International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online)
An Online International Journal Available at http://www.cibtech.org/jgee.htm
2012 Vol. 2 (2) May-August, pp.148- 156/Padigala Bhakar
Research Article

URBANIZATION AND CHANGING GREEN SPACES IN INDIAN CITIES (CASE STUDY – CITY OF PUNE)

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ABSTRACT
Urban green spaces are one of the most significant elements of any urban ecosystem, both due to its ecosystem dynamics and its essential contribution in well being of human race. However, it is ironic that despite of its immense significance, vegetation is undergoing destruction and degradation in the modern times due to rapid and haphazard urbanization in developing countries, making urban settlements major source of GHG emissions and at the same time making them more vulnerable to global environmental change impacts. Hence, landuse/landcover and green cover changes monitoring becomes very crucial in decision making and conserving green spaces in cities and at this stage significant contributions can be provided by remote sensing technologies. The study deals with changes with urban Land Use / Land Cover Changes using remote sensing technique. For this purpose Landsat ETM+ images of 1999 and 2009 was obtained for the study area. Land use / land cover change pattern was mapped by supervised classification with the maximum likelihood classification algorithm. Results showed that city's built up area has increased from 30.86% in 1999 to 48.50% in 2009, whereas barren & fallow land area has decreased considerably from 36.20% in 1999 to 21.80% in 2009. A total of 7.24 sq km. of combined vegetated (sparse and dense) area has been lost between 1999 and 2009.

Key Words: *Urbanization, Urban Green Spaces, Land Use / Land Cover Changes, Remote Sensing, Landsat*

INTRODUCTION
With only 2% of the world population urbanized in 1800, global urban population reached 15% mark in 1900 and today almost 1,80,000 people are added to the world's urban population every day (Pitale, 2011). Hence, making urbanization an inevitable and yet favoured phenomenon for development of any nation on this planet.

Urbanization is the spatial concentration of people and economic activity (Roberts and Kanaley, 2006) can simply be defined as the transformation of rural society into an urban society and is a result of socio-economic and political growth leading to formation and expansion of urban agglomerations and city centres along with changing rural institutions, organizations and land use pattern.

With increase in supporting factors like mechanisation of transport and goods production, better health services has led to the increase in the world population especially the urban population which consequently has increased the demand for dwelling places and hence leading to exponential increase in the growth of new cities and rapid expansion of the existing ones. Amidst demand exceeding the supply of dwellings and associated infrastructure resulting scenario what is being observed is that; all over the world especially in the developing countries it the haphazard urban development and urban sprawl along the urban amenities and infrastructure like roads and highways.

The urban population in India at the beginning of 20th century was only 25.85 million constituting 10.84 per cent of India's population in 1901, which increased to 285.35 million comprising 27.78 per cent of total population in 2001 (Singh, 2006) with natural growth contributing about 60% and rest added by migration and expansion of cities (Sivaramakrishnan *et al.*, 2005). India's urban population grew from 286 million in 2001 to 377 million in 2011 – an increment of 91 million, which is larger than the rural

population increment of 90.5 million for the first time since independence (Bhagat, 2011) and is expected to hit figure of 550 million or 42% of the total population by 2030 (Roberts and Kanaley, 2006).

Table 1: Table Showing Pattern of Urbanization in India

Census Year	Urban Population (in millions)	Percentage Urban	Annual Exponential urban growth rate
1961	78.94	17.97	-
1971	109.11	19.91	3.23
1981	159.46	23.34	3.79
1991	217.18	25.72	3.09
2001	286.12	27.86	2.75
2011	377.10	31.16	2.76

Source: Bhagat, 2011

With growing cities the demand of resources like water, land etc. has grown proportionally to the growing rate of the urban population. Hence, Cities are experiencing increasing signs of environmental stress, notably in the form of poor air quality, excessive noise, and traffic congestion (Ruangrit & Sokhi, 2004). At the same time, irregular and unsustainable extension of cities has caused destruction of urban green areas and resulted from increasing demand for land (Hassan-Ali Laghai *et al.*, 2012).

Urban green spaces are an integral part of any city landscape, providing city and its residents with numerous benefits both tangible and in-tangible (Gaodi *et al.*, 2010), ecosystem services like pollutant sequestration and ambient temperature regulation etc. (Nowak et al, 2006) (Jim and Chen, 2008), social services and health (Grahn and Stigsdotter, 2003), and also economic services like tourism, increased property prices etc. (Chaudhry and Tewari, 2010) (Luttik, 2000). But it is ironic that despite realising the numerous benefits availed by green spaces in an urban ecosystem, yet vegetation is undergoing destruction and degradation in the modern times due to rapid and haphazard urbanization in developing countries, making urban settlements major source of GHG emissions and at the same time making them more vulnerable to global environmental change impacts.

Hence, the main objective of this study was to analyse the urbanization trend and to find out reasons which are motivating modern cities to favour developmental models wherein urban green spaces are being treated as liability and hurdle in the growth of the city instead of an asset for overall social, environmental and economical growth and how this developmental trend will impact the cities especially in developing countries in future with threats like climate change and global warming adding up to the prevailing environmental issues.

Study Area

Pune City (Pune municipal corporation limit), lies between latitudes 18°25' N and 18°37' N and 73°44' E and 73° 57' E longitudes covering an area of 243.84 sq km. Situated on the Deccan plateau and lies on leeward side of the Western Ghats and is at a height of 560m above the mean sea level. The establishment of the city goes back to the 8th century when it was a tiny agricultural city and under British rule in 1857 the total area for Pune was around 7.74 sq. Km, which increased to 138.98 sq. Km in 1958. Total area of Pune city has increased from 145.92 sq km to 243.84 sq km with addition of 23 villages to the old municipal limit in year 1999 (See table 2) (CDP, 2006). As per provisional census data for 2011, demographically Pune city is the 9th largest city in India with a population of 3,115,431 (Census, 2011).

Using remote sensing and entropy technique analysis (Shekhar, 2004) revealed that the Pune city is under highest rate of sprawl, and the sprawl is taking place along the national highway at the cost of adjacent agricultural, forestlands. City has lost 37.75% of cultivable land between the period of 1980 and 2001. Presently almost 70-80% of open/vacant/cultivable land has been brought under urban land use and open lands located inside the city and close to the outskirts of the city are being mostly converted into big townships, new colonies, Institutions, shopping complexes or apartment complexes (Desai et al, 2009).

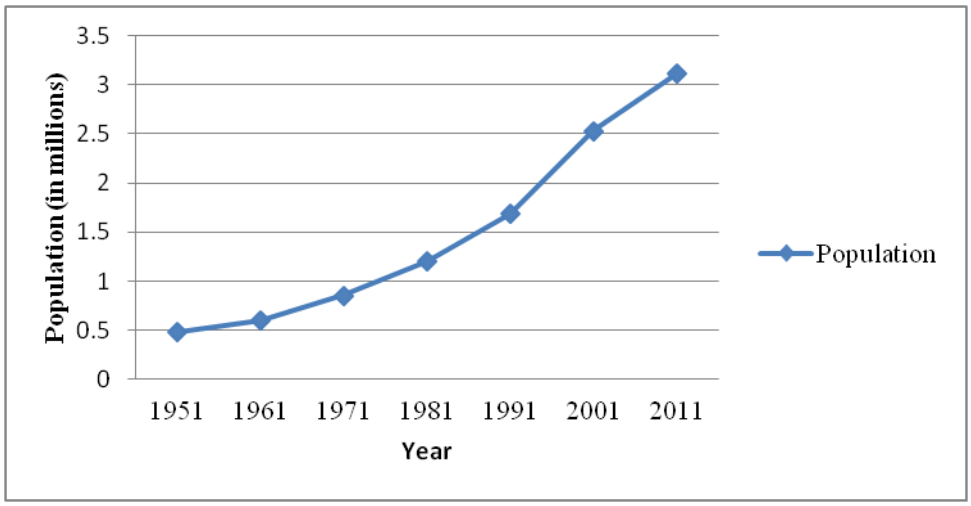


Figure 1: Demographic Trend of Pune City *(Source: Census of India, 1951-2011)*

Table 2: Morphological Development of Pune City

Year	Total Area (sq km.)	Area Added (sq km.)	Name of the Added Area
1857	7.74		South Shankarsheth road to Ambila Road, NE – right Bank of Mutha River, East – Wesley road to new Modikana near Nagzari
1889	9.86	2.12	Area between Shankarsheth road, Satara road and Golibar maidan
1890	18.04	8.17	Erandawana and Bhamburda village
1931	18.79	0.75	Parvati gaothan and area till Hingne
1935	19.05	0.26	Chaturshringi area
1958	138.98	27.02	Inclusion of 18 villages
1975	138.05	-0.84	Exclusion of some part of Bhosari
1981	146.95	7.33	Inclusion of Sutarwadi
1983	146.11	0.014	Inclusion of survey no. 79 of Ghorpadi
1997	243.87	97.84	Inclusion of 23 villages

Source: CDP, 2006

MATERIALS AND METHODS

Data Acquisition and Image Processing

For studying the temporal changes in land-use /land-cover and green spaces pattern of Pune city, survey of India (SOI) toposheets (Sheet Number 47 F 10,13,14,15 and 47 J 2; scale 1:50000 and year 1972) and Landsat 7 ETM+ satellite imagery of November month for year 1999 (WRS-2, Path- 147, Row – 47) and 2009 (WRS -2, Path - 147, Row – 47) with 30 m resolution were acquired. The following SOI toposheets on 1:50000 scales were used as base maps. Atmospheric corrections band combination manipulation, band stretching, and contrast adjustment image enhancement tools were employed on satellite images using remote sensing software's ERDAS IMAGINE 9.1, ArcGIS version 9.3 and ENVI 4.7.

In the field, an exploratory survey of the study area was done using Garmin 12X-GPS, with reference to the 1: 50,000 scale SOI toposheets maps, and was used to delineate the ground control points all over the study area. With the help of GCP's and respective points on satellite images the satellite images of year

1999 and 2009 were georefrenced and the study area (Pune municipal corporation) boundary was delineated and digitized for further analysis in ERDAS IMAGINE 9.1 software.

Visual Interpretation & NDVI Mapping

Typically, false-colour composite images are employed in visual image interpretation, for this study Landsat 7 ETM + bands 4, 3, and 2 were combined to make FCC images for year 1999 and 2009 ,where band 4 represented the red, band 3 represented the green, and band 2 represented the blue portions of the electromagnetic spectrum. In this scheme of band combination type of FCC images, vegetation appears in different shades of red depending on the types and conditions of the vegetation, since it has a high reflectance in the NIR band (Crisp, 2001). Respectively, urban structures appear bluish white in colour whereas; dark shades of blue represent water bodies.

NDVI is a good indicator of the ability for vegetation to absorb photosynthetically active radiation and has been widely used by researchers to estimate green biomass (Lillesand & Kiefer, 2004) (Wang et al, 2003). The calculation of Normalized Difference Vegetation Index (NDVI) is done using near-infrared (NIR) and visible (VIS) bands as follows (Mariappan, 2010).

NDVI = (NIR−VIS)/ (NIR+VIS).....Eq. (1)

For this study band 4 and 3 for year 1999 and 2009 were selected and analysed using eq. (1), resultant obtained was the single band dataset with values ranging from between -1.0 and 1.0 (See fig 1), where lower values corresponds to correspond to built structures, barren areas of rock, sand. Moderate and high values represent sparse and dense vegetation (Esri, 2008).

Image Classification & Accuracy Assessment

Landsat 7 ETM+ satellite images were classified using supervised image classification with maximum likelihood algorithm (see fig 2). This Classification uses the training data by means of estimating means and variances of the classes, which are used to estimate probabilities and also consider the variability of brightness values in each class (Perumal & Bhaskaran, 2010). For this study, 75 training site were randomly selected and ERDAS Imagine 9.1 software was used to classify the satellite images for year 1999 and 2009 based on the landuse characteristics and spectral signature of the selected training sites.

Satellite images of year 1999 and 2009 were later classified into five classes (level I classification) considered for the study are built-up land, barren & fallow land, water bodies, sparse (shrub, grassland, and agricultural land) & dense vegetation based on the supervised classification technique and land use/land cover areas were calculated using Arc GIS software.

During field survey landuse characteristics of the training sites was also recorded which in later stages of the data analysis were used as ground truth observation points. These GTO points were used to assess the overall mapping accuracy using the error matrix. The overall accuracy of the output was calculated using following equation:

Overall mapping Accuracy: D/ N x 100% .....Eq. (2)

Where: D = Total number of corrected cells as summed along the diagonal

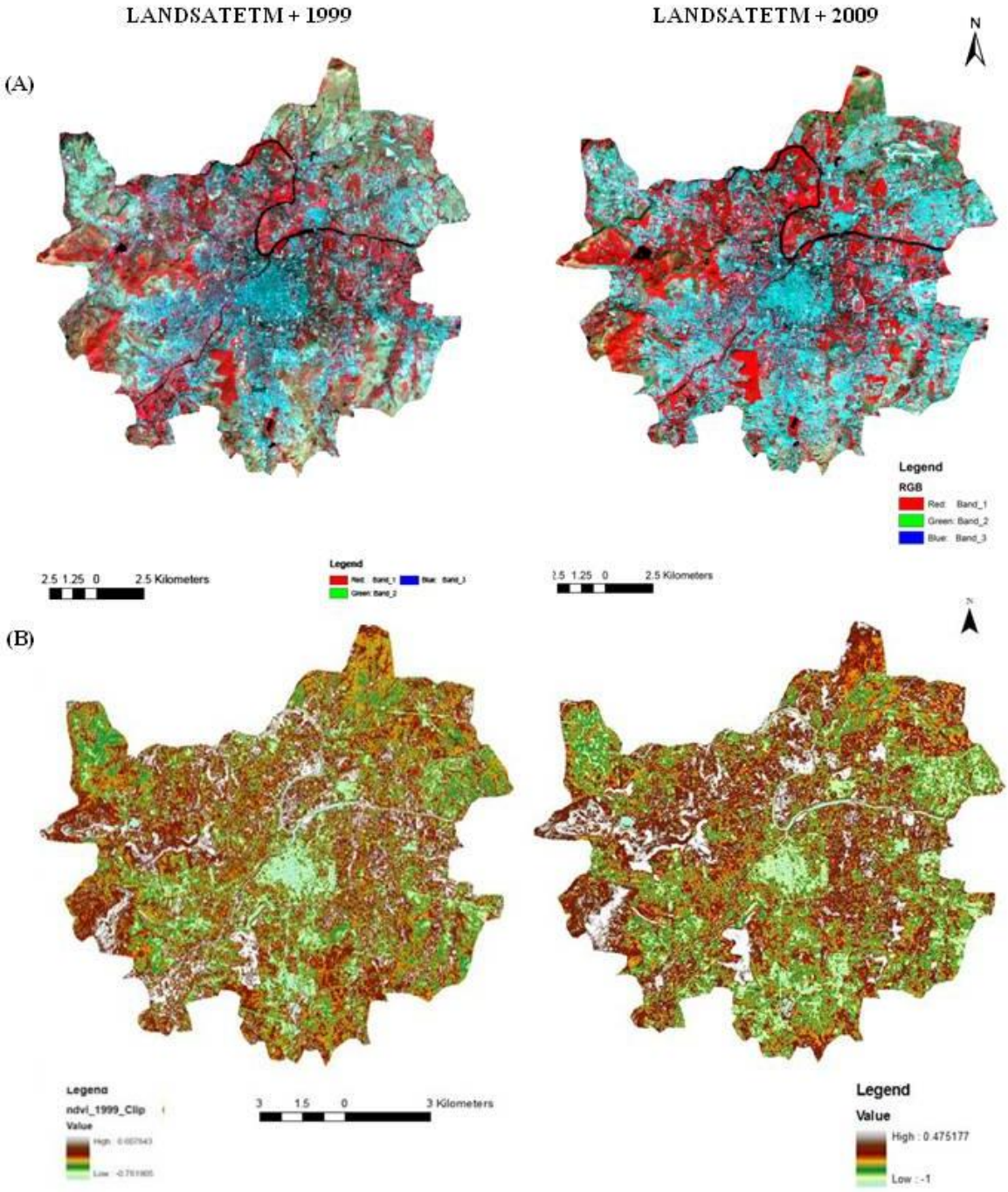
N = total number of cells in error matrix

RESULTS AND DISCUSSION

Pune is growing exponentially both in terms of spatial extent, economic activities and demography. Remote Sensing analysis of satellite images of Pune city (1999 and 2009) was used for land use/ land use changes assessment, analysis indicated the alarming rate and manner in which of urbanization and urban sprawl is occurring in Pune.

Results (see table 1) showed that Pune's built up area has increased from 30.86% in 1999 to 48.50% in 2009 i.e. substantial increase of 43.01 sq km. of area in just last 10 years, on the other hand barren & fallow land area has decreased considerably from 36.20% in 1999 to 21.80 % in 2009. Major objective of the study was to analyse the changing trend of the urban green spaces in the city, it was noticed that both sparse and dense vegetation showed decrease in areas of 5.58 and 1.66 sq km. respectively in past 10 years. Thus, this analysis highlights that the city is under high pressure of urbanization and sprawl, and its

taking place by grabbing and converting existing habitat like agricultural, barren, fallow land & forestlands into built habitat and grey infrastructure. The overall mapping accuracy of the land use/ land cover map was 86.73%.



(A) False colour composite images LANDSAT 7 ETM+ (B) NDVI mapping of Pune city

Figure 2: Visual Interpretation & NDVI Mapping

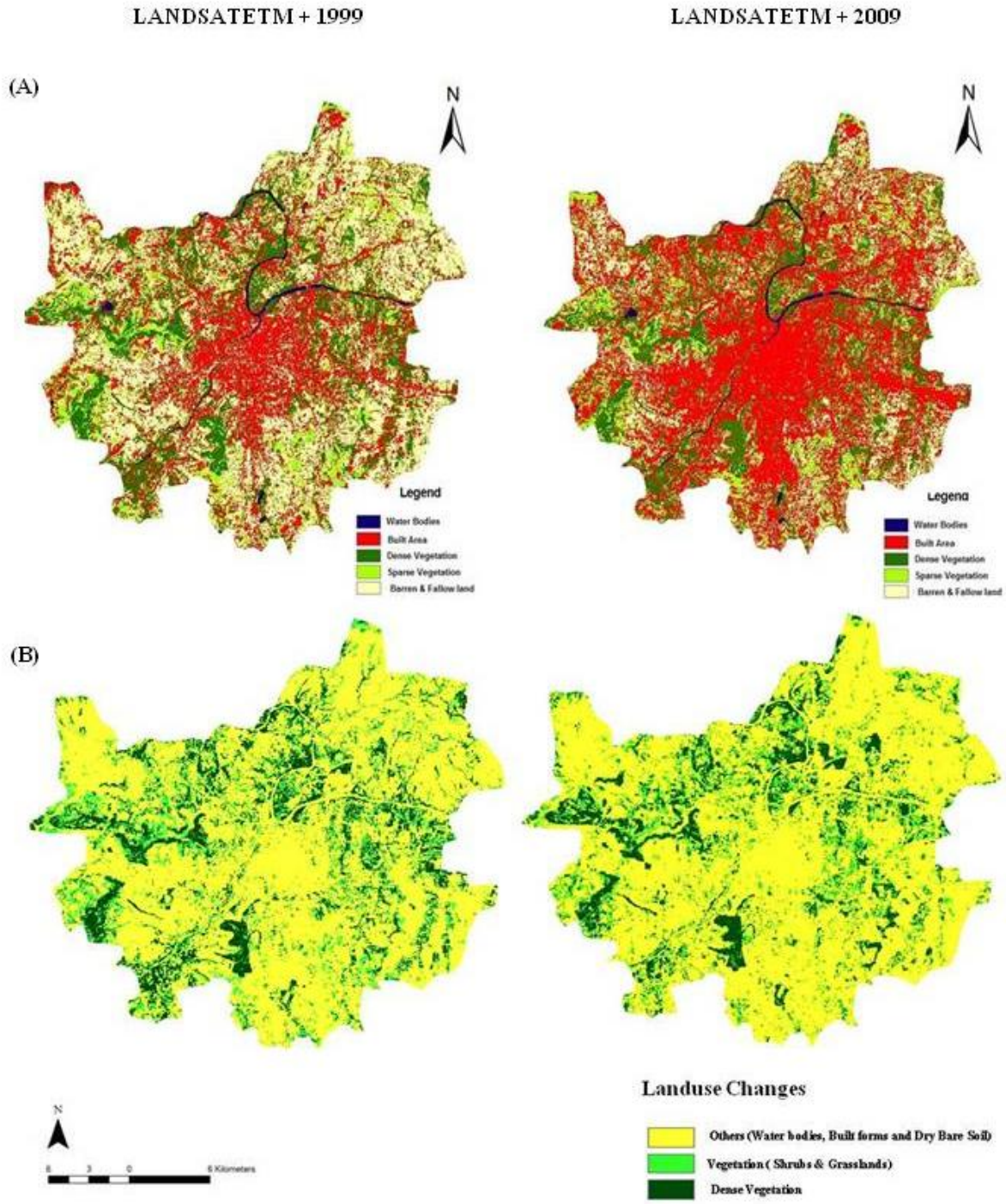
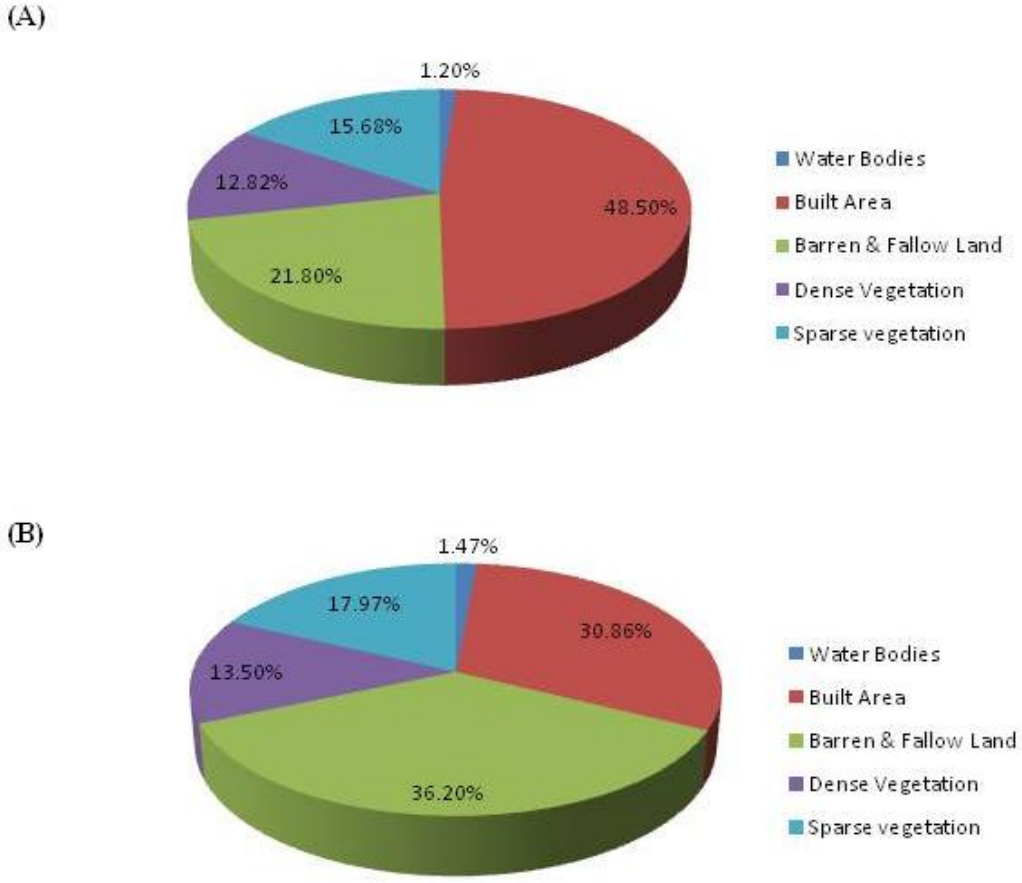


Figure 3: Landuse/Landcover Changes in Pune City

Presently city is experiencing large number of immigration from other regions of state and nation in search of economic opportunities, which is leading up to leapfrog increase in the city population

Table 3: Land Use/ Land Cover Changes in Pune City

Landuse Class	Area in 1999 (%)	Area in 2009 (%)	Area in 1999 (Sq. Km.)	Area in 2009 (Sq. Km.)	Area Difference (Sq. Km.)	Area Difference (%)
Water Bodies	1.47	1.20	3.58	2.93	-0.66	-0.27
Built Area	30.86	48.50	75.25	118.26	43.01	17.64
Barren & Fallow Land	36.20	21.80	88.27	53.16	-35.11	-14.40
Dense Vegetation	13.50	12.82	32.92	31.26	-1.66	-0.68
Sparse vegetation	17.97	15.68	43.82	38.23	-5.58	-2.29
Total Vegetation	31.47	28.50	76.74	69.49	-7.24	-2.97



(A) Landuse/ Landcover of Pune City in 1999 (B) Landuse/ Landcover of Pune City in 2009

Figure 4: Graphical Representation Landuse/Landcover Changes in Pune City

consequently escalating demand for allocation of residential sector in developmental plans and increased allocation of land and funds for associated infrastructure to facilitate such a large population.

This scenario is leading into increased need for vacant land for both residential purpose and infrastructural services (roads etc). This urgent and growing need is taking its toll on the other habitats of the city, like urban green spaces, barren and fallow lands, agricultural lands are being converted into residential complexes and shopping malls, also encroachment of hill slopes and riverbeds by slums have led to degradation of both these habitats.

Green cover is also being depleted not in forest only but also on other fronts, like, artificial plantations of exotic species etc this is leading not only degradation of local habitat but also disturbing the local biodiversity. Thus, clearly highlighting the issue of rapid urbanization due to exponential increase of population in urban centres leading to various environmental issues both at regional and collectively at global level.

Despite all the rapid urbanization and land conversion into built up areas, one interesting and important observation was made i.e. the improvement of vegetation on few hills and hill slopes. This has been observed through NDVI mapping, visual assessment, and literature review and field survey of the study area. Satellite images for year 1999 showed maximum hill areas were under sparse vegetation, but by next 10 years these vegetation can be classified under dense vegetation. This analysis can be attributed to the fact that, during 1980s mass plantations and declarations of Parvati-Pachgaon and Bhamburda (Vetal hill) hills as forest parks by forest department, converted these hills which earlier were almost barren with scattered grass into with dense vegetation.

Lastly it can be concluded from this study that, urbanization and urban sprawl is one of the most important and urgent issue which all developing countries like India are facing, and it needs to tackled holistically involving all stakeholders like general public, corporate sector and NGO's, not just the decision makers of any urban ecosystem. And to facilitate these conservative measurers remote sensing can play a vital role in both monitoring the landuse changes and sustainable urban planning.

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