



Spatio-Temporal Dynamics of Land Use Land Cover in Kozhikode City and Suburbs

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Abstract

Kozhikode is a bustling city, located on the southwest coast of India. Fast paced urbanization, industrialization and population growth have drastically altered the land use and land cover in the study area. The main objective of present study is to examine LULC change in Kozhikode city and suburbs during the year 1993 to 2023. For this purpose, supervised classification has been carried out using Landsat images and LULC change analysed for the years 1993, 2003, 2013 and 2023. The result spatio temporal changes of LULC revealed that Kozhikode city and suburbs witnessed drastic changes. Built up land boomed from 1371.12 hectares in 1993 to 13211.38 hectares in 2023. The area under agriculture, vegetation, barren land and water bodies were declined. As Kozhikode city has grown, agricultural lands are replaced by commercial complexes, residential areas and infrastructural developments. Vegetation has also been cleared to make path for urban development. As cities expand, the demand for land rises, agricultural land and vegetative area become prime target for real estate and illegal construction. Thus, the findings of this study are significant in implementing sustainable planning interventions in Kozhikode City and suburbs.

Keywords: Land Use Land Cover; Urbanization; Built up; Landsat

1 Introduction

The pattern of Land Use Land Cover is changing in an unbalanced manner due to urban expansion⁽¹⁾. Urbanization is a global phenomenon characterized by expansion of built up lands and alters the natural biophysical environment for residential and commercial purposes⁽²⁾. Rapid urbanization affects the LULC dynamics of an area⁽³⁾. Urban expansion transforms non urban land

into built up lands such as roads, parking lots, rooftops and other commercial urban spaces, which significantly booming the proportion of impervious surface⁽⁴⁾. Thus, the analysis of LULC changes in terms of both spatial and temporal dimension is essential for evaluating the extent and magnitude of urban expansion⁽⁵⁾. Geo spatial technologies are effective for deriving accurate spatial and temporal dynamics of LULC. Although extensive studies have been

carried out on LULC dynamics, comparatively little has been carried out on Kozhikode City and suburbs, despite the fact that it is one of the fastest growing cities⁽⁶⁾. According to the report of UN Environment and the Lincoln Institute of Land Policy, Kozhikode is the fastest growing urban habitat with highest growth rate⁽⁷⁾. Kozhikode District Urbanization report (2011)⁽⁸⁾ also stresses that Kozhikode is the fastest growing urban space as it is a nodal point for all northern district in Kerala. The city also contributes to the very high potential for the economic development of entire northern region of the Kerala state. Hence, Kozhikode is one of the priority cities in Kerala. In this context the studies necessitate to understand spatio temporal dynamics of LULC in Kozhikode city. As per the Kozhikode city Municipality Act 1961, Kozhikode Corporation was constituted in 1962 by adjoining adjacent villages. The extension of the corporation was 84.232 sq.km. In 2010 the corporation expanded to 118 .59 sq km by merging neighboring panchayaths (Elathur, Beypore and Cheruvannur Nallalam). National highway 66 runs roughly north south along the west coast of India and passes through Kozhikode from Panavel (Maharashtra) in the north to Kanyakumari in the south, which connects major cities and towns of Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu state. Hence this connectivity to the north and south of the state has played a vital role in expanding the city and to concentrate new commercial ventures along this corridor. Kozhikode city’s growth is directed to all directions along the major corridors; however, its growth is more prioritized along the National Highway 66 bypass through Pooladikunnu, Thondayadu, Cyber Park – Palazhi, Panthirakavu Azhikillam and Ramannatukara direction. The NH bypass fragmented the wetlands in this area and the city has almost encroached upon Olavanna, Kadalundi, Feroke and Ramanattukara. The NH 66 bypass through this area is lined with restaurants, recreational centers and vast areas left barren by land developers. These characteristics signify that Kozhikode city subsequently grew into an urban agglomeration extending up to Kunnamangalam in the east, Ramanatukara in the south and Elathur in the north. This region takes over favorable condition to become urban in the near future. Thus, the main objective of present study is to examine spatio temporal dynamics of LULC in Kozhikode city and suburbs. Analysis of LULC is very crucial in understanding rapid urban expansion characterized by altering wetland, agricultural land and vegetation in to built up areas over the years. By understanding past and current land use and land cover patterns, stakeholders and policy makers can anticipate future trends, prioritize conservation, restoration, and identify areas of concern and sustainable development initiatives. Today, faster pace of urban growth and population pressure leading to tremendous land degradation. For sustainable development projects, a spatio temporal study of land use and land cover is

crucial. Remote sensing techniques offer a powerful tool for understanding the complex dynamics of land use and land cover.

2 Materials and Methods

Landsat images of Kozhikode city and suburbs for the year 1993, 2003, 2013 and 2023 were downloaded from USGS Earth Explorer in order to monitor land use and land cover change over three decades. Landsat 5 TM, Landsat 7 ETM and Landsat 8 OLI were acquired. The methods applied to monitor changes in land use and land cover (LULC) using multi-temporal satellite imagery includes acquisition of satellite imagery, image pre-processing, LU/LC classification scheme, training data sample selection, supervised classification, accuracy assessment, and change detection. ERDAS Imagine 15 and Arc Map 10.8 software were used. Methodology adopted for the study has been depicted in Figure 1.

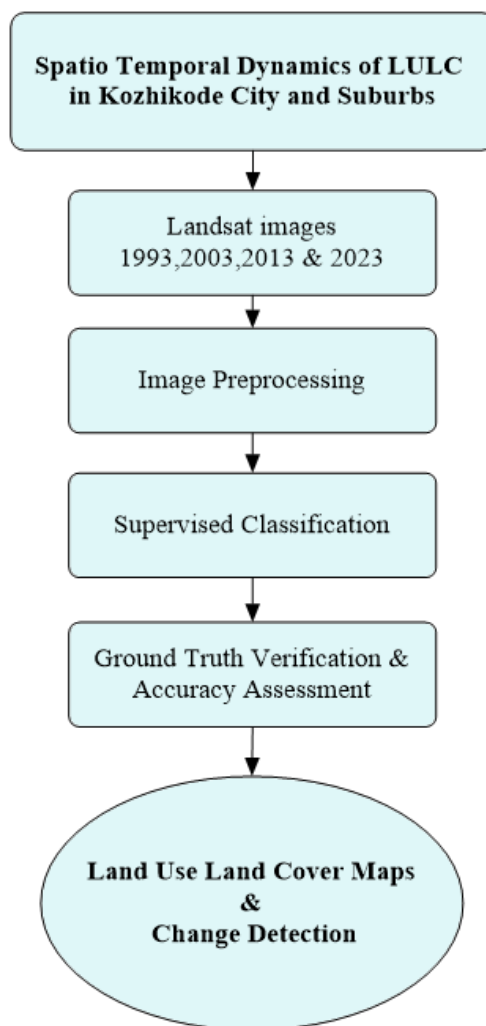


Fig. 1. Flow chart of methods adopted

3 Study area

Kozhikode city is located on the Malabar Coast in Kerala. The study area comprises Kozhikode Corporation, Feroke and Ramanattukara municipalities, Kadalundi, Olavanna, Perumanna, Peruvayal, Mavoor, Kunnamangalam, Kuruvattur, Kakkodi, Chelannur, Thalakkulathur, Atholi, and Chemanchery panchayaths and lies between the coordinates 11°7'24" N - 11°26'26" N latitude and 75° 42'35" E-75° 58'15"E longitude. The area chosen for the study includes major urban clusters and peripheral areas with low to high degree of urbanization. Location of the study area is given in Figure 2.

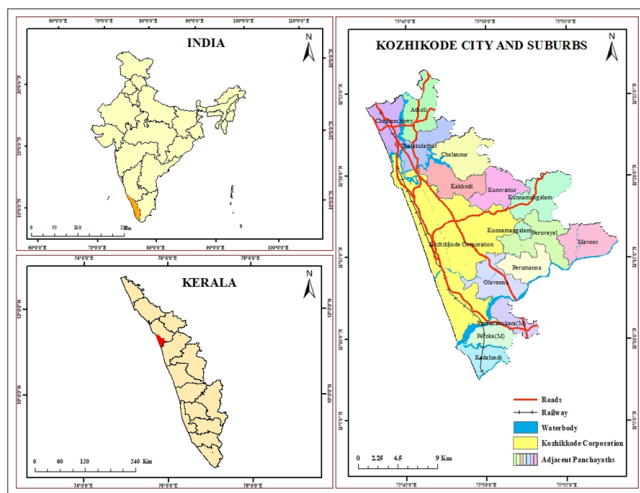


Fig. 2. Location of the study area

4 Results and Discussion

4.1 Land Use Land Cover Classification

Landsat images of Kozhikode City and its suburbs for the year 1993, 2003, 2013 and 2023 were downloaded from USGS to analyze land use land cover change. A False Color Composite (FCC) image was created by stacking multiple bands of satellite images into a single image using the ERDAS software's layer stack tool (Figure 3). These images have been undergone atmospheric, radiometric and geometric correction. Supervised classification with the Maximum Likelihood Classifier was employed. NRSC Level I classification was adopted for the study.

For understanding the changes in LULC pattern, the study area was categorized into five LULC classes- built up, agriculture land, vegetation, barren land and water bodies. LULC maps prepared for the year of 1993 and 2003 is shown in Figure 4.

Accuracy assessment of the classified image was done. The ground truth was verified using Google Earth, SOI

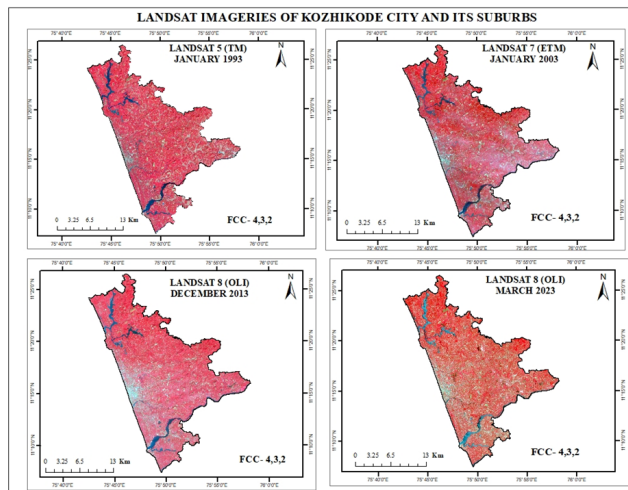


Fig. 3. Landsat images of the study area

Toposheet and field survey. Satellite images of 1993, 2003 and 2013 were mostly verified using Google Earth and SOI Toposheet. Classified image for the year 2023 is validated with field verification. Sample points of latitude and longitude transferred to handheld GPS for field verification. The accuracy assessment was carried out by taking 220 sample points randomly. 52 samples for built up, 43 samples for agriculture, 44 samples for vegetation, 41 samples for barren land and 30 for water bodies and were taken. The researcher has visited all the selected sample area for ground truthing. Then, the Error Matrix and Kappa Co-efficient were generated for assessing the accuracy of classified images with ground verification. The error matrix or confusion matrix signifies the classified and actual result in table format. Classified LU/LC is placed in rows and ground verified samples are placed in columns. Cohen's Kappa Coefficient is also widely accepted method for the classified LU/LC accuracy assessment by many researchers (Sanjoy Roy et al., 2015 and Arumugam et al, 2021). Kappa Co-efficient computes degree of agreement between two variables that measure the same land use. The result is less than or equal to one with the values near to one represents the perfect agreement and near to zero represents the worst agreement. Error matrix of LULC accuracy assessment is given in Table 1.

In the year 1993, built up land covered an area 1371.12 hectares and shared only 3.59 % of study area. Area under agriculture was 7765.73 ha (20.36%), vegetation was 26536.73 ha (69.56%), barren land was 345.83 ha (0.91%) and water bodies were 2129.24 ha (5.58%). In the year 2003, area under built up, agriculture, vegetation, barren land and water bodies was 3621 ha (9.49 %), 6952.90 ha (18.23%), 25206.27 ha (66.07%), 269.87 ha (0.71%) and 2098.13 (5.50%) respectively. In the year 2013, area under built up was 5006.96 ha (13.12%) and agriculture was 6644.77 ha (17.42%). Vegetation covered

Table 1. Accuracy Assessment of LULC

	Built up	Agriculture	Vegetation	Barren land	Water bodies	Total (User)	User accuracy
Built up	50	1	1	0	0	52	96.15
Agriculture	1	42	0	0	0	43	97.67
Vegetation	2	0	42	0	0	44	95.45
Barren land	1	0	0	40	0	41	97.56
Water bodies	0	0	0	1	29	30	96.67
Total (Producer)	54	43	43	41	29	210	
Producer Accuracy	92.59	97.67	97.67	97.56	100.00		
Overall Accuracy	= 96.67						
Kappa Co-efficient	= 0.94						

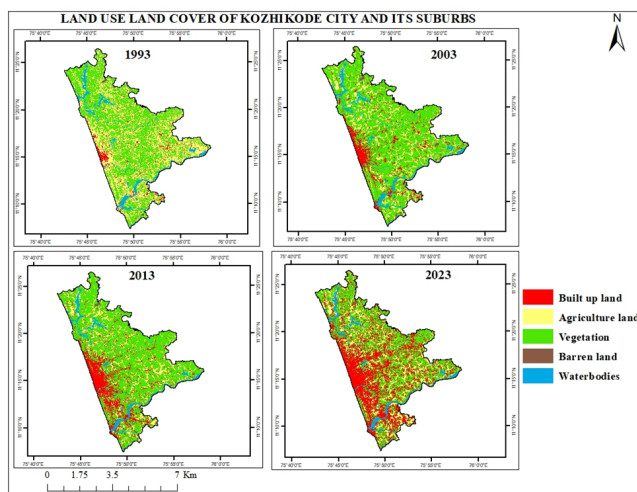


Fig. 4. Land Use Land Cover of Kozhikode City and suburbs

63.24% of study area with an area of 24126.92 hectares, whereas barren land and water bodies covered an area of 269.41 ha (0.71%) and 2100.60 ha (5.51%) respectively. In the year 2023 built up area encompassed 34.63 % of study area with an area of 13211.38 ha while agriculture was 6032.06 ha (15.81 %). Area under vegetation was 16790.58 ha (44.01). Barren land occupied only 98.19 ha (0.26%) and water bodies covered 2016.44 ha (5.29%). Table 2 and Figure 5 shows land use land cover of Kozhikode City and its suburbs.

4.2 Spatio Temporal Dynamics of LULC in Kozhikode City and suburbs during 1993 and 2023

The result of spatio temporal changes of LULC classification has shown in Table 3 and Figure 6 reveals that Kozhikode city and suburbs witnessed drastic changes. During the period 1993-2003, there was rise in built up land, whereas agri-

culture, vegetation, barren land and water bodies declined. Built up area shows positive growth and increased by 2250 ha (16.13%). Agriculture, vegetation, barren land and water bodies decreased by 812.83 ha (10.47%), 1330.46 ha (5.01%), 75.96 ha (21.96%) and water bodies 31.11 ha (1.46 %) respectively. During the period 2003 and 2013, built up area expanded by 1385.47 ha (38.26 %) and water bodies shows slight increase of 2.47 ha (0.12%). Area under agriculture, vegetation and barren land declined by 1079.34 ha (4.28 %), 308.13 ha (4.43%), and 0.47 ha (0.17 %) respectively. during 2013 -2023, built up area drastically expanded by 8204.42 ha (163.86%) whereas vegetation, agriculture, barren land and water bodies declined by 7336.34 ha (30.14 %), 612.71 ha (9.22%), 171.21 ha (63.55%) and 84.16 ha (4.01%) respectively.

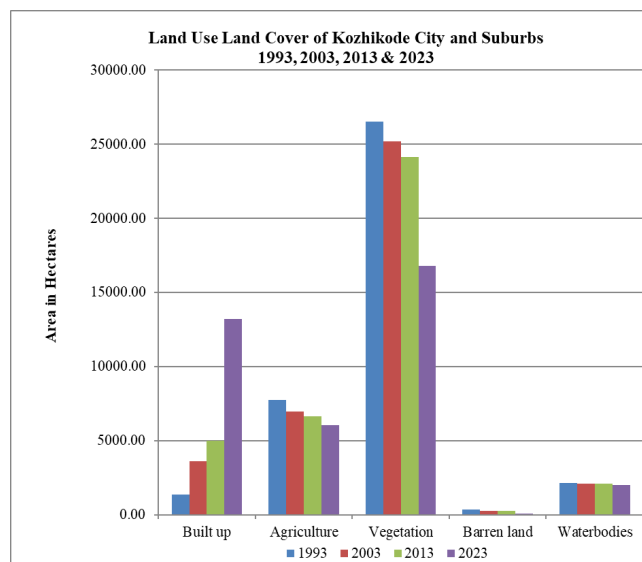


Fig. 5. LULC of Kozhikode City and its suburbs for the years 1993, 2003, 2013 & 2023



Table 2. LULC of Kozhikode City and its suburbs for the years 1993, 2003, 2013 & 2023

LULC Class	1993		2003		2013		2023	
	Area (Ha)	Area (%)	Area (Ha)	Area (%)	Area (Ha)	Area (%)	Area (Ha)	Area (%)
Built-up	1371.12	3.59	3621.49	9.49	5006.96	13.12	13211.38	34.63
Agriculture	7765.73	20.36	6952.90	18.23	6644.77	17.42	6032.06	15.81
Vegetation	26536.73	69.56	25206.27	66.07	24126.92	63.24	16790.58	44.01
Barren land	345.83	0.91	269.87	0.71	269.41	0.71	98.19	0.26
Water bodies	2129.24	5.58	2098.13	5.50	2100.60	5.51	2016.44	5.29
Total	38148.66	100.00	38148.66	100.00	38148.66	100.00	38148.66	100.00

Table 3. Change in LULC of Kozhikode City and its suburbs from 1993 to 2023

LULC Class	1993-2003		2003-2013		2013-2023	
	Changes in Area (Ha)	Changes in Area (%)	Changes in Area (Ha)	Changes in Area (%)	Changes in Area (Ha)	Changes in Area (%)
Agriculture land	-812.83	-10.47	-308.13	-4.43	-612.71	-9.22
Built-up land	+2250.37	+164.13	+1385.47	+38.26	+8204.42	+163.86
Vegetation	-1330.46	-5.01	-1079.34	-4.28	-7336.34	-30.41
Barren land	-75.96	-21.96	-0.47	-0.17	-171.21	-63.55
Water bodies	-31.11	-1.46	+2.47	+0.12	-84.16	-4.01

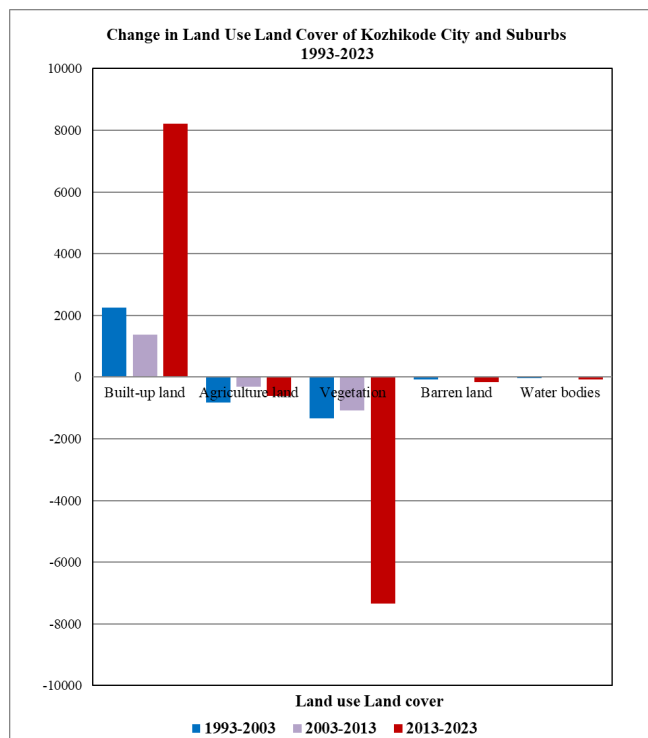


Fig. 6. Temporal changes in each LULC Classes for the three decades of Study period

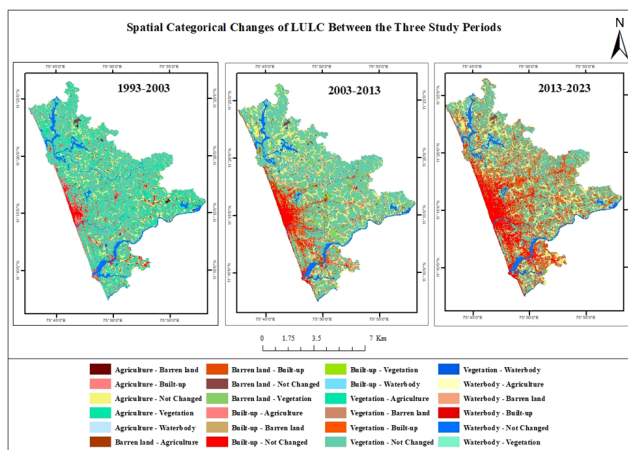


Fig. 7. Spatial Categorical changes in each LULC Classes for the three decades of Study period

5 Conclusion

Land Use Land Cover of Kozhikode city and suburbs have been analyzed for the years 1993, 2003, 2013 and 2023 using Landsat images. The findings of the study revealed that built up area increased due to rapid urbanization and huge amount of vegetation and agricultural land were converted to built up land. Real estate pressure leading to the encroachment of agricultural land is a significant problem in Kozhikode city, as it is in many urban areas. As cities expand, the demand for land rises, agricultural land and vegetative area become prime target for real estate and illegal construction. Thus, the findings of this study are significant in implementing



sustainable planning interventions in Kozhikode City and suburbs.

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