

**National Remote Sensing Centre, ISRO****Balanagar, Hyderabad*****User Interaction Meet – 2013******21-22, February, 2013*****Comprehension of temporal land use dynamics in urbanising landscape**

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**ABSTRACT**

Land use changes are irreversible changes and directly influence the regional and global environmental quality. Urbanisation is one of the major drivers of land use land cover (LULC) changes. Planned urbanisation would help in maintaining the environmental quality and sustenance of natural resources while meeting the demand of population in cities. However, unplanned urbanization in most of the rapidly urbanising cities has caused serious concerns in both environmental quality and on human's livelihood due to urban sprawl. Urban sprawl refers to the uncoordinated land use resulting from lack of integrated and holistic approach in regional planning. Information related to the rate of growth, pattern and extent of sprawl is required by urban planners to provide basic amenities. This paper discusses land cover and land use dynamics of Belgaum a tier II city in Karnataka. Temporal land use dynamics is assessed for urbanizing landscape - Belgaum city with a buffer of 5 km. Vegetation over changes have been analysed using slope based vegetation indices NDVI, which show 91.74% vegetation in 2012. Temporal land use analysis for the period 2006 to 2012 show that urban area has increased from 4.81% to 5.74%.

**Keywords:** Land use, Land cover, Urbanisation, Belgaum, IRS.

**1. INTRODUCTION**

Land use Land cover (LULC) dynamics is a major concern, as the abrupt changes in these dynamics has a negative impact on ecology, climate, regional hydrology, and also people's livelihood in the region. LULC dynamics are specific to a region and vary from region to region (Ramachandra et al., 2012). Land Cover refers to the observed physical cover on the earth's surface. Land cover essentially distinguishes the region under vegetation with that of non-vegetation (Lillesand and keifer, 2005). Land use refers to use of the land

surface through modifications by humans and natural phenomena (Lillesand and keifer, 2005). Land use can be classified into various classes such as water bodies, built up, forests, agriculture, open lands, sand, soil, etc. Land use modifications alter the structure of the landscape and hence the functional ability of the landscape (Ramachandra, et al., 2012). The modification includes conversion of forest lands, scrublands to agricultural fields, cultivation lands to built up, construction of storage structures for water bodies leading to

submergence of land features that may vary from small scale to large scale.

Land use and land cover patterns and their changes over time for the region are quantified with the spatial data acquired through space borne sensors. Remote sensing data with synoptic repetitive coverage aids in understanding the landscape dynamics. The spatial data are analysed using Geographic Information System (GIS). Temporal remote Sensing data with GIS platforms have been used to acquire and comprehend the changes in land use, land cover and the urban sprawl dynamics of urbanizing landscape Belgaum city during 1989 and 2012. Satellite remote sensing technology has the ability to provide consistent measurements of landscape condition, allowing detection of abrupt or slow trend in changes over time. Long-term change detection results provide insight into the stressors and drivers of change, potentially allowing for management strategies targeted toward cause rather than simply the symptoms of the cause (Kennedy et al., 2009).

Analyzing the spatio-temporal characteristics of landscape dynamics are essential for understanding and assessing ecological consequence of urbanization. Urbanization is taking place all over the world, but most commonly now in cities/towns of developing nations. In countries like India, urbanization is due to the increase in population in a region due to industrialization. Large scale land use land cover changes with industrialization prominently took place in outskirts during post 2000. Spurt in IT and BT sectors lead to the large scale migration from different parts of the country and also from other parts of the globe for the employment opportunities in the industry. To meet the residential requirements, dispersed growth or sprawl has taken place in per-urban areas. Sprawl phenomenon drives drastic changes in land use patterns leading to haphazard growth affecting local ecology and the environment. Sprawl occurs either in radial direction around the city centre or in linear direction along the highways, ring roads, etc. The built-up is the parameter used for quantifying urban sprawl. The study on urban sprawl is attempted in the developed countries and recently in developing countries such as China (Yeh and Li, 2001) and India (Ramachandra et al., 2012, Sudhira et al., 2003, Sudhira et al., 2004). In India alone currently 25% of the population (Census of India, 2001) lives in the urban centers and it is projected that in the next fifteen years about 33% would be living in the urban centers (Sudhira et al 2004). In order to understand the

dynamics, urbanization quantification and assessment of the extent of sprawl is necessary. Shannon's entropy helps to measure the degree of spatial concentration or dispersion among 'n' zones (Yeh and Li, 2001; Sudhira et al., 2003; Sudhira et al 2004; Ramachandra et al., 2012). Objective of the current study is to analyze the land use land cover dynamics of urbanizing landscape apart from assessing the underlying effects of urbanisation such as urban sprawl through Shannon's entropy.

## 2. STUDY AREA

Belgaum City (Figure1) geographically located in the north western part of Karnataka state. The city extends from  $74^{\circ}28'29.071''$  to  $74^{\circ}34'54.92''$  E and  $15^{\circ}49'23.189''$  to  $15^{\circ}54'0.142''$  N with an average elevation of 751m above mean sea level and spatial extent of 5798 hectares. For the study a 5 km buffer from the administrative boundary was considered as shown in Figure 2, with a gross area of 38013.27 hectares, to account for the growth in peri urban regions. The city has about 58 wards, with population of 488292 (2011 Census provisional) and population density of 84.21 persons per hectare, the population in the region has a decadal increase of 7.31%. Temperature varies from as low as  $18^{\circ}\text{C}$  (winter) to  $40^{\circ}\text{C}$  (summer) and annual average rainfall is about 1418 mm. Soils in the region consist of shallow to very deep black soils, red loamy soils, lateritic soils, etc. The city is surrounded by Kanburgi, Yamanspura, Kangrali.B, Kangrali.K villages to the north, Hindalga, Binakanahalli, Savagaon, Madoli to the West, Angol, Wadgaon, Madhavapura, Haldge to the South and Sindoli, Mutuge, Nilage Villages to the East.

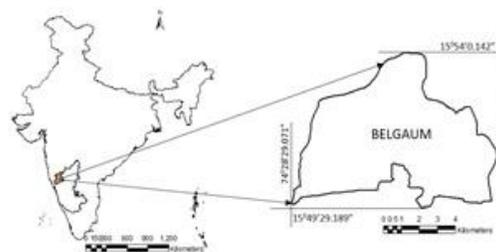


Figure 1: Study Area

Figure 2 demarcates the study area (Google earth) with 5 km buffer along the city administrative boundary



Figure 2: Study Area with 5 Km Buffer Overlaid on Spatial Data (Google Earth)

### 3. DATA COLLECTION

Multi resolution remote sensing data from of Landsat TM, IRS (Indian Remote Sensing) LISS 3 Sensors were used, specifically from IRS 1C and IRS R2. Training data were collected from field using pre-calibrated Global Positioning System (GPS) and online map Google earth. The details of the data used are given in table 1. The administrative boundary was digitized from toposheets (1:50000) of the Survey of India, online village map (<http://bhuvan.nrsc.gov.in>).

Table 1: Data Used

Data	Year	Purpose
IRS LISS III (24m)	2006 2012	Land cover and Land use analysis
Survey of India (SOI) toposheets of 1:50000 and 1:250000 scales		To Generate boundary and Base layer maps.
ISRO - Bhuvan and Google Earth		For verification and preparation of boundary
Field visit data – captured using GPS		For geo-correcting and generating validation dataset

### 4. METHODOLOGY

Temporal landscape dynamics are assessed through LULC changes. Figure 3 outlines the process followed for the study. Data acquisition includes obtaining data about the region such as the satellite images, Statistics, the ancillary data (Gazetteer, Census), the Maps such as Village maps, District maps. Preprocessing of the data is

done to remove the haze and other factors through atmospheric correction, removal of noise and other radiometric errors through radiometric corrections. Image enhancement is done using standard image processing techniques. The data pertaining to the study region is extracted by cropping using the boundary. For visual interpretation and for creation of the training sets for classification of the images, a false color Composite (FCC) image of the study area is created. FCC is created by composition of band 2 (green), band 3 (red) and band 4 (IR).

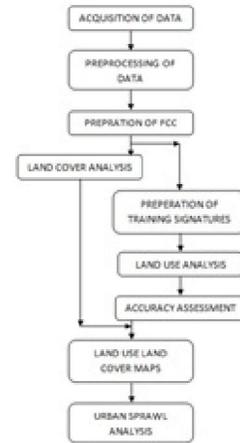


Figure 3: Procedure involved in data analysis

Assessment of landscape dynamics involves the analysis of temporal land use and land cover. Land cover analysis involves the computation of extent of vegetation through well-established vegetation indices. Vegetation indices help in mapping the regions under vegetation and non-vegetation. Vegetation Indices are the Optical measures of Vegetation Canopy. Vegetation indices are dimensionless radiometric measurements that indicate the relative abundance and activity of green vegetation; this includes the leaf area index (LAI), percentage green cover, chlorophyll content, and green biomass. The main requirement of vegetation indices measurement is to combine the chlorophyll absorbing (Red Band) spectral region with the non-absorbing (NIR band) spectral region to provide a consistent and robust measure of area under the canopy. Vegetation Indices algorithms are designed to extract the active greenness signal from the terrestrial land cover. The accuracy of the VI product varies with time, space, geology, seasonal variations, canopy background (soil, water). Among all techniques Normalized Difference Vegetation Index (NDVI) is most widely used for LC analysis. NDVI is expressed as the ratio of difference in NIR and Red bands to the sum of NIR and Red band. NDVI has the ability to minimize the topographic effect in the region. NDVI ranges between -1 to +1, ratio less

than 0 i.e., the negative values represent non-vegetation and positive values represent vegetation.

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

Land use analysis involves categorizing each pixel in the spatial data into different land use themes such as water bodies, vegetation, built up, cultivable land, barren lands, *etc.* A multispectral data is useful to perform classification as it shows the numerous spectral patterns/signatures for different features. Spectral pattern recognition refers to the family of classification procedures that utilizes pixel by pixel spectral information as a basis for land use classification. Land use analysis involves collection of training data from field, attribute data for the chosen polygons in FCC, and goggle earth. These training sets were employed for classification of the data into various classes. 60% of training data is used from classifying the spatial data, while the balance has been used for verification. GRASS GIS, open source software was used for analysis of the data. Land use analysis was carried out using the Gaussian maximum likelihood classifier (GMLC) algorithm. Accuracy assessment is done through error matrix, comparing on a category by category basis, the relationship between reference data (ground truth) and the corresponding classified results.

Computation of Shannon's entropy: Shannon's entropy (Yeh and Li, 2001, Ramachandra et al., 2012) was computed to detect the urban sprawl phenomenon and is given by,

$$H_n = -\sum P_i \log(P_i)$$

Where;  $P_i$  is the Proportion of the urban density in the  $i^{th}$  zone and  $n$  the total number of zones. This value ranges from 0 to  $\log n$ , indicating very compact distribution for values closer to 0. The values closer to  $\log n$  indicates that the distribution is much dispersed. Larger value of entropy reveals the occurrence of urban sprawl.

## 5. RESULTS AND DISCUSSIONS

**Land Cover Analysis:** Slope and Distance based vegetation indices were computed, of which NDVI shows significant results and is given in Figure 5 and the details in Table 2. The vegetation cover has decreased from 96.35% (2006) to 91.74% (2012).

Table 2: Land Cover details

Year	Vegetation	Non Vegetation
2006	96.35 %	3.65 %
2012	91.74 %	8.26 %

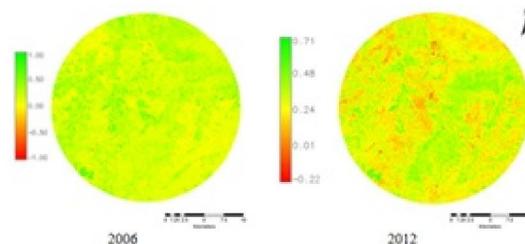


Figure 5: Land cover Classification

**Land Use Analysis:** Temporal land use changes during 2006 and 2012 are given in Figure 6 and in Table 3. Results show an increase built-up from 4.81 % (2006) to 5.74 % (in 2012), water bodies and vegetation fairly constant, while other category (including the cultivation lands, barren lands, open lands, *etc.*) have changed from 92.93% (2006) to 91.58% in 2012. Overall classification accuracy achieved is about 93 % for the classified images, and table 4 gives the summary of overall accuracy and the agreement between the true value and the sensed value i.e., kappa statistics. Higher kappa indicates that the classified data (sensed data) is in agreement with the ground data (true data).

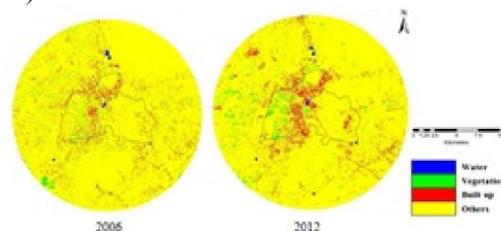


Figure 6: Land Use Classification

Table 3: Land use details

Particulars	Percentage	Area(Ha)
<b>Year 2006</b>		
Water	0.23 %	87.47
Vegetation	2.33 %	886.07
Built up	4.81 %	1829.17
Others & Cultivation	92.93 %	35339.95
<b>Year 2012</b>		
Water	0.24 %	92.03
Vegetation	2.44 %	928.73
Built up	5.74 %	2190.15
Others & Cultivation	91.58 %	34904.41

Table 4: Overall Accuracy and Kappa Statistics

Year	Overall Accuracy	Kappa Value
2006	93.64 %	0.92
2012	93.12 %	0.93

**Urban sprawl assessment:** Shannon’s entropy was calculated in four directions and the results are given in figure 7 and table 5 respectively. The threshold limit of Shannon’s Entropy is log 11 (1.0414), and the values closer to the threshold value indicates the growth is scattered indicating sprawl in the region. The Shannon’s Entropy values close to zero indicates that the growth is clustered and confined. The results show increasing tendency of urban sprawl in 2006 and 2012, indicating that a tendency of dispersed growth in all directions and is evident in Figure 6.

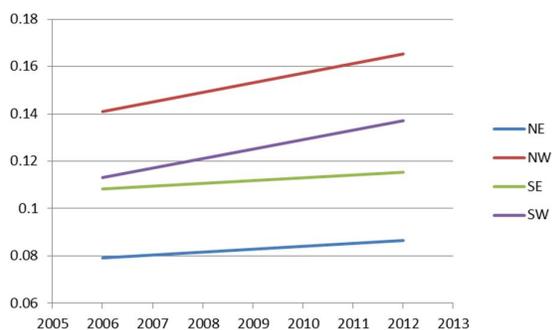


Figure 7: Shannon Entropy

Table5: Shannon’s Entropy Analysis

	NE	NW	SE	SW
2006	0.079145	0.14097	0.108442	0.113038
2012	0.086431	0.165239	0.115427	0.137098

## 6. CONCLUSION

LULC change analysis depicts the landscape dynamics, which show conversion of agriculture lands into built up area. Also, open lands and scrub lands are converted to agricultural fields. Land cover analysis show an increase in vegetation cover in the region from 96.35% (2006) to 91.74% (2012). The temporal land use analysis through supervised Gaussian MLC show an increase in built up from 4.81% (2006) to 5.74% (2012). Shannon’s entropy values indicate the increasing tendency of urban sprawl in the region.

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