

Land use land cover study of Bhimbetka Rock Shelters using Satellite Remote Sensing (RS) and Geographic Information System (GIS) Techniques

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Abstract - In recent past, there are several instances where the impact of anthropogenic activities has led to significant changes in the geographical and cultural landscape of an area over a period of time. Bhimbetka Rock Shelters is one of the World Heritage Archaeological Sites dating back to ~1,60,000 years located about 45 km south of Bhopal in the state of Madhya Pradesh, India. This study was undertaken to understand the land use land cover (LULC) of Bhimbetka and its peripheral region to assess the LULC changes due to increased anthropogenic activities. In order to understand the changes in the study area, digital classification of Landsat satellite imagery of years 1992, 2006 and 2016 was carried out using various techniques. The result of this analysis is coupled with the census data and the different patterns of land use change and urban growth is analysed. The accuracy of image classification was assessed using ground field data collection through error matrix. The user, producer and overall accuracies of the year 2016 were estimated to be 95.22%, 91.94% and 89.58% respectively, with kappa coefficient of 0.85. Significant changes had taken place in the LULC of the study area over a period of 24 years. The process of urbanization has increased in study area during the period, resulting in reduction of dense scrub and open forest areas. Agricultural occurrence of these activities had increased considerably in the study area. Changes indicate a possible negative impact of anthropogenic activities on the sustenance and preservation of such rare heritage site. The present study brought out the utility of remote sensing technique for multi-temporal analysis of a World Heritage Site. Remotely sensed satellite imageries have been found to be a valuable tool for the characterization of the archaeological landscape and locations of core area and buffer zone.

Keywords - Anthropogenic activities, Cultural landscape, digital classification, Landsat, LULC, Remote sensing, World Heritage Site.

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1. INTRODUCTION

India is often referred to as the land of cultural wealth and the heritage in India is an integral part of all living entities. Our cultural heritage is a mirror of our national unity. UNESCO (The United Nations Educational, Scientific and Cultural Organization) seeks to preserve and protect the heritage sites through the convention concerning the protection of World Cultural and Natural heritage. Bhimbetka Rock Shelters is one of the World Heritage Archaeological Sites located near Bhopal, Madhya Pradesh. Bhimbetka was discovered as an archaeological site in 1957 by V. S. Wakankar¹ (Wakankar, 1975) and it was inscribed as a World Heritage Site by UNESCO in 2003. There are widespread evidences from nearly all over India of the workmanship of the Homo erectus, the earliest human ancestor, in the form of Palaeolithic tools. Direct and indirect evidences so far indicate the earliest presence of this ancestral form in the country approximately 1,60,000 years ago² (India, 2003). It signifies a remarkable accomplishment of humanity and serves as evidence of our intellectual history on the planet earth. Bhimbetka is therefore selected as a study area as it is one such a rare primary site in which the earliest human occupation was observed. Its discovery is of vital significance for the people

of prehistory and it provides evidences which are unique in the entire world.

In recent past, heritage sites are subject to process of degradation with time and impact of anthropogenic activities has led to significant changes in the cultural landscape of these sites over a period of time. Conservation of heritage is important for identifying, recording, analysing and protecting heritage and cultural resources. It possesses historical values resulting from the beautiful architecture and their correlation with important religious or social events that occurred in the heritage area. A conservation guideline of heritage is one of the proposed resolutions for the protection of the cultural heritage failing to which leads to its deterioration. For this reason, several researches were conducted all over the world to assess the existing conditions of heritage.

Remote sensing has increasingly been used as a source of information for characterizing land-use land-cover change at local, regional and global scales^{3,4} (Justice, 2002) (Lyons, 2003). Satellite Remote Sensing has very important role in providing synoptic, regular, multi-spectral and multi-temporal coverage of a geographic area. In addition, spectral remote sensing has been used in many applications including archaeological investigations. Also,

satellite data and its analysis are used as major tools in investigating natural formations as well as man-made structures.

In conjunction with GIS (Geographical Information System), satellite remote sensing can be used as an effective tool for generating the necessary information for surveying and monitoring the land use land cover changes in a region.

Identification of changes in land use and land cover that have either undesired or desired effects on environment deserves special focus. Conventional methods used for mapping land use land cover are time consuming, expensive with low repetitive value. Rapid evolution in satellite remote sensing and Geographic Information System (GIS) has developed the new techniques for facilitating the mapping of natural resources. Satellite remote sensing has been recognized as a powerful and

helpful tool for mapping and monitoring the natural resources as it provides detailed information available through the electromagnetic spectrum in a synoptic and a systematic manner. Also it provides the detailed information regarding extent of the land use land cover in the landscape.

In the present study, an attempt has been made to study the changes in land use land cover of Bhimbetka since 1992 – 2016. This paper presents an overview of some important studies that have used satellite remote sensing to assess the land use degradation activities. Through this study, the LULC changes in site were analysed and evaluated by using satellite imageries. The utility of interfacing remote sensing and GIS for effective study of land use and land cover changes in the study area has been emphasized.

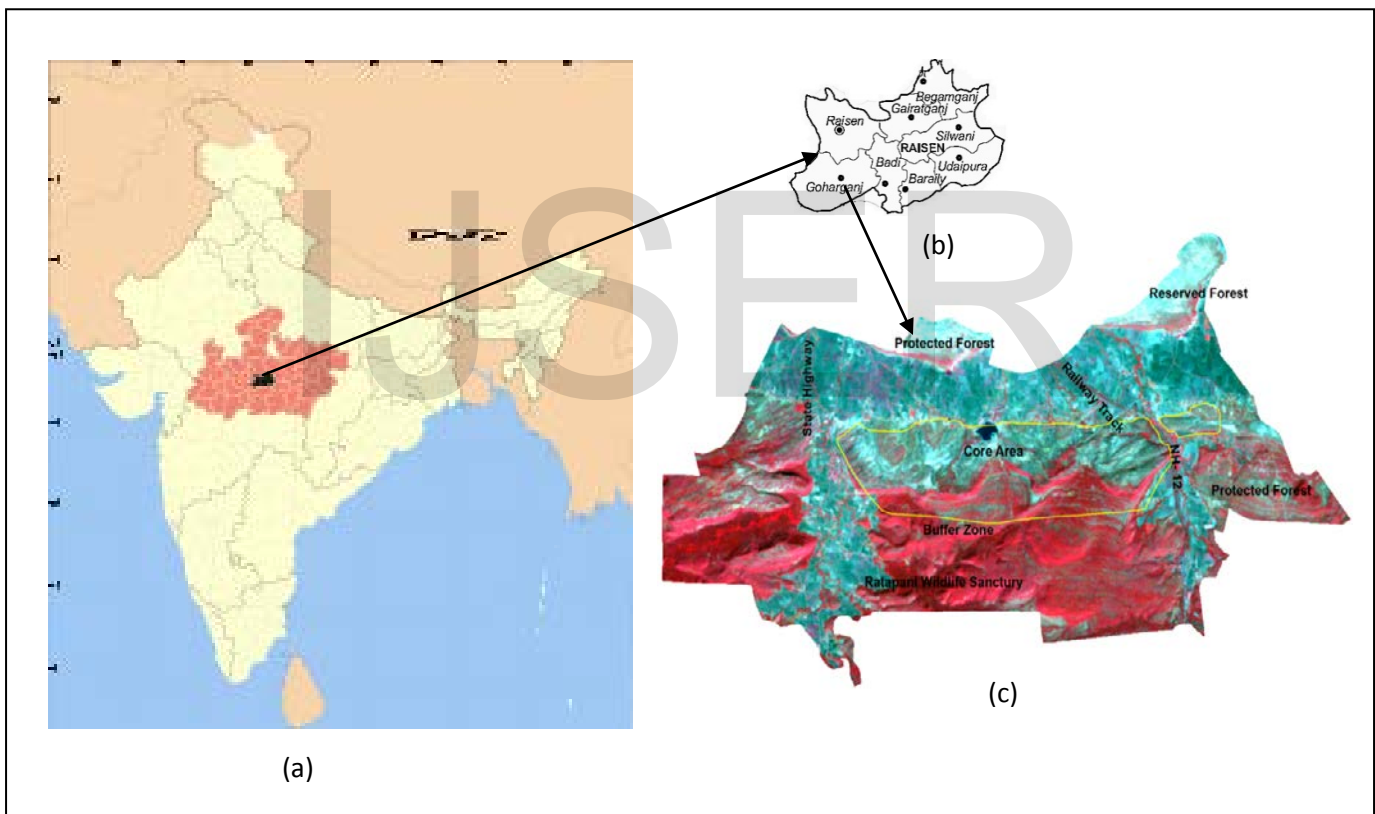


Figure 1: Location of Study Area (a) Map of India showing Madhya Pradesh and Raisen district, (b) Map of Raisen district, (c) False Colour Composite (FCC) of Bhimbetka, (source NRSC)

2. Description of Study Area

Bhimbetka is situated in the Vindhya Mountain Range rising over 100 m above the Deccan plain and over 600 metres above mean sea level amidst the Ratapani wild life sanctuary in Raisen District, Madhya Pradesh. It lies 45 km south of Bhopal and 30 km northwest of Hoshangabad

on Obaidullaganj – Itarsi National Highway number 69. Bhimbetka is 8.5 km away from Barkhera railway station.⁵ The study area is located at the latitude between 22° 52' N and 23° 00' N and longitude between 77° 30' E and 77° 43' E (Figure 1).

The scientific research survey of the region has led to the information that geographically, the cluster of shelters is extended over a wide area from Kari Talai to beyond the Bhopal-Rehti road and includes seven topographical areas (I - VII), in which I – Bineka, II – Bhonrawali, III – Bhimbetka, IV – Lakha Juar (East) and Lakha Juar (West) are in the core area. The westernmost hill is known as VI – Muni Baba Ki Pahari and forms part of the buffer zone. The Bhimbetka group has 243 rock shelters out of which 133 contain paintings. The study reveals that the Lakha Juar Group with 178 shelters spread over 2 hills (IV – East and V - West) contains more rock paintings than Bhimbetka group.⁶ (Mathpal Y, 1984) Bhimbetka site complex has a core area of 1893 hectares forms a part of the Vindhyan range in central India, within the northern periphery of the Ratapani Wildlife Sanctuary. It is buffered all round by reserved and protected forests, including agricultural land and tribal villages towards its east and west directions having area 10280 hectares.

The prehistoric cave shelters area is massively sculpted sand stone rock formation is classified as core area and buffer zone. The core area (1893 hectares) of the agglomeration of the caves is surrounded by buffer zone (10280 hectares) covering 21 largely adivasi village settlements.⁷ Bhimbetka rock shelters was brought under the control of ASI (Archaeological Survey of India) in 1962. This hill range with painted rock-shelters runs east-west for a length of more than 8 km.⁸ (Mathpal Y, 1984) The Table 1: Details of Landsat satellite imagery

Bhimbetka group of hills is formed of sandstones⁹ (Purakala, 1994) of the Lower Bhandar Group of the Vindhya Super Group, one of the oldest geological formations. The sandstone is medium grained and exhibits different primary sedimentary structures. It has been slightly metamorphosed and has turned into orthoquartzite.

3. Materials and Methods

3.1 Satellite Data Used

Landsat TM satellite image of the year (October 1992), Landsat ETM+ satellite image of the year (October 2006) and Landsat TM (OLI and TIRS) satellite image of the year (October - 2016) were employed for digital image processing. To compute changes in the land cover classes between different time domains using multi temporal satellite images it is required that all the images should have same projection. The Landsat satellite data provided by GLCN (Global Land Cover Network) was radiometrically and geometrically corrected and reprojected to UTM/WGS 84 projection to have same projection parameters. The data of satellite Landsat 8 which carries an OLI and TIRS sensors has been used which has same spectral bands as that of TM (Thematic Mapper). These multi-temporal orthorectified Landsat datasets were used for further processing which were acquired during October from 1992–2016. The details are shown in Table1.

Satellite Imagery	Year	Spatial resolution (m)	Spectral resolution (µm)
Landsat 4 TM	October 1992	30m	Green 0.52-0.60 Red 0.63-0.69 NIR 0.76-0.90
Landsat 7 ETM+	October 2006	30m	Green 0.52-0.60 Red 0.63-0.69 NIR 0.76-0.90
Landsat 8 TM (OLI & TIRS)	October 2016	30m	Green 0.53 - 0.59 Red 0.64 - 0.67 NIR 0.85 - 0.88
Note: TM = Thematic Mapper, ETM+ = Enhanced Thematic Mapper Plus, OLI & TIRS = Operational Land Imager and Thermal Infra Red Sensor.			

3.2 Ancillary Data Used

3.2.1 SOI Toposheet: The SOI (Survey of India) topographic map (55F/9) of 1:50,000 scale pertaining to the study area was used as base map for geo-referencing of satellite images and demarcation of core area, buffer zone, forest area and non-forest area boundaries.

3.2.2 District Maps: Relevant district maps of Raichur District provided by GSI (Geological Survey of India), Nagpur were used for reference purpose.

3.2.3 Softwares: ArcGIS 9.3 and ERDAS Imagine 10 and Primewin were used to process and analyse the input parameters. All the rectified and georeferenced datasets

were interpreted for land use land cover information and correlated to identify the spatial changes.

3.2.4 Research articles published in various national and international journals, conference proceedings, etc were used in the study.

3.3 Methodology

3.3.1 Flowchart:

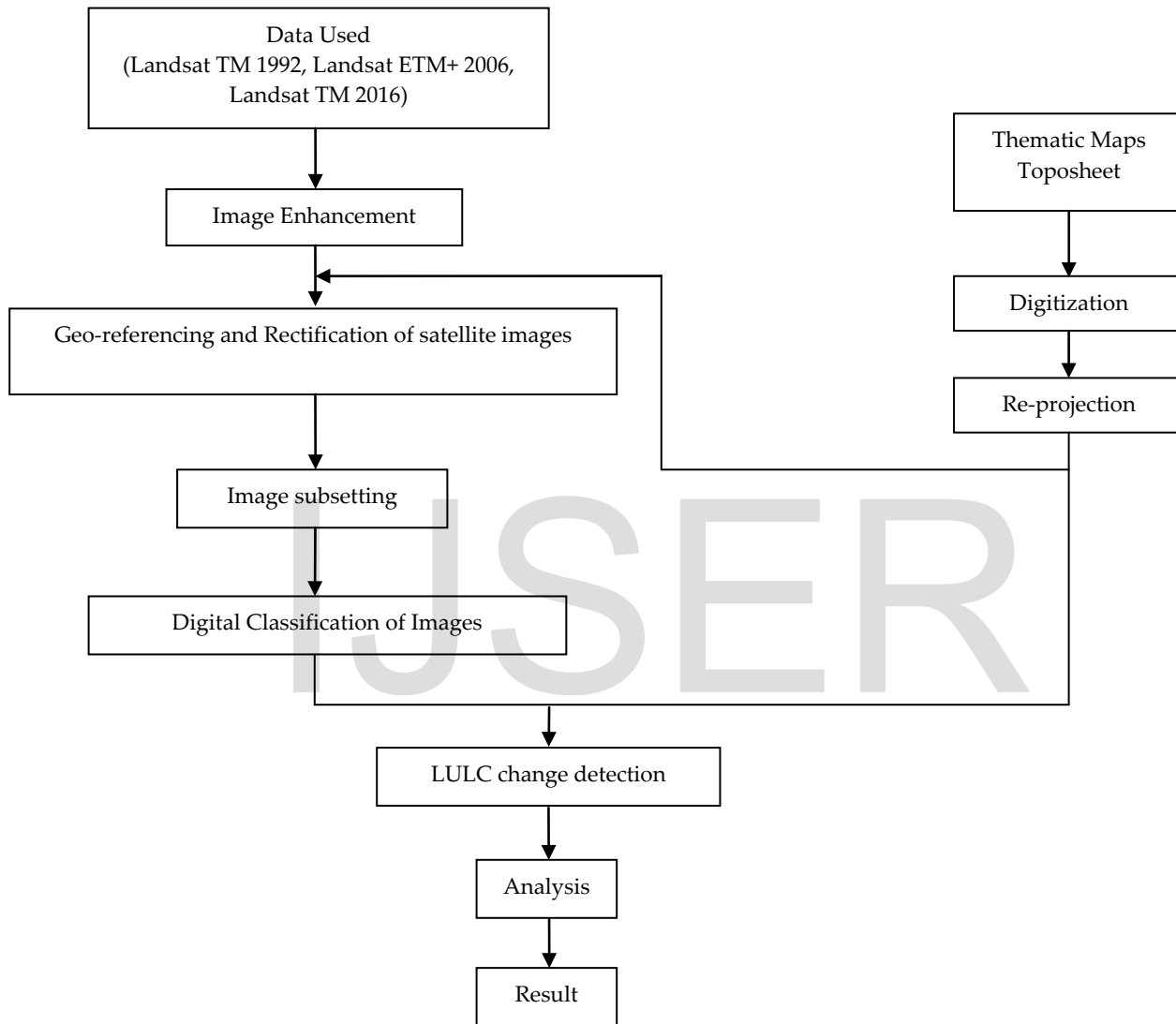


Figure 3: Flowchart of the study

3.3.2 Data preparation

1. Generation of study area boundaries

Initially the toposheet was scanned and converted into digital raster format. A vector layer was prepared. The boundaries of the core area, buffer zone, forest and non-forest were digitized using toposheet.

2. Subset of imagery:

These boundaries were superimposed on Landsat 1992 image and the subsets were extracted. Similar procedure was adopted for other Landsat images. Reprojection was applied so that all dataset have same projection parameters.

3.3.3 Digital Classification using supervised classification algorithm

After georeferencing of all datasets, the broadly identified areas were used for classification. A procedure was adopted for identifying spectrally similar areas on an image by identifying 'training' sites of known targets and then extrapolating those spectral signatures to other unknown targets. Various supervised classification algorithms are used to assign an unknown pixel to one of the possible classes. The choice of the particular classifier or decision rule totally depended on the nature of the input data and the desired output. Supervised classification relies on apriori knowledge of the location and identifies the land cover types that are present in the image. Training areas, usually small samples compared to the full image which are used to "train" the classification algorithm to recognize land cover classes based on their spectral signatures, as found in the images. The training areas for any land cover class need to fully represent the variability of that class within the image.

There are numerous aspects that must be considered while conducting a supervised classification. The first is developing an appropriate classification scheme. Training areas must be selected for each of the classes and statistics calculated for them. The appropriate classification algorithm has to be selected, and once when each and every pixel in the image is evaluated and assigned to a land cover class, the accuracy of the classification has to be assessed.

3.3.4 Field Data Collection

A pre-field interpretation map was prepared and some areas were identified for ground truth cross validation. Ground truth information was collected by GPS survey with the help of Bhuvan POI software. Recent satellite data were used during field survey and the current land use practices are recorded in the field. The GPS points were downloaded and overlaid on the imagery and used for assessment and evaluation purpose.

4 Results

4.1 Analysis of the Satellite Image

Using ERDAS Imagine software, Landsat images were processed and reprojected to a LCC (Lambert Conformal Conic) projection and WGS 84 (World Geodetic System) Datum. Buffer zone of Bhimbetka was selected as study area, it was divided into forest and non-forest areas. As the boundaries of the forest areas were already prepared on the toposheet, NDVI (Normalized Difference Vegetation Index) was done for forest area to know the rate of changes and was evaluated using statistical data.¹⁰ The area under forest was divided into three classes namely, open forest, moderate dense forest and very dense forest. A supervised classification with the maximum likelihood algorithm was conducted to classify the non-forest areas of the images using green, red and NIR bands in ERDAS IMAGINE software. For these areas, training samples were collected for 5 land cover classes, which are crop and fallow land, barren land and open scrub, dense scrub, water body and settlements.

Figures 4, 5 and 6 shows the result of digital classification and table – 2 shows the summary of image classification.

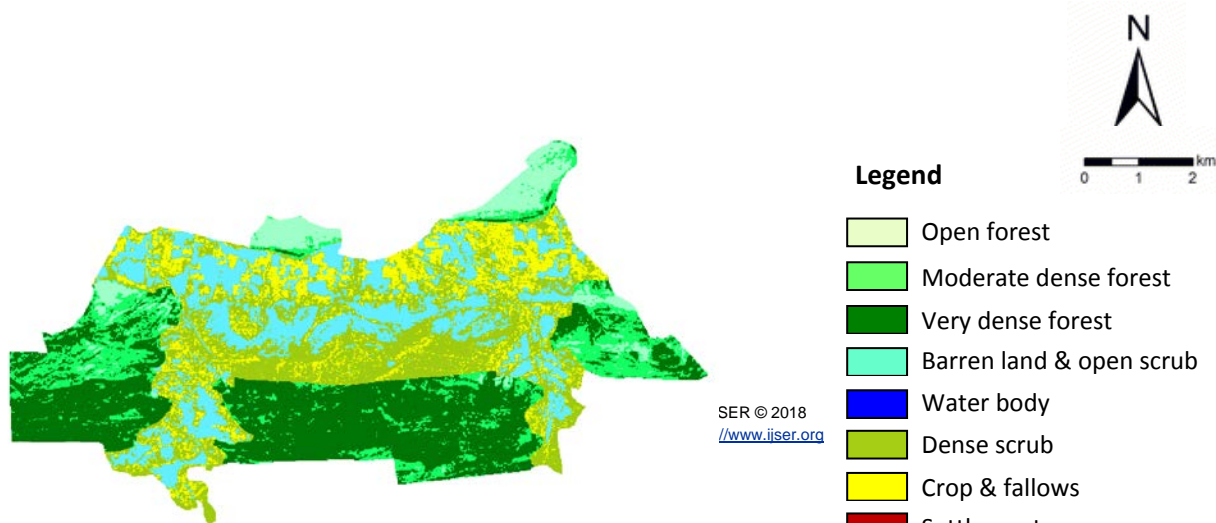


Figure 4: Classified output of 1992 image

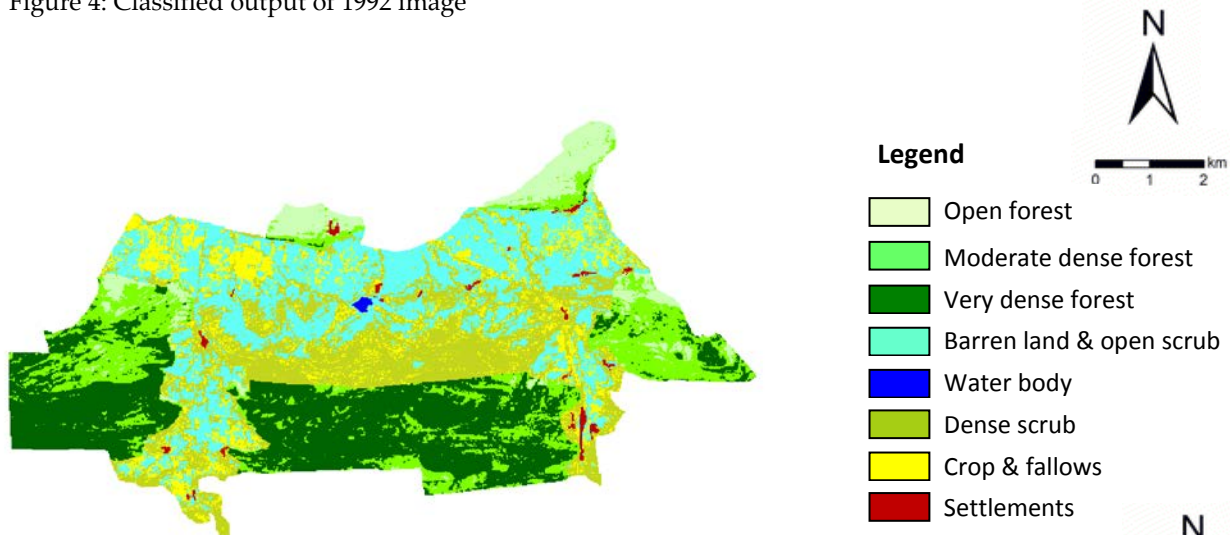


Figure 5: Classified output of 2006 image



Figure 6: Classified output of 2016 image

Table 2: Summary of image classification

Class Name	Landsat 1992 Area (ha.)	Landsat 2006 Area (ha.)	Landsat 2016 Area (ha.)
Open forest	732.6	757.657	708.627
Moderately dense forest	1563.75	1890.57	1758.03
Very dense forest	3479.85	3120.61	3295.12

Barren land and open scrub	2237.94	2729.8	2652.01
Waterbody	Could not classify	14.297	16.7358
Dense scrub	3055.86	2730.73	2614.92
Crop and fallows	1456.83	1209.61	1366.12
Settlements	Could not classify	81.9975	123.627

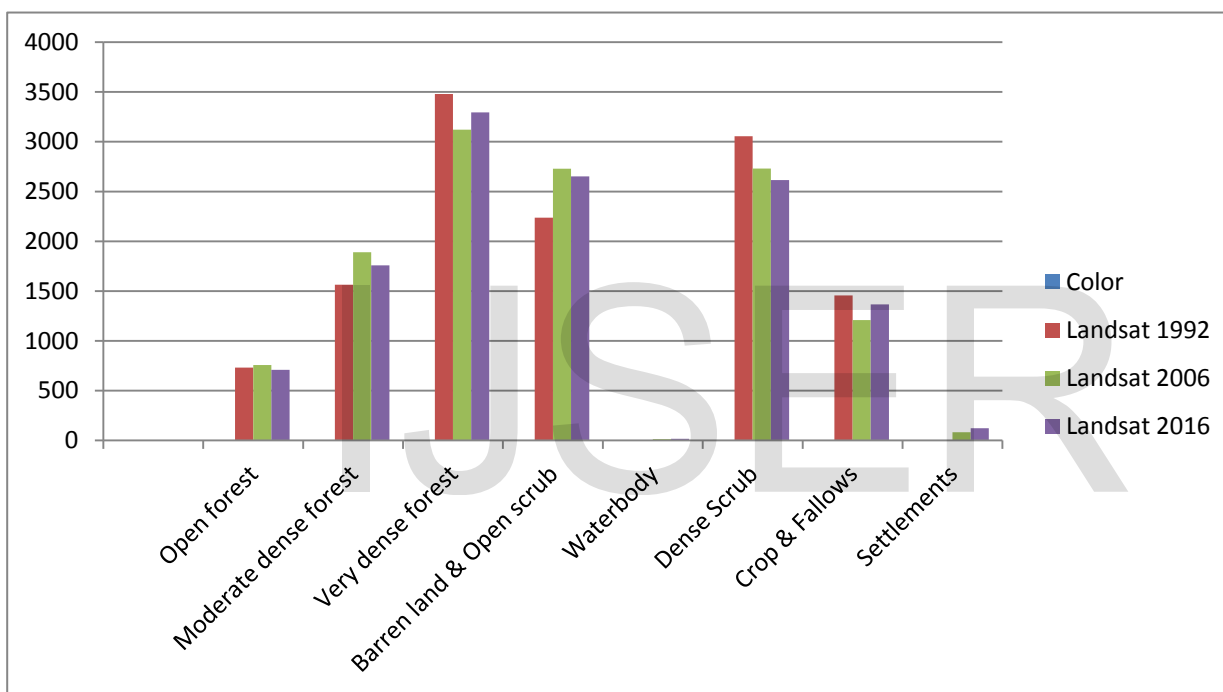


Figure 7: Graphical representation of classified data

4.2 Accuracy assessment and kappa analysis:

Accuracy is considered as the degree of closeness of results to the true values.¹² It determines the quality of the information derived from remotely sensed data. Accuracy assessment was done based on the visual

interpretation of images supported by 144 validation points (ground truth). Here, the accuracy of image classification was assessed using ground field data collection through error matrix (table 3).

Table 3: Error matrix of referenced and classified data of 2016

Classified data	Barren land and open scrub	Waterbody	Dense scrub	Crop and fallows	Row Total	User's Accuracy
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Barren land and open scrub	30	0	0	1	31	96.77%
Waterbody	0	10	0	0	10	100%
Dense scrub	0	0	37	7	44	84.09%
Crop and fallows	0	0	0	52	52	100%
Column Total	30	10	37	60	144	-
Producer's Accuracy	81.08%	100%	100%	86.67%	-	-

5 Discussion

LULC classes were defined as open forest, moderately dense forest, very dense forest, barren land and open scrub, water body, dense scrub, crop and fallow land, and settlements on the basis of Anderson's classification system level-I (Anderson et al. 1976).¹¹ From table 2 it is found that the major part of LULC is dominated by forest in which very dense forest has the larger area. Areas under very dense forest appear high during 1992 with 3479.85 hectares and thereby reducing largely in 2006 with 3120.61 hectares. In the later periods it again rises to 3295.12 hectares. Likewise, open forest occurring in the midst of the forested areas reduced till 2016. Areas under moderate dense forest increased since 1992 onwards. The reduction in the areas of very dense forest and open forest is attributed to the increase in the areas of moderate dense forest. As the forest boundaries were already prepared on the toposheet, so the transformations are carried out within the three forest classes only.

In the class barren land and open scrub, barren areas are the places devoid of vegetation cover and characterized by rocky-stony surface while open scrub areas includes low trees and shrubs having vegetation cover <40%. In 1992, the area occupied by barren land and open scrub was 2237.94 hectares, in 2006 it became 2729.8 hectares and it was 2652.01 hectares in 2016. That means, from 1992 to 2006, the significant changes has occurred in this class thereby the area is increased by 491.86 hectares. Later on in 2016, this class remains more or less stable and not showing any remarkable change during the study period. While ground data collection, it was noticed that in many areas the land was harvested recently and left open.

In the year 1992, waterbody could not be mapped. Waterbody appeared in the core part of Bhimbetka with 14.297 hectares area in 2006 and it became 16.7358 hectares in 2016. The probable reason in the formation of waterbody might be due to rainfall or by gathering of surface water during rainfall which became the source of water for the nearby village people. In the satellite image of the year 1992, the area is seen as fallow. It means some areas under fallow land were low lying and were inundated with water

during 2016. At the time of ground truth it was found that the waterbody is situated at the village Amchha Khurd and known as Amchha dam. The local people of the villages Amchha Khurd and Amchha Kalan used the water from this source as it is only the source of water for them.

The area occupied by dense scrub in 1992 was 3055.86 hectares. It became 2730.73 hectares in 2006 and decreased to 2614.92 hectares in the year 2016. That means in the span of 24 years, the areas under dense vegetation have decreased continuously from 1992. From the satellite image, it can be seen that the vegetation towards the south of the core area has decreased. This vegetation is nothing but the part of the forest area coming inside core area. In this part, teak wood plantation was mainly identified. So, the area was densely occupied by teak wood giving rise to decrease in the percentage of dense scrub.

Agriculture includes settled agricultural fields with soyabean and wheat as major crops including fallows. Agriculture was seen more or less stable in the span of 24 years. In 1992, crop and fallows category has the area of 1456.83 hectares which became 1209.61 hectares in 2006 and increased to 1366.12 hectares in 2016. The fluctuations in the percentage of agriculture and fallow land might be due to crop-harvesting. Fallow land observed was comparatively less in 1992 due to less agricultural activities. The increase in fallow land from 1992 to 2016 was the consequence of harvesting and less area cultivated under agriculture. It might be possible that some part of the land was not used for cropping and left fallow in the later periods. From the image it can be seen that the agriculture at Nasipur and surroundings is decreased during this period.

Area under settlements are digitized on high resolution google images for the respective years as digitization of villages was not possible with landsat data having 30 metre resolution. It was found that the area under settlement in the year 2006 was 81.9975 hectares and increased to 123.627 hectares in 2016. The probable reason for increased settlements might be due migration of rural people in search of their livelihood. Due to high cost of living in the city and difficulties in getting employment and

accommodation, people set up their temporary shelters along the villages, riverbed, next to railway lines and bridges. Settlement class in the year 1992 was unclassified. As per UNESCO guidelines, the area under settlements is not to be increased inside the core area boundary. Field data collection shows that all the 21 villages were settled in the buffer zone boundary and there were no households inside the core area. Figure 7 gives the graphical representation of the trend over the span of the 24 years.

From table 3, the accuracy estimation of the remote sensing data were presented. The user, producer and overall accuracies of the year 2016 were 95.22%, 91.94% and 89.58% respectively, with kappa coefficient of 0.85. Kappa coefficient for each class are 0.9566 for barren land and open scrub, 1 for waterbody, 0.7859 for dense scrub and 1 for crop and fallows. Kappa values indicate that there is substantial agreement between reference data and classified data of the image analysis without bias in sample selection. The classes of 1992 image were more or less similar to 2006 and 2016 except for waterbody.

6 Conclusions

The present study brings out the significance of the utility of remote sensing techniques for Multi-temporal analysis of a World Heritage Site. It reveals changing pattern of land use/land cover in the study area over a span of 24 years. The analysis of land use/land cover through satellite imagery and topographical map of the study area provide significant clues for the future planning of the area.

In this paper, using Landsat TM images from 1992, 2006 and 2016, land use changes inside the buffer zone of Bhimbetka region were evaluated and analysed. Landsat satellite has applications potential in a wide range of disciplines such as agriculture, inventory of forest

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resources, geography, geological mapping and water resources assessment. Monitoring of the temporal changes in and around the site becomes easier with the help of remote sensing technique. It helps in detecting the type of change, location of the change and quantifies the changes taking place in an ecosystem. Corrective measures can be taken to avoid the damages to the site which is otherwise not possible.

The multi-temporal satellite data greatly enhanced the detection of various physiographic units. With the help of high spatial resolution images, it was observed that the urbanization increased inside the buffer zone. The major findings of the image analysis were reduction in the dense scrub and open forest, as well as increase in settlements and agricultural activities over the decades. Other LULC classes were also compared and found to be responsible for changes. The results of the study revealed that during the year 1992 to 2016, the significant increase in the forest areas was observed. This increase might be due to its high regeneration capacity. Results can be further validated by using high resolution satellite imagery of the areas where the settlements exist. It will help to forecast the human impacts and rate of change of urbanization inside the study area.

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