



Land cover and land use change detection by using remote sensing and GIS in Himchari National Park (HNP), Cox's Bazar, Bangladesh

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ABSTRACT

Himchari National Park (HNP) is a protected area that has been degraded, fragmented and converted severely into various land uses. In this study, land use changes of HNP were assessed from 1977 to 2017 by using Landsat 8 OLI-TIRS, Landsat 5 TM and Landsat 2 MSS satellite imagery. The ArcGIS v10.4 and ERDAS Imagine v15 software were used to process satellite imageries and assessed quantitative data for land use change assessment of this study area. Maximum likelihood classification algorithm was used for the assessment of supervised land use classification. Spatial and temporal dynamics of land use/cover changes (1977-2017) were quantified using three Satellite/Landsat images, a supervised classification algorithm and the post classification change detection technique in GIS. Some negative changes of land uses were showed from 1997-2017; but land use changes pattern from 1997-2017 showed comparatively better changes than 1977-1997 time period. But overall land use changes from 1977-2017 showed Dense Forest (529.4 ha) tends to degraded; agriculture (20.1 ha), degraded land (232.4 ha), settlement (82 ha), light forest (192.6 ha) and water body (2.2 ha) were increased. For the next 20 years of land use/cover changes, it is predict that more than 27.59% dense forest (145.83ha) will be decreased; on the other hand, 20% agriculture (4.02 ha), 9.86% degraded land (35.49 ha), 20 % settlement (16.40ha), 12.17% light forest (89.47 ha) and 20% water body (0.45 ha) will be increased in 2037. The overall supervised classification accuracy was found 88.64% for 2017, 85.19% for 1997, and 87.67% for 1977 with Kappa values of 0.812, 0.71, and 0.78 for 2017, 1997, and 1977 respectively and these were satisfactory. The present study is suggested for the sustainable management, protection, conservation and proper utilization of the natural resources of HNP.

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I. Introduction

In the study of global change, Land use/land cover (LULC) changes play an important role. Deforestation, biodiversity loss, global warming and increase of natural disaster-flooding have been consequence for the largely Land use/land cover and human/natural modifications (Dwivedi *et al.* 2005; Mas *et al.* 2004; Zhao *et al.* 2004). These environmental matters are often connected with the LULC changes. Therefore, for the decision-making of environmental management and planning in future, the available data on LULC changes can provide critical input (Fan *et al.* 2007). The growing population and increasing socio-economic needs create a new pressure on land use/land cover. The unplanned and uncontrolled changes in LULC are the results from this unwanted pressure. (Seto *et al.* 2002). Alterations in the surface cover result in changes to the balance of energy, water, and the geochemical fluxes at the different levels (eg. local, regional and global) and these changes will inevitably influence the sustainability of natural resources and socio-economic activities (Vescovi *et al.* 2002). LULC change is the key driver of environmental change (Riebsame *et al.* 1994) and land cover is changed primarily by direct human influences (Meyer, 1995). The causes of LULC changes are many (Lambin *et al.* 2001; Veldkamp and Lambin, 2001; Zeng *et al.* 2008). Tropical deforestation, rangeland modification, agricultural intensification, urbanization and globalization as the prime causes and factors for global and regional land use/land cover changes (Lambin *et al.* 2001). Beside these, socio-economic and biophysical characteristics are also contributing to this significant change in land cover (Zeng *et al.* 2008; Aspinall, 2004).

Remote sensing and Geographical Information Systems (GIS) are powerful tools to derive accurate and timely information on the spatial distribution of land use/land cover changes over large areas (Zsuzsanna *et al.* 2005; Guerschman *et al.* 2003; Carlson and Azofeifa, 1999; Rogana and Chen, 2004). GIS provides a flexible environment for collecting, storing, displaying and analyzing digital data necessary for change detection (Wu *et al.* 2006). Remote sensing imagery is the most important data resources of GIS. Satellite imagery is used for recognition of synoptic data of earth's surface (Ulbricht and Heckendorf, 1998). It has given scientists a remarkable way to determine the reasons for land use/ land cover changes and the resultant consequences due to human activity (Cardille and Foley, 2003).

The aim of change detection process is to recognize LULC on digital images that change features of interest between two or more dates (Muttilanon and Tipathi, 2005). The aim of the study is to analyze LULC changes using satellite imagery and GIS in Himchari National Park (HNP), Cox's Bazar. This study considered 1977 as the base year and examined the LULC change from 1977 to 2017 so that recent changes could be identified. A number of techniques are available for detecting and assessing LULC changes. Among them, remote sensing and GIS technique were widely used by researchers in the field of LULC changes study (Mamun *et al.* 2013; Dewan and Yamaguchi, 2009 a, b; Wang *et al.* 2009; Mallick *et al.* 2008; Zhan *et al.* 2002). Remote sensing and GIS technique are also applied in this study to detect LULC changes in HNP with the aim of answering the question of how the land use has been changed in HNP in the year 1977, 1997, and 2017.

II. Materials and Methods

Study area

Himchari National Park (HNP) is located ($21^{\circ}35'$ to $21^{\circ}44'$ N and $91^{\circ}98'$ to $92^{\circ}05'$ E) on the outskirts of Cox's Bazar city extending from Lighthouse para on the north to Rejhukhal on the south with an expansion of around 17 sq. km. It consists of three unions namely South Mithachari, Jhilongja and Khuniapalong union. In exercise of the power conferred by the section 23(II) of Bangladesh Wildlife Preservation act, 1974 the Government of the People's Republic of Bangladesh proclaimed the forest area measuring about 1,729 Hectare (ha) or (4,271.15 acres) of Cox's Bazar district to be a National Park on 15th February 1980. The gazette notification number XX/FOR-63/79/89. It was proclaimed as National Park under three forest block named Bhangamura Reserve Forest (872 ha), part of Chainda Reserve Forest (62 ha), and part of Jhilongja Protected Forest (795 ha). These three blocks at present covers four forest beats namely Kolatoli, Chainda, Jhilongja and Link Road. The total landscape area of the Protected Forest (PF) is about 10,849 Hectare (ha) of which 1,729 Hectare (ha) core zone (Figure 01), 5,247 ha buffer zone and 3,873 ha private land. It is under the jurisdiction of Cox's Bazar South Forest Division within Cox's Bazar district.

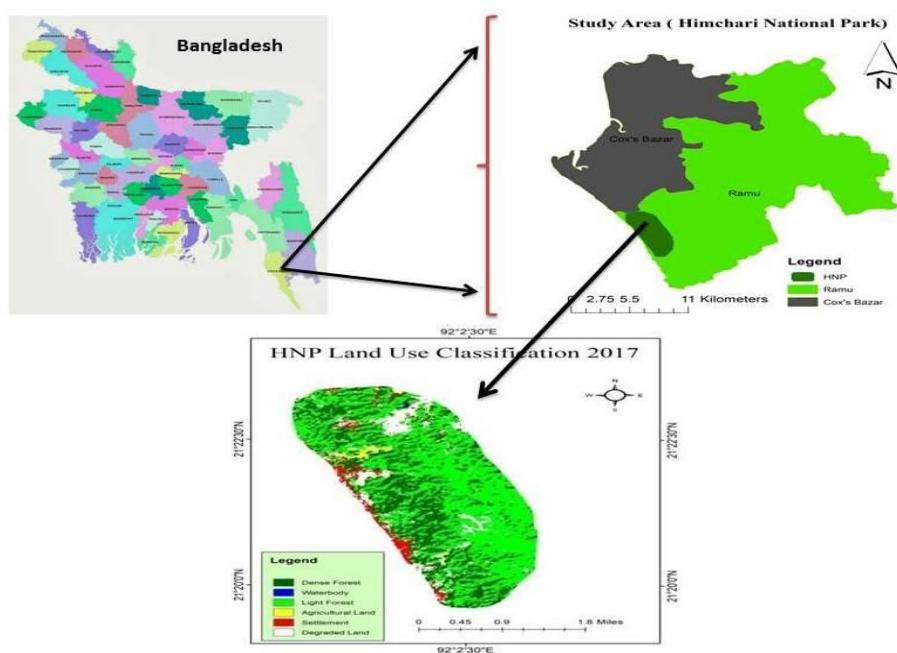


Figure 01. A landscape map on Himchari National Park (Core Area).

Data used for detecting land use changes

The latest high resolution satellite imagery provided by USGS (United States Geological Survey) for Landsat 8 OLI-TIRS (Operational Land Imager/Thermal Infrared Sensor), Landsat 5 TM (Thematic Mapper) and Landsat 2 MSS satellite imagery for the time period of 2017, 1997 and 1977 were used for visual image interpretation, land use identification and land use classification. The spatial resolution of Landsat 2 is 60 m and 30 m for Landsat 5 and 8 ([Table 01](#)). A total of 1,728 ha of the land area were estimated for the whole Himchari National Park after supervised image classification by using ERDAS Imagine v15. However, the actual total area of the Himchari National Park is 1,729 ha, which is very close to estimated value of this study. For the study, this value considered as accurate.

Image processing

Image processing and performing supervised image classification helps to extract information from imageries. ERDAS Imagine v15 software was used for image processing. Layer stacking of this software was used to convert three bands (5, 4, 3 for Landsat 8; 4, 3, 2 for both Landsat 5 and 2) into a single layer. From the layer file, Himchari National Park was clipped by using sub-set tool and shape file of Himchari National Park. Vector layer of Himchari National Park was collected from the WFP (World Food Programme) website.

Table 01. Detailed information about the satellite data used

Satellite	Sensor	Path/Row	Acquisition Date	Spatial Resolution (m)	Spectral Bands (μm)	Data sources
Landsat 8	OLI-TIRS	136/44	27-02-17	30	B2 (Blue): 0.45–0.51 B3 (Green): 0.53–0.59 B4 (Red): 0.64–0.67 B5 (NIR): 0.85–0.88 B1 (Blue): 0.45–0.52	U.S. Geological Survey
Landsat 5	TM	146/44	19-01-97	30	B2 (Green): 0.52–0.60 B3 (Red): 0.63–0.69 B4 (NIR): 0.76–0.90 B4 (Blue): 0.50–0.60	
Landsat 2	MSS	146/44	02-01-77	60	B5 (Green): 0.60–0.70 B6 (Red): 0.70–0.80 B7 (NIR): 0.80–1.10	

Atmospheric correction is another important processing step that needs to be followed. Signal measured at the satellite could be affected due to the presence of gases, solid and liquid particles from the atmosphere. The radiance measured near the sensor is termed as Top of Atmosphere (TOP) radiance ([López-Serrano et al. 2016](#)). Though less atmospheric affected imageries have been taken, atmospheric correction process was not done in that study.

Methodology for LULC change detection

The base map of the study area was prepared by using satellite imageries and shape file of Bangladesh administrative area which was obtained from WFP website. For image interpretation, ERDAS Imagine v15 and ArcGIS v10.4 software were used to prepare land use category map of the study area considering field survey data using the base map to identify different categories of land uses. A field survey was conducted in Himchari National Park to find out latitude and longitude of specific land use category and recorded. During (January 2017 to May 2018) field survey, the study area's land uses were categorized into following 6 groups including (1) Agriculture , (2) Degraded Land, (3) Settlement, (4) Dense Forest, (5) Light Forest, and (6) Water Body respectively. After image classification on the basis of above land use categories, relevant map layouts were prepared on 1(inch):0.47(miles) scale. The latitude-longitude of a specific area was collected from a wider area as it would be easily traceable. The collected land uses data was used to find out the color tone of 2017 Landsat 8 images while training dataset.

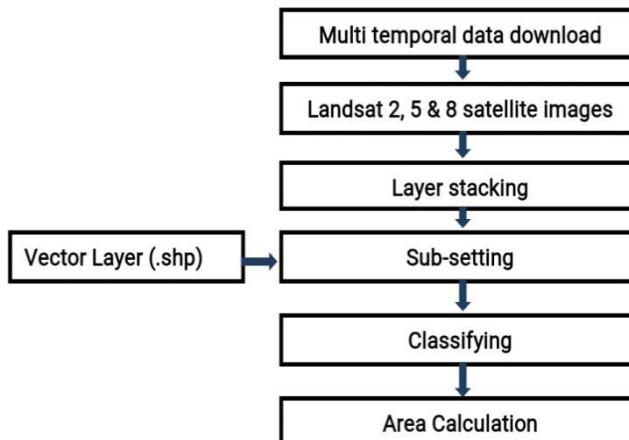


Figure 02. Procedure of Satellite image classification.

Maximum likelihood classification (MLC) approach is being widely used for land use change assessment. The magnitude change for each land use class was calculated by subtracting the area coverage from the 2nd year and initial year as shown in equation (1) ([Islam et al. 2017](#)).

$$\text{Magnitude} = \text{magnitude of the new year} - \text{magnitude of the previous year} \quad (1)$$

Percentage change (trend) for each land use type was then calculated by dividing magnitude change by the base year (the initial year) and multiplied by 100 as shown in equation (2) ([Islam et al. 2017](#))

$$\text{Percentage Change} = \frac{\text{Magnitude of Change} * 100}{\text{Base Year}} \quad (2)$$

To obtain annual rate of change for each land use type, the difference between final year to initial year which represents magnitude of change between corresponding years was divided by the number of study year i.e. 1977-1997 (20 years), 1997-2017 (20 years) and 1977-2017 (40 years) respectively as appropriate using equation (3).

$$\text{Annual Rate of Change} = \frac{\text{Final year} - \text{Initial Year}}{\text{No. of Years}} \quad (3)$$

Accuracy assessment

An accuracy assessment for the supervised land use classification was done for the 2017 image by using ERDAS Imagine v15. From the classifier 88, 81 and 73 points were generated randomly for 2017, 1997 and 1977 supervised images, respectively. Each and every point had specific color tone and the pixel value which was recognized by the software itself when the data sets were trained during supervised land use

classification. These values were considered as reference values. All the randomly generated points were then identified by the user and assigned in different classes. This process was done for the 3 supervised classification images (i.e. 2017, 1997 and 1977). The correctly identified points were considered as classified values. An Error Matrix and Kappa statistics were also generated from this reference and classified data from the report section of ERDAS Imagine v15 software.

In the Error Matrix, the rows denote the categories as derived from the reference values. The diagonal of the matrix shows the agreement of the 'from-to' categories which indicate the error (omission and commission errors) that remains between the classified and reference data (Afify, 2011).

Overall accuracy was calculated from the error matrix by dividing the sum of the entries that make major diagonal by the total number of examined pixels. Kappa co-efficient of agreement was also calculated by using following equations (Afify, 2011).

$$K^* = \frac{P_o - P_c}{1 - P_c} \quad (4)$$

$$P_o = \sum_{i=1}^r P_{ii} \quad (5)$$

$$P_c = \sum_{i=1}^r (P_{i1} * P_{i2}) \quad (6)$$

Here,

r = The number of rows in the error matrix.

P_{ii} = The proportion of pixels in row 'i' and column 'i'.

P_{i1} = The proportion of the marginal total of row 'i'.

P_{i2} = The proportion of the marginal total of column 'i'.

III. Results and Discussion

Relative changes of land use in HNP

Relative changes in land uses of HNP were assessed based on data presented in Table 02 and 03. Trends of land use changes from 1997-2017 showed some negative changes; but land use changes pattern from 1997-2017 showed comparatively better changes than 1977-1997 time period (Figure 03). An area of 199.7 ha dense Forest and 55 ha degraded land were increased from 1977-1997. On the other hand, an area of 254.7 ha light forest was decreased due to degradation. In 1997-2017, a significant changes of Dense Forest (729.1 ha) was decreased; on the other hand, agriculture (20.1 ha), degraded land (177.4 ha), settlement (82 ha), light forest (447.3 ha) and water body (2.2 ha) were increased. But overall land use changes from 1977-2017 showed Dense Forest (529.4 ha) tends to deforestation. On the other hand, agriculture (20.1 ha), degraded land (232.4 ha), settlement (82 ha), light forest (192.6 ha) and water body (2.2 ha) were increased (Table 03; Figure 04).

Prediction of future (2037) land uses of HNP

The prediction method which was followed to estimate the future land uses of Himchari National Park (HNP) is not empirical. During the estimation, it was assumed that the growth trend of HNP will remain constant. If the present growth trend will remain unchanged, projection of future land use/cover changes for the next 20 years predicts that more than 27.59% dense forest (145.83ha) will be decreased; on the other hand, 20% agriculture (4.02 ha), 9.86% degraded land (35.49 ha), 20 % settlement (16.40 ha), 12.17% light forest (89.47 ha) and 20% water body (0.45 ha) will be increased in 2037 (Table 04; Figure 05).

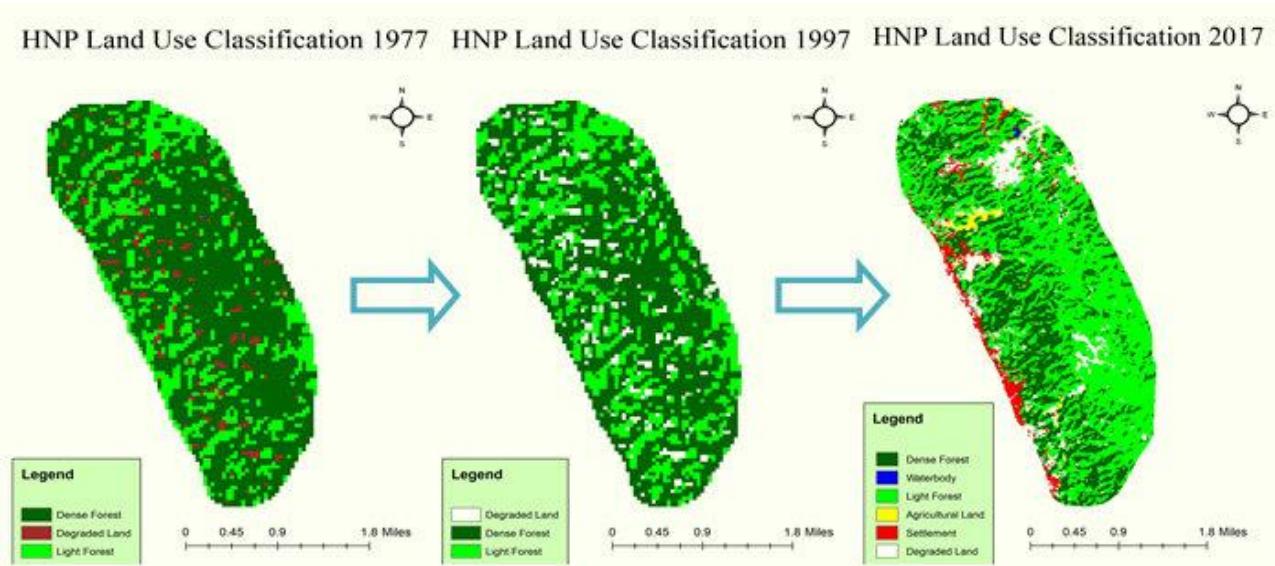


Figure 03. Relative changes of land use from 1977-2017 in HNP.

Table 02. Category wise land use distribution of HNP from 1977-2017

Land use category	Land Use (A) in 1977		Land Use (B) in 1997		Land Use (C) in 2017	
	Area (ha) 1977	% of land	Area (ha) 1997	% of land	Area (ha) 2017	% of land
Agriculture	0.00	0.00	0.00	0.00	20.12	1.16
Degraded Land	127.44	7.38	182.43	10.56	359.86	20.83
Settlement	0.00	0.00	0.00	0.00	81.99	4.74
Dense Forest	1058.04	61.23	1257.75	72.79	528.62	30.59
Light Forest	542.52	31.40	287.82	16.66	735.17	42.54
Water Body	0.00	0.00	0.00	0.00	2.24	0.13
Total	1728.00	100	1728.00	100.00	1728	100.00

Table 03. Land use change assessment of HNP based on time frame data (1977-2017)

Land use category	Land Use Change (B-A): 1977-1997			Land Use Change (C-B): 1997-2017			Land Use Change (C-A): 1977-2017		
	Changed Area (ha)	% Change	Annual rate of change (ha)	Changed Area (ha)	% Change	Annual rate of change (ha)	Changed Area (ha)	% Change	Annual rate of change (ha)
Agriculture	0.0	0.0	0.0	+20.1	0.0	0.0	+20.1	0.0	0.0
Degraded Land	+55.0	+43.1	+2.7	+177.4	+97.3	+4.9	+232.4	+182.4	+4.6
Settlement	0.0	0.0	0.0	+82.0	0.0	0.0	+82.0	0.0	0.0
Dense Forest	+199.7	+18.9	+10.0	-729.1	-58.0	-2.9	-529.4	-50.0	-1.3
Light Forest	-254.7	-46.9	-12.7	+447.3	+155.4	+7.8	+192.6	+35.5	+0.9
Water Body	0.0	0.0	0.0	+2.2	0.0	0.0	+2.2	0.0	0.0

Note: (+) sign denotes increase and (-) sign denotes decrease of magnitude of change of land use category in different periods.

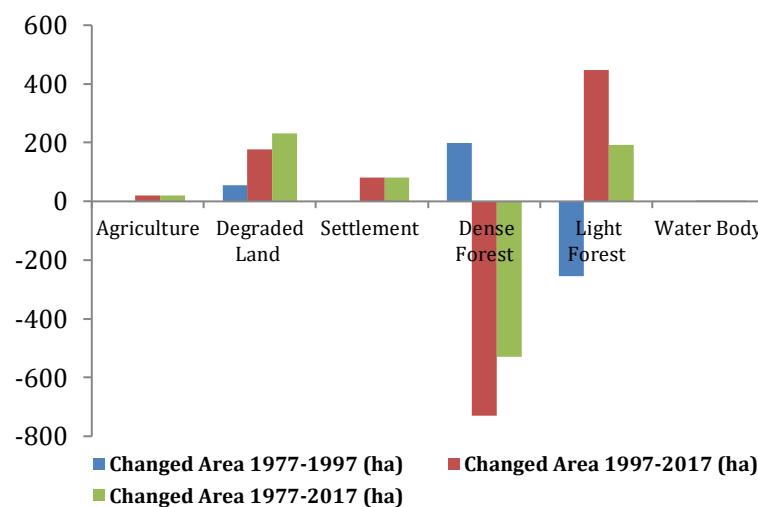


Figure 04. Relative changes of land use in HNP.

Table 04. Predicted Land use change assessment of HNP for time frame (2017-2037)

Land Use Category	Predicted Land Use in 2037		Land Use in 2017		Predicted Land Use Change: 2017-2037		
	Area (ha)	% of Land	Area (ha)	% of Land	Changed Area (ha)	% Change	Annual rate of change (ha)
Agriculture	24.14	1.40	20.12	+0.20	+4.02	+20.00	+0.20
Degraded Land	395.35	22.88	359.86	+1.77	+35.49	+9.86	+1.77
Settlement	98.39	5.69	81.99	+0.82	+16.40	+20.00	+0.82
Dense Forest	382.79	22.15	528.62	-7.29	-145.83	-27.59	-7.29
Light Forest	824.64	47.72	735.17	+4.47	+89.47	+12.17	+4.47
Water Body	2.69	0.16	2.24	+0.02	+0.45	+20.00	+0.02
Total	1727.98						

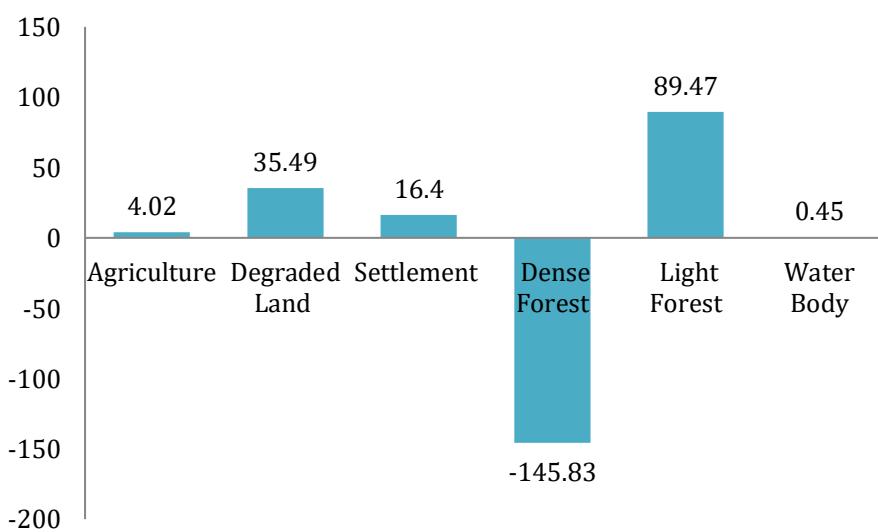


Figure 05. Predicted land use change area (ha) of HNP from 2017-2037.

Overall accuracy and Kappa (K^*) statistics for supervised classification

Summary of supervised classification accuracy for the three different time frames (1977, 1997 and 2017) found from accuracy assessment is shown in **Table 05**. The highest accuracy was found for 2017 supervised classification (88.64% accuracy) and the lowest for 1997 (85.19% accuracy). Kappa statistics

is a measurement mechanism between referenced data and user identified classified data. Kappa value is also used to check accuracy in classification and having a Kappa value (0.81–1.00) denotes almost perfect/perfect match between the classified and referenced data in the classification system ([Van Vliet et al. 2011](#); [Landis and Koch, 1977](#); [Yang and Lo, 2002](#)). This study reveals that supervised land use classification was a better option for land use study and multi-temporal change assessment of land use. The overall classification accuracy along with the Kappa value for 1977, 1997 and 2017 supervised land use classification was good enough to detect the changing scenarios of HNP.

Table 05. Overall classification accuracy and overall kappa statistics of supervised classification of 1977, 1997 and 2017 satellite imageries of HNP

Accuracy assessment	Overall classification accuracy		
	1977	1997	2017
	87.67%	85.19%	88.64%
Overall Kappa Statistics			
	1977	1997	2017
	0.78	0.71	0.812

IV. Conclusion

Once the HNP was very rich in flora and fauna but many of the species have disappeared from the area due to habitat destruction, over-exploitation, habitat fragmentation, fire hazard, encroachment, indiscriminate harvesting of tree species and Non-Timber Forest products and human-wildlife conflict. The park has been under manifold pressures from the surrounding populations. The Park has been degraded severely and land has been fragmented and converted into various land uses. This study revealed the extent of land use changes in the HNP with the application of remote sensing and GIS technique by using satellite imageries. This simple technique can be used in land use zoning and planning ([Dutta et al. 2015](#); [Rawat and Kumar, 2015](#); [Rawat et al. 2013](#)). The trend of land use changes found in this study, especially percentage increase in deforested land and decrease in natural/dense vegetation cover will be helpful to policy makers to protect the national park in the current state with effective measures of diverting the forest dependent people towards non forest related livelihood alternatives or reducing dependency on the forest, there is a greater possibility of this forest to develop into a better quality forest in future.

On the other hand, the maximum accuracy found for the Landsat TM data while the lowest accuracy attained for the MSS image. The study used the facilities of GIS and RS (Remote Sensing) techniques to assess the land cover change in HNP over the last 40 years. Although the overall accuracy of this present study was favorable but still there are some issues which need to be corrected. For supervised classification, it was tried to select imageries of same growth season but due to cloud cover and unavailability of quality imageries, it couldn't be done. This resulted some problems like class mismatching. For the future study, it is recommended to select imageries of same growth season. Socio-economic variables are considered highly related to the changes in land use/land cover of an area ([Verburg et al. 2004](#); [Aspinall, 2004](#)). Thus incorporating socio-economic and demographic data of the study area along with temporal change pattern would give a critical reasoning for land use/land cover assessment.

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Conflict of Interest

The authors declare that no conflict of interest exists.

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