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Application of Geospatial Technology for Land Use/ Land Cover Analysis and Change Detection Study of Thiruvananthapuram City

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Abstract

The present study has shown that remote sensing techniques have tremendous potential for mapping and monitoring of land use. The geographic information system and remote sensing tools are very useful for the urban land use classification and change detection of LULC. The study of land use / land cover changes is an essential feature of urban geography. The process of urbanization is a universal phenomenon taking place all over world and has increasingly become a major issue facing many metropolitan areas. The land use/land cover pattern of a city or region is an outcome of natural and socio–economic factors and its utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural activity, urban sprawl and demographic pressure. Hence, information on land use / land cover and possibilities for its optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. The information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population. It is also useful to the different departments and government agencies like revenue, agriculture, irrigation, forest, environment, urban development & urban planners for land use planning and decision making. For betterment of human beings well planning of city is needed. In this regard there is need to study urban growth and land use /land cover. An attempt has been made in this paper to study the Application of Geospatial Technology for Land Use/ Land Cover Analysis and Change Detection Study of Thiruvananthapuram City. Three aspects viz. Water bodies, Built-up area & vegetation changes have been studied.

Keywords: Geospatial Technology, Urbanization, City, Land Cover/Land Use

Introduction:

Urbanization has been understood statistically as the increasing concentration of population living in urban areas. Urbanisation at the global level has increased from around 30 per cent of the global population in 1950 to 55 per cent in 2018 (United Nations, 2018). Cities are Cities are generally considered as hubs of productivity and growth and thus, urbanisation is usually encouraged at the policy level. This is especially so in the developing countries where urbanisation is often used as an index of industrialisation and regional competitiveness. It is estimated that around 2.5 billion people will be added to urban areas by 2050, with around 90% of the change being concentrated in Asia and Africa (United Nations, 2018).

Urbanization in India:

India's official rate of urbanisation is measured using Census data. Urban areas are classified according to two definitions:

a) Administrative definition, set by the state government that identifies statutory towns according to certain parameters like population, density of population, revenue by local administration, percentage of non-agricultural employment, etc. and accordingly have an urban local government, and

b) Census definition, set by the Census office that includes those that have an urban local body notified by the state government (statutory towns) as well as those administrative units (census towns) that meet three-fold criteria: (i) A minimum population of 5,000 persons; (ii) A density of population of at least 400 persons per sq. km.; and (iii) 75 percent and above of the male main working population being engaged in non–agricultural pursuits.

As like other developed and developing countries, India has also shown a considerable level

of urbanization, particularly after independence. Population and percentage share of urban population in total population of India from 1901 to 2011 are given in table 1 and represented in figure.

Table 1: Percentage of Urban and Rural Population in Total Population of India (1901 to 2011)

Census Years	Population (in million)			% of Urban Population	% of Rural Population
	Urban	Rural	Total		
1901	25.86	212.54	238.40	10.85	89.15
1911	25.94	226.15	252.09	10.29	89.71
1921	28.09	223.23	251.32	11.18	88.82
1931	33.46	245.52	278.98	11.99	88.01
1941	44.15	274.51	318.66	13.85	86.15
1951	62.44	298.65	361.09	17.29	82.71
1961	78.93	360.30	439.23	17.97	82.03
1971	109.11	439.05	548.16	19.90	80.10
1981	159.46	523.87	683.33	23.34	76.66
1991	217.72	628.70	846.42	25.72	74.28
2001	286.12	742.49	1028.61	27.82	72.18
2011	377.11	833.46	1210.57	31.15	68.85

Source: Census of India, 2011

Analysis of data reveals that in 1901, population of India was about 23.84 crore. It increased up to 36.11 crore in 1951 and 121 crore in 2011. While taking into consideration the growth of urban population, it is observed that in 1901, the proportion of urban population in total population was 10.85 percent (Table 1.2). This proportion increased up to 13.85 percent in 1941 and 17.29 percent in 1951. By the year 1981 share of urban population in total population of India increased up to 23.34 percent. In the next thirty years this proportion further increased, and in 2011 it reach up to 31.15 percent. Of course, level of urbanization varies from state to state and also from region to region.

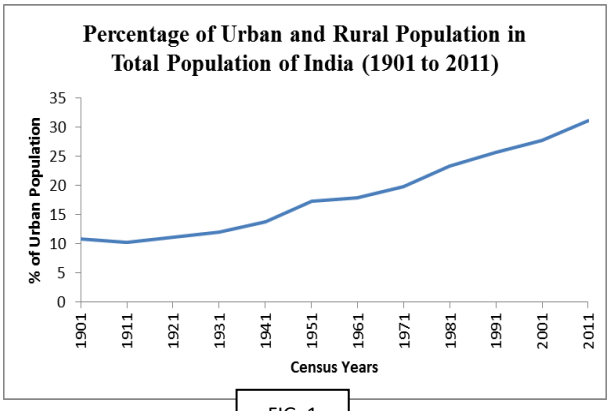


FIG. 1

According to 2011 Census data, Goa (62.17%), Mizoram (51.51%), Tamil Nadu (48.45 %, Kerala (47.72 %) and Maharashtra (45.23%) are highly urbanized states in the country. On the other hand, Bihar (11.30%) and Assam (14.08%) states have recorded very low proportion of urban population.

Urbanization in Kerala:

As per Census of 2011, the share of urban population in statutory towns in India is 26.69% and in census towns is 4.46%, and therefore, total urban population is 31.16%. During 2001-11, India witnessed an unprecedented increase in the number of census towns. Of the addition to Census Towns, Kerala recorded the second highest increase (after West Bengal) from 99 in 2001 to 461 in 2011. This has significantly contributed to increasing the share of urban population from around 26% to nearly 48% in the state, raising the share above the national average and registering a decadal growth rate of 92.72%.

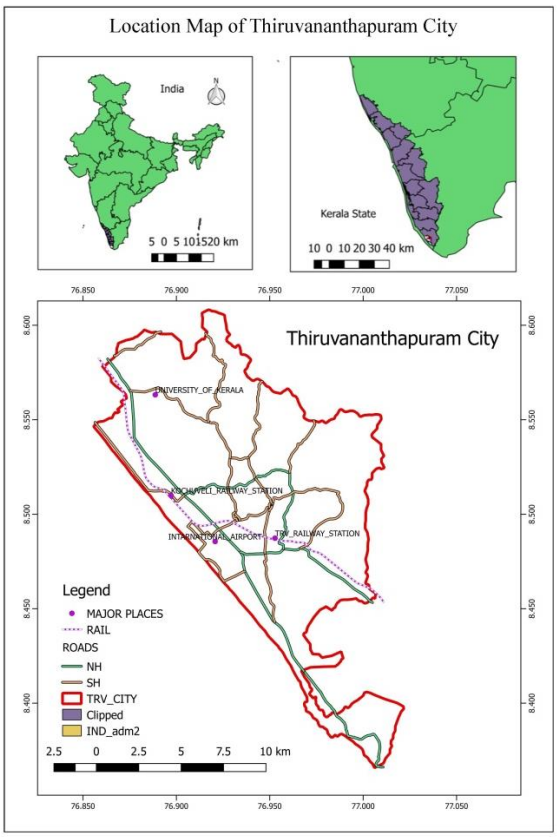
Urbanization and Land Use:

Land use refers to man's activities and the various uses which are carried on the land. This can be built up land, cultivated agricultural land, open spaces, etc. Land cover refers to natural coverage of earth's surface like natural vegetation, forests, water bodies, etc. LULC maps are important in resource mapping, development planning, irrigation projects, environmental conservation, etc. LULC maps are often prepared using satellite images – thus, this helps in understanding real time scenario as well as trends over a period of time.

Urbanization, which is the concentration of urban population, and growth of cities, inevitably affects the land use patterns of a region. The land use change usually involves the increase in built-up area and the reduction of agricultural fields, forest cover, open fields, etc. Though this can benefit the region economically, it can also have undesirable environmental consequences. Moreover, urbanisation as a process can itself follow different trends resulting in cities of different classes with different patterns of urban settlement. These variations in land use and urban patterns can be a detected using geospatial technology which becomes an important topic of research as well as for policy making.

Study Area:

The area selected for the study is Thiruvananthapuram Corporation, which is the largest city corporation in Kerala state in India by area and population. It is the Municipal Corporation that administrates the city of Thiruvananthapuram, the capital of Kerala. The city corporation is spread over 214.86 km2 with 100 wards and a population of 957730 inhabitants, as per Census of 2011. The population density of 4,454/km² which is four times the average population density of 860 persons/km2 recorded for the State. Literacy rate of the city is 86.75%.. It lies between 8°12'23"N to 8°36'27"N latitudes and 76°51'17"E to 77°0'58"E longitudes. The region is characterized by undulating terrain of low coastal hills with mean elevation ranging from 0 to 80 m above MSL.



During 2001-11, Thiruvananthapuram has registered an increase in percentage of urban population from 33.75% to 53.80%, registering a decadal growth of around 62%. The total number of towns increased from 5 to 31 and the whole of this increase is attributed to the 26 new Census Towns in 2011. Thiruvananthapuram is the second most populous and the most densely populated district in the state. The district is also home to the capital city of Kerala.

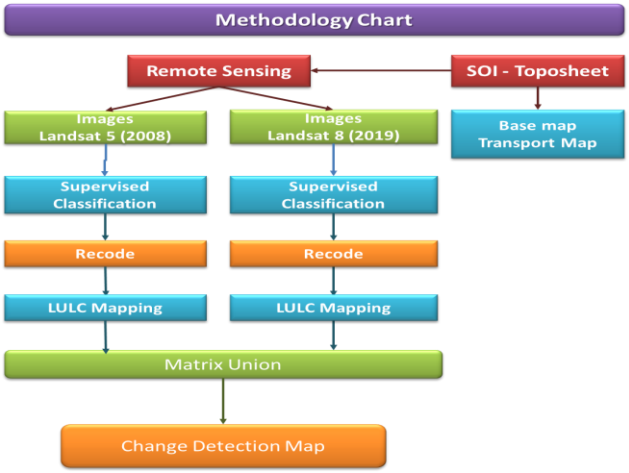
Objective:

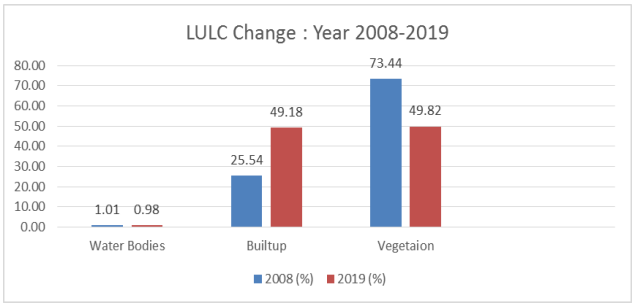
- To analyse Land Use/Land Cover changes in Thiruvananthapuram Corporation by analysing satellite images from 2008 and 2019.

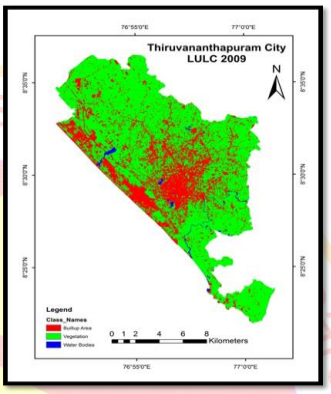
Source of Data and Research Methodology:

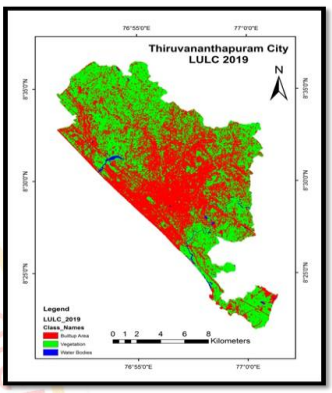
To study the land use/land cover changes in Thiruvananthapuram Corporation from 2009 to 2019 the satellite imageries have been obtained from United States Geological Survey's (USGS) Earth Resources Observation & Science (EROS) The base map of the city and Thiruvananthapuram obtained from Municipal Corporation. The subsets for LANDSAT TM image were taken for further interpretation and classification process. Supervised classification for the LANDSAT OLI has been performed with parametric rule as maximum likelihood in Erdas 14 software. The classified images showing area under different land use categories in 2008 and 2019 are given in figure 2, 3 and 4 respectively. The resulted data have been used for land use / land cove change detection analysis.

For the present study initially the ward-wise map was scanned and geo-referenced to use as base layer for image registration and transport network and other important places scanned and digitised through Open Street Map. The digital remote sensing data like LANDSAT 5 (Oct 2008) & LANDSAT OLI (Dec-2019) having spatial resolution 30m, were processed and geo-referenced using Ground Control Points (GCP) from Google Earth. The satellite images were projected into WGS 1984 Complex UTM Zone 43N projection system. The data used for this study is mentioned in Table 1. The Thiruvananthapuram Corporation boundary AOI layer was overlaid upon so that study area could be extracted from the whole image.









3.2 Land Use / Land Cover:

The study of land use and land cover changes is an essential aspect of urban geography. The problem of rapid urbanization across the world has led to a crisis in availability of land the most valuable fix the resource affecting human life land use/ land cover changes as you have for reaching environmental impact that require careful and holistic understanding. Hence, the understanding of land use/ land cover changes along with their balance and attitude management is of prime importance in present context.

Table 2 : Land Use-Land Cover Change Matrix

Class Name	(All)	Pivot Table		
Sum of area(sq.km)	2019			
2008	Water Bodies	Built-up Area	Vegetation	Grand Total
Water Bodies	1.12	0.38	0.65	2.14
Built-up Area	0.21	6.19	47.61	54.00
Vegetation	0.76	97.42	57.08	155.27
Grand Total	2.08	103.99	105.34	211.41

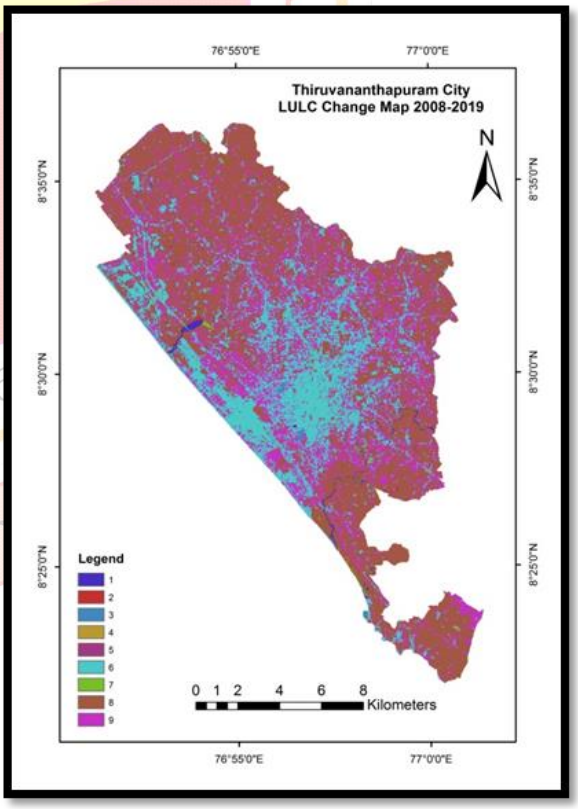


Table 3: Land Use-Land Cover Change Matrix

LULC Class	Area in Sq. Km (2008)	2008 (%)	Area in Sq. Km (2019)	2019 (%)	Change (%)
Water Bodies	2.14	1.01	2.08	0.98	-2.8%
Built-up Area	54.00	25.54	103.99	49.18	+92.57%
Vegetation	155.27	73.44	105.34	49.82	-32.15%
Total	211.41	100	211.41	100	

Result:

The Land Use-Land Cover Change Matrix helps us to detect changes in the area under different classes. As part of this project, we have identified three classes – namely, water bodies, built-up area

and vegetation. The matrix shows that there is a dramatic change in land use in Thiruvananthapuram corporation area. The built-up area was around 54 sq. km in 2008, while in 2019 it has increased to 103.99 sq. km. The vegetation cover has accordingly decreased from 155.27 sq. km in 2008 to 105.34 sq. km in 2019. The area under water bodies has also decreased modestly from 2.14 sq. km to 2.08 sq. km.

This means that there has been a reduction in vegetation cover by 49.93 sq. km which translated to a reduction by 32.15%. The built up area has increased by 49.99 sq. km, which is a dramatic increase by 92.57%. The area under water bodies has also shrunk by 0.06 sq. km which is a reduction by 2.80%.

Discussion

The LULC change analysis shows that there is an increase in built up-area at the expense of vegetation cover. This means that built-up area has increased at the cost of green cover due to human intervention. Thus, over a decade, we see that existing agricultural lands have been converted to settlement areas, which can be residential as well as commercial. This point to the urbanisation that has occurred in the region, largely due to the growth of the service sector, including IT/ITeS and tourism industries.

This would severely impact the ecology of the region, especially due to the population pressure, given that the corporation area is extremely dense. One immediate consequence would be occurrence of water logging in core city areas due to heavy rainfall. This is primarily because the excess water cannot be absorbed naturally by the soil as agricultural fields have been levelled to construct buildings, which in turn affects the natural drainage system. This has been a problem that the city has been facing and suitable mitigation measures are being undertaken.

Conclusion

The study shows that the integration of remote sensing data along with Geographic Information System helps in analysing spatio-temporal variations in land use in Thiruvananthapuram Corporation. It was seen that there was an unprecedented increase in built-up area at the expense of green cover in the region. The paper also discussed how this might impact the ecology of the city, especially given the repeated occurrence of flash floods in the core area. The study underlines the importance of geospatial technologies in understanding land use changes that are pivotal to urban as well as development planning.

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