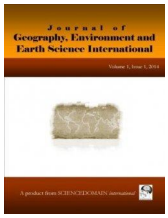

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Land Use Land Cover Change Detection & Urban Sprawl Study: A Case Study on Shimla Tehsil, Himachal Pradesh, India

C. Prakasam[1*], R. Aravinth[1] and Varindar S. Kanwar[1]

[1]Department of Civil Engineering, Chitkara University, Himachal Pradesh, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author CP designated the nature of study and study area. Author RA carried out the core research regarding data analysis and results and wrote the final draft of the manuscript. Author VSK helped in providing valid literature resources. All the authors read and approved the manuscript.

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ABSTRACT

Land is the most important natural resource containing soil, water, flora & fauna involving total ecosystem. Mapping of Land use and Land cover change is essential for a wide range of applications such as landslide and erosion control, land planning etc. In this research land use change and urban sprawl has been studied for period of 37 years (1980-2017) using remote sensing and GIS techniques in Shimla Tehsil, Himachal Pradesh. The images are layer stacked and supervised classification technique is adopted to the LANDSAT images between 1980 to 2017. Image classification is carried out using Level 1 NRSC Land use classification system. The acquired output is reclassified and change detection was obtained for every consecutive images and overall changes were acquired by comparing 1980 and 2017 satellite imageries. Accuracy assessment was carried out for the year 2017. 100 random reference points were generated from the classified image of 2017 and cross-correlation has been carried out against the unsupervised classification of the same temporal data. Overall classification accuracy of the image is 92% with kappa statistics of 0.87. Change detection was carried out between the year 1980 and 2017. The

**Corresponding author: E-mail: cprakasam@gmail.com;*

results obtained indicates a greater change in the growth and declination of forest cover in the study area. Forest cover reduced from 81.58% in 1980 to 60.77% in 2017. Same way Built-up land has increased from 3.59% to nearly 13.64% in the year 2017. Agriculture practice has also increased from 1.91% to 16.51% in the year 2017. Slope area that represents the barren land in the study area is reduced from 12.9% to 9.09% in 2017.

Keywords: Land use; land cover; supervised classification; digital image processing; change detection.

1. INTRODUCTION

Humankind has been changing the environment for a long time to suit their own needs such as procuring products like food, fiber, Timber, Medicinal herbs etc. This pace is greatly accelerated in the last three centuries since the industrial revolution. The change in Land Use Land Cover pose a great threat globally as humankind change the environment to suit them it also leads to the endangerment of particular ecosystem or biodiversity of that area [1]. Land use and Land cover are two different terminologies that are often used together [2,3]. Land cover refers to the physical characteristics of the earth surface such as Forest, Waterbodies, Soil and Vegetation etc. Land use refers to the land used by humans and their habitat for social and economic activities [4]. As a result of increased population pressure and economic development in terms of Urbanization and Industrialization and conversion of various land for agricultural purposes leads to overexploitation of land resources which leads to land degradation [5]. Land degradation is the result of immense population pressure that leads to improper Land use without proper management practices [6]. Urbanization takes places in two different ways, either in radial direction around a well-established city or along the highways. This kind of dispersed development is called urban sprawl [7]. A wide section of people lives along the margin of urban cities, towns and residential areas. People from urban areas are more engaged in Industrial and IT sectors. Also, the cities have been regarded as the center of Cultural, Social, Intellectual and a major economic development of any countries [8]. By the year 2030, nearly 60% of the population will live in urban areas and most of them will be in developed countries [9].

[10] quoted that change detection is the study of change in an object or Phenomenon over time. The fundamental study of the Land use and Land cover and Urban sprawl is to understand the social and spatial changes of a particular area so that suitable proposals can be made on the use of land and mode of development. Many researchers have previously studied the importance of Land Use Land Cover in the past. [11] studied the behaviour of Land use and Land cover along Vamanapuram river basin, southern Kerala, India. [12] studied the Land use and Land cover with special reference along the Mandovi-Zuari Estuarine complex in Goa. to mangrove changes [13] study the relationship between Land use changes and change in water flux for Sal watershed in Chamba region. [14] studied Land use changes for Mandhala watershed located in Solan district. He concluded that the forest area has reduced from 90% at the year 1972 to 30% during 2007. [15,16] studied Land use and Land cover changes for Kinnaur and Kullu districts of Himachal Pradesh respectively. Present study has been carried out to assess the Land use and Land cover change and monitor urban sprawl of Shimla Tehsil, Himachal Pradesh. The Shimla Tehsil includes a subjective number of problems such as rapid growth of city, aggravated forest degradation and unsustainable slopes etc. The study has been conducted to better understand of LULC change and urban sprawl assessment.

The objective of the research is to study temporal changes in LULC for the year 1980, 1989, 2001, 2010 and 2017 and to assess the transformation in LULC between 1980 and 2017. The research also aims to produce change detection map of forest cover and urban sprawl.

1.1 Study Area

Shimla Tehsil is located between 30°59'3" to 31°14'10" North latitude and 76°58'19" to 77°19'21" East longitude. It covers a total area of 418 sq.km. As of 2011 Shimla Tehsil consist of Five hundred seventy-six villages [17]. Shimla Tehsil can be divided into Shimla rural and Shimla urban. As of 2011 census data the total population of Shimla tehsil is 1,71,640 people, among which 1,69,578 of them reside in Shimla

municipal corporation and 2,062 of them belong to Shimla Rural monitored by Jutogh cantonment board. Literacy rate of Shimla Tehsil stands at 93.63% which is higher than the state average 82.8%. Shimla municipal corporation accounts for about 35 sq.km of the total area. The highest altitude of Shimla is at 2454 meters at Jakhoo hills [18]. Three rivers drain through Shimla namely Sutlej, Pabbar and Giri. As of 2017 Shimla Tehsil covers about 60% of the forest which constitutes both (dense, Moderate and open forest) and 13% of the area comes under Built-up lands including (Settlements, Factories and Recreational areas). Some of the major forest produce of this area are Timber and Charcoal. Besides major produce some resins, Grass, Medicinal herbs and Bamboos are also produced in Minor Quantity [19]. Agriculture and Horticulture are the important economic activities of Shimla. Most of the area under Agriculture in Shimla district are rain-fed. The season is suitable for growing types of cereals, off-season vegetables, temperate and stone fruits. The soil is sandy loam at the valleys and Skeletal in the mountainous areas. Geologically, the rock formations in Shimla district ranges from Pre-Cambrian to Quaternary period. The climate is Sub-tropical in the valleys and temperate in the hilltops. The average annual rainfall of the district is 999.4mm out of which 75% occurs during the monsoon period June to September [20]. The temperature can go as low as 0°C during winter times and as much as 40^0c during summer times. The study area is given in Fig. 1.

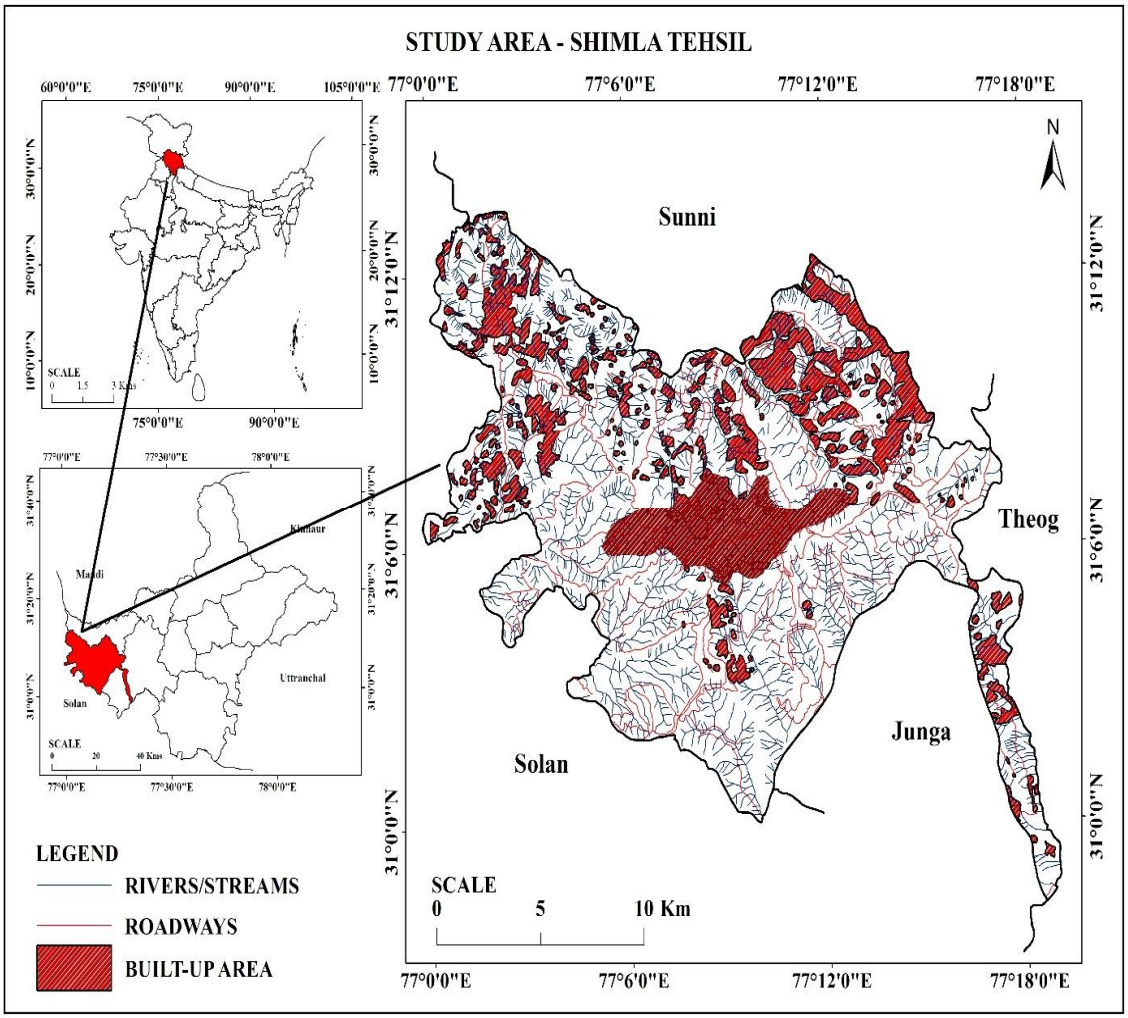

Fig. 1. Study area

Table 1. Data source

S. no	Data	Source	Year	Resolution
1	Landsat MSS	Earth explorer (USGS)	22/10/1980	70 mts
2	Landsat MSS	Earth explorer (USGS)	16/04/1989	70 mts
3	Landsat 7 ETM+	Earth explorer (USGS)	21/12/2001	30 mts
4	Landsat TM	Earth explorer (USGS)	03/10/2010	30 mts
5	Landsat 8 OLI	Earth explorer (USGS)	17/10/2015	30 mts
6	Landsat 8 OLI	Earth explorer (USGS)	06/10/2017	30 mts

1.2 Data Used

The base map was created using Survey of India Topographical map with the scale of 1:50,000. To study the change detection analysis different periods of satellite data i.e - LANDSAT MSS, TM, ETM+ and LANDSAT 8 OLI were selected for the year 1980, 1989, 2001, 2010, 2015 and 2017. Table 1 depicts the data used.

2. MATERIALS AND METHODS

The base map was prepared from the Survey of India topographical maps with the scale of 1:50,000. The satellite imageries were downloaded from United States Geological Survey (USGS) website for six different years. The False color composite images (FCC) were created in GIS environments for respective years. The image was subset using Tehsil boundary and Image analysis was carried out. The FCC images of each year have been used to create training sets for various Land use categories. Supervised classification technique using maximum likelihood classifier method had been used to study change detection analysis. The images are classified using National Remote Sensing Centre (NRSC) Level 1 classification system. Fig. 2 describes the overall methodology.

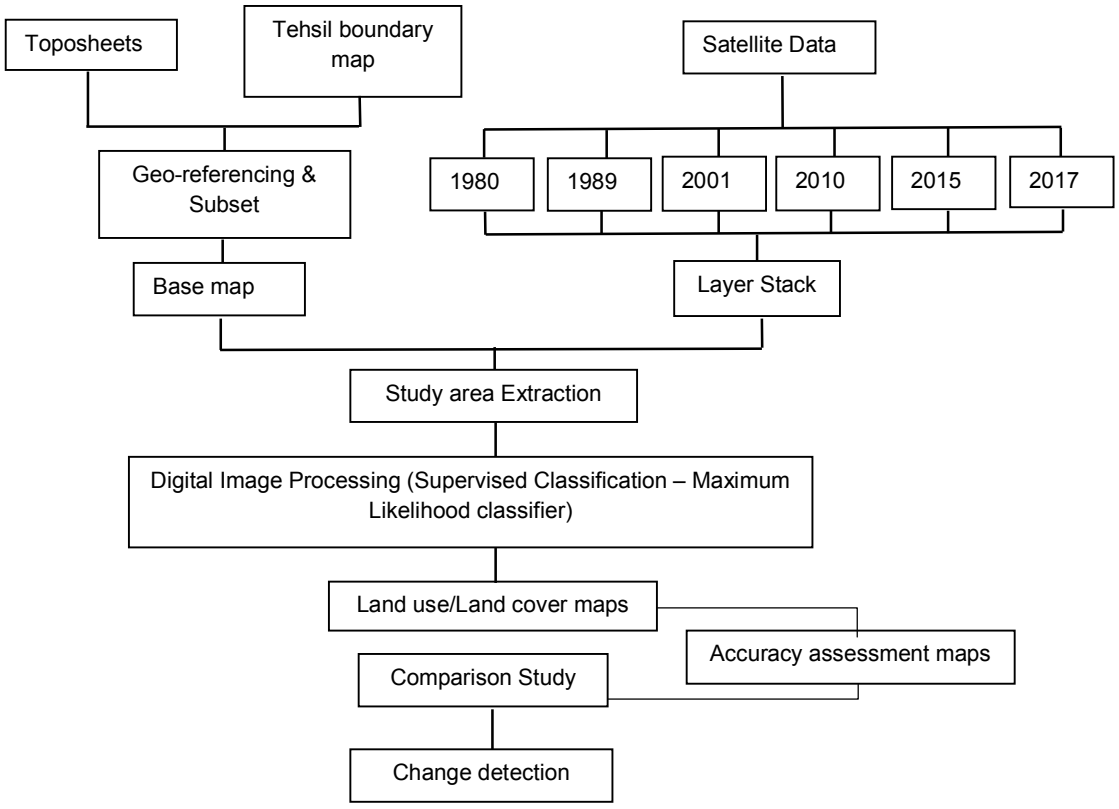

Fig. 2. Methodology

Table 2. NRSC, India (Land Use Classification)

Sl. no	Level 1	Level 2	Level 3
1	Urban	Urban	Residential, Mixed, Communications, Public utilities, Transportation, Vegetated area, Industrial/Mine dump
		Rural	Rural
		Mining	Mine/Quarry, Abandoned Mine Pit, Landfill area
2	Agriculture	Cropland	Kharif, Rabi, Zahid, Two cropped, More than two
		Plantation	Plantation-Agriculture, Horticulture, Agro Horticulture
		Fallow	Current and Fallow
		Current Shifting cultivation	Current Shifting cultivation
3	Forest	Evergreen / Semi-Evergreen	Dense, Closed and Open
		Decidious	Dense, Closed and Open
		Forest Plantation	Forest Plantation
		Scrub Forest	Scrub Forest, Forest Blank, Current and Abandoned Shifting Cultivation
		Swamp / Mangroves	Dense, Closed and Open Mangrove
4	Grazing	Grass / Grazing	Alphine, Sub-Alphine, Temprate/Sub Tropical, Tropical / Desertic
5	Wasteland	Salt Affected Land	Slight, Moderate and Strong salt affected land
		Gullied / Ravinous Lnad	Gullied, Shallow ravine and Deep ravine area
		Scrub Land	Dense, Closed and Open
		Sandy Area	Desertic, Coastal and Riverine sandy area
		Barren Rocky	Barren rocky
		Rann	Rann
6	Waterbodies	Inland Wetland	Inland Naturaland nland Manmade Wetland
		Coastal Wet land	Coastal Natural and Coastal Manmade
		Rivers / Streams / Canals	Pernnial and Dry river/Stream and Line and Unlined canal/drain
		Waterbodies	Pernnial, Dry, Kharif, Rabi and Zaid extent of lake/pond and reservoir and tanks
7	Snow and Glacier		Seasonal and Permanent snow

3. RESULTS AND DISCUSSION

In the present study, Landsat satellite imageries for the period of 37 years (1980,1989, 2001, 2010, 2015 and 2017) were classified and compared for Land use and Land cover analysis. The results obtained through analysis of Multi-spectral satellite imageries were illustrated in the (Figs. 3, 4, 5). Fig. 6 depicts the change in Land use categories for the different year. Total area coverage of various Land use classes was provided in Table 2. A brief summary of the results was discussed in the following paragraph.

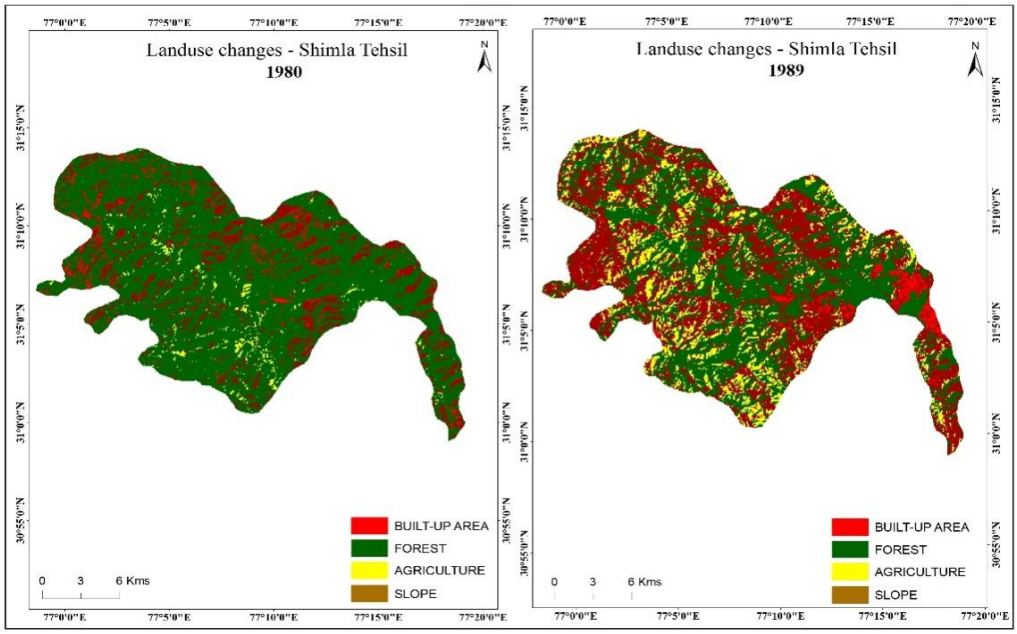

Fig. 3. Land use changes (1980 & 1989)

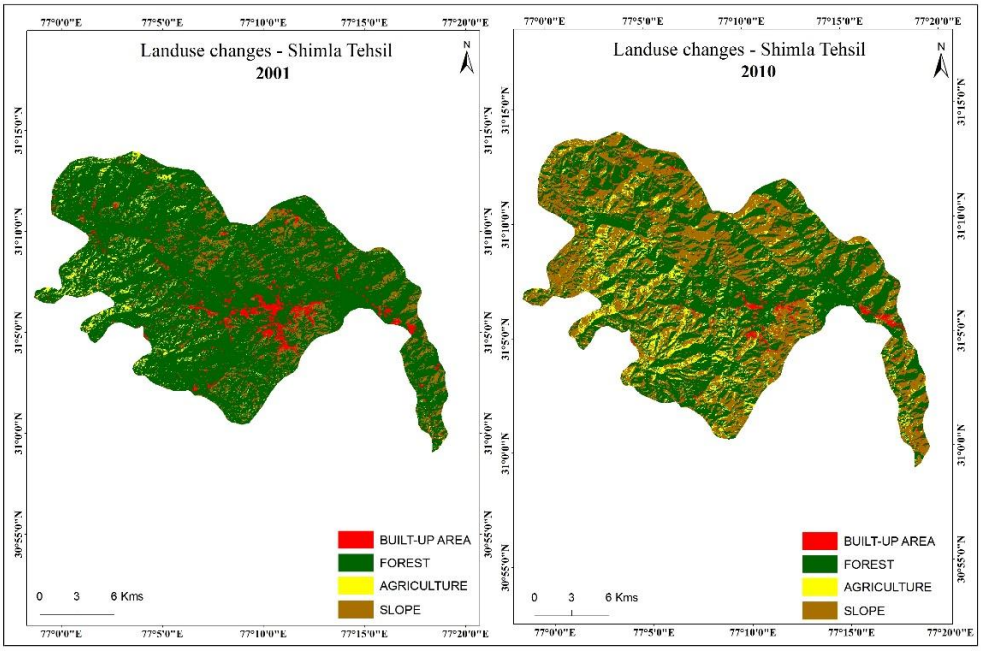

Fig. 4. Land use changes (2001 & 2010)

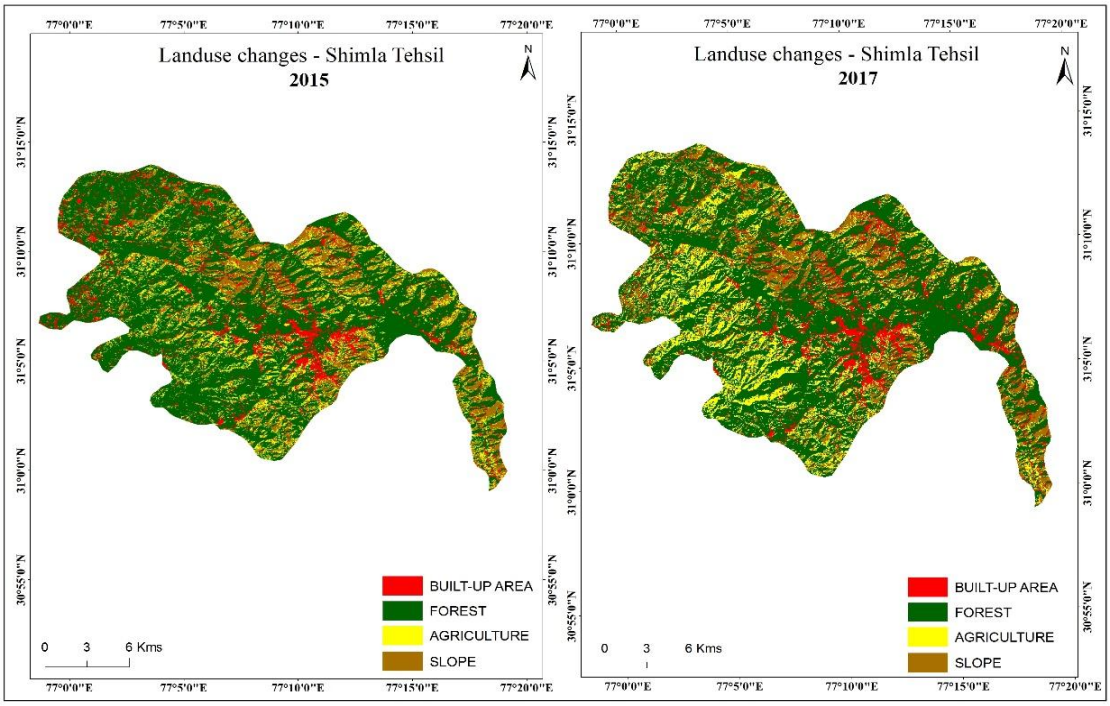

Fig. 5. Land use changes (2010 & 2017)

Table 3. Area coverage of Various LULC categories

S. no	Class / Year	1980	1989	2001	2010	2015	2017
	Area	Hectares	Hectares	Hectares	Hectares	Hectares	Hectares
1	Agriculture	800	2400	4000	4500	5600	6900
2	Forest	34100	31800	31300	29900	27800	25400
3	Build-up	1500	1900	2050	3100	4000	5700
4	Slope (Barren land)	5400	5700	4450	4300	4400	3800
	Total (Hectares)	41800	41800	41800	41800	41800	41800

(Source: Author calculation)

Most of the Shimla Tehsil composed of Very dense, Moderate dense and Open Forest (Himachal Pradesh forest department). During 1980 the forest covered about 34100 Hectares of the area (81.6%) had gradually decreased in subsequent years and during early 2001 the Forest cover reduced up to (31300 hectares). As of 2017 only 25400 Hectares (60.77%) of the area comes under Forest area. Since Shimla is one of the important tourist destination and recreational places. Built-up land that include Settlements, Industries, Government buildings and other recreational areas increased from 1900 Hectares (3.5%) to 5700 Hectares (13.64%) between the year 1980 and 2017. Built-up lands have increased drastically after the year 2010 from 31300 Hectares to 5700 Hectares in 2017. The main type of agricultural activity involves in growing various types of cereals, off-season fruits and vegetables. Agriculture was the main economically important activity in Shimla increased from 2000 Hectares (4.78%) of the total land area in 1980 to 6900 Hectares (16.5%) in 2017. The slope area depicts the barren land present along the hilly terrain was greatly reduced from 5400 Hectares (38.7%) in 1980 to 3800 Hectares (9.09%). The changes undergone by Shimla in each successive year is been demarcated in Figs. 4 and 5. Most of the slope areas are converted to settlements and other buildings for human purposes. Some of the slope have been converted to agriculture purpose. The total area coverage for the various year were given in Table 3 and Fig. 6 depicts the graph chart of the temporal variations of each LULC features between the year (1980 to 2017).

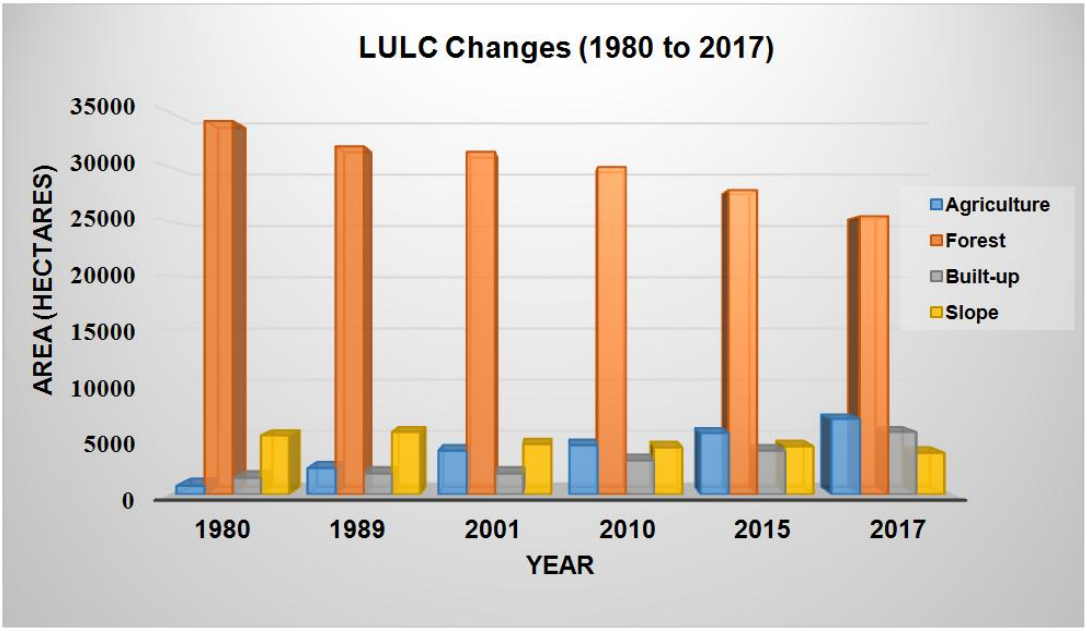

Fig. 6. Land use & Land cover (1980 to 2017)

In order to make sure the results are valid between the images used to obtain change detection results (1980 and 2017) an accuracy assessment has been carried out for those images. The accuracy assessment has been carried out by collection 100 random sample points from each supervised classification image and compare it with the values of unclassified image of the same year. The accuracy of the classified image stands at **92% and 88%** for the year 2017 and 1980 respectively. The Kappa statistics of the images are **0.87 and 0.61** for the year 2017 and 1980 respectively.

4. CHANGE DETECTION

Change detection was carried out between the year 1980 and 2017 to find the maximum change for various classes. The result revealed that Agriculture, Forest and Built-up land had more changes and slope also known as barren land along the hilly terrain had reduced to a certain extent. Nearly 55.85% of the forest remains same from 1980. 10.7% of the forest has been converted into Agriculture and 6.44% of the area has converted into built up area. 7.40% of the forest had been turned into slopes. Another major change observed in Slope to Agriculture were 4.77% of the area is converted into Agriculture from 1980 to 2017. 1.43% of the slope were converted to built-up land. Only 0.9% of the Built-up land had become slope.

The reduction of Built-up land to Slope can be attributed due to the numerous flash floods and Landslides occurring in the Shimla Tehsil. Recent landslides along the Parwanoo – Shimla National highway, September 2 Dhalli landslides that destroyed numerous buildings can be of some example [21,22,23,24]. The overall change in various class is depicted in Fig. 11. Fig. 7 represents the total forest reduction happened between 1980 to 2017. The forest cover reduced from 80% in 1980 to 60% in 2017. Fig. 8 represents that there is a negative trend in forest indicating a declination in forest distribution while Fig. 10 represents urban expansion which is represented in a positive trend that indicates a growth in urban expansion. Figs. 8 and 10 reveals the scatterplot analysis of both forest and Urban sprawl of Shimla Tehsil for the Year 1980 to 2017. Fig. 9 depicts the spatial distribution pattern of the Built-up land in Shimla Tehsil. The image reveals that most of the built-up lands were located closely to the National highways. From the analysis, it can be concluded that almost 81.5% of the area was covered by forest in 1980. By 2017, the percentage reduced to 60% showing a decrease in forest area by 20% in the last 37 years. The trend analysis indicates there was a gradual decrease in forest area. Built-up land has increased from 3.5% in 1980 to 13.6% in 2017. This growth rate is indicated by the positive trend analysis of Fig. 10.

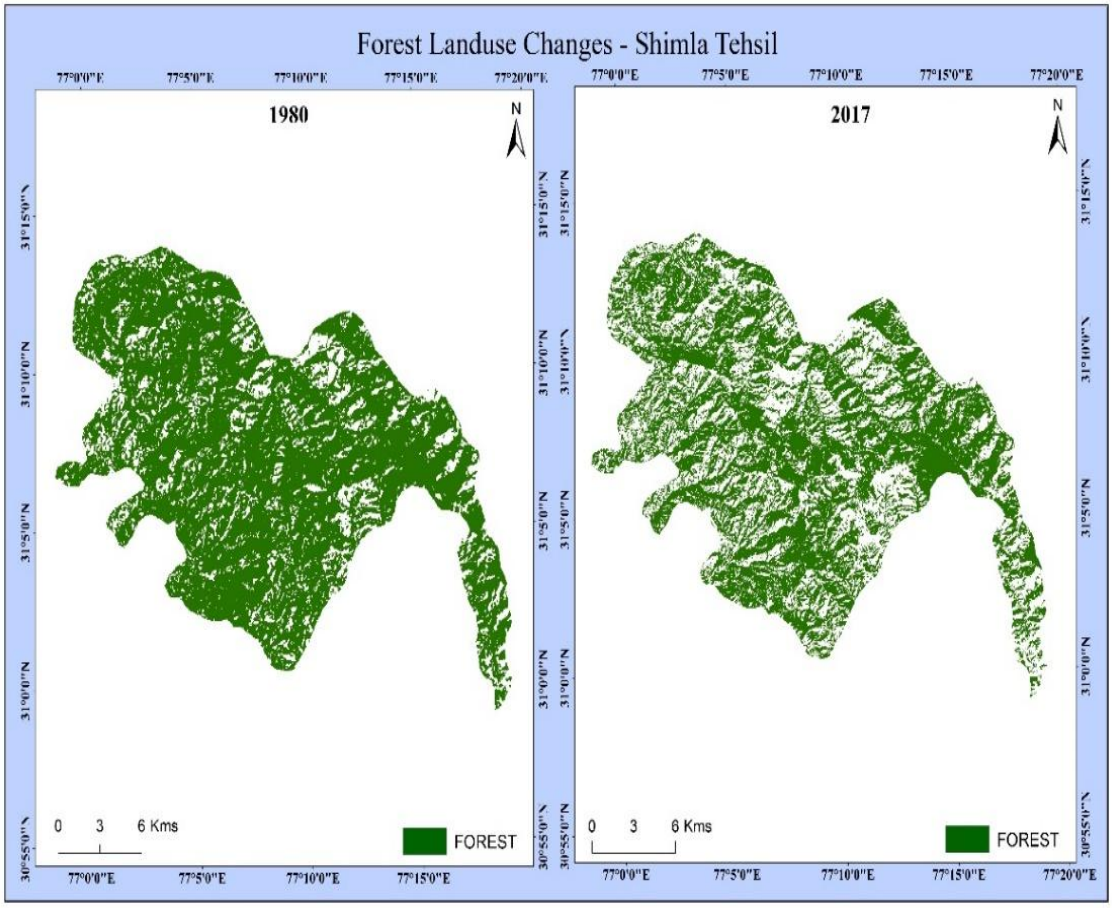

Fig. 7. Forest Land use changes 1980-2017

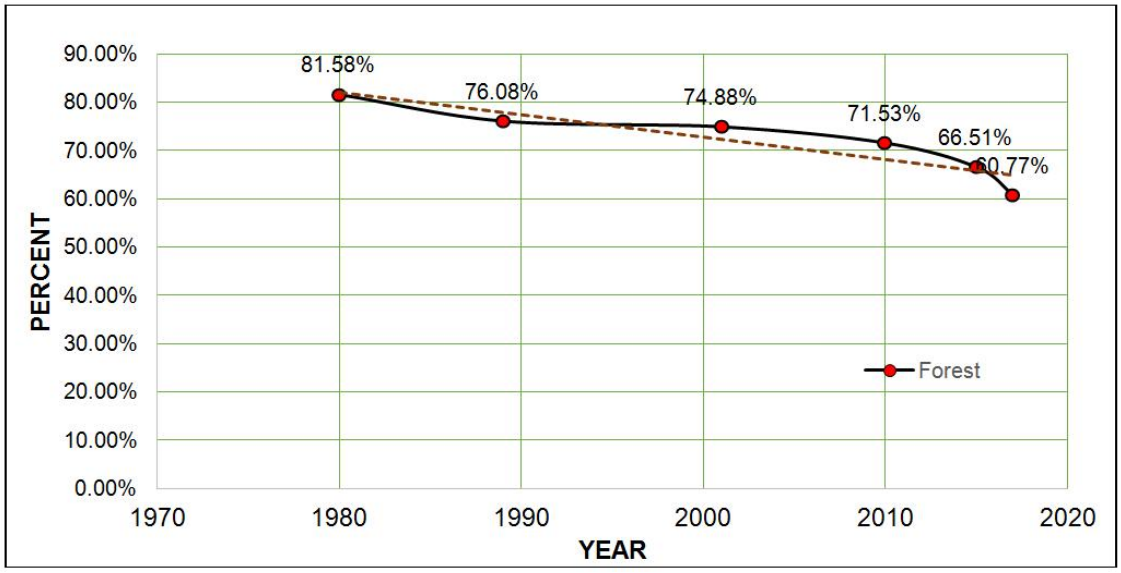

Fig. 8. Forest decrease trend (1980 to 2017)

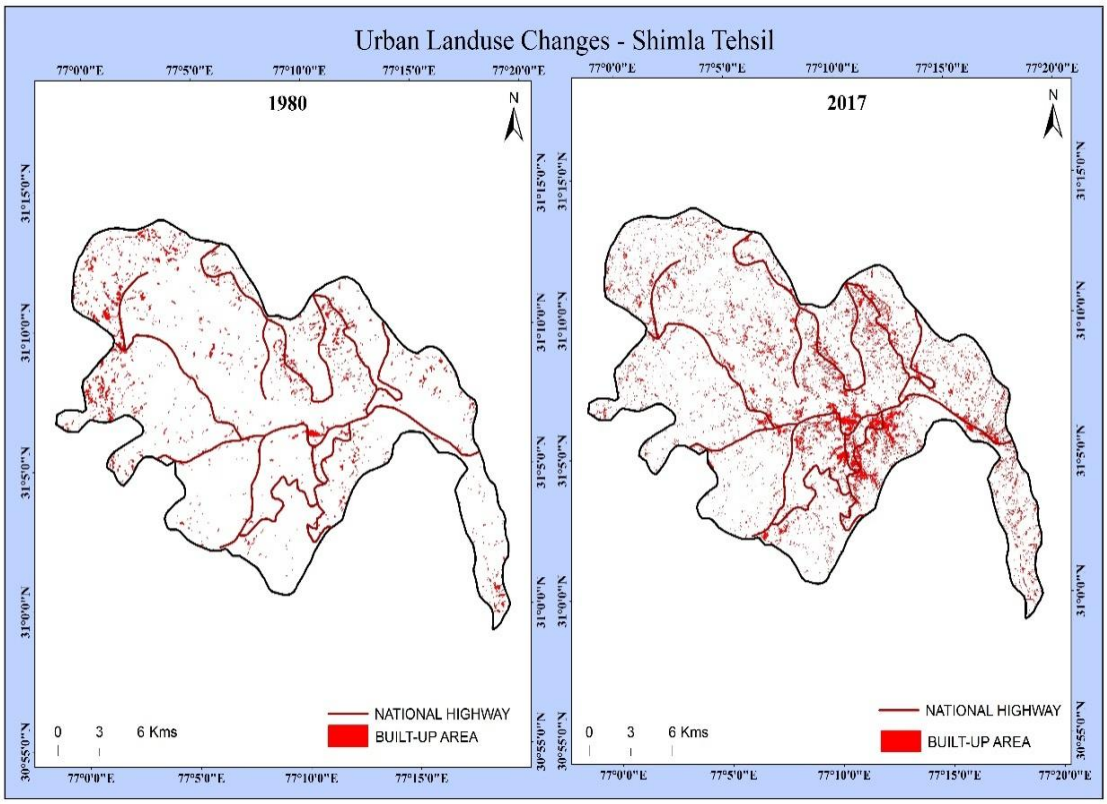

Fig. 9. Urban Land use changes 1980-2017

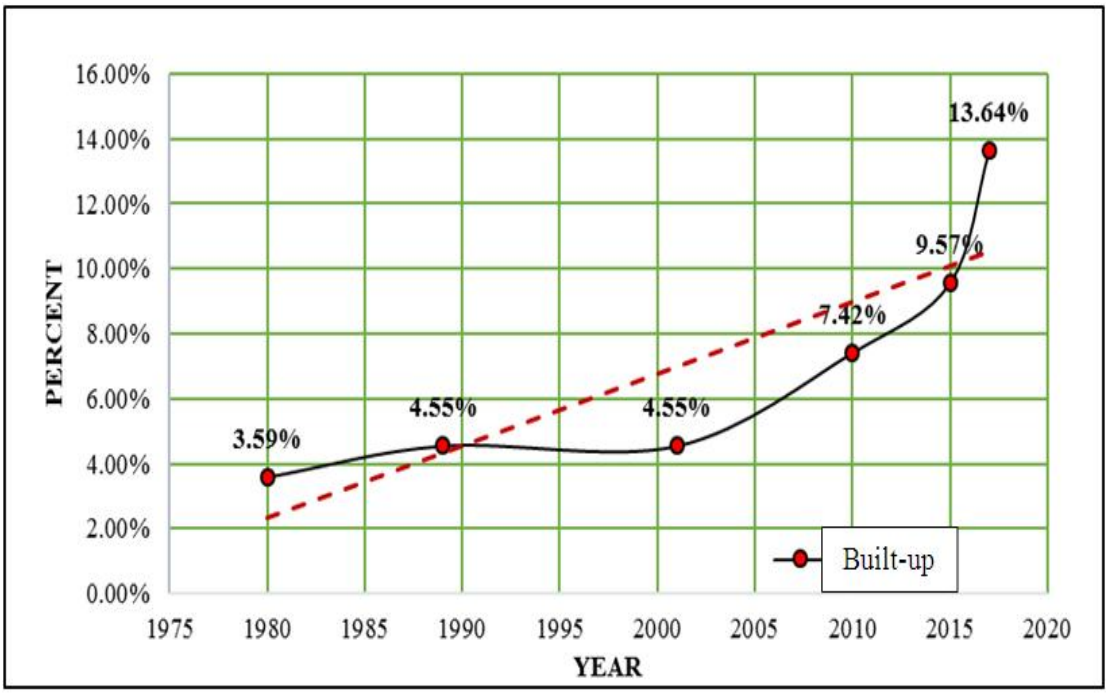

Fig. 10. Built-up Land growth trend (1980 to 2017)

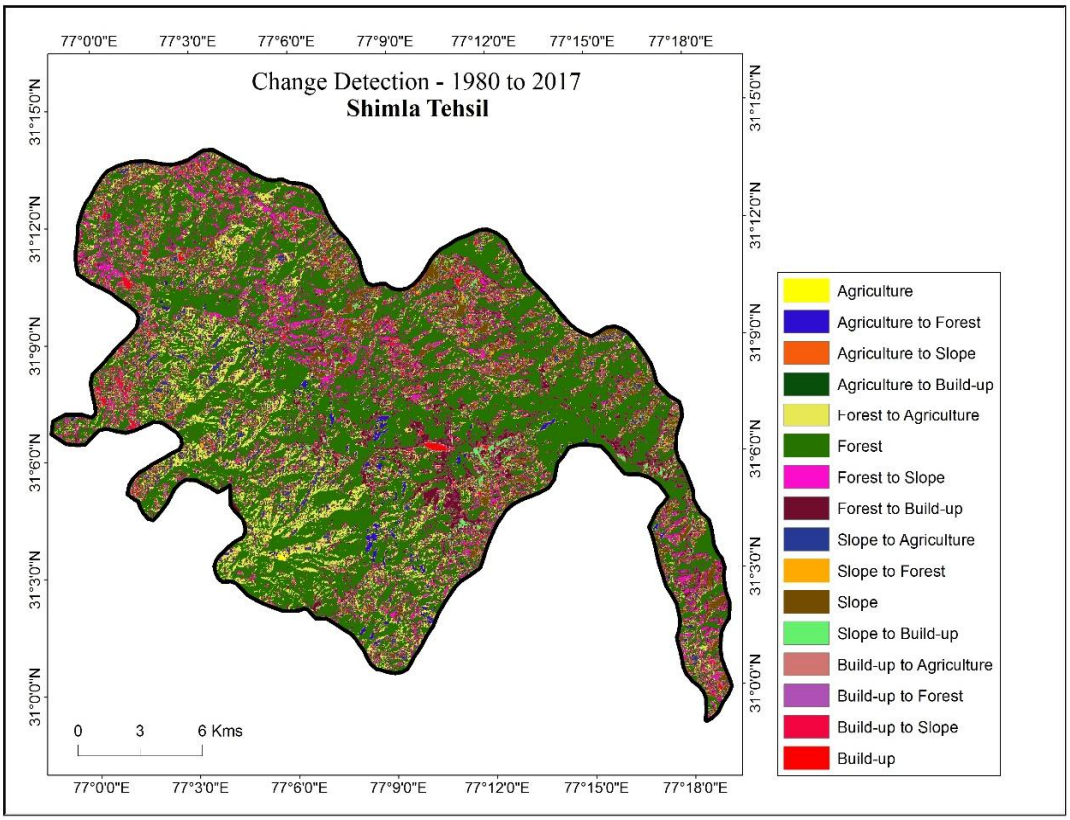

Fig. 11. Change detection (1980 to 2017)

5. CONCLUSION

The study conducted indicates the necessity of multi-temporal satellite imageries in quantifying temporal and spatial changes of an area, which is highly difficult through conventional process. The study revealed that major Land use changes occurred in Forest, Agriculture and Built-up land. The forest has decreased dramatically from 34200 Hectares in 1980 to 25400 Hectares in 2017. Built-up area has increased from 1500 Hectares to 5700 Hectares in 2017. Built-up area is highly concentrated in the Shimla town and rest of the Tehsil has spares built-up density. Land use and Land cover change mapping can provide insight into developing strategies for managing natural resources and environmental issues. Unplanned urban expansion might result in decreased air quality, increased local temperature and decreased water quality etc. Remote sensing and GIS has been proved an effective tool in planning Land, Water and Other natural resource management. Thus the study will help out in better understanding of the growth pattern of various Land use classes and enabling decision makers to devise proper management strategies for economic and sustainable development.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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