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Geospatial assessment of Land use and land cover change: A case study of Morni Hills of Panchkula District in Haryana, India

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ABSTRACT

Land is a unique and perpetual gift of nature to humans. It is essential for human existence and survival. Accurate and up-to-date land use land cover assessments are important to devise the strategies and policies for conservation and management of natural resources. This study is an attempt to assess the changes in Land use and land cover (LULC) and the annual rate of change in Morni Hills area of Panchkula district in Haryana during 1997 and 2017. The satellite images acquired from Landsat-5 Thematic Mapper (TM) and Landsat-8 Operational Land Imager (OLI) sensors were used for the preparation of LULC map for 1997 and 2017. Unsupervised classification technique was applied for LULC preparation and images were classified in to eight classes including Very Dense Forest (VDF), Medium Dense Forest (MDF), Open Forest (OF), Agriculture, Barren land and Other, Scrubland, Water body/River and Settlement. The assessment of temporal change in LULC area shows increase in VDF (10.96%), MDF (0.68%), Agriculture land (1.31%), Water bodies (0.34%) and settlement (0.6%). The decrease was observed in OF (10.13%), Barren and other (2.23%) and scrub land (0.32%). Among all Land Use categories, VDF (132.62 ha/Year) has the highest amount of annual positive change followed by Agriculture (16.73 ha/year), MDF (8.71 ha/year), Water Bodies (4.29 ha/year) and Settlements (4.16 ha/year). The high increase of forest cover and water body during the year 1997 to 2017 are indicators of sustainable forest management and implementation of People Participatory Approach (PPA) in governance.

Keywords: Forest Cover, Land use, Changes, Landsat, Morni Hills

1. INTRODUCTION

Land, the solid part of the earth surface, is broadly defined to include all that nature provides, including minerals, forest and its products, food, water, biodiversity and several other resources. It is a unique and perpetual gift of nature to humans (Nolen, 2009). It is essential for human existence and survival as all kinds of human activities are ultimately conducted on the land surface. The way a portion of land is used by the human is classified as a specific land use, whereas, the biophysical cover of the land, be it vegetation, soil, water or a human settlement *etc*, is described as a specific type of land cover (Turner et al. 1994; Moser, 1996; Lambin et al, 2001; Ellis, 2007).

Land use and land cover pattern of a region is an outcome of several natural and socio-economic factors and their utilisation by humans. Humans have been altering land since its origin to acquire the goods and the services for their subsistence, but the rate and quantum of utilization was sustainable and far less than that of recent times. Nowadays, the rapid rate of exploitation of land resources has brought unparalleled changes in ecosystems and environmental processes at local, regional and global scales. The exponential increase in the human population and the subsequent increase in the demand of various products and services are the drivers of tremendous and unprecedented level of changes to the land use and land cover globally. These changes are affecting the natural balance of the earth and its ecosystems. The problems of global warming and climate change, biodiversity depletion and pollution of water, soil and air have been generating overwhelming concerns. Consequently, monitoring and reconciliation the adverse consequences of land use and land cover changes while maintaining the sustainable production of indispensable resources has become a foremost priority of governments and policy makers around the world (Erle and Pontius, 2007).

Accurate and up-to-date land use land cover assessments are important to define natural resource management strategies and policies for conservation in tropical regions. Information about the location, extent, and changes in land use and land cover areas is important for identification of threats to ecosystems and biodiversity due to it and allowing solutions to be evaluated and implemented (Lambin*et al*, 2003; Roy & Roy, 2010). Understanding the causes and consequences of land cover change and their tumbling effects on many components of functional ecosystems, are the keys for identifying negative effects on biological resources and human development (Lambin*et al*, 2001).

The science and the art of acquiring information about the earth surface or phenomenon without touching the surface is termed as remote sensing. This process is carried out by a recording device, sensitive to either reflected or emitted radiation. Remote sensing techniques offer benefits in the field of land use land cover mapping and their change analysis. One of the major advantages of remote sensing systems is their capability for repetitive coverage, which is necessary for change detection studies at global and regional scales. Detection of changes in the land use land cover involves use of at least two period data sets (Jenson, 2005). The changes in land use land cover due to natural and human activities can be observed using current and archived remotely sensed data (Kumar et al, 2014;Lekha and Kumar, 2018). With the availability of multi-sensor satellite data at very high spatial, spectral and temporal resolutions, it is now possible to prepare up-to-date and accurate land use land cover maps in less time, at lower cost and with better accuracy (Herold *et al*,2005, Roy & Roy, 2010). Simultaneously, change monitoring is also became possible (Shalaby and Tateishi, 2007**;** Yin et al, 2011;Rawat, and Kumar, 2015).

There are four general stages in process of change detection and monitoring of natural resources. They include: (a) finding the changes that have occurred, (b) identification of the nature of the change, (c) measurement of the extent of the change and lastly (d) assessment of the spatial pattern of the change (Macleod and Congation, 1998). The basis of using remote sensing data for change detection is that changes in land cover result in changes in radiance values which can be remotely sensed. A remote sensing device records response which is based on many characteristics of the land surface, including natural and artificial cover. An interpreter uses the element of tone, texture, pattern, shape, size, shadow, site and association to derive information about the land cover.

The conventional ground-based methods of land use mapping are labour intensive, time consuming but remotely sensed imageries provide an effective means of attaining information on temporal trends and spatial distribution of land cover of any areas needed for understanding, modelling and predicting the future scenarios of land use and the land cover changes (Kumar *et al*, 2014). Keeping the above in view, the present work has been undertaken to prepare the multi-temporal land use and land cover maps of Morni Hills of Panchkula district in Haryana using Landsat satellite data and to assess the changes in various land use land cover classes using remote sensing and GIS techniques. The village-wise changes in the land use and land cover of the area has also been assessed.

2. MATERIALS AND METHODOLOGY

2.1 Study Area

The Morni Hills lie in Morni Sub-Tehsil of District Panchkula in Haryana. It is part of lower Shiwalik hills. The study area extends from 76°11' to 77°11' East longitude and 30°34’ to 34°45' North latitude. The area comprises hills, open valleys, foothills and two small lakes(Tals). The highest peak *viz.* DharotKahlog (1499 m AMSL) lies on the northern ridge and Thandok (1246 m AMSL) on the southern ridge.The climate is characterized by a very hot and dry summer and a very cold winter season. The average rainfall in the district is 985.1 mm. The rainfall in the district generally increases from March and reaches a peak in May and June. The mean daily maximum temperature is about 41°C and minimum is about 26°C. The highest maximum temperature recorded up to 46°C in summer and minimum falls sometimes below 0°C in winter.

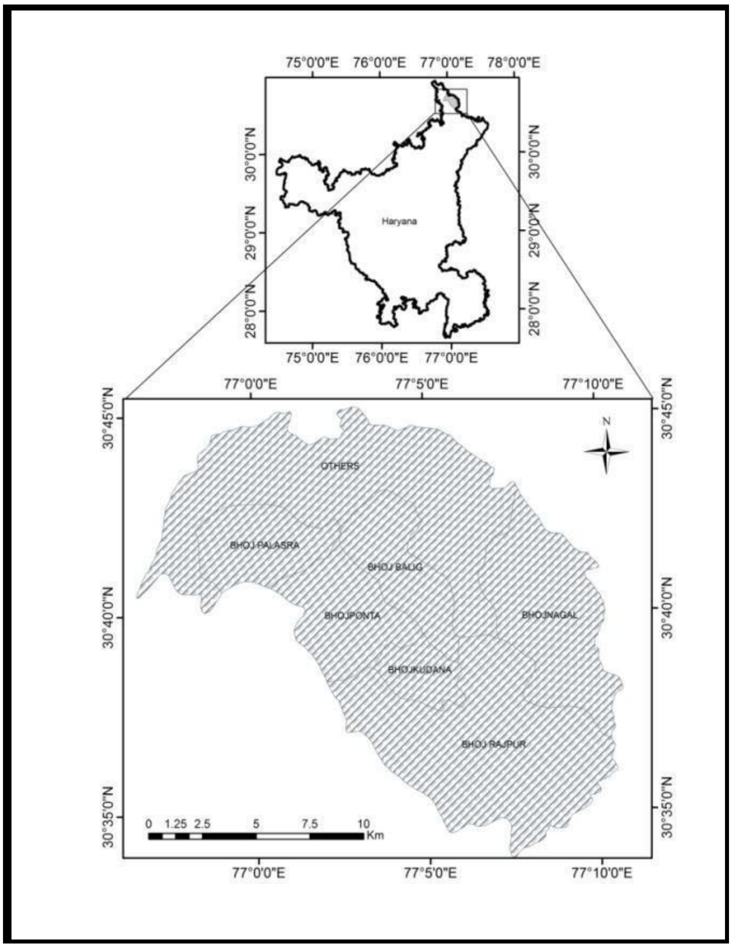

Figure 1: Map of the Study area

2.2 Materials Used

2.2.1 Satellite Images Used

The Landsat-TM (Thematic Mapper) and Landsat-OLI (Operational Land Imager) of October month for 1997 and 2017 has been utilized in this study. The data were obtained from earth explorer USGS (United State Geological Survey) website (https://earthexplorer.usgs.gov). All the images covering the study area were downloaded. The details of Landsat images used in this study is represented in the table 1.

Table1: Information about Landsat Images used in this study.

Satellite	Sensor	Acquisition Date	Bands	Spatial Resolution	Wavelength (µm)	Spatial Resolution (m)
			Band 1	Blue- Green	0.45-0.52	30
			Band 2	Green	0.52-0.60	30
Landsat-5	TM	15 Oct. 1997	Band 3	Red	0.63-0.69	30
			Band 4	NIR	0.76-0.90	30
			Band 5	Mid-IR	1.55-1.75	30
			Band 6	TIR	10.40-12.50	120
			Band 1	Coastal aerosol	0.43-0.45	30
			Band 2	Blue	0.45-0.51	30
			Band 3	Green	0.53-0.59	30
Landsat-8	OLI	22 Oct. 2017	Band 4	Red	0.64-0.67	30
			Band 5	NIR	0.85-0.88	30
			Band 6	SWIR1	1.57-1.65	30
			Band 7	SWIR2	2.11-2.29	30
			Band 8	Panchromatic	0.50-0.68	15
			Band 9	Cirrus	1.36-1.38	30
			Band 10	TIRS	10.60-11.19	100
			Band 11	TIRS	11.50-12.51	100

2.2.2 Methodology

The Landsat images of 1997 and 2017 were used in the present study for the forest classification and LULC mapping. The Unsupervised Iterative Self Organized Data (ISODATA) classification technique was applied for this process. First, the whole image was divided into 50 classes, then each of these classes were identified on false colour composite (FCC) images by on-screen visual interpretation and classified into a unique class. The forest areas were classified on this basis of their tone and textural characteristics. It was found from a reconnaissance survey that the VDF shows dark red reflectance, MDF shows medium red and open forest shows light red tone on false colour composite images. Similarly, other land uses and land cover classes were also identified based on their tone and texture in the satellite images. Initially, all the LULC classes were in the form of several clusters. Further, these clusters were recoded into eight unique classes based on their tone, texture and association on FCC and finally a LULC map was generated for 1997 and 2017. The eight unique LULC classes were as follows:

1. Very Dense Forest (VDF)	2. Medium Dense Forest (MDF)	3. Agriculture
4. Open Forest (OF)	5. Barren and other	6. Scrub
7. Water/river	8. Settlement	

The Post classification comparison method of change detection was used for analysing changes in forest cover and other LULC classes. Flowchart of methodology applied is presented as Figure 2.

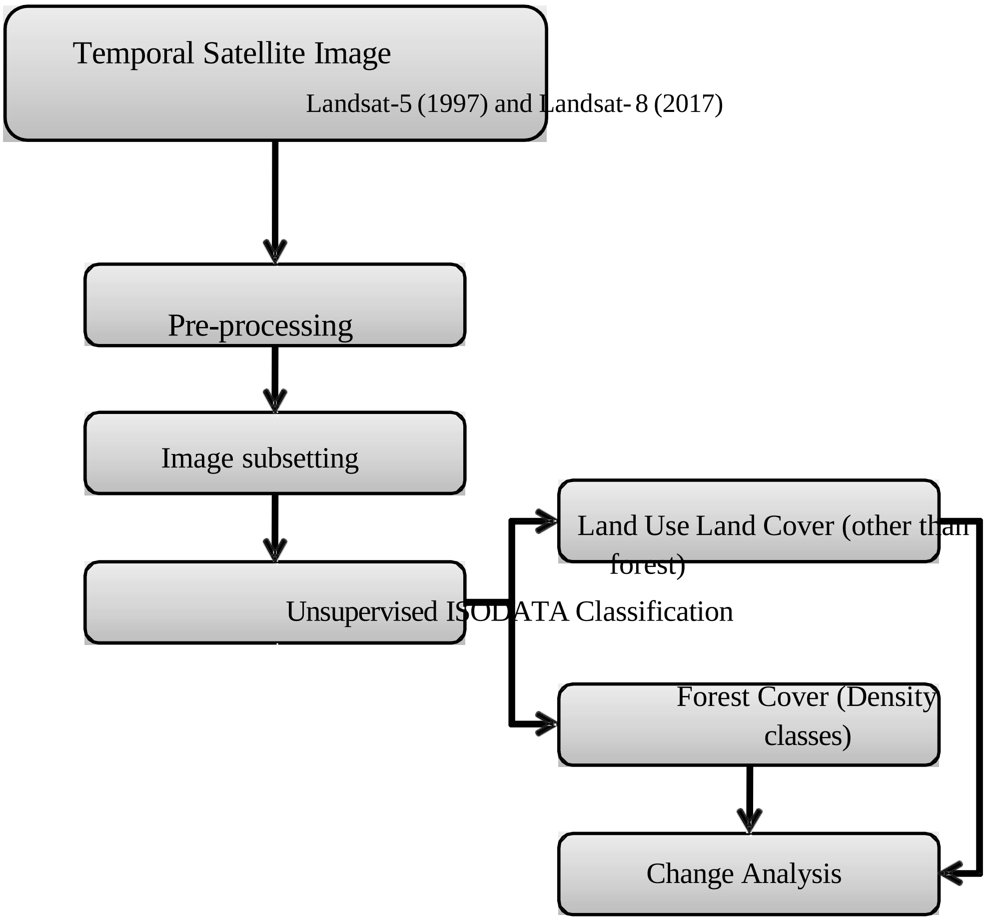

Figure 2: Flowchart of the methodology

3. RESULT AND DISCUSSION

3.1 LULC of 1997

The satellite image acquired by Landsat-5 Thematic Mapper (TM) for 1997 was classified and analysed for different LULC classes as represented in Figure 3 and their respective areas are shown in Table 2. The percentage area provided in pie chart (Figure 4) shows that the MDF has the highest area followed by OF and VDF. The Forest cover is found in more than 83% of the total geographical area of the study region.

Table 2: The LULC classes and their area (ha) in 1997

LULC	VDF	MDF	Agriculture	OF	Barren and other	Scrub	Water/river	Settlement
Area_(ha)	6390.48	7622.28	876.12	7305.39	1025.11	1480.18	896.46	8.82

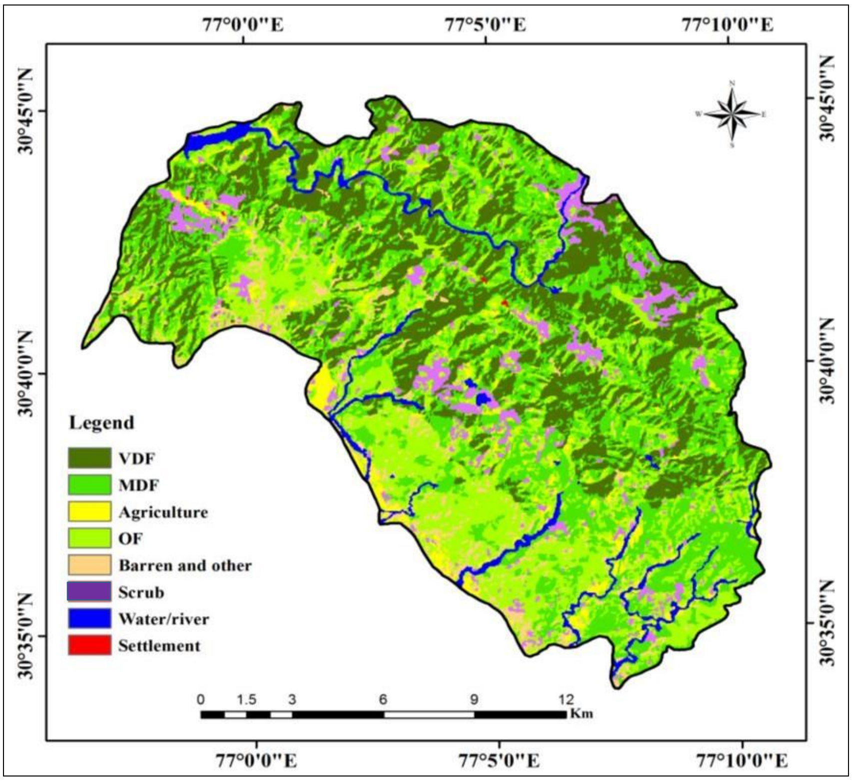

Figure 3: LULC map of 1997

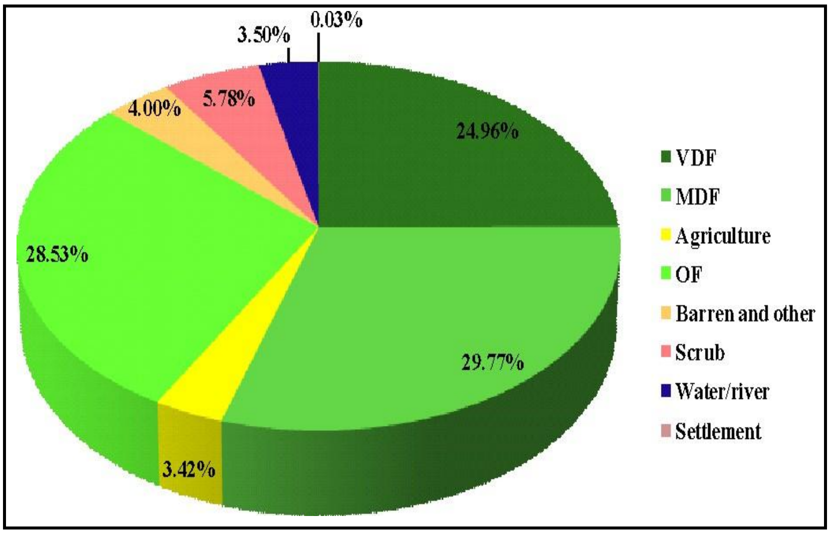

Figure 4: Percentage area under different LULC classes in 1997

3.2 LULC of 2017

The imagery acquired by the Operational Land Imager (OLI) sensor of Landsat-8 satellite were processed and classified to extract the different LULC classes for 2017 (Figure 5) and their respective areas are shown in Table 3. The percentage area of different LULC classes is provided in Figure 6. The forest cover (VDF) is found to have the highest area followed by the MDF and OF respectively.

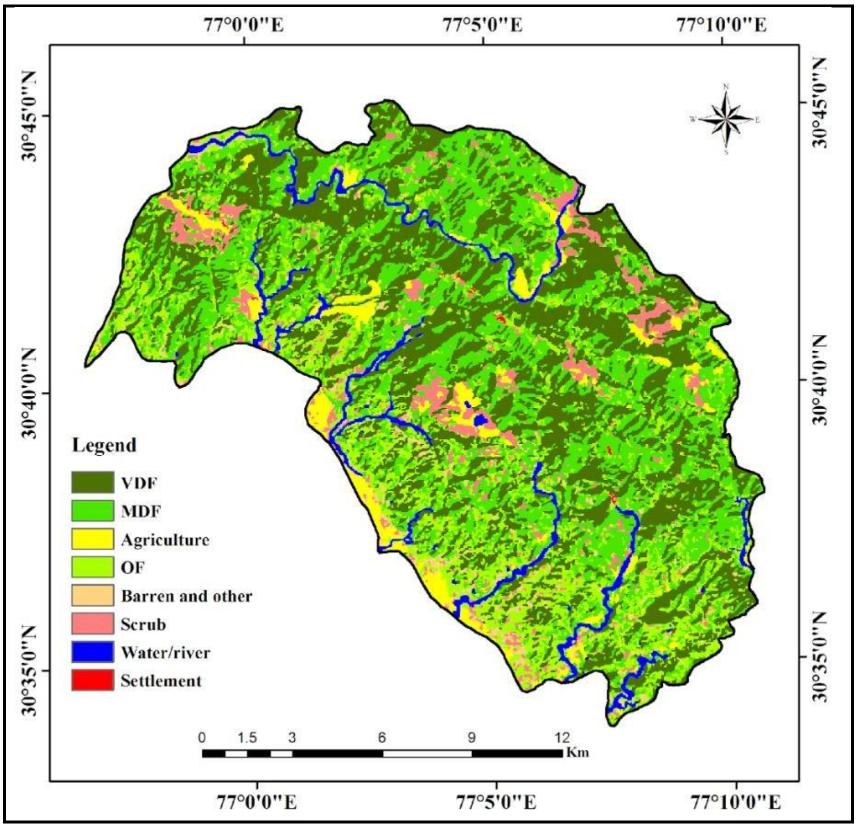

Figure 5: LULC map of 2017

Table 3: The LULC classes and their area (ha) in 2017

LULC	VDF	MDF	Agriculture	OF	Barren and other	Scrub	Water/river	Settlement
Area (ha)	9042.87	7796.48	1210.74	4713.32	437.97	1396.91	982.35	24.22

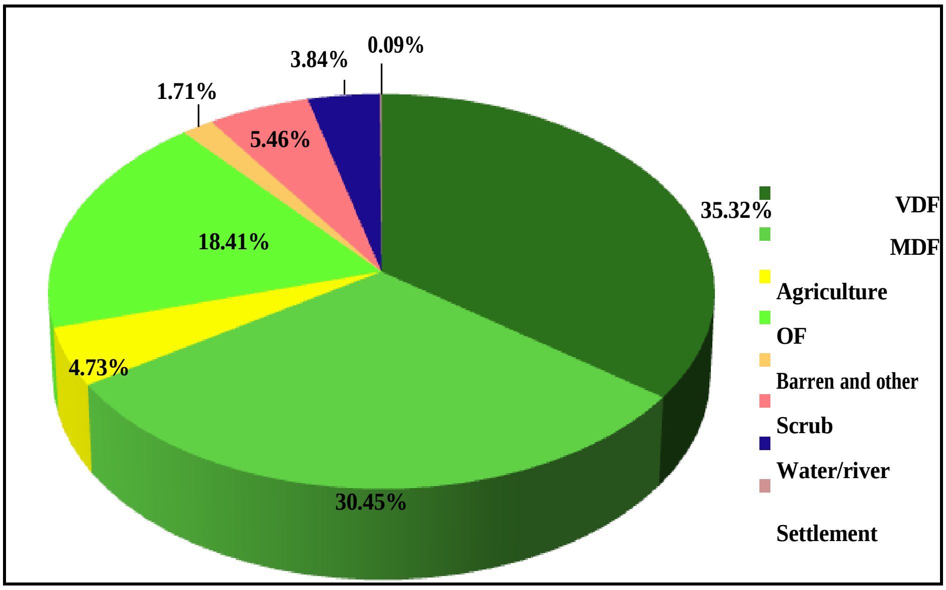

Figure 6: Percentage area under different LULC classes in 2017

3.3 LULC change dynamics between 1997 and 2017

The post classification comparison of LULC changes were analysed and presented in Table 4. The changes were categorized into positive change (where area of the class increases) and negative change (where area of the class decreases). It was observed that the forest, water, agriculture and settlement have increased in the last two decades. The highest positive increase was observed in VDF class followed by agricultural land. On the other hand, the open forest shows maximum decrease in areas followed by the barren land.

Although, the sustainable management of forest and conservation efforts of the forest department has resulted in increase in the area of MDF but decrease in open forest, barren land and Scrub during 1997 to 2017 is due to either inter-conversion of LULC classes or anthropogenic pressure. The dynamics of LULC changes are shown in Figure 7. The positive changes can also be attributed to the impact and effectiveness of the government policies and People Participatory Approach (PPA) in government activities like afforestation activities. Some of the losses of open forest, barren land and scrub can be attributed to its conversion to agriculture lands.

Table 4: Land Use Land Cover (LULC) Changes (%) of the Morni Hills (1997-2017)

Class Name	Area (1997) (hac)	Area (%)	Area (2017) (hac)	Area (%)	Change (hac)
VDF	6390.48	24.96	9042.87	35.32	+2652.39
MDF	7622.28	29.77	7796.48	30.45	+174.20
Agriculture	876.12	3.42	1210.74	4.73	+334.62
OF	7305.39	28.54	4713.32	18.41	-2592.07
Barren and other	1026.11	4.00	437.97	1.71	-587.14
SCRUB	1480.18	5.78	1396.91	5.46	-83.27
Water Bodies	896.46	3.50	982.35	3.84	+85.88
Settlement	8.82	0.03	24.22	0.09	+15.39

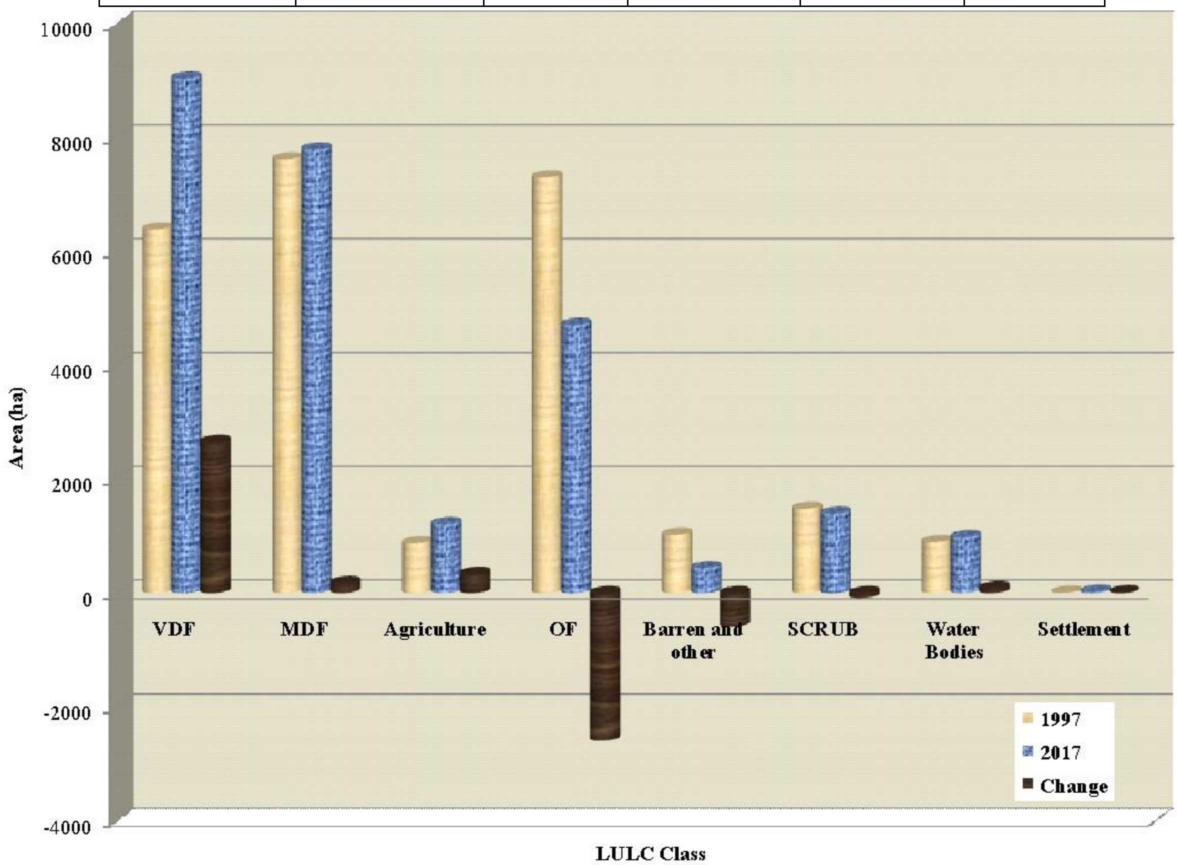

Figure 7: LULC Changes of the Morni Hills (1997-2017)

The annual rate of LULC changes during 1997 to 2017 is shown in Table 5. Among all Land use categories, the annual rate of changes in VDF (132.62 ha/year) was found to be highest.

Table 5: Annual rate of changes of LULC (1997-2017)

Land Use Categories	**Change Detection of LULC (1997-2017)**	
	Change in Area (ha)	Annual rate of change in Area (ha)
VDF	2652.39	132.62
MDF	174.20	8.71
Agriculture	334.62	16.73
OF	-2592.07	129.60
Barren and Other	-587.14	29.36
Scrub	-83.27	4.16
Water Bodies	85.89	4.29
Settlement	15.40	0.77

3.4 Village-wise LULC for 1997

Table 6 shows village-wise LULC classes for 1997. BhojRajpur village showed highest VDF *i.e.* 2843.46 while lowest was in BhojNagal *i.e.* 94.85 ha. MDF was highest in Bhojrajpur village *i.e.* 2272.07 while lowest in Bhojnagal *i.e.* 318.11 ha. OF was highest in Bhoj Ponta *i.e.* 2849.33 ha and lowest in Bhojnagal *i.e.* 315.85 ha. Most of the barren land was distributed in Bhojponta village and may be utilized for afforestation activities.

Table 6: Village wise in LULC area (ha) for the year 1997

Village Name	**VDF**	**MDF**	**Agriculture**	**OF**	**Barren and other**	**Scrub**	**Water/ river**	**Settlement**
Bhojrajpur	2843.46	2272.07	149.29	1479.15	123.25	491.81	331.22	8.86
Bhojponta	400.76	2145.30	392.80	2849.33	496.42	252.19	376.25	0.00
Bhojkudana	497.24	466.04	147.03	728.72	124.69	197.85	133.28	0.00
Bhojnagal	94.85	318.11	42.32	315.85	32.91	102.54	6.24	0.00
Bhojbalig	1417.66	1369.01	47.38	779.54	7.32	254.90	25.14	0.00
Bhojpalasra	826.74	537.12	56.42	417.67	31.47	98.02	23.96	0.00
Others	298.13	512.79	41.14	749.16	208.43	83.01	0.00	0.00

3.5 Village wise LULC area (ha) for the year 2017

The village-wise status of different land use land cover classes for 1997 has been shown Table 7. The Bhojrahpur shows the highest area of VDF and MDF followed by the Bhojpoanta. The maximum area of agriculture land and OF is found in Bhoj Ponta.

Table 7: Village-wise in LULC area (ha) for 2017

Name	VDF	MDF	Agriculture	OF	Barren &other	Scrub	Water/ river	Settlement
Bhojrajpur	3135.14	2543.09	228.76	1038.72	80.65	400.01	259.50	12.66
Bhojponta	1930.96	1723.36	424.33	1953.38	247.20	251.90	376.68	6.69
Bhojkudana	613.85	435.36	246.84	556.52	49.46	226.50	166.19	0.00
Bhojnagal	285.45	274.87	29.66	209.32	21.16	79.30	13.02	0.00
Bhojbalig	1617.66	1410.34	131.92	448.56	5.24	256.79	30.20	0.00
Bhojpalasra	907.43	749.02	61.30	119.44	14.83	107.14	28.84	3.26
Others	534.91	670.90	88.07	388.34	19.53	76.31	112.57	1.72

3.6 Village wise LULC change

The village-wise percent changes in LULC classes during 1997 to 2017 are shown in Table 8. The bar diagram for these percent changes are shown in Figure 8.

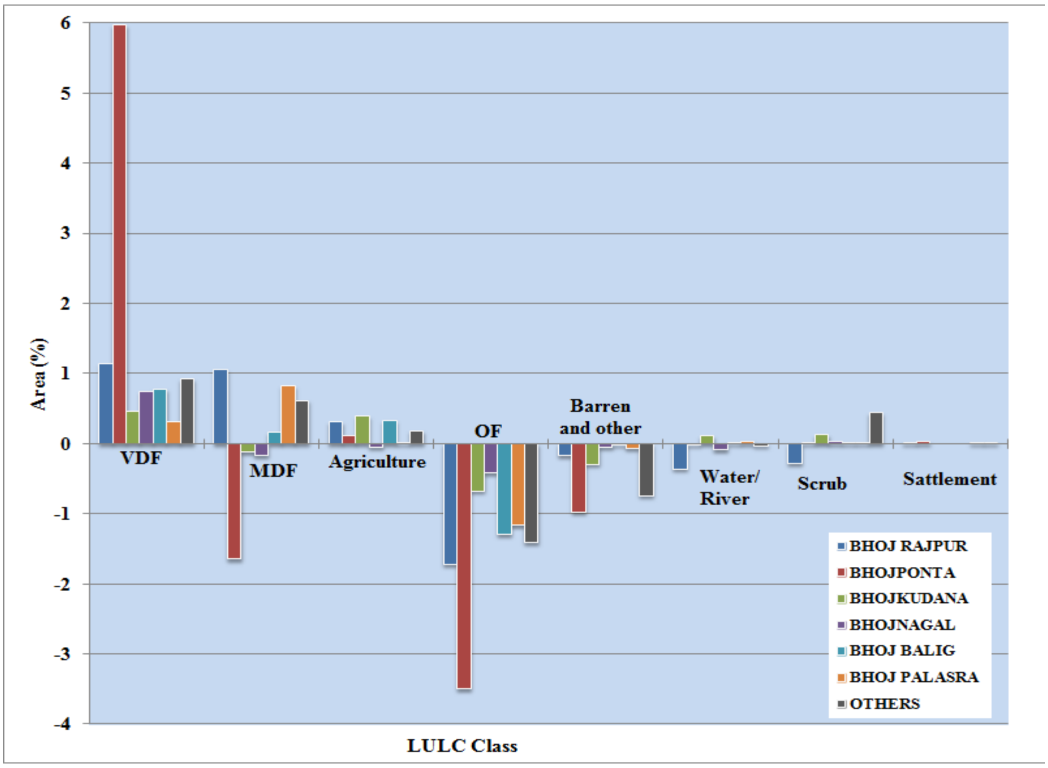

Figure 8: Village-wise LULC change (%) between 1997 and 2017

Table 8: Village-wise LULC change area (%) between 1997 and 2017

Name	VDF	MDF	Agriculture	OF	Barren and Other	Scrub	Water/ river	Settlement
BhojRajpur	1.14	1.06	0.31	-1.72	-0.17	-0.36	-0.28	0.01
Bhojponta	5.98	-1.65	0.12	-3.50	-0.97	0.00	0.00	0.03
Bhojkudana	0.46	-0.12	0.39	-0.67	-0.29	0.11	0.13	0.00
Bhojnagal	0.74	-0.17	-0.05	-0.42	-0.05	-0.09	0.03	0.00
Bhojbalig	0.78	0.16	0.33	-1.29	-0.01	0.01	0.02	0.00
Bhojpalasra	0.32	0.83	0.02	-1.16	-0.06	0.04	0.02	0.01
Others	0.92	0.62	0.18	-1.41	-0.74	-0.03	0.44	0.01

4. CONCLUSION

The Study highlights the increase in forest cover and water bodies in the study area during 1997 to 2017. These positive changes can be attributed to effective implementation of government policies like afforestation and People Participatory Approach (PPA) in forestry sector. The inter-conversion of open forests and scrub to MDF and VDF in due course of time lead to the significant increase in the area of MDF to VDF classes. The minor changes in settlement were observed which is expected in such a long time span due to increase in the population of forest dwellers.

Spatial distribution of LULC information and its changes is desirable for any planning, management and monitoring programmes at local, regional and national levels. This information not only provides a better understanding of land utilization aspects but also play a vital role in the formulation of policies and program required for developmental planning. For ensuring sustainable development, it is necessary to monitor the ongoing changes in land use land cover pattern over a period of time.

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