Journal of Geography and Cartography (2021) Volume 4 Issue 2
doi:10.24294//jgc.v4i2.437

ORIGINAL RESEARCH ARTICLE

Application of remote sensing and GIS in land resource management

Sathees Kumar*, Nazeer Khan

Department of Civil Engineering, Mohamed Sathak Engineering College/ Anna University, Kilakarai 623806, India. E-mail: satheeskumar@msec.org.in

ABSTRACT

Land use or land cover (LU/LC) mapping serves as a kind of basic information for land resource study. Detecting and analyzing the quantitative changes along the earth's surface has become necessary and advantageous because it can result in proper planning, which would ultimately result in improvement in infrastructure development, economic and industrial growth. The LU/LC pattern in Madurai City, Tamil Nadu, has undergone a significant change over the past two decades due to accelerated urbanization. In this study, LU/LC change dynamics were investigated by the combined use of satellite remote sensing and geographical information system. To understand the LU/LC change in Madurai City, different land use categories and their spatial as well as temporal variability have been studied over a period of seven years (1999-2006), by analyzing Landsat images for the years 1999 and 2006 respectively with the help of ArcGIS 9.3 and ERDAS Imagine 9.1 software. This results show that geospatial technology is able to effectively capture the spatio-temporal trend of the landscape patterns associated with urbanization in this region.

Keywords: GIS; LANDSAT; Land Use; Land Cover; Remote Sensing

ARTICLE INFO

Article history:
Received 12 July 2021
Received in revised form 31 August 2021
Accepted 5 September 2021
Available online 11 September 2021

1. Introduction

Planning and development of urban areas with well-developed infrastructure, utilities, and services has its legitimate importance and requires extensive and accurate LU/LC classification. Information on changes in land resource classes, direction, area and pattern of LU/LC classes form a basis for future planning. It is also essential that this information on LU/LC be available in the form of maps and statistical data as they are very vital for spatial planning, management and utilization of land. However, LU/LC classification is a time-consuming and expensive process. In recent years, the significance of spatial data technologies, especially the application of remotely sensed data and geographic information systems (GIS) has greatly increased. Nowadays, remote sensing technology is offering one of the quick and effective approaches to the classification and mapping of LU/LC changes over space and time. The satellite remote sensing data with their repetitive nature have proved to be quite useful in mapping LU/LC patterns and changes with time[1-4].

Quantifying the anthropogenic or human activity that governs the LU/LC changes has become a key concept in the town planning process. A major objective of planning analysis is to determine how much space and what kind of facilities a community will need for activities, in order to perform its functions. An inventory of land uses will show the kind and amount of space used by the urban system.

LU/LC study with the use of remote sensing technology is emer-

ging as a new concept and has become a crucial item of basic tasks in order to carry through a series of important works and processes such as the prediction of land use change, prevention and management of natural disaster, and protection of environment, etc. Most importantly, it is of great significance in analyzing the present development and future development scope of the nation. In the recent years, with the enhancement of more advanced remote sensing technology and geo-analysis models, monitoring the status and dynamical change of LU/LC thoroughly by using remotely sensed digital data has become one of the most rapid, credible and effectual methods.

The main aim of this paper is to assess the LU/LC changes, and to observe the growth of various urban classes over a period of seven years in Madurai City by using remote sensing and GIS technology. For this purpose, multi-spectral, multi-temporal Landsat images were downloaded from USGS Earth Resources Observation and Science (EROS) Center[5]. The classification, identification and graphical representation of the changes detected in the classes defined for the study area were performed with the help of ERDAS Imagine 9.1 software and ArcGIS 9.2 software. The paper focuses on the analyses and discussions of the results including the pattern of changes in LU/LC studied from year 1999 to 2006.

2 Study area

The study area is Madurai City, Tamil Nadu (**Figure 1**), one of the famous historical and cultural cities in India. It is located in south central Tamil Nadu, and is the second largest city after Chennai as well as the headquarters of Madurai District. In 2011, the jurisdiction of the Madurai Corporation was expanded from 72 wards to 100 wards covering area 151 km^2 and dividing into four regions Zone I, II, III, and IV. There has been rapid growth in Madurai from 1967 and it keeps developing over the years as well as its surrounding areas. However, most of the areas around Madurai are still least developed and require transforming. It extended geographically from 9°50’ North latitude to 10° North latitude and 78°02’ East longitude to 78º12’ East longitude, and approximately 100 m above the mean sea level (MSL). The terrain of the city is gradually sloping from the north to south and west to east.

The River Vaigai is the prominent geological feature which bisects the city into North and South zones with the north sloping towards Vaigai River and the south zone sloping away from the river. The city became municipality in 1867 and was upgraded as a corporation in 1971 after 104 years. The corporation limit was extended from 52.18 km^2 to 151 km^2 in 2011. As per 2011 census, the population of the city is 15.35 lakhs[6]. The area has been experiencing remarkable land cover changes due to urban expansion, population pressure and various economic activities in the recent years.

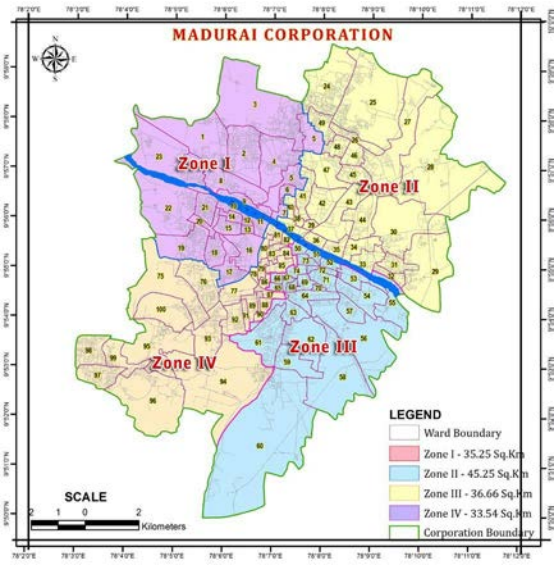


Figure 1. Location of Madurai City[7].

3. Methodology

3.1 Data

For this study, Landsat ETM+ (path 143, row 53) images were used (**Table 1**). Landsat images were downloaded from USGS Earth Resources Observation and Science (EROS) Center[5]. A base map of Madurai City was provided by Local Planning Authority of Madurai. The Landsat ETM+ image data consists of eight spectral bands, with the same spatial resolution as the first five bands of the Landsat TM image. Its 6th and 8th (panchromatic) bands have resolutions of 60 m and 15 m, respectively. All visible and infrared bands (except

the thermal infrared) were included in the analysis. Remote sensing image processing was performed using ERDAS Imagine 9.1 software. Landsat data of 1999 and 2006, as well as SOI Toposheet were selected and used to find the spatial and temporal changes in the study area during the study period.

Table 1. Landsat satellite data used in the study

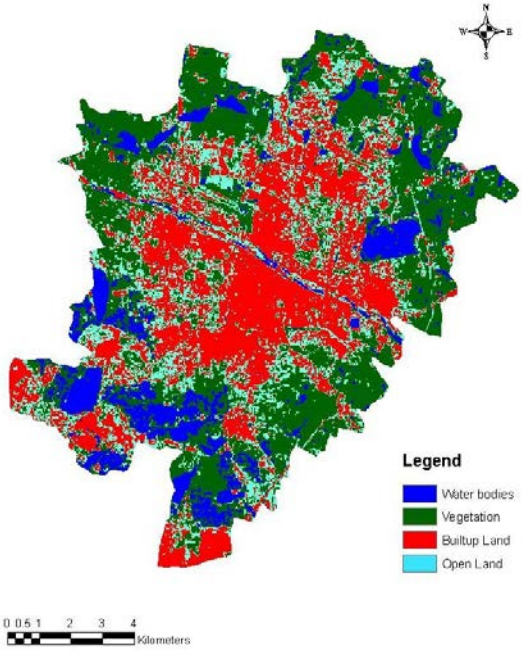
Sl.No	Data product	Imagery date	Resolution (m)	Path/Row
1	Landsat	04/12/1999	30	(143 - 53)
2	ETM+	21/01/2006	30	(143 - 53)

3.2 Image classification

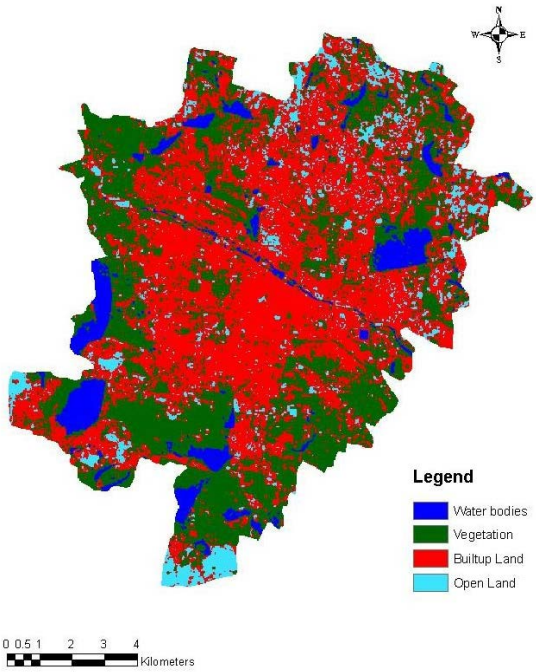
In this study, there are totally four LU/LC classes, that is, vegetation, built-up land, waste land, and water area. The classes in the images were decided based on the LU/LC classification system devised by National Remote Sensing Agency (NRSA) for Indian conditions[8]. The LU/LC classes are presented in **Table 2**.

Table 2. LU/LC Classification scheme of Madurai

Sl.No	LU/LC Classes
1	Vegetation
2	Built-up land
3	Waste land
4	Water area



(a)



(b)

Figure 2. LU/LC classified images **(a)** 1999; **(b)** 2006**.**

In the study area, a supervised classification of the image was performed using the signature files from the unsupervised classification. For the supervised classification, a maximum likelihood rule was used as a parametric rule[9,10]. The LU/LC classified maps for 1999 and 2006 were produced from Landsat images. See in **Figure 2**.

4. Result and discussion

4.1 LU/LC change analysis

The LU/LC classification results from the year 1999 to 2006 are summarized in **Table 3**.

Table 3. Summary of areas for LU/LC classes from 1999 to 2006

LU/LC Class	Area (ha)	
	1999	2006
Built-up land	4533.57	7020.45
Open Land	2891.79	1170.45
Vegetation	5526.99	5411.79
Water bodies	1602.72	952.38
Total	14555.07	14555.07

From 1999 to 2006, built-up area increased by 17.09%. On the other hand, open land decreased by 11.82% respectively. The fluctuations were observed in vegetation and water area due to seasonal

variation found in the study area. All these land use change are closely related with the development of regional economy and the population growth in the city. The trend of LU/LC and urban change in the city is shown in the **Figure 3**.

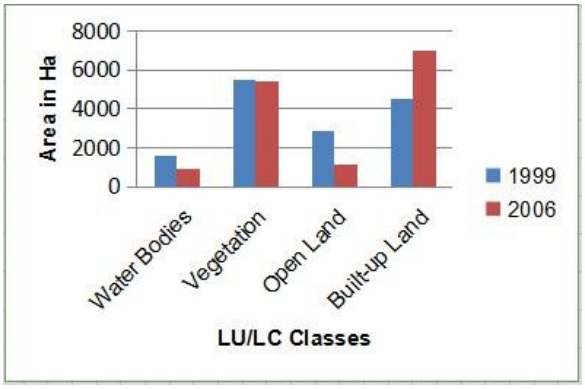


Figure 3. Comparison of LU/LC from 1999 to 2006**.**

5. Conclusion

This paper aims to investigate LU/LC changes occurred in Madurai City between 1999 and 2006 by using remote sensing and GIS technology. The areas of urban settlements and construction land in Madurai City increased by 17.09% from 1999 to 2006. The results of the study suggest that the analysis of sequential satellite data offers means of extraction of information on LU/LC. In fact, satellite data are very helpful for the detection of LU/LC changes due to repetitive coverage at very short intervals[11]. In this study, analysis has been done for a period of seven years. This work shows that it is feasible to analyze and monitor LU/LC change based on remote sensing images and GIS applications. The results would be of great help for the land management department to make quick quick decision in future land use planning.

Conflict of interest

The authors declare that they have no conflict of interest.

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