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Urban Growth Assessment of Chennai District by Remote Sensing and Gis Techniques

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Abstract: ***Urban growth of Chennai district is exponential and heading towards extreme urbanisation. Hence this necessitates the study of urban growth in Chennai district. The recent advancement in Remote sensing and GIS has an excellent ability to derive various data from the satellite images obtained .This helps us to map, monitor and picturise various aspects of development with respect to their demands. The basic principle of remote sensing is followed as the methodology. By following the methodology correctly and by proper processing of the data acquired from the satellite images, the exact requirements of information can be obtained. The Change in the urban growth of the Chennai district for three decades from 1989 to 2019 have been found by using remote sensing and GIS techniques. The satellite images of various years are obtained from Landsat satellite from the USGS Earth Explorer .The Land use characteristics of Chennai district of each year can be obtained by preparing the land use land cover map of Chennai district by the use of landsat satellite images. The two software namely ArcGIS and ERDAS Imagine are used to create the Land use land cover map. From the Land use land cover map of Chennai district, the change detection and statistical analysis of three decades are done and these analysis clearly shows that the urban growth of Chennai district is constantly increasing and there is a huge decrease in other natural features such as vegetation, water body and barren land. By performing urban trend analysis the urban growth of Chennai district for the upcoming years are predicted to prove the urban agglomeration in Chennai district.***

Keywords**: *Chennai, Land use/cover, Remote sensing, GIS.***

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I. INTRODUCTION

A. General

Urban growth generally refers to the increase in population of a city or place which subsequently leads to the increase in economy, market demands, capital cost, living cost, standard of living etc. It is a positive sign for the growth of a city and the country only when other natural features are given importance. The process of destroying other natural features in the name of urbanization is a major loss which simultaneously lead to drought, scarcity etc. It is very important to prevent the ecosystem of a city to avoid such disasters and to establish biodiversity in the country.

Urbanization is the integral part of the economic development of a particular country. As the economy of the country increases, there is increase in living standard of people which causes further people to migrate from their native to the urban city. Migration of people from a rural area to urban city occurs mainly due to the employment facilities that exists in an urban area and the advanced medical and educational facilities etc. When the growth of urban has become extreme, the people will start to deploy the other land covers such as dried water body or deforestation which affects the fertility of the soil and the environment.

During the 1960s or before, the Indian cities would have never been through a concept called urbanization but since then the indian cities started to evolve more due to various factors. The employment has become a major factor for the movement of people from their own land. Chennai is one of the four metropolitan cities of India which defines that the city is enriched with all basic fundamentals and hence leading to urbanization. During the last three decades, the urban growth the very high and reaching towards urban agglomeration [17].

B. Need for Study

- GIS can be effectively use for the classification and analysis of urban growth. Nowadays urbanization is increasing along with the depletion of agricultural lands. The advancement of GIS makes easier to face the urban growth problems [18].
- Due to the sudden increase in IT sectors, Employment facilities and increase in population causes many urban growth problems including water crisis etc., It directly affects the economy of the state and the country.

C. Objectives

1. To prepare Land use/ Land cover map of Chennai district from 1989-2019.
2. To analyze the growth and development of Chennai district from 1989-2019.
3. To do the statistical analysis for Chennai district from 1989-2019.

D. Scope of the Study

- The trend towards sub urbanisation and the urban sprawl has a direct and indirect effects in overcrowding in urban cities
- Major changes in migrations threaten the environmental and economical stability of a urban city.
- Urban growth is a consequences of socioeconomic activities which needs to be rectified.

II. MATERIALS AND METHODS USED

growth in medical facilities are some of the common reasons and hence the study was conducted in Chennai district. Chennai district has the geographic coordination that Latitude/Longitude: 13.04◦ N 80.17◦ E Country - India, State – Tamilnadu The data for the study was collected from the USGS Earth explorer. The data used are LandSat 5, LandSat 7, LandSat 8 ETM+ for the years as shown in table 1. Elevation is generally calculated from a standard level called mean sea level. Chennai is located between 6m to 60m above from the mean sea level. Chennai district covers an area of about 426 sq.km. The Software used to find the urban growth development are ArcGIS 10.4.1 and ERDAS Imagine 2014.The Satellite image acquired is preprocessed in ERDAS Imagine and then the unsupervised classification is done in the preprocessed image in the ERDAS Imagine. Likewise, the process is repeated for further years and accuracy assessment is done by field knowledge and iterations. The land use land cover map is done in ArcGIS software and the layer for each year is made.

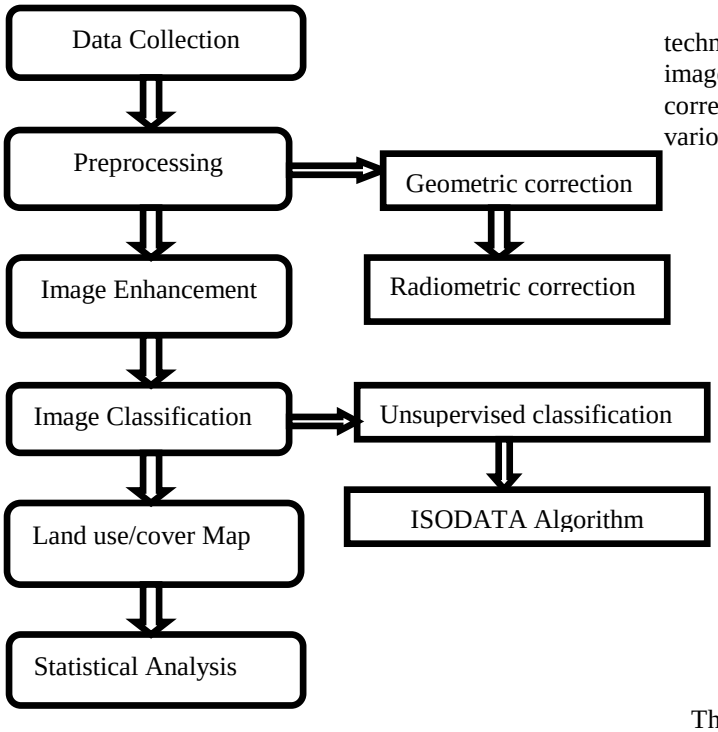
Table 1. Sources of Data

Year	Data	Source	Resolution			
			Spatial (m)	Spectral (µm)	Radiometric	Temporal
1989	LandSat 5	USGS	30	Band 1 (0.45-0.52) Band 2 (0.52-0.60) Band 3 (0.63-0.70) Band 7 (2.08-2.35)	8 bit	16 days
1994						
2005						
2010						
2000	LandSat 7					
2014	LandSat 8 ETM+			Band 2 (0.45-0.51) Band 3 (0.53-0.59) Band 4 (0.64-0.67) Band 8 (0.50-0.68)		
2019						

Fig 1 Chennai District Map

For the study of urban growth, Chennai district as shown in Fig 1 was chosen as the study area due to the increase in extreme urbanization of this district. Chennai is one of the populous cities of India. And over the period of last 30 years the urban growth in Chennai is very high due to the increase IT sectors, educational institutions, tremendous

Flowchart for methodology



III. RESULTS AND DISCUSSION

A. Pre Processing

Pre-processing is called process of image restoration and rectification, are provided to rectify the satellite platform-specific radiometric and geometric deviations of data [2]. In addition to this, the environment will attenuate the signal propagating from the target to the sensor.

B. Geometric Correction

A Geometrical correction is one of the preprocessing technique which is done to assign the spatial coordinate system to the satellite image acquired. It is also called as Geo-referencing. *[2]*.

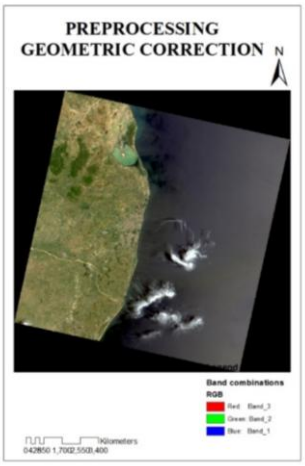


Fig 2 Geometric correction

The acquired satellite image is geo-referenced by fixing the image to the latitude and longitude of the Chennai district by using ArcMap 10.4.1 Software as shown in 2.

C. Radiometric Correction

Radiometric correction is another preprocessing technique done to reduce the flaws and errors in the satellite images and improving the quality of the image. Radiometric corrections are important when the images are compared for various years *[20]*.

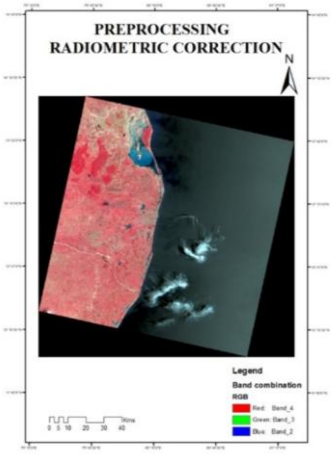


Fig 3 Radiometric Correction

The geo-referenced image is converted to color-infrared from natural satellite image (i.e true color composite to false color composite) as shown in Fig 3.

D. Image Enhancement

Image enhancement refers to manipulating the quality of the image by using softwares. These softwares use editors, filters and other tools for changing various properties of image to enhance the satellite image acquired.

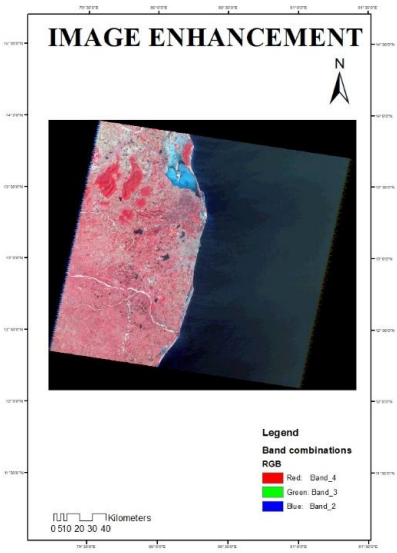


Fig 4 Image Enhancement

The Color infrared image is enhanced by noise reduction, haze reduction done in ERDAS Imagine software as shown in Fig 4.

E. Image Classification

The next step involved in the process of preparing LULC Map is image classification. The pre-processed satellite images can be classified by two methods namely unsupervised classification and supervised classification.

In this process we use unsupervised classification method which is done using ERDAS Imagine software .In supervised classification method, signature editor tool is used. The polygons are drawn based on the field knowledge on the map having various features and the polygons of each features are stored as a signature tool. Then by using the signature tool as a reference the maximum likely hood algorithm classifies the image based on the specific land use.

F. Unsupervised Classification

We use unsupervised classification method which is done by using ERDAS Imagine software. In this method, the satellite image is classified according to the number of classes given and the DN values of the pixels in the image. The DN values of the pixels having same values are grouped into one class. Likewise, several iterations are performed by the software while classifying the DN values of the image. More the number of classes given more will be the accuracy. The accuracy assessment is done by classifying the image multiple times and field knowledge. When more number of classes are classified, the same featured classes can be grouped into one class.

Unsupervised classification can be done in two ways

- ISODATA algorithm
- K- means algorithm

Here, ISODATA clustering algorithm is used as it is inbuilt in the ERDAS Imagine software.

G. Land Use / Land Cover Map analysis

Land use Land cover maps are used to determine the amount of various land features that exists in the boundary for which the map is prepared. Land use Land cover area of every city has been changed over the past thirty years but how effectively it has changed does really matters. It is necessary to prepare and compare the LULC map of various places to determine its growth and development for the period. The Chennai district is clipped from the satellite image by using the ArcGIS software. The layout and the legends of the LULC map is created by using the ArcGIS Software.

The Classified Land use map for distribution for the study year 1989-2019.Classified values from the Attribute table given below

- Urban
- Barren Land
- Water Bodies
- Vegetation

Unsupervised classification of satellite image is done with accuracy by verifying with Google Earth Satellite Images. The Classified LULC Maps of Chennai districts for the years from 1989 to 2019 is prepared and their results are inferred below.

H. LULC Analysis of Chennai district 1989

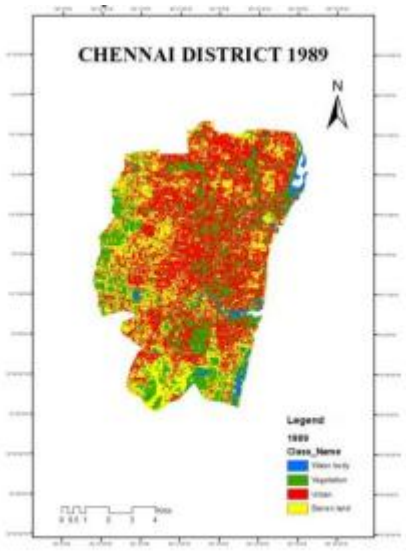


Fig 5 LULC Map of Chennai District 1989

From the Fig 5, It can be inferred that area of built-up (urban) is 180.57 sq.km which is of 42.39%, vegetation is 128.20 sq.km which is 30.09 %, water body is 14.14 sq.km which is of 3.32% and barren land is 103.09 sq.km which is 24.20 % of the total area. The total area of Chennai district is 426 sq.km.

I. LULC Analysis of Chennai district 1994

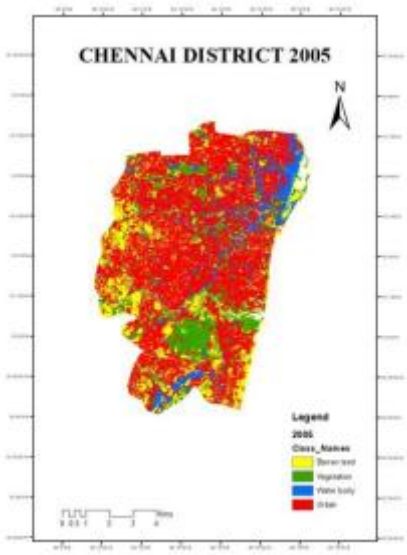


Fig 6 LULC Map of Chennai District 1994

From the Fig 6, It can be inferred that area of built-up (urban) is 203.72 sq.km which is of 47.82%, vegetation is 105.04 sq.km which is 24.66%, water body is 11.82 sq.km which is of 2.77% and barren land is 105.42 sq.km which is 24.75 % of the total area. The total area of Chennai district is 426 sq.km.

J. LULC Analysis of Chennai district 2000

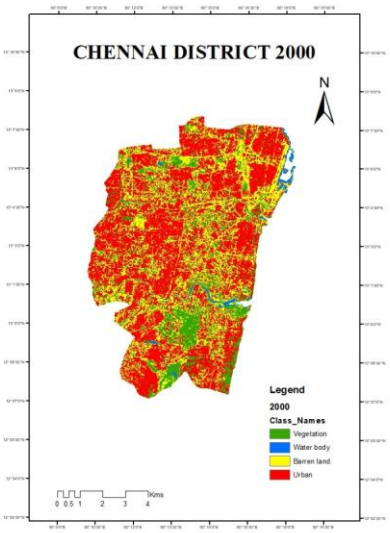


Fig 7 LULC Map of Chennai District 2000

From the Fig 7, It can be inferred that area of built-up (urban) is 218.59 sq.km which is of 51.31%, vegetation is 76.37 sq.km which is 17.93%, water body is 11.30 sq.km which is of 2.65% and barren land is 119.74 sq.km which is 28.11 % of the total area. The total area of Chennai district is 426 sq.km.

K. LULC Analysis of Chennai district 2005

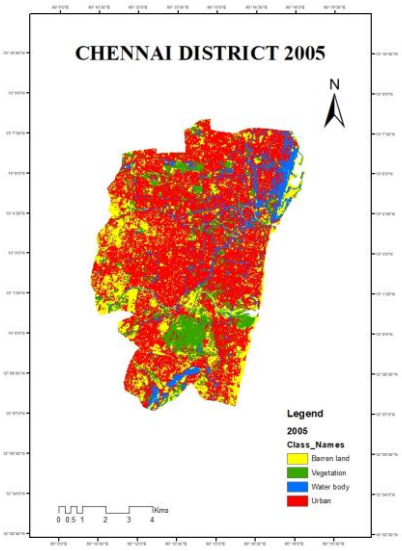


Fig 8 LULC Map of Chennai District 2005

From the Fig 8, It can be inferred that area of built-up (urban) is 243.85 sq.km which is of 57.24%, vegetation is 52.45 sq.km which is 12.31%, water body is 39.74 sq.km which is of 9.33% and barren land is 89.96 sq.km which is 21.12 % of the total area. The total area of Chennai district is 426 sq.km.

L. LULC Analysis of Chennai district 2010

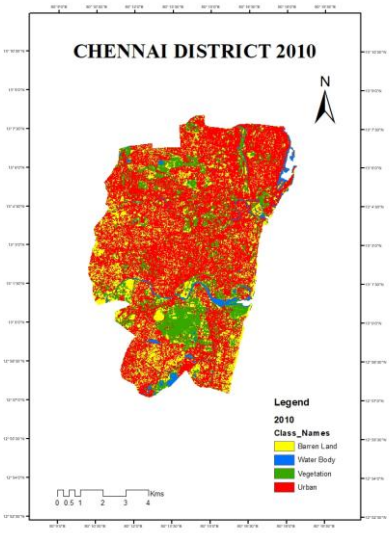


Fig 9 LULC Map of Chennai District 2010

From the Fig 9, It can be inferred that area of built-up (urban) is 251.20 sq.km which is of 58.99%, vegetation is 73.67 sq.km which is 17.29%, water body is 10.99 sq.km which is of 2.58% and barren land is 90.04 sq.km which is 21.14 % of the total area. The total area of Chennai district is 426 sq.km.

M. LULC Analysis of Chennai district 2014

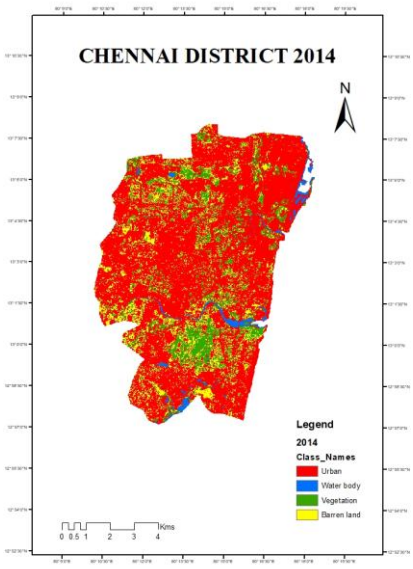


Fig 10 LULC Map of Chennai District 2014

From the Fig 10, It can be inferred that area of built-up (urban) is 302.48 sq.km which is of 71%, vegetation is 52.62 sq.km which is 12.35%, water body is 8.34 sq.km which is of 1.96% and barren land is 62.55 sq.km which is 14.69% of the total area. The total area of Chennai district is 426 sq.km.

N. LULC Analysis of Chennai district 2019

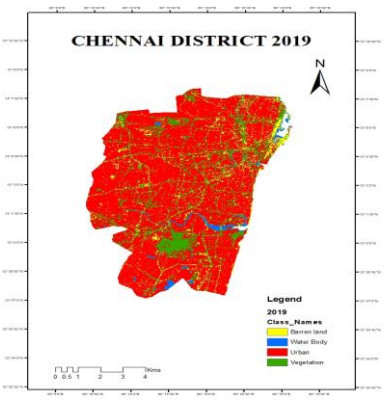


Fig 11 LULC Map of Chennai District 2019

From the Fig 11, It can be inferred that area of built-up (urban) is 323.91 sq.km which is of 76.06%, vegetation is 60.17 sq.km which is 14.12%, water body is 7.41 sq.km which is of 1.74% and barren land is 34.51 sq.km which is 8.10 % of the total area. The total area of Chennai district is 426 sq.km.

O. Change Detection from Statistical Analysis

. In the year 1989-2019 we calculated the change detection for Chennai district. We classified the Chennai district as follows urban, barren land, vegetation and water bodies.

Table 2 Statistical analysis of Chennai district in sq.km

Year	Area (in sq.km)			
	Barren Land	Vegetation	Water body	Urban
1989	103.09	128.2	14.14	180.57
1994	105.42	105.04	11.82	203.72
2000	119.74	76.37	11.3	218.59
2005	89.96	52.45	39.74	243.85
2010	90.04	73.67	10.99	251.3
2014	62.55	52.62	8.34	302.48
2019	34.51	60.17	7.41	323.91

Table 3 Statistical analysis of Chennai district in %

YEAR	Area (In %)			
	Barren Land	Vegetation	Water body	Urban
1989	24.2	30.09	3.32	42.39
1994	24.75	24.66	2.77	47.82
2000	28.11	17.93	2.65	51.31
2005	21.12	12.31	9.33	57.24
2010	21.14	17.29	2.58	58.99
2014	14.69	12.35	1.96	71
2019	8.1	14.12	1.74	76.06

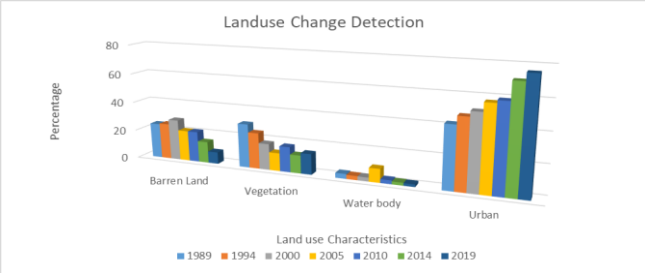


Fig 12 Land use characteristics vs Percentage of area

From these Table 1 and Table 2, it is clearly shown that there is rapid increase in the growth of urban area from 42.39% to 76.06 % and there is a huge depletion in the other classes that vegetation decreases from 30.09% to 14.18 %, water body decrease from 3.32% to 1.74%, Barren land decreases from 24.20% to 8.10 % [17].

From the Fig 12, we can infer than there is a predominant increase in the urban growth and there is a depletion in other land use characteristics such as barren land, vegetation and water body. The sudden hike in the area of water body observed in the year 2005 is due to the Tsunami occurred in the month of December 2004. There is an uneven growth in the vegetation which may be due to difference in natural parameters. Comparing other years, the area of barren land is very high in the year 2000.

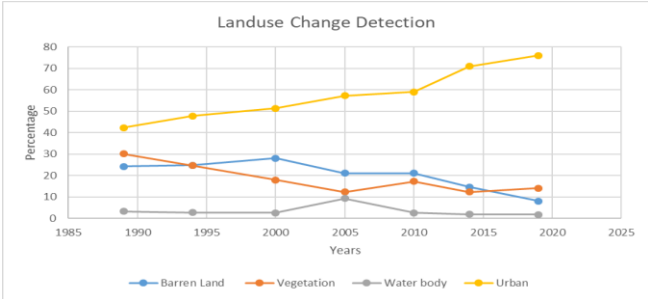


Fig 13 Years vs percentage

From the Fig 13, it can be inferred that barren land had been decreased even though marshy land protection has been implemented and water body, vegetation decreased due to construction activities in and around the town causes this change and in 2005 Chennai district affected much due to the natural disaster tsunami that happened in December 2004 and in 2019 the whole district is more urbanized that increased built up area by destroying many water path, water drainage area and vegetation [1].

IV. CONCLUSION

In this work we have taken the Landsat 5 Landsat 7 ETM+, Landsat 8 OLI images of Chennai District collected from USGS website from 1989 to 2019 study period. The land use map of study area developed by unsupervised classification of the images. Four land use classes have been identified as Urban (built up), Water body, Vegetation and Barren land.

Change detection shows that urban area increases from 42.39% to 76.06% and there is depletion in the other classes that Vegetation decreases from 30.09% to 14.18 %, Water body decrease from 3.32% to 1.74%, Barren land 24.20 % to 8.10% during the study period 1989 to 2019*[6]*.This data helps us in determining various changes in demands that occur due to rapid increase in population.

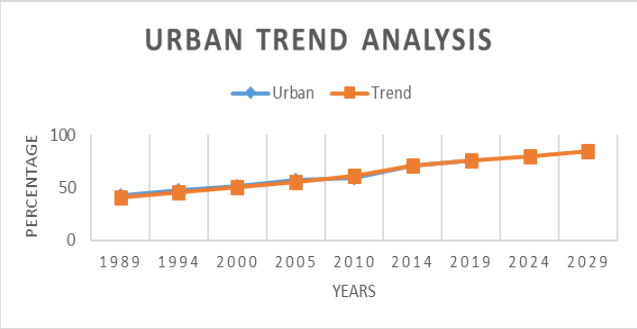


Fig 14 Urban Trend Analysis

The Fig 14, Urban Trend Analysis shows that the urban growth of Chennai district is forecasted to reach 79.28% in 2024 and 84.75% in 2029 which subsequently indicates the decrease in other natural features. This proves extreme urbanization of the district. Chennai is being experiencing a rapid urbanization, the urban growth in this district is seen as one of the potential threats to sustainable development.

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