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Spatio-temporal dynamics of Raichur City

Vinay S[1], Bharath H Aithal[1, 2], and Ramachandra T V[1,2,3]
[1]Energy & Wetlands Research Group, Centre for Ecological Sciences,
[2]Centre for Sustainable Technologies,
[3]Centre for infrastructure, Sustainable Transportation and Urban Planning (CiSTUP)
Indian Institute of Science
Bangalore – 560 012, INDIA
Tel: 91-80- 22933099/22933503 (extn 107)
Fax: 91-80-23601428/23600085/23600683[CES-TVR]
E-mail: energy@ces.iisc.ernet.in; bharath@ces.iisc.ernet.in; cestvr@ces.iisc.ernet.in
http://ces.iisc.ernet.in/energy

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 Raichur a tier II city in Karnataka. Spatio-temporal land use changes have been analysed for Raichur city with a buffer of 2 km. Land over changes have been analysed using distance based vegetation indices, which indicated vegetation to be 80.80% through NDVI in 2009. Land use analysis show during the period from 1989 to 2009 urban area has increased from 1.45% to 5.80%.

Keywords: Raichur, Land use, Land cover, Urbanisation.

1. INTRODUCTION

Land use Land cover (LULC) dynamics is a major concern as the abrupt changes in these dynamics affects the ecology, geology, climate, regional hydrology, and livelihood of 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 can be confined to describe Vegetation and Manmade features (Lillisand and keifer, 2005) and designates the visible evidence of land use to include both vegetation and non-vegetation. Land use refers to use of the land surface through modifications by humans and natural phenomena (Lillisand and keifer, 2002). The Land use can be classified into various classes such as Water Bodies, Built up's, Forests, Different Vegetation Classes, Irrigation lands, Open Lands, Sand, Soil, *etc*. Land use modification 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.

To understand the land use and land cover of the region it is necessary for data to have spatial reference, hence remote sensing plays an important role as a tool to understand such dynamics. Remote Sensing and GIS platforms are used to acquire and understand the land use, land cover and the urban sprawl dynamics for the study area (Raichur city) between 1989 and 2009. Remote sensing refers to the acquisition of information about an area, object by analyzing the information acquired by the device that is not in contact with the object. Remote Sensing has the advantages of repetitive data acquisition, synoptic view, long-term historical archives, high spatial-resolution, and stable quality for example. (Lillisand and kiefer, 2002). Remote Sensing facilitates in detection and characterization of features based on the spectral reflectance behavior of different features, to monitor LULC dynamics over large areas, and also the areas that is hazardous and inaccessible to reach. 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 can 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 land cover and land use changes are essential for understanding and assessing ecological consequence of urbanization. Urbanization is a universal phenomenon taking place all over the world, but most commonly in cities/towns of developing nations. In countries like India, urbanization is due to the increase in population, industrialization leading to increase in employment opportunities which demands for workmanship, due to which people from various location regional or global are employed, higher the employment opportunities increases the demand for settlements and hence leading to urban sprawl. Sprawl is one such phenomenon that drives the change in land use patterns. Sprawl normally takes place in radial direction around the city centre or in linear direction along the highways, ring roads. The built-up is generally considered as the parameter 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 25.73% of the population (Census of India, 2001) lives in the urban centers while 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 regions dynamics quantification of urbanisation and sprawl is necessary. Shannon's entropy is a good and established measure of the degree of spatial concentration or dispersion of a geographical variable among 'n' zones (Yeh and Li, 2001; Sudhira et al., 2003; Sudhira et al 2004;Ramachandra et al., 2012) and indicates distribution is spread across the region. Objective of the study is to analyze the land use Land cover dynamics of the region, analysis of the expanding urban region and the underlying effects of urbanisation such as urban sprawl through indicators such as Shannon's entropy.

2. STUDY AREA

Raichur City (Figure 1) is located in the North Eastern part of Karnataka State. The city extends from 16°9'17.804" North to 16°15'2.521"North in Latitude and 77°18'23.912"East to 77°24'43.895" East in Longitude and at an elevation of 410m above MSL with an area of 5868.78 hectares. A buffer region of 2 km around the administrative boundary of the city (Figure 2) was considered for the study, the total study area was 15732.27 hectares. The city had a total population of 207421 in the year 2001(Census). The climate is characterized by dryness for major part of the year and very hot during summer. The low and highly variable rainfall is liable for drought. Annual average rainfall is about 729 mm (District at a glance 2010-2011).Temperature during summer attain up to 45 °C, during winter season would drop down to 17 °C, due to the dry climate, even during the monsoon, the humidity levels are low. The region consists of light green, reddish-brown, black soils. The major portion is comprised of black soil, occurring near the hornblende schists and the gneisses rocks. The city is surrounded by Yermaras and Potgal to the North, Manslapura, to the North West, Eklaspura and Rampura to the West, Nelhal, Asapur, Araibechi, and Malibad to the South, Sidrampura to South East, Wadwati and Bodamanudoddi to East, and Katlakur to the North West.

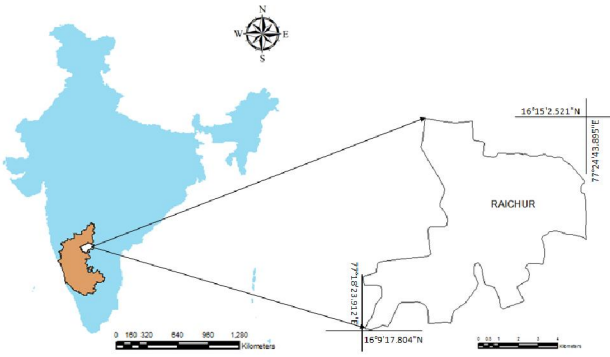

Figure 1: Study Area

Figure 2 illustrate the study area as seen in Google earth, showing 2km buffer region along the city administrative boundary

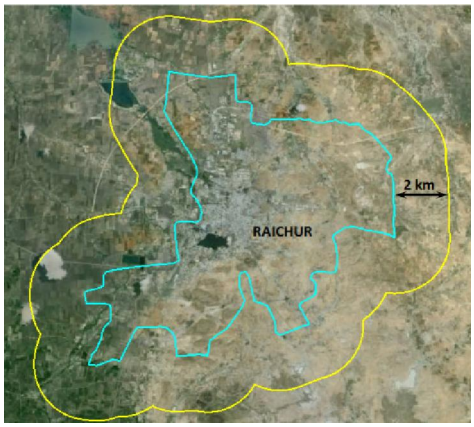

Figure 2: Study Area with 2 Km Buffer Overlaid on Spatial Data (Google Earth)

3. DATA COLLECTION

The spatio temporal remote sensing data were used for the region was from the multispectral satellite imageries from US based satellites, and from Google earth. The details of the imageries are given in table 1.The administrative boundary map of the study area was digitized using the topo-sheets of Survey of India.

Table 1: Details of Satellite Imageries

Satellite	Date of Acquisition	Resolution
Landsat 5 TM	21 November 1989	30 m
	14 November 1998	
	27 October 2009	

4. METHODOLOGY

To understand the temporal dynamics of a region, LULC and Urban Sprawl pattern analysis is necessary; Figure 3 depicts the process followed during 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 necessary to remove the haze and other factors through atmospheric correction, removal of Noise and Filling of missing scan lines through radiometric correction. The region of study is then extracted by cropping the processed data. For visual interpretation and for creation of the training sets for classification of the images, a False Colour 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) bands.

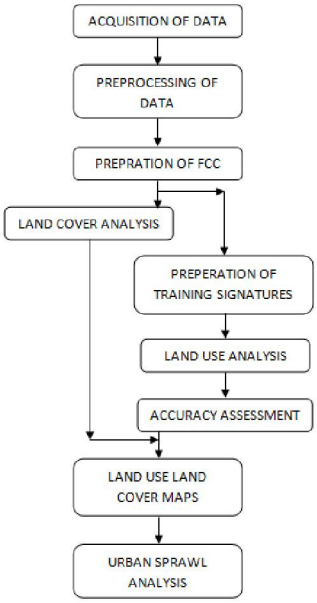

Figure 3: Procedure involved in data analysis

Spatio temporal dynamics entails the analysis of multi temporal land use and land cover. Land cover analysis involves the calculation of vegetation indices. Vegetation indices help in mapping of 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, 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. The 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 accepted for land cover mapping. Normalized Difference Vegetation Index is expressed as the ration of differenced 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, ration less than 0 i.e., the negative values represent non-vegetation and positive values represent vegetation.

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

Land use analysis involves categorizing each pixel in the satellite imageries 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 polygons from the satellite imageries and from goggle earth for verification. These training sets were employed for classification of the data into various classes. GRASS GIS, open source software was used for analysis of the data. Land use analysis was carried out using the Gaussians maximum likelihood algorithm.

Accuracy assessment is the process of measuring the spectral classification inaccuracies by a set of reference pixels. One of the most common means of expressing classification accuracy is the preparation of classification error matrix, Error matrices compare on a category by category basis, the relationship between known reference data (ground truth) and the corresponding results of an automated classification.

Urban sprawl analysis through Shannon's entropy: The 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; *Pi* 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 was computed vegetation indices were calculated, of which NDVI shows significant results and is shown in Figure 5 and the details in Table 2. The vegetation cover has increased from 77.59% in 1989 to 80.80% in 2009.

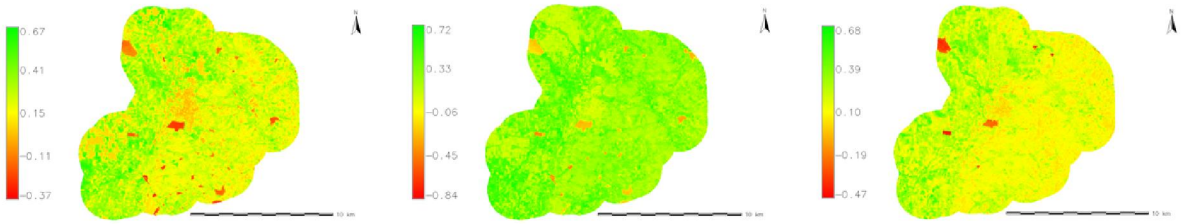

Figure 5: Land cover Classification

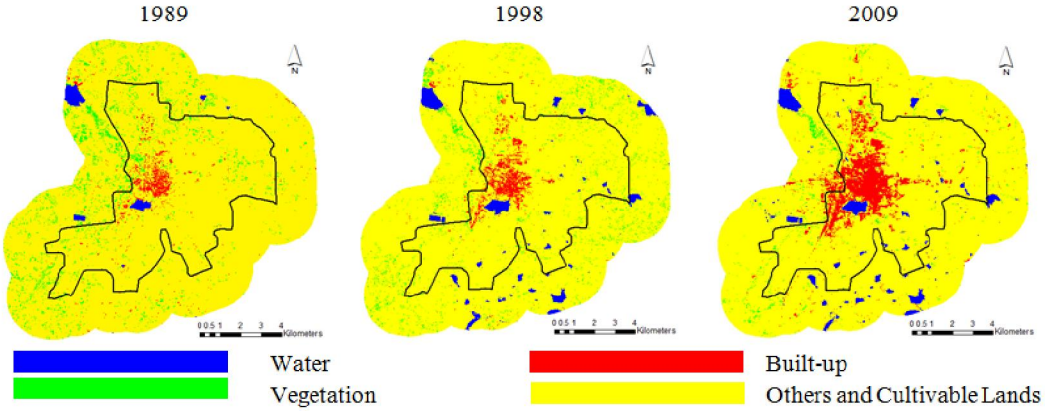

Figure 6: Land Use Classification

Table 2: Land Cover details

Year	% Vegetation	% Non Vegetation
1989	95.60	4.33
1998	94.68	5.31
2009	93.57	6.39

Land Use Analysis: The Spatio Temporal Land use changes between 1989 and 2009 are shown in Figure 6 and the details in Table 3. The results show an increase in water bodies from 0.84 % in 1989 to 2.47 % in 2009, the built-up has increased from 1.45% in 1989 to 5.80% in 2009; Vegetation has reduced from 3.89% in 1989 to 1.10% in 2009, others (including the cultivation lands, barren lands, open lands, *etc*) have changed from 93.82 % in 1989 to 90.64%. The Overall Classification Accuracy of more than 91 % was observed for the classified images, table 4 gives the summary as the agreement between the true value and the sensed value.

Table 3: Land use details

Year **1989**		
Particulars	Area(Ha)	Percentage
Water	130.45	0.83%
Vegetation	613.01	3.90%
Built up	228.45	1.45%
Others	14742.99	93.82%
1998		
	Area (Ha)	Percentage
Water	366.12	2.33%
Vegetation	414.63	2.64%
Built up	325.62	2.07%
Others	14625.90	92.97%
2009		
	Area (Ha)	Percentage
Water	388.08	2.47%
Vegetation	172.35	1.10%
Built up	913.14	5.80%
Others	14258.70	90.64%
Total Area	15732.27 Hectares	

Table 4: Overall Accuracy

Year	Overall Accuracy
1989	93.64
1998	94.17
2009	91.27

Urban sprawl assessment: Shannon's entropy, indicator of urban sprawl was calculated and the results are shown in table 4. The threshold limit of Shannon's Entropy is log 5 (0.6987), values closer to the threshold value indicates the growth is scattered indicating sprawl in the region and if the Shannon's Entropy values are close to zero, it indicate that the growth is clustered and confined and there is no or little sprawl and. The results show that the distribution of the built up is clustered in the year 1989 and 1998, while in 2009, Shannon's Entropy has increased indicating that there is a dispersed growth of built up, and this is evident in Figure 6.

Table5: Shannon's Entropy Analysis

Year	Built Up (Ha)	Shannon's Entropy	Log(n)
1989	228.45	0.158	0.699
1998	325.62	0.182	
2009	913.14	0.273	

6. CONCLUSION

Large LULC changes involve conversion of irrigable lands into built up area, some of the open lands and scrub lands are converted to Agricultural Fields. A wide range of small scale irrigation projects (water bodies) have come up in the region increasing the water storage capacity in the region. The Land Use analysis was done by supervised classification using the Gaussian MLC algorithm. The temporal change in land use and land cover has been observed. The Land cover results show an increase in vegetation cover in the region from 95.6% in 1989 to 93.57% in 2009. The temporal analysis of the Land use show an increase in Built up area from 1.45% in 1989 to 5.80% in 2009, the vegetation has declined from 3.9 % in 1989 to 1.1% in 2009. Shannon's entropy has increased 0.182 in 1998 to 0.273 in 2009, shows the tendency of urban sprawl in the region

7. REFERENCES

1) Gazetteer District at a Glance - Raichur District 2008 to 2010.
2) IDRISI Taiga Guide to GIS and Image Processing, Clark Labs, USA, Ver. 16.02, pp 213 – 222
3) Landsat 7 Science Data Users Handbook, NASA
4) Mysore District Gazetteer – Raichur District 1970, Government Press Publication, 1-28
5) Firmino, A., 1999. Agriculture and landscape in Portugal. Landscape Urban Plann. 46, 83–91.
6) Gyanesh Chander , Brian L. Markham, Dennis L. Helder ,"Summary of current radiometric calibration coefficients for Landsat MSS, TM, ETM+, and EO-1 ALI sensors", 895- 896
7) http://censusindia.gov.in/
8) ICIMOD, 1999. Integration of GIS, remote sensing and ecological methods for biodiversity

inventory and assessment. In Issues in Mountain Development.
9) Jin S. Deng, Ke Wang, Yang Hong, Jia G. Qi, 2009, Spatio-temporal dynamics and evolution of land use change and landscape pattern in response to rapid urbanization, Elsevier
10) Lillesand, T.M., Kiefer. R. W., 2002. Remote Sensing and Image Interpretation, Fourth Edition, John Wiley and Sons, ISBN 9971-51-427-3, 215-216
11) Maria Zomeni, Joseph Tzanopoulos, John D. Pantis, 2008, Historical analysis of landscape change using remote sensing techniques: An explanatory tool for agricultural transformation in Greek rural areas , Landscape and Urban Planning,
12) Ramachandra T V , 2007, "Comparative Assessment of Techniques for Bioresource Monitoring using GIS and Remote sensing", Vol1, No2.
13) Ramachandra T V, Uttam Kumar, 2009, Geoinformatics for Urbanization and Urban Sprawl pattern Analysis, NOVA Science
14) Ramachandra. T.V., Bharath H. Aithal and Durgappa D. Sanna, 2012. Insights to Urban Dynamics through Landscape Spatial Pattern Analysis. 2012. International Journal of Applied Earth Observation and Geoinformation, Vol. 18, 329-343.
15) Robert E. Kennedy , Philip A. Townsend, John E. Gross, et al., 2009 , Remote sensing change detection tools for natural resource managers: Understanding concepts and tradeoffs in the design of landscape monitoring projects, Elsevier.
16) Sudhira H.S, Ramachandra T.V and Jagadish K.S, 2004, Urban sprawl: metrics, dynamics and modelling using GIS, International Journal of Applied Earth Observation and Geoinformation
17) Sudhira, H. S., Ramachandra, T. V., and Jagadish, K. S., 2003. Urban sprawl pattern recognition and modelling using GIS. Paper presented at Map India, New Delhi. January 28–31, 2003.
18) Thomas M Lillesand, Ralph W Kiefer, Jonathan W Chipman 2004, Remote Sensing and Image Interpretation", Edition 5, John Wiley and Sons
19) Wood, R., Handley, J., 2001. Landscape dynamics and the management of change. Landscape Res. 26 (1), 45–54.
20) Yeh, A.G.O., Li, X., 2001. Measurement and monitoring of urban sprawl in a rapidly growing region using entropy. Photogrammetr. Eng. Remote Sens. 67 (1), 83.