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URBAN CHANGE DETECTION BASED ON REMOTE SENSING AND GIS STUDY OF SALEM REVENUE DIVISION, SALEM DISTRICT, TAMIL NADU, INDIA.

Shanmugam TAMILENTHI
Tamil University, Department of Earth science, Thanjavur - 613010, India
http://www.tamiluniversity.ac.in/, rst_geo2011@yahoo.com

Rajagopalan BASKARAN
Tamil University, Department of Earth science, Thanjavur - 613010, India
http://www.tamiluniversity.ac.in/, rst_geo2011@yahoo.com

Abstract

Rapid urbanization has significant impact on resources and urban environment. With increased availability and improved quality of multi-spatial and multi-temporal remote sensing data, it is now possible to detect urban changes in a timely and cost-effective way. This study aims to quantify changes in urban area of Salem revenue division, Tamil nadu located in India, using Land sat and IRS-LISS-III image. Urban changes were detected by satellite images of Land sat MSS in 1973, Land sat and IRS-LIS-III in 2010 using a geographic information system (GIS). The settlement area has grown 2.07 times during the past 37 years as a result of industrial development, population growth and permanent migration was the main driving forces for settlement area expansion. According to the results, the extent of urban areas 69.899sqkm and 144.97sqkm in the years 1973 and 2010 respectively.

Keywords: *Settlement, Salem revenue division, Remote sensing, Change detection, and GIS*

1. INTRODUCTION

Land use is influenced by economic, cultural, political, and historical and land – tenure factors at multiple scales. Land use referred to as man's activities and the various uses which are carried on land. Urbanization is inevitable, when pressure on land is high, agriculture incomes are low and population increases are excessive, as is the case in most of the developing countries of the world. In a way urbanization is desirable for human development. However, uncontrolled urbanization has been responsible for many of the problems, our cities experiences today, resulting in substandard living environment, acute problems of drinking water, noise and air pollution, disposal of waste, traffic congestion etc. To improve these environmental degradations in and around the cities, the technological development in relevant fields have to solved these problems caused by rapid urbanization, only then the fruits of development will reach most of the deprived ones.

Recent technological advances made in domain of spatial technology, cause considerable impact on planning activities. This domain of planning is of prime importance for a country like India with varied geographic patterns, cultural activities etc. The purpose of using GIS is that, maps provide an added dimension to data analysis, which brings us one step closer to visualizing the complex patterns and relationships that characterize real-world planning and policy problems. Visualization of spatial patterns also supports change analysis, which is important in monitoring of social indicators. This in turn should result in improving need assessment.

According to Macleod and Congalton (1998), in general, remote sensing considers following four aspects of change detection (a) detect the changes, (b) identify the nature of change, (c) measure the aerial extent of change and (d) assess the spatial pattern of change.

The objectives of this paper are to explain remote sensing and GIS applications in various stages of planning, implementation and monitoring of the urban area.

1.1. Overview of Detect Changes in Urban

A variety of change detection techniques are available for monitoring land use/land cover changes. These techniques can be grouped into two main categories: post classification comparison techniques and enhancement change detection techniques (Nelson, 1998).

(a). Post classification techniques

The post classification technique involves the independent production and subsequent comparison of spectral classifications for the same area at two different time periods (Mas, 1999). Post classification techniques have the advantage of providing direct information on the nature of land cover changes. The classification process used with these techniques can be either supervised or unsupervised.

Sohl (1999) reported accuracies of 96 percent for the identification of new forest land and 62 percent for new agricultural land using a post classification technique in a semi-arid environment. Furthermore, Sohl (1999) noted the strength of the method for providing users with a complete descriptive comparison between images. Pilon et al. (1988) employed post classification in combination with a simple enhancement technique to differentiate areas of human induced change from areas of natural change. Mas (1999) also obtained the highest accuracy with this technique in a study comparing six different techniques.

(b).Enhancement change detection techniques

Enhancement techniques involve the mathematical combination of images from different dates which, when displayed as a composite image, show changes in distinctive colors (Pilon et al. 1988). The enhancement change detection techniques have the advantage of generally being more accurate in identifying areas of spectral change (Singh, 1989). However, these techniques often require additional analysis to characterize the nature of the spectral change, and also require more accurate image normalization and co-registration.

<u>(i). Image differencing</u>

Image differencing is a technique by which registered images acquired at different times have pixel DN values for one band subtracted from the corresponding pixel DN values from the same band in the second image to produce a residual image, which represents the change between the two dates (Mas, 1999).

Ridd and Liu (1998) reported image differencing was fairly effective in its ability to detect change in an urban environment, with TM band 3 producing the highest accuracies. Sunar (1998) and Sohl (1999) reported that the image differencing technique was extremely straightforward, but with the qualification that image differencing technique becomes slightly more complicated when using multiple bands, instead of single bands, due to the difficulty of interpreting the colors of multiband false color composites.

(ii) Principal component analysis

Principal component analysis (PCA) is a commonly used statistical method for many aspects of remote sensing image analysis, including estimation of the underlying dimensions of remotely sensed data, data enhancements for geological studies, and land cover change detection (Fung and Le Drew, 1987). The PCA technique for change detection requires the separate images first be stacked in a multi-temporal composite image (Sunar, 1998). The major strength of this technique is its ability to reduce the dimensionality of the data with relatively minor loss of overall information content. The major weakness of this technique is that it can be difficult to interpret.

Li and Yeh (1998) compared principal component analysis to post classification techniques and concluded that principal component analysis was much more accurate than post classification techniques and therefore suggested it as an accurate alternative for detecting land use change.

(iii) Normalized difference vegetation index (NDVI)

The Normalized Difference Vegetation Index (NDVI) estimates the vitality of vegetation by exploiting the known gap in vegetation reflectance between the visible and near infrared channels. Common change detection methods include the comparison of land cover classifications, multi-date classification, band arithmetic, simple rationing, vegetation index differencing and change vector analysis (Jomaa, 2003). The NDVI is calculated as a normalized ratio (ranging from -1 through 1) from the NIR and the red band and emphases apparent vegetation (Sabins, 1996).

2. STUDY AREA

Salem is an interior district of Tamil Nadu in India with an area of 8634.23 Km2 (Fig.1) and is bounded by Dharmapuri district on the North, Coimbatore on the West, South Arcot on the northeast and Tiruchirapalli on the South and South-West. The district lying between latitudes N 11°00' and 12°00 and longitudes E 77°40' and 78°50'. Study area is extracted from the distric map with area covering 1737 sqkms.It is The lying between latitudes N 11°25' and 11°55 and longitudes E 77°48' and 78°32'.

The soils of Salem District can be assorted into the main types viz., Red Calcareous, Red non-calcareous, brown soil calcareous, Red collurial careareous, Red collurial non calcreous, Black soils, Alluvial calcareous, Brown soil non calcareous.

Salem district is underlain entirely by Archaean Crystalline formations with Recent alluvial and Colluvial deposits of limited areal extents along the courses of major rivers and foothills respectively. Weathered and fractured crystalline rocks and the Recent Colluvial deposits constitute the important aquifer systems in the district. Ground water occurs under phreatic conditions and is developed by means of dug wells. They are important from ground water development point of view in the hilly terrain.

The District has a hot tropical climate with temperature ranging from 18.9° C (Minimum) to 37.9° C (Maximum) and the relative humidity is high at 79% with an average ranging from 80% to 90%.

The major source for groundwater in the study area is rainfall during monsoonal season. The average 10 years annual rainfall is about 759.03 mm.

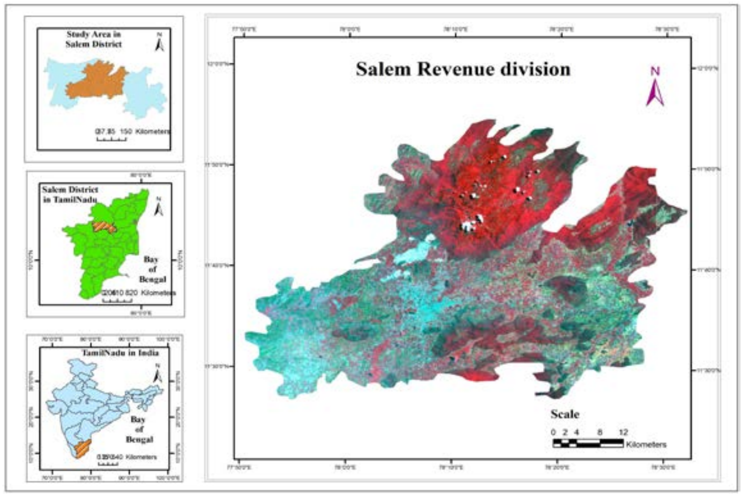

Figure 1. Study area- Salem Revenue Division.

3. MATERIALS AND METHODS

In the present study, for assessing the temporal changes in the Urban/Settlement cover Landsat 1 Panchromatic RBV,MSS- 154/52, 57X57, 1973 from GLCF and IRS LISS III (P6)- 101/65, 23.5 x 23.5, 2010 from NRSC were used. As a time series data, the Survey of India (SOI) toposheet of 1972 was also used. Moreover, the urban planning reports and administrative maps were also taken into account. (Fig.2)

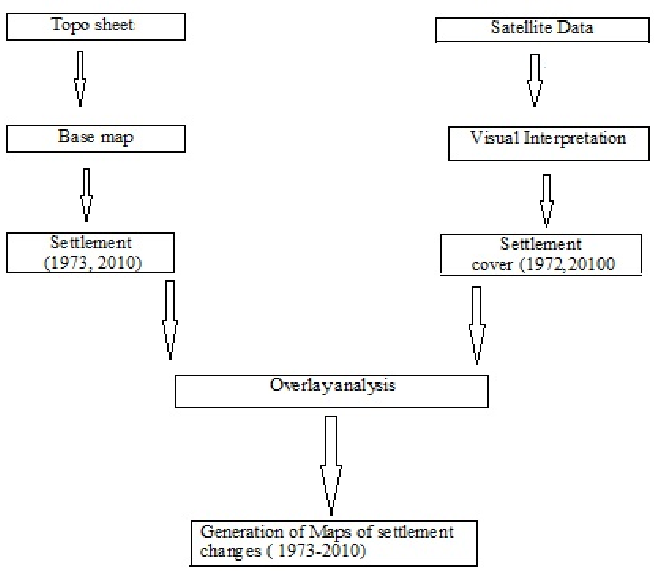

Figure 2. Methodology flow chart

The study area map was prepared from SOI topographical sheets on 1:50,000 scale. The settlement in the study area, during 1973 and 2010 were derived from the Satellite images were compared with one another and were used for carrying out change detection studies for the period 1973 and 2010.

The same classes were then visually interpreted from the 1973 satellite data by using the common image interpretation elements. Necessary field checks were carried out and correction were made at required places. Then, the software such as Arc GIS9.3 and Erdas imagine9.2 were used to prepare the urban/settlement cover changes during 1973-2010.

3.1. Change Detection Methods Adopted in this Study

The change detection techniques will be discussed, using the two main categories, post-classification comparison techniques and enhancement change detection techniques described in the literature section.

4. IMAGE ANALYSIS

The acquired images of 1973 and 2010 are used to prepare the cluster of study area in order to better analysis purpose which clearly shown all categories (fig.3)

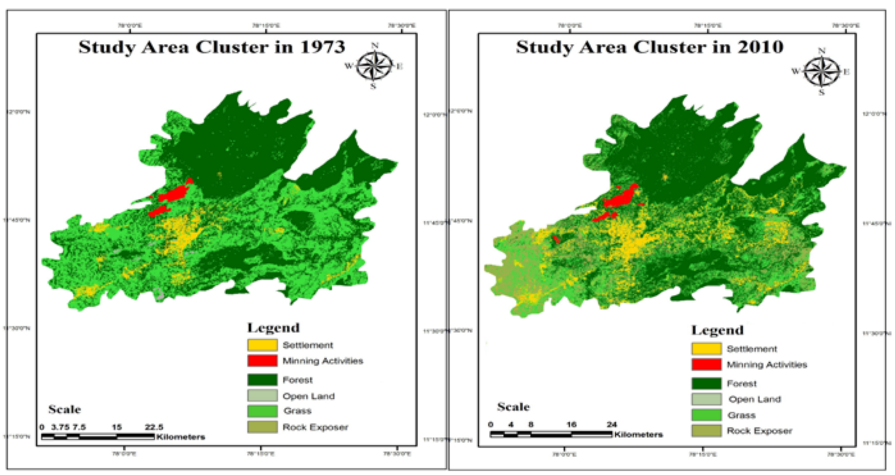

Figure 3. Cluster analysis for 1973 and 2010 data.

4.1. Post Classification Techniques

For the classification-based approach a supervised classification was done on both the 1973s and 2010s images for both test sites. The main advantage of using a supervised classification is that was able to produce the same number of classes for each set of images.

The classifications were then combined using the to produce a map of all class transitions (Erdas Imagine 8.4 Tour Guides, 1999).The transitions were then assigned colors, based on the type of change that was occurring, to produce the final output image.

The maps clearly express the spatial cover of settlements in 1973 and 2010(Fig.4) and it occupied 69.89sqkm in 1973 and 144.97sqkm in 2010.The settlements/urban change area is 75.07 sqkms(Fig.5)

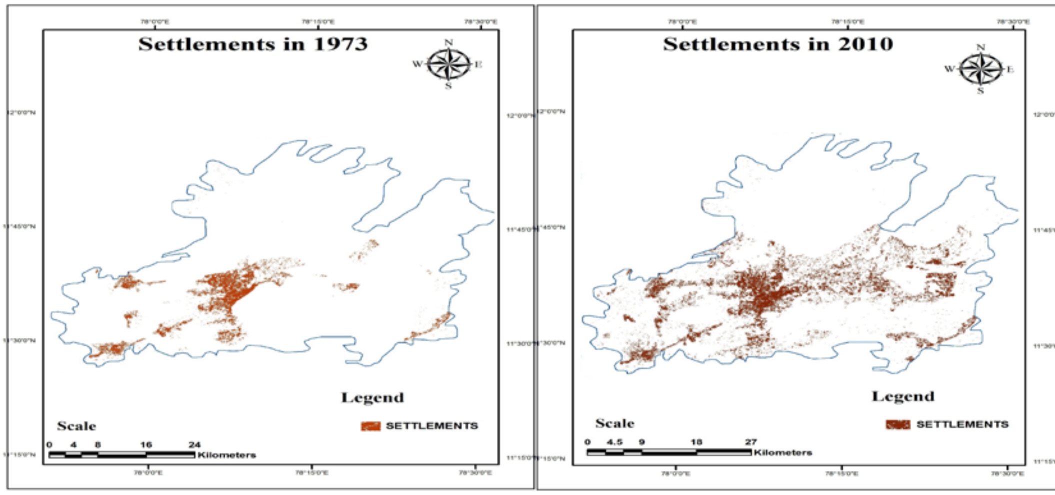

Figure 4. Settlements cover in 1973 and 2010.

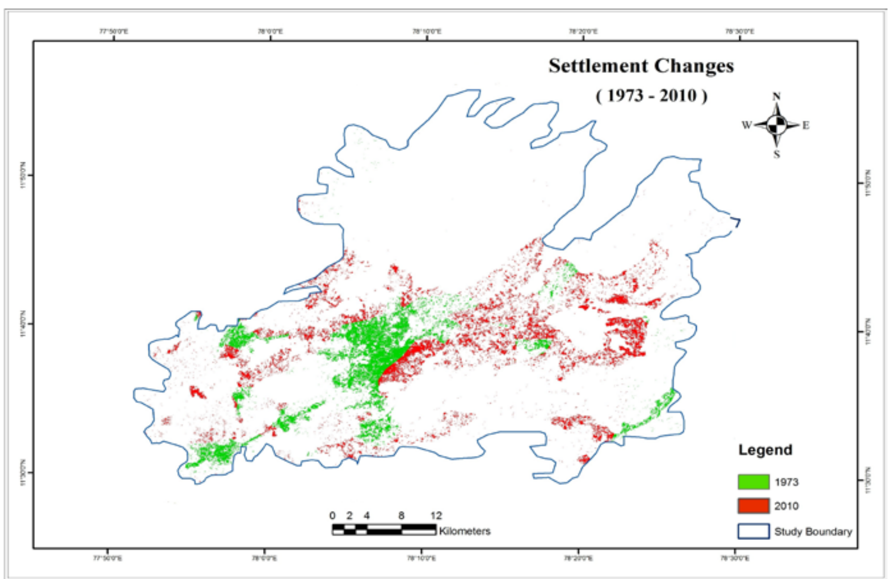

Figure 5. Settlements cover change in 1973 and 2010.

4.2. Enhancement Change Detection Technique

4.2.1. Principal component analysis

PCA was performed using the Imagine Principal Component program in the standardized form (Erdas Imagine 8.4 Tour Guides, 1999). Out of all four bands of each of the 1973s and 2010s images the settlement showing is extracted for both and others were made false colour composite to create the major change classes. Here in the high shows that settlement occupied area with dark red colour(Fig.6)

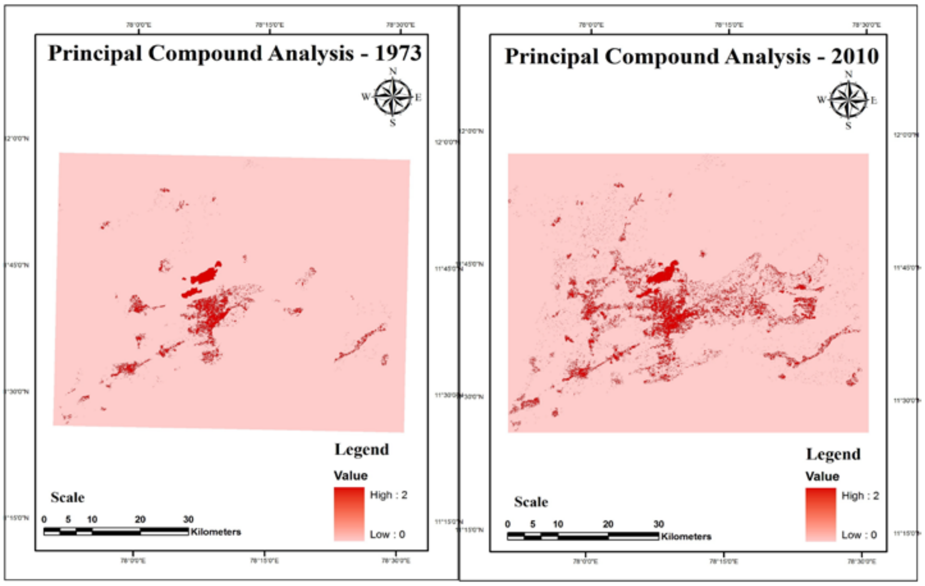

Figure 6. Principal component analysis -1973 and 2010

4.2.2. Normalized difference vegetation index (NDVI)

NDVI is calculated from the visible and near-infrared light reflected by vegetation. Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1);0 means no vegetation NIR=Red +1 (0.8 -0.9) indicates the highest possible density of green leaves. 0 to -1 Indicated higher red reflectance than NIR.

The NDVI analysis reveals that 1)Decrease in NDVI between two scenes will be the result of new development 2)Increase in NDVI between two scenes will be the result of forest re-growth 3)Urban changes in red signal may be unrelated to vegetation(Source: NSAS Earth Observatory)

The two NDVI results shows there is a increase in vegetation due to government policy on aforestation and encourage of social forest besides permanent pasture and tree type of crop commercial cultivation. The settlement area is also increased in the same side by side vegetal cover too along with their residential area (Fig.7).

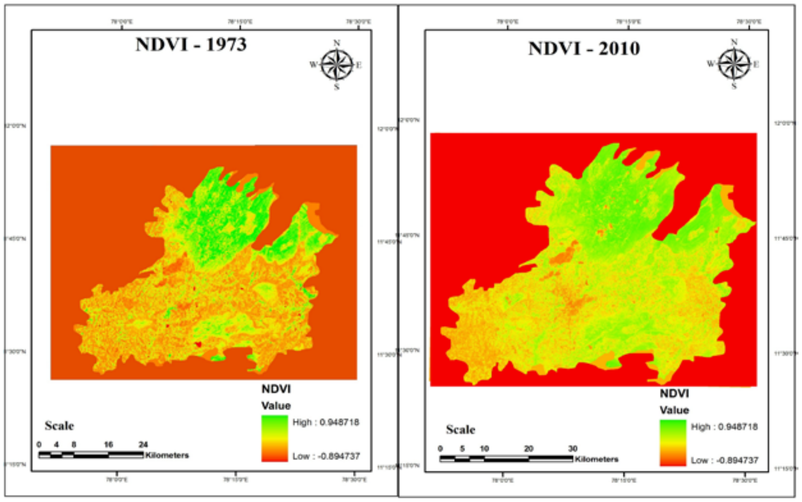

Figure 7. Normalized Difference Vegetation Index

4.3. Change Detection

The analysis reveal the following information and changes also shown in clearly in the table.(Table 1.) This will help the planners and other researchers for further research at micro level and macro level. The changes is mostly cause of human inference which affects the natural ecosystem one or other way. The normal temperature raised significantly compare with last 3 decades this result of urbanization and settlement expansion.

Table 1. Showing spatial changes.

Sl. No	Components	1973	2010	Changes in area(Sqkm)*	Changes in %
1	Settlements	69.89	144.977	+75.07	+207.4
2	Mining activities	17.44	18.96	+1.52	+8.71
3	Forest	611.95	594.92	-17.95	-2.93
4	Rock expose	31.18	29.11	-2.07	-6.63
5	Grass land and others	714.04	604.12	-109.92	-15.39
6	Open land	292.5	344.99	+52.49	+17.94

(*+ is Increase, - is Degrease of area)

5. RESULTS AND DISCUSSION

This section deals with the settlements, urban and human occupancy land covers in the study area over the period of 37 yrs. Settlement and urban cover categories in 1973 and 2010: The spatial cover of 1973 and 2010 is vividly shown in Fig. 3.

In the year 1973, Settlement /urban occupied by 69.89 km^2, which is about 4.02 % of the total study area. Mining occupied 17.44Km^2 with 1%, forest 611.95 km^2 with 35.23%, rock expose is 31.18 Km^2 with 1.79%, Grass and others is 714.04 km2 with 41.1% and Open land is 292.5 km^2 with 16.83%.

In the year 2010, Settlement /urban occupied by 144.977 km^2, which is about 8.34 % of the total study area. Mining occupied 18.96 Km^2 with 1.1%, forest 594.92 km2 with 34.24%, rock expose is 29.11 Km^2 with 1.67 %, Grass and others is 604.12 km^2 with 34.77% and Open land is 344.99 km^2 with 19.86%.

The thirty seven years (1973-2010) of urban and settlement/human interference variations has been precisely analyzed.

The study reveals that the rate of settlement and urban occupancy is more during the period 2010 with doubled the settlement area of 144.977 km^2. The result shows that the population increases and migration taken place. Mining area has increased with 1.52 km2 8.71%. Forest area degreased 17.03 km^2 with 2.93%. Rock expose has decreased 2.07 km^2 with 6.6%. Grass land and others has decreased 109.92km^2 with 15.39% and Open land is 52.49 km^2 with increase of 17.94 %.

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