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Urban Sprawl Mapping and Landuse Change Detection in and around Udupi Town: A Remote Sensing based Approach

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ABSTRACT
Major changes in land utilization during 2003-2013 period have been analyzed to understand urban sprawl pattern in and around Udupi town using satellite images. LISS III and PAN images of January 2003 and LISS IV and Cartosat images of January 2013 were utilized for preparing hybrid products. The study is area geographically located between $12^0$45'N to $13^0$45'N latitudes and $74^0$30'E to $75^0$00'E longitudes. The study shows that there is a significant increase in settlements and built-up land during the study period. The settlement and built-up land increased from 16.7 sq.km to 41.9 sq.km showing an increment of 150% compared to 2003. Agricultural land increased by 22% whereas plantation decreased by 8%, forest by 12% and scrub vegetation by 42%. Barren/waste land also showed decrease due to conversion to settlement and built-up area. The notable increase in settlement and built-up land in the study area is attributed to the intensive urbanization and industrial expansion in the recent time.

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Keywords *- Urban Sprawl, RS, GIS, Landuse, Change Detection.*

1. INTRODUCTION

Sprawl is defined as the increased development of land in suburban and rural areas outside of their respective urban centers. Growth along coastal area occurs at the same rate as in other landscapes but over a much smaller area, it creates higher rate of density. Urban sprawl is correlated with increased energy use, pollution, and traffic congestion and a decline in community distinctiveness and cohesiveness. Urban sprawl indicates a transformation of vacant land or natural environment to construction of urban fabrics including residential, industrial and infrastructure development. It mostly happens in the fringe urban areas (Shenghe and Sylvia, 2002). This process can be regarded as the spatial representation of the economic structural shift of labour away from agricultural to industrial based activities. Crucial to this shift are the output gains associated with resource transfers from the low productivity agricultural structure sector to high productivity industrial sector (Chan and Kam, 1994).

The sprawl normally takes place in radial direction around a city centre or in linear direction along highways. Usually sprawl takes place on urban fringe, at the edge of an urban area or along transportation routes. Several studies on urban sprawl are carried out in developed countries (Batty et al., 1991; Torrens and Alberti, 2000) and recently in developing countries such as China (Yeh and Li, 2001) and India (Sudhira et al., 2003). Mapping of urban sprawl helps to clearly identify the areas where environmental and natural resources are threatened and also to suggest the future directions and patterns of sprawling growth. The extent of urbanization or the urban sprawl is one such phenomenon that drives the change in landuse patterns. An attempt is made in the present study to map urban sprawl and quantify landuse changes in and around Udupi town during the period 2003-2013.

Viewing the Earth from the space is now crucial to the understand the influence of man's activities on his natural resources base over time. In situations of rapid and often unrecorded landuse change, observations of earth from space provide comprehensive information on human utilization of landscape. Over the past ten years, data from remote sensing images has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental changes.

2. AREA OF STUDY

The study area is geographically located in 12° 45' - 13° 45' N latitudes and 74° 30' - 75° 00' E longitudes. The study area falls under Udupi district. It is bordered by Western Ghats in the East and Arabian Sea in the West. It has good transportation systems containing port, air, train and road facilities. The area enjoys high precipitation which ranges from 3000-4000 mm per annum. The species diversity is very high as the region falls in the foot of Western Ghats. However, the recent

urbanization and industrial expansion have resulted in significant increase of settlements and population density. This has led to the destruction of natural resources, ground water sacristy, increase of pollution, etc. Udupi town is very famous for financial institutions, industries and hence has brisk economic activity. Udupi is one of the most visiting place in the coastal tract of West Coast of India. Udupi is a popular pilgrimage centre and tourist spot. It is also world famous for its world class cuisine.

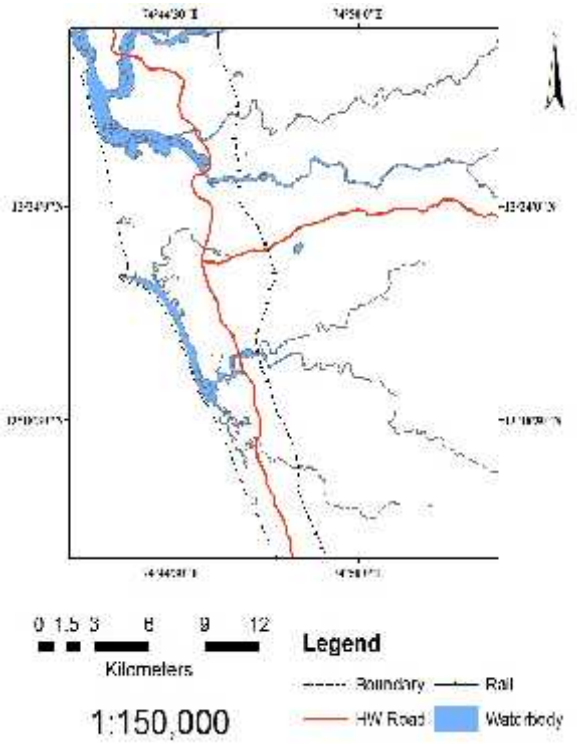

Fig. 1: Base map of the study area

3. MATERIALS AND METHODOLOGY

3.1 Image Rectification and Enhancement

Topographic map (1967) of Survey of India (SOI) on 1: 50000 scale map was taken as the base map. All the satellite images were geo-corrected using UTM projection and WGS 84 datum and co-registered with the Topographic map using Ground Control Points (GCP). Image enhancement is a method widely used to provide effective display for image interpretation (Cetin, 2009). Therefore; in this study, multispectral images were enhanced with panchromatic images using Resolution Merging Technique available in Erdas Imagine software. In the study area, spectral properties of beaches, barren lands, settlements and built-up areas are similar. For that reason, visual interpretation using the enhanced images, auxiliary data and intensive ground verification was carried out for deriving training sets for classification features.

3.2 Image Classification and Accuracy Estimation

It is known that classification accuracy is largely dependent on the number of classes in addition to other factors like classification algorithm, training sets, spectral quality of the images, etc. Therefore, landuse and landcover categories in 2003 and 2013 were carefully examined and based on visual interpretation and ground truth verification, it was decided that seven feature classes would be optimum for the purpose of this study. These categories are settlement and built-up land; crop land; fallow land; plantation; scrub vegetation; forest; and beach, barren land and others

The satellite images were classified using density slicing and maximum likelihood algorithms. LISS III and LISS IV data were classified separately using density slicing technique since PAN and Cartosat are single band images. The density slice algorithm classifies pixel values of the single band image according to a threshold value at which the best discrimination is obtained. Several threshold values were evaluated and finally the one with the best visual separation of among the class was applied to classify single band images.

Accuracy assessment is a very important indicator to draw an idea about the quality and reliability of results and the uncertainty information derived from remotely sensed data (Congalton and Green, 1999). In the landuse monitoring studies using the post-classification comparison method, it is necessarily to pay attention to the classification accuracy of different classes since the classification error will affect the standard of 85% accuracy which is an acceptable level for digital image classification Congalton (1991). Further it is suggested that a minimum of 50 samples for each landcover class in the error matrix would be an acceptable guide to assess the classification results. In the present study, accuracy assessment of the classified output was carried out using 100 pixels per group from fused images and corresponding field data. The location of the control points was chosen using random stratified method to represent different feature classes of the area. The overall classification accuracy found for 2003 classified output is 91% and for the same of 2013, it is 94%.

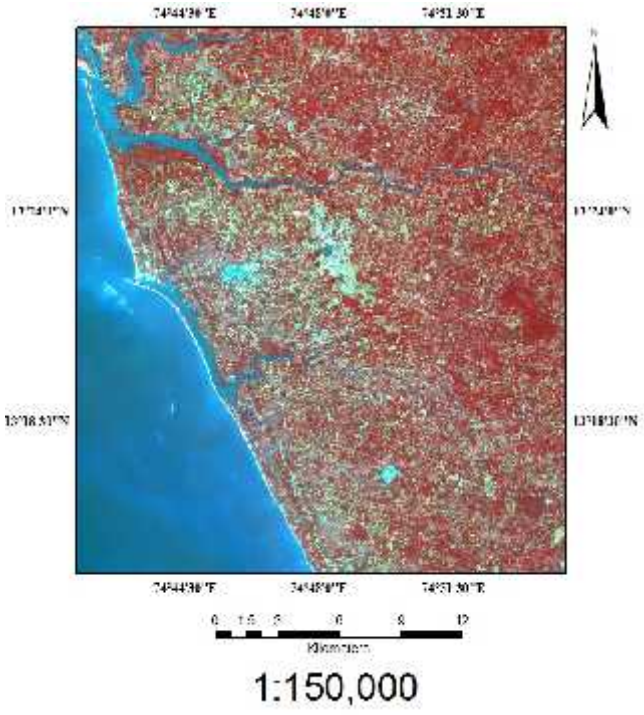

Fig. 2: LISS III and PAN Hybrid Product

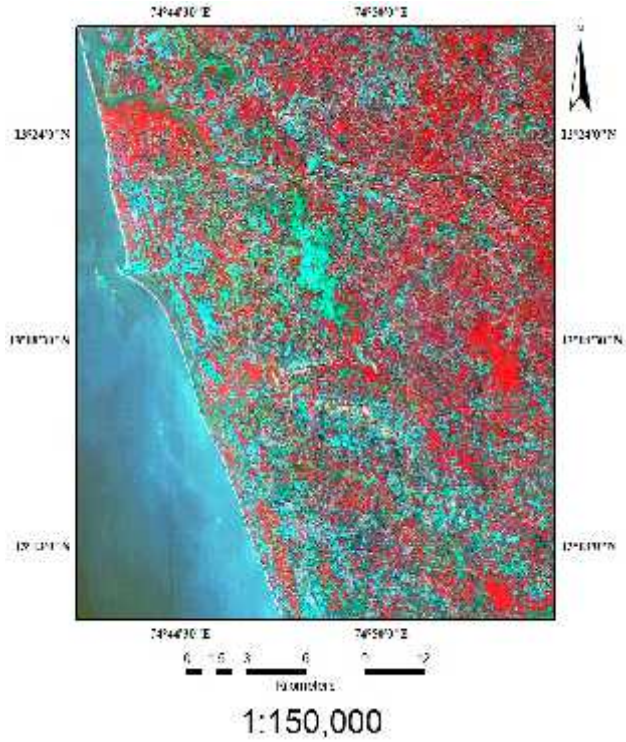

Fig. 3: LISS IV and Cartosat Hybrid Product

4. RESULTS AND DISCUSSION

The landuse/lancover maps for the periods 2003 and 2013 have been prepared and the major changes have been quantified. The results are presented below.

4.1 Settlement and Built-up Land:

Settlement and built-up land increased from 16.7 sq.km to 41.9 sq.km with a percentage increase of 150.4%. urban sprawl is mainly noticed towards the hinterland in north, north-east and eastern directions. Notable increase of settlements and built-up land is observed in heart of Udupi & Manipal townships. It shows linear growth along the land-ward bank of the Udyavara river and either side of major roads.

4.2 Agricultural Land:

Agricultural land includes both crop and fallow lands. It increased from 41.45 sq.km to 63.931 sq.km during the study period.

4.3 Plantation:

Plantations decreased marginally by 2.9 sq.km. Especially cashew nut plantations have been converted into settlements during the study period.

4.4 Scrub Vegetation:

A severe decline in scrub forest is noticed in the study area. Most of the scrub vegetation land in the urban-rural fringe noticed in 2003 period map are now falling in settlement and built-up land category. In some parts agricultural practices are being taken up in these areas.

4.5 Forest Land:

Forest class includes both deciduous and evergreen categories. They show bright red color on the FCC and dark tone on the black and white image. Forest in the study are decreased by 12%.

4.6 Sandy Beach, Waste Land and Others:

Waste/barren lands in the study area decreased notably during the study period, owing to the expansion in small and medium scale industries. Encroachment of beaches in northern region of Udyavara estuary is noticed. Illegal sand mining and constructions are observed in these regions.

Udupi district was created in 1997 by bifurcating three Taluks namely Udupi, Kundapura and Karkala from undivided parent district Dakshina Kannada and making Udupi as the capital city. In 1998, some parts of the Udupi taluk were declared under Special Economic Zone (SEZ). These things have lead to intensive urban growth and infrastructure development, thereby resulting migration of people from surrounding rural areas to the city centre. The fertile coastal land, availability of good natural and marine resources and enhanced job opportunities also acted as pull factors for increased migration. The population of Udupi town as per 1991 census was

117674 which increased 127124 in 2001. But a drastic increase was recorded in 2011 with population reaching 165401. The migration of people from surrounding rural areas and other parts is evident from the above figures. The increase of population, increase of residential and industrial areas resulted in the scarcity of land in townships making the sprawl towards fringe and backward rural regions.

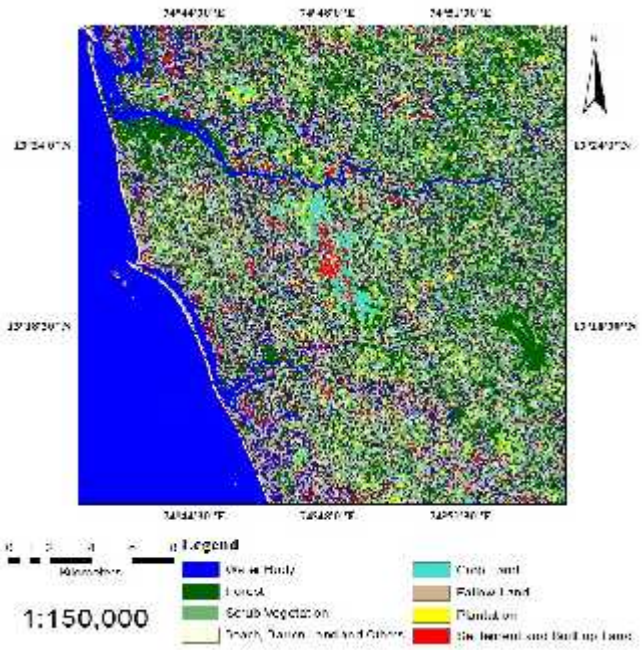

Fig. 4: Landuse/landcover map for year 2003 (with special reference to urban sprawl)

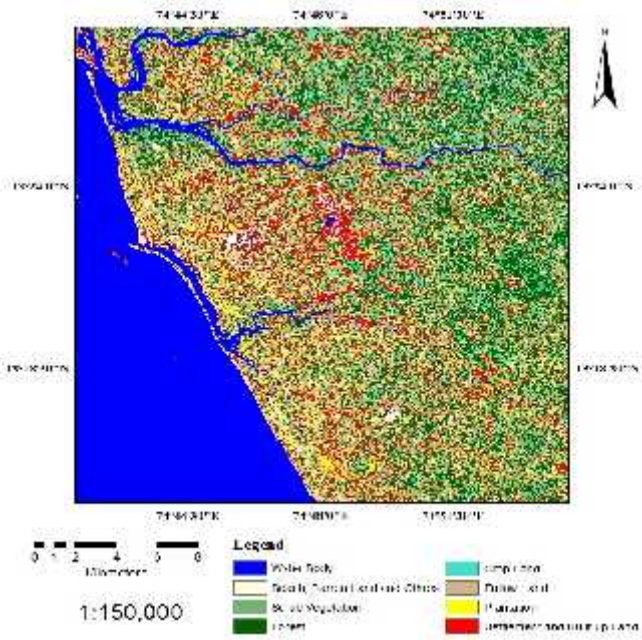

Fig. 5: Landuse/landcover map for year 2013 (with special reference to urban sprawl)

Table 1: Landuse/landcover changes between 2003 and 2013

Landuse/Landcover classification	Area (sq.km)		changes in (sq.km)	Changes in %
	2003	2013		
Settlement and Built-up Land	17.726	41.895	+25.169	+150.478
Crop Land	19.833	28.167	+8.334	+42.02
Fallow Land	21.617	35.674	+14.147	+65.443
Plantation	35.389	32.518	-2.871	-8.112
Scrub Vegetation	55.349	32.3	-23.049	-41.643
Forest	50.779	44.503	-6.276	-12.359
Beach, Barren Land and Others	27.323	19.603	-7.72	-28.254

- reduction, + increment

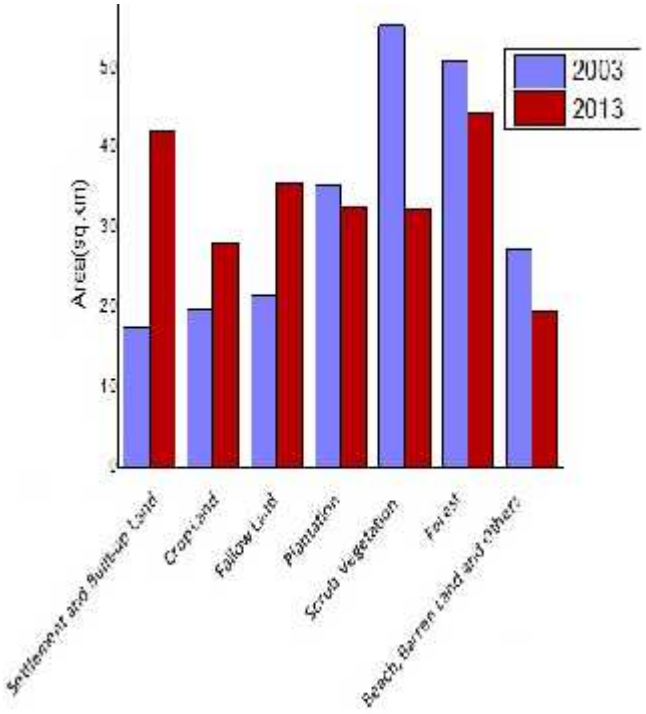

Fig. 6: Graphical representation of landuse/landcover changes

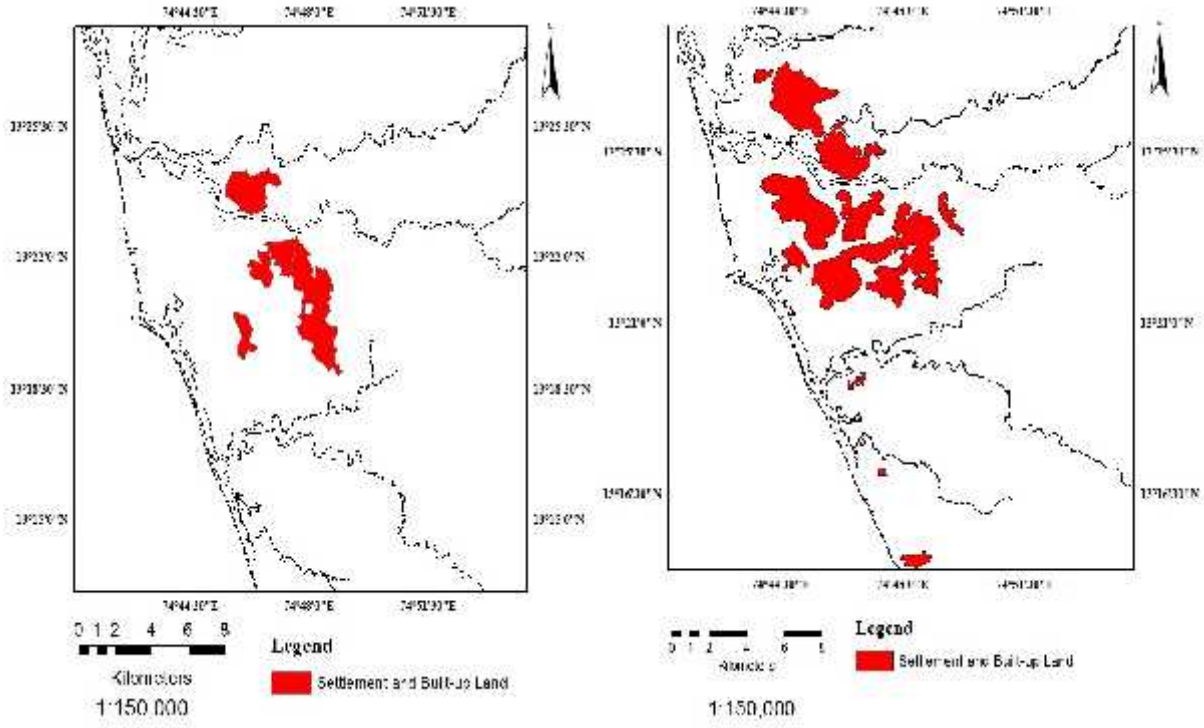

Fig. 7: Major changes in settlement and built-up land between 2003 and 2013

Plate 1. Infrastructure development work noticed in urban-rural fringe of the study area

5. CONCLUSION

The study clearly demonstrates the use of remote sensing to analyze the urban sprawl and detection of changes in urban landuse over a period of time. Satellite hybrid products are found to be very useful in mapping and quantifying the extent of urban area in different time periods. Urban growth is mainly found in the north, north-east and eastern parts of the study area. Apart from these, increase of settlements also noticed along the land-ward side of Udyavara river bank and along main transportation routes of the town. A direct relation between increase in settlements and population expansion is observed in the study area.

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