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Assessment of spatio-temporal variations in land use land cover over pimipri chinch wad Municipal corporation using Remote sensing data

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ABSTRACT

The status and trends of urban land use/land cover (LULC) significantly impacts the quality of human life and urban ecosystems. Pimpri-Chinchwad (PCMC) is one of the rapidly urbanizing municipal corporation which has been experiencing vast modifications in land use/land cover in the last few decades. This paper is an attempt to assess the spatio-temporal variations in LULC over PCMC region during the last 14 years. The research involves collection and processing of satellite images (Landsat TM) for 1997 and 2011 as well as preparation of land use/land cover map of PCMC region. Supervised classification using maximum likelihood classifier was performed to obtain LULC, where accuracy of the classification obtained was quite promising (Overall accuracy 90.81% and 89.68% and Kappa 0.86 (1997) and 0.88 (2011)). During the period of assessment LULC map results showed a striking pattern in the study area. In the last 14 years the built up areas have increased by 4% while the areas under vegetation have considerably increased by 6%. Increase in the vegetation cover is due to the various governmental schemes like afforestation on hills and hill slopes, establishment of parks and green spaces, etc. The amount of barren land has decreased significantly by 8% while the hills (slopes) decreased by 2%, due to increasing demand of land for residential and commercial purposes.

Keywords: Land use/land cover (LULC), supervised classification

1. Introduction

Urban areas and their urban rural linkages are characterized by high dynamics of human influences and the associated land use patterns. To effectively deal with these land use change processes, a well-founded knowledge of underlying causes and driving factors is needed. Spatially explicit land use modeling techniques have successfully been applied to model the present and likely future land use patterns of urban areas (Bhagwat 2011). Urban LULC data have been widely utilized in quantifying urban areas and monitoring urban change. The status and trends of urban LULC significantly impact the quality of human life and urban ecosystems. Accurate, up-to-date and spatially explicit data on urban land cover and land use are required to support land management decision-making, ecosystem monitoring and urban planning (Ridd 1995). Spatial distribution of land use/land cover information and changes in it 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 plays a vital role in development of any region (Dhorde et al., 2012). The conventional approach of identifying land use land cover

changes are costly, low in accuracy and present a picture of only small area (Jaiswal et al., 1999).

Remote sensing, because of its capability of synoptic viewing and repetitive coverage, provides useful information on land use/land cover dynamics (Sharma et al., 1989). Depending on the planning context, availability of remote sensing information, and analysis constraints, the extraction of either structural-temporal or functional-temporal land-surface information is most useful. While elaborating on the usage the status and trends of remotely sensed data for such studies Prenzel (2004) uses the terms 'land cover' and 'land use' to represent pattern and process or structure and function, respectively. 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. Jenson (1986) suggested that detection of changes in the land use/land cover involves use of at least two period data sets. A practical approach to study changes in land use/land cover, which may be caused due to natural/human activities, can be accomplished by using current and archived remotely sensed data (Luong, 1993). 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.

The main objective of the present work is to assess the changes in the PCMC area in terms of LULC and bring out the pattern of changes in Land use during a period of 14 years. The results obtained from such studies will not only reveal the kind of change that occurred but would be of immense help for future planning since the area is a rapidly growing urban center.

2. Study area

The study area comprises of the Pimpri-Chinchwad Municipal Corporation (PCMC), is a sister city of Pune and is situated on Mumbai - Pune National Highway (Part of NH 4). It was established in 1982 covering an area of about 87 square km. Some time back, this was the richest municipal corporation of Asia and the reason behind it is that, it has an industrial belt of small as well as big national and multinational companies.

Pimpri-Chinchwad is situated north-east of Pune and is 160 km from Mumbai. Pimpri-Chinchwad lies between 18o 25' to 18o 42' north latitude and 73o 42' to 73o 57' east longitude (Figure 1). Pimpri-Chinchwad (PCMC) area covers 171.59 sq. km composed of 105 general electoral wards according to 1997 PCMC zoning, which comes under 4 administrative wards of Pimpri-Chinchwad Municipal Corporation. It is situated at an average altitude of 530 to 566m. From mean sea level. The east-west ridge running midway between Indrayani and Pavana rivers separate this area into two parts. The northern portion slopes towards Indrayani River while the southern portion slopes towards Pavana River.

Since the study area has witnessed tremendous urban and industrial growth, estimating and mapping LULC change for this area will prove to be valuable for environmental management and urban planning. To achieve this goal, remote sensing data from the satellites are been used to map land use changes in the PCMC during the 14 year period from February 1997 to 2011.

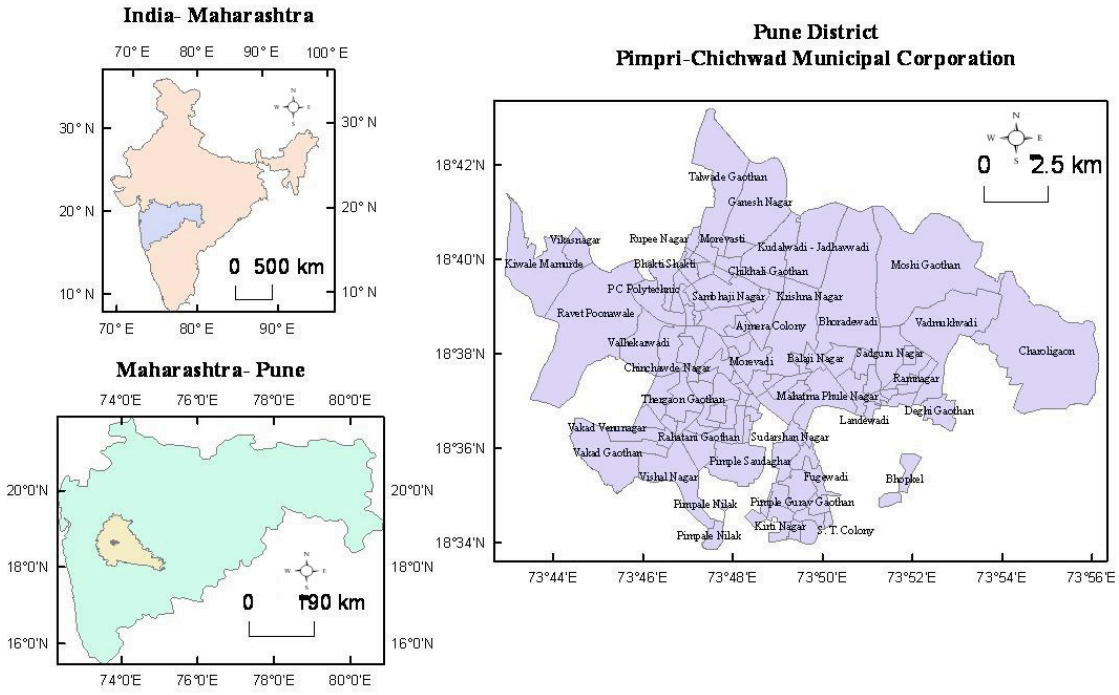

Figure 1: Location map of the study area

3. Methodology

3.1 Data acquisition and preprocessing

Landsat TM data of February 1997 was acquired from NRSC, Hyderabad and Landsat TM data of February 2011 was downloaded from the earth explorer site: www.usgc.com. Table 1 depicts the type of satellite data used.

Table 1: Satellite data used for the study

Satellite	Sensor	Spectral resolution	Spatial resolution	Date
LANDSAT	TM	Bands – 7 Blue, Green, Red, NIR, MIR, TIR, MIR	**30m** (B,G,R,NIR,MIR) **120m** (TIR)	February 1997 and 2011

Both the images were processed for the geometric, atmospheric and radiometric correction in ERDAS 9.1 using standard techniques.

3.2 Image Classification

Supervised classification technique with Maximum Likelihood Classifier (MLC) was employed to obtain a LULC classified map for both the images. Training sets were decided on the basis of visual interpretation for 1997 and 2011 images. Extensive field survey was carried out in the months of September and November 2011 to record the GPS readings along with the land use type. These proved to be helpful in refining the training sets for the 2011 image and crosschecking the classified images obtained by the supervised classification technique. Six major classes (built up area, agricultural fields, vegetation, water bodies, hills

and barren land) were taken in to consideration during the classification process. The classified images were further subjected to accuracy assessment wherein the K-hat (kappa) statistics and overall accuracy was computed.

Both the images were then reprojected to geographic Lat/Long with the WGS 84 spheroid and datum in order to be able to cross compare and/or perform multi-image analysis. In order to extract the AOI from the entire image a vector layer was prepared in the same projection as that of the images. This AOI was the boundary of present day Pimpri Chinchwad Municipal Corporation (PCMC). The AOI digitized as polygon feature was then overlaid on the raster image and subset was obtained. Data subsetting was done for both the images of Landsat TM. These subsets were further employed for obtaining the desired parameters.

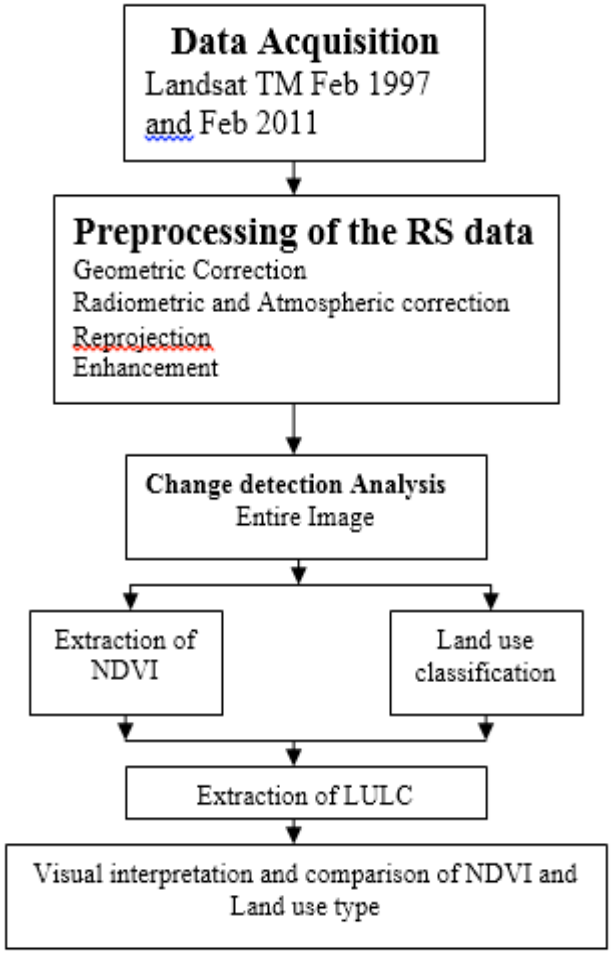

Figure 2: Methodology

A number of land use classification schemes are used for different studies. In India, usually one follows the standard land use land cover classification scheme given by NRSC. However, that scheme is quite extensive. Taking in to consideration the fact that the classified images obtained would only be used for identifying the major land use in the city, which would further augment the understanding of the spatial pattern of ISA, only six major classes were considered. These classes are given, see Table 2.

Table 2: Major land use classes considered for classification of the images

No.	Identified Classes	Remark
1.	Agricultural fields	Included all the agricultural fields with current fallow land
2.	Vegetation	Natural/planted vegetation mostly along the settlements and hill slopes.
3.	Water bodies	Rivers, Lakes, Ponds, Reservoirs, etc.
4.	Hills	Main hill complex, hill slopes, mostly without vegetation
5.	Barren land	Included the barren hill slopes , bare rock surfaces, (mostly the exposed rock surface)
6.	Urban Built-up area	Included the densely built-up as well as sparsely built-up area

Accuracy assessment of the classified maps was done for both the classified images. For the quantitative assessment k-hat (Kappa) coefficient was measured which was found to be 0.86 and 0.88 for 1997 and 2011 images respectively. Whereas the overall classification accuracy obtained was 82.54% for 1997 image and 89.68% for 2011 image. Since the overall accuracy obtained for both the images was above 80% and the kappa statistics was above 75%, it indicated that the classification accuracy was reasonably good to excellent.

3.3 Land use/ land cover Change during the Study Period

Table 3a: Error matrix February 1997

	Water-bodies	Vegetation	Hills	Agriculture	Builtup	Barren Land	Row Total
Water-bodies	36	0	0	0	0	0	36
Vegetation	0	28	0	7	0	0	35
Hills	0	0	21	7	3	5	36
Agriculture	0	0	0	34	2	0	36
Builtup	1	0	0	0	32	3	36
Barren Land	0	0	0	1	2	33	36
Column Total	37	28	21	49	39	41	215

Overall Classification Accuracy = 82.54% and Kappa Statistics = 0.8559

Table 3b: Error matrix February 2011

	Hills	Vegetation	Water bodies	Builtup	Agriculture	Barren Land	Row Total
Hills	28	2	0	3	0	3	36
Vegetation	0	30	1	0	5	0	36
Waterbodies	0	0	36	0	0	0	36
Builtup	1	1	0	31	2	1	36

Agriculture	0	0	0	1	34	1	36
Barren Land	2	0	0	1	1	31	35
Column Total	31	33	37	36	42	36	215

Overall Classification Accuracy = 89.68% and Kappa Statistics = 0.8796

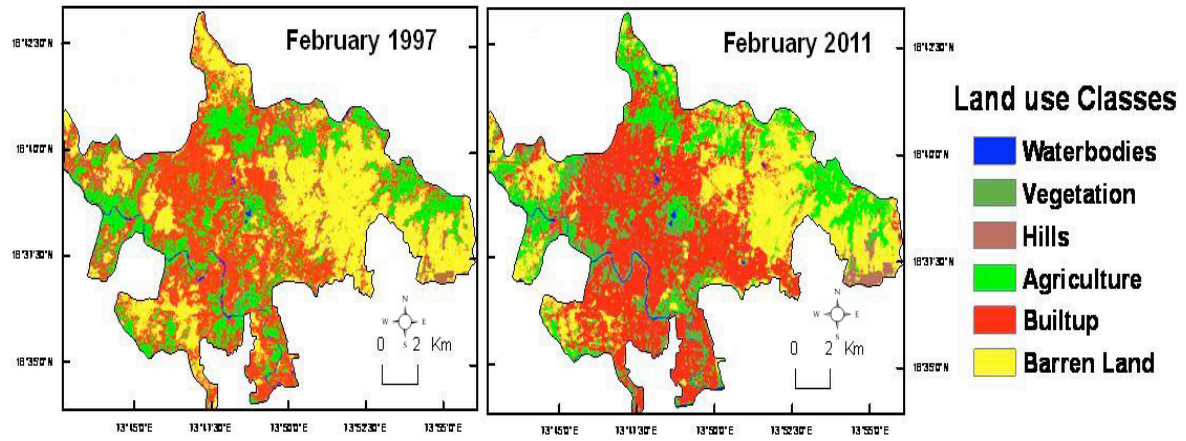

Figure 3: Land use classified map of February 1997 and 2011

Figure 3 depicts the land use land cover maps for the year 1997 and 2011 and the results are depicted in Table 3a and 3b. Table 4 shows the percentage of area under different land use classes as obtained from the supervised classification of images. The maps brought out a striking pattern of changes in the study area. It was observed that the built up area has significantly increased in the core of PCMC and also in area away from the center. Agricultural settlements of Chiroli Gaonthan, Chikaligaon, Rupeenagar, Vikas Nagar, Ravet Poonawale, Vishal nagar, Pimple Saudagar, Dighi Gaonthan are transforming into fringe settlements. The barren land decreased significantly by 7.60% while the hills (slopes) decreased by 2%. The reduction in the area of these two can be attributed to the two prominent land uses in the study area, the built up area and the area under vegetation. In the southern parts of PCMC the land under cultivation has decreased during this period, which may be caused by the change of occupation of many of the residents in the fringe areas. Agricultural activity has remained more or less similar in the north-eastern areas. The decrease in barren land is due to the development of lands for residential, industrial and agricultural purposes. It is expected that the percentage of barren land is bound to go down further in the years to come.

During the past 14 years the built up areas have increased by 4% while the areas under vegetation has considerably increased by 6.34%. Increase in the vegetation cover is due to the various governmental schemes like afforestation on hills and hill slopes, establishment of parks and green spaces, etc. Some concentration of plantation can be observed in the industrial areas. Also tree plantations have been done on open spaces in government and semi government organizations like MIDC and Pradhikaran area.

The comparative changes of the two different years show a tremendous urban growth especially in the north-western direction of PCMC.

Table 4: Percentage area under different land use classes as obtained from the supervised classification of images

Classes	1997 (%)	2011 (%)	Change(%)
Hills	4.54	2.85	-1.69
Vegetation	1.11	7.46	6.34
Crop land	20.40	19.56	-0.84
Builtup	39.49	43.16	3.67
Waterbodies	0.73	0.84	0.11
Barren Land	33.72	26.13	-7.60
	100	100.00	

3.4 Calculation of Normalized Difference Vegetation Index (NDVI)

The NDVI calculation was done in ERDAS imagine by running the indices option. Normalized difference vegetation index uses the combination of band 3 (0.63-0.69 mm), i.e. Red band and band 4 (0.76-0.90 mm), i.e. Near Infrared band. NDVI for Landsat TM, ETM+ images were calculated by using equation (1).

$$NDVI = \frac{(band4 - band3)}{(band4 + band3)} = \frac{(NIR - R)}{(NIR + R)} \ldots\ldots \text{eq.1}$$

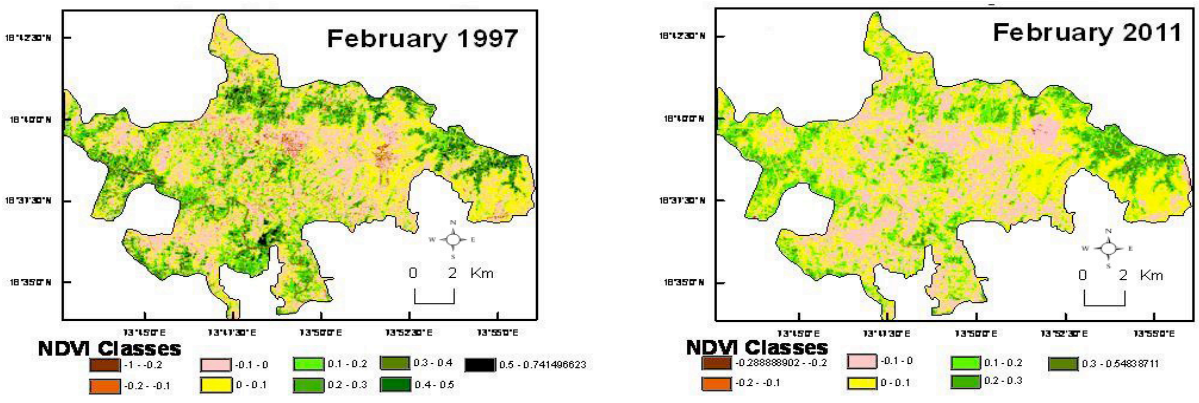

Figure 4: NDVI Images for February 1997 and 2011

3.4 Variations in NDVI (1997-2011)

Normalized Difference Vegetation Index (NDVI) is a good indicator of vegetation cover and its density in the area. Figure.4 shows that there is an increase in vegetation in the areas from 1997 to 2011 (6.34%). The NDVI image of 1997 shows lower values of (-1 to -0.2) over the city and some fringe areas due to, the presence of buildings, roads and other infra-structural facilities. The areas near the river banks and the western part of PCMC show higher values

(0.4 to 0.5) This is because of relatively dense vegetation in these areas. The NDVI values tend to decrease as one goes from the center towards the east. Moderate NDVI values (0.1 to 0.2) can be observed mostly in the southern areas of the city. This can be attributed to the presence of sparse vegetation cover and barren lands with rock exposure. Very high values of NDVI (0.5 to 0.74) can be noticed in very few places, which may indicate the presence of undisturbed thick and dense cover of vegetation.

NDVI values in the 2011 image vary from -0.288 to +0.548. The pattern of NDVI for 2011 shows lower values (-0.288 to -0.2). It is evident that the areas with lower values of NDVI have increased considerably in 2011 suggesting decrease in vegetation cover due to expansion of urban areas and industrial growth. In comparison with the city core the areas near the river banks and the western part of the water bodies show slightly higher values (0.1 to 0.2). This is again because of relatively dense vegetation in these areas. When compared with 1997, in 2011 image it can be seen that though the NDVI values have remained almost the same in the northern areas, however in the southern areas the higher NDVI values have decreased. Very high values of NDVI (0.3to 0.548) can be observed in some areas where the vegetation is very dense and undisturbed. The presence of water hyacinth also affects the NDVI values. This fact has been verified by on field survey where it was seen that in the month of February, the rivers in these parts are covered by water hyacinth.

The range of NDVI values is different for 1997 and 2011. The chief cause for this fact is that the vegetation cover has changed its arrangement and orientation with time. So, it is practically impossible to get same ranges of NDVI values for two different time periods. It can be inferred from the NDVI images obtained for 1997 and 2011 that there are some clear variations in the amount of area covered by different NDVI value classes. The spatial extensions have increased in 2011 but, the density of vegetation seems to be more in 1997 than 2011. Though the area under vegetation has increased in 2011, density is lesser because afforestation schemes are still in process. These vegetation patches are mostly limited to industrial areas and in areas like Talawade, Chikhali, Ravet, Kiwale Mamurdi and some parts of Pimpri.

4. Results and discussion

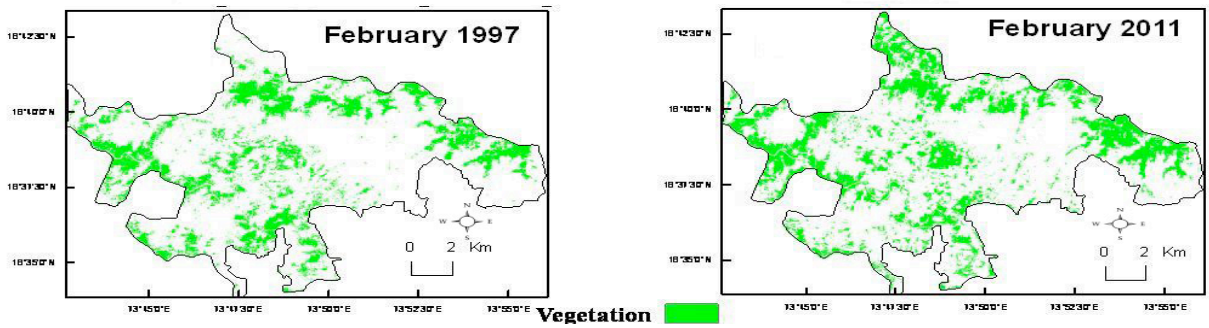

Figure 5: Change in vegetation from February 1997 and 2011

Taking into consideration the ever-growing population of the city an increase in built up area is quite understandable. During the past 14 years the built up areas have increased by 4% while the area under vegetation has considerably increased by 6%. However the increase in vegetation presents a soothing effect over the impact of increasing population over the city's

environment. One of the major reasons for increased vegetation is the fact that the local civic bodies have implemented various projects like plantation and increasing the green spaces within the city. The PCMC garden department has planted trees on either side of 34 roads. The department has also developed 128 gardens that covers an area of 130 hectares. Tree plantations drives are been carried out on open spaces in government and semi government organizations in MIDC and Pradhikaran area.

There is a remarkable increase in vegetation mostly in the northern parts of PCMC including Talawade Gaonthan, Rupee nagar, Ganeshnagar, Chikhali Gaonthan and along the Pavana river. The western parts of Kiwal Mamurde Vikasnagar, Ravet Poonawale show a tremendous increase in vegetation which could be due to the gardens developed in the societies and jogging parks. In the eastern areas of Vadmukhvadi, Charoligaon and southern areas of Vakad Gaonthan, Vishalnagar, and Pimple Saudagar also show a good vegetation cover. Some central areas of Ajmera Colony, Sangavi Kesari College, HDFC Colony, Krishna nagar show an increase in vegetation compared to 1997.

However, there a variation in the density of the vegetation. High density vegetation are the old undisturbed trees that can be seen in areas of Kaljewadi, Charoli Budruk and Moshi in north-eastern parts of PCMC, in the north-eastern parts of Triveninagar and Krushnanagar and Kiwali, Tathawade and Poonawale in weatern parts. The less dense vegetation is observed in areas where there is cutting down of trees for roads, development, construction, etc. The population of PCMC has increased more than three times in the last two decades due to which the builtup area has increased considerably.

4.1. Major findings of the study

4.2 Changes in Land use

Considering the LULC values, striking changes were observed in the different classes for the two years of 1997 and 2011. As the development activities of urbanization and industrialization are going on the barren land has decreased by 8% and the built up area has increased by 4% and the agricultural land has decreased by 1%. More and more agricultural land is going under the built up area. The hills have decreased by 2% due to the construction and developmental activities. Surprisingly the vegetation has increased by 6%, due to the various schemes like afforestation, etc. by the local governmental and/or non-governmental organizations especially in the rural areas. It can be concluded that though the level of development has gone up in terms of increasing built up areas it has resulted in the decrease of barren land and the vegetation cover in the area.

5. Conclusion

The study undertaken has helped to understand changes in the land use land cover pattern. One of the major factors that identify the changing land use pattern is vegetation, changes in which were studied by comparing Normalized Difference Vegetation Index (NDVI) maps. The study also highlights the expansion of PCMC area over the last two decades. This growth is accompanied with rapid change in the land use pattern where natural landscape is altered and replaced by the cultural landscape.

However, the major question is about the future changes in the city. The town planners should lay down stringent rules for allotment and construction of buildings. Overcrowding in a specific area can lead to different types of socio economic and environmental issues. Farmers can be encouraged to continue with agricultural occupations rather then selling land and migrating in the urban occupations. The Government can implement more tree plantations schemes and keep a check on cutting down of old trees in the city. This can improve the environmental health and wellbeing in the PCMC area.

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