Spatio-Temporal Assessment of Land use / Land cover using Normalized Difference Vegetation Index (NDVI) of Satellite Imageries and its relationship with Landslide-prone Zones in Kodaikanal Hill Station of Tamil Nadu, India

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Abstract
The land use exercises at last influence the land cover briefly as well as spatially. The primary consideration liable for the adjustment in land cover is to satisfy the developing requests of expanding populace through horticultural increase for nourishment and clearing of typical land covers like the forests and sparsely inhabited regions for settlement and business activities. The adjustment in land cover additionally upsets the other characteristic parts like soil ripeness, soil disintegration, environment, biodiversity, air quality and water system of the upset area. Remote sensing and GIS have been deployed to examine the changes in land use and land cover of the zone at spatial and transient scales.

In the present study, the NDVI-based grouping explored a significant change in land use- land cover between 2009 and 2016. A significant change has been found in the forest cover area where around (3.34%) of the forest was occupied between 2009 and 2016. A comparison between the land use/land cover and landslide hazard zones was carried out which indicated the excessive anthropogenic activities (of construction and mechanized agriculture) as identified by built-up land and crop-land by NDVI studies need to be monitored and planned to maintain the safety, stability and popularity of this precious and geo-climatically strategic region.

Keywords: NDVI, Remote Sensing, Resourcesat-2 LISS III Images, Change Detection, Vegetation Index.

Introduction
Land cover refers to the physical state of the land surface including cropland, forest, wetland etc.[7] In comparison, land use refers to biophysical assets used by human[4,5]. Land use/land cover analysis is vital for agricultural planning, urbanization and environmental studies[8,9,11,13,21,22] and this detail helps to understand the relevance between cropland, forestland, settlement etc. In modern times, urbanization and demographic development have increased land use and thereby affecting the land cover[17]. The assessment of the global land use and land cover change and environmental monitoring can be derived using remote sensing data and GIS because of its spatial and temporal coverage[2,10,16].

Normalized difference vegetation index (NDVI) can be used as an appropriate method to compare by using multi-date satellite data and the proposed methods for change detection in land use and land cover[18,20,24]. Geoinformatics allows us to detect and assess the land cover over a large area and a longer course period. The change in land cover and land use (LULC) varies in different places. In rural areas, because of agriculture expansion, deforestation and illegal tree cutting, while in urban areas, it is mainly due to urbanization and commercialization[19].

The change in land use and land cover of an area is not only related to various environmental indicators like groundwater quality and soil fertility but also the potential for natural hazards like landslide[21,25]. In fact, detection of land use and land cover and their spatio-temporal variability play very crucial roles in landslide hazard zonation. There are sporadic efforts by researchers to use digital image processing of satellite data, primarily NDVI, as a tool for the mapping of the changes in the land cover[12,23]. In fact, the assessment is often affected by evaluating the difference between images derived by transforming multi-temporal images into digital indicators of those changes[15].

In the present study, an investigation of land use/land cover over the period of 2009 and 2016 is employed to identify the type of changes and the change in trend for delineation of potential landslide zonation. The main objective of the present study is to bring out the evolution and extent of land cover changes in the study area and to define the principle factors behind changes, which need to be arrested for freezing the expansion of landslides.

Study Area and Geology
Study Area: The study area is considered as one of the most popular hill stations in Tamil Nadu of India, situated at the height of around 2560 m on the southern tip of upper Palani slopes in the Western Ghats. The study area is geologically located in the west piece of the Dindigul region, lying between $10^0$07’00”N to $10^0$16’00”N latitude and

$77^0$16'00"E to $77^0$21'00"E longitudes, thereby covering an area of 104.77 sq. km (Fig. 1). The study area's administrative part is located in the south direction of Bodinayakanur Taluk, the west direction of Kerala State, the east direction of Kodaikanal Block and the north direction of Udumalaippetai Taluk. The temperature in the area is quasi-temperate, with summer temperatures contacting 24°C as the most extreme and 13°C as the minimum. The maximum temperature during winter is 12-16°C and the minimum is 7-8°C. Precipitation is dispersed consistently, with normal precipitation of 1300 mm yearly.

The atmosphere of the study zone is extremely special, with a calm fall, winter, spring and gentle summer. The study area also receives rain consistently, making it a perfect situation for agricultural developmental activities. Therefore, there are wide varieties of fruits and vegetables in this area, many of which are only grown here including hill bananas, passion fruit, peaches, pears, grapes, plums, cauliflower, potatoes, carrots and also coffee. The plants in these areas include pine, walnuts, blue gum and other fruit trees which are cultivated. The total population of the study area is about 13933 persons according to the 2001 census.

Geological Settings: The Palani hills, which rise abruptly from the plain, form a part of the Western Ghats. The general trend of the hill ranges is found to be northeast to southwest. The study area forming a part of the northern slopes of Palani hills comes in the Southern Granulite terrain of South India. The Kodaikanal area of the Madurai block lies between the Palghat-Cauvery and Achankovil shear zones. The study area comes within the Dindigul district with the following rock types. They are granitic gneiss, laterite and anorthosite. Rocks are exposed in the area with thin to thick overburden cover. The overburdened soil comprises humus material, lithomarge and slope wash materials.

Fresh rock outcrops are seen on the cut slopes of roads and terraces as well as scarp faces seen on hills. Mannavanur, Pundi area exposures are well observed. The areas seen are leucocratic to mesocratic, characterized by grey colour from medium to coarse-grained phenocrysts of feldspar. The steep to very steep slopes observed in the top and middle of the study area generally consist of thick overburden materials with rock exposure seen intermittently in stream cuts or other cut slopes. Rocky outcrops show varying degrees of weathering, ranging from highly weathered to moderately weathered depending on slope gradient and other local factors.

Material and Methods

Imageries: The image of the study area was acquired during February and March of 2009 and 2016 respectively.

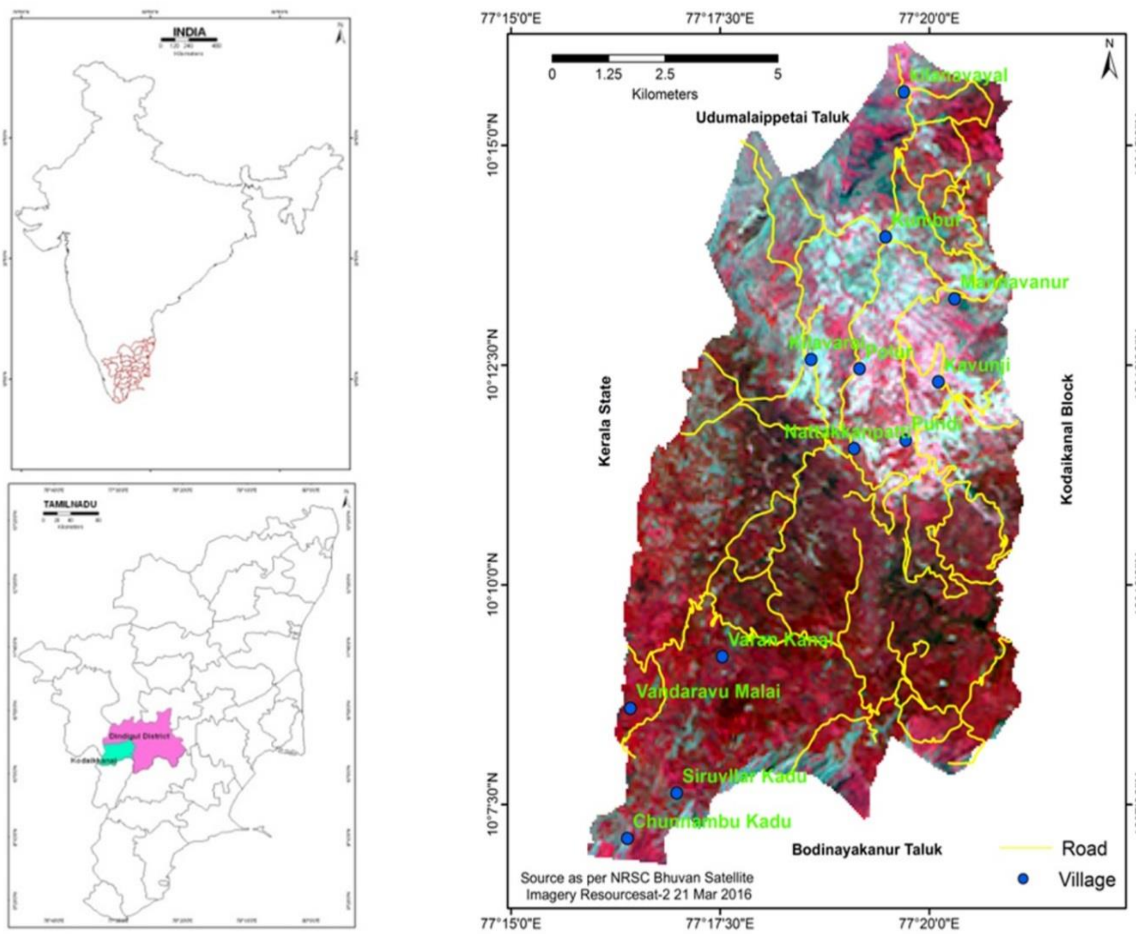

Figure 1: Location Map of the Study Area

Table 1
Details of the images used

Image	Path/row	Date of Acquisition	Spatial Resolution
NRSC Bhuvan Satellite Imagery (Resourcesat-LISS III)	103/67	16/02/2009	24 meter
		21/03/2016	

Image Processing:
1. Stacking of Layers: The raster processing bands were performed on the Arcmap 10.3 software.
2. Projection: Universal Transverse Mercator (UTM) projection of the image downloaded is reprojected to Geographic WGS 84, spheroid and datum Everest.

Identification of Changes: The classification of images in both years (2009 and 2016) was performed through NDVI, including the following steps: Multispectral satellite data set observed by Resourcesat-2 LISS III and Maps of Survey of India Topo sheets were used in the study. The study area map is drawn using the toposheet published during 1990-91 at 1: 25000 scale and was used for the analysis of Linear Imaging and Self Scanning Sensor (LISS III) sensors with 4, 5 multispectral. The resolution is 24 meters/pixel classification of digital land cover by NDVI process. Arc GIS is used to extract land use and land cover layer from the map and satellite imageries. The land use and land cover classes include built-up land, cropland, low-land, dense forest and reserved forest areas. This classification is performed using the NDVI method based on the classification scheme.

Results and Discussion

The weight of expanding populace and impromptu land use rehearses has an incredible effect on characteristic land cover. The vast vegetation cover has been changed over into cropland and built-up land and the characteristic low-lands are at risk of dryness. The change in LULC has been considered subsequent to understanding the effect of progress on the atmosphere and the area's biological system. In the present investigation, two pictures (2009) and 2016) have been grouped based on a standardized distinction vegetation file (NDVI), a vegetation file determined by:

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

NDVI is record dependent on the spectral reflectance of the ground surface component. Each element has its own reflectance fluctuating as per the wavelength. NDVI esteem extends between - 1 to +1. An estimation of enhanced NDVI deduces the nearness of solid vegetation in the area while its lesser is the marker of scanty vegetation. NDVI has been utilized for examination of progress recognition in numerous things[1,6].

The NDVI esteem was determined from Resourcesat-2 LISS III satellite image of 2009 territories from 0.66 to - 0.03. The higher estimation of NDVI was found in the upper part of the area Vandaravu Malai and on the border of the Chunnambukadu locality south of the Kumbur stream (Fig. 2).

The upper part of the area having higher NDVI values relates to the Umaiyar block reserved forest. The lower estimations of NDVI were found in the streams and low-land of the study area. In contrast with the year 2009, the NDVI estimations of the year 2016 show a noticeable difference over the entire locale and its range extends from 0.78 to - 0.03 (Fig.2). Some scattered patches are also showing higher NDVI. The decline in the NDVI index demonstrates the adjustment in land utilization of the area for the most part because of the loss of timberland zone in light of farming development and human infringement.

Change in land cover: Changes in land use/land cover during the period of study between 2009 and 2016 were assessed utilizing satellite images. The entire area was divided into five classes using supervised classification (maximum likelihood method) and characterization (greatest probability technique) utilizing the image processing software. The classes are built-up land, cropland, low-land, dense forest and reserved forest areas. The acquired satellite images of the year 2009 and 2016 show a definitive change in land use/land spread in the investigation region.

The arranged image of 2009 (Fig.3) shows that about 63 % of the area is under dense and reserved forest (Table 2). A dense wood area has been seen in the south of the area lying close to and along the sloping region of the Vandaravu malai area and plantations resembling rose myrtle, bamboo, acacia, eucalyptus and casuarinas were found along the north of Kizhanavayal area (Fig. 3). The classified image of 2016 (Fig. 4) shows a considerable change in land use and land cover. A significant change has been found in the forest cover area where around 60 % (3.19%) have been deforested during the period of study. The progressions happen fundamentally because of human encroachment and agricultural developments.

Population growth also has played a role in the changes in the land cover pattern via overexploitation of land assets for their livelihood. The populace residing near wooded areas depends on valuable timber of woodland and agriculture[3]. The horticultural extension for the most part, cauliflower, potatoes, broccoli, butter beans, French beans, carrots, peas, cabbage yields and settlement has also become a reason. The region of the farming field expanded in 2015-2016 to around 15.09 km^2, which is 1.23 % more than the year 2009-2010 (Figure 4).

According to the Resourcesat-2 LISS III Imagery of the corresponding year, vegetation covered almost 66.03 km^2 of the study area (Table 2). This declined to 62.69 km^2 in 2015-2016, over the period of time. It has been found that in the eight years, almost 42% (Fig. 3 and table 2) of the forest lands have been transformed into built-up land, cropland, low-land and developed areas because of human encroachment, urbanization and migration.

The cropland, built-up land area which covered an extent of 13.80 and 6.79 Km^2 respectively, the land in 2009, amplified to 15.09 and 7.99 Km^2 respectively in the year of 2016. From figure 3, it could be revealed that forest lands were converted to cropland, built-up land (developed) for the agricultural plantation largely[14]. It shows that most of the land was also occupied by farming activities, which were dense forests during 2009. Currently, cardamom plantation and mixed plantation have been the major types in the developed area, whereas wattle plantation covers Vandaravu Malai, Siruvilarkadu, Varankanal and Chunnambukadu at present. It is evident that these patterns reveal the transformations of the forestlands to agricultural land and built-up land.

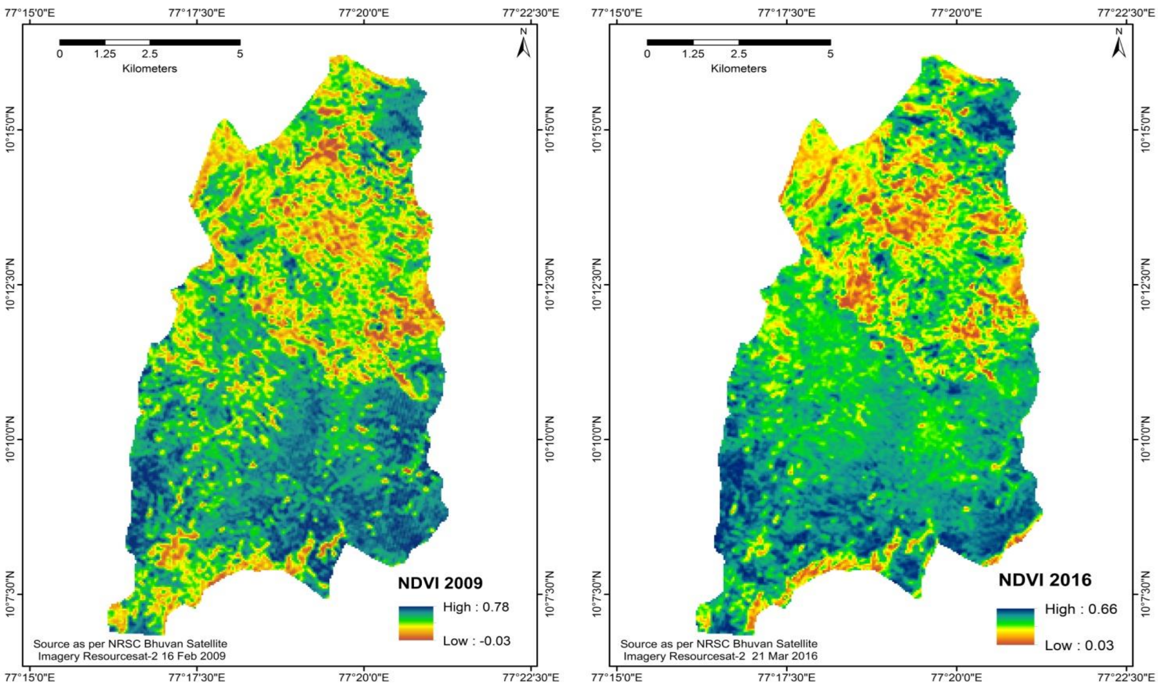

Figure 2: NDVI Variation in the study area in (a) 2009 and (b) 2016

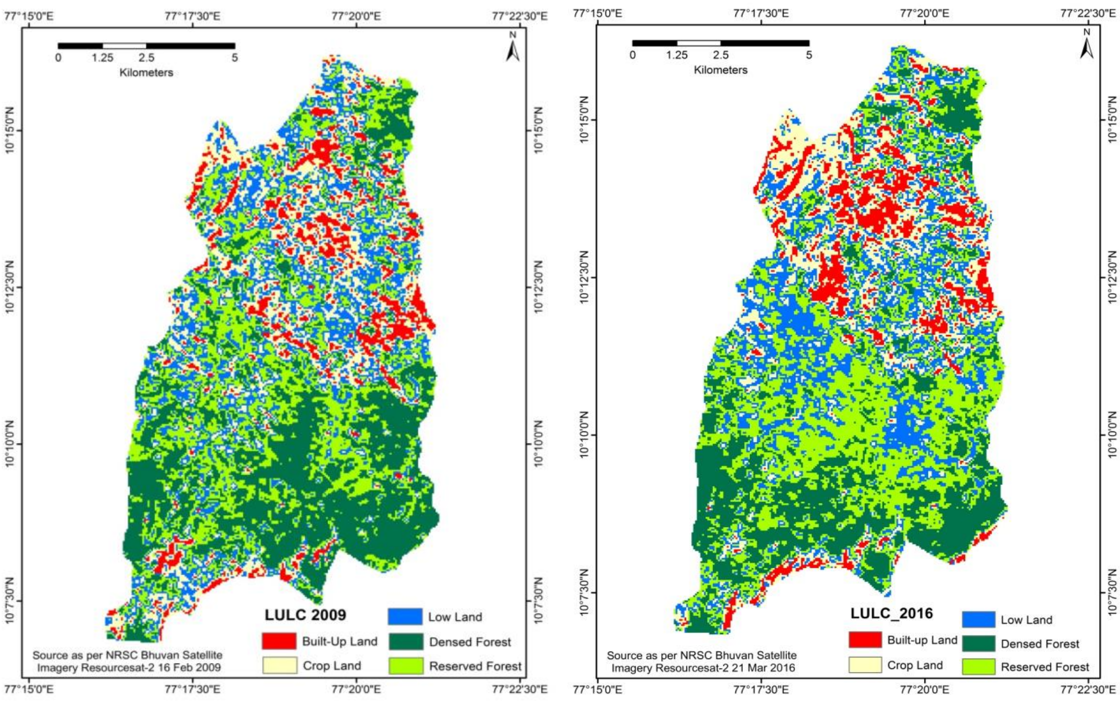

Figure 3: Change in Land Use/Land Cover in the study area in (a) 2009 and (b) 2016

Table 2
Change in Land/Use Land Cover of the study area

Year	2009	2016	2009	2016	2009	2016
LU LC Category	**Area (km^2)**		**% of the total area**		**km^2**	**Change %**
Built-Up Land	6.79	7.99	6.48	7.63	-1.2	-1.15
Crop Land	13.80	15.09	13.17	14.41	-1.29	-1.23
Low Land	18.15	18.99	17.32	18.13	-0.84	-0.80
Reserved Forest	31.20	29.20	29.78	27.87	2	1.91
Dense Forest	34.83	33.49	33.24	31.97	1.34	1.28
Total	66.03	62.69	63.02	59.84	3.34	3.19

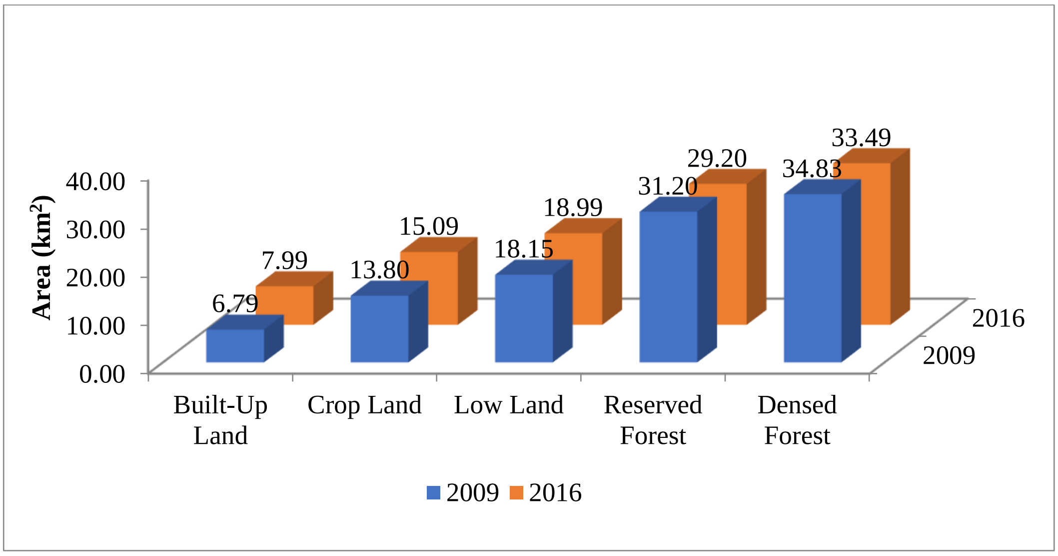

Figure 4: Graphical presentation of the change in Landuse/Landcover of the study area

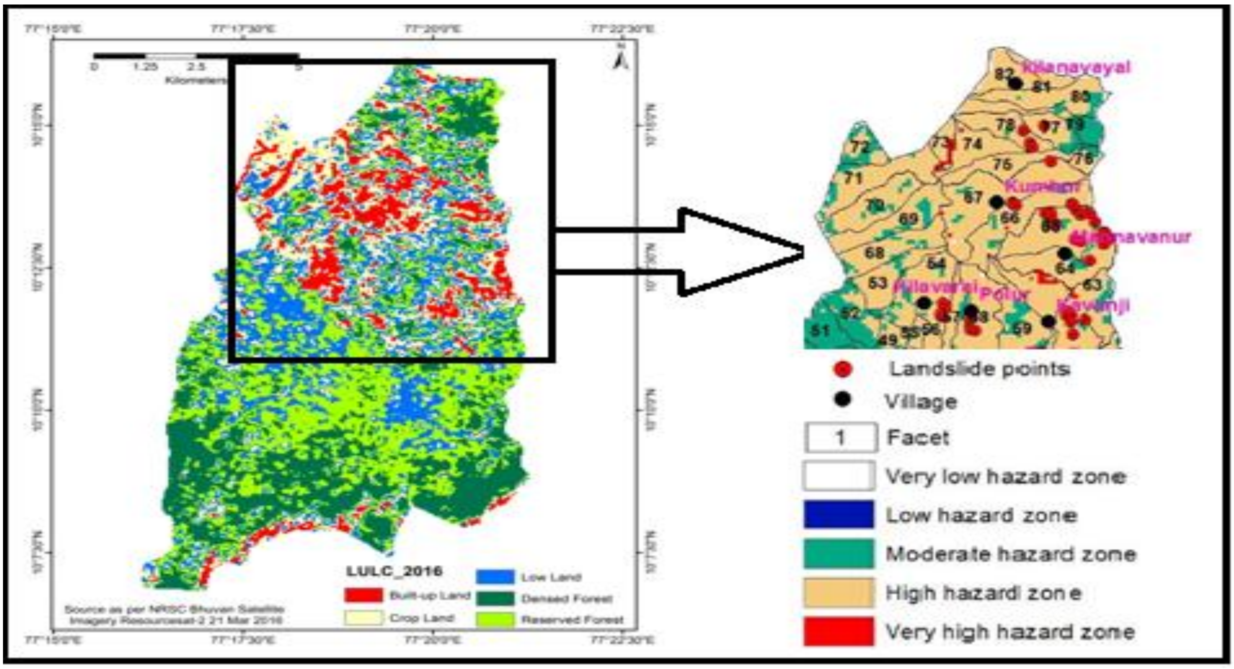

Figure 5: Landslide-prone zonation of the study area

Low-land water bodies include reservoirs, lakes, ponds, rivers and streams in and around the study area covering about 18.15 % during 2009 and decreased by about 3.9 % in 2016 when compared with 2009 (Fig. 4). This variation might be due to the rainfall during monsoon season. The waterlogged areas and low land areas in the scattered part of the study area might have also been categorized under water bodies. The fact that the Kumbur river basin, a mountainous region, also acts as the catchments of the rivers and streams taken into account as a critical role in the assessment.

Landslide-prone zonation in relation to Land-use/Land-cover: As evident from the comparative assessment of the Land use/Land cover thematic map and the landslide hazard zones, we find that built-up and croplands (rather than low-lands and forests) are more closely related to higher landslide hazard potential, marked as high and very high landslide hazard zones (Fig. 5).

Hence, the use of NDVI-based land use/landcover identification can be directly indicative of hazard potential and the attempts to arrest anthropogenic intervention of deforestation and mechanized agriculture can reduce landslide hazard potential.

Conclusion

In contrast with 2009, 2016 shows a critical change in land use and land cover due to the modernization, expanding demographic activities and over-abuse of common assets becoming a significant danger for degradation of forest cover and loss of forestland in the investigation zone. The absolute 66 km^2 of forest cover, around 7.99 km^2 of built-up land and 15.09 km^2 of cropland have been modified during the entire study period due to agrarian escalation and human infringement. This disturbing condition is required to be dealt with logical administration of land use for reasonable improvement in the area in future.

As revealed from the study, increasing built-up and crop-land (caused by extensive deforestation and mechanized agriculture, respectively) would lead to an increased risk of landslide occurrence. Hence, regular monitoring of land use/land cover through NDVI and corresponding logistic planning on control anthropogenic interventions would lead to a possible reduction of the frequency and magnitude of landslides in this popular hill station.

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