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Urban Sprawl Analysis of Tiruppur City Using Gis and Rs

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Abstract:
A rural economy's transformation into an industrialized and service-based economy is known as urbanization. Urban sprawl is an important result of urbanization which occurs when a city's population is scattered over an expanding geographic region. In the 20th century, the process of urbanization has spread throughout the world. Because urban areas experience greater horizontal expansion than vertical expansion, the growth of the city is typically more apparent in its periphery. The population of rural areas with primary activity moves to urban areas with secondary and tertiary sectors as a result of this horizontal expansion. India is a nation that is largely urbanizing, which has 461 million people living in urban areas. This number is rising by 2.3% annually and urban infrastructure needs to be built, which is a difficult task [17]. Tamil Nadu is the tenth largest state and it ranks third on the urban population. Tiruppur city is one of the developing urban area and textile hubs of Tamil Nadu. Urbanization is rapid in this city and should be assessed for strong and sustainable growth. Satellite images for 3 different years have been taken and Land Use / Land Cover map is prepared to analyse the change in land use category. Also, it helps to find about the sprawl direction and measures can be taken according to that in future. Also, the Urban Expansion Intensity Index (UEII) was calculated to evaluate the rate and speed of urban growth, gives a clear view of the city expansion during the study period.

Keywords: Urban Sprawl, Tiruppur City, Land Use / Land Cover, Geographic Information System.

Introduction:

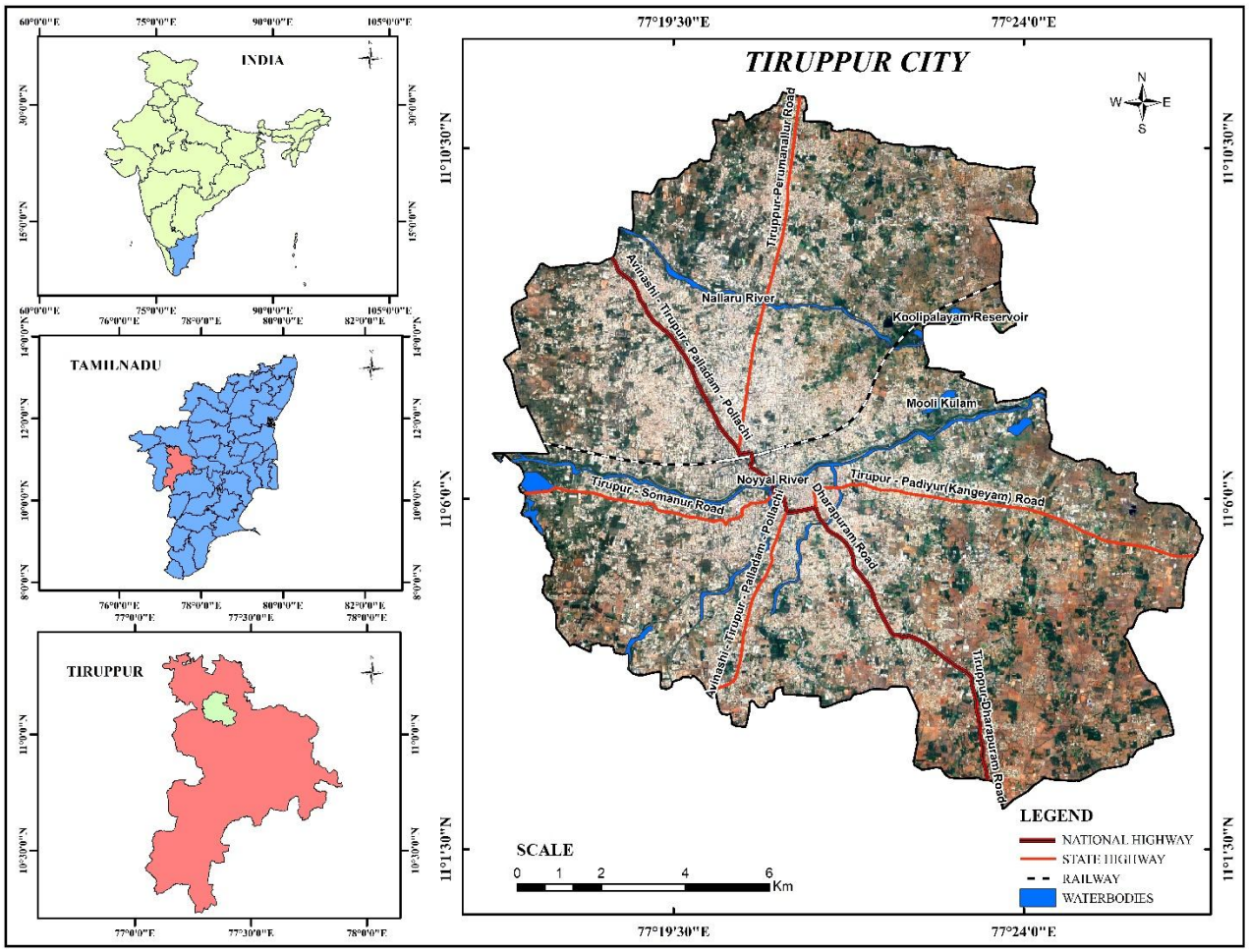
Urbanization has become one of the most important modern developments, shaping the physical and social structure of cities throughout the world. The space taken up by urban areas is increasing faster than the urban population itself. Between 2000 and 2030, the world's urban population is expected to increase by 72%, while the built-up areas of cities of 100,000 people or more could increase by 175% [4]. As migration takes place, the city experiences huge demand for space and it is forced to grow outwards which is known as Urban Sprawl. Understanding the reason and causes of the expansion is necessary for managing the growth in a planned and sustainable way. Geospatial techniques have been used to analyze the changes in urban area over a period of time. The temporal spatial data allows to visualize the changes in land use practices in an area and to find out the driving factors which influences the changes and helps in making decisions accordingly [10]. The remote sensing is a powerful and useful tool for studying urban related issues like land use /land cover change detection, urban growth analysis, urban planning, etc [11]. It should also be noted that LULC mapping using remote sensing has long been a research focus of various investigators [7]. Urban Expansion Intensity Index, (i.e., UEII) could be used to evaluate the urban spatial

expansion difference in a quantitative manner. Additionally, UEII could be employed to recognize the preferences of urban growth and to compare the speed or intensity of urban land use changes in a certain period [12]. The main aim of this study is to analyze spatial and temporal changes in Tiruppur city and uses Urban Expansion Intensity Index to find the growth level during the study period.

Study Area:

Tirupur city, located in the western part of Tamil Nadu, is called as the "Knitwear Capital of India" for its developing textile industry. Tiruppur started off as a small union and became a town with the inclusion of Thennampalayam, Karuvampalayam and Valipalayam villages on 1st of December 1917. It was constituted as a Third Grade Municipality then and the town was upgraded as a City Municipal Corporation from 01.01.2008. The total area of the corporation is 166 Sq.km with 60 wards dividing into four regions zone 1, 2, 3, 4 respectively and the total population as per 2011 census is 8,77,778. The city lies between 11° 3' N to 11° 10' N latitude and from 77° 16' E to 77° 26' E longitude in the western part of Tamil Nadu, equally divided by river Noyyal flowing through the middle of the city. It is bounded on the North by district Erode and on the West by Coimbatore, on the East by Karur and South by Dindugul. The city's economy depends on garment manufacturing, with numerous factories and export units contributing significantly to India's textile exports. With a growing population, Tirupur continues to develop rapidly, blending modern infrastructure with its cultural heritage.

Figure1: Study Area Map



Data & Methodology:

This study is based purely on secondary data sources. Land Use/Land Cover (LULC) maps were created using Landsat 5 TM images for 1995, 2005 and Landsat 9 OLI/TIRS imagery for 2024. The satellite images were stacked, pre-processed, enhanced using standard digital image processing techniques and clipped to the exact boundary of the study area. Supervised classification method was used to prepare the LULC maps and sample points for each land use category were selected manually to ensure that every class was clearly represented. The result is reclassified to remove errors and accuracy of the final maps was checked using the Kappa coefficient. The change detection analysis was carried out to understand the shift in land use over the years. The urban category was extracted separately and using these values, the Urban Expansion Intensity Index (UEII) was calculated to measure the growth of urban sprawl and its direction.

For urban sprawl, Urban Expansion Intensity Index was calculated using the following formula:

$$UEII_{it} = \left(\frac{ULA_{ib} - ULA_{ia}}{t}\right) \div TLA_i \times 100 \qquad (1)$$

Where "$UEII_{it}$ is the annual average urban expansion intensity index of (*i*th) zone in time period (t) and ULA_{ia} and ULA_{ib} are the quantity of built-up area at time periods *a* and b in (*i*th) spatial zone, respectively. TLA_i is the total area of (*i*th) spatial zone" [2].

Figure 2: Data and Methodology Flow Chart

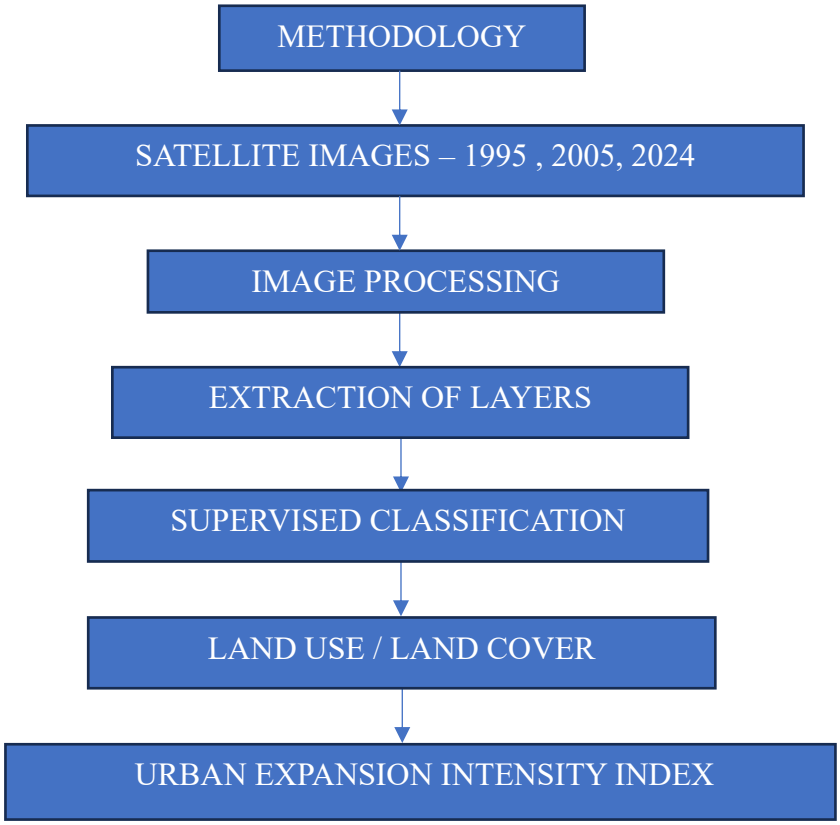


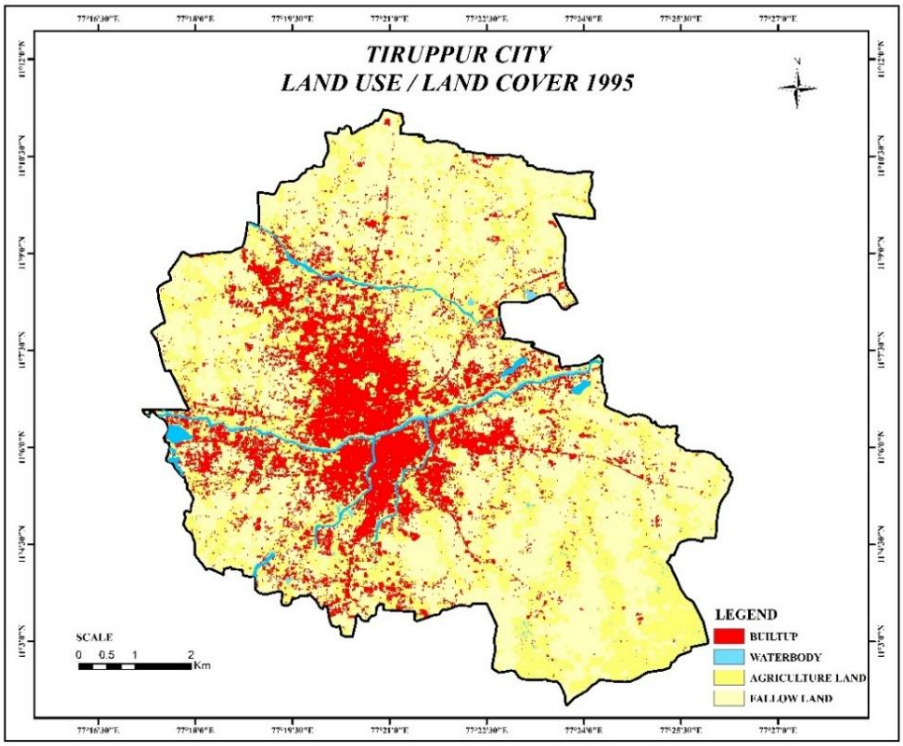
Image Analysis:

LULC – 1995:

The largest area of Tiruppur city is Fallow land, having 79.04 sq.km, contributing 45% of the city and it is followed by Agriculture having 53.68 sq.km. In 1995, Tiruppur was primarily a rural-agrarian region

with limited industrial and residential development. The textile industry and large-scale land conversion had not yet begun, leaving most of the landscape dominated by agriculture and fallow lands. Following it, 29.61 sq.km of Built up makes up the third most important land use in the region. Water body covers only 4.03 sq.km and has the least area of the land area in Tiruppur city in 1995, which is mainly consisting the river Noyyal with few perennial tanks within the city. During 1995, the area had clean water availability which played an important role in farming and also supported agriculture activities. In this period Odakkadu, Karuvampalayam, Alangadu, Pudhukadu, & Nesavalar colony areas only have notable built-up areas.

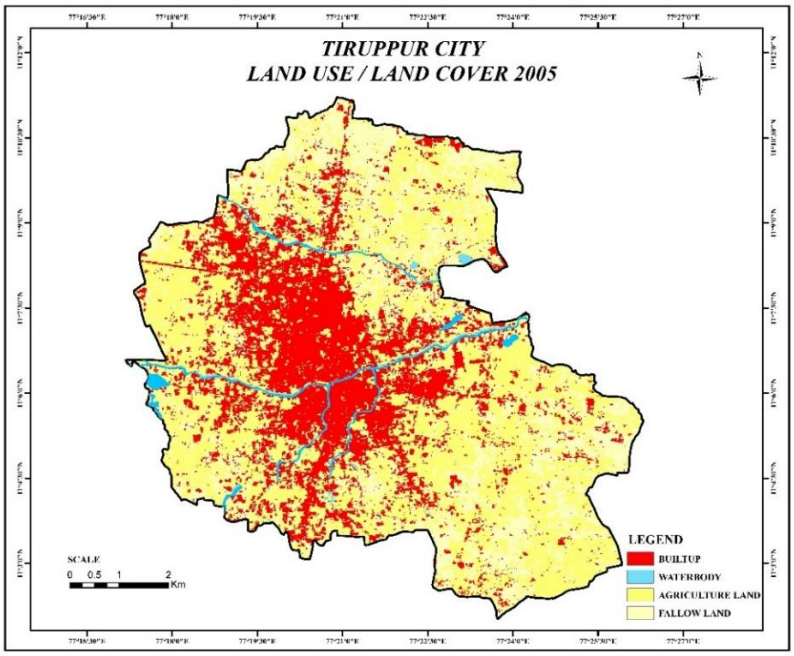
Figure 3: Land Use / Land Cover Map - 1995



LULC – 2005:

In 2005, the city shows an increase in Built-up area contributing 42.47 sq.km and a slight decrease found in Fallow land having 48.84 sq.km. Although, there is a rise in Built-up area, Agriculture land also increases to 71.21 sq.km which shows that farming activity is still active in many parts of the region. The main reason for increase in Built-up is developing textile business and dyeing industries which increases land demand. Waterbody have decreased to 3.84 sq.km due to over use by textile sector. It is clearly shown that the urban sprawl is expanding outwards from the core of the city in all directions and also notable sprawl is found in Gandhinagar, Velampalayam, Chettipalayam, Palayakadu, Thennampalayam, Sirupooluvapatti.

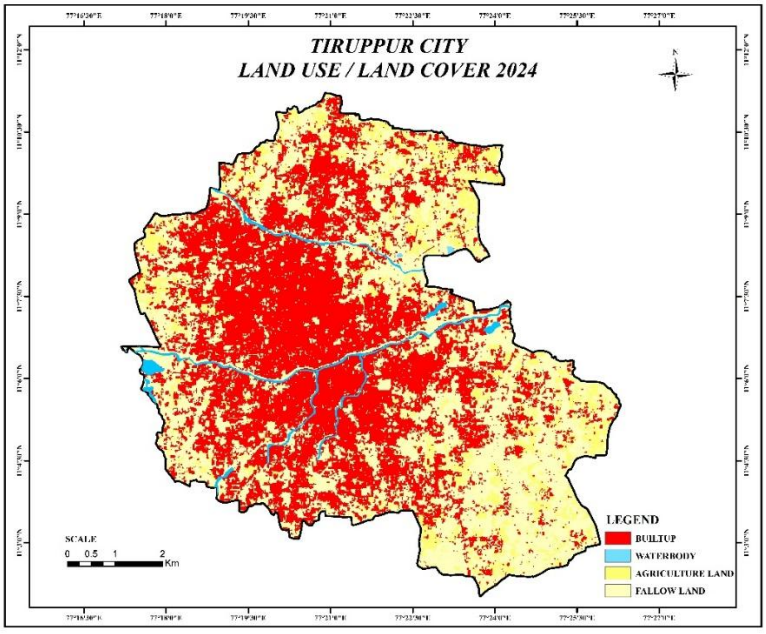
Figure 4: Land Use / Land Cover Map - 2005



LULC – 2024:

In 2024, Built-up area increases to 78.56 sq.km which shows a rapid urban growth. At the same time, huge decrease seen in Agriculture land having 26.24 sq.km as many farmlands were converted into Built-up land. Fallow land increases to 58.60 sq.km, mainly because several farmers stopped cultivation due to poor water availability and weak maintenance of irrigation sources. Waterbodies also reduce further to 2.96 sq.km, showing continuous pressure on natural resources. Overall, the city shows rapid urbanization, with built-up areas expanding outward and reaching the city's edges, especially around Thirumuruganpoondis, Andipalayam, Pooluvapatti, Nallur, and Kanakkampalayam.

Figure 5: Land Use / Land Cover Map - 2024



Urban Expansion Intensity Index:

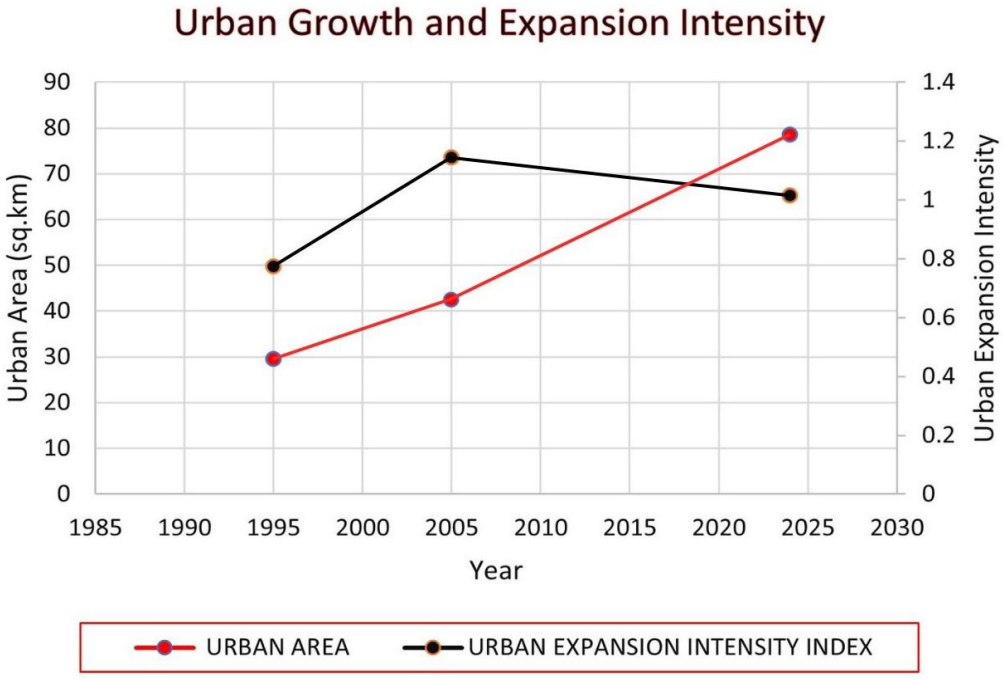
The city has been expanding quickly, and most of this growth is happening along the national highway. Many factories have also come up near the road and close to the Noyyal River since the textile industry needs a steady supply of water. Because the city is spreading outward so fast, the Urban Expansion Intensity Index is used to understand rapid expansion.

Table 1: Urban Expansion Intensity Index

Period	Built-Up Area (Start)	Built-Up Area (End)	Changes (Sq.km)	Years (T)	UEII	Sprawl Level
1995 - 2005	29.61	42.47	12.86	10	0.774	Low - Moderate
2005 - 2024	42.47	78.56	36.09	19	1.144	High
1995 - 2024	29.61	78.56	48.95	29	1.016	Moderate - high

The Urban Expansion Intensity Index (UEII) shows how Tiruppur city has grown over the past thirty years. In 1995, the city experienced low to moderate expansion (UEII = 0.774) which tells that the urban growth is less and only develops around the urban center. A sudden change happened between 2005 showing (UEII = 1.144), which is the time of rapid urban sprawl. Noticing the whole period from 1995 to 2024, the (UEII = 1.016) indicates a moderate to high level of urban expansion is ongoing. The growth has led to gradual conversion of agricultural and unused land to built-up land areas. Overall, the study

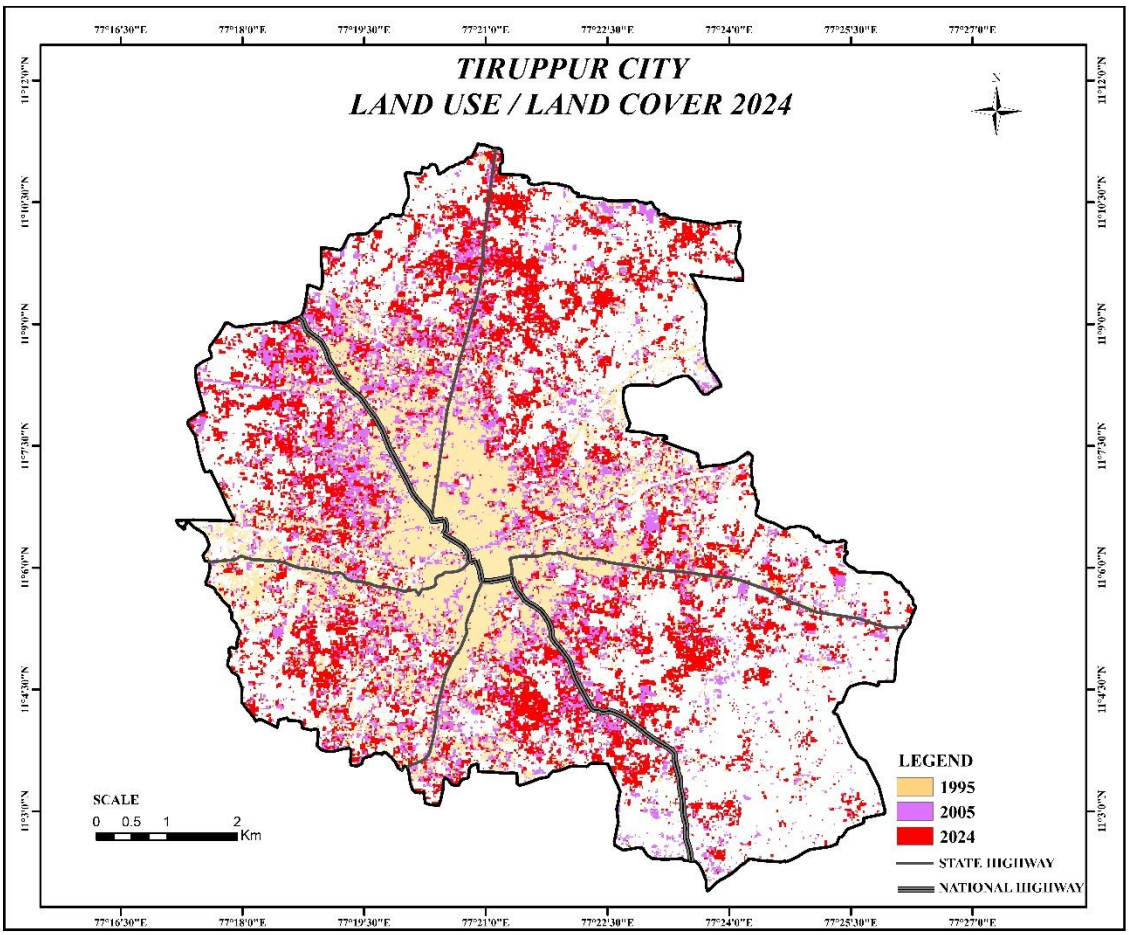
Table 2: Urban Growth and Expansion Graph



shows that the urban sprawl has shifted from compact to more spread-out pattern, especially after 2005. The growth of textile industry is the main factor of urban growth in the city as emergence of industries

and a resultant inflow of population, which increases the demand for accommodation as well as services like hospitals, schools, and other amenities. The city lacks development and growth in the southern part due to dry climate and water scarcity.

Figure 6: Urban Expansion and Sprawl Direction Map



Conclusion:

The analysis shows that Tiruppur city area has expanded rapidly between 1995 and 2024, were its growing outward in all directions. The Land Use/Land Cover changes clearly show a rapid increase in Built-up land, which is caused by industrial growth, developing transportation networks, and increase in population. We can see much of the expansion is found along the Noyyal River and around major transportation networks, such as NH 381, SH 19, SH 169 respectively. At the same time, the region has undergone a huge decline in Waterbodies, including severe water pollution which is linked to sewage from textile industries. Agricultural land has reduced significantly, showing a change towards a doubt in long term sustainability. Limited surface water and groundwater availability makes it harder to support housing and industrial development in the southern part of the city. Overall, the growth and pattern show fast urbanization that brings economic growth and development, but also have a huge impact on the environment and natural resources of Tiruppur city.

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