LAKE 2014: ***Conference on Conservation and Sustainable Management of Wetland Ecosystems in Western Ghats***
Date: 13th -15th November 2014
Symposium Web: http://ces.iisc.ernet.in/energy

LAND USE DYNAMICS IN CENTRAL AND SOUTHERN WESTERN GHATS

Shweta Gupta[1,4], Swati Gupta[1,4], Bharath H. Aithal[1,2], Ramachandra T. V.[1,2,3]

[1]Energy & Wetlands Research Group, Centre for Ecological Sciences,
[2]Centre for Sustainable Technologies (Astra),
[3]Centre for infrastructure, Sustainable Transportation and Urban Planning (CiSTUP), Indian Institute of Science, Bangalore – 560012, India.
[4]Department of Remote Sensing, Banasthali University, Rajasthan, India.
email: cestvr@ces.iisc.ernet.in

ABSTRACT

Geospatial technologies helps in finding out the forest cover along with different land use types in remote and inaccessible areas. Understanding of landscape dynamics is essential for sustainable management of natural resources. The Western Ghats, a pristine ecosystem, has been undergoing changes in the land use patterns due to anthropogenic pressures. The modifications in the structure of landscape with the conversion of forests into agricultural land and industries has affected the ecological services. This paper focuses on land use land cover changes in Central and Southern Western Ghats during 1991 to 2014. The results indicate that there is expansion in agricultural and plantation activities. The agricultural area has increased from 7.30 % (1991) to 10.39 % (2014) and the area under plantations has increased from 11.58 % (1991) to 17.38 % (2014). Land use land cover changes account for the major variations in biodiversity due to demographic pressure and resource consumption.

Keywords: Central and Southern Western Ghats, land use land cover dynamics, natural resources, sustainability

INTRODUCTION

Landscape is defined as a distinct, measurable unit represented by its spatially repetitive cluster of various interacting systems (Forman and Godran, 1986). The functional aspect of the landscape is dependent on its structure which deals with its size, shape and configuration. Landscape influenced by humans, external disturbances and development alters the homogeneous landscape into heterogeneous mosaic of patches (Ramachandra and Aithal, 2012). The causal factors of these changes are resource extraction, globalization and natural calamities (Sua et al., 2010). Land cover changes induced by human and natural processes play a significant role in global as well as at regional scale patterns of the climate and biogeochemistry of the Earth system (Kumar et al., 2007).

Land Cover (LC) describes the Earth's physical state in terms of the natural environment and man-made structures such as vegetation, soil, water or anthropogenic features (Boulies and Szejwach, 1998; Ramachandra, 2008). LC helps in assessing the forest cover which is important for conservation as it harbors great level of biological diversity and unique landscape elements (Gadgil report). Land Use (LU) is the utilization of land by human beings to fulfill their physical and economic needs and exploit the land cover in the form of industries, anthropogenic disturbances and deforestation activities. Land Use Land Cover Changes (LULCC) driven by interaction of ecological, geographical, economic and social factors (Zhang and Huan, 2006), locally change the ecosystem and globally induce the climate change (Setturu and Ramachandra, 2012). Transformations in landscapes are the most dynamic processes varying the hydrology, local ecology and natural environment (Bharath et al., 2013). The impacts of landscape changes on habitats, biodiversity, complexity and fragmentation of the landscape can be explained with the interactions between landscape spatial pattern and ecological processes (Zeng and Wu, 2005). There is a need to consider both the spatial arrangement modifications and their consequences for quantification of landscape changes (Ramachandra and Bharath, 2012). At regional level, temporal LU changes have been quantified by various researchers (Sudhir et al., 2004; Setturu and Ramachandra, 2012). By the early 1990s, at the cost of forests and grasslands nearly 40% of the earths' surface has been transformed to cropland and permanent pastures (Ramachandra and Shruthi, 2007). These alterations can result in a change of the microclimate within and surrounding the remnant intact forest patches (Saunders et al., 1991) and a change in forest ecosystem function and condition (Wickham et al., 2008). For managing the ecosystem services and species conservation, it is extremely essential to know how spatio-temporal variations occur in LULCC and how it affects the landscape structure (Barlow et al., 2007). Since changes are very frequent and at large scale, LULCC needs monitoring and assessing the changes that happened over time which leads to sustainability of natural resources (Bharath and Ramachandra, 2012).

Remote Sensing data acquired through space borne remote sensors enables a bird eye view of the landscape at low cost (Lillesand and Kiefer, 2005). The advantage of remote sensing data is to acquire repeated measurements of the same area on periodic basis which helps in detection and monitoring of LULCC and surveillance of problematic sites (Campbell, 2002). The analysis of changes at local, regional and global scales is possible through the collection of remote sensed data covering the larger spatial extent. Remote sensing aids in identification and assessment of land use patterns which is important for environmental management and decision making. Objective of the current study is to assess landscape dynamics in the central and southern Western Ghats using temporal remote sensing data.

STUDY AREA

The Western Ghats is one among the 35 global hotspots of biodiversity, also known as Sahyadris, forms a continuous mountainous chain extending from 8˚ 0´ N to 22˚ 26´N latitude and 72˚ 55´E to 78˚ 11´E longitude. Western Ghats traverses the six states of Indian continent viz. Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu constituting 51 districts, except the 30 km long Palghat gap. The great escarpment stretches nearly 1600 km in length from Tapti River in the North to Kanyakumari in the south. The mean elevation of the Western Ghats is higher than 600 m and exceeds 2000 m at some places, Anaimudi peak being the highest with 2695 m elevation. The annual rainfall received by this area is between 2000 mm and 8000 mm.

Central and Southern Western Ghats shown in figure 1, extending from 8˚ 7'11.99'' N to 16˚23'24'' N latitude and 74˚ 5'24''E to 78˚3'36'' E longitude includes the states of Karnataka, Kerala and Tamil Nadu. It forms the major watershed and an important source of water in Peninsular India and the major rivers in this region are the Cauvery, the Kali, the Bedthi, the Aghanashini and the Sharavathi. The evergreen forests are found on the high western slopes of the Ghats and it changes to moist and dry deciduous forest types as one move towards eastern slopes of the Ghats along the rainfall gradient. Degradation of the forests is mainly due to the increasing habitat pressures, forest fragmentation and agricultural expansion, which has led to the global variations in land use (Vanwambeke et al., 2007). These activities have paved the path for various developmental projects largely, adversely affecting the biological richness of the region.

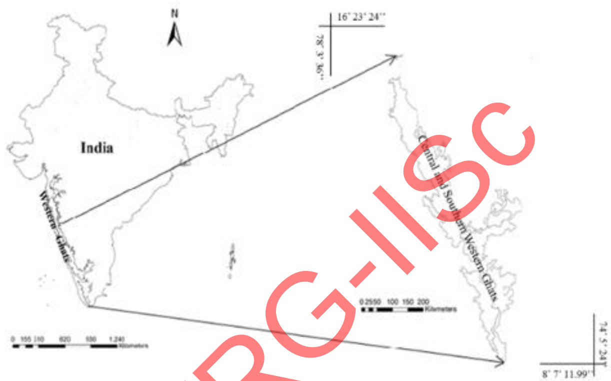

Figure 1: Central and southern Western Ghats - the study area

METHOD

The monitoring of land cover change requires medium spatial resolution imagery with a high temporal frequency for which Landsat data constitutes the longest record (Sexton et al., 2013). The remote sensing data used in this study are Landsat 5 TM and Landsat 8 for the year 1991 and 2014, respectively. The Landsat data was downloaded from the US Geological Survey with zero or minimal cloud cover (http://glcf.umiacs.umd.edu/data). A total of 13 scenes covered the study area of which 3 scenes fall into UTM Zone 44 North rest others fall into UTM Zone 43 North.

The image preprocessing was done which includes geometric correction using Google Earth as the reference. The Histogram equalization, an image enhancement technique, was carried out after geometric correction. The satellite data was then cropped pertaining to the study area acquired through French Institute of Pondicherry database.

For Land Cover mapping, NDVI is the most widely accepted and applied vegetation index (Weismiller et al., 1977; Nelson, 1983). NDVI refers to Normalized Differential Vegetation Index and is calculated as (1)

$$NDVI = \left({NIR(\lambda) - RED(\lambda)} \Big/ {NIR(\lambda) - RED(\lambda)]} \right) \quad \ldots\ldots\ldots..1$$

The value of NDVI ranges from -1 to +1, with values towards -1 indicating soil, barren areas of rock, sand or urban built up, values near zero as water and values of NDVI towards +1 represents healthy vegetation. The Land Use analysis (Ramachandra et al., 2012) involves (i) generation of FCC (False Color Composite) of remote sensing data with Green, Red and NIR bands (ii) selection of training sites which covers at least 15 % of the study area and uniformly distributed over the entire study area. 60 % of the training sites are used for classification of the data set and 40 % of it is used for validation purpose. The training polygons were obtained from false color composite and virtual online software Google Earth (http://www.earth.google.com) for the year 1991 and 2014, respectively. The supervised classification classifier – Gaussian Maximum Likelihood parametric algorithm is used to classify the temporal data which preserves the basic land cover characteristics through statistical classification techniques using a number of well-distributed training pixels. The following classes of land use were examined: forest, agriculture, plantation, urban, water body and others. GRASS (Geographic Resources Analysis Support System) a free and open source software has the capability of manipulating and processing both the vector and the raster datasets, has been used for the analysis, accessible and downloadable at http://wbgis.ces.iisc.ernet.in/grass/index.php.

Accuracy assessment is used to assess the accuracy of classification performed. A set of reference pixels helps in measuring spectral classification inaccuracies. On the basis of test samples, confusion or error matrix, kappa (k) statistic, producers' accuracy and users' accuracy were computed. Kappa is used for determining the statistical significance of any matrix or the differences among matrices according to the magnitude of misclassification. The figure 2 shows the method followed in this study.

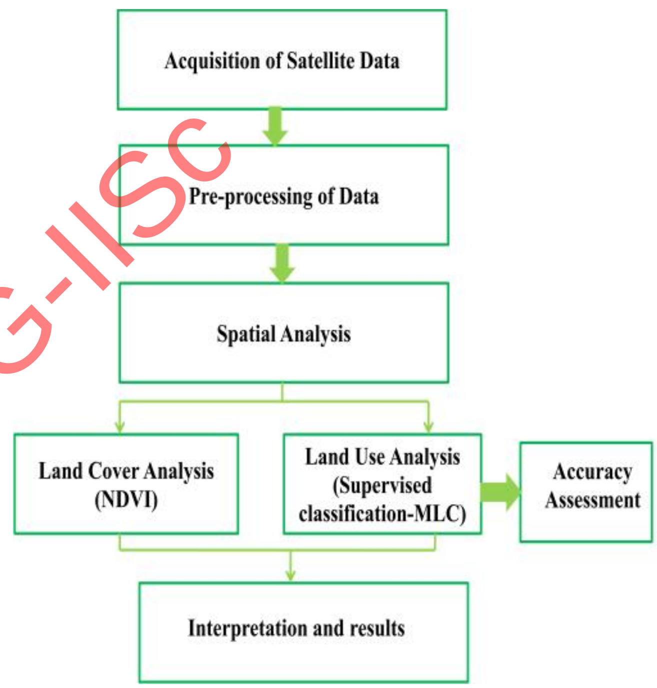

Figure 2: Method followed in the study

RESULTS AND DISCUSSION

Land cover: The NDVI computed for the year 1991 and 2014 is given in figure 3 and listed in table 1. This shows the spatio-temporal changes in the vegetation cover. The non-vegetative part has increased from 30.90 % (1991) to 33.28 % (2014) while the vegetative cover has reduced from 69.10 % (1991) to 66.72 % (2014).

Land Use: The spatio-temporal land use changes from the year 1991 to 2014 are shown in figure 4 and table 2. The agricultural area has increased from 7.30 % (1991) to 10.39 % (2014) and the area under plantation has increased from 11.58 % (1991) to 17.38 % (2014), showcasing the variations in the land use pattern due to human-induced activities and excessive resource utilization. There is an increase in the built up area from 2.36 % (1991) to 4.37 % (2014). The practice of raising plantations of coffee (*Coffea arabica*), tea (*Camellia sinensis*), cardamom (*Elettaria cardamom)*, teak (*Tectona grandis*), acacia (*Acacia auriculiformis*), areca nut (*Areca catechu*), rubber (*Hevea brasiliensis*), etc. have been undergoing in Central and Southern Western Ghats for commercial and economic purposes by clearing high biodiversity areas affecting the habitat of species of flora and fauna. Forest resources such as hard and soft wood, sandalwood, pulpwood, bamboo, etc. have been utilized for raising many industries such as paper mills, matchwood, plywood, tanning industries and for other commercial purposes appending the deforestation activities. The development of railway lines and hydroelectric power projects also add to the degradation of natural resources. The conversion of land for alternative land use patterns is due to the expansion of agricultural and plantation activities accompanied by mining activities as well.

Year	Vegetation %	Km square	Non-Vegetation %	Km square
1991	69.10	47022.20	30.90	21027.29
2014	66.72	45402.62	33.28	22646.87

Table 1: Temporal change in land cover

Year / Category	1991 %	1991 Km square	2014 %	2014 Km square
Forest	43.54	29628.75	40.30	27423.95
Agriculture	7.30	4967.61	10.39	7070.34
Plantation	11.58	7880.13	17.38	11827.00
Urban	2.36	1605.97	4.37	2973.76
Water Body	3.66	2490.61	2.22	1510.70
Others	31.58	21490.03	25.32	17230.13

Table 2: Temporal change in land use

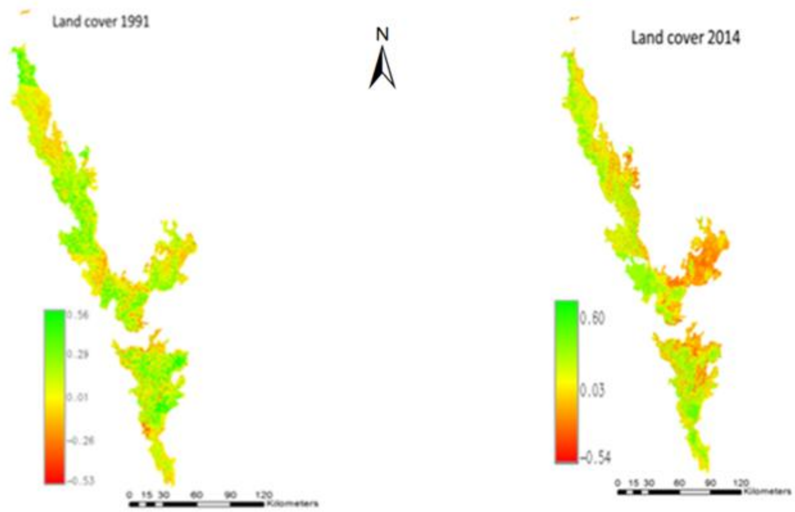

Figure 3: Land Cover of Central and Southern Western Ghats in the year 1991 and 2014

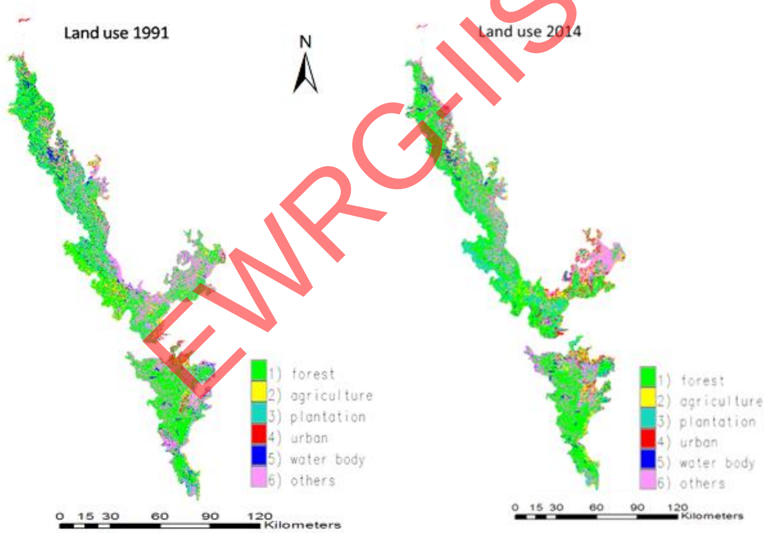

Figure 4 showing the Land Use of Central and Southern Western Ghats in the year 1991 and 2014

CONCLUSION

Changes in land cover show the decrease in vegetative cover which is the main causal factor for climate change. The demand for land and natural resources is rising exponentially with the enhancing demographic pressure. Anthropogenic activities in the vicinity of the global biodiversity hotspot, Western Ghats, pose a serious threat to the habitat of diverse flora and fauna. Land use analysis was done using supervised classification approach through Gaussian Maximum Likelihood classifier. Overall accuracy of the classification ranges from 82 % to 89% and kappa value ranges from 0.79 to 0.87. There has been 2.38 % growth in built up area during last two decades. The analysis shows that there is an increase in agricultural activities from 7.30 % (1991) to 10.39

% (2014) and plantation practices from 11.58 % (1991) to 17.38 % (2014). The transformation of the diverse natural ecosystem to agriculture and plantation has led to the forest loss, fragmentation and degradation of the habitats available for most species which is the major threat to biodiversity. There is a need for comprehensive assessment at the landscape level for sustainable land use planning activities.

REFERENCES

1. Barlow, J., Mestre, L.A. M., Gardner, T. A., Peres, C. A., 2007. Value of primary, secondary and plantation forests for Amazonian J. birds, Biological Conservation, vol. 136, 212–231.
2. Baulies, X., Szejwach, G., 1998. LUCC Data Requirements Workshop, Report Series No.3, Institute Cartographic ds Catalunya, Spain, 141.
3. Campbell, J. B., 2002. Introduction to Remote Sensing (3rd Edn). Taylor & Francis, London, UK, 605.
4. Forman, R.T. T., Godron,M.,1986. Landscape Ecology, John Wiley and sons.
5. Lillesand, T. M., Kiefer, R. W., 2002. Remote Sensing and Image Interpretation, 4th ed. John Wiley and Sons, 215–216.
6. Ramachandra T.V. and Shruthi, B. V., 2007. Spatial mapping of renewable energy potential, Renewable and Sustainable Energy Reviews, vol. 11(7), 1460-1480.
7. Ramachandra T.V., 2008. Regional land cover mapping using remote sensing data, Journal of Agricultural, food and environmental sciences, vol. 2(1), 1-15.
8. Ramachandra T.V. and Bharath H. Aithal, 2012. Land Use Dynamics at Padubidri, Udupi District with the Implementation of Large Scale Thermal Power Project, International Journal of Earth Sciences and engineering, vol. 5 (3), 409-417.
9. Ramachandra. T.V., Bharath H. Aithal and Durgappa D. Sanna, 2012. Insights to Urban Dynamics through Landscape Spatial Pattern Analysis., *International Journal of Applied Earth Observation and Geoinformation*, Vol. 18, Pp. 329-343.
10. Saunders, D.A., Hobbs, R.J., Margules, C. R., 1991. Biological consequences of ecosystem fragmentation: a review, Conservation Biology, vol. 5, 18–32.
11. Sua, W., Gub, C., Yanga, G., Chena, S., Zhenc, F., 2010. Measuring the impact of urban sprawl on natural landscape pattern of the Western Taihu Lake watershed, China, Landscape and Urban Planning, vol. 95, 61–67.
12. Setturu, B. and Ramachandra T.V., 2012. Landscape dynamics of Uttara Kannada district. National Conference on Conservation and Management of Wetland Ecosystems.
13. Kumar, U., Kerle, N., Ramachandra, T. V., 2007. Constrained Linear Spectral Unmixing Technique for Regional Land Cover Mapping Using MODIS Data, International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering, 1- 8.
14. Vanwambeke, S. O., Lambin, E. F., Eichhorn, M. P., Flasse, S. P., Harbach, R. E., Oskam, L., Somboon, P., Van Beers, S., Van Benthem, B.H. B., Walton, C., Butlin, R. K., 2007. Impact of land-use change on dengue and malaria in northern Thailand. Eco-health, vol. 4, 37–51.
15. Wickham, J., Riitters, K., Wade, T., Homer, C., 2008. Temporal change in fragmentation of Continental US forests, Landscape Ecology, vol. 23, 891–898.
16. Zang, S., Huang, X., 2006. An aggregated multivariate regression land-use model and its application to land-use change processes in the Daqing region (northeast China), Ecol. Model, vol. 193, 503–516.