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Analysis of Urban Sprawl and Land Use Land Cover Change with Remote Sensing and GIS Techniques

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Abstract**:** Urban sprawl refers to the extent of urbanization. Urban sprawl is a worldwide phenomenon which has significant effect on natural resources and urban environment. Urban sprawl is mainly driven by population growth and large scale migration. With increased availability and improved quality of multi-spatial and multi-temporal remote sensing data it is possible to analyse urban sprawl in a timely and cost effective way. This study aims to analyse the urban sprawl and land use land cover change with remote sensing and GIS techniques for Palayamkottai Taluk, Tirunelveli district, Tamilnadu lokcated in India. The changes were analysed from Landsat images of 1992 and 2017. The images for the two periods were downloaded, layer stacked and corrected before main processing work. Erdas Imagine and ArcGIS were used for data processing and analysis. The results were presented in maps, tables and charts.

Keywords— *Urban sprawl; land use land cover change; remote sensing; GIS techniques;*

I. INTRODUCTION

Urban sprawl is basically another word for urbanization. Urban sprawl is the rapid expansion of the geographic extent of cities and towns, often characterized by low-density residential housing and increased reliance on the private automobile for transportation. Urban sprawl is caused in part by the need to accommodate a rising urban population. The process of urbanization brings about significant and long term change in population, social, economic, environmental, ecological and political structure. It normally takes place in radial direction around the city centre or in linear direction along the highway. Very high urbanization in most of developing countries has been discovered as the major causes of land use and land cover (LU/LC) changes. Unfortunately, the conventional survey and mapping techniques are expensive and time consuming for the estimation of urban sprawl and land use land cover change. .As a result, increased research interest is being directed to the monitoring of urban sprawl using GIS and remote sensing techniques. Remote sensing is increasingly used for identifying and analysis of urban sprawl since it is cost effective and technologically efficient. In recent years, these methods have progressed and have been widely used in management of natural resource and urban planning.

II. OVERVIEW OF CHANDE DETECTION TECHNIQUES

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.

2.1. 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. 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.

2.2. 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. The enhancement change detection techniques have the advantage of generally being more accurate in identifying areas of spectral change. 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.

(i*). Image differencing*

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 . 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. The PCA technique for change detection requires the separate images first be stacked in a multi-temporal composite image. 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.

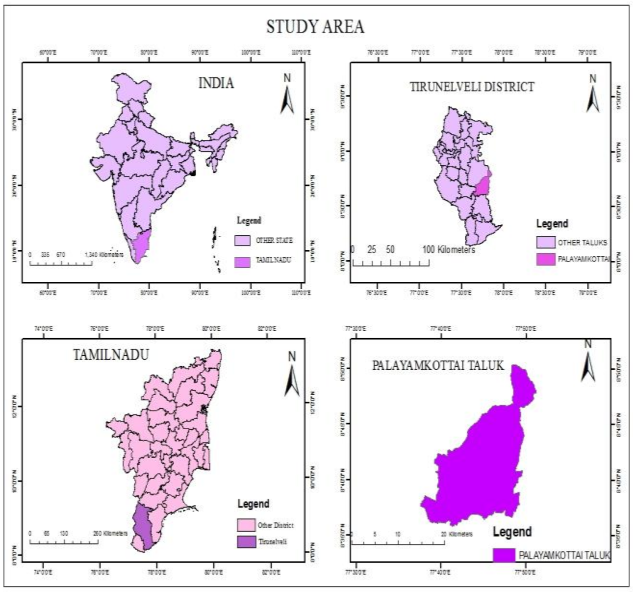
(iii) *Normalized difference vegetation index (NDVI)*

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 . The NDVI is calculated as a normalized ratio (ranging from -1 through 1) from the NIR and the red band and emphases apparent vegetation .

III. STUDY AREA

Palayamkottai is one of the Taluks of Tirunelveli District. Palayamkottai town serves both as an administrative headquarters and as an educational centre since most of the Government offices and educational institutions are located here.

Palayamkottai was one of the oldest Municipalities. It was constituted on November 1866 as 3rd grade Municipality. In 1953 it was upgraded as 2nd grade Municipality and it was further upgraded as first grade Municipality on 13th April 1965. As per 2011 census, the total population of Palayamkottai Taluk is 98185. Out of this, 48757 are male and 49428 are females. Total number of revenue villages is 77. The area of Palayamkottai Taluk is 371.62 sq.km. Rural population is 76664 and urban population is 21521. The density of population is 264.20 per sq.km.



IV. DATA AND METHODOLOGY

The present study requires satellite imagery for the study area for the year 1992 and 2017. The images are downloaded from the USGS Earth Explorer. Processing the imagery and image interpretation for the development of land use/land cover maps is in done in ERDAS Imagine software. The obtained maps are studied and analysed to detect the change in urban sprawl.

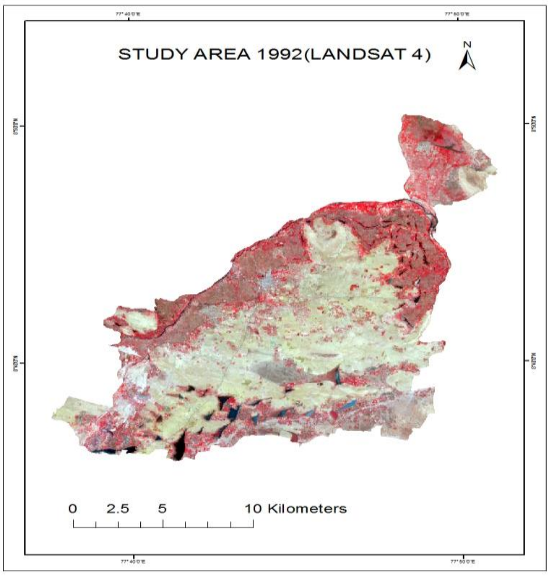


Fig.1: Study area 1992

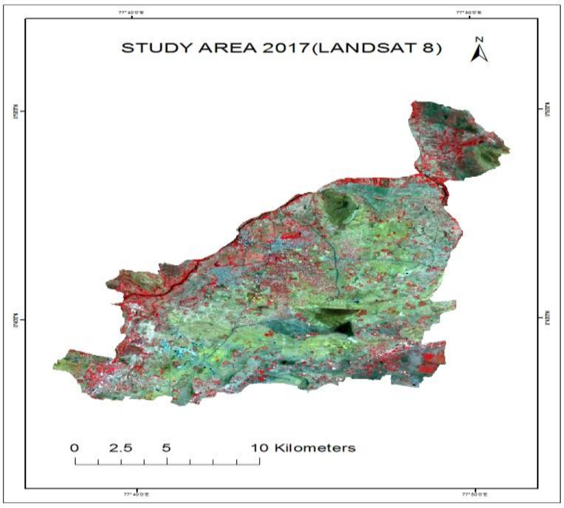
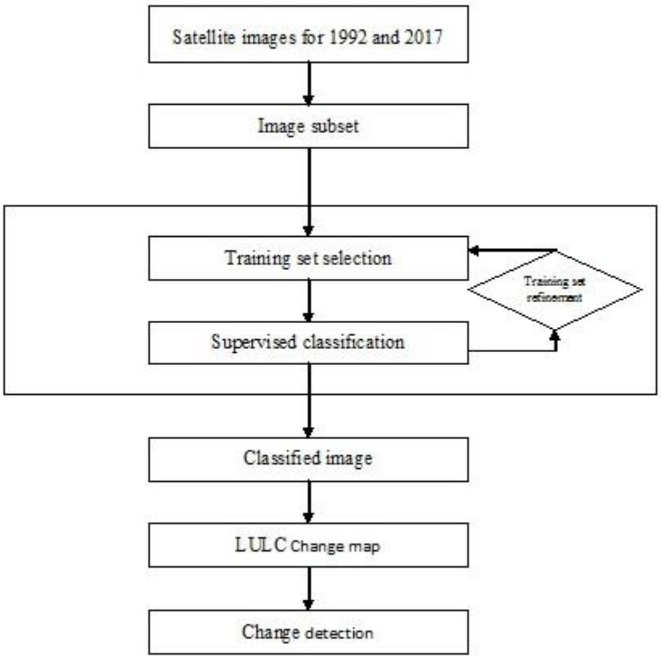


Fig.2: Study area 1992

4.1 Methodology



The methodology followed for the analysis is given below as a chat.

4.2 Classification of image

The images are classified by supervised classification method. In the supervised classification technique the maximum likely hood algorithm will classify the image based on the training sets (signatures) provided by the user based on his field knowledge. The training data given by the user guides the software as to what types of pixels are to be selected for certain land cover type.

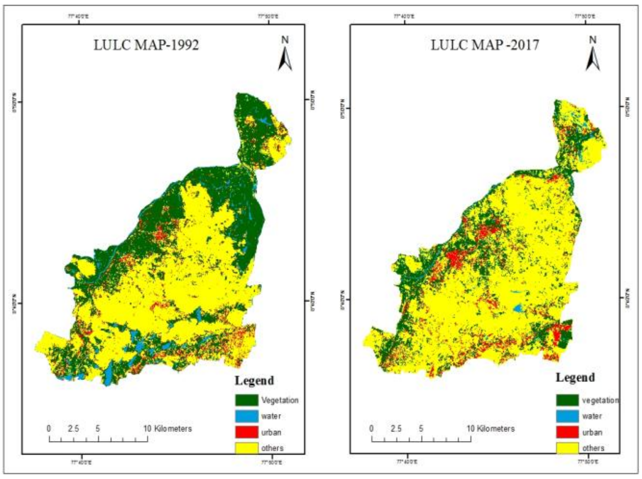


Fig.3: Classified Image

The classification finally gives the land use/land cover image of the area. Four land cover classes namely vegetation, built up area, water bodies and others are identified in the study area.

4.3 Change detection

Change detection analyses describe and quantify differences between images of the same scene at different times. The classified images of the two dates can be used to calculate the area of different land covers and observe the changes that are taking place in the span of data. This analysis is very much helpful to identify various changes occurring in different classes of land use like increase in urban built-up area or decrease in agricultural land and so on.

V. RESULTS AND DISCUSSION

5.1. Land use/land cover images

The classified images obtained after pre-processing and supervised classification which are showing the land use and land cover of the study area are given. These images provide the information about the land use pattern of the study area. The red color represents the built-up area, dark green color shows the Vegitational area, blue color shows the water bodies and yellow color shows the other features

5.2. Change detection analysis

The dominant causative factors of the different types of land degradation were identified in the field and also collected from the available technical reports. The main type of human induced land degradation in the investigated areas is urbanization. These degradation variables were assessed showing the changes that occurred during the period of 1992 and 2017 for human induced land degradation using multi-dates satellite images. In the year 1992, built up area covered 18.222016 sq.km. In the year 2017, built up area is dramatically increased, to cover 23.255775 sq.km.

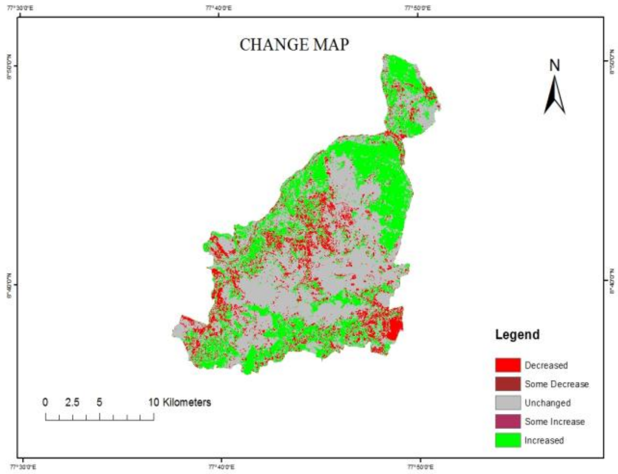


Fig.5:Change Map

Table 1: Area coverage for various land use

CLASS	AREA 1992 in sq.km	AREA 2017 in sq.km
BUILD UPS	18.222016	23.255775
VEGETATION	114.74879	66.267
WATER BODIES	12.192989	4.605075
OTHERS	163.6169	214.81988

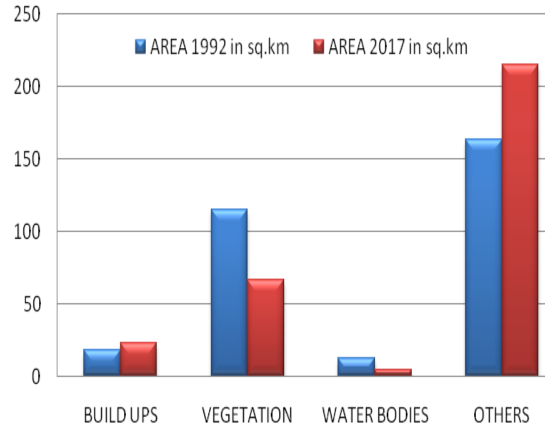


Fig.5:Land use statistics

CONCLUSION

The main cause of urbanization is the rapid population growth. This problem needs to be seriously studied, through multi-dimensional fields in order to preserve the precious and limited agricultural lands. In this work it is highlighted the urban sprawl analysis of Palaymkottai taluk, Tirunelveli, Tamilnadu, India and their environs, using remote sensing and GIS techniques. Based on this study, the analysis of the results leads to the following findings: In the year 1992, built up area covered 18.222016 sq.km while in the year 2017, built up area is increased, to cover 23.255775 sq.km.

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