

Urban Dynamics with Population Changes in Thanjavur City, Tamil Nadu, India – A Geospatial Approach

S. Sreekala^{1*}

¹Kunthavai Naacchiyaar Government Arts College for Women, Autonomous, Thanjavur – 613007

*Corresponding author email: sreegeo.2007@gmail.com

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Abstract: Globally, over 50% of the population lives in urban areas today. By 2045, the world's urban population will increase by 1.5 times to 6 billion. The urban planners must plan for providing the basic amenities and infrastructure for the expanding population's need. Urban sprawl is unavoidable in accommodating the rising urban population, the influence of which can be limited through innovative land use planning techniques and community cooperation. Sustainable cities have been the leading global paradigm of urbanism. The present study analyses the urban dynamics in terms of decadal growth of population and the aerial expansion of built-up features in Thanjavur city from 2001 to 2021. The population increase was at lower rate during the period 2001 to 2011 and aerial expansion of built-up land was at higher rate. In the period 2011 – 2021, the population increase rate is high with slow rate of increase in built-up area inferring a stress in demand of land for future developments. The demand for land is assessed using the urban growth indicators of Land Consumption Rate (LCR) and Land Absorption Coefficient (LAC). The < 2 % of LCR values in the study area reveals a controlled and sustained urban growth. The LAC value of < 1 ha/ population shows an efficient land absorption with high density of urban development.

Keywords: Urban dynamics, Aerial Expansion, Land Consumption Rate (LCR), Land Absorption Coefficient (LAC)

1. Introduction

Urbanization is a dynamic and multifaceted process that includes a complex set of social, economic, demographic, cultural, and environmental factors and results in an increase in the proportion of the population thereby increasing the concentration of population in the larger settlements with high population density. (Ahmad, 2023). Urban dynamics mainly govern the pattern of development in the city and population growth is the main factor driving it. Land consumption is increasing rapidly with the exponential growth of population. (Sharma et al., 2012)

The United Nations (UN) Population Division projected that by 2030, each of the major regions of the developing world will hold more urban than rural dwellers and by 2050, two thirds of their inhabitants are likely to live in urban areas (Montgomery, 2008). In most metropolitan regions throughout the globe, urbanised land area is increasing to accommodate increasing population size. (Marshall, 2007).

Rapid pace of urbanization is a global phenomenon in most of the developing countries. (Amin and Fazal, 2012). Urbanization process (urban sprawl) is one of major significant drivers of land cover/use change, and it is associated with growth of populations (Barredo and Demicheli, 2003; Weng Q, 2001).

Based on the reports of NITI Aayog, the Economic Survey 2023-24 presented that by the year 2030, more than 40 percent of India's population will live in urban areas. (Economic Survey of Rural Urban Population, 2024).

There is tremendous growth of population in India where land resources are limited and are in urgent demand for developmental purposes. The growing human population exerts increasing pressure on the landscape as the demand for resources such as food, water, shelter, and fuel multiply. (Sharma et al., 2012).

Urbanization in India is happening at a rapid pace since past three decades. initial population and capital city status have a strong positive impact on city growth. The proximity to cities also causes nearby cities to be larger. (Abhishek, 2017).

At present, growth in urban populations worldwide is considered as the factor directly responsible for the unprecedented rate of urban sprawl being recorded majorly in cities within the global south. As the population of an urban center increases, its need for infrastructures such as transportation, water, sewage and facilities such as housing, commerce, health, schools, and recreation increases, most often resulting in the phenomenon known as urban sprawl (Fenta et al. 2017; Sumari et al. 2017; Tanveer et al. 2019; I. Ujoh and Paul 2019).

The increasing population leads to congestion in the city or region, thereby driving it toward increased demand for land resources. Congestion can be decreased only by moving/rehabilitating the population to a new location. The increasing population needs shelter and uses available resources for building and infrastructural development, and the urban sprawl further consumes the land for them. The demand for resources and socioeconomic factors often

dictates how land is being used for developmental and infrastructural activities (Ojima et al., 1994).

The most important issues for urban planners are measuring of urban growth and determining the urban requirements that must be accomplished earlier to get ready for future urban demands, rather than waiting for urban expansion will occur or not. The percentages of built up area and percentages of population were related and used as an alternative sprawl measure rather than using the population data as an indication function of the built up land. Land absorption rate is another measure of urban sprawl applied in evaluating the changes of built-up area and population in time period. (Abubakr et al., 2013).

Land consumption rate and population growth rate (LCRPGR) is an indicator used to assess the sustainability of urban growth, which takes into account both the change in the built-up area and of the population. The method is based on the change intensity analysis inside the cities. The intensity analysis implies the comparison between a uniform expected growth rate noticed over a certain period of time (Holobaca, 2022).

The concentration of people in densely populated urban areas, especially in developing countries, calls for the use of monitoring systems like remote sensing. Such systems along with spatial analysis techniques like digital image processing and geographical information system (GIS) can be used for the monitoring and planning purposes as these enable the reporting of overall sprawl at a detailed level. (Jat, et al., 2008).

RS and GIS provide tools for advanced spatial monitoring and planning, and also provide a potential means for understanding how urban patterns evolve and change over time (Yu & Ng, 2007; Herold et al., 2003). Also, RS and GIS prove to be effective means of extracting and processing spatial data of varied resolutions to obtain the necessary information for monitoring urban growth (Masser, 2001).

2. Study Area

The study is conducted for Thanjavur city, which is located in the Cauvery Delta at $10^{\circ} 47''$ latitude and $79^{\circ} 08''$ longitudes. Thanjavur is the headquarters of the Thanjavur District. The district is an important Agricultural Centre and is known as the Rice bowl of Tamil Nadu (Figure1).

Thanjavur city is administered by a municipal corporation covering an area of 128.02 km² and had a population of 222943 in 2011. Thanjavur is a resilient smart city, which has the capacity to grow with the available resources. It is a city of rich cultural and historical importance, the vision for smart city emphasizes on enhancing the identity of the city as “Cultural Capital of Tamil Nadu”, in addition to provision of resilient infrastructure and sustainable environment. Thanjavur was selected in the second round of Smart City Challenge competition on 20th September

2016. It is one of the 11 smart cities in the state of Tamil Nadu. The present study required satellite imageries of the study area for the years 2001, 2011 and 2021 (Figure 2).

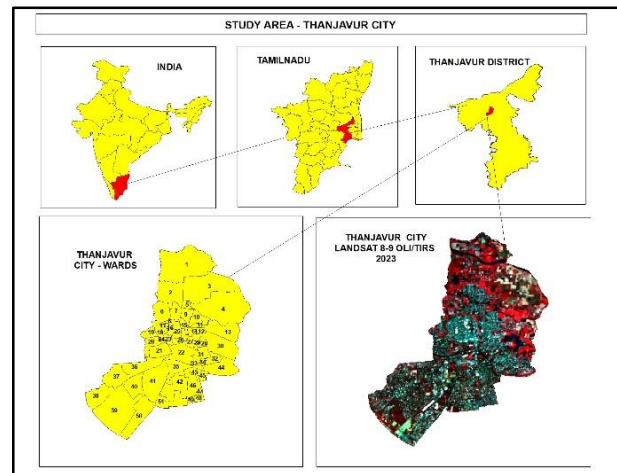


Figure 1. Study area – Thanjavur District

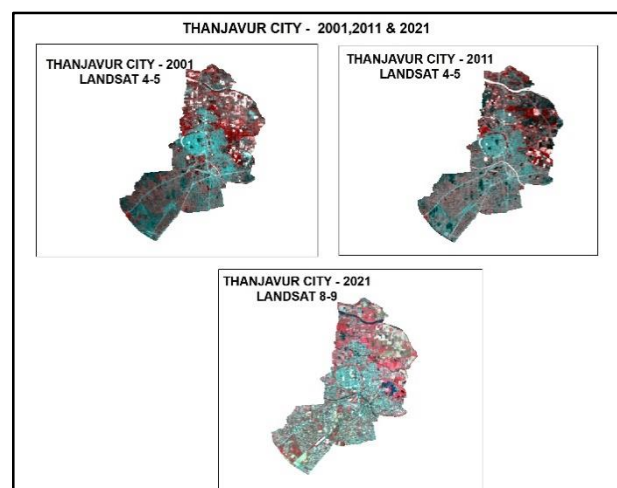


Figure 2. Satellite images for the study period

3. Materials and Methods

The aim of the present study is to analyse the urban dynamics in terms of aerial expansion in built-up areas with increase of population. Ward level study of the changes occurred in population and built-up areas are carried out for two decades from 2001 to 2021. Geospatial techniques are adopted to analyse the population characteristics along with spatial expansion of the city. The ward wise population are mapped with the help of Arc GIS software.

The statistical information is collected from secondary sources like Census abstract, District Hand Book, Hand book of Urban Statistics – India 2022, National Mission on Sustainable Habitat, 2021-2030, SRS Bulletin Sample Registration System, India, Vol. 53 No.1 May, 2021 (Reference Year: 2019) etc.

The Ward wise population is collected from the city corporation office for the years 2001 and 2011 and for the year 2021 projected population is calculated using Geometrical increase method. The built-up features are extracted from Landsat images for these years. The city built-up land for the years 2001 and 2011 is extracted from Landsat 4-5 image and Landsat 8-9 image is processed to get built up lands for the year 2021. The isocluster unsupervised classification and also the NDBI spectral calculation methods are adopted to identify the built-up lands in the study area. and the built-up area maps are prepared for the years 2001, 2011 and 2021 and ward wise areal spread are calculated.

The urban dynamics in terms of population growth and built-up land expansion is accomplished by the computation of urban indicators like Land Consumption Rate (LCR) and Land Absorption Coefficient (LAC).

4. Data Analysis

4.1 Thanjavur City Ward Wise Population 2001

Thanjavur city has a total population of 215725 as per the Census 2001 and is distributed among the 51 wards (Figure 3). In the wards 8,13,23, 25 – 28, 33 and from wards 47 to 50, the population is between 2000 and 3000. The population ranges from 3000 to 4000 in the wards of 5, 12,15 ,17 – 19, 21, 29,34,43. A population of 3001 – 4000 is found in the wards of 1,2,4,7 – 11, 14, 16, 30,31,35, 37, 38, 42. Above 5000 numbers of population is distributed over ward 3, 6, 20,32, 36, 39 – 41, 44- 46 and 51.

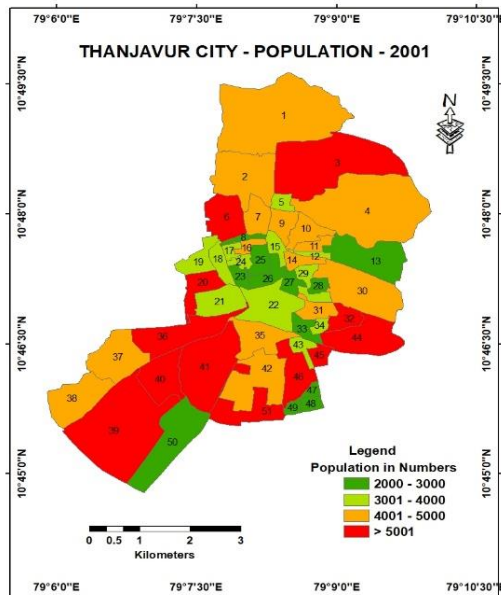


Figure 3. Population 2001

4.2 Thanjavur City Ward Wise Population – 2011

The population for the year 2011 is given as 222943 in Census 2011, which is distribute over the 51 wards (Figure 4). It is observed that below 2000 population is seen only in ward 8. The wards 5, 12 – 18, 22 – 28, 33 – 35, 43 and the wards from 47 – 50, the population is found to be from 2000 to 4000. 4001 to 6000 population is found in the wards of 1 -4, 7, 9 – 11, 19, 21, 30, 31, 37,38, 42, 45, 46. Above 6001 population is observed in 6,20,32, 39- 41, 44 and 51 wards.

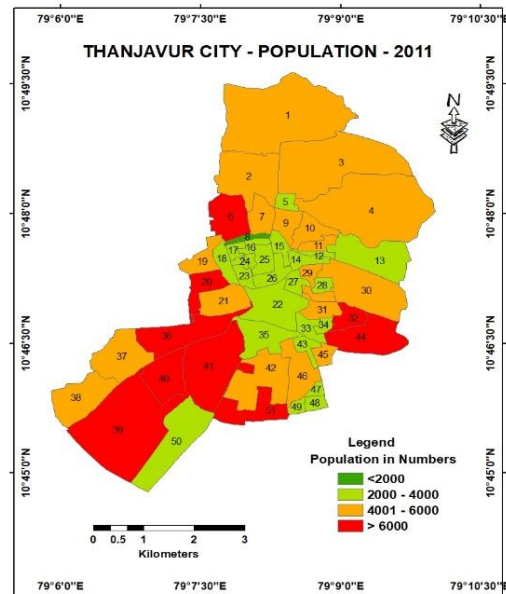


Figure 4: Population 2011

4.3 Thanjavur City Ward Wise Population 2021(Estimated)

The population for the year 2021 is estimated using Geometric projection method and it is calculated as 288934. Below 3000 number of populations is observed in 8,15,15,27, 47 and 48 wards (Figure 5). The population between 3000 to 6000 are distributed in 1,5,7,10,12 – 14, 16 – 19, Nearly fifteen wards of the study area have 6000 to 9000 number of populations. Above 9000 population is observed in 32, 39 – 41, 44 and 51 wards.

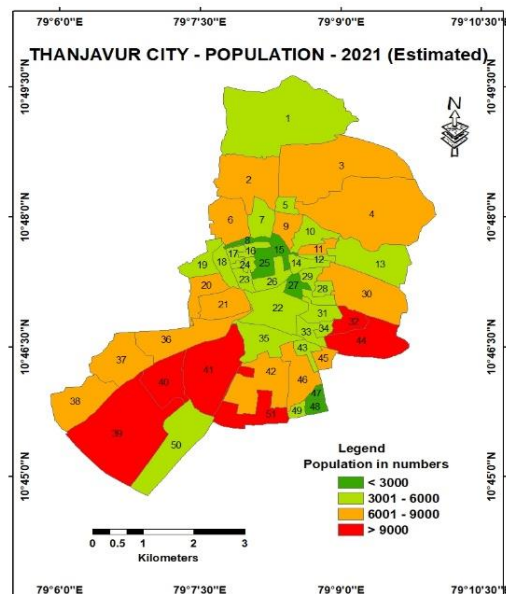


Figure 5. Population 2021

4.4 Thanjavur City Ward Wise Built-up Land - 2001

The total built-up area in the year 2001 is extracted as 32 sq.km. The built up are found clustered in the centre and is found as wards 1,3,4 and 30 have built-up areas from 1.8 sq.km to 2.5 sq.km (Figure 6).

The wards 13,2,10,26,14,18,25 have built-up areas from 1 sq.km to 1.3 sq.km. Nearly 18 wards have built-up areas from 0.5 sq.km to 0.8 sq.km., nearly 19 wards have built-up areas from 0.1 km to 0.4 km and built-up areas are not found in 40,47,48 and 49 wards in the year 2001.

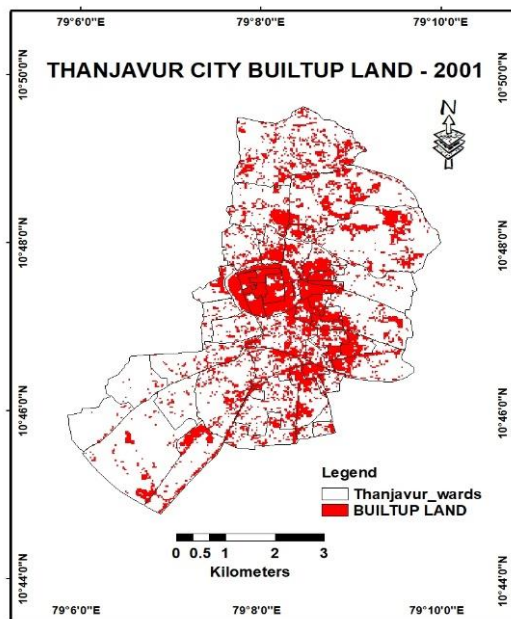


Figure 6. Built-up land – 2001

4.5 Thanjavur City Ward Wise Builtup Land 2011

Total built up area in the year 2011 is calculated as 89.5 sq.km which is distributed among the 51 wards. A maximum of 8.2 sq.km of built-up area is found in ward 39. A built-up area of 3 sq.km to 4.2 sq.km is found in the 44,41,50,37,42,1,36 and 38 wards. Nearly fifteen wards have built up lands between 1 sq.km to 1.9 sq.km. and about 17 wards have builtup lands above 0.5 sq.km to 0.9 sq.km. the wards 33,45, and 49 have less areas under built up lands (Figure 7).

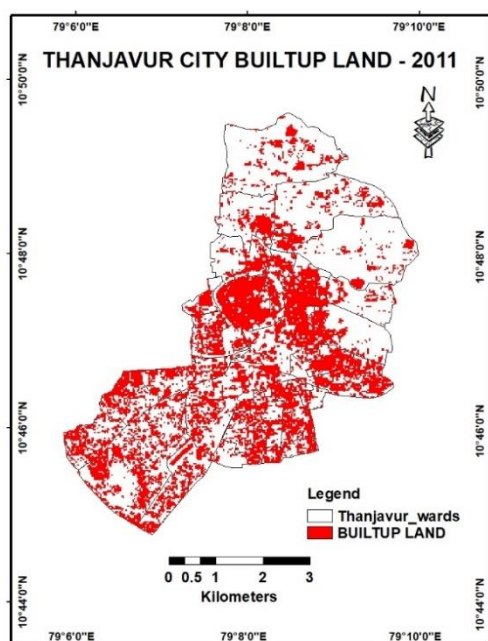


Figure 7. Built-up land - 2011

4.6 Thanjavur City Ward Wise Built-up Land 2021

The total area under built up land for the year 2021 is calculated as 101.8 sq.km. It is found that an area of 8.7 sq.km of built-up lands are occupied in ward 39. The wards 41,42, 44 and 50 occupies 4.2 sq.km to 5.2 sq.km of built-up. A built up between 3 sq.km to 3.7 sq.km are observed in the wards 36,38,37,1,46,3 and 51. 2 sq.km to 2.9 sq.km of built-up are found in 22,40,35,4,2 and 21 wards (Figure 8).

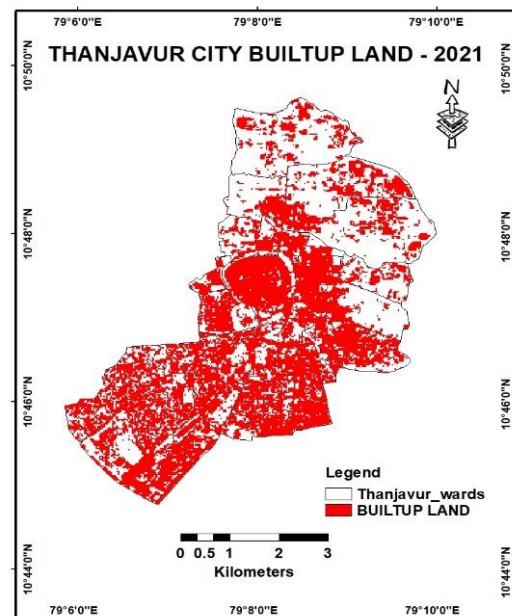


Figure 8. Built-up land – 2021

5. Results and Discussion

5.1 Thanjavur City Ward Wise Population Change 2001 – 2011

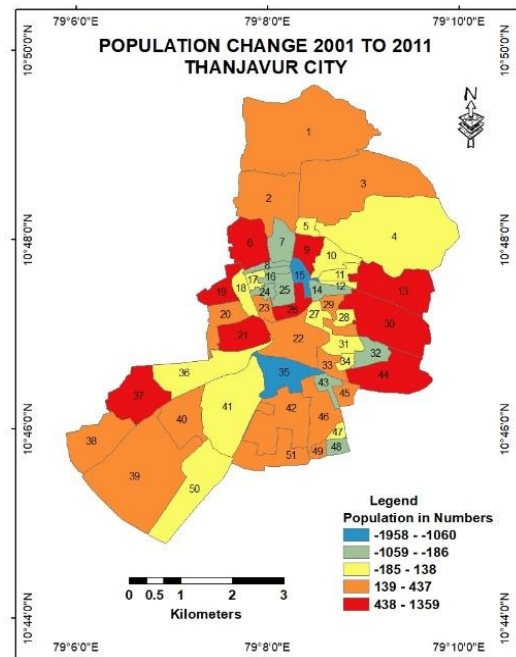
The total population of the study area in the year 2001 is observed as 215725 which is increased to 222943 in the year 2011 and is found that there is a very small increase of 7218 persons in these years. It is seen that the wards 21,30 and 37 has above 1000 number of population increase. The wards 6, 26,9,13, 19 and 44 has an increase of 691 to 915 number of populations (Table 1).

In the wards 45,42,2,46,38,51,40,22,20,1,3, 49,39,29,33 and 23, we can find an increase of 203 to 437 number of populations. In the wards 50,11,27,10,41,18,31 and 4, an increase of 23 to 138 persons is observed (Figure 9).

It is also observed that in the wards 12,34,36 and 5, there is a decrease of below 100 persons. In other wards 47,17,28,8,7,48,14,24,16,43,32 and 25, there is a decrease of 100 to 500 persons. In 15 and 35 wards, there is a drastic decrease of 1060 and 1958. This may be because of migration due to removal of encroachments and there was also rehabilitation of the residents in the outskirts.

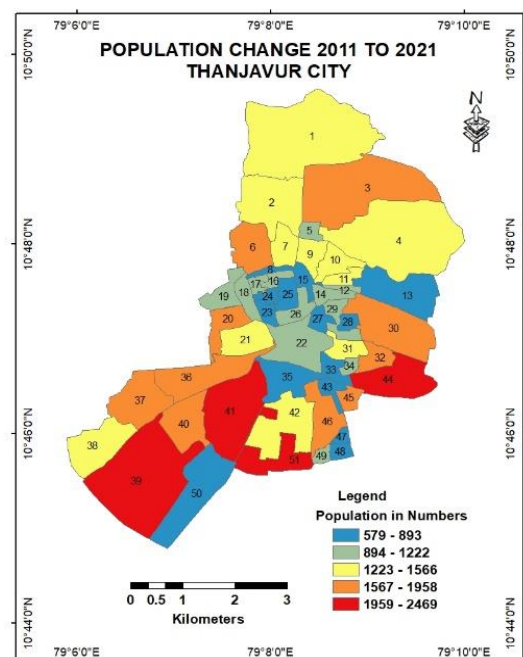
Table 1. Thanjavur city - Decadal change in population from 2001 to 2021

| Ward No | Population changes 2001 - 2011 | Population changes 2011 - 2021 |
|---------|-----------------------------------|-----------------------------------|
| 1 | 313 | 1289 |
| 2 | 388 | 1566 |
| 3 | 265 | 1694 |
| 4 | 23 | 1409 |
| 5 | -88 | 1159 |
| 6 | 915 | 1787 |
| 7 | -230 | 1352 |
| 8 | -186 | 580 |
| 9 | 766 | 1541 |
| 10 | 72 | 1293 |
| 11 | 104 | 1504 |
| 12 | -16 | 1061 |
| 13 | 761 | 822 |
| 14 | -265 | 1134 |
| 15 | -1060 | 625 |
| 16 | -381 | 1125 |
| 17 | -131 | 1014 |
| 18 | 62 | 1019 |
| 19 | 709 | 1222 |
| 20 | 316 | 1814 |
| 21 | 1161 | 1463 |
| 22 | 324 | 1172 |
| 23 | 203 | 893 |
| 24 | -318 | 824 |
| 25 | -572 | 664 |
| 26 | 823 | 995 |
| 27 | 89 | 668 |
| 28 | -136 | 789 |
| 29 | 236 | 1222 |
| 30 | 1160 | 1608 |
| 31 | 35 | 1289 |
| 32 | -449 | 1840 |
| 33 | 212 | 726 |
| 34 | -27 | 1082 |
| 35 | -1958 | 771 |
| 36 | -51 | 1824 |
| 37 | 1359 | 1741 |
| 38 | 343 | 1511 |
| 39 | 237 | 2367 |
| 40 | 327 | 1959 |
| 41 | 69 | 2189 |
| 42 | 426 | 1388 |
| 43 | -425 | 847 |
| 44 | 691 | 2469 |
| 45 | 437 | 1663 |
| 46 | 369 | 1765 |
| 47 | -130 | 639 |
| 48 | -263 | 686 |
| 49 | 238 | 924 |
| 50 | 138 | 826 |
| 51 | 333 | 2177 |

**Figure 8.** Population Change 2001-2011

5.2 Thanjavur City Ward Wise Population Change 2011 – 2021

The ward wise population for the year 2021 is calculated using the geometric increase method, based on the overall city population as received from the municipal records. It is found that there is an increase of 65991 persons from the year 2011 to 2021. An increase of 2000 to 2500 persons is observed in the wards 44,39,41 and 51. About 31 wards out of 51 wards have a population increase of 1000 to 2000 persons. In wards 6, 49, 23, 43,50,24,13,28, 35, 33, 48,27, 25,47,15 and the ward 8 have population increase from 500 to 1000 persons between the year 2011 and 2021 (Figure 10).

**Figure 10.** Population Change 2011-2021

5.3 Change in Urban Built up Area From 2001 To 2021

The urban built up features of Thanjavur city are extracted from Landsat image and the area is computed. It illustrates that between the years 2001 and 2011, the built up areas are changed in very low quantity about < 40 hectares in the central parts comprising the wards 10 -18, 23- 27, the wards 3,5 in the north and 13,30,33,34,43,45 wards in the east. The north west part of the study area exhibits a medium quantity of changes. The wards 22,28,29,31,32 in the central parts also have medium range of changes (Figure 11). Further it implies that the wards in the southern parts, the ward 4 in the north and 44 in the east are found to have more changes in the built-up lands with an increase of 120 to 760 hectares of lands newly converted to urban built up in this period.

Table 2 classifies the decadal changes into five classes for the city as a whole and Table 3 illustrates the changes in built-up area for 51 wards.

Table 2. Decadal change in Built up area 2001 – 2021

| Class | 2001 – 2011 Change in Area (sq.km) | 2011 – 2021 Change in Area (sq.km) |
|-------|--|--|
| I | 0 - 40 | 0 - 10 |
| II | 41 – 120 | 11 – 20 |
| III | 121 – 220 | 21 – 50 |
| IV | 221 - 390 | 51 – 110 |
| V | 391 - 760 | 111 - 150 |

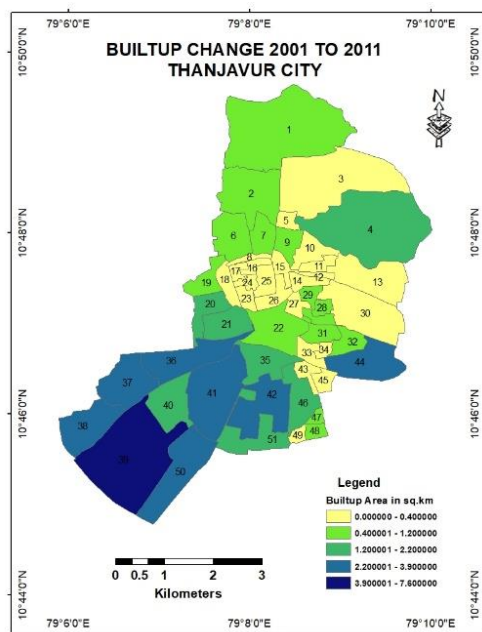


Figure 11. Builtup Change 2001-2011

There is an increase of < 20 hectares of area in the wards located in the middle part of the study area. A total of 150 hectares of built-up lands has been increased between these years, especially in the outskirts (Figure12).

The city centres as already occupied its maximum limit, the sprawl is occurring towards north and south of the study area with lower rate. About 21 to 110 hectares of

Table 3. Thanjavur city - Decadal change in Built up land from 2001 to 2021

| Ward No | Builtup area in sq.km 2001 | Builtup area in sq.km 2011 | Builtup area change in sq.km 2001-2011 | Builtup area in sq.km 2021 | Builtup area change in sq.km 2011-2021 |
|---------|----------------------------|----------------------------|--|----------------------------|--|
| 1 | 2.5 | 3.2 | 0.7 | 3.3 | 0.1 |
| 2 | 1.2 | 2.3 | 1.1 | 2.3 | 0 |
| 3 | 2 | 2.3 | 0.3 | 3 | 0.7 |
| 4 | 2 | 3.9 | 1.9 | 2.4 | -1.5 |
| 5 | 0.3 | 0.5 | 0.2 | 0.7 | 0.2 |
| 6 | 0.7 | 1.8 | 1.1 | 1.3 | -0.5 |
| 7 | 0.3 | 1.3 | 1 | 1.2 | -0.1 |
| 8 | 0.5 | 0.6 | 0.1 | 0.6 | 0 |
| 9 | 0.3 | 1.1 | 0.8 | 1.5 | 0.4 |
| 10 | 1.2 | 1.3 | 0.1 | 1.4 | 0.1 |
| 11 | 0.6 | 0.9 | 0.3 | 0.9 | 0 |
| 12 | 0.3 | 0.5 | 0.2 | 0.5 | 0 |
| 13 | 1.3 | 1.5 | 0.2 | 1.5 | 0 |
| 14 | 1.1 | 1.3 | 0.2 | 1.4 | 0.1 |
| 15 | 0.5 | 0.6 | 0.1 | 0.7 | 0.1 |
| 16 | 0.8 | 0.8 | 0 | 0.9 | 0.1 |
| 17 | 0.6 | 0.7 | 0.1 | 0.7 | 0 |
| 18 | 1 | 1.3 | 0.3 | 1.3 | 0 |
| 19 | 0.2 | 1.1 | 0.9 | 1.2 | 0.1 |
| 20 | 0.1 | 1.4 | 1.3 | 1.9 | 0.5 |
| 21 | 0.4 | 1.8 | 1.4 | 2 | 0.2 |
| 22 | 0.8 | 2 | 1.2 | 2.9 | 0.9 |
| 23 | 0.8 | 0.9 | 0.1 | 0.9 | 0 |
| 24 | 0.7 | 0.7 | 0 | 0.7 | 0 |
| 25 | 1 | 1.2 | 0.2 | 1.3 | 0.1 |
| 26 | 1.1 | 1.2 | 0.1 | 1.4 | 0.2 |
| 27 | 0.5 | 0.9 | 0.4 | 1 | 0.1 |
| 28 | 0.3 | 0.8 | 0.5 | 0.8 | 0 |
| 29 | 0.7 | 1.5 | 0.8 | 1.6 | 0.1 |
| 30 | 1.8 | 1.9 | 0.1 | 1.9 | 0 |
| 31 | 0.2 | 0.9 | 0.7 | 1.1 | 0.2 |
| 32 | 0.8 | 1.6 | 0.8 | 1.8 | 0.2 |
| 33 | 0.2 | 0.3 | 0.1 | 0.7 | 0.4 |
| 34 | 0.3 | 0.5 | 0.2 | 0.6 | 0.1 |
| 35 | 0.7 | 2.2 | 1.5 | 2.6 | 0.4 |
| 36 | 0.3 | 3.2 | 2.9 | 3.7 | 0.5 |
| 37 | 0.1 | 3.5 | 3.4 | 3.6 | 0.1 |
| 38 | 0.1 | 3 | 2.9 | 3.7 | 0.7 |
| 39 | 0.6 | 8.2 | 7.6 | 8.7 | 0.5 |
| 40 | 0 | 1.8 | 1.8 | 2.8 | 1 |
| 41 | 0.2 | 4.1 | 3.9 | 5.2 | 1.1 |
| 42 | 0.2 | 3.4 | 3.2 | 4.9 | 1.5 |
| 43 | 0.3 | 0.6 | 0.3 | 1 | 0.4 |
| 44 | 0.6 | 4.2 | 3.6 | 4.2 | 0 |
| 45 | 0.1 | 0.3 | 0.2 | 0.8 | 0.5 |
| 46 | 0.6 | 2.8 | 2.2 | 3.2 | 0.4 |
| 47 | 0 | 0.5 | 0.5 | 0.6 | 0.1 |
| 48 | 0 | 0.6 | 0.6 | 0.8 | 0.2 |
| 49 | 0 | 0.2 | 0.2 | 0.6 | 0.4 |
| 50 | 0.7 | 3.8 | 3.1 | 5 | 1.2 |
| 51 | 0.4 | 2.5 | 2.1 | 3 | 0.5 |

urban built up has been increased in the southern wards and 3,6 and ward 9 in the north. The highest increase

calculated as 110 hectares to 150 hectares in the wards 4,42 and ward 50.

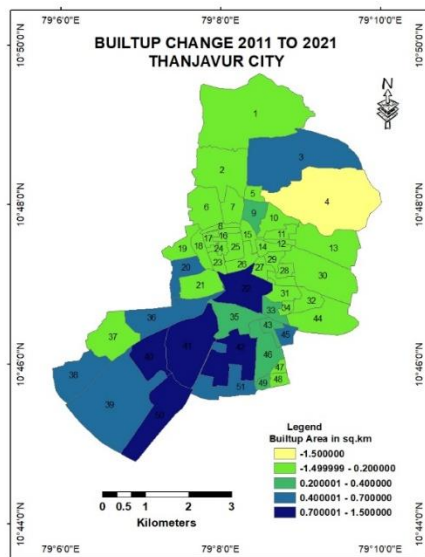


Figure 12. Builtup Change 2011-2021

5.4 Urban Dynamics – Thanjavur city

The present study of urban dynamics takes into account the changes occurred in population and built-up area in the study area between 2001 and 2021. The overall changes shown in Table 4 infers that between the years 2001 to 2011 there is an increase of 5750 hectares of land under built up and an increase of 7218 population. Between the years 2011 and 2021, it is observed that there is an increase of 1230 hectares of built up and an increase of 65991 population (Figure13 & Figure14).

Table 4. Urban Dynamics – Thanjavur City 2001 to 2021

| Year | Increase in Built up area (in hectares) | Increase in Population (in number) |
|-------------|---|------------------------------------|
| 2001 - 2011 | 5750 | 7218 |
| 2011 - 2021 | 1230 | 65991 |

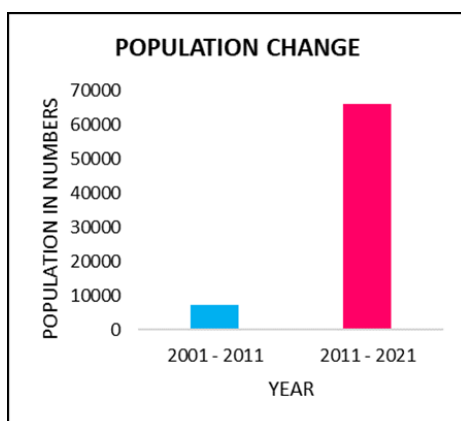


Figure 13. Population change

In the period from 2011 to 2021, the builtup land has increased at a lower rate compared to the previous decade.

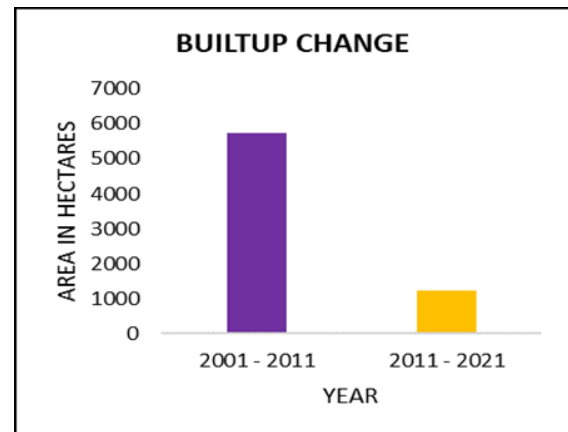


Figure 14. Builtup area change

5.5 Thanjavur City Urban Growth Indicators

The Land Consumption Rate (LCR) and Land Absorption Coefficient (LAC) are taken as indicators of growth status in the study area.

5.5.1 Land Consumption Rate (LCR)

Land consumption rate is the rate at which urbanized land change during a period of time, expressed as a percentage of the land occupied by the city at the start of that time. It is a measure of land transformed to urban land use. The land consumption rate measures the compactness of land. (Oloukoi, et.al., 2014)

The LCR value is calculated using the Formula 1

$$LCR = \frac{A}{P} \quad \text{----- (1)}$$

Where,

A = Areal extent of the city in hectares

P = Population

The LCR value for the years 2001,2011 and 2021 is depicted in graph. (Figure 15)

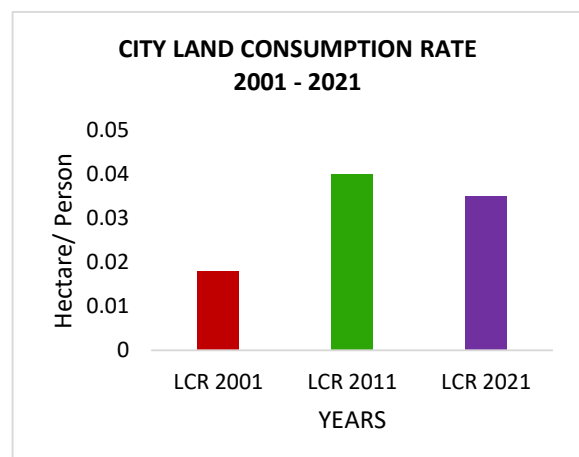


Figure 15: Land Consumption Rate

As LCR is a measure of compactness, the present study reports that the spatial expansion of the city is low in the year 2001, about 0.018 %. This value increases to 0.04 % in the year 2011 and is again lowered slightly to 0.035 % in 2021. Further it shows that the rate of change of land into urban usage was low in the year 2001, which is increased to a maximum in a period between 2001 and 2011. In the successive years there is a gradual increase of land under urban land use, as it has reached to a maximum in the previous decade.

Figure 16 illustrates the ward wise LCR values for Thanjavur city for the years 2001, 2011 and 2021. These values are undergoing gradual increase in recent period and may be continued in the near future, even though there was remarkable decrease in the past decade.

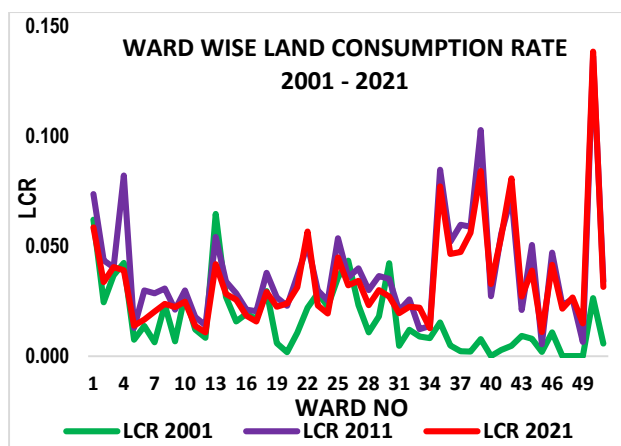


Figure 16. Ward wise LCR value 2001 – 2021

5.5.2 Land Absorption Coefficient (LAC)

The land absorption coefficient (LAC) is an indicator of urban growth as it denotes Demand of land per person. Apart from population parameter as the indicator of growth the LAC takes in to account the areal extent of built-up as a measure of growth and the availability of land per increase of population. It is a measure of consumption of new urban land by each unit increase in urban population, which represents the aerial expansion of the city along with increase of population. (Oloukoi, et.al., 2014) It indicates how new land is being used for built-up purposes and population is expanding outskirts or sprawl is taking place. To fulfil the needs of the increasing population in the city, the infrastructure has to be developed, and therefore there will be an inclusion of new areas from outskirts added to the city. The LAC value is computed using the Formula 2, given below.

$$\text{LAC} = \frac{A_2 - A_1}{P_2 - P_1} \quad (2)$$

Where,

A1 and A2= Areal extent (in hectares) for the early and later years, and

P1 and P2= Population figure for the early and later years, respectively

The LAC value for the period 2001 -2011 is calculated as 0.797 ha/ population. The land available for the existing

population is high in the period from 2001 to 2011, where there is very low rate of increase in population as per the municipal records. The population for the year 2001 has been 215725 and it was 222943, in 2011 with a small increase of about 7218 persons, with an increase in built up area by 5750 hectares between these years, which has resulted in the high value of the LAC, during the period. The LAC value for the study area as a whole is featured in Figure 17 and the ward wise LAC value is depicted in Figure 18.

The LAC value for the period 2011 – 2021 is calculated as 0.019 ha/population. There was a sudden increase of population between these years as about 65991 persons, with a gradual increase of urban built up area with 1230 hectares of increase in the decade. This caused for the dropping of LAC value in these years. This elucidates that the population in the study area is getting congested in the available land and there is no or very little aerial expansion has happened in this period. The Table 5 denotes the urban indicators for the city as a whole and Table 6 indicates the ward wise LCR and LAC values for the years 2001, 2011 and 2021.

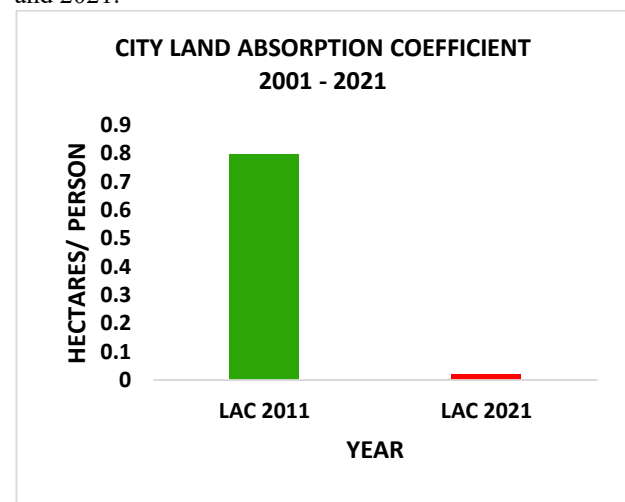


Figure 17. LAC value -Thanjavur City 2001 – 2021

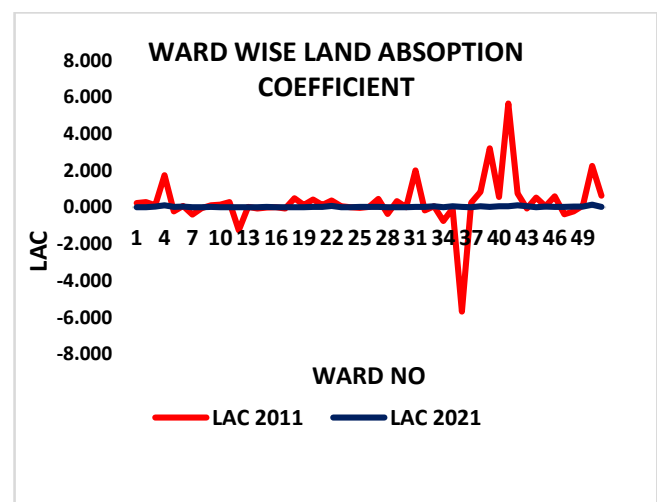


Figure 18. LAC value -Ward wise 2001 – 2021

Table 5 Thanjavur City– Urban Indicators

| YEAR | INDICATORS | |
|------|------------|------------------------------|
| | LCR (%) | LAC (ha /1000 population) |
| 2001 | 0.018 | ----- |
| 2011 | 0.04 | 0.797 |
| 2021 | 0.035 | 0.019 |

Table 6 Thanjavur City Ward Wise – Urban Indicators

| Ward no | LCR 2001 | LCR 2011 | LCR 2021 | LAC 2011 | LAC 2021 |
|------------|-------------|-------------|-------------|-------------|-------------|
| 1 | 0.062 | 0.073 | 0.058 | 0.224 | 0.008 |
| 2 | 0.024 | 0.043 | 0.034 | 0.284 | 0.000 |
| 3 | 0.037 | 0.040 | 0.040 | 0.113 | 0.041 |
| 4 | 0.042 | 0.082 | 0.039 | 1.739 | 0.106 |
| 5 | 0.007 | 0.013 | 0.014 | -0.227 | 0.017 |
| 6 | 0.014 | 0.030 | 0.017 | 0.066 | 0.028 |
| 7 | 0.006 | 0.028 | 0.020 | -0.391 | 0.007 |
| 8 | 0.023 | 0.031 | 0.024 | -0.054 | 0.000 |
| 9 | 0.007 | 0.021 | 0.022 | 0.104 | 0.026 |
| 10 | 0.028 | 0.030 | 0.025 | 0.139 | 0.008 |
| 11 | 0.012 | 0.018 | 0.014 | 0.288 | 0.000 |
| 12 | 0.008 | 0.014 | 0.011 | -1.250 | 0.000 |
| 13 | 0.064 | 0.054 | 0.042 | 0.026 | 0.000 |
| 14 | 0.027 | 0.034 | 0.028 | -0.075 | 0.009 |
| 15 | 0.016 | 0.028 | 0.026 | -0.009 | 0.016 |
| 16 | 0.019 | 0.021 | 0.018 | 0.000 | 0.009 |
| 17 | 0.017 | 0.020 | 0.016 | -0.076 | 0.000 |
| 18 | 0.030 | 0.038 | 0.029 | 0.484 | 0.000 |
| 19 | 0.006 | 0.027 | 0.022 | 0.127 | 0.008 |
| 20 | 0.002 | 0.023 | 0.024 | 0.411 | 0.028 |
| 21 | 0.011 | 0.036 | 0.031 | 0.121 | 0.014 |
| 22 | 0.022 | 0.051 | 0.057 | 0.370 | 0.077 |
| 23 | 0.028 | 0.030 | 0.023 | 0.049 | 0.000 |
| 24 | 0.023 | 0.025 | 0.019 | 0.000 | 0.000 |
| 25 | 0.036 | 0.054 | 0.045 | -0.035 | 0.015 |
| 26 | 0.043 | 0.036 | 0.032 | 0.012 | 0.020 |
| 27 | 0.023 | 0.040 | 0.034 | 0.449 | 0.015 |
| 28 | 0.011 | 0.030 | 0.023 | -0.368 | 0.000 |
| 29 | 0.018 | 0.036 | 0.030 | 0.339 | 0.008 |
| 30 | 0.042 | 0.035 | 0.027 | 0.009 | 0.000 |
| 31 | 0.005 | 0.021 | 0.019 | 2.000 | 0.016 |
| 32 | 0.012 | 0.026 | 0.022 | -0.178 | 0.011 |
| 33 | 0.009 | 0.012 | 0.022 | 0.047 | 0.055 |
| 34 | 0.008 | 0.014 | 0.013 | -0.741 | 0.009 |
| 35 | 0.015 | 0.084 | 0.077 | -0.077 | 0.052 |
| 36 | 0.005 | 0.052 | 0.046 | -5.686 | 0.027 |
| 37 | 0.002 | 0.060 | 0.047 | 0.250 | 0.006 |
| 38 | 0.002 | 0.059 | 0.056 | 0.845 | 0.046 |
| 39 | 0.008 | 0.103 | 0.084 | 3.207 | 0.021 |
| 40 | 0.000 | 0.027 | 0.033 | 0.550 | 0.051 |
| 41 | 0.003 | 0.055 | 0.054 | 5.652 | 0.050 |
| 42 | 0.005 | 0.072 | 0.081 | 0.751 | 0.108 |
| 43 | 0.009 | 0.021 | 0.027 | -0.071 | 0.047 |
| 44 | 0.008 | 0.050 | 0.039 | 0.521 | 0.000 |
| 45 | 0.002 | 0.005 | 0.011 | 0.046 | 0.030 |
| 46 | 0.011 | 0.047 | 0.041 | 0.596 | 0.023 |
| 47 | 0.000 | 0.023 | 0.021 | -0.385 | 0.016 |
| 48 | 0.000 | 0.026 | 0.027 | -0.228 | 0.029 |

| | | | | | |
|-------|-------|-------|-------|-------|-------|
| 49 | 0.000 | 0.006 | 0.015 | 0.084 | 0.043 |
| 50 | 0.026 | 0.136 | 0.138 | 2.246 | 0.145 |
| 51 | 0.006 | 0.034 | 0.031 | 0.631 | 0.023 |
| Total | 0.018 | 0.040 | 0.035 | 0.797 | 0.019 |

6. Conclusions

The present study emphasis the urban dynamics in terms of population growth and built-up land expansion. The population increase was at lower rate during the period 2001 to 2011 and aerial expansion of built-up land was at higher rate. But in the period 2011 – 2021, the rate of increase of built-up area became slow and the population increase rate is high inferring a stress in demand of land for future developments in the study area.

The urban indicators of Land Consumption Rate (LCR) and Land Absorption Coefficient (LAC). The LCR value for the year 2001 is about 0.018 % which has increased to 0.04 % in the year 2011 and is again lowered slightly to 0.035 % in 2021. The LCR values < 2 % reveals a controlled and sustained growth in the study area. There is a drastic decrease of LAC value from 0.797 ha/ population during 2001- 2011 to 0.019 ha/ population in 2011 – 2021 period. Normally < 1 ha/ population LAC value is considered as efficient with high density of urban development, implying the absorption of land by population growth is low.

As the study area is a part of agrarian economy, the controlled development in urban land use with increase of population is appreciable. The successful implementation of smart city project is evident in the study area. The town planners and authorities must take action to maintain this sustained development.

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