Land use and Land cover change detection of Tirunelveli City Using GIS and RS

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ABSTRACT

Tirunelveli is one among the popular city in Tamil Nadu, and it needs to be focused on regulating the urban growth. The urban growth of Tirunelveli should be planned and regularised as it was selected as one of the smart cities project in India. It is necessary to sort out the current spatial growth and to predict the model for spatial dynamic growth for future urban development. In this research, Land Use (LU), Land Cover (LC) change detection of Tirunelveli taluk has been analysed for the years 2000 and 2020 using Landsat series satellite images. GIS and RS techniques are used to analyse the urban growth of Tirunelveli city. Maximum likelihood algorithms are used for the supervised classification of the satellite data and Post classification image-to-image comparisons were applied for the important features like land, water, forest, vegetation and build-up areas. The changes in these features were detected using QGIS and ENVI statistical computational software tools. This change detection, gives an idea to the predict the urban sprawl of the Tirunelveli city in upcoming years.

Index terms: GIS, Land Cover, Land Use, RS, Urban Sprawl.

1.INTRODUCTION

Urban sprawl is a global phenomenon which has major impact on natural resources and urban environment. Rapid urban growth leads to the change in land use and land cover areas which affects the environment ecosystem. This growth in most of developing and undeveloped countries was not predicted and planned properly which makes an imbalance growth and thus leads to water scarcity, traffic and heavy polluting problems [7]. Well planned urban growths can control and avoid environmental hazards and also makes a balanced growth of the city. The urban sprawl mapped with conventional survey for the city is time consuming and expensive. With advancements in technologies, the pattern of urban sprawl is easily determined by remote sensing techniques. This helps the town planners to analyse the city and to take proper effective decisions for the development of the city. The fast growth rate of population growth in India has generated a fast uncontrolled urban sprawl in all its forms and created serious environmental problems. In India the Central Government have initiated the smart city projects and selected around 100 cities initially and Tirunelveli, located in South Tamil Nadu, India, which is the 5th largest municipal corporation in Tamil Nadu incorporating 2000 years of heritage with it, is one among them.

In this study the urban growth over the last 20 years from 2000 to 2020 in Tirunelveli is analysed. There is a vast growth in the city expansion for the past 20 years as various infrastructure developments were started around Tirunelveli taluk regions. The urban sprawl rate and the feature changes will be statistically recorded. The change detection statistics is analysed and will be useful for the modelling of the city growth in the future years. Urban sprawl growth of all features in the city between the years 2000 and 2020 are deeply studied

using remote sensed data's and this will give an idea about current trend of urbanization of the city area such as Direction of growth, shape of growth, Patterns of growth, size of growth and intensity of growth of the city.
In this research we have established changes in Land use and Land cover in major 5 categories: 1) Vegetation 2) Barren land 3) Fallow Land 4) Built-up land 5) Water bodies [7].

2.STUDY AREA AND DATA SET

Tirunelveli is a city located in Tamilnadu, South India. It is the headquarters of Tirunelveli District. The present study, is focused on Tirunelveli taluk in Tirunelveli District. Its area will be around 560 km^2.Tirunelveli taluk consists of 85 revenue villages like Abeshegapetti, Alaganeri, Manur, Kodakanallur etc., as shown in fig1. Tirunelveli is one of the few cities in India which have been selected to develop as smart cities by government of India. Geographically Tirunelveli taluk is located between longitudes 77°30'E to 77°48'E and latitudes 8°39'N to 8°56'N.

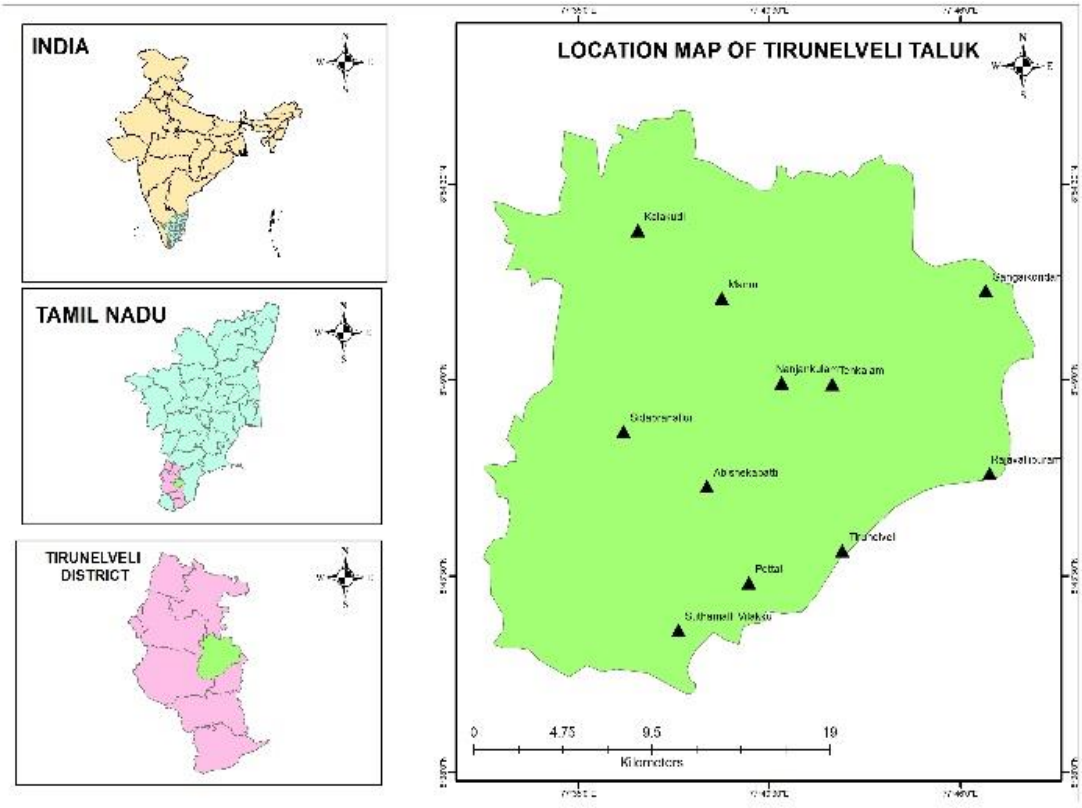

Fig-1: Study Area

3.METHODOLOGY

The acquired landsat-7 and landsat-8 TM data of the Tirunelveli city area were processed and analysed using Remote Sensing Techniques in order to quantify and analyse the changes occurred in each and every features in the city area due to urban growth. Supervised classification process of recent data will give details about ongoing trends of urbanization in the city area and will give details about the change detection statistics of each and every land use and land cover features. The Multi-spectral Landsat satellite images of the year 2000 and 2020 are taken for this research. The land use land cover classifications is done by supervised

classification process. Post classification and Changes Detection process progress data is analysed using ENVI software [4].

The satellite image is taken and supervised classification is carried out through manual interpretation of the data. Major area features like Water body, Build-up land, Barren land, Fallow land, Vegetation has been classified for the urban sprawl. By manual interpretation, the required features samples have been selected and given as input for the classification process. With the sample input, the pixel based target classification for the entire area is done through the ArcGIS software. Then after processing the entire area, the classified image is then cross verified with the raw image for accurate classifications.

This procedure is carried out for the year 2000 and 2020 and the classifications are done and compared for the urban sprawl. The comparison must be done with the statistical data of the feature areas in both years. Spatial analysis of converting the raster classified image data to the vector data is carried out. The areas of the features are calculated in the sq.km units. The data values are displayed in the Table-1.

After calculating the vector data values of the year 2000 and 2020, the change detection in the features is needed to be calculated. For this, ENVI software is used for calculating the change detection statistics between these 2 years. This methodology is shown in Fig-2.

3.1Flow Chart

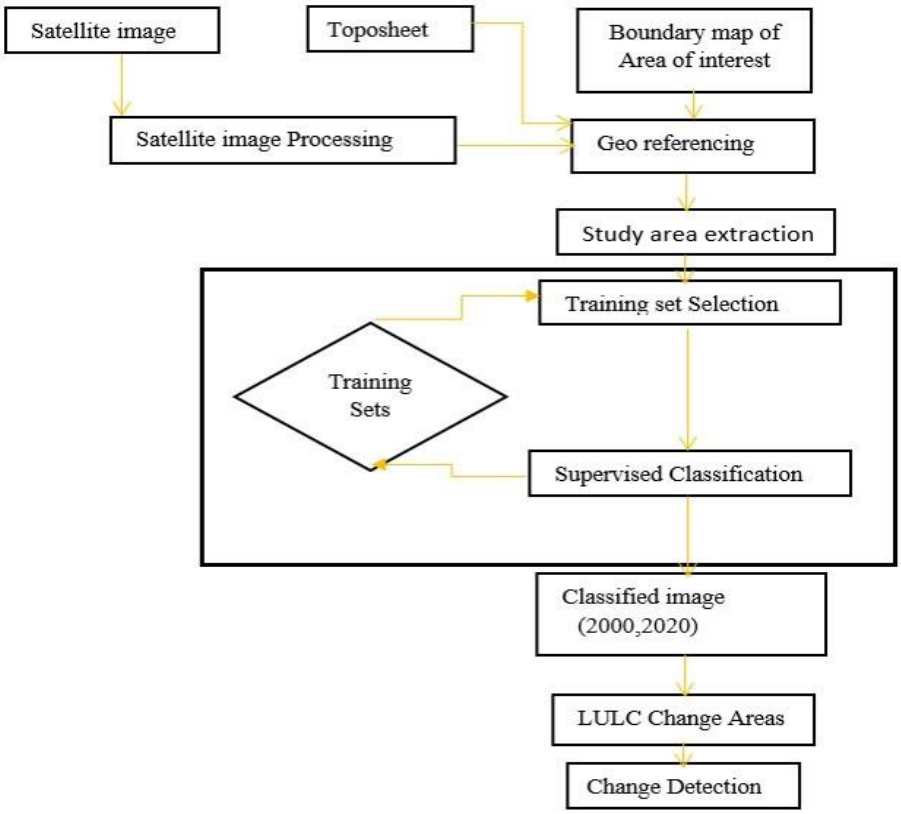

Fig-2: Processing change detection

3.2 Sources of Data

For the study, Landsat satellite images of Tirunelveli Taluk were acquired for two Epochs: Landsat 2000 and 2020. These Epochs were obtained from USGS Earth explorer. Landsat image of the city for the year 2020 is shown in Fig-3. The Tirunelveli city boundary is cropped with

using the local government boundary map. Tirunelveli city Administrative map was obtained from Tirunelveli corporation office.

3.3 Tools used in the study

Various software programs have been used in this study to analyse, validate the spatial dataset. For the preliminary data processing, extracting the study area and mosaicking satellite images, ArcGIS and ENVI was used.

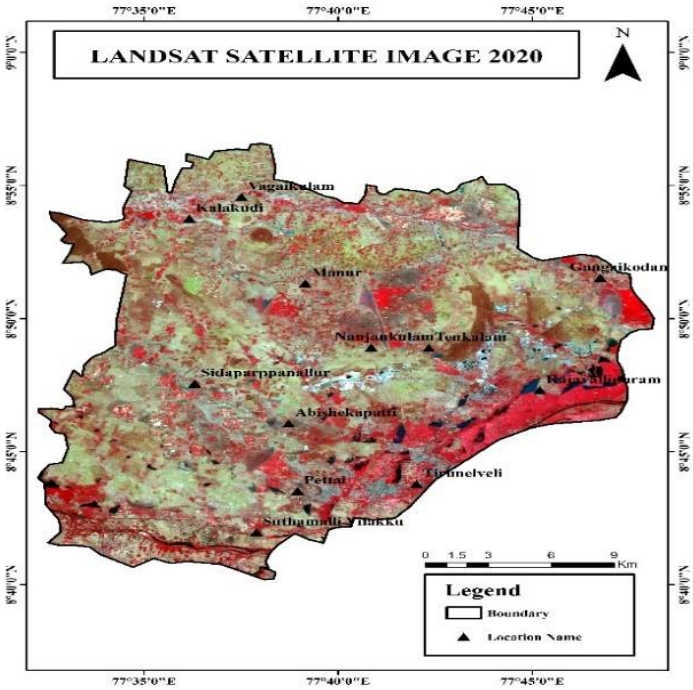

Fig-3 Landsat Natural colour composite image

3.4 Image classification

The large dataset of satellite imagery is to be processed and analysed for all respective timelines. Its processing segregates the land into its different use functions. Classification techniques are widely used for LULC mapping to be used as source data for many different applications.

3.5 Post classification Techniques for change detection

This post classification technique involves the spectral classification and production for the same area at two different time periods. It has the advantage of providing needed information on the pattern of land cover changes. The supervised classified maps were used because of its higher accuracy when compared to unsupervised maps. Change detection analysis is carried out between the years 2000 and 2020. Maximum likelihood classification is carried out for the post processing classification.

The principles used by the algorithms tools in Maximum likelihood classification are:

The algorithm that was used by the Maximum Likelihood Classification tool is based on these principles:

- Normal distribution of the cells in each class sample in the multidimensional space.
- Bayes theorem of decision making, that describes the probability of an event, based on prior knowledge of conditions.

4. RESULTS AND DISCUSSION

4.1 Area coverage of each land use of Tirunelveli taluk between 2000 and 2020

To achieve the sprawl detection of Tirunelveli taluk in three LULC of Tirunelveli taluk is obtained for different periods (2000 & 2020), and were analysed using post classification detection processes. In order to find the urban sprawl, the images were classified as shown in Fig-3,4, 5 and 6. The results indicate area coverage of Water body, Build up Land, Barren Land, Fallow Land, and in Vegetation during the years 2000 and 2020 as shown in Table-1.

4.2 Land Transformation of Tirunelveli taluk between 2000 and 2020

The dynamic process of the spatial-temporal characteristics of land use changes in a period of 20 years from 2000 to 2020 in Tirunelveli taluk was analysed to find the driving forces of land use changes. In the present study, overlay analysis was performed to detect the land use change pattern and hence the transformation of land use pattern can be identified. This processing is done through ENVI software. The data derived from this study is given in Table-1 & 2.

Change detection difference is characterizing the difference between initial and final stages. If the final stage pixels are brighter than the initial stages, it indicates positive change and if its dimmer, it indicates negative change in the features area. These change detection statistics, are displayed in Table - 2.

Year	2000 (sq.km)	2020 (sq.km)
Water body	82	15.04
Build up Land	13.95	43.32
Barren Land	340	371.24
Fallow Land	72.12	94.80
Vegetation	50.40	35.11

Table-1: Total area of each features in year 2000 and 2020

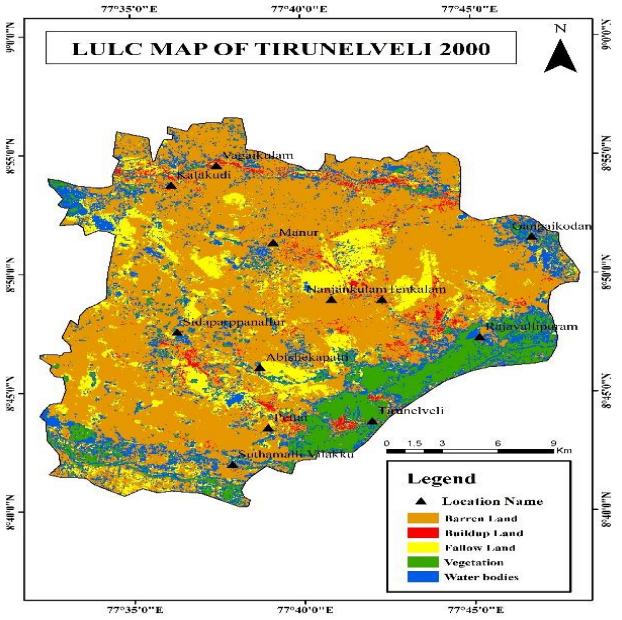

Fig 4: Landsat 2000 classified image

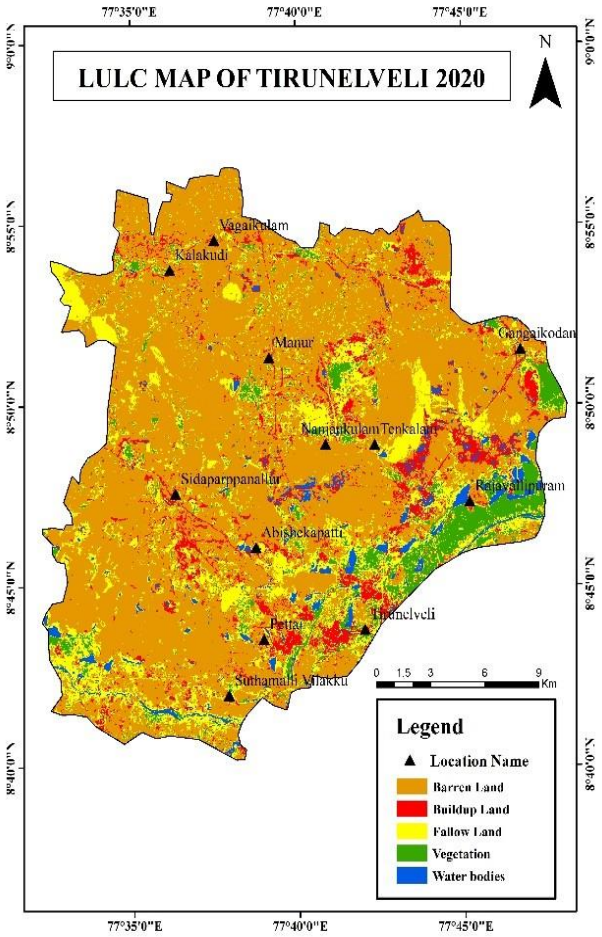

Fig-5: Landsat 2020 classified image

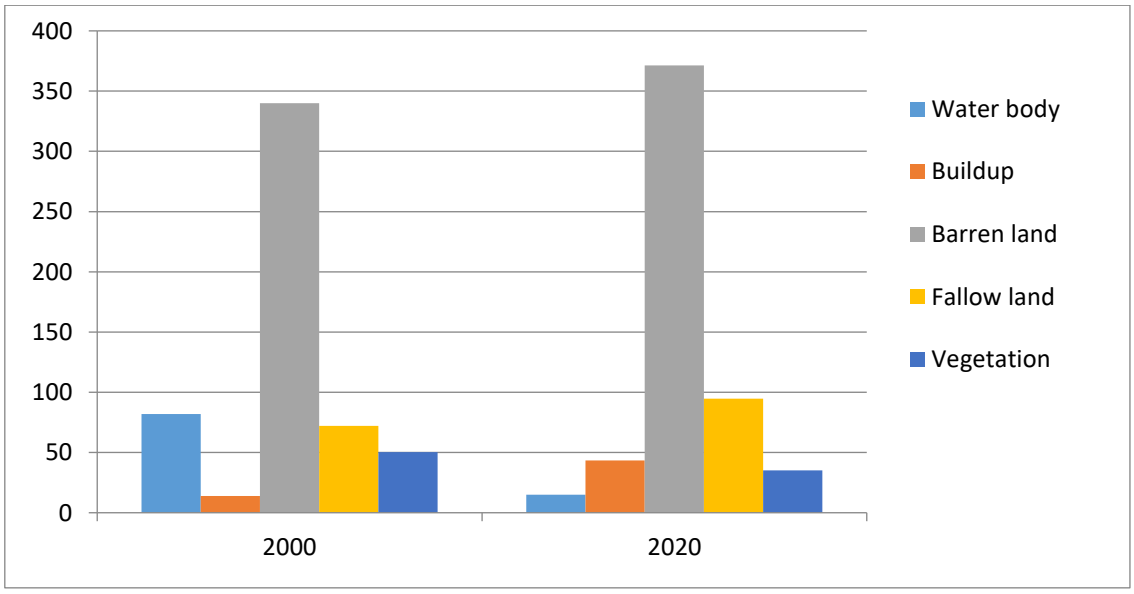

Fig-6: Land use statistics of years 2000 and 2020 in sq,km

	***Unclassified* (sq.km)**	***2000_ Water* (sq.km)**	***2000_ Build-up*(sq.km)**	***2000_ Vegetation*(sq.km)**	***2000_ Barren*(sq. km)**	***2000_ Fallow* (sq.km)**	***Row Total* (sq.km)**	***Class Total* (sq.km)**
Unclassified	316.11	0	0	0	0	0	0	316.11
2020_Water body	0	4.73	0.39	3.03	4.94	1.95	15.04	15.04
2020_Buildup Land	0	5.8	4.78	1.4	24.58	6.77	43.33	43.33
2020_vegetation	0	8.96	0.59	15.33	7	3.23	35.11	35.11
2020_Barren Land	0	36.32	6.98	13.27	276.02	38.55	371.14	371.15
2020_Fallow Land	0	26.47	1.21	17.37	28.1	21.64	94.79	94.79
Class Total	316.11	82.28	13.95	50.4	340.65	72.14	-	-
Class Changes	0	77.55	9.18	35.07	64.62	50.5	-	-
Image Difference	0	-67.24	29.38	-15.29	30.5	22.65	-	-

Table-2: Change detection statistics between 2000 and 2020

5. CONCLUSION

The present study reveals the possibility of applying Remote Sensing and GIS techniques on evaluating the change detection of LU&LC of Tirunelveli taluk. The results showed that urbanisation leads to LULC change and pattern alteration which responded to urbanisation phases. The loss of agriculture and water bodies due to urban sprawl should be notified and planned properly. Based on this study, it also noticed that the built-up area has been increased to 43.92 sq.kms in these years. The results implicate that the water bodies and vegetation showed a decline in area of 81% and 30% respectively and the barren land and fallow land showed increase in area of 9% and 30% respectively. But the Build-up area showed a massive growth in area of nearly 230% from year 2000 to 2020. This study proves that Tirunelveli city has undergone tremendous urban expansion and the major directional growth is observed in North-East and South-West slice of the district. This study helps to analyse and predict the future growth trend of the Tirunelveli city. With the GIS prediction tools like Cellular automata, Sleuth model etc., the change detection between the years 2000 and 2020 is analysed and used as input for future growth prediction of the city for the future years like 2030. Thus this analysis gives the government an idea about the current growth rate, growth pattern of the city and for predicting the city growth model in future.

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