Dynamics of Urbanisation in Bangalore Urban from Landsat Observations

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ABSTRACT

Urbanization is a dynamic process involving all sides' expansion of urban regions. This rapid expansion is due to rise in population and economic growth thereby causing a change in land use patterns as well as an increase in demands and destruction of natural resources. Land Use is a key element in temporal studies of urban imagery. Land-use change is the main driving force for the Social and industrial development which affects largely on local ecology, hydrology and environment and also globally. This change has been studied using Remote Sensing and GIS technologies for a rapidly growing place namely Bangalore Urban district. Remote sensing data enables the synoptic monitoring and visualization of urban growth patterns. The present work emphasizes on the major land use changes and urban sprawl in this region thereby determining the urban patches and would be employed to estimate the change in surface runoff, flood phenomenon and natural resources (Water bodies and Vegetation). The satellite imageries of 2006, 2011 and 2016 are taken and classified into 5 different classes like Water, Agricultural (Culturable wastelands and Crop lands), Built ups, Barren and Vegetation by Maximum Likelihood Classification. The results indicate that the region is expanding with the change of vegetation from 22.16 percent to 7.53 percent into Built-up areas from 18.12 percent to 25.28 percent out of the total area during the study period.

Keywords: Temporal, Synoptic, Impervious and Culturable

1. INTRODUCTION

Urbanization is a blessing to mankind if it is controlled, coordinated and structured in a planned way. However unplanned urbanization is a curse to human society. During the past two decades' urbanization has mushroomed across India at a high accelerating rate thereby resulting in massive structural changes and function of the global ecosystem. During this time the population has grown dramatically and unprecedented of humans in urban regions. Forests were cleared, grasslands ploughed or razed, wetlands drained and croplands were destroyed in sake of expansion. Such types of unplanned expansions have a direct influence on the quality of the urban environment as well as affecting the overall socio-economic development. So assessment and monitoring of urbanization are highly essential to overcome the problems like unsystematic & uncontrolled development, deteriorating environmental quality and loss of vegetation and agricultural lands. For this, we should have the knowledge of the present distribution of areas in different classes such as agricultural, urban lands and vegetation. This evaluation and estimation of change in land use patterns manually are very difficult or next to impossible at regionally as well as globally. For which this land use/cover classifications are done by remote sensing. This system offers a promising technology for monitoring land cover changes through satellite observations. This observation technology provides repetitive measurements of earth surface conditions throughout the year. The Landsat Program is a series of Earth-observing satellites begun in 1972 and controlled by USGS & NASA and provides the continuous space-based record of Earth's land in existence. This program is the longest running enterprise for the acquisition of satellite imageries of the earth. The high spatial resolution and regular revisit time of the Landsat are most convenient for the study of urbanization while Census data provide an analytical and statistical view of economics. Moreover, the data acquired by the satellites are more accurate than the models obtained from field work. The different bands in Landsat, with diverse spectral range, provide highly differentiated applications. Thus, the Land cover determination has become a very common use of Landsat Imagery and remotely sensing generated images all around the world.

The main objective of this study is to identify the land use/cover change in India using Landsat images with obtaining total area of each separate classes thereby checking its accuracy with the real environment.

2. STUDY AREA

The present study has been carried out on Bangalore Urban, located in 12.9700° N, 77.6536° E coordinates. Bangalore urban is a district of Karnataka state. It is spread over an area of 2182 sq. km and surrounded by Bangalore Rural on the east and north, Tamil Nadu on the south and Ramanagara district on the west. In 1986, Bangalore was divided into Bangalore Urban and Bangalore Rural. The electronic city so called as the Information technology hub Bangalore is located in Bangalore Urban district which is one of the key attraction for the increase in population. This is the most advanced district in Karnataka and had a population of 6.54 million people in 2001 and later increased by 47% and changed into 9.58 million of people in 2011 according to the Census of India. The district has a population density about 4,378 people per square km which are considered to be very high. The district lies between an averages of 875 to 940 meters above the Mean Sea Level (MSL). The climate here is moderate. It receives a good amount of sunlight in summer and not too cold in winters. The lowest average temperature here is about 16–18 °C and highest temperature is about 33-35 °C. The hottest months are March to May with temperature touching 34°C whereas the coolest months are December to February where temperature falls about 15°C. The monsoon season lasts from May to October with maximum rainfall of 195mm in the month of September

3. DATA PRODUCTS

In the present study, Temporal remote sensing data of Landsat 8 for the year 2016 and Landsat 5 for the year 2011 and 2016 has been utilized for the Land use/cover change detection.

Satellite	Sensor	Bands	Spatial Resolution	Year of Acquisition	Source (Public Domain)
Landsat 8	ETM+	3 2 1	30m	2016	Earth Explorer - USGS
Landsat 5	TM	3 2 1	30m	2011	Earth Explorer - USGS
Landsat 5	TM	3 2 1	30m	2006	Earth Explorer - USGS

4. METHODOLOGY

In the current study, the satellite images and data were acquired for the three years 2006, 2011 and 2016. Topographic sheets of the Bangalore Urban district, obtained from the Survey of India were used for ground reference. The satellite imageries of a single year were added in ArcMap 10.2.1 version and composite image was obtained using the appropriate satellite images through the Image analysis window. Geometric correction was performed on the composite image utilizing the topographic map from the Survey of India. Geo-referencing was done by giving different ground control points. The image was enhanced before classification for better results. It was done by adjusting the contrast, brightness, transparency and gamma in the similar image analysis window. Radiometric enhancement was performed by changing the stretch type options from the symbology tab of layer properties. After that spatial enhancement was done by changing the resampling technique in the Image analysis window. The resampling methods like bilinear interpolation, cubic convolution, nearest neighbourhood and Majority. Bilinear Interpolation creates a smooth looking image; Cubic Convolution creates a sharper looking image whereas in the Majority the pixel is assigned to the most common value within a specific filter window thereby smoothing the image. After all the corrections and pre-processing was done for enhancing the data, the Area of Interest (AOI) was masked from the enhanced image. This was done by extraction by mask from spatial analyst tool using the shapefile of Bangalore Urban district which is freely available.

After obtaining the AOI image, LULC classification was performed. In preparing the LULC image, the most significant step is to choose the appropriate LULC classification scheme. Supervised and Unsupervised Classification is provided to obtain the classified image. Unsupervised Classification is the automatic classification where the outcomes are based on the software analysis without providing any sample classes by the user. This doesn't aid in the proper classification process, So Supervised classification was performed which is based on the idea that a user can select sample pixels in an image of different specific classes and then direct the image processing software (ArcGIS) to use these training sites as references for the classification of all other pixels in the image. Five separate LULC classes were defined namely Built-up (Urban areas and Roads), Barren lands, Vegetation (Forests or Collectively Plants habitat), Water Bodies and Agricultural lands (Crop lands and Culturable wastelands). The training areas were defined on the image that is known to be representative of a particular land cover type using Google Earth Software. Approximately 200 training sites were used to train the image in order to cover a full range of variability with each land cover type. The spectral signature of the pixels within each training area was determined by the software. A supervised Maximum Likelihood Classification (MXL) algorithm was selected for the classification process by assigning each pixel in the image based on its spectral signature. After the Classification, Post classification was performed to remove the isolated pixels and noise from the output classified image. The image was filtered by the majority filter from the spatial analyst tool and later smoothened the ragged class boundaries and clumps by the boundary clean tool. The classified images are shown in Figure 1. Now the resultant classified image was then analyzed to compute the areas under each class as adopted in the classification scheme. Accuracy assessment was performed by comparing the classified image with reference image data from Google Earth. The kappa coefficient and the overall accuracy was calculated from the confusion matrix which was obtained after performing Accuracy assessment.

The Kappa coefficient of agreement (K) was developed by Cohen in 1960 which is the measure of the Observed agreement (indicated by the diagonal elements of the confusion matrix) minus expected agreement (indicated by the product of row and column marginal). It uses all the cells in the confusion matrix and takes into account both the commission and omission errors (Rosenfield & Fitzpatrick-Lins, 1986). A Kappa value measures how the classification performs as compared to the reference data.

$$Kappa\ Coefficient\ of Agreement = \frac{Observed\ Agreement - Expected\ Agreement}{1 - Expected\ Agreement}$$

Where

$$Overall\ Agreement = Overall\ Accuracy = \frac{No. of\ pixels\ correctly\ classified}{Total\ No. of\ Pixel}$$

And

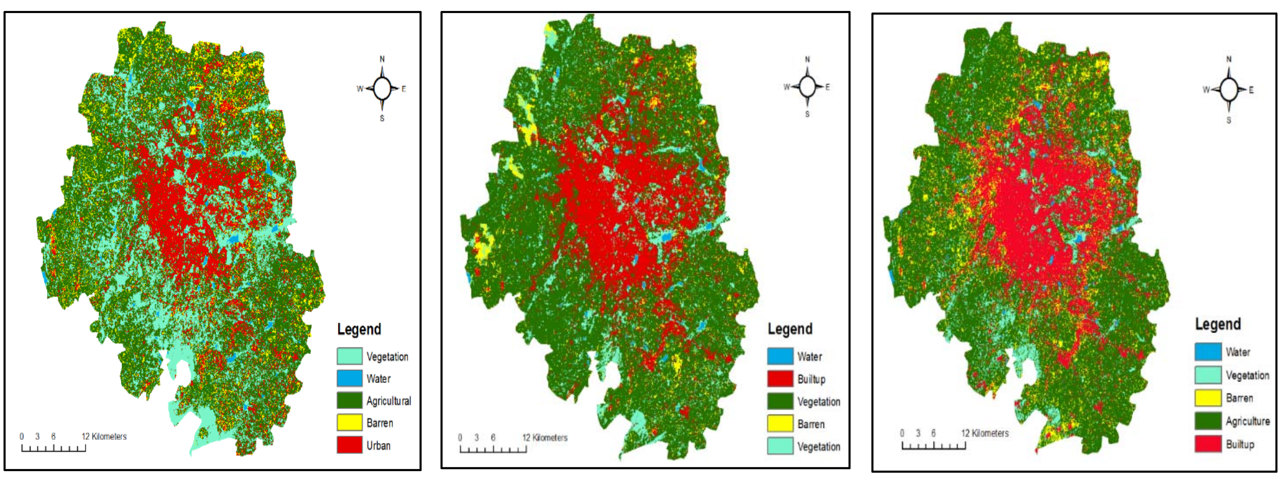
$$Expected\ Agreement = \frac{Sum\ of\ Diagonal\ Elements\ (\ Confusion\ Matrix\ )}{Total\ number\ of\ all\ elements}$$

Simultaneously, Producer’s Accuracy and Users Accuracy was obtained from the Confusion Matrix. Producers Accuracy is the ratio of the number of pixels correctly classified by the Classified Image and Actual number of pixels needed for that class in the reference map whereas the User's Accuracy is the ratio of number of pixels correctly classified by the Classified Image and Total number of pixels under that class defined by the classified image. The Error of Commission and Error of Omission are corresponding to the User's Accuracy and Producer's Accuracy respectively. The measure of Error of Commission is the ratio of the number of pixels’ commission by the total number of pixels whereas the Error of Omission is the ratio of a number of pixels omitted by the total number of pixels.

5. RESULTS AND DISCUSSIONS

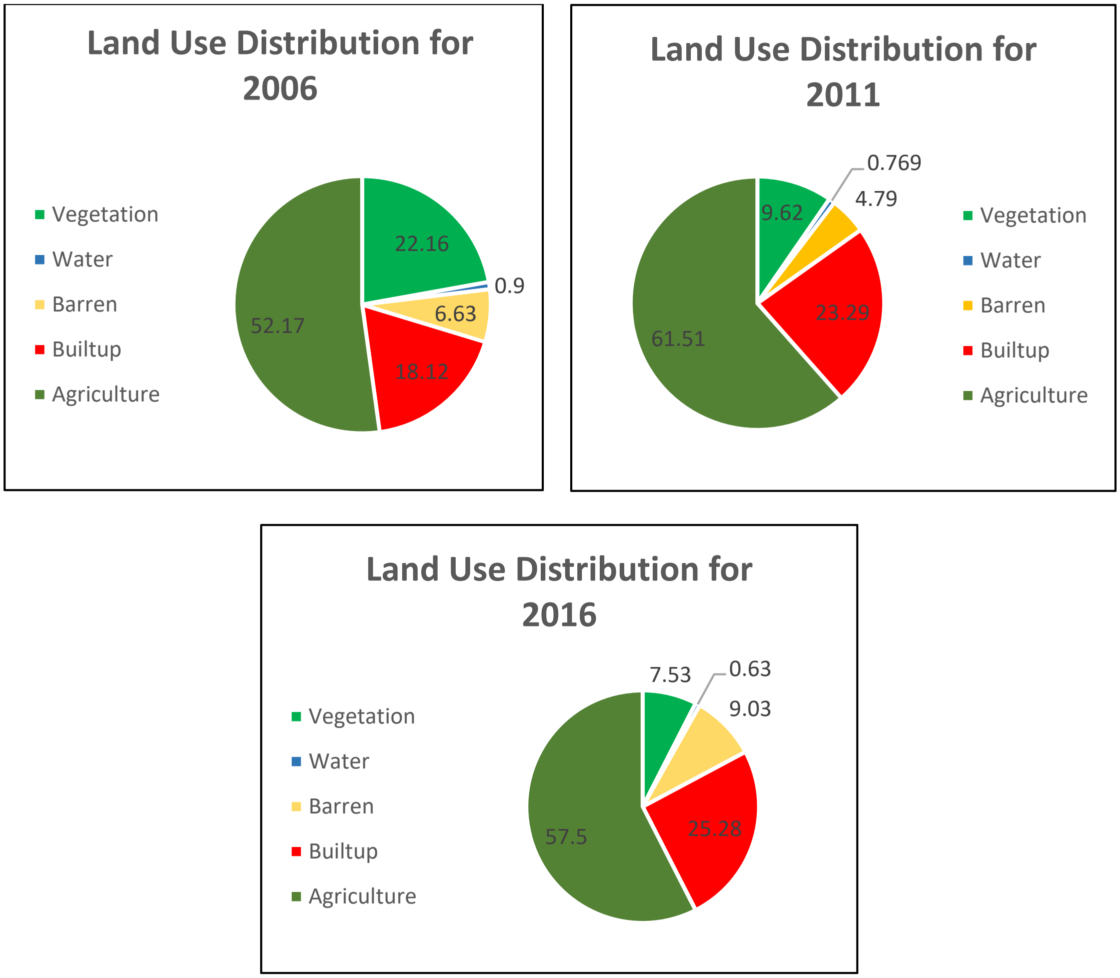
The change analysis presented in this study was focused on the effect of rapid urbanization on natural resources like Vegetation and Water Bodies by taking the statistics from the three classified images of the year 2006, 2011 and 2016 of five different classes include Water, Agricultural, Barren, Built-up and Vegetation. In Figure 3 and Figure 2, it can be clearly visible that there is a vast change in the Built-up and vegetation areas. The vegetation pattern showed a lot of variation across the Bangalore Urban District, depending in part on the location, population density, development intensity and surrounding natural vegetation cover. The high percentage of vegetation was observed in 2006 imagery which was calculated to be 22.16 percent out of the total, but in subsequent years there was decrease and the most noticeable reduction was observed between 2011 and 2016 which is 9.62 percent and 7.53 percent out of the total study area respectively. It means a large percentage of decrease was noticed in the plantation and the forest areas in the city periphery. The built-up areas showed a rapid increase from 2006 to 2011 from 18.12 percent to 23.29 percent but there was a steady increase between 2011 and 2016 from 23.29 percent to 25.28 percent out of the total region.

Furthermore, there is a significant increase in agricultural area by 5.33 percent in addition with the decrease in crop lands and increase in fallow or Culturable lands. The Culturable lands remained unploughed for more than 5 years. A significant decrease in water bodies by 0.267 percent from 2006 to 2016 which is obtained by combining deep and shallow water bodies. It is worth mentioning that water bodies had a total area of 19.72 sq.km in 2006 that got reduced to 16.7 sq.km in 2011 which is about 15.3 percent decrease and later reduced to 13.91 sq. km which is reduced by 29.4 percent from 2006. The net decrease in water bodies and vegetation together account for the total decrease of 324.94 sq.km against an increase of 208.568 sq.km of built-up area and barren lands. Thus it is concluded that increase in built-up areas in the city has been at the expense of majorly from the agricultural, Vegetation and water bodies.



2006 **2011** **2016**

Figure 1. Classified Images of 2006, 2011 and 2016



Total Area = 2182 Km^2

Figure 2. Land Use Distribution for different classes from 2006-2016 (In Percentage)

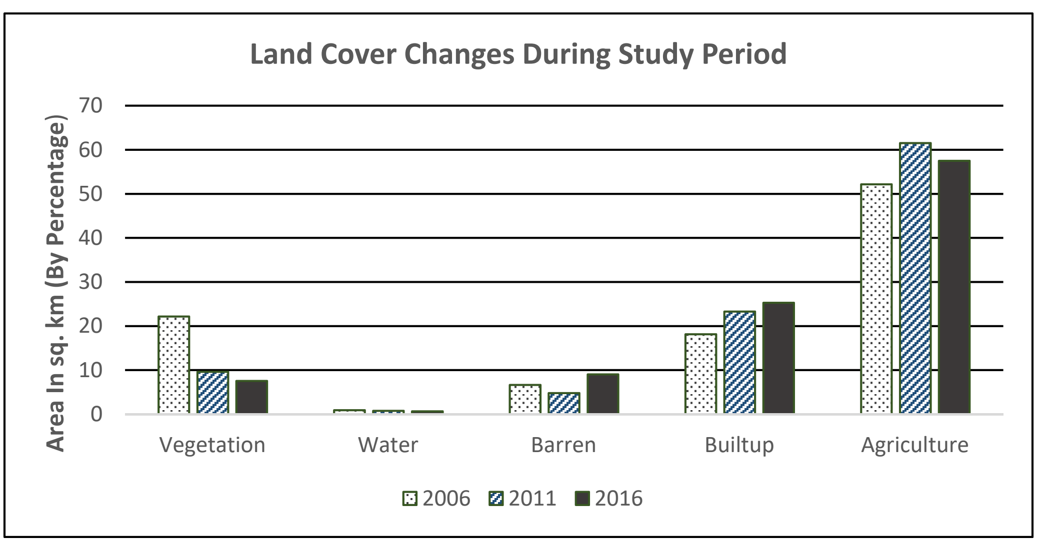


Figure 3. Land Cover changes for different classes from 2006-2016 (In Percentage)

The Overall Accuracy is found to be 86, 85 and 88.5 percent for the year 2006, 2011 and 2016 respectively. The kappa coefficient is found 0.83, 0.813 and 0.85 for the year 2006, 2011 and 2016 respectively as shown in the Table 1. The kappa coefficient above 0.8 is considered to be a good classification. The kappa values lie in between 0.4 to 0.8 is considered to be moderate classification and below 0.4 indicates poor classification (Lillesand, Kiefer, & Chipman, 2014). The Producer's accuracy and User's accuracy for the individual class show that the Vegetation classification for 2011 is 94.44 and 85 percent accurate respectively. This high value could lead a resource manager to conclude that this classified image is sufficiently accurate for his needs. However, upon identification of specific forest sites on the classified image for use in the field, the forester will be disappointed to find that only 85 percent of the sites identified as forests on the classified image is actually forested (Rosenfield & Fitzpatrick-Lins, 1986). In other words, 94.44 percent of the forest has been correctly identified as such, but the only 85 percent of those areas identified as forests are actually forests while 15 percent of those areas identified as forests are either water or barren. Although these measures of accuracy may seem very simple, it is critical that they both be considered when assessing the accuracy of a classified image. The values of the Producer's and User's Accuracy of different classes are mentioned in the Table 2 and the Corresponding values of Error of Omission and Error of Commission are mentioned in the Table 3 respectively for different classes.

Table 1. Overall accuracy and Kappa Statistics for different years

Year	Overall Accuracy (By Percentage)	Kappa Coefficient
2006	86	0.83
2011	85	0.813
2016	88.5	0.85

Table 2. The Producer's accuracy and User's Accuracy for different classes of Imageries

Class	Producer's Accuracy (In %Age)			User's Accuracy (In %Age)		
	2006	**2011**	**2016**	**2006**	**2011**	**2016**
Vegetation	80	94.44	86.67	80	85	86.67
Water	100	100	93.75	100	100	100
Agriculture	72.72	68.18	92.8	80	75	86.67
Barren	80	69.5	75	80	80	90
Built-up	100	100	92.3	90	85	80

Table 3. The Error of Omission and Error of Commission for different classes of Imageries

Class	Error Of Omission			Error of Commission		
	2006	2011	2016	2006	2011	2016
Vegetation	20	5.56	13.33	20	15	13.33
Water	0	0	6.25	0	0	0
Agriculture	27.27	31.82	7.2	20	25	13.33
Barren	20	30.5	25	20	20	10
Built-up	0	0	7.7	10	15	20

6. SUMMARY AND CONCLUSION

Land Use/Cover is a significant component in change studies and its precise and updated information is very crucial for understanding the factors, causes and environmental consequences of the changes. Precautionary measures should be taken to keep the sustainability of the natural resources. Such studies aim to contribute managers, decision makers and urban planners on land use/cover changes and help them to define a policy to contain uncontrolled urban sprawl driven by frenzied population migration. The results demonstrated in the study proved that Landsat can give quick monitoring of large areas with no cost data and gives accurate information to map and analyse in land cover and land use investigations.

From the above analysis, it can be clearly deduced that there is a very rapid growth during 2006 to 2011 and very steady growth during 2011 to 2016. There is huge a destruction of vegetation in sake of expansion from 2006 to 2011 which was later reduced from 2011 to 2016. There is steady decrease in water bodies during the complete study period. As we can observe there is an enormous area for agriculture in Bangalore Urban. But maximum are fallow lands which are left uncultivated for many years. This can be the cause of the migration of rural areas to urban areas for city life. It is very much essential to create urban green space and embrace a systematic method to deal with the maintenance of water bodies and vegetation and to restrain frequent flooding of lower regions of city during rainy season, so that Bangalore can retain its position as green city.

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