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# Urban Sprawl Prediction and Change Detection Analysis in and around Thiruvannamalai Town Using Remote Sensing and GIS

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**ABSTRACT:** Distribution network for conveying water, power and sewage are essential for urban development. Because of rapid growth on urbanization and industrialization, there is an exponential growth in population which results in a greater surge in community development program and urban growth. As a prelude to the mapping of the area under such growth help us to device the appropriate town/city planning. Now-a-days, rural areas are changed into urban (i.e.) metropolitan area. In the present study remote sensing and Geographical information system techniques are used for detecting land use and land cover changes for the year 1995, 2005 and 2015 in Thiruvannamalai by using satellite image and secondary data of this area. With the help of these data, urban growth for the forthcoming year 2025 and 2035 is estimated by using trend line analysis and Marcov chain analysis. This study mainly highlights the time to time changes of urban growth using Remote sensing and GIS techniques.

KEYWORDS: GIS techniques, Trend line analysis and Transistion probability matrix.

# I. INTRODUCTION

Urban growth is a spatial and demographic process, involving the concentration of human population with higher level of economy. It is a dynamic complex phenomenon involving large scale changes in the landuses at local levels. Analysis of changes in land uses in urban environments provide a historical perspective of landuse and an opportunity to assess the spatial patterns, correlation, trends, rate and impacts of the change which would help in better regional planning and good governance of the region. The prediction and simulation of urbanization is very important among the studies of land use. Satellite remote sensing is a potentially powerful means of monitoring land-use change at high temporal resolution and lower costs than those associated with the use of traditional methods (El-Raey et al., 1995). Modeling is essential for analyzing, especially for the prediction of the dynamics of the urban growth (Clarke & Silva, 2002). In this study, we demonstrate how satellite imagery can be displayed, mapped and analyzed by using digital image processing software like ERDAS IMAGINE 9.1 and Arc GIS 10.1. The aim and objectives of this paper is

- > To monitor and to analyse the urban growth for a period 3decades at 10 years interval i.e., 1995, 2005 & 2015
- > To develop the thematic maps like land use/land cover of 1995, 2005 and 2015.
- > To predict the future urban growth in 2025 and 2035.



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# **II. STUDY AREA**



Fig. Study Area

The study area is **Thiruvannamalai** and its surrounded by: Latitude: 12°00′00″to12°15′00″N Longitude: 79°00′00″to79°15′00″E Mean sea level: 174 m = 570 ft

The Thiruvannamalai is located to the east of Eastern Ghats. The topography of Thiruvannamalai is almost plain sloping from west to east. Thiruvannamalai experiences hot and dry weather throughout the year. The temperature ranges from a maximum of 40 °C (104 °F) to a minimum of 20 °C (68 °F). Like the rest of the state, April to June is the hottest months and December to January are the coldest. The area of investigation is about 30.13 sq.km. It is one of the most famous temple towns of India. It receives large number of piligrims throughout the year. It has high potential for growth in industries around the town. To create better urban solutions for this growing city. Urban growth is one of the main problems that reduces the limited highly fertile land in these cities. In this context, Thiruvannamalai is facing various urban environmental problems. For sustainability of urban systems a balanced land use/land cover is planned.

# **III .METHODOLOGY**

### A. Data used:

DATA	SOURCE	PURPOSE
SATELLITE IMAGE	USGS-LANDSAT TM-1995, 2005 and 2015, resolution-30m, Row/path: 143/52.	Land use and land cover classification-1995, 2005, 2015.
TOPOSHEET	D44T4 toposheet on 1:50000 scale.	Study area extraction.
REFERENCE MAP(secondary data for landuse and landcover map)	Town planning department, Municipalityoffice, Thiruvannamalai.	Accuracy assessment

The whole project divided into following methodology:



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### B. Flow of work:



Fig 2. Methodology.

## **IV.RESULTS AND DISCUSSION**

#### A. Land use/Land covers classification:

The term Land cover relates to the type of feature present on the surface of the earth. The information gained like Land use /Land cover permits a better understanding of the land utilization aspects on Dry land, Barren land, Water bodies, Forest area and Built-up area. Land use information that can be gained by LANDSAT imagery visually and digitally interpreted.



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### B. Mapping of Landuse/Landcover for 1995, 2005 & 2015



Fig 3. Classification map 1995

### B.1 .Built- up area

Built- up area is the area of human habitation which has a cover of buildings, transport, communication utilities in association with water, vegetation and land. Most of the rural settlements could not be identified on the imagery, because of their small area extent and their spectral signatures are mixed with vegetation. Due to the presence of port, rapid industrialization and for various other reasons, the demand for the land is very high.

### **B.2.** Forest area

The forest show bright red colour on the FCC and dark tone on the black and white images. The eastern ghats and its slopes and some residual hills noticed below the foothills of the study area.



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Fig 4. Classification map 2005

### **B.3.** Waterlogged area

Water logged area show medium to dark tone on the black white images, light to blue on FCC in which that the features near to the stream.

### **B.4.** Barren land

Barren land shows light tone on black and white images and yellow to brownish colour on FCC. They occur as hills, rock beds etc.,

### B.5. Dry land

Dry land show mild light tone on black and white images and yellow colour present in FCC.



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Fig 5.Classification map 2015

LU/LC	AREA IN HECTARES			PERCENTAGE (%)		
	1995	2005	2015	1995	2005	2015
Water bodies	135.864	101.016	64.44	4.5	3.4	2.1
Built-up area	662.112	1065.15	1402.72	22	35.3	46.6
Forestarea	974.952	854.352	769.806	32.4	28.3	25.5
Barrenland	603.072	393.194	236.61	20	13.15	7.9
Dryland	637.164	599.586	539.586	21.1	19.85	17.9
TOTAL	3013.164	3013.186	3013.16	100	100	100

Table 1. Area calculation in 1995, 2005 & 2015



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#### C. Performance Analysis of Change Detection in 1995, 2005 and 2015

Change Detection Analysis used to identify, describe, and quantify differences between images of the same scene at different times or under different conditions. The classified images of three different years are used to calculate the area of different land covers and to observe the changes that has taken place during the span of data. This analysis is very much helpful to identify various changes occurring in different classes of landuse like increase in urban built-up area or decrease in agricultural land and so on.

LU/LC	Change area 1995/2005(hectares)	Change area 2005/2015(hectares)
Waterbodies	-34.848	-36.576
Built-up area	+403.038	+337.52
Forestarea	-120.6	-84.546
Barrenland	-209.898	-156.564
Dry land	-37.692	-59.886

Table 2. Change detection between 1995, 2005 & 2015

In the year 2005 the water bodies' area reduced to 34.848 hectares, Built-up area increased to 403.038 hectares, Forest area reduced to 120.6 hectares, Barren land reduced to -209.898 hectares and Dry land reduced to -37.692 hectares. In the year 2015 the Water bodies area reduced to 36.576 hectares, Built-up area increased to 337.572 hectares, Forest area reduced to 84.546 hectares, Barren land reduced to 156.564 hectares, Dry land reduced to 59.886 hectares.



Chart 1: Comparison of Land Use / Land cover in 1995, 2005 & 2015



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#### **D.** Urban Sprawl:

The increase population and rapid urbanization causes great change in the centre of the city and the problem. Thus the pressures of the continuous growing city center gradually change the surrounding environment and neighborhoods. **Sprawl** generally refers to some type of development with impacts such as loss of agricultural land, open space, and ecologically sensitive habitats. In simpler words, as population increases in an area or a city expands to accommodate the growth, this expansion is considered as sprawl. Usually sprawls take place on the urban fringe, at the edge of an urban area or along the highways.

### E. Future Prediction:

#### MAPPING OF URBAN SPRAWL 1995, 2005 AND 2015







Fig 6. Urban Sprawl map in 1995, 2005 & 2015



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In the year 1995 Urban sprawl was around 662.112 hectares and its suddenly increased in the year 2005 to 1065.15 hectares and in the year 2015 urban sprawl became 1402.722.

The future land use and land cover predicted by using two methods such as TRENDLINE ANALYSIS and TRANSITION PROBABILITY MATRIX.

### F. Method1: Trend line Analysis:

Trend line analysis is the analysis which would helpful to predicting future. This analysis mainly used for business and marketing to predicting future.

YEAR	URBAN SPRAWL AREA IN
	HECTARES
1995	662.112
2005	1065.15
2015	1402.722

Table 3. Urban Areas in 1995, 2005 & 2015



Chart 2. Trend line prediction in 2025 & 2035

Various trend line were fitted to predict the Built-up area growth of study area, the best result were given by a linear trend line such as Y = 370.3X+302.7 and  $R^2 = 0.997$ . The estimated Built-up area in 2025, and 2035 will be around 1770 and 2250 hectares.

### G. Method2: Transition Probability Matrix:

Transition probability matrix analysis or Markova chain analysis. Markov chain models are particularly useful to geographers concerned with the problems of movement, both in terms of movement from one location to another and in terms of movement from one state to another. Its mainly used for describing and analyzing the nature of changes generated by the movement of such variables. In some cases Markov models may be used also to forecast the future changes.

Transition probability matrix forms mainly based on post classification matrix. Post classification or cross tabulation is a means to determine quantities of conversions from a particular land cover to another land cover category at a later date. The changes matrices based on post classification comparison were obtained are shown in Table 4 and 5.

Markov model result is a transition matrix which shows the probability of changes from each class of land cover or land use to each other class in future. Table 6 is the probability transition matrix of different land cover types of this study area. In this research 1995, 2005 and 2015 land cover maps to predict the 2025 land areas. Future land use statistics can be observed in Table7 and Figure 7.



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2005	1995					
		Water	Built-up	Forest	Barren	Dry land
		bodies	area	area	land	
	Water	101.16	0	0	0	0
	bodies					
	Built-	0	662.112	301.316	101.7216	0
	uparea					
	Forest	0	0	613.359	0	240.993
	area					
	Barren	34.848	0	0	358.326	0
	land					
	Dry	0	0	60.263	143.024	396.1846
	land					

# Table 4. Post matrix in 1995&2005

	2005					
2015		Water	Built-up	Forest	Barren	Dry Land
		Bodies	Area	Area	Land	
	Water	64.44	0	0	0	0
	Bodies					
	Built	0	1065.165	301.3164	36.242	0
	uparea					
	Forest	0	0	311.862	0	457.664
	area					
	Barren	36.576	0	0	148.248	51.786
	land					
	Dry	0	0	241.053	208.511	90.022
	land					

Table 5. Post matrix in 2005 & 2015

TPM	WATER	BUILTUP	FOREST	BARREN	DRY
	BODIES	AREA	AREA	LAND	LAND
WATER	0.638	0	0	0	0
BODIES					
BUILTUP	0	1	0.324	0.0547	0
AREA					
FOREST	0	0	0.2865	0	0.6986
AREA					
BARREN	0.0400	0	0	0.4137	0.1445
LAND					
DRY	0	0	0.5648	0.559	0.1209
LAND					



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Table 6. Transition probability matrix in study area

LU/LC	AREA IN 2025 (hectares)	Change area 2015/2025(hectares)
Water bodies	41.113	-23.327
Built-up area	1772.05	+369.33
Forest area	662.8675	-107.36
Barren land	153.1379	-83.4721
Dry land	474.234	-65.352

Table 7. Areas in 2025 & Change detection 2015/2025



Fig 7. Predicted land cover in Thiruvannamalai area in 2025

The above figure that represented as land use and land cover changes in the year 2025

# **V. CONCLUSION**

It is evident from the study that there was a significant increase in built-up land over a period of 20 years, i.e., from 1995 to 2015. It is noticed that built-up land increased (by 112 %). It is expected to increase further and occupy about 60% of the total area by 2025. Except built-up land, all other classes decreased in their spatial extent. Decrease in water bodies (by 53%) and vegetative cover (by 21%) shows that there is an imbalanced urban growth in the region which will pose a severe threat to the environmental sustainability in the future. However, decrease in waste land (i.e., Barren land by 61% and Dry land by 15%) reveals that these areas were brought under land utilization during the above period. This study also highlights that remote sensing techniques are very useful for quantitative estimation of earth features in a quick and economical manner for proper planning and decision making.



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