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LAND USE LAND COVER CHANGE DETECTION IN MADURAI DISTRICT, TAMIL NADU, INDIA: USING SATELLITE REMOTE SENSING

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Abstract

Land use and land cover (LULC) changes is a dynamic, widespread and accelerating process, mainly driven by natural phenomena and anthropogenic activities, which in turn drives changes that world impact natural ecosystem. Change detection is one of the landscape ecological aims. Major aim of this study is to prepare land use land cover and their change detections by using remote sensing and GIS techniques. Empirical observation revealed a change in land use land cover classification in Madurai district in Tamil Nadu state, India. In this paper an attempt is made to study the changes in land use and land cover in Madurai over 33 year period (1973 - 2006). The study has been done through Landsat imageries of February 1973, April 1990 and January 2006. The land use and land cover classification maps were prepared through remote sensing and GIS technology. Ground truth observations were also performed to check the accuracy of the classification. The results indicate that there was a significant increasing trend in built up land and decreasing trend in agricultural land.

Keywords: Land use Land cover, change detection, Image classification, Madurai District, GIS and Remote Sensing.

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Introduction

Land is the most important natural resource, which comprises soil and water and the associated flora and fauna, thus involving the total eco system. Knowledge of the spatial distribution of land use and land cover is essential for the planning and management activities. Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. Definition of land use in this way establishes a direct link between land cover and the actions of people in their environment. It can be defined as the use of land by human, usually with emphasis on the functional role of land in economic activities. In contrast, land cover, in its narrowest sense, often designates only the vegetation either national or man-made, on the earth's surface. Land cover lacks the emphasis on economic function that is essential to the concept of land use.

The term land cover describes the types of materials/features present on the surface of the earth. Land cover is the observed (bio) physical over on the earth's surface. Land use patterns reflect the character of a society's interaction with its physical environment, fact that becomes obvious when it is possible to see different economic and social systems occupying the similar environments. Knowledge of land use and land cover is important for many planning and management activities concern concerning the surface of the earth. Survival of human race depends on its living in harmony. Many a civilization has perished in the past when its people misused and over and over exploited the land, and interfered with the environment. Land use refers to 'man's activities on land, which are directly related to land' (Anderson et al., 1976). Building, lakes, forest, trees and glacial ice are all examples of land cover types. The term land use relates to the human activity associated with specific place of land. Land use can also be described as urban use, residential use, or single family residential use.

Land use and land cover change (LULCC) is general term for the human modification of Earth's terrestrial surface. Land use land cover arrangement makes landscape patterns. Land use land cover change (LULCC) detection is very essential for better understanding of landscape dynamic during a known period of time having sustainable management. Land use land cover changes is a dynamic, widespread and accelerating process, mainly driven by natural phenomena and anthropogenic activities, which in turn drives changes that would impact natural ecosystem.

Land use patterns reflect the character of a society's interaction with its physical environment, a fact that becomes obvious when it is possible to see different economic and social systems

occupying the same or similar environment. Scientific research community called for substantive study of land use changes during the 1972 Stockholm conference on the Human Environment, and again 20 years later, at the 1992 United Nations conference on Environment and Development (UNCED).

Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy (Kachhwala, 1985) in association with Geographical Information System (GIS) that provide suitable platform for data analysis, update and retrieval (Star et al. 1997). Space borne remotely sensed data may be particularly useful in developing countries where recent and reliable spatial information is lacking (Dong et al. 1997).

Prakasam (2010) studied the land use and land cover change in Kodaikanal region of Western Ghats in Tamilnadu State of India to observe changes during a span of 40 years from 1969 to 2008, using Landsat satellite data and performing supervised classification techniques, he found that 70% of the region was covered in forests in 1969 but has decreased to 33% in 2008, The built-up lands have increased from 3% to 21% showing that the region is affected by rapid urbanisation which is leading to adverse environmental effects for the identified bio-diversity rich region of Kodaikanal.

Land use land cover mapping and detection of change using remote sensing and GIS techniques is of paramount importance to planners, geographers, environmentalists, and policy makers, in fact to everybody who cares about human sustainable development. Land use patterns reflect the character of a society's interaction with its physical environment, a fact that becomes obvious when it is possible to see different economic and social systems occupying the same or similar environment.

At national levels, land use information is an important element in forming policies regarding economic, demographic, and environmental issues. In the United States, such policies might pertain to determining the location, extent, and character of surface mining, losses of agricultural land to Urbanisation; national parts and defence installations; or storage and disposal of hazardous wastes, to mention only a few of today's many controversial issues pertaining to land use. At local levels, it may be practical to gather data by direct observation or to combine direct observation with the use of remote sensing imagery. At the state level it would seem to be impractical to rely on any method except aerial photography or other remote sensing imagery.

Land use information is of great significance in scientific and scholarly research. National and regional land use patterns reflect the character of the interaction between man and environment and the influence of distance and resources based on mankind's basic economic activities. As a result, geographers, economists, and others have long regarded knowledge of regional land use patterns as a fundamental element in their studies of economic system. The importance of land use in the theories developed by Von-Thune, Losch, and others in the fields of regional science, economics, and geography demonstrates evidence of the fundamental importance of land use in both theoretical and applied research.

Remotely sensed images are useful to accurate analysis of land use and land cover mapping in part because land cover information can be interpreted more or less directly from evidence visible on aerial and satellite images.

This study attempts an assessment on land use and land cover changes of Madurai District, Tamil Nadu state, India, by means of Satellite images taken on different dates with the aim of identifying changes due to human activities and its impact on the environment. The method which was used for the purpose of the study depends on comparative analysis of three independently classified Land sat TM images.

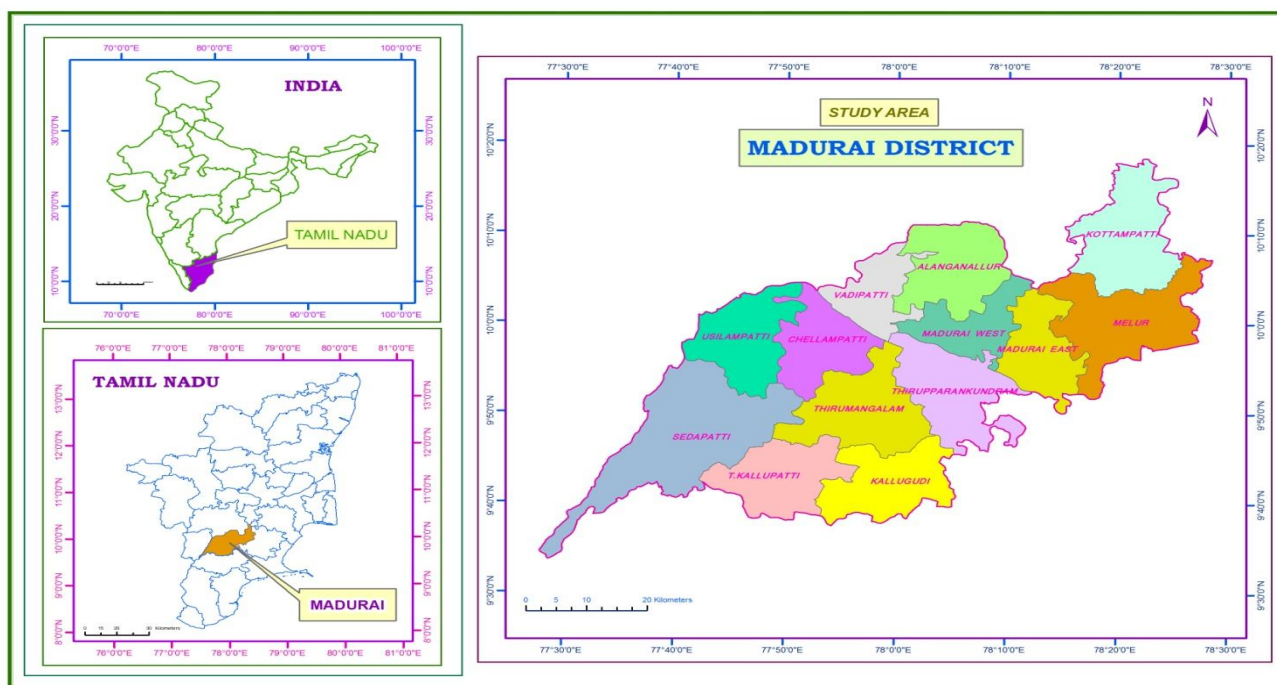**Study Area**

Location of the Study Area

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Figure No: 1

Madurai district is extended to an area of 3,741.73 Sq.Kms. and is bounded by Dindigul district in the North, Sivaganga district in the East, Virudhunagar district in the South and Theni district in the West. The district lies between 9º30' and 10º50' Northern Latitude and between 77º10' and 78º30' Eastern Longitude (Figure No: 1). More then 85 per cent of the soil of the districts classified as red soil (the regular) predominants in Thirumangalam taluk and parts of Peraiyur and Usilampatti Taluk. Vaigai Dam was constructed during 1954-1959. The Vaigai River originates on the eastern slopes of the Varushanadu hills in Theni taluk at an altitude of 1525 M (5000 Feet). The Vaigai River traverses about 43 KM. The First Vaigai Water Supply Scheme was commissioned in 1996 with the Vaigai Dam as source and under this scheme 900 MCF of water is drawn annually. Madurai district experiences a semi-arid type of climate. Hot and dry climate generally prevails over the districts. As the district is having hills and plains, the climate varies. During summer season, form March to July, temperatures is very high and December to January marks the winter season in which the temperature is below the normal. Madurai has two Meteorological Observatories, one is located at Madurai Airport and the other is in Madurai South. As per 2011 census, the total population of Madurai district has registered as 3,041,038 persons, with 1,528,308 males and 1,512,730 females. In 2001, the total population of Madurai district was returned as 2,579,201; the rural as 1,134,025 and the urban as 1,444,176. In 1991, these were 2,400,399, 1,203,791 and 1,196,548 respectively.

Objective

The main objective of the present study is to analyse and identify the nature and extent of land use and land cover changes in Madurai district in the past 33 years and to identify the main forces behind the changes.

Methodology

In the present study, six land use land cover (LULC) categories were identified namely Agriculture, built up, fallow land, forest, harvested land and water bodies. Description of these land clover classes are presented in Table 1.

Table No: 1

Land Cover Classification

Land Cover Classification	Description

Agriculture	Crop land and Pasture
Forest	A dense growth of trees, plants, and underbrush covering a large area.
Fallow land	Crop land that is not seeded for a season, waste and uncultivated land
Harvested land	The crop that ripens or is gathered in a season.
Water bodies	River, canals, lake and Pond
Built up	Residential, industrial, transportation, communications, commercial Complexes and services.

Multi – temporal satellite data set observed by LANDSAT 1, Multi spectral scanner (MSS), LANDSAT 5, Thematic Mapper (TM) and LANDSAT 7, Enhanced Thematic Mapper+ (ETM+) were used for the analysis (Table: 2).

Table No: 2

Spatial Data Sources

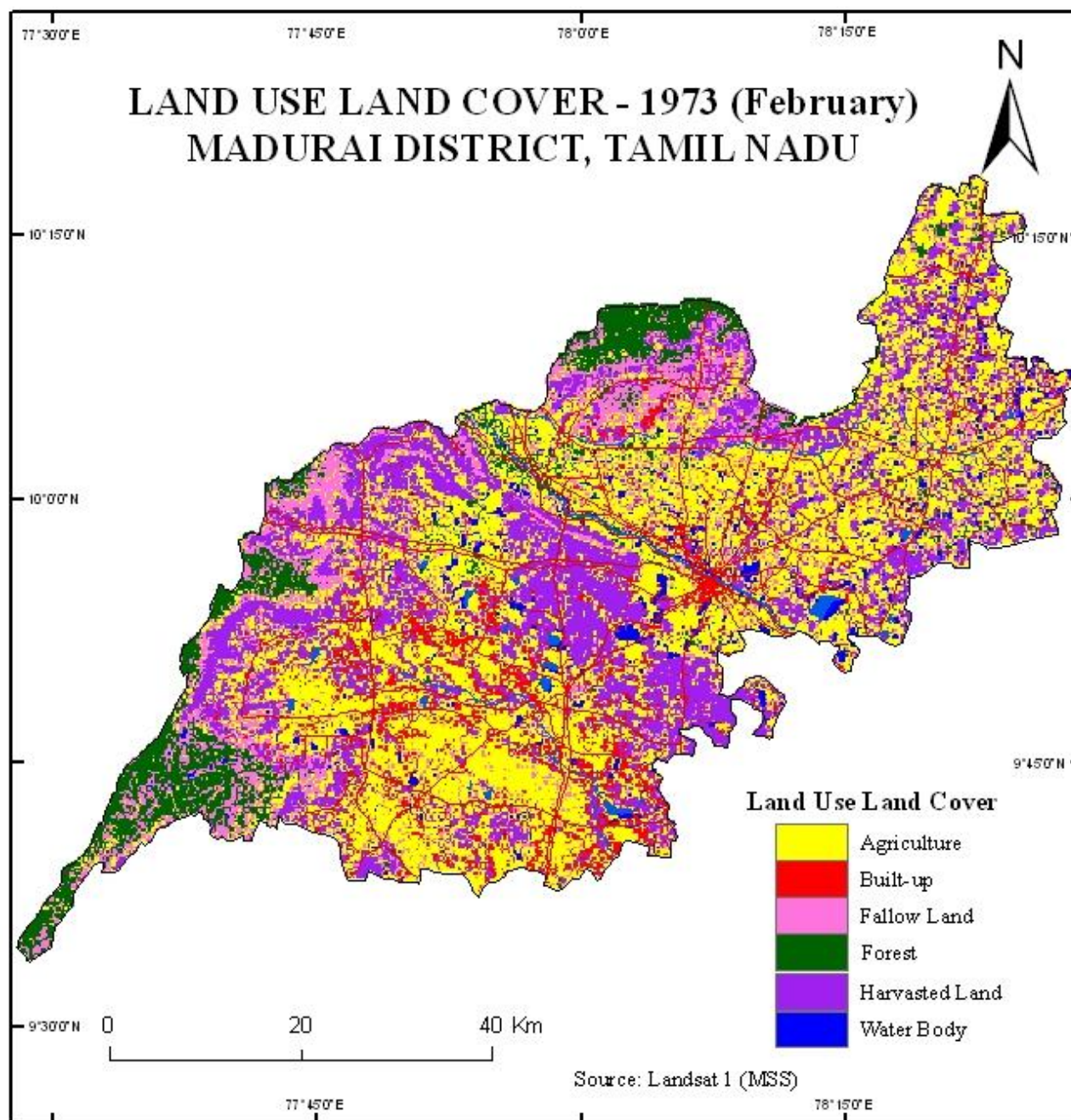| Data	Month of Observation	Spatial Resolution
Landsat 7 (ETM+)	2006 - January	30m
Landsat 5 (TM)	1990 - April	30m
Landsat 1 (MSS)	1973 February	30m

Result and Discussion

Agriculture is the major activity in this study area. The findings of the present investigation are presented in table 3. Most of the agricultural lands are cultivated paddy, Maize, Pearl millet, cotton, sugar cane and groundnut. But day by day agricultural lands are converted to built up (settlement and transport) and fallow land.

According to Land sat imageries of the year 1973 agricultural lands covered above 57 per cent of the study area (Table: 3). This has been decreased to 6 per cent in 2006 (January Landsat ETM+) imageries and 14 per cent in 1990 and increasing in harvested land (Landsat 5 TM), because this is harvested period of southern Tamil Nadu.

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Land use land cover- 1973 (February)

Figure No: 2

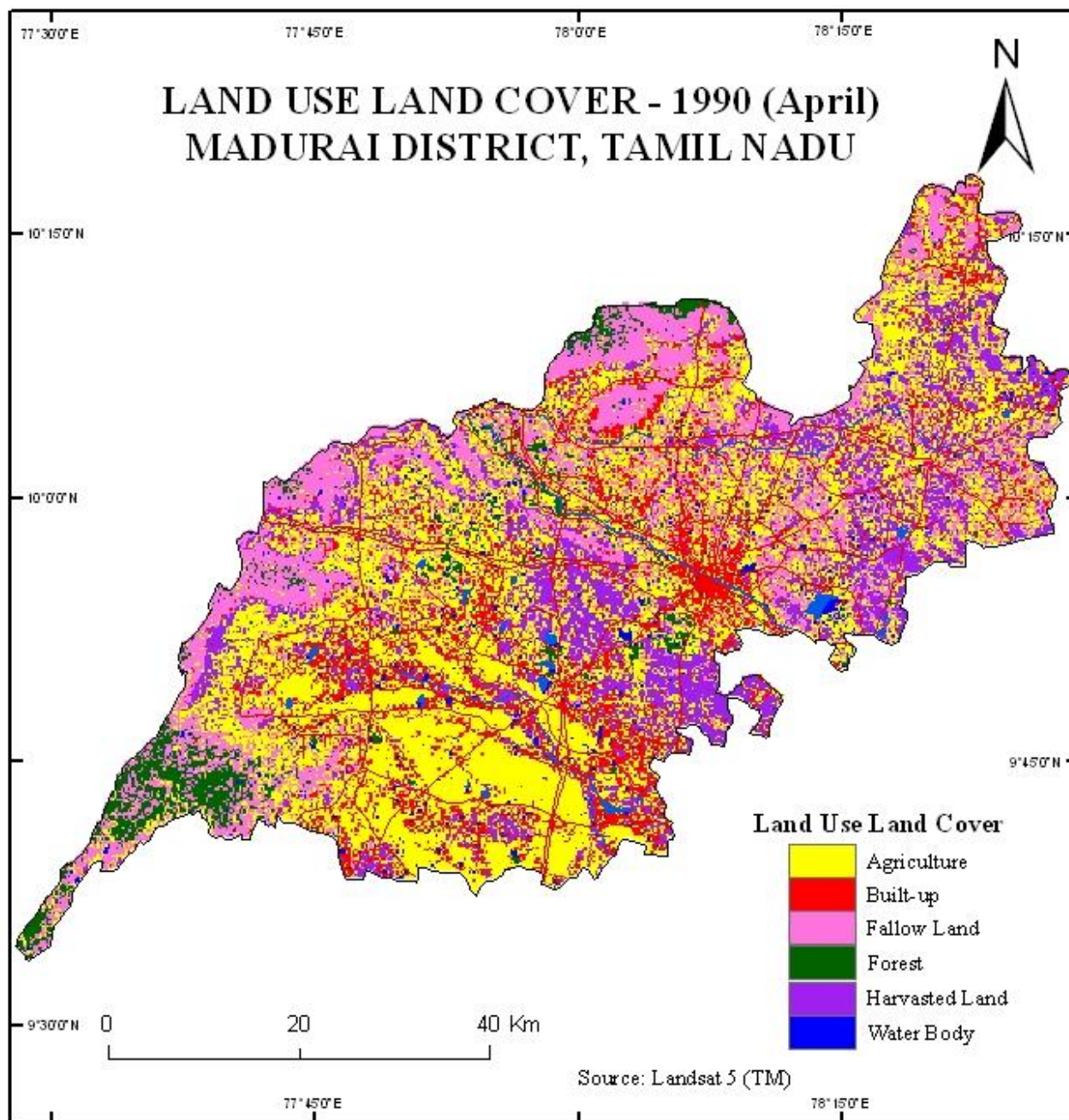*Land Use land cover -1990 (April)*

Figure No: 3

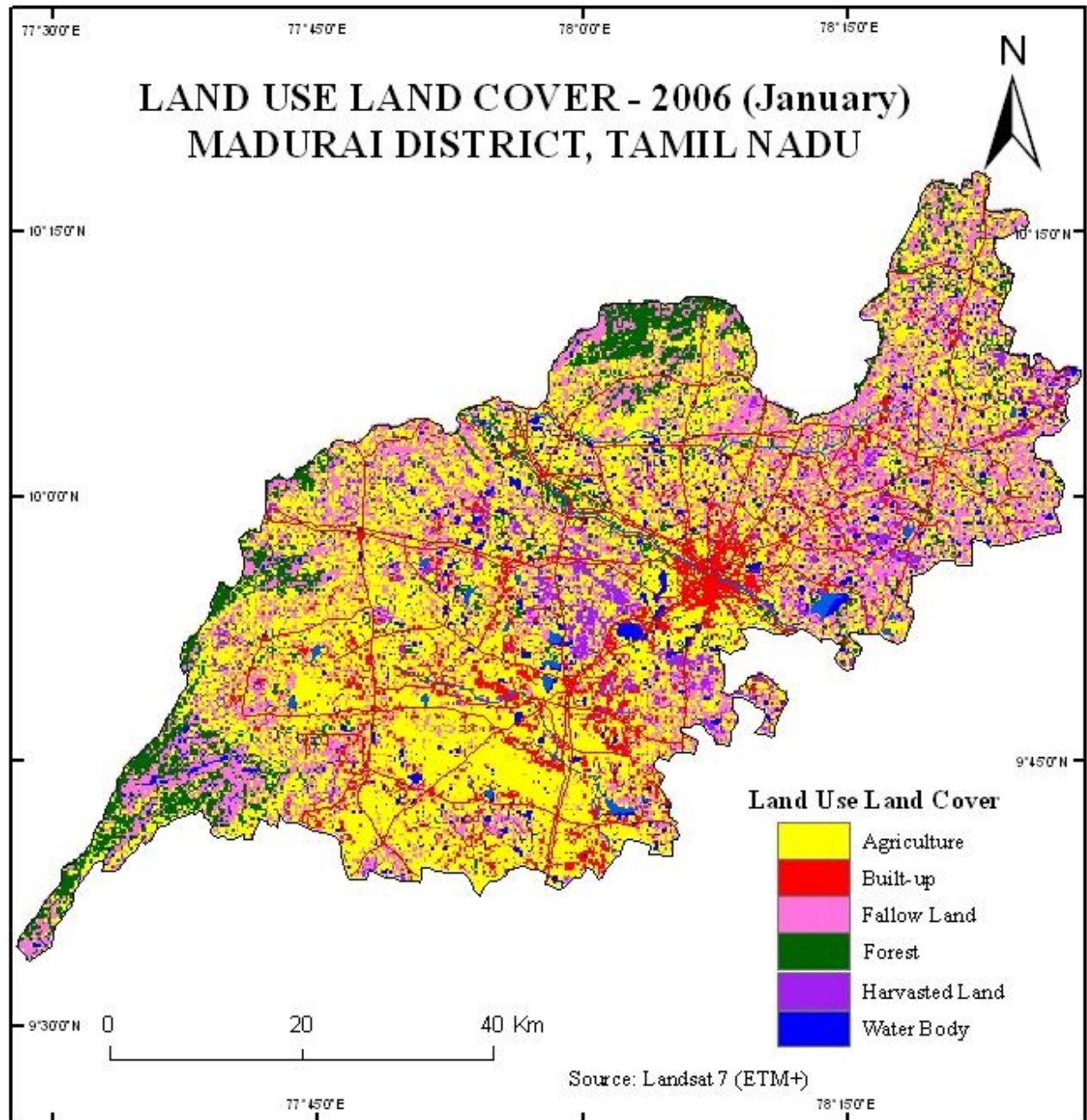*Land Use land cover – 2006 (January)*

Figure No: 4

Table No: 3

Madurai District: Area under Land Use and Land Cover

S.No.	LU LC	February - 1973 (MSS)		April - 1990 (TM)		January - 2006 (ETM)	
		Area in Hect's	Area in %	Area in Hect's	Area in %	Area in Hect's	Area in %
1	Agriculture	214671.80	57.37	162887.90	43.53	192582.00	51.47
2	Fallow land	51370.00	13.73	69776.00	18.65	70745.70	18.90
3	Forest	25092.20	6.71	20443.80	5.47	15736.80	4.21
4	Harvested land	31803.60	8.50	69197.82	18.49	26005.50	6.95
5	Water bodies	30731.40	8.21	20887.48	5.58	10384.10	2.78
6	Built-up	20504.00	5.48	30980.00	8.28	58718.60	15.69
	Total	374173.00	100	374173.00	100	374173.00	100

Built up land includes settlements, transportation and recreation places. The growth and development of urban areas is around the Sri Meenakshi Amman Temple. Sri Meenakshi Amman Temple is the core of this study area. This study area has four way transports constructed on 2005.

Distribution of Land Use Land Cover Change during the three periods in the study area.

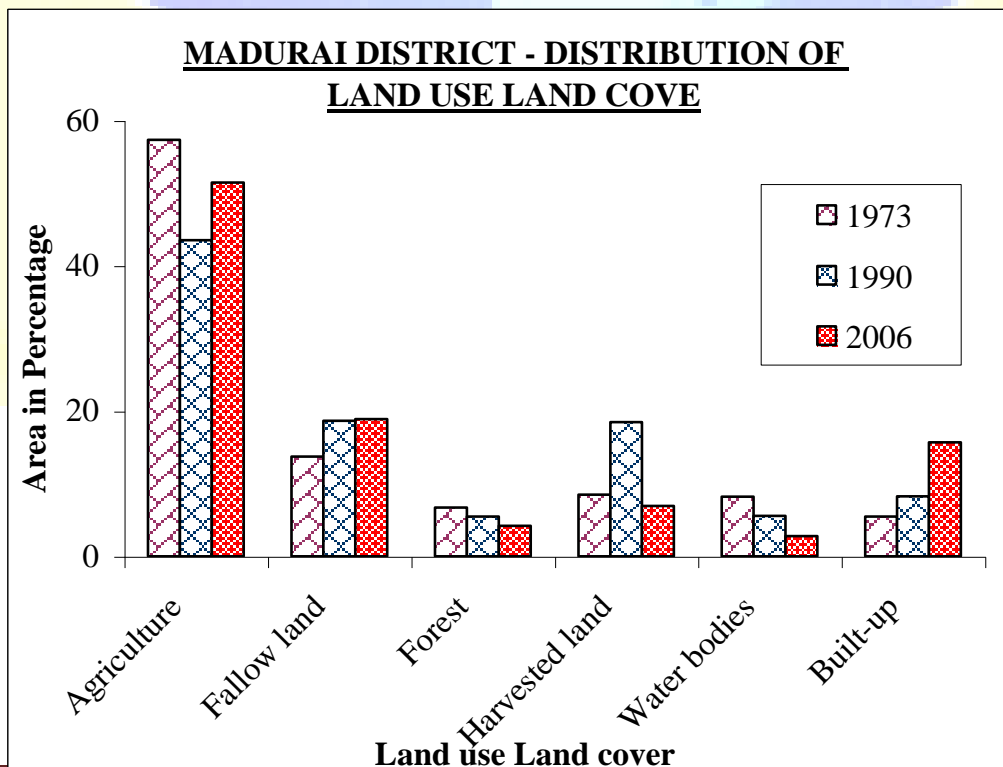MADURAI DISTRICT - DISTRIBUTION OF LAND USE LAND COVE

Figure No: 5

Water bodies include rivers, ponds, canals and wells. Water bodies covered only 8.25 per cent of the study area in 1973 (Figure No: 5 and table 3). It has decreased 5.58 per cent in the year of 1990 and 2.78 per cent in 2006. The reasons of decreasing water bodies are; Water bodies are changed to settlements and transport. Failure of seasonal rainfall and. Government did not proper maintenance.

But now a day's urbanisation is a major problem in the area, because the agricultural labourer's area goes and searches the job for tertiary activities. For reason attraction of Technology, no interest in involve the agricultural activities, shortage of source of water facilities, climatic change and low income. People have exchange form agricultural land to settlement because the demand of settlement in the study area. They also occupy the dry water bodies for their settlements, transport facilities and industrial development. The industrial and settlement waste material are putting in water bodies. This is the important one for decrease water bodies. Later this water bodies are carrying waste materials and changed to sewage (for e.g. Vaigai River and Kiruthumal Nathi).

Table 4

Madurai District: Changes in Land Use and Land Cover Change

S.No.	LU/LC	February - 1973 (MSS) Area in%	April - 1990 (TM) Area in%	January - 2006 (ETM) Area in%	Changes in 1990-1973	Changes in 2006-1990	Changes in 2006-1973
1	Agriculture	57.37	43.53	51.47	-13.84	7.94	-5.9
2	Fallow land	13.73	18.65	18.9	4.92	0.25	5.17
3	Forest	6.71	5.47	4.21	-1.24	-1.26	-2.5
4	Harvested land	8.5	18.49	6.95	9.99	-11.54	-1.55
5	Water bodies	8.21	5.58	2.78	-2.63	-2.8	-5.43
6	Built-up	5.48	8.28	15.69	2.8	7.41	10.21
	Total	100	100	100			

From this analysis, it is found that agricultural land, water bodies and forest are decreasing in trend, and fallow land and built up land are increasing in trend.

Findings, Implications and Recommendations

1. The study area has experienced a change in its land utilisation between 1973 and 2006.

2. Land used for agriculture has experienced a decline from 57.37 per cent to 43.53 per cent in 1990 and 51.47 per cent. The decline in land used for agriculture is not healthy trend.

3. Land classed under fallow has increased from 13.93 per cent to 18.90 per cent. This also is not a healthy trend for sustainable development. Personal observation revealed that farmers have a tendency to leave the land as fallow for about 5 years continuously and sell it to the property promoters and real estates.

4. The fluctuating trend in harvested land may safely be attributed to season of observation of the data.

5. An alarming declining trend in area under water bodies from 8.21 per cent in 1973 to 5.58 per cent in 1990 and to 2.78 per cent in 2006.   The water bodies also when they are died encroached by real estates and property promoters.

6. The land utilised for built up area has experienced a three fold increase from 5.48 per cent to 15.69 per cent between 1973 and 2006 within a period of 33 years. The study area had a population of 1,730,109 persons in 1971, 2,042,704 persons (1981), 2,400,339 (1991), 2,578,201 (2001) and 3,041,038 persons in 2011 marking an increase of 175.77 per cent between 1971 and 2011.

Summary and Conclusion

This paper aims investigating land use land cover changes occurred in Madurai district between 1973 to 2006 using remote sensing and GIS technology. The study has clearly brought to light a decline in land under cultivation. Any planning towards sustainable development should aim at preserving the land under cultivation. This sustainable development should have a far vision to leave land for cultivation for our successors. An unplanned conversion of land under agriculture and water bodies to build up area must be checked by government legal procedures. This will enable the land to be sustained for agriculture.

Land use land cover mapping and detection of changes shown here may not provide the ultimate explanation for all problems related to land use/land cover changes but it serves as a base to understand the patterns and possible causes and consequences of land use land cover changes in the study area.

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