GIS and RS based analysis of LULCC in Indian Himalayan

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Abstract. Land use is the main essential resource of the total ecological system. Analysing LULCC is important for a vast range of applications such as landslide, land planning etc. In this study, LULCC have been considered for a period of 20 years (2000-2021) using RS and GIS based analysis of Shimla, Himachal Pradesh, India. Supervised classification technique is used to analyse LANDSAT images from the year 2000 to 2021. The output is identified and changes in land use pattern was obtained for each successive imagery and final changes were obtain by comparing 2000 and 2021 usgs data. The result obtained indicate a major change in the growth. Thickly vegetated land reduced from 95.52% to 20.22% in the year 2021 whereas the Moderately Vegetated land reduced from 60.25% to 10.50%. In the year 2021, The Urban Land increased from 75.65% to 180.50% while the agricultural land is also increased from 70.63% to 150.23%. Barren Land also gets increased from 65.25% to 150.23%.

Keywords:- LULCC, Thickly Vegetated, Moderately Vegetated, RS

1. Introduction
Landuse Landcover Change (LULCC) is a primary issue for changing the pattern of land use because of human anthropogenic activities. The population has changed the atmosphere for a very long time to satisfy their own desires for obtaining products like food, fibre, timber, healthful herbs etc. This accelerated to a great extent within the last 3 decades since the economic. As world population is increasing very fast, stress exerts on the land surface which show inadequate forces between environmental variables. So it is essential to inspect the changes in LULC, so that its impact on the worldly ecosystem can be noticed, and sustainable land use planning can be formulated. LULCC are two different terminology that are used together. Land cover are the ground cover surface like Forest, Waterbody, Soil, and Vegetation etc. Whereas Land use define to the land used by people and their habitat for different activities. As the increasing population pressure and the development in the various fields especially in the aspects of urban and industrial field changing the land use pattern drastically and causing land degradation. This increasing change warning us and cause an huge impact on the local, regional, national and global environment and consequently affect food availability. The LULC is continuously changing the surface of the earth. The increasing population pressure puts bad effect on LULC. There are many other factors on the land cover dynamics. A few researchers concluded that demographic factor is intensively accelerated to LULC change [1–3].
As shown in Figure 1, geographical information systems (GIS), remote sensing (RS) and global positioning systems (GPS) are widely used as a powerful and efficient tool for detecting and analysing the change in the pattern of land around the area. RS offers a multispectral data which shows the changes in the land through the sensor without come under physical contact. GPS are often used to collect the positioning information of a reference point for Remote Sensing classification and correction. GIS is beneficial for capturing, analysing and storing the information and change of pattern for LULC. Integrative use of this technology has established its effectiveness with relation to the change of spatial data and particularly to the provision of correct and timely geospatial information illustrating LULC change patterns [4–6]. This information will then come under a knowledge of urban area planners for designing and township planning. Many researchers already studied about the importance of LULC in the area studied Land use changes for the Mandhala watershed located in Solan, HP, India. studied the behaviour of LULC of Vamanapuram geographical area, southern Goa, India. studied the LULC with special reference on the Mandovi-Zuari water complex in Chamba, Himachal Pradesh, India [7,8].

Now this study has been focused to examine the LULC modification and monitor the urban area of Shimla Tehsil, Himachal Pradesh. The Shimla Tehsil includes a variety of issues such as fast growth of urban area, rapid reduction of forest area, and steep slopes etc. The study has been conducted for better understanding of LULC modification. The main objective of this study is to select the study area for LULC detection, analysis of LULC detection using various datasets of previous two decades, to study the present status of forest land, urban land, and agricultural land using satellite data [9,10].

2. Description of Study Area
Shimla is situated between 30°59’3” to 31°14’10” North latitude and 76°58’19” to 77°19’21” East line of longitude covering an area of 418 sq. Km as shown in Figure 2. It has an average altitude of 2206 meters above mean sea level. Shimla is divided into Shimla rural and Shimla urban. Literacy rate of Shimla stands at 83.64% which is higher than the state rate. Total 3 rivers evacuate through Shimla specifically Sutlej, Pabbar and Giri. Most of the area in the shimla comes under agriculture land. The main crop for growing in Shimla is apple. The season of apple generally has during the months from August-October. The soil is sandy soil at the plains and starved within the mountainous areas. The main trees in the forest are pine, deodar and oak. The climate is moderate within the plains and little bit high within the hilltops. The annual precipitation is 999.4mm out of which 75% occurs throughout the monsoon period July to September. The temperature varies from 0°C in winter to 40°C in summer [11,12], see figure 2.
3. Materials and Methods

The topographical maps were prepared with the scale of 1:50,000. The data has downloaded from United States Geological Survey (USGS) website for eight different years (2000, 2003, 2006, 2009, 2012, 2015, 2018, 2021). A maximum likelihood classifier method (Supervised Classification) has been performed for change detection analysis. To execute the change detection analysis, for respective periods of downloaded data i.e., LANDSAT 4-5, LANDSAT 7 ETM+, LANDSAT 8 (OLI) are selected for the year 2000, 2003, 2006, 2009, 2012, 2015, 2018 and 2021 as given in Table 1. To know the changes in LULC classes of eight years, a post classification comparison of change detection was used [13]. A comparison between the classified maps were carried out by post classification technique. The methodology adopted for analysing LULC pattern of this study area is mentioned in the flow chart in Figure 3.
Figure 3 Methodology adopted for analysing LULC pattern

Table 1: Temporal information

| S.NO. | DATA          | SOURCE                    | YEAR           |
|-------|---------------|---------------------------|----------------|
| 1.    | LANDSAT 7 ETM+| USGS Earth Explorer       | 05/03/2000     |
| 2.    | LANDSAT 7 ETM+| USGS Earth Explorer       | 01/05/2003     |
| 3.    | LANDSAT 4-5   | USGS Earth Explorer       | 16/03/2006     |
| 4.    | LANDSAT 4-5   | USGS Earth Explorer       | 25/05/2009     |
| 5.    | LANDSAT 4-5   | USGS Earth Explorer       | 01/05/2012     |
| 6.    | LANDSAT 8 (OLI)| USGS Earth Explorer     | 26/05/2015     |
| 7.    | LANDSAT 8 (OLI)| USGS Earth Explorer     | 18/05/2018     |
| 8.    | LANDSAT 8 (OLI)| USGS Earth Explorer     | 10/01/2021     |
4. Results and Discussions

The downloaded USGS data for two decades (2000, 2003, 2006, 2009, 2012, 2015, 2018, and 2021) are classified and compared for LULC analysis. Spectral satellite imageries are illustrated in the Figures 4, 6, 8, 10, 12, 14, and 16 whereas Figures 5, 7, 9, 11, 13, 15, 17 shows the nature of the trend of the change in LULC categories for the respective years.

**Figure 4** Land changes between 2000 (a) and 2003 (b)

**Figure 5** Trend of Land changes between 2000 (a) and 2003 (b)

Figures 4 and 5 indicate that the Thickly Vegetated Land (TVL) is reduced from 95.25% in year 2000 to 73.66% in the year 2003 whereas Moderately Vegetated Land (MVL) is reduced from 60.25% to 55.95% respectively. Urban Land (UL) is increased from 75.65% in year 2000 to 79.54% in 2003 while Barren Land (BL) increased from 65.25% to 70.26% [14–16]. Agriculture Land (AL) also increased from 70.63% to 85.25%.
From year 2003 to 2006, Figures 6 and 7 indicates that the Thickly Vegetated Land (TVL) is reduced from 73.65% to 63.62% and Moderately Vegetated Land (MVL) is reduced from 55.95% to 47.95%. 

**Figure 6** Land change between 2003 (a) and 2006 (b)

**Figure 7** Trend of Land change between 2003 (a) and 2006 (b)
The Urban Land (UL), Barren Land (BL), and Agricultural Land (AL) got increased from 79.54% to 86.92%, 70.26% to 76.55%, 85.25% to 92.66% respectively.

![Figure 8](image1.png)

**Figure 8** Land change between 2006 (a) and 2009 (b)

![Figure 9](image2.png)

**Figure 9** Trend of Land change 2006 (a) and 2009 (b)

Figures 8 and 9 show the Thickly Vegetated Land (TVL) and Moderately Vegetated Land (MVL) reduced from 63.62% to 59.35% and 47.95% to 30.25% respectively from year 2006 to 2009. The Urban Land (UL), Barren Land (BL), and Agricultural Land (AL) increased from 86.92% to 95.84%, 76.55% to 79.25%, and 92.66% to 95.36% from years 2006 to 2009 [17–19].
Figures 10 and 11 indicate that the Thickly Vegetated Land (TVL) and Moderately Vegetated Land (MVL) reduced from 59.35% to 53.38% and 30.25% to 20.25% respectively from year 2009 to 2012. The Urban Land (UL), Barren Land (BL), and Agricultural Land (AL) increased from 95.84% to 115.23%, 79.25% to 90.25%, and 95.36% to 150.26% respectively from year 2009 to 2012.
Figure 12: Land change between 2012 (a) and 2015 (b)

Figure 13: Trend in Land change between 2012 (a) and 2015 (b)

Figure 12 and 13 indicates that the Thickly Vegetated Land (TVL) and Moderately Vegetated Land (MVL) reduced from 53.38% to 40.25% and 20.25% to 19.25% respectively from year 2012 to 2015. Urban Land (UL), Barren Land (BL), and Agricultural Land (AL) increased from 115.23% to 125.09%, 90.25% to 100.25%, and 150.26% to 155.25% respectively from year 2012 to 2015.
Figure 14 Land change between 2015 (a) and 2018 (b)

Figure 15 Trend in Land change between 2015 (a) and 2018 (b)

Figure 14 and 15 indicates that the Thickly Vegetated Land (TVL) and Moderately Vegetated Land (MVL) reduced from 40.25% to 35.25% and 19.25% to 15.25% respectively from year 2015 to 2018. The Urban Land (UL), Barren Land (BL), and Agricultural Land (AL) increased from 125.09% to 140.5%, 100.25% to 110%, and 155.25% to 170.25% respectively from year 2015 to 2018.
Figure 16 and 17 indicates that the Thickly Vegetated Land (TVL) and Moderately Vegetated Land (MVL) reduced from 35.25% to 20.22% and 15.25% to 10.5% respectively from year 2018 to 2021. The Urban Land (UL), Barren Land (BL), and Agricultural Land (AL) increased from 140.5% to 180.5%, 110% to 150.23%, and 170.25% to 190.25% respectively from year 2018 to 2021. The nature of change of LULC classes is mentioned in Table 2.
Table 2. Summary of LULC Classification of area between 2000 and 2021

| LULC Types               | 2000   | 2003   | 2006   | 2009   | 2012   | 2015   | 2018   | 2021   |
|--------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| %                        | %      | %      | %      | %      | %      | %      | %      | %      |
| Thickly Vegetated Land   | 95.25  | 73.65  | 63.62  | 59.35  | 53.38  | 40.25  | 35.25  | 20.22  |
| Moderately Vegetated Land| 60.25  | 55.95  | 47.95  | 30.25  | 20.25  | 19.25  | 15.25  | 10.5   |
| Urban Land               | 75.65  | 79.54  | 86.92  | 95.84  | 115.23 | 125.9  | 140.5  | 180.5  |
| Barren Land              | 65.25  | 70.26  | 76.55  | 79.25  | 90.25  | 100.25 | 110.00 | 150.23 |
| Agricultural Land        | 70.63  | 85.25  | 92.66  | 95.36  | 150.26 | 155.25 | 170.25 | 190.25 |

Most of the area in Shimla is composed of moderately vegetated forest, and thickly vegetated forest. In year 2000 Thickly Vegetated Land covered about 95.25% of the study area which is reduced up to 20.22% in 2021. Shimla city is one of the important tourist destinations. Urban land includes Residential buildings, Industries, Pubic buildings, off street car parking buildings and other recreational areas increased from 75.65% to 180.50% between the years 2000 and 2021. Urban Land has increased drastically after the year 2009 to 2021 from 95.84% to 180.50%. The agricultural land which has increased from 70.63% to 190.25% from year 2000 to 2017. The barren land is increased from 65.25% to 150.23% from year 2000 to 2021. In the study area, most of the land is converted to settlements and agricultural lands. The changes of each LULC class between the years 2000 to 2021 is shown in Figure 18 in the form of bar chart.

Figure 18. Land Use Change between 2000 and 2021

5. Conclusion
This study shows the spatial temporal changes of the LULCC pattern which cannot easily done by normal method. The study disclose major Land use changes occurred in Thickly Vegetated Land, Moderately Vegetated Land, Urban Land, Barren Land, and Agricultural Land. The Thickly
Vegetated Land reduced from 95.52% to 20.22% from years 2000 to 2021 whereas the Moderately Vegetated Land reduced from 60.25% to 10.50%. A major change has been observed in Urban Land which increased from 75.65% to 180.50% while the agricultural land is also increased from 70.63% to 190.25%. The Barren land gets increased from 65.25% to 150.23%. LULC mapping provide awareness into the working plan for controlling natural resources and environmental issues. Unplanned Urban Land (UL) may shows increased land surface temperature, decrease the purification of water, increase air pollution etc. Remote sensing and GIS prove effective tools in township planning, water shed design etc. Therefore, this study will help in better understanding the growth pattern of various LULC classes and suggests planners to design a proper management strategy for economic and sustainable development.

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