

# AN ANALYSIS OF URBAN LAND USE / LAND COVER CHANGE IN CHENNAI METROPOLITAN: A GIS AND REMOTE SENSING APPROACH - 1991-2006

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## **Abstract**

*Land Use / Land Cover Change is increasingly recognized as being an important driver of Global Environmental Change. Current technologies such as Geographical Information Systems (GIS) and Remote Sensing (RS) provide a cost effective and accurate alternative to understanding landscape dynamics. The study focuses on the analysis of urban growth trend, examines the land use/land cover change and predicts the urban growth patterns by using the Markov Chain models at Chennai Metropolitan Area over the time period of 15 years and prediction of 2021 has been adopted. The correlation analysis is used to find the relationship between urban built-up, population growth and land value of Chennai Metropolitan. Chennai Metropolitan Area shows a rapid increase in urbanization from 1991 to 2006. Urbanization shows expanding the area of urban built-up. Despite from the horizontal expansion the density or thickness of built-up land is increasing in existing urban lands. Both Vegetation cover and Water bodies in Chennai Metropolitan is gradually decreasing. The projected Land Use / Land Cover for 2021 shows that Chennai Metropolitan area should be dominated by Built-up lands and the area covered by Vegetation will show a steep decline. The Land value analysis shows that Land value is increase is faster than the process of urbanization.*

**Key words:** Land Use / Land Cover, Urbanization, Markov Chain, Horizontal expansion, Vertical expansion.

## **Introduction**

Land Use / Land Cover Change are increasingly recognized as being an important driver of Global Environmental Change (Turner et al.1994). To ensure a sustainable management of natural resources, it is necessary to understand and quantify the process of landscape change. Urbanization is an inevitable process due to economic development and rapid population growth. It is generally believed that urbanization has both direct and indirect impacts on land use transformation. Urban growth remains a major topic concerning GIS and remote sensing applications. Remote sensing and GIS have proved to be effective means for extending and processing varied resolutions of spatial information for monitoring urban growth. The study focuses on the analysis of urban growth trend, examines the land use / land cover change and predicts the urban growth patterns by using the Markov Chain models at Chennai Metropolitan Area over the time period of 15 years and prediction of 2021 has been adopted. Markov process models are a class of probability models used to study the evolution of a system over time. Transition probabilities are used to identify how a system evolves from one time period to the next. A Markov chain is the behavior of the system over time, as described by the transition probabilities and the probability of the system being in various states. The results of the simulation can be effectively used to understand the relationship between the spatial pattern and urban growth in Chennai Metropolitan area. The correlation between land value and growth in urban land area as determined using the statistical method of correlation

## Study area

Chennai, the capital City of Tamil Nadu is the fourth largest Metropolitan City in India. The Chennai Metropolitan Area (CMA) comprises the city of Chennai, 16 Municipalities, 20 Town Panchayats and 214 Village Panchayats in 10 Panchayat Unions. The extent of CMA is 1189 Sq.kms. The CMA falls in three Districts of the Tamil Nadu State viz. Chennai District, part of Thiruvallur District, and part of Kancheepuram District. The extent of the Chennai District (covered in Chennai Municipal Corporation area) is 176 sq.kms and comprises 55 revenue villages in five Taluks.

## Objectives

The main objectives of this study to find out **Land use / Land cover change of Chennai Metropolitan Region between 1991 and 2006**. To predict the future Land use /Land cover change and suggest optimum planning strategy

## Methodology

Supervised Classification (level -II) is carried out using the satellite Imagery. Amount of area falling under each Land use / Land cover can be calculated. Change detection Map was prepared. Markov Chain Model can be used to predict future Land use / Land cover for 2021. Correlation analysis is used to find the relationship between urban built-up land and land value. The techniques used for this study include layer stacking process of multispectral satellite imagery. From the satellite imagery Chennai Metropolitan area is subset using the shape file. Supervised classification method is used to create the Land Use / Land Cover.

## Land use land cover change

### Land use land cover Chennai metropolitan – 1991

In 1990 thick built up covers an area of 6.67 Sq.Kms which covers 0.56% of the total Chennai Metropolitan Land Area. Moderate Built-up area covers 66.34 Sq.kms and covers 5.6% of the area. Sparse Built-up covers 442.1Sq.kms and occupies 37.12% of the total area. Thick vegetation has an area of 111.9 Sq.kms and covers an area of 9.4% of the total area. Moderate vegetation covers an area of 270.3 Sq.kms and occupies 22.7% of the total area. Water body covers 47.2 Sq.kms and has 5.2 % of the total area. Scrubs & Barren Land occupies 32.1 Sq.kms and covers 3.96% of the total area. Marshes & Swamps covers an area of 214.3 Sq.kms and covers 17.9% of the total area.

### Land use land cover Chennai metropolitan - 2000

In 2000 Thick Built up covers an area of 44.30 Sq.kms which covers 3.7 % of the total Chennai Metropolitan Land Area. Moderate Built-up area covers 189.4.kms and covers 15.9% of the area. Sparse Built-up covers 420.24 kms and occupies 35.27% of the total area. Thick vegetation has an area of 164.52 Sq.kms and covers an area of 13.8 % of the total area. Moderate vegetation covers an area of 176.97 Sq.kms and occupies 14.85% of the total area. Water body covers 23.65 Sq.kms and has 1.98 % of the total area. Scrubs & Barren Land occupies 84 Sq.kms and covers 7.0 % of the total area. Marshes & Swamps covers an area of 88 Sq.kms and covers 7.39 % of the total area

### Land use land cover Chennai metropolitan – 2006

In 2006 Thick Built up covers an area of 38.25 Sq.kms which covers 3.21% of the total Chennai Metropolitan Land Area. Moderate Built-up area covers 224.49 Sq.kms and covers 18.84% of the area. Sparse Built-up covers 478.40 Sq.kms and occupies 40.16% of the total

area. Thick Vegetation has an area of 118.70 Sq.kms and covers an area of 9.96% of the total area. Moderate Vegetation covers an area of 180.19 Sq.kms and occupies 15.13% of the total area. Water body covers 43.20 Sq.kms and has 3.62% of the total area.

### **Land use / land cover change of Chennai metropolitan 1991-2006**

In 1991, 47% of the land use was under vegetation. IN 2000, 28% of the total land area is covered by vegetation. In 2006, 25% of the total land area is covered by vegetation. Amount of vegetation is considerably reduced from 1991-2006. During this time interval 22% of the total vegetation is converted into other land area. The area under built up during 1991 constitutes 45.21%, in 2001 54.90% of area is covered by built up features and 59.67% of the land area was under built up in 2006. 14% of the built area is increased during 1991 to 2006. Water body shows 8.50% decrease from 1991 to 2006. Marsh and Swamp show a decrease of 58.93% from 1991 to 2000. From 1991 to 2006 Marsh and Swamp shows a decrease of 10.56%. From 1991 to 2006 Barren land shows a decrease of 9.76%.

### **Change detection analysis Chennai metropolitan 1991-2000**

#### **Land Use / Land Cover Change Matrix**

Overlay analysis provides change matrix of Land Use Land Cover from 1991 to 2000. Eight by eight (8 by 8) matrix table is presented below. From the change matrix it can be identified that how much quantity of each Land Use Land Cover transformed into other Land Use Land Cover and how much remained as same Land Use Land Cover. Matrix can represent picture about Land Use Land Cover from 1991 to 2000. 117.13 Sq.kms of Moderate Built-up is remained as Moderate Built-up. 0.18 Sq.kms of Moderate Built-up is converted into Scrubs & Barren. 20.71 Sq.kms of Moderate Built-up is converted into Dense Built-up. 0.20 Sq.kms of Moderate Built-up is converted into Marsh & Swamp. 22.24 Sq.kms of Moderate Built-up is converted into Moderate Vegetation. 91.13 Sq.kms of Moderate Built-up is converted into sparse Built-up. 23.93 Sq.kms of Moderate Built-up is converted into Dense Vegetation. 0.61 Sq.kms of Moderate Built-up is converted into Water body. 15.75 Sq.kms of Scrubs & Barren is remained as Scrubs & Barren. 9.16 Sq.kms of Scrubs & Barren is converted into Dense Built-up. 1.87 Sq.kms of Scrubs & Barren is converted into Marsh & Swamp. 36.31 Sq.kms of Scrubs & Barren is converted into Moderate Built-up. 17.78 Sq.kms of Scrubs & Barren is converted into Moderate Vegetation. 60.41 Sq.kms of Scrubs & Barren is converted into Sparse Built-up. 13.26 Sq.kms of Scrubs & Barren is converted into Thick Vegetation. 0.26 Sq.kms of Scrubs & Barren is converted into Water body. 1.68 Sq.kms of Sparse Built-up is remained as Sparse Built-up. 0.15 Sq.kms of Sparse Built-up is converted into Barren & Scrubs. 7.20 Sq.kms of Sparse Built-up is converted into Dense Built-up. 0.89 Sq.kms of Sparse Built-up is converted into Marsh & Swamp. 24.62 Sq.kms of Sparse Built-up is converted into Moderate Built-up. 0.53 Sq.kms of Sparse Built-up is converted into Moderate Vegetation. 0.15 Sq.kms of Sparse Built-up is converted into Thick Vegetation. 0.91 Sq.kms of Sparse Built-up is converted into Water body. 118.60 Sq.kms of Moderate Vegetation is remained as Moderate Vegetation. 18.41 Sq.kms of Moderate Vegetation is converted as Scrubs & Barren. 27.40 Sq.kms of Moderate Vegetation is converted as Dense Built-up. 1.28 Sq.kms of Moderate Vegetation is converted as Marsh & Swamp. 42.94 Sq.kms of Moderate Vegetation is converted into Moderate Built-up. 119.54 Sq.kms of Moderate Vegetation is converted into Sparse Built-up. 94.98 Sq.kms of Moderate Vegetation is converted into Thick Vegetation. 0.41 Sq.kms of Moderate Vegetation is converted into Water body. 24.76 Sq.kms of Dense Vegetation is remained as Dense Vegetation. 3.06 Sq.kms of Dense Vegetation is changed as Scrubs & Barren. 0.38 Sq.kms of Dense Vegetation is converted as Dense Built-up. 0.13 Sq.kms of Dense Vegetation is converted into Marsh & Swamp. 5.86 Sq.kms of

Dense Vegetation is converted into Moderate Built-up. 8.56 Sq.kms of Dense Vegetation is converted into Moderate Vegetation. 14.32 Sq.kms of Dense Vegetation is converted into Sparse Built-up. 0.28 Sq.kms of Dense Vegetation is converted into Water body. 11.40 Sq.kms of Dense built-up area is remained as Dense Built-up. 0.23 Sq.kms of Dense built-up is changed into Scrubs & Barren. 0.059 Sq.kms of Dense built-up is converted into Marsh & Swamp. 0.029 Sq.kms of Dense Built-up is converted into Moderate Built-up. 0.0073 Sq.kms of Dense Built-up is converted into Moderate Vegetation. 0.011 Sq.kms of Dense Built-up is converted into Sparse Built-up area. 0.020 Sq.kms of Dense Built-up is converted into Thick Vegetation. 35.63 Sq.kms of Water body is remained as Water body. 13.26 Sq.kms of Water body is converted into Scrubs & Barren. 0.08 Sq.kms of Water body is converted into Dense Built-up. 9.48 Sq.kms of Water body is converted into Dense Built-up. 1.84 Sq.kms of water body is converted into Marsh & Swamp. 0.60 Sq.kms of Moderate Vegetation is converted into water body. 1.92 Sq.kms of Sparse Built-up is converted into Water body. 0.96 Sq.kms of Thick Vegetation is converted into Water body.

Overlay analysis provides change matrix of Land Use Land Cover from 2000 to 2006. Eight by eight (8 by 8) matrix table is presented below. From the change matrix it can be identified that how much quantity of each Land Use Land Cover transformed into other Land Use Land Cover and how much remained as same Land Use Land Cover. 12.21 Sq.kms of Barren & Scrubs is remained as Barren & Scrubs. 0.79 Sq.kms of Barren & Scrubs are converted into Marsh & Swamps. 9.23 Sq.kms of Barren & Scrubs is converted into Moderate Built-up. 4.74 Sq.kms of Barren & Scrubs is converted into Moderate Vegetation. 33.02 Sq.kms of Barren & Scrubs is converted into Sparse Built-up. 1.26 Sq.kms of Barren & Scrubs is converted into Dense Built-up. 6.85 Sq.kms of Barren & Scrubs is converted into Thick Vegetation. 0.01 Sq.kms of Barren & Scrubs are converted into Water body. 87.24 Sq.kms of Moderate Built-up is remained as Moderate Built-up. 3.70 Sq.kms of Moderate Built-up is converted into Barren & Scrubs. 5.32 Sq.kms of Moderate Built-up is converted into Marsh & Swamp. 5.29 Sq.kms of Moderate Built-up is converted into Moderate Vegetation. 68.55 Sq.kms of Moderate Vegetation is converted into Sparse Built-up. 11.55 Sq.kms of Moderate Built-up is converted into Dense Built-up. 0.33 Sq.kms of Moderate Built-up is converted into Thick Vegetation. 0.063 Sq.kms of Marsh & Swamp are remained as Marsh & Swamp. 0.31 Sq.kms of Marsh & Swamp are converted into Barren & Scrubs. 19.73 Sq.kms of Marsh & Swamp is converted into Moderate Built-up. 0.07 Sq.kms of Marsh & Swamp is converted into Moderate Vegetation. 20.76 Sq.kms of Marsh & Swamp is converted into Sparse Built-up. 3.18 Sq.kms of Marsh & Swamp is converted into Dense Built-up. 0.11 Sq.kms of Marsh & Swamp is converted into Thick vegetation. 0.21 Sq.kms of Marsh & Swamp is converted into Water body. 46.87 Sq.kms of Moderate Vegetation is remained as Moderate Vegetation. 10.49 Sq.kms of Moderate Vegetation is converted into

Marsh & Swap. 5.53 Sq.kms of Moderate Vegetation is converted into Moderate Built-up. 46.37 of Moderate Vegetation are converted into Sparse Built-up. 0.09 Sq.kms of Moderate Vegetation is converted into Dense Built-up. 12.13 Sq.kms of Moderate Vegetation is converted into Dense Vegetation. 2.11 Sq.kms of Moderate Vegetation is converted into Water bodies. 464.36 Sq.kms of Sparse Built-up is remained as Sparse Built-up. 21.87 Sq.kms of sparse Built-up is changed to Moderate Settlements. 15.22 Sq.kms of Sparse settlements is changed into Dense Built-up area. 0.21 Sq.kms of Sparse Built-up areas are converted into Marsh & Swamps. 36.97 Sq.kms of Thick Vegetation is remained as Thick Vegetation. 59.47 Sq.kms of Thick Vegetation is converted into Sparse Built-up. 16.90 Sq.kms of Thick Vegetation is converted into Moderate Built-up. 33.03 Sq.kms of Thick

Vegetation is converted into Moderate Dense Vegetation. 0.19 Sq.kms of Thick Vegetation is converted into Water body. Almost all the Dense Built up area is remained as Dense Built up. 87.24 Sq.kms of Moderately Dense Built area is remained as the same during this period. 11.53 Sq.kms of Moderate settlements are changed into Dense Built-up. 16.78 Sq.kms of Water body is remained as Water body. 0.03 Sq.kms of Water body is changed into Barren & Scrubs. 1.48 Sq.kms of Water body is changed into Marsh & Swamp. 0.22 Sq.kms of Water body is converted into Moderate Built-up. 0.008 Sq.kms of Water body is converted into Moderate Vegetation. 1.61 Sq.kms of Water Body is converted into Moderate Vegetation. 1.61 Sq.kms of Water body is converted into Sparse Built-up. 0.02 Sq.kms of Water body is converted into Dense Built-up. 3.41 Sq.kms of Water body is changed into thick vegetation.

Average residential land value of Chennai metropolitan showing a rapid increase from 350 RS/SQ.M in 1991 to 1432 RS/SQ.M in 2001 and 2300 RS/SQ.M in 2006. Urbanized area in Chennai metropolitan shows an increase from 51523 hectares in 1991, 65402 hectares in 2001 and 74135 hectares in 2006. Land value shows a rapid increase of 75.55% from 1991 to 2001. During this period urbanization shows an increase of 21.22%. Between 2001 and 2006 land value shows an increase of 37% in the same duration urban areas showed an increase of 11.78%. Correlation can be used to find the relationship between land value and urbanization.

### Marcove chain model

#### Change detection matrix (area in sq.km) land use land cover change 1990-2006

	Baren	Marsh	Mod.stms	Mod.veg	s.builtup	t.stms	t.veg	w b
<b>Barren</b>	27.96	2.66	45.54	4.7473	33.031	12.66	6.87	0.01
<b>Deep.builtup</b>	0.23	0.059	0.029	0.0073	0.011	64.86	0.02	0
<b>Marsh</b>	0.31	2.973	23.56	2.98	22.05	3.23	1.4	0.23
<b>M.bup</b>	3.88	5.52	204.37	27.53	137.5	32.26	24.26	0.61
<b>M.veg</b>	25.24	11.77	48.47	165.47	165.91	27.49	107.11	2.52
<b>S.bup</b>	0.15	1.1	46.49	0.53	466.04	22.42	12.28	0.91
<b>Thick.veg</b>	3.06	0.13	22.76	41.59	478.68	0.67	61.73	0.47
<b>Water bodies</b>	13.29	10.96	2.06	0.608	3.53	0.1	4.37	52.41

Urban growth dynamics attracts the efforts of scientists from several disciplines with the objectives ranging from theoretical understanding to the development of carefully tuned realistic models that can serve as planning and policy tools. Theoretical models are often abstract and of limited applied value while most applied models yield little theoretical understanding. Urban growth modeling has evolved over recent years to capture increasingly well the details of urban morphology and structure on a qualitative as well as quantitative level. (Claes Andersson, Steen Rasmussen and Roger White, "Urban settlement Transitions "Environment and Planning", 2002). Markov chain models are

particularly useful to geographers concerned with problems of movement, both in terms of movement from one location to another and in terms of movement from one "state" to another. "State", in this context refers to the size class of a town, income classes, type of agricultural productivity, land use, or to some other variables (Lyndhurst Collins, "An Introduction to Markov Chain Analysis", 1995). Markov chain model can be used to predict future changes based on the rates of past change. The method is based on probability that a given piece of land will change from one mutually exclusive state to another. Land use change transition probability in Markov analysis indicates the probability of making a transition from one land use class to another within two discrete times. In this study, transitional probability matrix table derived from the two time periods land use land cover map of 1990 and 2006 to predict the change of 2021. Eight by eight (8 by 8) matrix table is presented below. The Transitional Probability Matrix shows the probability that a land pixel will change from one land use category to another. Table shows transition probability from 1990 to 2006.

## Result & Discussion

Land Use Land Cover Change analysis is one of the major concentrations of this study. In 1991, 47% of the land use was under Vegetation. In 2000, 28% of the total land area is covered by vegetation. In 2006, 25% of the total land area is covered by vegetation. Amount of vegetation is considerably reduced from 1991-2006. During this time interval 22% of the total Vegetation is converted into other land area. The area under Built up during 1991 constitutes 45.21%, in 2001 54.90% of area is covered by built up features and 59.67% of the land area was under built up in 2006. 14% of the built area is increased during 1991 to 2006. Water body shows 8.50% decrease from 1991 to 2006. Marsh and Swamp show a decrease of 58.93% from 1991 to 2000. From 1991 to 2006 Marsh and Swamp shows a decrease of 10.56%. From 1991 to 2006 Barren land shows a decrease of 9.76%. Markov chain model provides Land Use Land Cover of 2021. Thick Built-up covers 133.22 Sq.km and which comprises 10.58% of land cover. Moderate built-up covers 219.45 Sq.kms and it comprises 17.43% of area. Sparse Built-up covers 670.37 Sq.kms and comprises 53.26 % of area. Thick vegetation covers an area of 75.22 Sq.kms and comprises 5.97 % of area. Moderate vegetation covers 83.80 Sq.kms and comprises 6.65% of area. Water bodies cover an area of 27.95 and comprise 2.22% of area. Barren & Scrubs covers 30.11 Sq.kms and comprises 2.39 Sq.kms of area. Marsh & Swamp covers 18.36 Sq.kms and comprise 1.45% of area. Study tries to analyze the relationship between average residential land value and urbanization. Average residential land value of Chennai Metropolitan showing a rapid increase from 350 RS/SQ.M in 1991 to 1432 RS/SQ.M in 2001 and 2300 RS/SQ.M in 2006. Urbanized area in Chennai metropolitan shows an increase from 51523 hectares in 1991, 65402 hectares in 2001 and 74135 hectares in 2006. Land value shows a rapid increase of 75.55% from 1991 to 2001. During this period urbanization shows an increase of 21.22%. Between 2001 and 2006 land value shows an increase of 37% in the same duration urban areas showed an increase of 11.78%. The correlation analysis is used to find the relationship between urban built-up and population growth. Correlation shows 0.997 and gives the result that two variables are positively correlated. The graph shows that the growth in urban population cause a growth in urban built up. The ratio of increase in urban population is equally proportional to the increase in urban settlements.

## Conclusion

Chennai Metropolitan Area shows a rapid increase in urbanization from 1991 to 2006.

Urbanization shows expanding the area of urban built-up. Despite from the horizontal expansion the density or thickness of built-up land is increasing in existing urban lands. Both Vegetation cover and Water bodies in Chennai Metropolitan is gradually decreasing. The projected Land Use Land Cover for 2021 shows that Chennai Metropolitan area should be dominated by Built-up lands and the area covered by Vegetation will show a steep decline. Land value analysis shows that Land value is increasing faster than the process of urbanization. So we can suggest that government can implement better planning strategies for sustainable development in Chennai Metropolitan by conserving natural vegetation and water bodies. Despite of the horizontal expansion now it's the suitable time for implementing vertical development strategies.

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