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Monitoring Urban Land-Cover Features using Resourcesat LISS-III Data

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Abstract In urban environment especially in the trans-urban regions the changes in land-cover features are quite frequent and substantial. With availability of medium resolution satellite-data reliable and timely information on changes in land-cover features in the peripheral areas of the urban settlement could be generated. In a case study presented here, we have analyzed the land-cover changes in the trans-urban area of Hyderabad metropolitan city using bi-temporal Resourcesat -1 and-2 Linear Imaging self-scanning Sensor (LISS-III) data for the period 2005 and 2011. Radiometric normalization using dark object subtraction (DOS) method followed by co-registration of geo-referenced datasets was carried out. Subsequently, image analysis for deriving land-cover features was carried out using Gaussian Maximum likelihood classifier (MLC). The results show that because of urbanization the most notable changes in spatial extent have occurred in the scrubs areas followed by cropland. The article describes in detail the changes that have taken place in the land cover features.
Keywords *Land-Cover Features; Trans-Urban; Multi Temporal; Multispectral; Resourcesat; LISS-III; MLC*

1. Introduction

Management and planning of urban areas requires current and accurate information about land use both on its spatial extent and distribution as well as on temporal behaviour. By virtue of high temporal frequency, digital format suitable for computation, synoptic view, and wider selection of spatial and spectral resolutions, the spaceborne multispectral data have been used very often for studying temporal behavior land-use/land-cover features including urban built-up features l (Chen, et al., 2012; Coops, et al., 2006; Lunetta, et al., 2004). Several procedures including comparison of land cover classifications, multi-data classification, image differencing/ratioing, vegetation index differencing, principal component analysis and change vector analysis have been employed for land-use and land-cover change detection (Singh, 1989). Furthermore, Bontemps et al. (2008) proposed a method for change detection based on a per-object approach and on a probabilistic procedure using SPOT-VEGETATION time series data. We report here a study, which was taken up (i) to derive information on spatial distribution of urban built-up land in part of Hyderabad metropolitan city, Telangana state, southern India using Resourcesat-1 and -2 LISS-III data.

2. Study Area

Hyderabad metropolitan city has a star shaped layout and seems to grow along the main transportation arteries Figure 1. The growth towards the north-west, north, and north-east is along the highway that connects the city to Mumbai, Delhi, and various districts headquarters, respectively coinciding with the directions having major industrial development. According to 2001 census, Hyderabad is the fifth largest metropolis of India with a population of 5,434,347. The test site covers part of Hyderabad district of Telangana. Because of industrialization and migration of rural population for livelihood, the city has grown considerably at the expanse of mainly wastelands during the last decade. However, at places pockets of scrubs and cropland have also been cleared for urbanization.

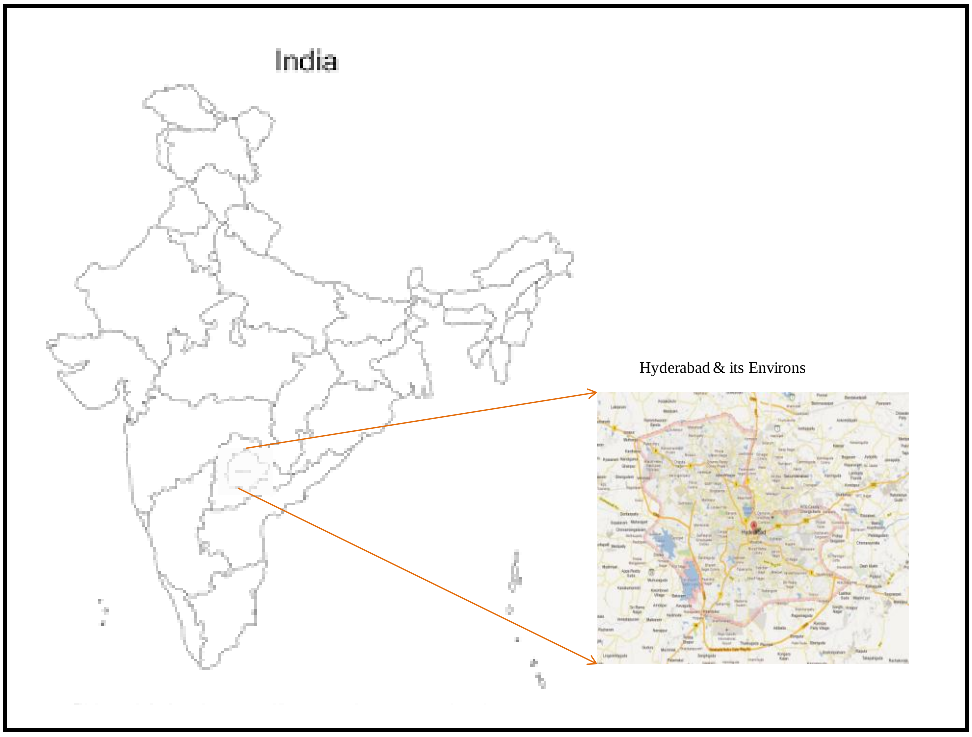

Figure 1: *Location Map of the Study Area*

3. Database

The bi-temporal Resourcesat-1 and 2 Linear Imaging Self-scanning (LISS-III) digital data covering the test site along with Survey of India topographic maps and published reports/maps were to derive information on urban land-cover features.

3.1. Remote Sensing Data

Resourcesat-1 LISS-III data with path row no. 99-60 and acquired on October 06, 2005 and October 23, 2011 covering the test site were used to derive information on urban land-cover features. Resourcesat-1 is the tenth satellite of the Indian Space Research Organization (ISRO) in the Indian remote sensing satellite (IRS) series, intended not only to maintain the continuity of providing remote sensing data services from IRS-1C and IRS-1D, both of which have far outlived their designed mission lives, but also to vastly enhance the data quality. Resourcesat-1 is the most advanced remote sensing satellite built by ISRO as of 2003. There has been improvement in the radiometry of LISS-III (from 7 bit to 10 bit) and Advanced Wide Field Sensor (AWiFS) (from 10 to 12 bits).

Table 1: *Salient Characteristics of LISS-III Sensor*

Band	**2 (Green)**	**3 (Red)**	**4 (NIR)**	**5 (SWIR)**
Spectral band(µm)	0.52—0.59	0.62—0.68	0.77—0.86	1.55 – 1.70
Pixel Size (m)	23	23	23	70
Quantization (bits)	10 bits (7 bits transmitted with DPCM)			
Swath (km)	127—141			

3.2. Ancillary Data

Survey of India topographic sheet on 1:250,000 and 1:50,000 scale covering the study area and other published reports from authorized sources were utilized. In addition, Google earth images and a mosaic of Resourcesat-1 LISS-IV data of 2009 was also utilized for map finalization.

4. Methodology

The approach involves the systematic visual interpretation of spaceborne multispectral digital data. The details are given below.

4.1. Preparation of Database

To begin with, Resourcesat-1 multispectral LISS-III digital data for the period October 6, 2005 covering the study area was geo-referenced to the Survey of India (SOI) digital topographical map at 1:50,000 scale using image-to- map tie-down approach available in the ERDAS/IMAGINE version 9.2. For studying the temporal behavior of land-cover pattern of the area Resourcesat-2 LISS-III digital data of October 23’ 2011 period were digitally co-registered to Resourcesat-1 LISS-III digital for 2005 using image-to-image tie down algorithm available in the ERDAS/IMAGINE version 9.2 with sub-pixel accuracy. Most of the change detection studies generally require a sub-pixel level geometrical registration accuracy is generally required by (Jianyaa et al., 2008). The output, thus generated, was resampled to 24m pixel dimension using second order polynomial transform and the nearest neighbour sampling approach. The geo-referenced satellite data for two periods, namely 2005-06 and 2011-2012 were used for delineation various land-cover categories.

In order to maintain the radiometric consistency of temporal remote sensing images radiometric corrections are carried out to account for errors caused by the variation in sensor characteristics, atmospheric condition, solar angle, and sensor view angle (Chen et al., 2005). Different radiometric correction methods are developed. The absolute radiometric correction (ARC) extracts the absolute reflectance of scene targets at the surface of the earth. The relative radiometric correction /normalization (RRC) reduces atmospheric and other unexpected variation among multiple images by adjusting the radiometric properties of target images to match a base image (Janzen et al., 2006; Yuan and Elvidge, 1996). The RRC include methods such as dark object subtraction (Chavez, 1988), Pseudo Invariant Features (PIF) (Chen, et al., 2005), automatic scattergram controlled regression (ASCR) (Elvidge, et al.,1995), Ridge method (Song, et al., 2001), and second simulation of the satellite signal in the solar spectrum (6S) (Vermote, et al.,1997). We used dark object subtraction (DOS) method for radiometric normalization of bi-temporal LISS-III data.

4.2. Preliminary Visual Interpretation

Based on our experience, ancillary data and terrain conditions, various land use/ land cover categories were broadly delineated on standard false colour composite (FCC) prints of Resourcesat-2 LISS-III digital data for 2011. Period generated from green, red and nearer spectral bands. Subsequently, the sample areas to be verified in the field were identified and precisely located on the Survey of India topographical maps at 1:50,000 scale.

4.3. Ground Truth Collection

A reconnaissance visit of the study area was made to have an overview of the area and to locate the sample areas identified on the satellite images during preliminary visual interpretation. After locating the parcels of land requiring field verification, existing land use/land cover was noted after recording their precise location in terms of latitude and longitude using GPS (model e-trix Garmin).

4.4. Map Finalization

The ultimate delineation of various land-cover categories from spaceborne multispectral data was accomplished on a Silicon Graphics (Octane) - based image analysis system using ERDAS IMAGINE software version 9.2 following on-screen visual interpretation approaches. To begin with, the Resourcesat-2 LISS-III digital for 2011 was displayed onto colour monitor of the Silicon Graphics (Octane) - based system and a blank vector layer was overlaid onto the image. Various land-cover categories delineated during preliminary visual interpretation were then located in the image and the boundaries were modified vis a vis ground truth. Various land-cover categories, thus delineated, were used as a reference for mapping land-cover pattern from LISS-III data of 2005.

4.5. Map Compilation and Area Estimation

As mentioned earlier, various land-cover categories were delineated on the colour monitor of the Silicon Graphics Octane system using ERDAS IMAGINE 9.2 software, and the vector coverage was generated and its topology built. Later corrections were carried out wherever necessary. The maps, thus generated, were composed and the areal extent of various land-cover categories was computed.

5. Results and Discussion

Land transformation is one of the most important fields of human-induced environmental transformation, with an extensive history dating back to antiquity. Of late the process has further accentuated in the wake rapid urbanization. Urban agglomeration is the most prominent landscape on the earth surface influenced by human activities. With the synoptic spectral measurements made by platforms at regular intervals not only the macroscopic change in land–cover pattern caused by urbanization could not only be recorded objectively, but also its location and temporal behavior could also be studied.

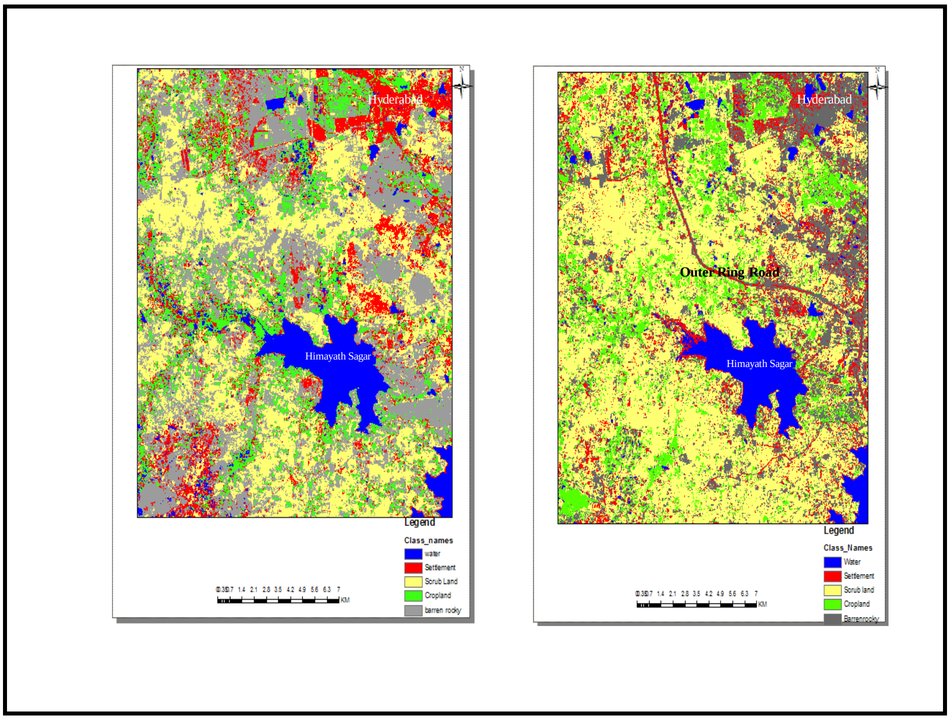

Figure 2: *Temporal Behavior of Urban Land- Cover Features (a) 2005 (b) 2011*

Hyderabad city has not been an exception to the above mentioned process. Since there has been no impediment (Major River or sea coast) for expansion of the city along with its periphery, there has been boom in the expansion of the city in almost all directions. The expansion has been most remarkable along the highways and the areas with potential for industrial and institutional growth. The land- cover map of the part of the Hyderabad city and its suburb for 2005 is portrayed as Figure 2(a). Apart from urban built-up features the other land use land-cover categories namely cropland, scrubs, barren / rocky and water bodies have also been delineated. As evident from the Figure 2(a), a fairly large area has been transformed into settlement in the year 2005. The major growth has been experienced

After a gap of 6 years, we have studied the growth of the city the year 2011. A look at the land -cover map of the city for 2011. Figure 2(b) reveals that there has been a significant increase in the spatial extent of settlements to the tune of 1463ha with concomitant shrinkage in other land use land cover categories especially scrubs and cropland. The area under settlement has increased from 2920 ha in the year 2005 to 4383 ha in 2011. However, a substantial area under scrubs and cropland has experienced remarkable shrinkage. Furthermore, it is a noteworthy fact that the major urbanization has taken place in scrubs followed by cropland. As a result the area under scrubs which was 16809 ha in 2005 has drastically shrunken to 10473 ha. However, the decrease in the spatial extent of cropland has been only marginal. The area under the scrubs has drastically reduced from 4571 ha to 1570 ha during the 6-year period.

6. Conclusion

A highly dynamic phenomenon like urbanization needs frequent monitoring for its proper planning and sustainable development. It is not only a spatial extent of the urban area but also spatial distribution of various land-cover features which is very important for developing urban and master plan. Through this case study we demonstrate the potential of spaceborne multispectral data in regular monitoring of the urban expansion/sprawl pattern for necessary mid-course correction in the planning process so as to address the facilities/ utilities required for growing urban population.

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