

# Evaluation of Spatial land use/land cover changes due to Urbanization and Industrialization in Tirupur city using Remote Sensing

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**Abstract.** Rapid urbanization and expansion of cities due to population growth and industrialization have a significant effect on the environmental surroundings and land use/land cover. Remote sensing data obtained from Landsat satellite are used to study land use land cover changes (LULC) happening in Tirupur city and neighbourhood. In the present work, LULC maps were generated using Landsat data for the years 2001 and 2018 and the changes have been evaluated. The study reveals that there is maximum increase in built-up area and decrease in fallow lands between 2001 and 2018 with a slight change in crop land, waste land and scrub land. This change is attributed to the expansion of Tirupur city due to industrialization..

**Keywords:** Land use/landcover, Tirupur, Landsat, Change detection, Remote sensing, GIS, Supervised classification.

## 1 Introduction

Land use / land cover are interchangeable two separate terminologies: land cover implies the distribution of landscapes including water bodies, geo morphological features, forests and natural covers whereas land use refers to anthropogenic impact on land use build-up areas<sup>1</sup>. Land use/Land Cover (LULC) marks the environmental changes and land use plan in developing regions. There is a continuous change in the degradation process in the Earth due to exponential growth in population and urbanisation, subsequently there is a decrease in green cover and barren land<sup>2</sup>. Land use/land cover dataset is an important tool in assessing the change in land use pattern required for proper land management which plays a vital role for smart city development<sup>3,4</sup>.

Nowadays, satellite images of any area for any period of time is easily accessible from various sources all around the world which helps in creating LULC maps. This remote sensing technology has a wide multi-disciplinary application in urban planning, hydrology, water quality study, LULC, etc., at low cost with better accuracy<sup>5</sup>. High spatial resolution satellite imagery (up to 30m) and advance open source image processing softwares with GIS technologies makes modelling and monitoring the LULC pattern often for any region<sup>6,7</sup>. Land area with faster development leads to urbanization process which has worsened the environmental scenario and therefore, it is required to determine the rate and trend of land cover/use conversion for devising a rational land use policy. Anthropogenic developments

mainly due to the industrial growth, directly leads to the conversion of natural land cover to different land uses<sup>8</sup>. This present work focus on the combined use of remote sensing and GIS data to track the changes observed in the LULC study between the years 2001 – 2018, for the semi-arid region of Tirupur corporation in the state of Tamilnadu, India.

## 2 Study area

Tirupur city is the fourth largest city in area in Tamilnadu, which extend between 77° 11' 43.74" E to 77° 23'18.14" E longitude and 11° 02' 01.42" N to 11° 10' 51.19" N latitude and located at an average elevation of 295 metres from the mean sea level. Figure1 shows the geographical location of the study area. The total area of the Tirupur corporation is about 159.60 square kilometres which is divided into 60 wards and records a population of 4,44,352 as per the 2011 census. Tirupur has a tropical climate with a temperature ranging from 22° C to 37° C<sup>9,10</sup>. The city records rainfall during the south–west monsoon in the months from June to August and a considerable amount of rainfall from the north–east monsoons are also recorded from the month of October to November. The city records an average rainfall of around 700 mm with south–west and north–east contributing about 28 % and 47 % respectively to the total rainfall.

River Noyyal runs at the heart of the city and get often flooded during monsoon season. Tirupur is also known as the knitwear capital of India and prompted as the textile industry in India for the past three decades. The soil is black cotton soil which is suitable for cotton cultivation, red loamy soil is also found in some parts. In the late 1970s, agriculture was the main source of economy of the Tirupur<sup>11</sup>. Later the farmers become owners of small textile related units. The tremendous growth in the textile industries made Tirupur as the India's textile hub with more of investors. This industrial development made Tirupur as a corporation in the year 2008. But, the city also faces severe environmental problems, due to the untreated waste water from the dyeing and bleaching industries, discharges into the open streams and lakes<sup>12</sup>.

## 3 Methodology

### *Data Acquisition*

The present study investigates the land use / land cover change (LULCC) from 2001 to 2018 through Landsat 5 and Landsat 8 satellite images, whose data acquisition details are given in Table1.

Table1 Satellite data details

Year	Data Used	Sensor	Resolution	Path/Row	Date of Acquisition
2001	Landsat 5 C1 Level-1	TM	30 m	144/052	23 <sup>rd</sup> Feb 2001
2018	Landsat 8 Level 1	OLI / TIRS	30 m	144/052	06 <sup>th</sup> Feb 2018

The Landsat satellite data was selected because of its free availability with high resolutions. The data set were obtained from the United State Geological Survey (USGS) earth explorer site (<http://earthexplorer.usgs.gov/>)<sup>13</sup>. These datasets were imported in ERDAS

Imagine, satellite image processing software to create a false colour composite (FCC). To process and analysis the data, software QGIS 2.18 was used<sup>14,15</sup>. The supporting study area boundary was collected from the Tirupur Corporation and it is shown in Figure 1.

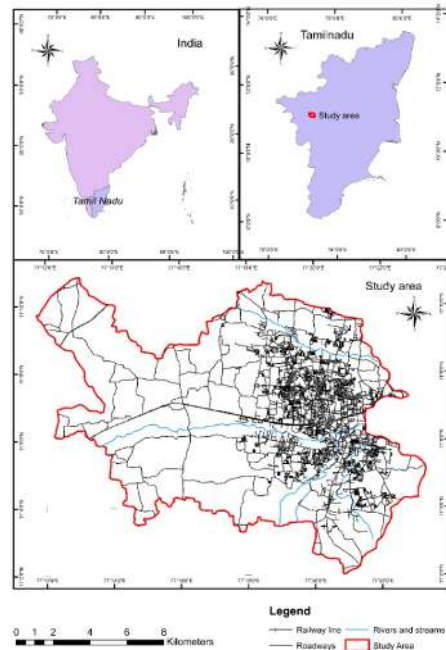


Figure 1. Map Showing the study area

#### *Image Processing and Classification*

Satellite images were layer stacked using image interpreter tool box in Erdas Imagine software and the study area is extracted using raster sub-set tool for the geo-referenced boundary of Tirupur city as AOI (Area of Interest). Supervised classification has been carried out for the raster image where the pixel signatures for different land cover types are captured by drawing delimiting polygons around the respective sites from the satellite imagery are stored as signature files and the raw digital numbers (DN) of each pixel was converted to radiance values, that belongs to a particular class of land use<sup>16</sup>. Maximum likelihood algorithm method was chosen for supervised classification where the accuracy assessment using kappa methods was done. However, to reduce the misclassifications due to heterogeneous mixture of features such as building, vegetation, bushes etc., visual interpretation is also made for enhancing the classification accuracy and to improve the quality of LULC map produced<sup>17,18</sup>.

Seven types of land use/cover are identified in the study region namely built-up land, agriculture – crop land, current fallow, plantation, wasteland, scrub forest and water bodies. The description of each class is given in the Table 2 and each class was assigned with a particular colour<sup>19</sup>.

Table 2 Land Use Classes defined on the basis of supervised classification.

SL No	Class Name	Description	Colour Code Used (RGB)
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1	<b>Built – up</b>	All man-made constructions including residential, commercial, industrial, transportation utilities and services, etc.,	255,0,0
2	<b>Agriculture – crop land</b>	Agriculture land with crop cultivation	158,81,43
3	<b>Current fallow</b>	Agriculture land kept ideal for one or two years with cultivation	245,245,219
4	<b>Plantation</b>	Mainly tree plantation like coconut	0,204,0
5	<b>Wasteland</b>	exposed soil and barren area influenced by human influence	209,181,133
6	<b>Scrub forest</b>	Includes bushes, plants which are not cultivated,	115,184,43
7	<b>Water bodies</b>	Includes river, open water, lakes, ponds, streams and reservoirs	0,158,222

### **Result and Discussion**

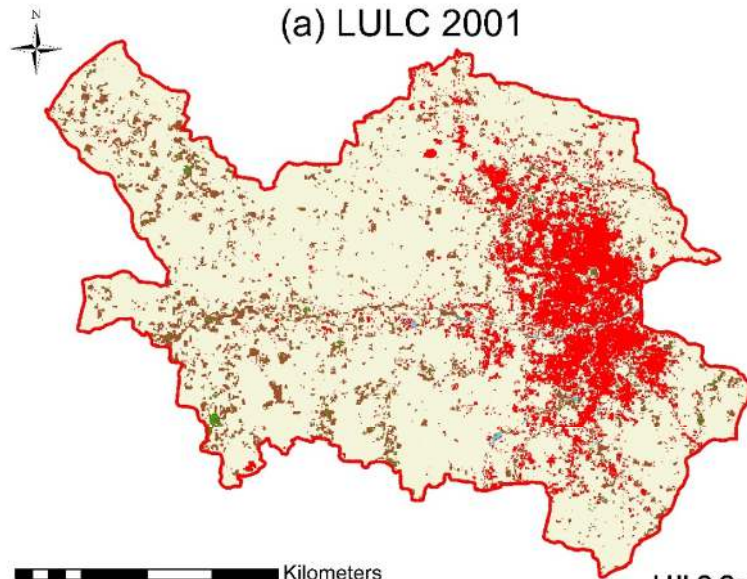
#### *LULC Classes Data and its Evaluation*

The area covers with seven land use classes in as depicted in Figure 2 (a) for the years 2001 and Figure 2 (b) for 2018 and the data given in Table 3 accounts for the area cover in hectare for each classes comprising the total area 18913.98 hectare of Tirupur city. Analysis of the data clearly proves that there is a change in the land use.

The main change in land use in largely noted to a depreciation of 17.52 % in current fallow land and intensification growth in built-up land of about 12.76 %. Whereas a minimal increase in land use change is noted for agricultural – crop land & plantation land, waste land, scrub forest to about 2.04 %, 0.10 %, 1.29 % and 1.34 % respectively.

The growth and decline in the land use classes for the study area of Tirupur city is clearly revealed from the data shown in Table 3 and Figure 2, 3&4. For the period from 2001 to 2018 there is an increase in built-up area from 2454.60 hectare to 4868.04 hectare which accounts to about 12.76 % in land use change. The agricultural – crop and plantation land has increased by about 2.14 % from accounting a change from 1612.64 hectare to 2016.23 hectare. The waste land and scrub forest area have also increased from 23.72 to 268 hectare and 12.94 to 266.18 hectare respectively, where current fallow land contributes more for this conversion.

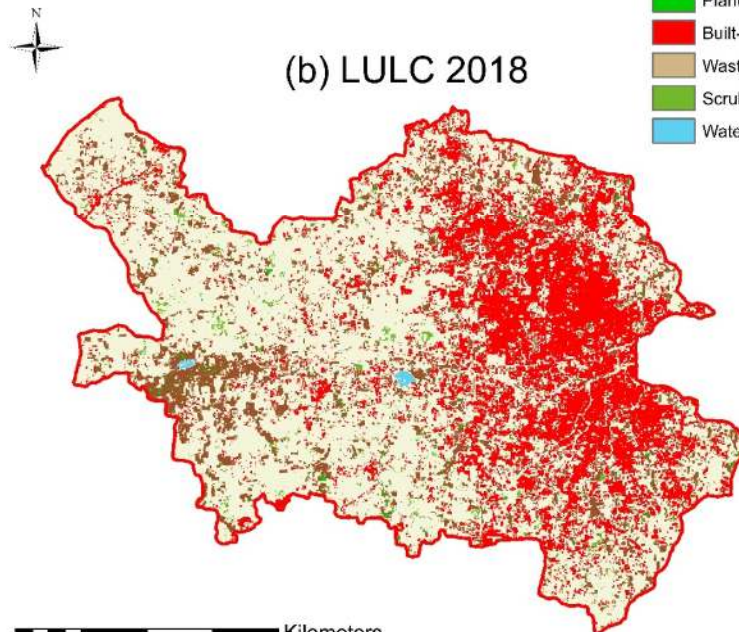
The current fallow land has been decreased from 14775.21 hectare to 11462.39 hectare. This accounts for highest depreciation in the LULC change for the last decade and records to 17.52 % decrease. It is noted that, there is an appreciable change in the water body class, which is mainly focused in change in location than change in total area cover. The encroachment along the bunds of the water bodies was one of the reasons for this change in location.



0 1 2 4 6 8 Kilometers

**LULC Category**

- Agriculture - Crop Land
- Current Fallow
- Plantation
- Built-Up Land
- Wasteland
- Scrub Forest
- Water Bodies



0 1 2 4 6 8 Kilometers

Figure 2 (a) Classified maps of Tirupur in 2001&(b) Classified maps of Tirupur in 2018  
 Table 3 LULC change deduction from 2001 to 2018

Land use Classes	Year – 2001		Year – 2018		Difference between 2001 – 2018	
	Area in hect	Area in %	Area in hect	Area in %	Area in hect	Area in %
Built-Up Land	2454.60	12.98	4868.04	25.74	2413.44	12.76
Current Fallow Land	14775.21	78.12	11462.39	60.60	-3312.82	-17.52
Agriculture - Crop Land	1578.67	8.35	1964.11	10.38	385.44	2.04
Plantation	33.97	0.18	52.12	0.28	18.15	0.10
Water Bodies	34.87	0.18	33.07	0.17	-1.80	-0.01
Waste Land	23.72	0.13	268.07	1.42	244.35	1.29
Scrub Forest	12.94	0.07	266.18	1.41	253.24	1.34
Total	18913.98	100	18913.98	100	0	0

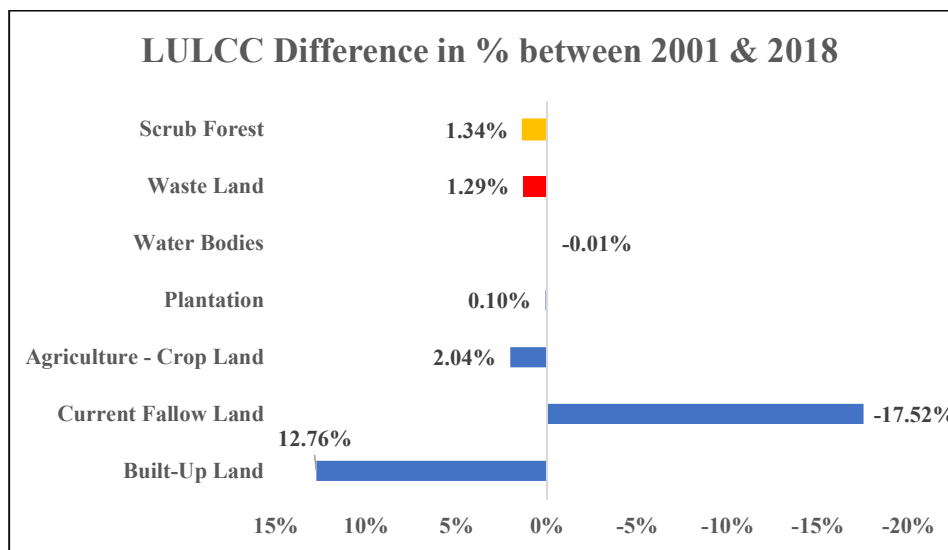


Figure 3 Graphical representation of LULCC % for the last decade in the study area

Table 4 Matrix showing the LULCclass conversion from 2001 to 2018

	To LULC class in year 2018 (area in hect)						
	Built-Up Land	Current Fallow Land	Agriculture - Crop Land	Plantation	Water Bodies	Waste Land	Scrub Forest
in year Built-Up Land	-	377.73	15.57	0	8.91	27.36	2.43

Current Fallow Land	2704.95	-	1249.38	34.38	17.01	215.1	218.61
Agriculture - Crop Land	80.91	742.59	-	15.57	1.17	21.15	42.48
Plantation	1.17	6.57	14.58	-	0	1.8	0.99
Water Bodies	4.23	18	7.29	0.36	-	0.27	0.18
Waste Land	13.05	6.39	0.27	0.36	1.44	-	0.09
Scrub Forest	2.16	0	2.52	0.27	0	0.18	-

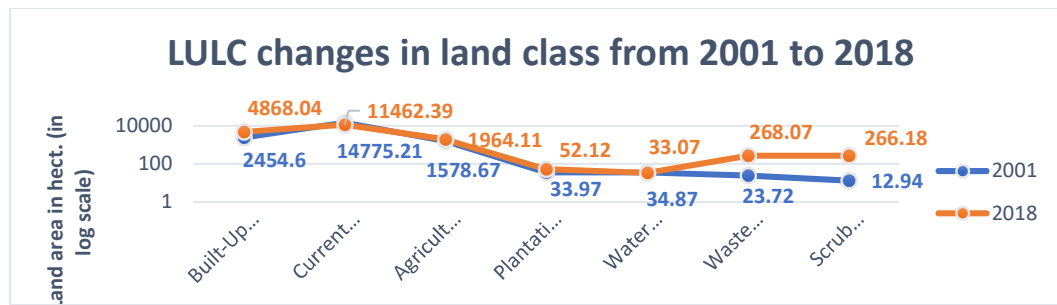


Figure 4 Graphical representation of LULC change area (in hect.) in log scale from 2001 to 2018

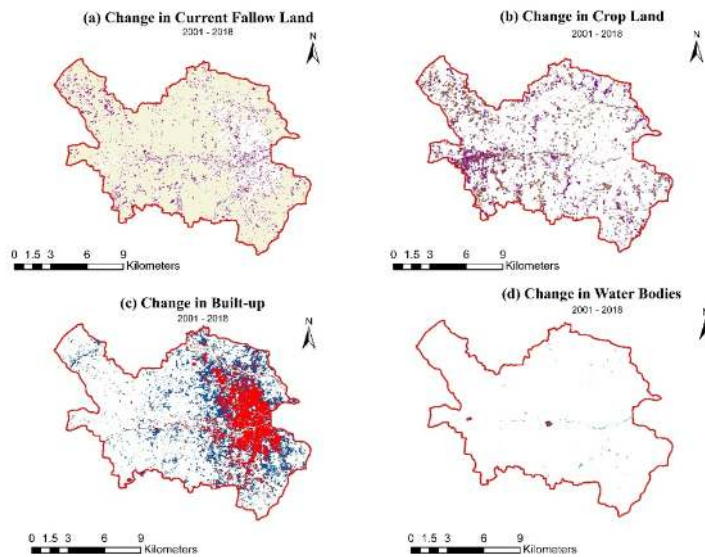


Figure 5 Land use/land cover change during 2001-2018 in Tiruppur Municipality (a) Fallow land (b) crop land (c) Built-up (d) water bodies (based on Landsat Satellite Image)

### *Ground Truth Verification*

Ground truth verification as shown in Table 5 was carried out at field with the help of hand held GPS for each land classes. Figure 2 (b) LULC classified map was used for verification along with the field data. Minimum of three points for each class was chosen randomly, then longitudinal and latitude of that points were collected in the field, later it was verified with the LULC generated map. It is found that all the land use classes are found correct and match with the real world.

Table 5 Ground truth verification

Sl No	Latitude	Longitude	Land use class	Ground truth Confirmed
1	11°4'43.763"N	77°17'10.072"E	Built up	Yes
2	11°9'56.424"N	77°18'29.737"E	Built up	Yes
3	11°7'35.513"N	77°20'39.084"E	Built up	Yes
4	11°7'47.174"N	77°21'54.3"E	Current Fallow Land	Yes
5	11°4'36.562"N	77°22'47.272"E	Current Fallow Land	Yes
6	11°4'32.627"N	77°15'37.987"E	Current Fallow Land	Yes
7	11°5'19.741"N	77°16'37.95" E	Current Fallow Land	Yes
8	11°5'10.863"N	77°23'8.113"E	Agriculture - Crop Land	Yes
9	11°4'46.114"N	77°16'22.14"E	Agriculture - Crop Land	Yes
10	11°7'58.463"N	77°19'2.792"E	Agriculture - Crop Land	Yes
11	11°3'35.618"N	77°17'36.449"E	Plantation	Yes
12	11°6'33.142"N	77°14'3.698"E	Plantation	Yes
13	11°7'36.627"N	77°21'36.496"E	Plantation	Yes
14	11°6'4.874"N	77°17'37.847"E	Water Bodies	Yes
15	11°9'1.729"N	77°20'58.721"E	Water Bodies	Yes
16	11°6'21.937"N	77°14'0.512"E	Water Bodies	Yes
17	11°6'16.592"N	77°13'45.709"E	Waste Land	Yes
18	11°9'58.609"N	77°19'16.251"E	Waste Land	Yes
19	11°4'0.014"N	77°17'4.103"E	Waste Land	Yes
20	11°9'44.715"N	77°19'28.843"E	Scrub Forest	Yes
21	11°6'23.009"N	77°16'56.357"E	Scrub Forest	Yes
22	11°6'2.818"N	77°14'45.124" E	Scrub Forest	Yes

*Land use / land change status*



Supervised classification methods for the land use change analysis depends on a combination of background professional knowledge and field experience. Thus per-pixel signatures are taken and stored in signature files by using this knowledge and the raw digital numbers (DN) of each pixel in the scene are therefore converted to radiance values.

To understand land encroachment for different land categories during the last two decades, a change detection matrix (Table 4 and Figure 4&5 (a)-(d)) was prepared which reveals that:

- From the matrix Table 4 and Figure 3 & 4, there is a much conversion observed in the current fallow land which accounted for about 4439.43 hect area. Out of which, 2704.96 hect. land was converted from current fallow land to built-up area, 215.1 hect and 218.61 hect land area was converted to waste land and scrub forest respectively. In reverse, effective usage of current fallow land in 2001 has been attributed to about 1283.76 hect area from fallow land to crop and plantation put together. This marked difference in agricultural area may be due to increase in seasonal rainfall.
- 903.87 hect. of agriculture – crop land was changed between the year 2001 to 2018 and it is noted that about 742.59 hect was occupied as current fallow land and 80.91 hect. as built-up land.
- An increased area under built-up usage between 2001-2018 is attributed by about 2704.95 hect. from fallow land, 80.91 hect. from agricultural land and a very minimal settlement of about 4.23 hect. around water bodies with 13.05 hect. as waste land.
- Rapid urbanization due to population growth and industrialization may be the cause for this marked difference in agricultural area and an increased built –up area.
- From Figure 3, there is a massive variation in the waste land and scrub forest area, which accounts for about 1.29 % (244.35 hect.) of waste land and 1.34 % (253.24 hect.) of scrub forest area from the total land area (Table 3). Table 4 depicts that 215.1 hect. of waste land and 218.61 hect. scrub forest land was converted from current fallow land which is highest in comparison to all other land classes.
- Among the water bodies in 2001, about 26.94% (8.91 hect.) has now been occupied as built-up area, 51.44% (17.01 hect.) as fallow land and 3.54% (1.17 hect.) for agricultural purpose in 2018 which may be attributed to the disposal of construction waste by landfills and encroachments.
- About 49.95 hect of fallow and crop land in 2001 has now been changed as plantation, a minor increase in plantation area of about 0.99 hect. was from water bodies, waste land and scrub forest in 2018. This may be due to the coconut plantation along the banks of the water bodies.

## Conclusion

The present study based on remote sensing and GIS was found to be an effective, easy tool in assessing the LULC changes through conventional mapping in the study area of Tirupur city in the last decade. The current quantitative study indicates that

- The maximum change in land use was noted in built-up area by about 12.76 %. In that 55.57% was subsidized from current fallow land from 2001 to 2018 mainly due to the expansion of the city during the last decades.

- During the study period (2001 – 2018), current fallow land has been decreased by 17.52% due to conversion in built-up land and agriculture.
- The next major category of land in the study area is agriculture land including crop land and plantation which was increased by 2.14% (403.59 hect) predominantly from current fallow land.

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