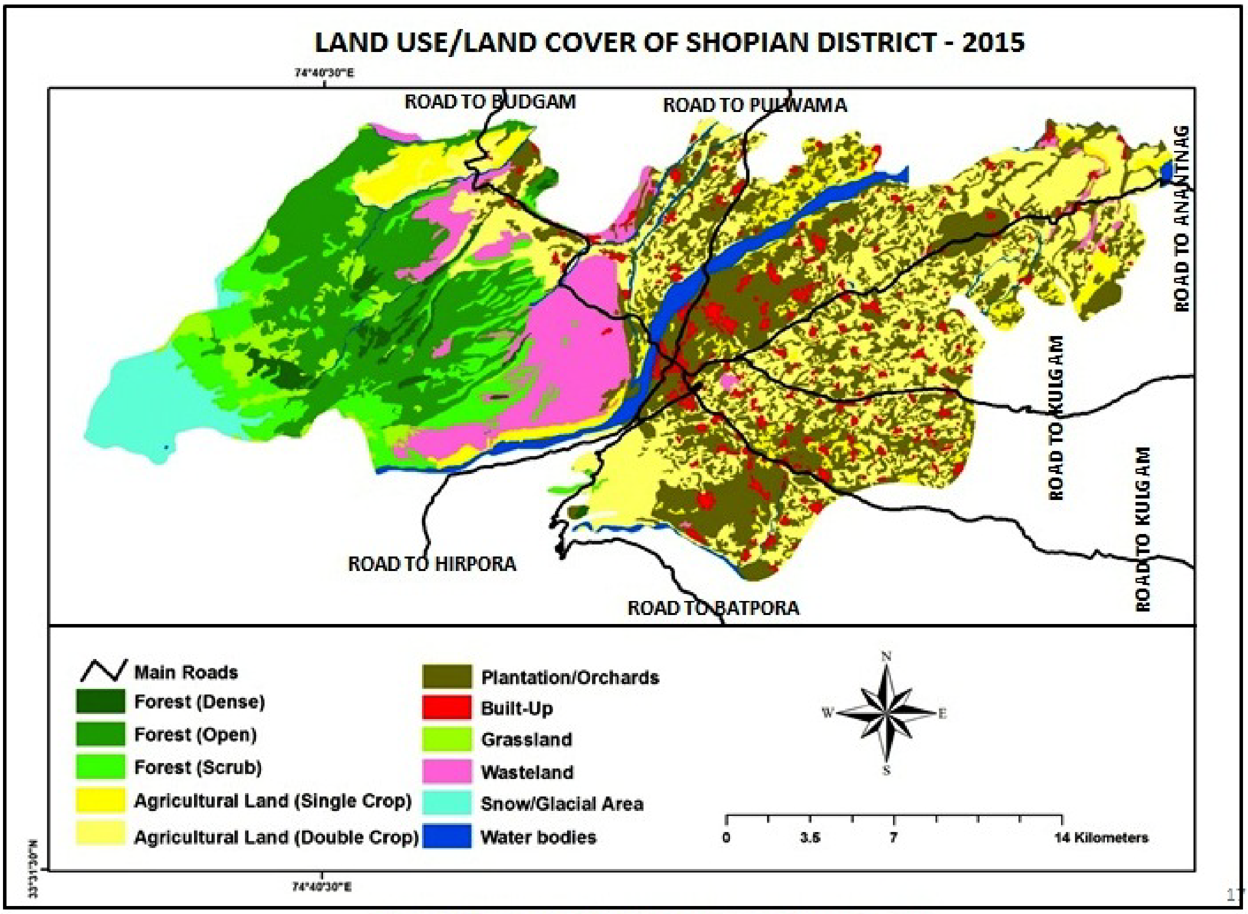

Figure 5. LAND USE LAND COVER OF SHOPIAN DISTRICT – 2015

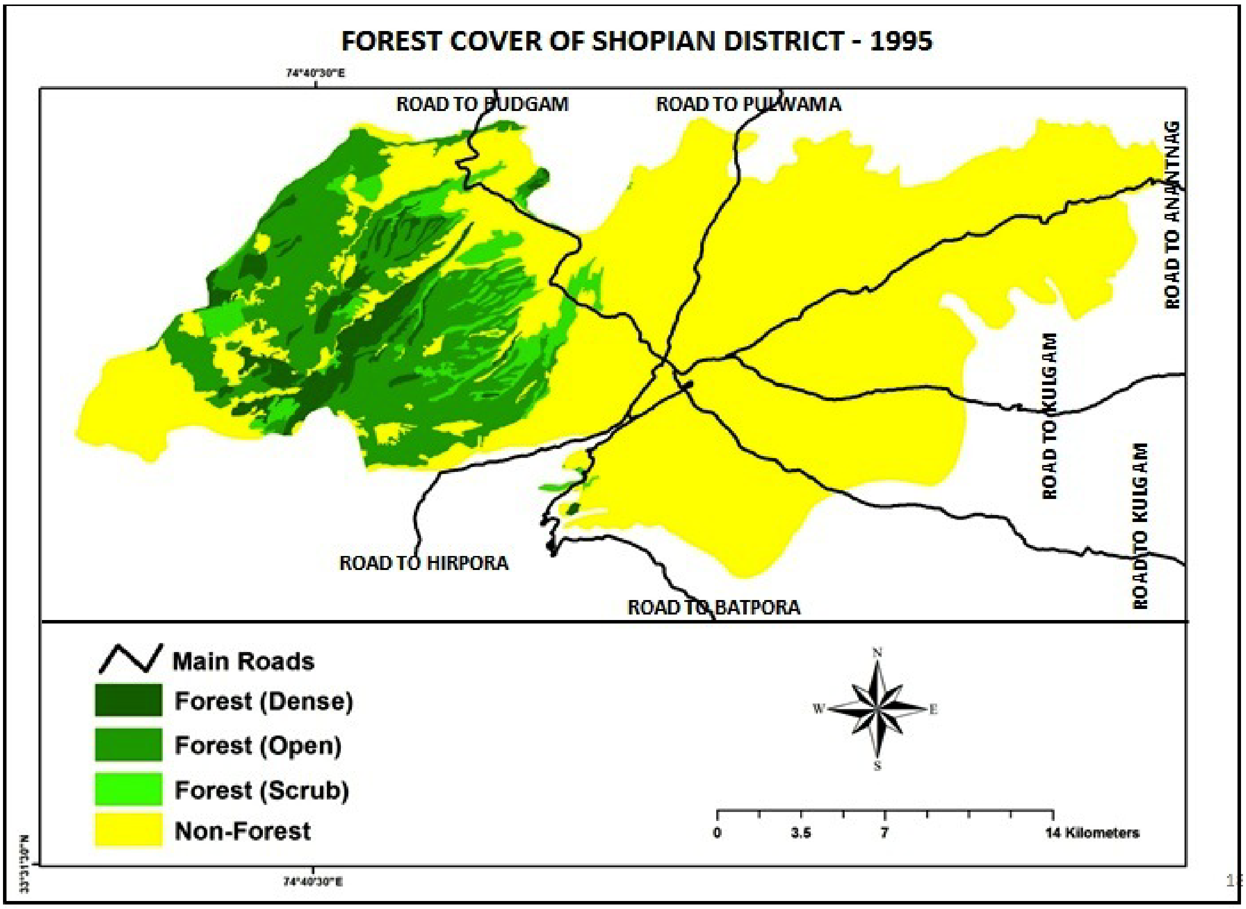

Figure 6. FOREST COVER OF SHOPIAN DISTRICT – 1995

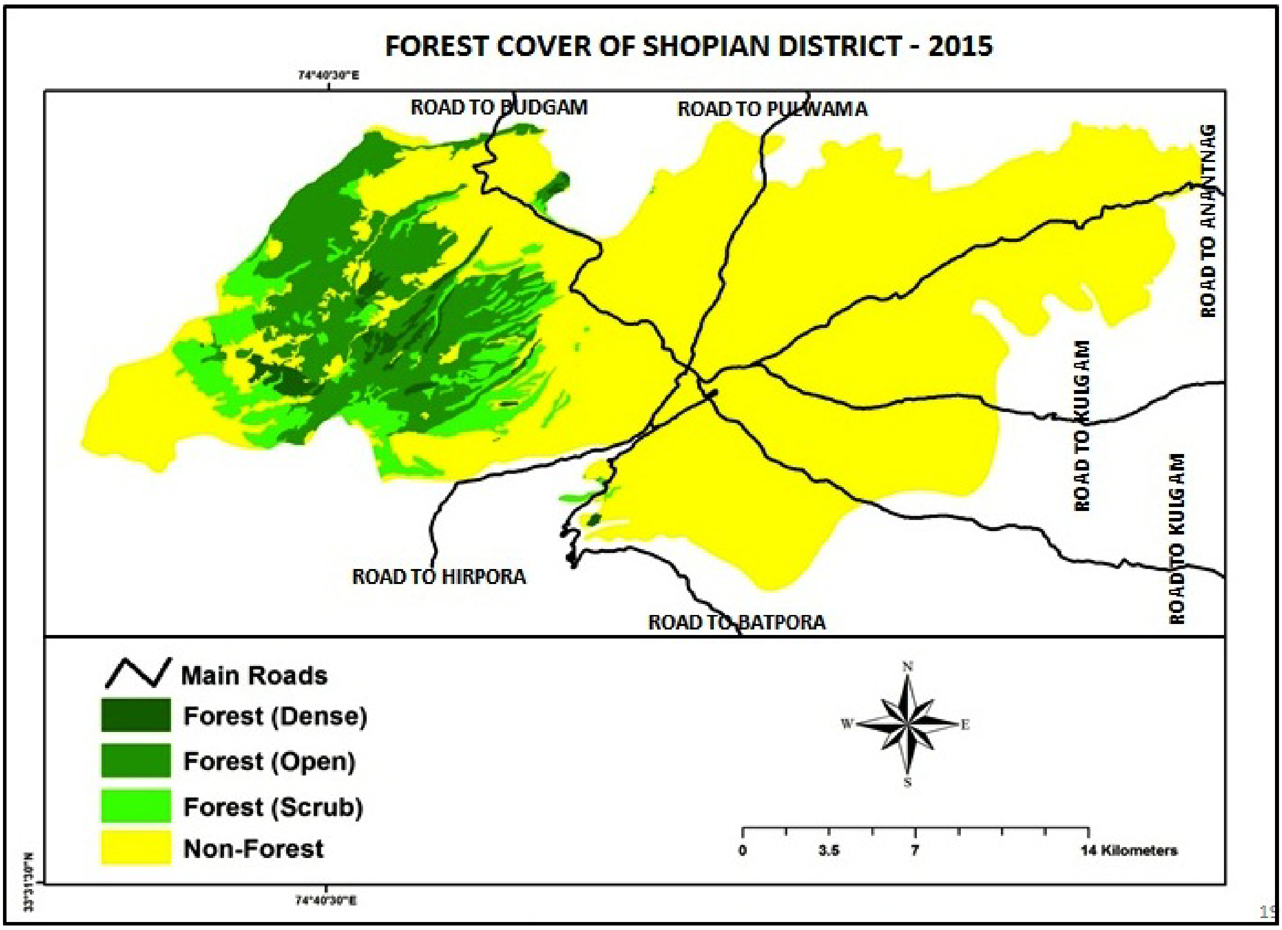

Figure 7. FOREST COVER OF SHOPIAN DISTRICT – 2015

Table 3. Srinagar City: Land Use/Land Cover (1995 & 2015)

Land use/ Land cover	**1995 (Area in Km^2)**	**2015 (Area in Km^2)**	**Area change (in Km^2)**	**% age Change**
Forest (Dense)	23.46 (4.26%)	8.50 (1.54%)	-14.96	-63.76
Forest (Sparse)	89.42 (16.25%)	73.69 (13.39%)	-15.73	-17.59
Forest (Scrub)	24.37 (4.43%)	39.51 (7.18%)	15.14	62.12
Agricultural Land (Single Crop)	22.31 (4.05%)	27.69 (5.03%)	5.38	24.11
Agricultural Land (Double Crop)	163.83 (29.78%)	142.01 (25.82)	-21.82	-13.31
Plantation/Orchards	128.8 (23.41)	135.39 (24.61%)	6.59	5.11
Built Up	11.57 (2.10%)	20.7 (3.76%)	9.13	78.91
Grassland	14.60 (2.65%)	13.54 (2.46%)	-1.06	-7.26
Wasteland	29.35 (5.33%)	46.33 (8.42%)	16.98	57.58
Snow/Glacial Area	21.79 (3.96%)	22.15 (4.02%)	0.36	1.65
Water Bodies	20.50 (3.72%)	20.50 (3.72%)	0.00	---
TOTAL	550	550		

Note: Area in Square Kilometers.
SOURCE: Based on Landsat-4 TM 1995 and IRS-1D LISS III 2015 satellite imageries of Shopian District.

The decrease in the area under forest (sparse) has been a boon for the area under agriculture land (Single Crop) in the north-western hilly parts of the district. Therefore the area under this class increased from 22.31 Sq. Km in the year 1995 to 27.69 Sq. Km in 2015 (increased by 24.11 %). In this area, forest (sparse) and forest (scrub) was cleared for the agricultural activities. Contrary to it, the area under agricultural land (double crop) has significantly decreased from 163.83 Sq. Km in the year 1995 to 142.01 Sq. Km in 2015 (decreased by -13.31 %). These areas include in Krawora, Nowpora and Kelro Malik Gund villages in the central part; Ura Pora, Drawni, Wadipora and Sofipora villages in eastern part and Nowgam, Reshnagri, Kanjiular, Adijan Adwan, Posh hamah and Mandojan Pursu villages in southern parts of the study area. The decrease is because of the shift of the farmers from the traditional crop growing activities to the horticulture activities. Since Shopian district has rich fertile soil for horticulture activities in the state of Jammu and Kashmir, therefore the horticulture suited products have turned to be more remunerative than the crop growing activities. These activities have led to the increase in the land area under plantaion/orchards from 128.8 Sq. Km in 1995 to 135.39 Sq. Km in 2015 (increase of 5.11 %). Similarly the area under built-up land use has almost doubled from 11.57 Sq. Km to 20.7 Sq. Km from the year 1995 to 2015 (increased by 78.91%). The increase was witnessed prominently in Pahano, Archana, Sangren, Lara Gam, Lawahend, Shupiyan (NAC) and Gagren villages in central part and Nowgam, Reshnagri, Dangam, Hadigam, Nilwa and Feripora in the south and south-eastern part. Only few sparsely distributed settlements were observed in the western hilly part of the study area. Due to the limitations in the spatial resolution of the available data those settlements could not be mapped.

The area under rich alpine grassland has slightly decreased by 1.06 Sq. Km during the study period. This could be attributed to the interpretation error occurred during the onscreen digitization of the coarse resolution land sat data. These high altitude grasslands were observed in the forest area in the west. The study found that there has been a decrease of 1.06 Sq. Km area under this land use/cover type during the study period of 20 years. Apart from it, the area under wasteland has increased significantly from 29.35 Sq. Km in the year 1995 to 46.33 Sq. Km in 2015 (increased by 57.58 %). This increase has been witnessed in Day Gam, Pahali Pora, Tharan Kandi, Katho Halan, Manio, Makan-i-Douaro villages in the western part of the study area. Similarly the area under snow/glacial area has marginally increased from 21.79 Sq. Km to 22.15 Sq. Km. Such increase is because of the slight seasonal variation in the satellite data used. Lastly, the total area under water bodies (20.50 Sq. Km) has remained unchanged during the study period. Rambiara and other small tributaries of Jhelum river are the important water bodies of this district.

5. Forest Area Change Detection of Shopian District

Normalized Differential Vegetation Index (NDVI) for the study area was calculated for the year 1995 and 2015. The aim was to validate the above changes in land use/cover specifically the changes in the area under forest land use. Vegetation index reflects the approximation relation between the spectral response and vegetation cover. This helped in assessing the degradation both in quality as well as the areal extent of the vegetation. The changes in vegetation index reflected the changing process of land use/cover (Figure 8 and Figure 9). NDVI = (near I.R - Red)/(near I.R + Red). The sub-scene bands 4 and 3 for Landsat-4 TM data and band 3 and 2 for LISS III data were used to create an NDVI image for the respective year. Later the change detection was carried out in two time period NDVI images by differencing them by subtraction of the 2015 NDVI image from the 1995 NDVI image using an image calculator in the software. Statistics (Table 4 and Table 5) shows the histogram data for NDVI difference (NDVI 1995-NDVI 2015). The statistics figure out the positive mean of NDVI difference of +0.076, which indicates the decrease in the spectral response of the vegetation. Thus it was deduced that the vegetation of the study area has degraded both in area as well as terms of its quality.

Table 4. NDVI results under frequency classes

Class	Lower Limit	Upper Limit	Frequency	Cumulative Frequency
1	-0.942	-0.826	85	722
2	-0.826	-0.719	637	2250
3	-0.719	-0.618	1613	4774
4	-0.618	-0.525	3161	10998
5	-0.525	-0.426	7837	23825
6	-0.426	-0.325	15988	63348
7	-0.325	-0.219	47360	242411
8	-0.219	-0.119	195051	1364247
9	-0.119	-0.016	1169196	3862428
10	-0.016	+0.091	2693232	3264148
11	+0.091	+0.184	570916	583514
12	+0.184	+0.285	12598	14862
13	+0.285	+0.391	2264	2653
14	+0.391	+0.488	389	456
15	+0.488	+0.544	67	126

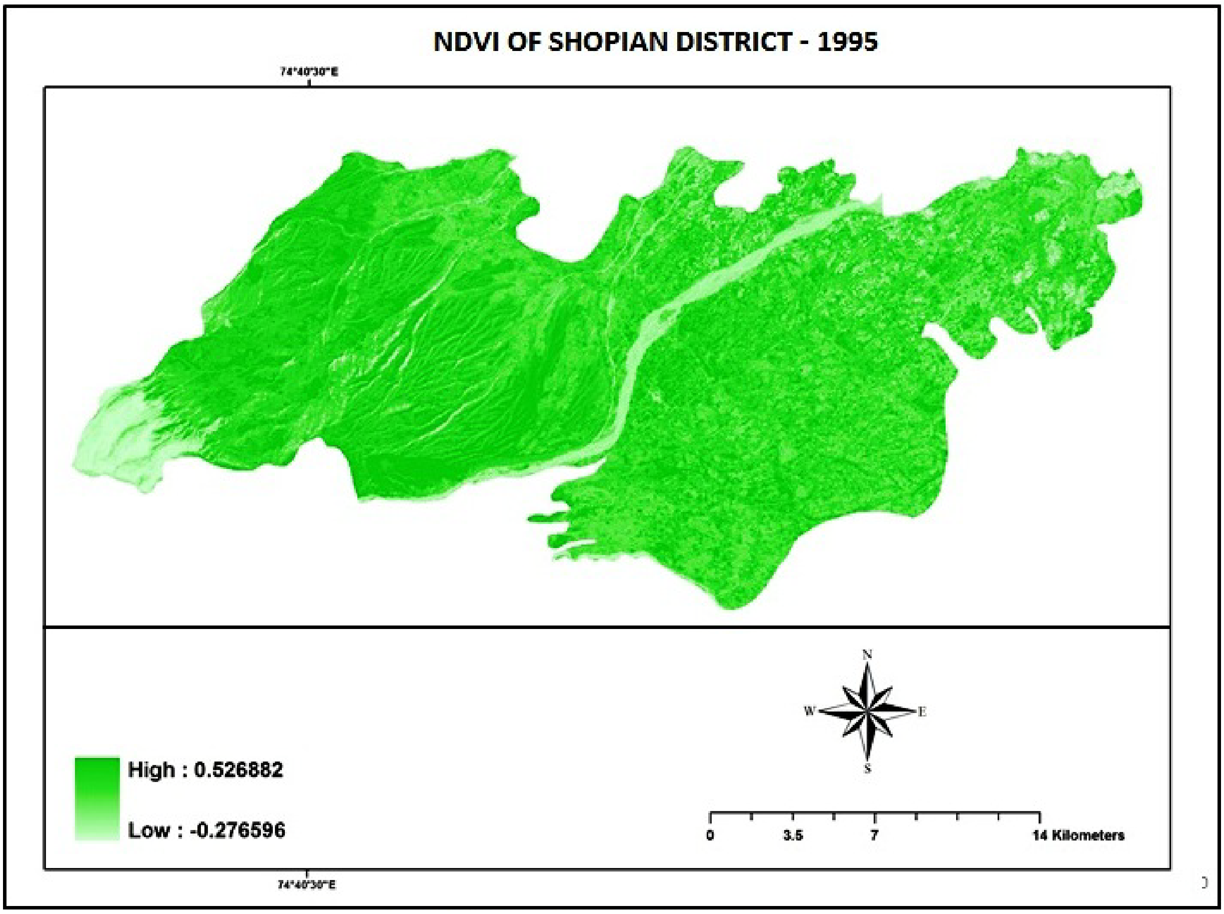

Figure 8. NDVI OF SHOPIAN DISRICT – 1995

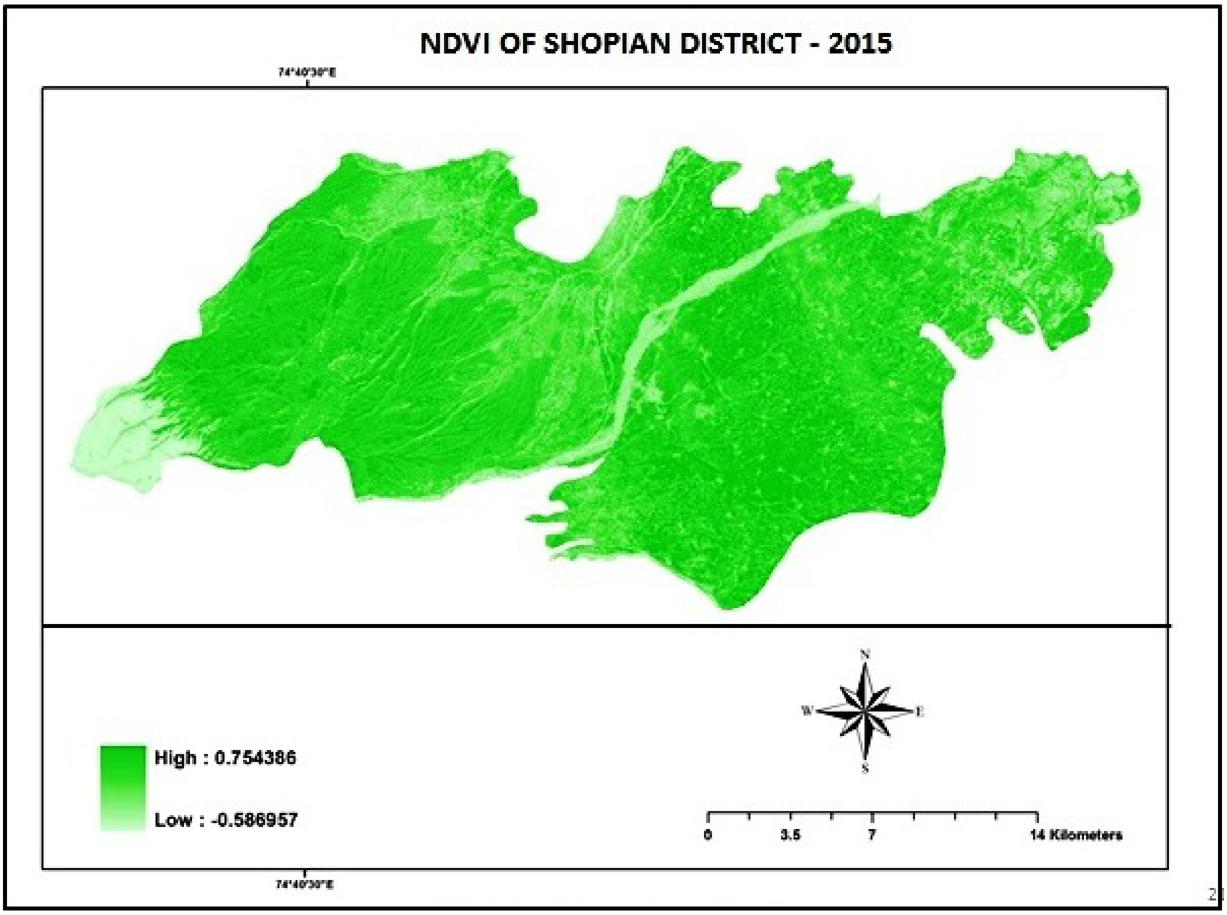

Figure 9. NDVI OF SHOPIAN DISRICT – 2015

Table 5. Statistical parameters of NDVI results

Actual Maximum	0.544
Mean	+0.076
Standard Deviation	0.090

6. Forest Land Fragmentation in Shopian District

The landscape fragmentation analysis distinguished the forest pattern of the study area into four classes; Core forest, Patch forest, Perforated and Edge forest (Table 6). “Core forest” is relatively far from the forest–non-forest boundary and ‘patch forest’ comprises coherent forest regions that are too small to contain core forest. ‘Perforated forest’ defines the boundaries between core forest and relatively small perforations, and ‘edge forest’ includes interior boundaries with relatively large perforations as well as the exterior boundaries of core forest regions [22].

The forest fragmentation during the study period of 20 years is shown in Figure 10. The respective changes in the forest classes from the year 1995 to 2015 are given in statistics (Table 7). From the statistics it is evident that the total area under forest has declined by -15.46 % during the study period. The area under core forests which are non-fragmented forests shows -16.90 % decrease, whereas core forests with area less than 250 hectares increased by 33.60 %. Perforated forest increased by more than 10 %, while edge forest and the exterior boundaries of core forest regions shows -5 % decrease. The increased perforation in the interior forest areas indicates the widespread degradation of the tree cover.

Table 6. Forest landscape fragmentation classes and criteria for their categorization.

S. No.	Class	Criteria
1.	Patch	Small pixels that area not degraded by “edge effect”
2.	Edge	Forest pixels along the exterior perimeter of a forest that are degraded by the “edge effect”
3.	Perforated	Forest pixels along the edge of an interior gap in a forest that are degraded by “edge effects”
4.	Core	Forest pixels that are not degraded by “edge effect”
	• Small core	smaller than 250 acres
	• Medium core	between 250 and 500 acres
	• Large core	larger than 500 acres

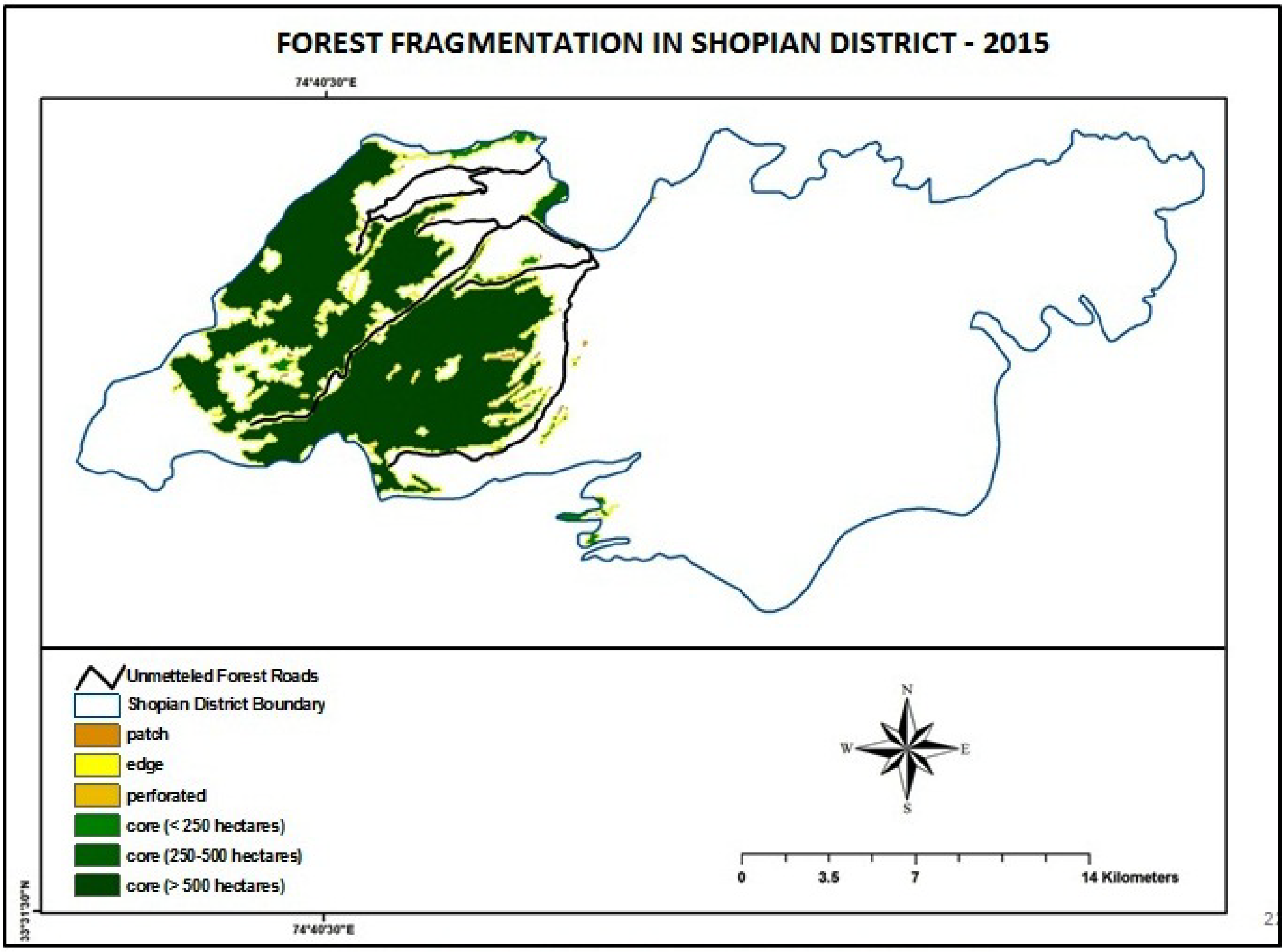

Figure 10. FOREST FRAGMENTATION IN SHOPIAN DISTRICT - 2015

Table 7. Changes in different classes of forest pattern in district Shopian in 1995 and 2015

S. No	Classes of Forest pattern	Area in 1995	Area in 2015	Change	% age change
1	Patch	33.11	48.3	15.19	45.88
2	Edge	1737.2	1650.2	-87	-5.01
3	Perforated	102	113.14	11.14	10.92
4	Core (<250 hectares)	168	225	57	33.93
5	Core (250 - 500 hectares)	270.5	102	-168.5	-62.29
6	Core (>500 hectares)	12018	9987	-2031	-16.90
	Total	**14328.81**	**12125.64**	**-2203.17**	**-15.38**

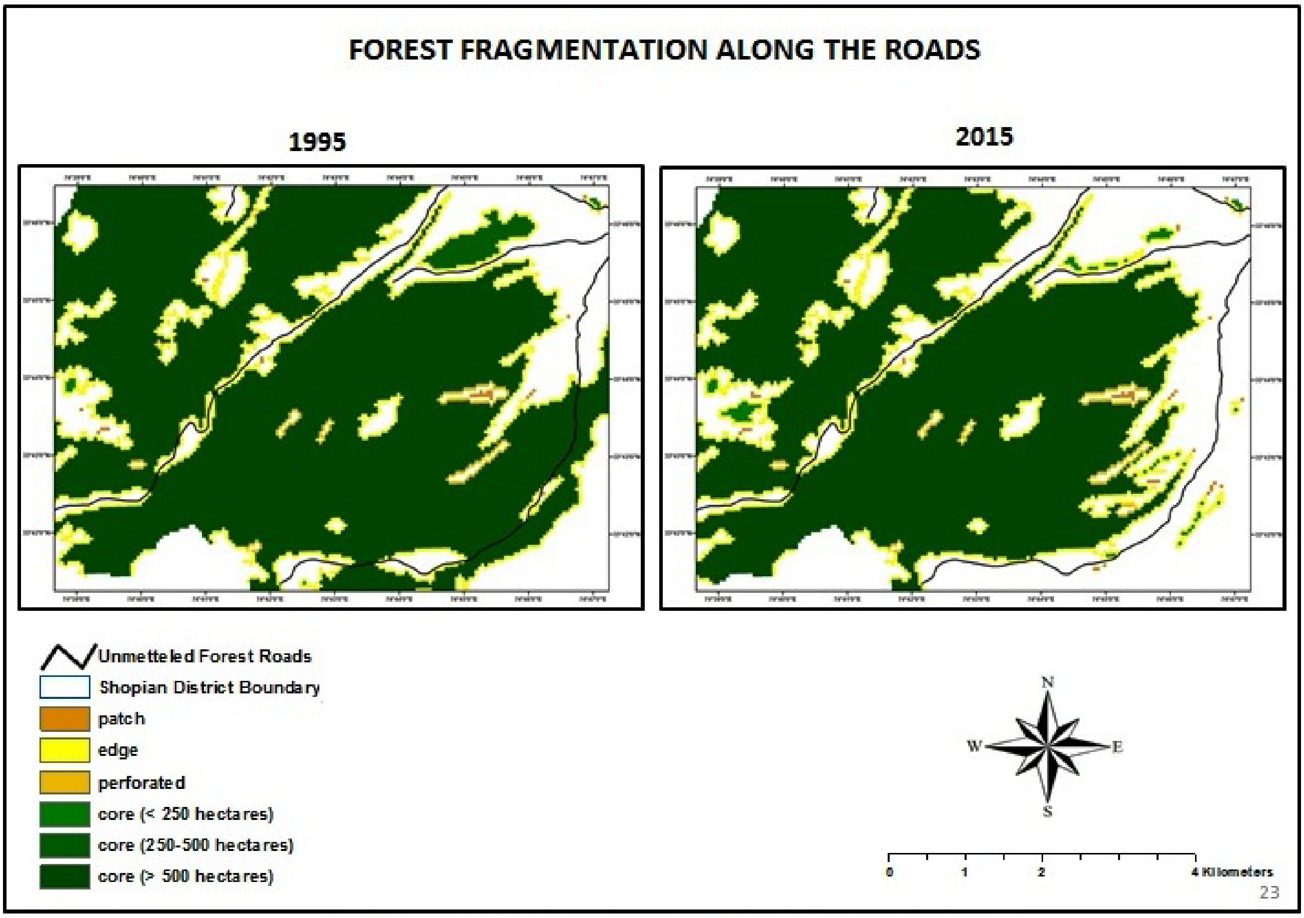

Figure 11. FOREST FRAGMENTATION ALONG THE ROADS – 1995 & 2015

Core forest between 250 and 500 hectares witnessed significant decrease of -62 % during the study period thereby validating the degradation of dense forest. Apart from this, the patch areas that are not degraded by edge effect have increased by 45.84 %. The fragmentation map suggests that the local people and the timber merchants access the forest through eastern part of forest area. It was also observed that the forest land has been fragmented mostly along the roads. Therefore it can be deduced that the existing roads in the forest area of the Shopian district provides an easy access to the forest and hence leads to the fragmentation of its land area. The map illustrates the development of the edges from simple lines and curves to more complex elongated boundaries which validates the anthropogenic pressure. Such changes have been shown in Figure 11 where the same road is crossing the forest area at different time periods.

7. Conclusions

The rapid rate of deforestation in Shopian forests is leading to widespread forest land fragmentation. The study revealed the significant increase in the total area under built-up (78.91% increase), agriculture (single crop) (24.11% increase), plantation/orchards (5.11% increase) at the cost of agriculture (double crop) and forest cover, which decreased by -13.31% and -11.67% respectively. The main emphasis of this study was to assess the forest degradation therefore further classification of forest class showed the decrease in area under forest (dense) (-63 %) and forest (sparse) (-17.59 %) class which testifies the extent of degradation during the past two decades. Apart from the decrease in the total area under forest cover, Shopian forest has witnessed significant decrease in the forest density. This forest area is dissected by many types of roads; unmetalled village roads, cart track and foot paths which help in easy access for the local people and the outside timber smugglers into the forest area. The study further calculated vegetation index for the entire study area and the results show a positive mean of 1995-2015 NDVI differencing which indicates the decrease in the area under vegetation cover in the past two decades.

Further the qualitative analysis of forest degradation through landscape analysis tool showed the decrease of -16.90 % in core forest area of more than 500 hectares and the increase of 33.60 % in the area under core forest of less than 250 hectares category. This indicated the decrease in the forest density. The increase in the area under perforated forest also indicated the increase in forest land fragmentation prominently in the eastern part of the forest area characterised with low to moderate slopes. These areas in the east form the access points or the axis of deforestation in Shopian forest area. Landscape fragmentation tool helped both in locating the places and quantifying forest land fragmentation. The landscape became more fragmented where the area under perforation and number of smaller patches increased, whereas the core area of larger patches decreased during the study period. Therefore the above quantitative and qualitative analysis concludes that the forest area of Shopian district is facing degradation at an alarming rate which needs to be stopped.

References

[1] Aasim M, Farooq M, Amin A, Rashid H. GEOSPATIAL MONITORING OF FORESTS A CASE STUDY OF PIRPANJAL FOREST DIVISION, J&K, International Journal of Remote Sensing & Geoscience, vol 3(3), pp. 16-25, 2015.

[2] Amin, A. and Fazal, S. Land Transformation Analysis Using Remote Sensing and GIS Techniques (A Case Study). *Journal of Geographic Information System,* 4, pp. 229-236, 2012.

[3] Collingham Yc, Huntley B. Impacts of habitat fragmentation and patch size upon migration rates. Ecol Appl 10: 131-144, 2000.

[4] Fahrig L. Effects of habitat fragmentation on biodiversity. Annu Rev Ecol Evol S 34: 487-515, 2003.

[5] FAO, State of the world's forests, Food and Agriculture Organisation of the United Nations, Rome, 1997.

[6] Fazal, S and Amin, A. Impact of Urban Land Transformation on Water Bodies in Srinagar City, India. Journal of Environmental Protection, 2 (2), pp. 142-153, 2011.

[7] Forman, T. T. and Sperling, D., Road Ecology. Science and Solutions, Island Press, Washington, DC, p. 481, 2003.

[8] Jensen, J. R. Introductory digital image processing: a remote sensing perspective. Englewood Cliffs, N.J., Prentice-Hall, 1986.

[9] Thomson M. J.. Forest Fragmentation, Federation of Ontario Naturalists (FON) www.ontarionature.org, 2015.

[10] Mitch and Gosselink. Landscape Ecological Planning Through a multi-scale characterization of pattern: Studies in Western Ghats, South India. Environ. Monit. Assess. pp. 215-233, 1993.

[11] Myers, N. TROPICAL FOREST: the main deforestation fronts. Environ. Conserv., 1993, 20, 9-16. NASA, Tropical deforestation. NASA facts, FS-1998-11-120- GSFC, National Aeronautics and Space Administration, Goddard Space Flight Center, 1998.

[12] Negi S.S. Forest policy and five year plan, A Handbook of Forestry, IBH Dehradun pp. 102-120, 1986.

[13] Parent, J. Landscape Fragmentation Analysis (version 2) University of Connecticut Press, USA, 2009.

[14] Richards, J.F and Flint E.P. Historical land use and carbon estimates for South and South east Asia 1880-1980, in Daniel R.C. (Ed.), ORNI/CDIAC-61, NDP-046. Oak Ridge National Laboratory, Tennessee, U.S.A. pp. 326, 1995.

[15] Roy P.S, Murthy M.S.R, and Roy A, et al. Forest Fragmentation in India, Current Science, vo 105(6), pp 774-780, 2013.

[16] Roy, P. S. and Roy, A.. Land use and land cover change in India: a remote sensing & GIS perspective. *J. Indian Inst. Sci.*, 90, 489-502, 2010.

[17] Sarma, V.V.L.N., Murali Krishna, G., Hema Malini, B., & Nageswara Rao, K. Land-use/Land-cover Change Detection through Remote Sensing and its Climatic Implications in the Godavari Delta Region, Journal of the Indian Society of Remote Sensing. Vol. 29, No.1&2, 2001.

[18] Sarmah K., Jha L.K. and Tiwari B.K. Spatio-temporal changes in land uses and land cover due to human interference in Meghalaya, India: A case study of Wah Shella microwatershed, Journal of Geography and Regional Planning, Vol. 4 (6), Pp. 338-343, 2011.

[19] Skole, D. and Tucker, C.. Tropical deforestation and habitat fragmentation in the Amazon: satellite data from 1978 to 1988. Science, 260, 1905-1910, 1991.

[20] Tian H, Banger K, Bo T and Dadhwal Vk. History of land use in India during 1880-2010: Large-scale land transformations reconstructed from satellite data and historical archives, Global and Planetary Change, vol 121, pp. 78-88, 2015.

[21] Vital Forest Graphics. UNEP United Nations Forum on Forests. pp. 4, 2009.

[22] Vogt, P., Riitters, K. H., Estreguil, C., Kozak, J., Wade, T. G. and Wickham, J. D. Mapping spatial patterns with morphological image processing. Landscape Ecology, 22,171-177, 2007.

[23] Wilcove Ds, Mclellan Ch, Dobson Ap. Habitat fragmentation in the temperate zone. In: Soul´e ME (ed) Conservation Biology: The Science of Scarcity and Diversity. Sinauer Associates Inc., Sunderland, 1986.