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Original Research Paper

Evaluating Environmental Land Use/Land Cover Change Detection in Sub Urban Fringe Area Around Madurai City Using GIS Technique

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ABSTRACT

Urban growth is most rapid in the developing world, where cities gain an average of five million residents every month in a year. The rapid urbanization and other infrastructure development in cities made workers to substitute a greater distance between their residencies and the cities so it encroached industries and businesses to locate or relocate in suburban fringe areas which contain all facilities such as in metropolitan areas. The urban service area-Madurai, a metropolitan area, is currently experiencing linear to horizontal expansion and a variety of development pressures due to the unabated scattered population growth and socio-economic status, which portrays the conversion of agriculture lands, wet lands and number of water bodies into housing and industrial sites in a haphazard manner at the outskirts of the city known as Madurai suburban fringe area. This study evaluates the effectiveness of high-resolution satellite data and computer aided GIS techniques in assessing the land use change dynamics within the study area, Madurai city and its suburban fringe areas, from 2001 to 2008. Satellite images were used for the year 2001 and 2008 at scale 1:50000.

INTRODUCTION

Process of urbanization often leads to haphazard growth in metropolitan cities, deterioration in living conditions and worsening of environmental scenario due to increase in socio -economic development. This unabated trend bloomed with the elevated pressure as well as changes in the natural land use along the myriad of landscapes, increases the limited land available in the city, sometimes they develop beyond the planned limits. The settlement of the people at the outskirts of the large cities has resulted in an unplanned urban sprawl. This dispersed settlement and its development at the outside of compact urban and village centres along highways and in rural countryside is defined as the urban sprawl (Theobald 2001). The increasing of urban sprawl in the past several decades has nowhere been more in evidence on the suburban area development than of the major metropolitan centres. The term suburban is defined as nothing but an outlying area of a particular city, which is itself an important region of that city. Specifically, larger towns and cities in developing nations have experienced rapid population increases and many are facing the emergence of unplanned and uncontrolled settlements at their fringes (Amarsaikhan et al. 2001, Amarsaikhan 2005). The term 'fringe' suggests a borderline case between the urban and rural space located at the outside limit of the city (Avram 2009, Saxena 2008), surrounding it and distinguishing it from the truly rural countryside. Largely, suburban fringe settlements develop outside of government control and do not follow strictly formal and traditional urban planning and development processes, (Hogrewe 1993). The suburban expansion encroaches the growth of fringe land closer to the city, provides a buffer for people, urban physiology and economy and in particular livelihood services, and results in change in land use. Such an environment creates a set of people who are physically rural and mentally urban (Anderson 1964)

Land use/land cover changes: A land use and land cover dynamic is widespread and accelerates significant processes driven by human actions but also produces impacts to humans (Agarwal et al. 2002). Land use is a key concept in the town planning profession (Chapin 1965). Recent settlements and sprawl development are becoming large active land use changes intending the employment of management strategy placed on the land cover by human agents, or land managers to exploit the land cover and reflects human activities such as industrial zones, residential zones, agricultural fields, grazing, logging and mining among many others (Zubair 2006, Chrysoulakis et al. 2004) and causes damage to the environment as well. This information monitor the dynamics of land use resulting out of changing demands of increasing population and highly influenced the land resources. Moreover, the public quality of life will be greatly influenced by the built urban landscape. An inventory of the land use/land cover will show the spatial and temporal details about the amount of space used and remained by the urban activities.

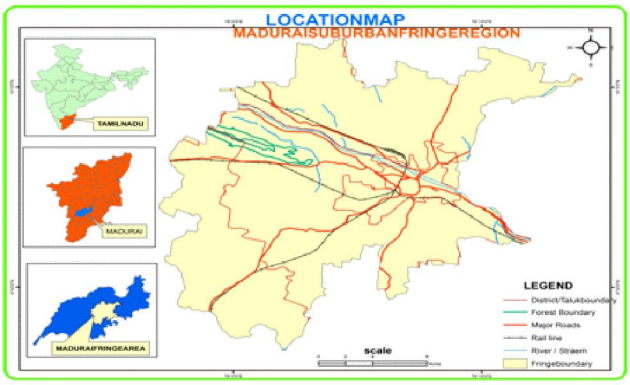

Fig. 1: Thre study area.

Land change detection: Information on the rate and kind of changes in the use of land resources is essential for proper planning management and to regularize the use of such resources (Gautam & Narayanan 1983). Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh 1989). Change detection is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest.

Role of GIS and remote sensing techniques in land use/land change detection analysis: The present study is based on the spatial data as well as the non-spatial data available from the various sources for different periods. Remote sensing (RS) refers to the science of identification of earth surface features and estimation of their geo-biophysical properties using electromagnetic radiation as a medium of interaction. GIS is a system hardware and software used for collecting/capturing, storage, processing, retrieval, mapping, managing, analysing and analysis of geographic data, which are essentially, referenced to the real world or the earth associated with the spatial features and associated attributes in same coordinate system for mapping analysis. Remote sensing along with GIS tools used together, display, store, analyse and output data related to the urban and sub-urban environment, can provide planners with certain data sets (Donnay et al. 2001, Bahr 2001). The land use/land cover change detection were evaluated by using GIS and remote sensing techniques. There are three steps used to analyse the land use-land cover detection in the suburban fringe areas around the Madurai city. Firstly, we can realize the pair-wise comparison of land use maps of different periods in order to detect changes in terms of area but also the geographic location of these changes. Secondly, urban and sub-urban areas can be identified and assessed, in order to produce the evolution map between two periods only for urban and sub-urban. Thirdly, by keeping in all land use categories, we can investigate the impacts on land change and vice-versa.

STUDY AREA

The study area comprises of Madurai city and its fringe villages, and it is of about 452 sq.km (Fig. 1). It extends geographically between 9°49' to 10°0' north latitude and 77°57' to 78°12' east longitude. It lies at a low altitude, only about 1000 meters above mean sea level. The city is linked by NH 7 and NH 49. Madurai city and its fringe villages have spread on either side of the River Vaigai. The study area is partly covered by three taluks namely Madurai North, Madurai South and Thirumangalam. There are 116 fringe villages covered by the study area excluding Madurai Corporation. The total population of the above area is 1436169 as per 1991 census and 1524027 as per 2001 census.

METHODOLOGY

Flow chart of the methodology adopted is shown in Fig. 2. The methodology adopted for land use change detection analysis is,

a. Survey of India Topographic sheet (1:50,000) of 1970 is used as a base map for registration and digitization of topography to prepare land use map of 2001, 2008.

b. IRS-1C-LISS III and IRS-1C-LISS IV geocoded data of 2001 and 2008 were used to interpreted the land use map status. The interpreted results were field validated with limited field checks. Land use map of 2001 and 2008 was digitized and attributed.

c. Secondary data and other spatial data were collected from various Government departments. The data collected were used to define administrative or jurisdiction boundaries, planned roads, drainage, water bodies, etc.

d. The land use maps of the year 2001 to 2008 were obtained by superimposing the respective years one over the other. This was achieved by using 'Union' analysis of PC ARC/INFO GIS, and necessary attributes were obtained.

RESULTS AND DISCUSSION

The results of land use change detection were obtained from imposing the two imageries of 2001 and 2008 and classified under the land use/land cover categories in the present study.

Detection analysis and accuracy assessment: In the study area built up land, wetland, dry land, fallow land, land with scrub, land without scrub, tanks, river and barren land changes of Madurai sub urban were compared using multi temporal GIS and remote sensing techniques, and to explain

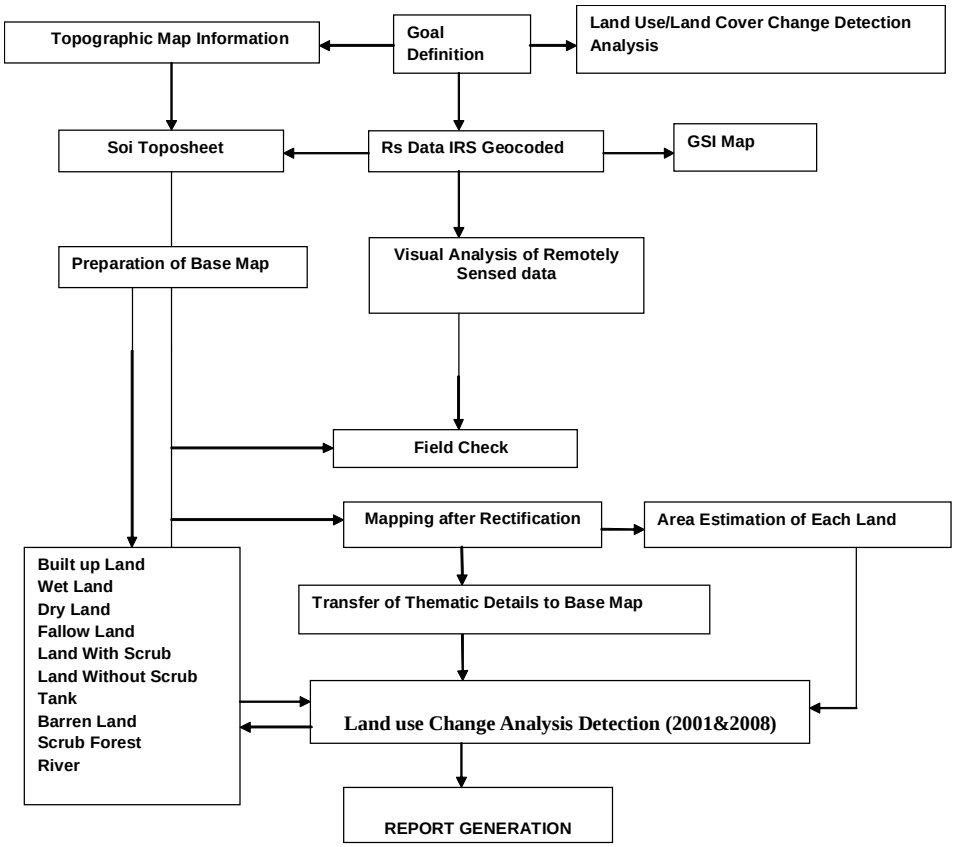

Fig. 2: Flow chart of the methodology adopted.

Table 1: Area covered by various land use and land cover classes during 2001 and 2008.

S.No	Land Use Classes	(Year 2001) area in sq. km	(Year 2001) area in %	(Year 2008) area in sq. km	(Year 2008) area in %	Change%
1	Built up Land	73.3	16.2	78.8	20.6	-4.4
2	Wetland	65.6	14.5	46.6	8.2	6.3
3	Dry Land	49.0	10.8	43.7	9.7	1.1
4	Fallow Land	41.6	9.2	50.4	11.1	-1.9
5	Land with Scrub	42.1	9.3	47.5	9.7	-0.4
6	Land without Scrub	117.1	26.0	121.6	26.6	-0.6
7	Tank	44.8	10.0	44.1	9.9	0.1
8	River	5.0	1.1	5.0	1.1	0.0
9	Barren Land	4.9	1.0	5.1	1.1	-0.1
10	Scrub Forest	8.6	1.9	9.2	2.0	-0.1
	Total	452	100	452	100	

the socio-economic reasons for the changes. Digital analysis was carried out using ARC GIS INFO (9.3) software and ERDAS (8.5) Imagine software. The digital data base was prepared on 1:50,000 scale. Contrast and spatial enhancement techniques were applied on raw data in order to make the raw image more interpretable. A standard FCC (RGB: 432 band combination) was prepared and this image was registered with the help of SOI toposheet. Registration was done with high accuracy (sigma = 0.159 pixels). The registered image was resample with the pixel size of 20m. The resample image was masked with the digitized base map. The accuracy was assessed based on the ground truth observations and training sets were identified on masked image for different land use/land cover. The land use map of the

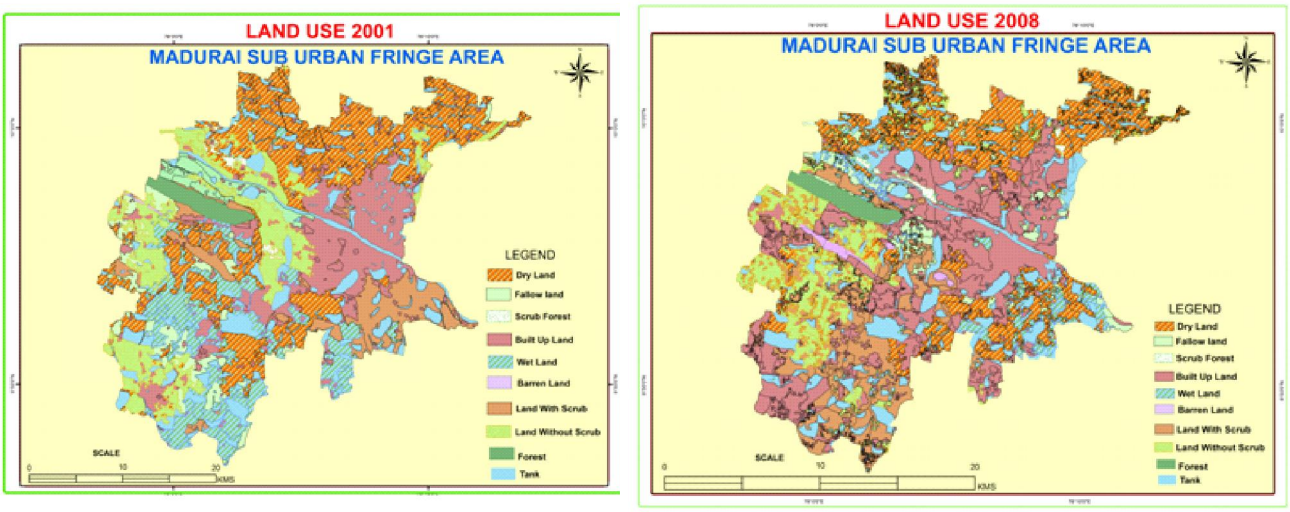

Fig. 3: Area covered by various Land Use and Land Cover classes during 2001 and 2008.

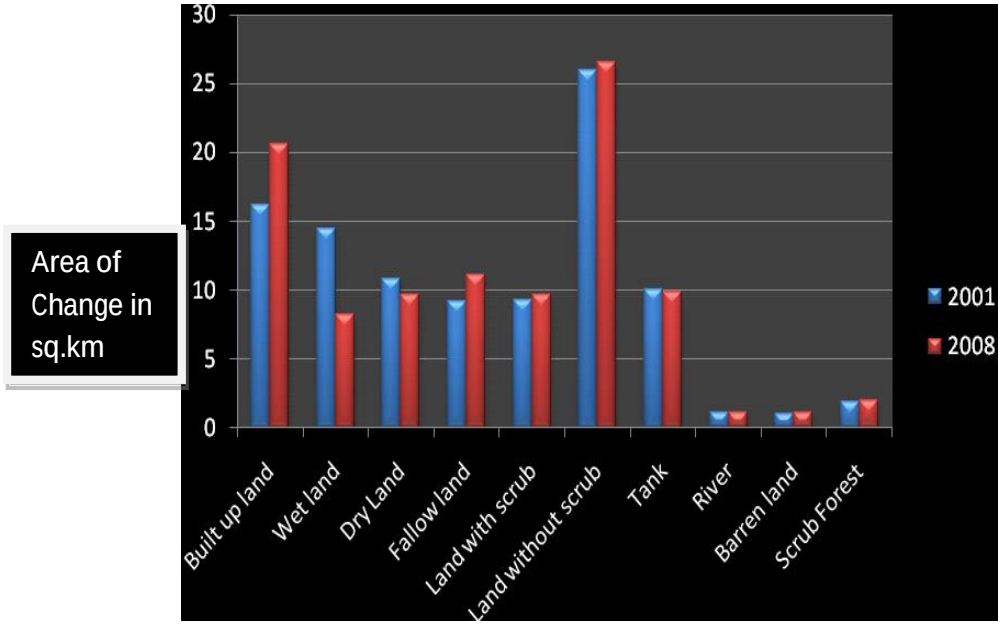

Fig. 4: Demographic variation of Land use/Land change detection analysis of Madurai suburban fringe area.

years 2001 and 2008 have been prepared from the Satellite digital data IRS 1C LISS III and IRS 1C LISS IV based on USGS classification. Finally, the masked image was classified using supervised classification to get a thematic map of land use/land cover for the years 2001 and 2008. Histogram for these maps was calculated to know the area of each class. The total area of each class is expressed in square kilometres (sq.km). The total areas related to each class defined from the digitized map as well as classified using multi-temporal images are given in Table 1.

In the meantime, the population increased by more than eight times. These changes were related to the following:

Population Growth and Problems in Madurai City

1. The growth of population in Madurai Corporation of 51.82 sq.km is multiplied nearly nine times from the year of 1991 to 2001, whereas that of the population of the Madurai City Municipal Corporation is 1,05,984 (as per

1991 census) and 9,22,913 (as per 2001 census) and urban agglomeration population percentage is certainly increased as 0.5% in 1991 and 1.48% in 2001.

2. High intensity of residential concentration within the four veli streets, i.e., in the old city.
3. The highly congested central area of the city, with multifarious economic activities, mixed transport modes and road users, which need a long term programme of urban renewal.
4. The existence of industries in the already crowded old city constitutes a source of nuisance and this position is being aggravated by inadequate and narrow circulation of roads and ill designed junctions and crossing.
5. Inadequate right of ways of arterial roads and ribbon development along the corridor is a source of obstruction to the free traffic flow.
6. Inadequate core services of water supply and drainage and traffic and transportation facilities.

Socio Economic Changes - Sub Urban Fringe Expansion Around Madurai City

1. In recent times, the observed developments and settlements of Madurai city beyond its traditional limit called as suburban fringe areas, brings many hitherto rural land under the influence of the city and exhibits urban character and creates anthropogenic activities.
2. The total population of the Madurai suburban fringe area is 1436169 as per 1991 census and 1524027 as per 2001 census.
3. This expansion became quite visible in the last five to seven years due to the encroachment of socio-economic changes resulting in increase in salaries, increase government resources that encouraged construction activities beyond the city and institutional expansion has given rise to typical urban-rural land use associations in the suburban fringe areas where the contemporary and dynamic land use pattern is developing side by side in the contemporary context, to the various land uses surrounding the cities and arid zones.

Madurai Suburban Fringe Land use/Land cover Change Analysis

The ongoing change (observed from the Figs. 3 & 4 and Table 1), in the Madurai suburban fringe land use/land cover change has provided the necessary physical and social facilities and infrastructure required to serve the immediate surrounding areas, and due to the fast industrialization the city is growing in a disorganized manner at the cost of the other smaller urban centres of the region creating unbalanced land use in the urbanization trends of the region. The change is due to anthropogenic character, playing an important part in the modification and spatial inconsistency of the land use and land cover changes in the region. The anthropogenic movement is due to population explosion and expansion taken place by converting the wetland, dry land, scrub land and fallow land in extension of built-up land, in 2001 it covered 73.3 sq.km (16.2%) and in 2008 it covered 78.8 sq.km (20.4%) . This is an interesting piece of information as it gives a clear impact of the various developmental policies which have caused the changes in various land use and land cover.

CONCLUSION

From the past years the human numbers and food demand grew at an unprecedented pace because of several environmental and socio-economic changes. Urbanization will continue at an accelerated pace, and about 70 percent of the world's population will be urban (compared to 49 percent today). As a result of urbanization, the city expands efficiently with number of changes in the land. Madurai city and its surrounding fringe areas also face this type of change. If this process is proceeded in future, the younger generation will pay for this huge barrier. At present there are many ways to prevent natural disasters like global warming, climate change, green house effect and hazard management like GIS and remote sensing techniques, use to derive satellite up-to-date land cover databases through LU\LC change modeling techniques. By using this technique, a sustained effort is needed to prevent the LU\LC changes.

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