IMPACT OF URBANIZATION ON AGRICULTURAL LAND USE CHANGES IN MADURAI METROPOLITAN AREA, TAMIL NADU, INDIA

Bharathi K.*, Thangamani V. **
Research Scholar and Assistant Professor, Department of Geography
Madurai Kamaraj University, Madurai 625 021 Tamil Nadu, India

Abstract
Rapid urbanization, population pressure and the governmental, housing, infrastructural, institutional, industrial and commercial needs of a fast growing city have stretched the land delivery system in Madurai, Tamil Nadu, India, to a breaking point. Agricultural lands, particularly crop and cultivable fallow lands, and waterbodies which serve as the main sources of livelihoods, have been encroached upon by the land use changes processes. This paper seeks to assess the impact of rapid urbanization on agricultural lands in developing cities, drawing empirical evidence from Madurai, India.As in others metropolitan areas, we expect the growth of residential land use and this is recognized being very important for economic and ecological planning. Urban pressure from Madurai metropolitan area has the result of decreasing importance of agriculture in the local economy.Several areas will preserve the agricultural features, mainly with vegetables, flowers or cereals. Nearer to Madurai arable land has been transformed into mainly built-up areas, because of escalating level land prices.

Key words*: Change detection, agricultural lands, built-up area, fallow land, urban impacts, remote sensing analysis*

Introduction

Urbanizationand industrialization have been leading to changes in land use patterns within the city and increasingly devouring agricultural lands in, about and at close proximity to the city. The two processes have been rather rapid paced in the last two decades and more, with the advent of economic liberalization and reforms in the country and the unprecedented growth of the economy before the recent slowdown. Population pressure and the governmental, housing, infrastructural, institutional, industrial and commercial needs of a fast growing city have stretched the land delivery system in Madurai, Tamil Nadu, India, to a breaking point. Agricultural lands, which serve as the main source of livelihoods in the rural-urban fringe and the villages beyond, have been encroached upon by the land use change processes. In simple terms, the present study is one of land use change detection, in space and time. Whereas the study is concerned primarily with the metropolitan region of Madurai in Tamil Nadu, including the rural-urban fringe areas and peri-urban areas in the two taluks of Madurai North and Madurai South of Madurai district in Tamil Nadu.

Land Use Dynamics and Change Detection

The term urbanization as traditionally measured by demographers is urban population divided by total population of a region. Urbanization is also defined as the annual rate of change of the percentage of people living in urban areas, or the difference between the growth rate of urban population and that of total population (Dale, 1997; Mabogunje, 1992). Urbanization affects all sectors of the economy. It is regarded as an inter-sectorial phenomenon involving all aspects of the human society and economy (World Bank, 2000). Urbanization is the outcome of the social, economic and political developments that lead to

urban concentration and growth of large cities, changes in land use and transformation from rural to metropolitan pattern of organization and government (Kundu, 1992). In effect, urbanization affects all spheres of human life both in the rural and urban setting (Lerise et al., 2013).

Change detection studies have been helpful in making policy decisions on urban and rural land resources management. Remote sensing and GIS have been widely used in change detection studies because of their potential for analyzing large volumes of land use data. Large volume of historical remote sensing data is however essential to assess the spatial patterns of land uses at various time intervals.The general characteristics of rapid urbanization experienced by most sub-Saharan countries, such as Ghana are rampant changes in land and building uses (Lerise et al., 2004). Growth in urban population goes with no equivalent growth in land supply (Olima, 2003). Agricultural lands are most affected by rapid urbanization and its functions of demand. Land uses for residential, industry and commercial, civic and culture tend to dominate agricultural lands in the bid for space in the urban place. This dominance tends to deprive farmers of arable land to cultivate thereby reducing agricultural productivity. There is a clear depiction of this situation in the Tamale metropolis and its trajectory areas (Naab, Dinye and Kasanga, 2013).

Change detection involves comparison of land use themes, prepared at different time periods to identify the variations in the land cover due to developmental activities (Kelarestaghi et al., 2006).Change detection studies are helpful in making policy decisions on land resource management. Remote Sensing and GIS are widely used in change detection studies due to their potential in analyzing large volume of land use data (Vahadi et al., 2013). Large volume of historical remote sensing data is essential to assess spatial patterns of land use at various time intervals.Researchers have employed satellite imagery (Chillar, 2000) and integration of GIS and remote sensing (Star et al., 1997; Haridas, 1998) for monitoring and mapping the changes in land use/land cover patterns and also water resources (Adepoju et al., 2006; Rogan and Chen, 2004; Rajan and Shibasaki, 2000). Land use and land cover analysis is vital to understand the impact of human-made actions on the environment.

Aim and Objectives

The purpose of the research reported here is to attempt a land use change detection in Madurai metropolitan area of the two taluks, namely Madurai South and Madurai North, covering a total area of 675.20 km^2, with the specific focus on the impact of urbanization in Madurai city, particularly in the city fringes, on the agricultural land uses over a period of nearly 23 years: 1991-2013. The study assesses the spatial and temporal changes in agricultural land uses in the metropolitan area of Madurai, which is in the taluks of Madurai South and North of Madurai district, in comparison with the changes in areas under water bodies, fallow lands (current and permanent), waste lands and built-up lands. The study has used both remote sensing analysis and GIS for change detection and mapping. The objectives of the present paper are: The analysis and description of land use dynamics in Madurai Metropolitan Area as well as other towns of the two taluks (Madurai South and Madurai North) since 1991 to 2013; How agricultural land uses have changed over the latest decades as an influence of the urban sprawl of Madurai metropolitan area; and The evaluation of what types of land have been converted to other land uses and where are they distributed in the metropolis and the towns in the two taluks.

A Profile of Madurai Metropolitan Area

Madurai is the second largest city in Tamil Nadu, and is the capital of the district of the same name. Madurai district had a total population of 3.04 million in 2011. There was a change of 17.84 per cent in the population over the previous census of 2001, much higher however than that was in the 1991 census (at 7.41 per cent). The density of population of the district was 819 to a km^2. Nearly 61 per cent of the population of the district lives in the urban areas of the district, and more than a third of the district population lives in the Corporation of Madurai at 1.02 million. Madurai city is administered by a Municipal Corporation since 1971 and it is the second largest Corporation after Chennai (formerly Madras) which is the capital of Tamil Nadu.

Madurai Corporation is actually divided between the taluks of Madurai South (291.93 km^2) and North (383.27 km^2), a total of 675.20 km^2. There are 27 towns in the two taluks, with 13 towns in Madurai North taluk and 14 towns in Madurai South taluk, with a total population of 585,047. But of these 27 towns in the two taluks, Madurai Urban Agglomeration, has 14 of them and has an aggregate population of 1.47 million (Census 2011).The population of the 14 towns is 497,674. All the other towns (13 in all) which are not in the urban agglomeration together account for a population of 87,373 and are thus very small towns or in fact big villages, with town characteristics. While the literacy of the Madurai Corporation exceeds 85 per cent, that of the city is even higher at 92.4 per cent. A detailed description and analysis of land uses in the two taluks and particularly in the metropolitan and town areas over space and time is given in the discussion under the land use dynamics between 1991 and 2013, using remote sensing data analysis and GIS for mapping.

Research Methodology

In the present study, the land use maps were prepared form IRS 1D LISS III digital satellite data. Land use maps for the study years were prepared based on the onscreen visual interpretation using ERDAS image processing software. The land use layers were integrated using the GIS software to determine the changes in the land uses. The change detection was performed by comparison of land cover thematic maps based on satellite imagery using ArcGIS10.1v.

A historical analysis of Survey of India maps of 1:50,000 have been made for several periods before the period of analysis in the paper. For the purpose of the present study however the Survey of India topo-sheets of 58 J/4 58 K/1, and 58 K/5 (1:50,000) 1969 have been used in the preparation of the base map which has been used in the demarcation and understanding of the then extent of the fast growing metropolis in the making.

Fieldwork observations and informal interviews with the people the scholars have come across while in the field have given them some very important insights into the land use change in the metropolitan area. For example, over-exploitation of land resources, predominantly during the initial phase of rapid urban and industrial developmental activities (1995-2005) in the metropolitan Madurai has led to impacts on the river Vaigai, irrigation tanks and lakes in the area as well. Institutional developments have eaten away the waterbodies, waste lands and even cultivable fallows.

Remotely sensed (digital) data of IRS 1D LISS III for different seasons, for reasons of cloud-free data, of 1991, 2001, 2006 and 2013 have been obtained from NRSA Data Centre and used in the change detection analysis. The now-famous NRSA classification of urban land uses has also been used in the study in determining changes in agricultural land uses to other land uses, particularly built-up lands (residential, commercial, institutional, industrial and recreational). Such changes have also been observed in the field and photographic

documents have been done on separate land uses, from agricultural to other uses. To become familiar with the changes in the last decade or so, Google Earth images for the period 2002-2014 have been constantly viewed to appreciate the year-by-year changes in the metropolis and in different pockets of the city, fringes and the peri-urban areas.

As for qualitative methods, personal discussions, and participant observations have been used, both diligently and effectively. As for quantitative methods, remote sensing, GIS and GPS survey techniques have been used in the analysis, mapping and ground verification of various land uses for the purposes of the study. IRS 1D images for the years 1991, 2001, 2006 and 2013 have been used and ERDAS image processing has been used in the process of land use change detection. On verification, no drastic land use change has been detected between the different seasons of the years considered for analysis, as land use changes are generally medium (residential, commercial) and long term (institutional, industrial and recreational), except may be for individual developer organized residential development (single houses).

The Geographic Information Systems (GIS) is a technical tool widely used as part of effective urban planning approach (Burrough, 1986). This approach has gained increasing importance in India, and elsewhere in the world, as a tool for decision making in planning since it links together different datasets. In this system, accurate information, for example, on land prices, supply of serviced land, present and future land projects and housing technologies can be accessed (Lerise et al., 2013: 263). This aids the rather inadequately staffed local governments to better manage rapid urban growth. Such information supports planning, decision making and private sector investment. In this study, the GIS has mainly been used as a mapping tool and as such the classified images of land uses have been imported into the GIS (ArcGIS 10.1) and maps have been prepared showing the different land uses and land use dynamics over 1991, 2001, 2006 and 2013.

Land Use Dynamics Derived from Satellite Images

Table 1 shows the land use patterns in Madurai South and North taluks of Madurai district in the years 1991, 2001, 2006 and 2013. In all the years, the distribution of rural and urban lands under various categories of land use aggregated to 674.86 km^2, which is slightly less than the total geographical area of the two taluks of our concern (675.20 km^2).The distribution of land between the six different categories of uses is however different, in uses of crop lands (agricultural lands), fallow lands (current cultivable fallow lands), waste lands (barren and uncultivable lands) and even under water bodies (irrigation and other ponds, lakes and tanks of different sizes) it has been variously declining whereas in built-up lands (lands under residential, commercial, institutional, industrial and recreational) it has been increasing rather tremendously as a result of population growth, urbanization, industrialization and urban sprawl. Only forest lands have remained constant and unchanging throughout the period of analysis, particularly in the northern and western edges of Madurai North and Madurai South taluks.

The land use patterns shown in Table 1 above are individually shown in graphical representations in Figure 1 (Crop Lands), Figure 2 (Fallow Lands), Figure 3 (Waste Lands), Figure 4 (Waterbodies), Figure 5 (Built-up Lands), and Figure 6 (Forest Lands). Maps 1 to 4, on the other hand,show the land use dynamics in Madurai South and North taluks for the years 1991, 2001, 2006 and 2013.

Agricultural Land Use Dynamics

The change detection from the remotely sensed data shows that the agricultural crop lands came down drastically from 370.3 km^2 in 1991 to 350.3 km^2 in 2001 (- 20 km^2 in 10 years), but increased slightly to nearly 354 km^2 in 2006 (+ 3.98 km^2 in 5 years) only to decline to nearly 347 km^2 in 2013 (- 6.99 km^2 in 7 years). The corresponding decline in proportion of the area under agricultural crops is -0.77 per cent during 1991-2001, - 0.30 per cent during 2006-2013, although the land under crops went up by 0.17 per cent during 2001-2006 (Figure 1). The overall decline in agricultural land uses was 23.27 km^2 between 1991 and 2013 or -0.9 per cent over the 23 years, from 13.8 per cent to 12.9 per cent of the total geographical area of the metropolitan and the proximal fringe and rural areas during 1991-2013. In real terms however this areal change means that 2,327 ha of crop lands have been converted to other land uses.

Table 1. Land Use Patterns in Madurai South-North Taluks 1991, 2001, 2006 and 2013

Land Use	**Area in km^2**			
	1991	**2001**	**2006**	**2013**
Built-up Lands	***68.52***	***73.76***	***82.46***	***91.22***
Crop Lands	***370.26***	***350.26***	***353.98***	***346.99***
Fallow Lands	**54.33**	**60.31**	**43.34**	**36.33**
Forest Lands	**17.14**	**17.14**	**17.14**	**17.14**
Waste Lands	***92.48***	***92.48***	***92.48***	***91.66***
Water Bodies	***94.13***	***92.91***	***92.46***	***91.52***
Total	**674.86**	**674.86**	**674.86**	**674.86**

Source: Remote Sensing Analysis of Land Uses 2014.

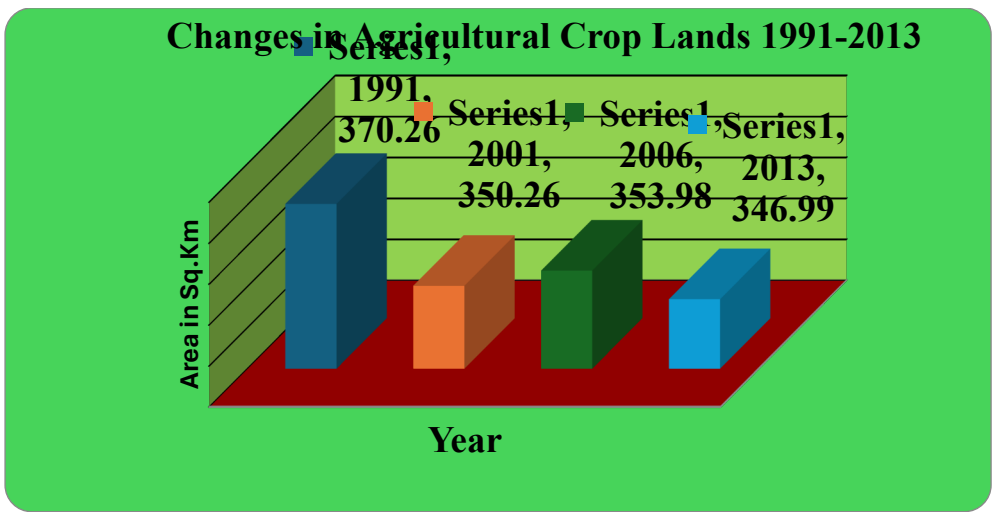

Figure 1. Changes in Agricultural crop Lands.

The general practice of the farmers in the rural-urban fringes and in the proximity of the metropolitan areas and urban agglomerations is to leave the farming lands fallow for a few years under the pretext of continuous drought and then declare the lands as uncultivated and sell them for plotting for various land uses. Thus, the cultivable fallow lands were 54.33 km^2 in 1991 which increased to 60.31 km^2 in 2001 (an increase of 0.24 percentage points in the decade) and then declined to 43.34 km^2 in 2006 (a decline of 16.97 km^2 over 2001 or -1.08 per cent) and further to 36.33 km^2 in 2013 (or a decline of 7.01 km^2 or -0.26 per cent). Overall change in cultivable fallow lands in the metropolitan,urban agglomeration and rural areas of the two taluks of our study was of the order of -0.65 per cent over the years of study (Figure 2). In real terms, this means a decline of 1,800 ha of the cultivable fallow which was converted into other land uses or still to be converted.

Dynamics of Wastelands

In comparison with the agricultural crop and current fallow lands, the dynamics of wastelands in the study area tended to be rather sluggish in that that the area under wastelands remained the same for three years of our study (at 92.48 km^2), that is, 1991, 2001 and 2006 (Figure 3), and only in 2013 the wastelands had seen a change of about -0.82 km^2 or 820 ha, from 92.48 km^2 in 2006 to 91.66 km^2 in 2013 (-0.9 per cent over 7 years). It is fairly obvious that even this part of the wastelands was used for other purposes, may be for infrastructural uses. Wastelands are often grabbed by the urban poor to have shelter over their heads as well, although in the presence of some semblance of regulation the wastelands could be converted to lands that could be used for building infrastructures.

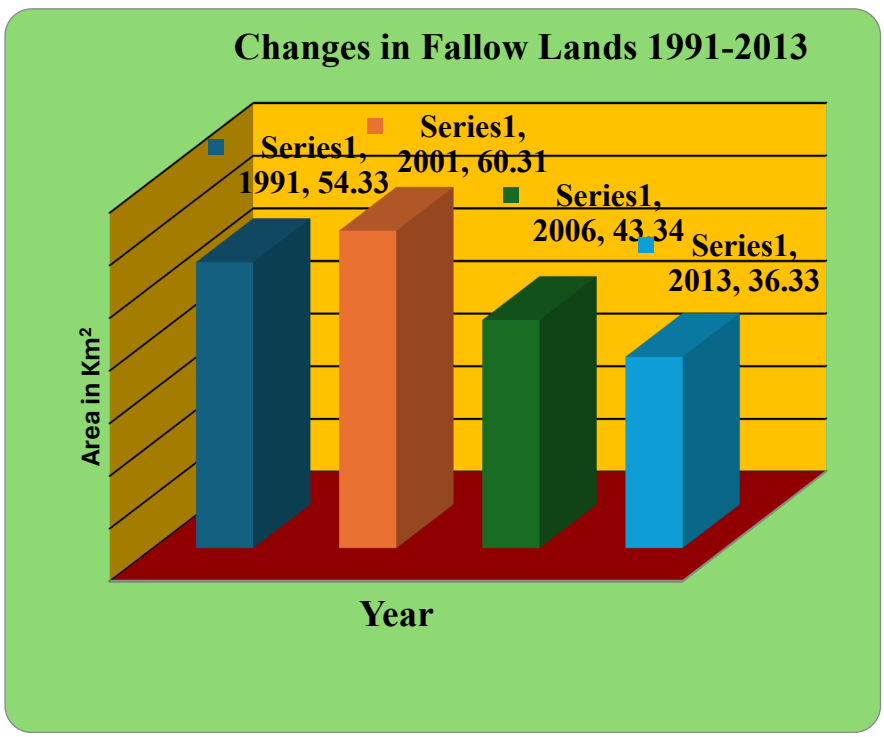

Figure 2. Changes in fallow land.

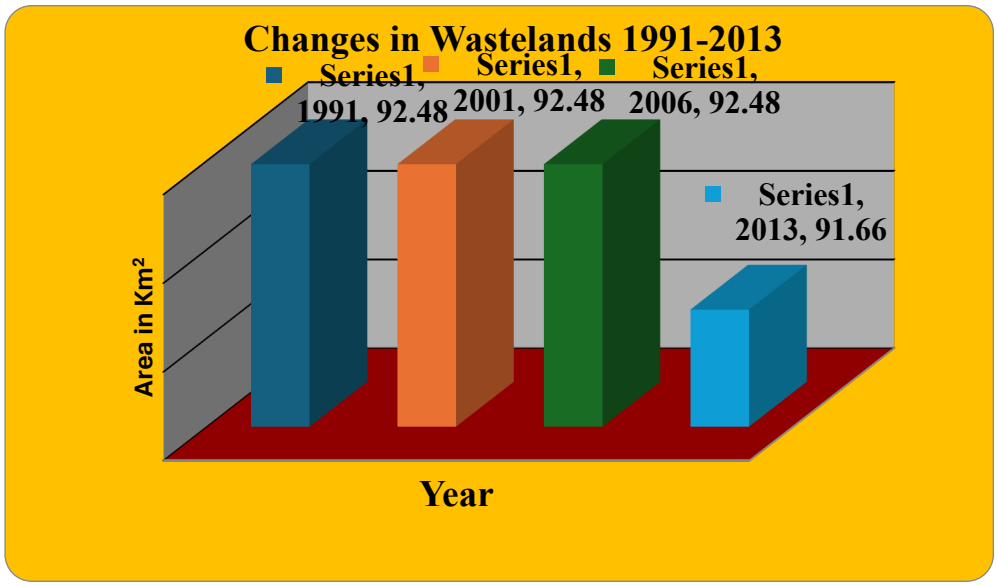

Figure 3. Changes in easteland.

Dynamics of Waterbodies

Figure 4 shows the changes in the areal extent of the waterbodies over the years 1991 to 2013. The change in the areal extent of waterbodies was gradual but in the periods between the years of our study and analysis. Over the 23-year period of our analysis, the waterbodies of the metropolitan area had lost 2.61 km^2 or 261 ha to other land uses as well. The decline during 1991 to 2001 was 122 ha whereas the decline during 2001 to 2006 was just 45 ha and during 2006 to 2013 was 94 ha, a change of -2.3 per cent, -0.41 per cent and -1.02 per cent in the three intervening periods, respectively.

Waterbodies in the city are often found to have been encroached upon by the poor or have been built over even by the Government agencies such as the Tamil Nadu Housing Board for public housing projects. Some of the waterbodies in Madurai South and North taluks have been filled-in by the private land developers and plotted and sold to the private developers as well. One such waterbody in the east of the city boasts even of a medical college constructed over it in the last decade or so.

Dynamics of Built-up Lands

The remotely sensed data analysis also shows that the built-up area increased from 68.52 km^2 (2.55 per cent of the total geographical area) in 1991 to 73.76 km^2 (2.74 per cent) in 2001 (an increase of 5.24 km^2 or by 0.19 per cent), to 82.46 km^2 (3.07 per cent) in 2006 (8.7 km^2 or 0.33 per cent) and further to 91.22 km^2 (3.39 per cent) in 2013 (8.76 km^2 or 0.32 per cent). This means that the built-up area had come to occupy 22.7 km^2 or 2,270 ha in the last 23 years, an increase of 0.84 percentage points over the period of analysis (Figure 5). Built-up lands are the only land use that showed increase throughout the period, almost 33 per cent increase over the 23-year period. It amounts to a compounded annual growth rate of 1.25 per cent over the entire period. But it is 0.74 per cent over 1991-2001, 1.88 per cent over 2001-06, and 1.48 per cent over 2006-13.

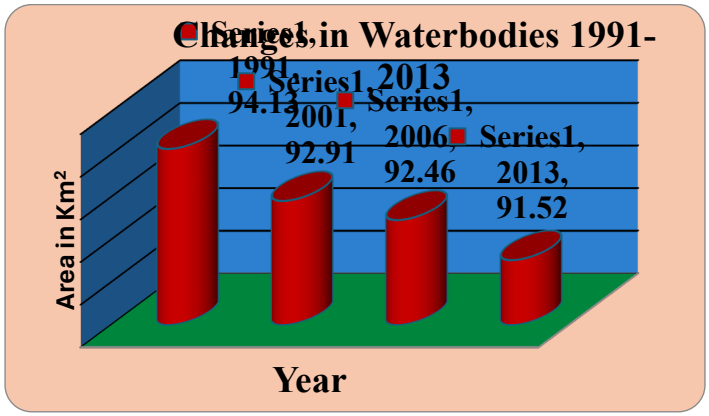

Figure 4. Changes in Waterbodies.

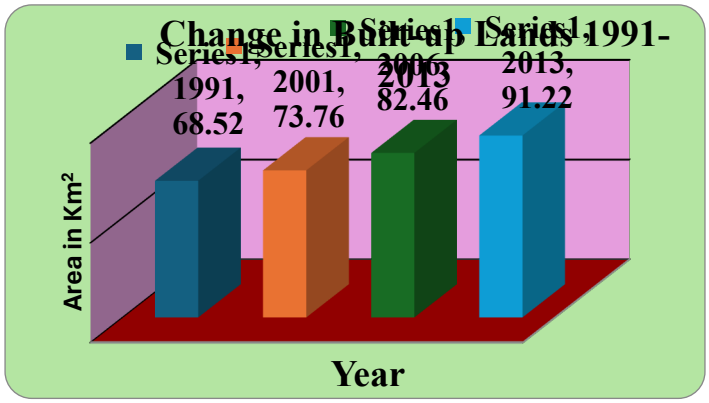

Figure 5. Changes in Built up lands.

Dynamics of Forested Lands

Throughout the study period, the forested lands remained without any change, at 17.41 km2 or 1,741 ha (Figure 6).

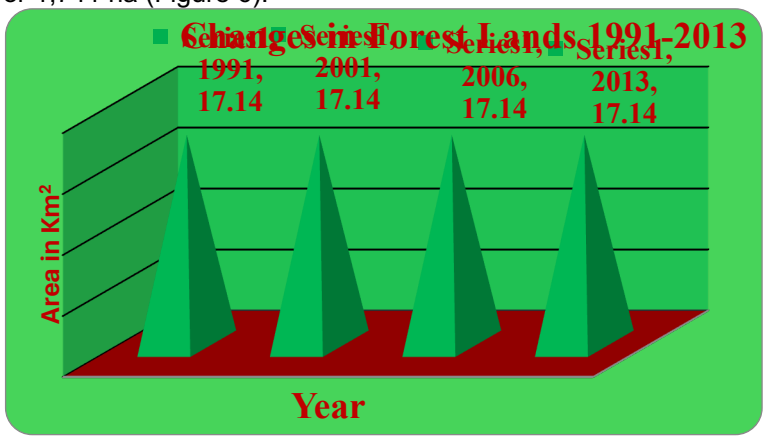

Figure 6. Changes in Forest Land

Conclusions

The land uses that had consistently lost throughout the period of our study (23 years) were the agricultural crop lands (CAGR = -0.28 per cent), current fallow lands (CAG = -1.73 per cent), wastelands (CAGR = -0.04 per cent) and waterbodies (CAGR = -0.12 per cent). Built-up lands were the only land use that showed increase throughout the period, almost 33 per cent increase over the 23-year period. It amounted to a compounded annual growth rate of 1.25 per cent over the entire period. But it was 0.74 per cent over 1991-2001, 1.88 per cent over 2001-06, and 1.48 per cent over 2006-13. The forest lands had not shown any change in their extent throughout the period of our study.

As in others metropolitan areas, we expect the growth of residential land use and this is recognized being very important for economic and ecological planning. Urban pressure from Madurai metropolitan area has the result of decreasing importance of agriculture in the local economy.Several areas will preserve the agricultural features, mainly with vegetables, flowers or cereals. Nearer to Madurai arable land has been transformed into mainly built-up areas, because of escalating level land prices.

There has been a general trend in the sale of agricultural lands to real estate operators or private land developers for residential, commercial, institutional and other uses. This trend has been possible because (a) agriculture has not been a profitable proposition, (b) there has been a general and fast decline in the interest in agriculture owing primarily to educational attainments and newer employment opportunities in the metropolis and other cities of the country, and (c) the money from the sale of agricultural lands has become the capital for investment in other economic activities in the metropolis as well as elsewhere.

References

Adepoju M.O., Millington A.C., Tansey K.T., 2006., Land use/land cover change detection in metropolitan Lagos (Nigeria): 1984-2002, ASPRS 2006 Annual Conference Reno, Nevada (May 1-5).

Burrough P. A., 1986., Geographic Information Systems for Land Resources Assessment, Oxford: Clarendon Press.

Chillar J., 2000. Land cover mapping of large areas from satellites: status and research priorities. *International Journal of Remote Sensing* 21(67), 1093-1114.

Dale P. 1997. Land tenure issues in economic development, *Urban Studies* 34, 1621–1633.

Haridas V.R. 1998., Evaluation of groundwater resources of Thevaram Basin, Tamil Nadu, India, An Integrated GIS Approach. Ph.D. Thesis (Unpublished).Bharathidasan University, Tiruchirapalli.

Kelarestaghi A., Ahmadi H., Jafari M. 2006., Land use changes detection and spatial distribution using digital and satellite data, case study: Farim drainage basin, Northern of Iran, *BIABAN* (*Desert Journal*). 11(2), 33-47.

Kundu A., 1992., Urban development and urban research in India. New Delhi: Khanna.

Lerise F., Lupala J., Meshack M., Kiunsi R., 2004., Managing urbanisation and risk accumulation processes: Cases from Dar 'es Salaam. Tanzania.Dar 'es Salaam: University College of Lands and Architectural Studies.

Mabogunje A. K., 1992., Perspectives on urban land and urban management policies in Sub-Saharan Africa.World Bank Technical Paper No. 196. Washington, D.C.

Naab F.Z., Dinye R.D., Kasanga R.K., 2013., Urbanisation and its impacts on agricultural lands in growing cities in developing countries: A case study of Tamale in Ghana. *Modern Social Science Journal* 2(2), 256-287.

Olima W. H. A., 2003., Urbanisation and housing challenges. Cities in Africa Conference. Rapporteur's report.

Rajan K.S., Shibakshi R., 2000., A GIS based integrated land use/cover change model to study human land interactions. *International Archive of Photgrammetry and Remote Sensing*, 33(B7), 1212-1219.

Rogan J., Chen D.M., 2004., Remote sensing technology for mapping and monitoring land-cover and land-use change.*Programming in Planning* 61, 301-325.

Star L., Estes J.E., McGwire K.C., 1997., Integration of geographic information systems and remote sensing. New York, NY: Cambridge University Press.