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Dynamics of Land Use/Land Cover in Mumbai, Maharashtra, India: A Systematic Review Through the ICA Framework

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ABSTRACT

The primary objective of this systematic review is to analyse land use and land cover (LULC) changes in Greater Mumbai, Maharashtra, from 2006 to 2024. This study aims to provide valuable insights for policymakers and local communities to ensure effective land resource management in the region. The review follows the Initialization, Conceptualization, and Actualization (ICA) framework to assess existing research on LULC changes in the study area. Relevant literature was retrieved from the Scopus database using keywords related to LULC. A comprehensive analysis of the available studies revealed a gap in systematic reviews specifically addressing LULC transformations in Greater Mumbai. This gap motivated the present study to synthesize and highlight key LULC trends. Geospatial technology-based studies have consistently shown a significant increase in built-up areas in Mumbai, while vegetation, water bodies, cropland, and barren land have declined considerably. Rapid population growth and urbanization have been identified as the primary drivers of these changes. These drastic LULC transformations have led to severe environmental consequences, including intensified urban heat islands, increased flood hazards, and widespread waterlogging. Given these challenges, it is imperative for the government to implement a well-structured LULC policy to curb unplanned and haphazard land conversions, ensuring sustainable urban development in the region."

KEYWORDS: *Urban heat Island; NDBI; Geospatial techniques; ICA-framework*

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INTRODUCTION

Land use land cover change has made its place in the global science agenda (Lambin et al., 2003; Waza, Pednekar, et al., 2025). Land use land cover (LULC) changes significantly impacted land suitability, influencing biodiversity, flora, and food security and affecting the fabric of socio-economic stability. Thus, it may arouse an interest to investigate the LULC for sustainable development planning (Farrow & Winograd, 2001). Perhaps the LULC change is considered a unique form of global environmental change due to its occurrence at both spatial and temporal levels and is directly or indirectly related to our daily lives. Generally, the terms land use /land cover are used interchangeably. However, these two have different interpretations and connotations. Land use refers to the human use of land, for example, plantation or agroforestry. While land cover means the biophysical cover of the earth's surface and constitutes both natural and anthropogenic features, for example, forests or crops (Dale, 1997; Waza et al., 2023), in technical terms, the LULC dynamics refers to the quantitative changes in areal dimension of any LULC category. LULC dynamics are the results of various drivers, including both natural (climatic) and anthropogenic(Li et al., 2017). For full filling the increasing demands, the interaction between humans and nature has altered the face of the earth to a great extent as no other living beings ever did (Melese, 2016). Generally, there are two categories of anthropogenic agents responsible for LULC change: proximate factors and underlying causes. The proximate factors describe the direct action of humans on regional land covers, which includes the extension of agricultural activities, exploitation of forests in an unsustainable manner, and development of infrastructure (Ramankutty et al., 2006). Technological, demographic, cultural, and economic changes considered as indirect or underlying forces that gears up the influence of proximate factors on the use of natural resources. Underlying factors impact the LULC together rather than causation of a single factor(Turner et al., 1993) and incorporate the manifold scale sources. Local Agricultural marketing or international tourism influenced by global factors can be indirectly responsible. Availability of roads, market access, and political instability are the regional factors that may directly affect land use decision-making. Productivity loss and the population boom may be contemplated as local factors. Hence the proximate causes are only the manifestations and expressions of the underlying causes. Thus, incorporating any intervention needs an hour to address the underlying factors(Melese, 2016).Knowledge and information about LULC change has wide use and application, especially in analysing the level and pace of deforestation, monitoring of disasters, expansion of urban sprawl, and effective planning and sustainable land management. Geo spatial technology has revolutionized the science of LULC detection. Satellite-based remote sensing provides the synoptic or bird's eye view to examine LULC changes from a spatiotemporal perspective(Chaudhry et al., 2015).""

After analysing the plethora of literature, the investigators have found that various studies have been carried out on LULC changes in the Mumbai Metropolitan region (Kamini et al., 2006; Rahaman et al., 2021; Sansare & Mhaske, 2018, 2020; Shahfahad et al., 2021; Vijay et al., 2020; Vinayak et al., 2021; Zope et al., 2015, 2017). Nonetheless, the researchers have observed that, most likely, there has been no systematic review produced on the LULC dynamics of the study area (Mumbai Metropolitan region). Thus, the sole purpose of this study is to review the LULC change studies done over the study area between 2006 and 2024. This research mainly focused on (1) drawing a road map for the planners and researchers interested in researching LULC changes and predicting the land cover in future, (2) highlighting the various LULC classes mentioned in the different studies of the study area. (3) to identify the numerous geospatial techniques in a straightforward way that were utilized by the various studies to detect LULC dynamics. (4) to illuminate the different drivers/factors behind the LULC dynamics of the study area. (5) Dynamics in major LUC (Land use cover) classes (6) to examine the impact of LULC change over the environment of the study region.

Literature Review

The earth's land cover characteristics and utilisation play a significant role in global change (Herold et al., 2006). Increasing population pressure and maximum output extraction from the limited available resources in developing countries severely impact the region's land cover. Besides changing the topographical aspects of the areal dimension of the different LULC classes, the LULC dynamics also results the disequilibrium of the several secondary processes, which in turn causes the consequent deterioration of the ecosystems of the globe(Roy & Roy, 2010; Waza, 2023; Waza, Ikram, et al., 2025). During the last few decades, there has been a paradigm shift in the notion of LULC change. It has shifted from simplistic to realistic and complex. In starting, the vital aim of LULC change studies was only restricted to the changes in the physical aspects. Gradually, with time, policymakers and think tanks observed that the dynamics in LULC affect the earth's climate. In the mid-1970s, researchers discovered that dynamics in LULC cover had changed the albedo of the earth's surface. Thus, the exchange of energy occurred in the surface atmosphere with apparent influence on the local climatic conditions of these areas(Rasool et al., 2021). The immense impact of LULC dynamics on biotic diversity, ecosystems, agriculture etc., came into observation in later phase(Praveen & Gupta, 2017). Satellite images and remote sensing are the primary data sources for detecting and monitoring LULC changes (Jensen et al., 1995). The change detection process is essential for the proper observation and assessment of natural resources and for preparing plans for the development of urban regions. Effective change observation should provide the knowledge and information on four essential dimensions, i.e., Areal change and rate of change; spatial distribution of changed types; change trajectories of different types of land cover; and incorporation of accuracy assessment for change detection validation. During the change detection project implementation, three significant steps must be considered. Image pre-processing includes geometric, radiometric, atmospheric, and topographic corrections if the study region is in hilly terrains. Choosing of appropriate methods to execute change detection analyses. And finally, the employment of accuracy assessment to measure the accuracy of change detection findings. For the LULC analysis, different types of satellite images are readily available free of cost from some authentic websites like USGS (United States Geological Survey_ earth explorer). Landsat, Multispectral scanner (MSS), Thematic Mapper (TM), Satellite Pour observation de la Terre (SPOT), Advanced Very High-Resolution

Radiometer (AVHRR), radar and aerial photographs are some of the common data sources. (Lu, Dengsheng, Mausel, Paul, Brondízio, Eduardo, Moran, 2004).

Study Area:

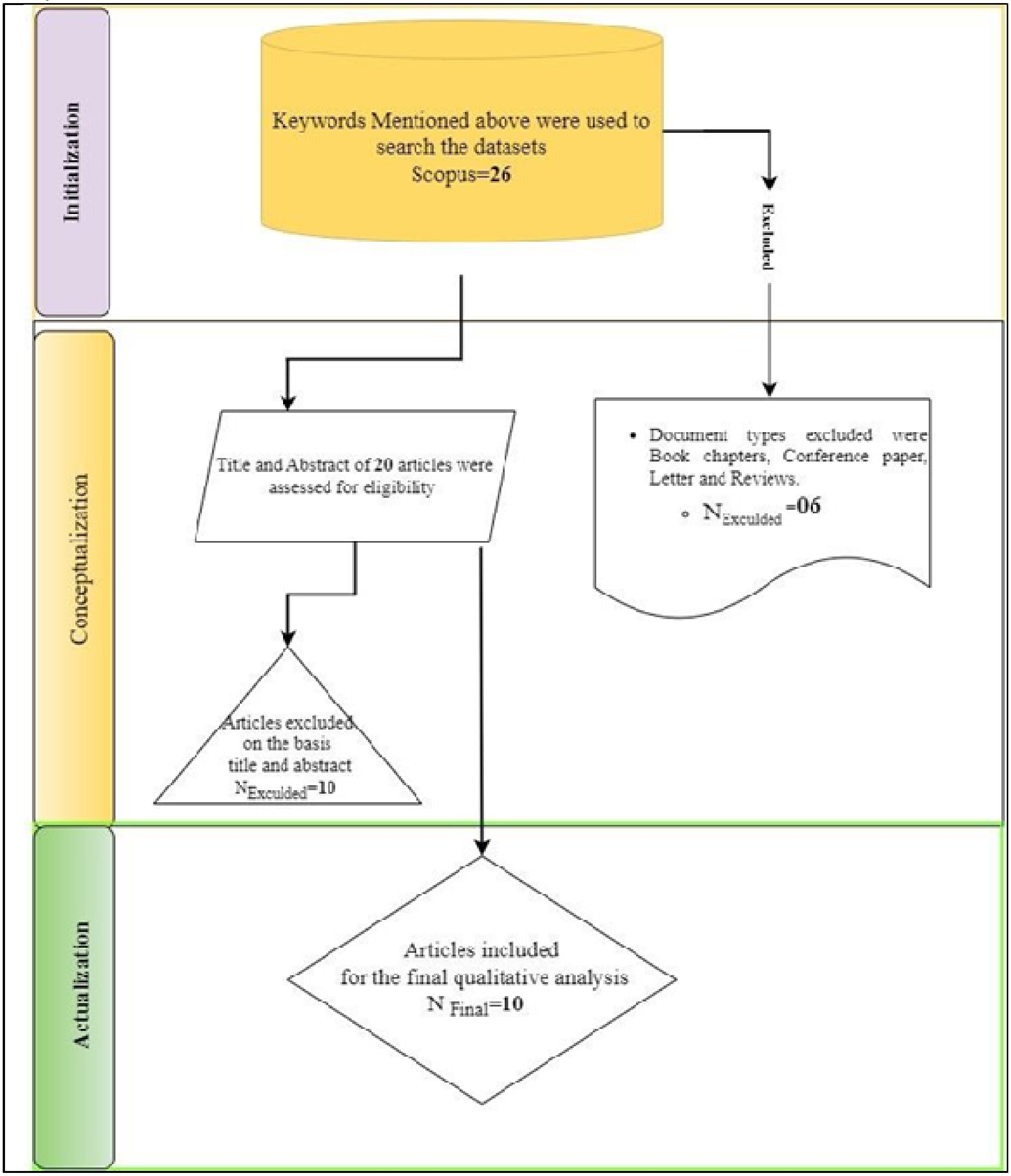

Figure 1, Flow diagram of Methodology

The Mumbai is located on western coast of India (see figure 1). Many financial and commercial institutions characterise Mumbai, India's commercial boom and financial capital. The total geographical area of Greater Mumbai is 603 sq. km. In 1901, the total population of the Greater Mumbai was just 9.27 lakhs and it increased to 12.44 million in the census of 2011, thus an increase of 115.13 lakhs over a period of 110 years. Due to its high population number, it is the India's most populated city and ranks 5th in the world. The population of Greater Mumbai constitutes about 11.1% and 01% of Maharashtra and India's population respectively. It has one of the highest densities of population amongst the large metropolises of the world (LEA Associates South Asia

Pvt. Ltd., The total number of households in Mumbai is approximately 6,74,339 as per the 2011 census. As the hub of finical, commercial and entertainment activities, Mumbai contributes about 6.16% of the country's Gross Domestic Production (GDP) and constitutes 25 % of Industrial output and 70% of maritime trade in India. Besides that, it also produces 70% of capital transactions to the country's economy[1]. Mumbai constitutes factories, industries, the information technology sector, customs duty, foreign trade, head offices of the innumerable Indian companies and multinational corporations, renowned scientific and nuclear institutes, Bollywood etc. Thus, all these sectors provide the strong base to its economy and ample amount of job opportunities in them attract the large number of migrants from the different nooks and corners of the country(TCPD, 2014). Mumbai has a moist tropical climate, and June and January are the hottest and coldest months of the year respectively. From June to August, the region receives the most rainfall of the season.(Vijay et al., 2020).

Methodology:

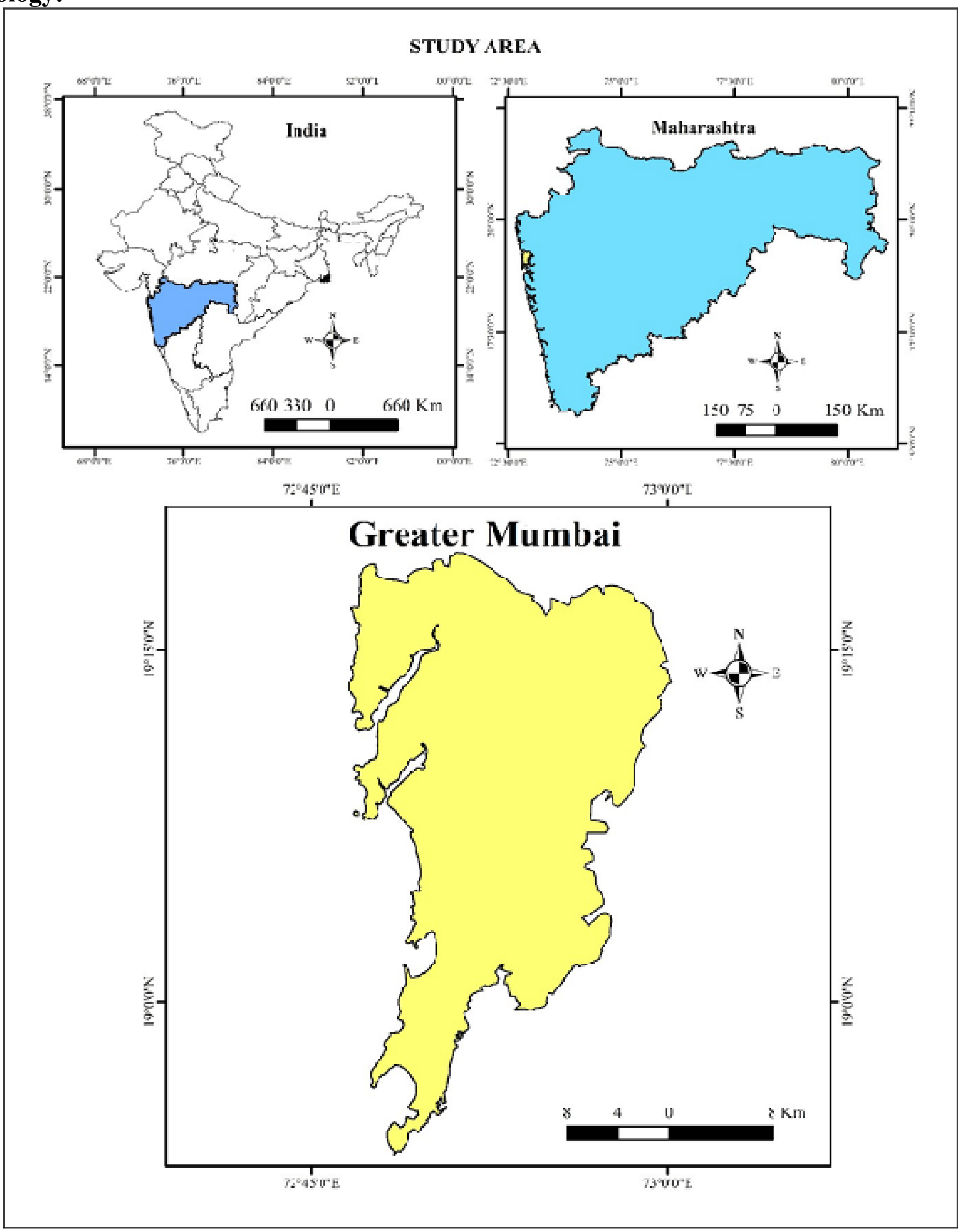

Figure 2, Map of Study Area

[1] https://censusindia.gov.in/census.website/

Table 01 strings

Database	Search string	Number of results
Scopus	TITLE-ABS-KEY ("Land use Land cover") AND TITLE-ABS-KEY ("Mumbai")	**26**
Date of search: 25/08/2024, the keywords "Land use Land cover" and "Mumbai" was used to search the database using the "AND" operator.		

This study incorporates the ICA (Initialisation, Conceptualization and Actualization) framework (Ansari et al., 2024; Vaidya et al., 2021; Waza et al., 2023) for the systematic review to evaluate papers on LULC dynamics about the study area. Only the Scopus database was used for the data retrieval process between 2006 to 2024. After inputting the keywords of "Land use Land cover" and "Mumbai" in the advanced search option of the database by using the 'AND' operator, it results in the 26 documents as shown in (Table 01). By excluding the six book chapters, conference papers, and letter and review documents, the investigators got twenty article-type documents for the title and abstract assessment. After scrutinizing all the articles based on title and abstract, ten articles were irrelevant to the main themes of the present study. Therefore, it includes only ten remaining articles for the final qualitative analysis, as shown in figure 2. In this study, a systematic review of already available literature was done to know the status of LULC in Greater Mumbai, Maharashtra. The important conclusions that the authors of this study have found are as under: Over the last few decades, increasing urbanization has resulted in a dramatic rise in the built-up area in the study region while green spaces, other vegetation cover and water body area have significantly reduced. An increase in built-up and a decrease in green spaces and other vegetation cover enhanced the intensity of Urban Heat Island and thus increased the city temperature. The LULC changes in the region also results in a significant increase and decrease in NDBI and NDVI respectively. LULC changes have also accelerated the intensity of floods in the study region. It has also been projected that if the rate of LULC change in the region remains the same, it will significantly affect the study area's climatic and environmental processes. Finally, it has been analyzed that increasing population and urbanization are the two main drivers responsible for the LULC dynamics in the study region. Unsustainable and unplanned LULC changes have more disadvantages and may have a few temporary positives. In our study area also, investigators of this study found that haphazard LULC dynamics have created many problems. If the pace of changes continues, it will cause many catastrophizes in the future. Thus, there is an urgent need for the government to develop a LULC policy to control this blind land transformation. Moreover, this review paper will act as a tool for the local people and policymakers for the efficient and sustainable management of land resources in the study area.

Analysis and Results

General Findings

Table 2, Overview of the peer review studies on lulc incorporating Geospatial Technologies

Sn. no.	Study Area	Satellite Images & Resolution (m)	Acquisition Date	Geospatial Techniques	Land use classes	Accuracy Assessment	Source
1	Mumbai	Landsat 5 TM (30m) Landsat 7 ETM (30m) Landsat 8 OLI (30m)	1991 2001 2018	MLSC	Dense, vegetation/Forest, Sparse vegetation/scrub land, Open land, Built up, Crop land, Water body	yes	(Shahfahad et al., 2021)
2	Mumbai	Landsat 5 TM (30m) Landsat 5 TM (30m) Landsat 8 OLI (30m)	1988 2008 2018	Supervised classification	Green spaces	yes	(Rahaman et al., 2021)

3	Mumbai	Landsat 5 TM (30m) Landsat ETM+ (30m) Landsat TM (30m)	1992 2002 2011	MLSC	Urban, Forest, Water, Coastal Features, Agricultural/Sparsely Vegetated and Barren	yes	(Vinayak et al., 2021)
4	Oshiwara River Basin, Mumbai	DEM SRTM Landsat TM (30m) Landsat TM (30m) Toposheets SOI	1966 2009	on screen digitisation	Built-up Vegetation Open land water body	yes	(Zope et al., 2016)
5	Poisar River basin	DEM SRTM Landsat TM (30m) Landsat TM (30m)	1966 2009	on screen digitisation	Built-up land, Vegetation, Open land, Water body	yes	(Zope et al., 2017)
6	Mumbai	Landsat MSS (30m) Landsat ETM+ (30m)	1973 2018	ISO cluster unsupervised classification	Built-up Forest Bare land Water and wetland	yes	(Zope et al., 2015)
7	Mithi River basin, Mumbai	Toposheets SOI Landsat TM	1966 2009	Digitisation and supervised classification	Open land, Built-up area, Water body, Vegetation and forest	Yes	(Zope et al., 2015)
8	Mumbai	Landsat MSS Landsat_5 TM Landsat_8 OLI	1972 1994 2016	OBIA	Agriculture (Cropland), Built-up, Barren land, Vegetation (Terrestrial), Mangrove, Mudflat, Saltpan, Sand.	yes	(Vijay et al., 2020)
9	Mumbai	Landsat MSS Landsat ETM+	1973 2018	Unsupervised classification	Water, Forest, Built-up, Open land, Wetland	yes	(Sansare & Mhaske, 2018)
10	Urban Mumbai	Landsat TM CARTOSAT-(2.5m)	1987 2005	on screen digitisation	Built-up Reclaimed land Airport area Open spaces/vacant land River/stream Lakes/Tanks Mudflats other (vegetation, quarries, barren land)	yes	(Kamini et al., 2006)

NOTE: **MLSC**; Maximum Likelihood supervised classification**, TM**; Thematic Mapper; **ETM**; Enhanced Thematic Mapper Plus**, OLI**; Operational Land Imager, **DEM;** Digital Elevation Model**, SRTM**; Shuttle Radar Topography Mission, **SOI**; Survey of India**, OBIA;** Object Based Image Analysis

After an in-depth discussion, four main themes and some sub-themes have been created by the authors of this paper, as shown in Table 2. More specifically, it has been found that three studies are related to the LULC of the river basins of Mithi, Poisar, and Oshiwara(Zope et al., 2017)(Zope et al., 2016)(Zope et al., 2015). One study highlights urbanisation's impact on Mumbai creeks(Vijay et al., 2020). Another study predicts the future LULC changes in the study area (Vinayak et al., 2021). Another study displays the spatiotemporal assessment of land use in urban Mumbai (Kamini et al., 2006). Urban heat island in response to LULC change of the study area presented by another study (Shahfahad et al., 2021). LULC dynamics of green spaces and their impact on the environment of the urban areas of the study regio are discussed in the study by(Rahaman et al., 2021). Two studies on the impact of LULC Change on stormwater runoff and peak discharge of the study area are mentioned in the studies of (Sansare & Mhaske, 2018, 2020). Among the ten articles investigated in the present study, three papers were published in 2021. Seven articles were published in 2020, 2019, 2018, 2017, 2016, 2015 and 2006. It can be seen from table 01 that these studies have utilised geospatial technology either directly or indirectly to produce results that have pivotal significance in the land use planning of the study area. There may be some limitations in these studies, like dataset selection, especially the resolution of satellite data and errors while performing the processes of classification and digitisation. However, most studies presented significant findings and validated them through the accuracy assessment procedure. Table 2 highlights the overview of these critical findings with the below-mentioned characteristics (1) Study area; (2) Satellite images with resolution (m); Geospatial techniques; (3) LULC classes (4) accuracy assessment; and (5) References/source of studies. Land use classes: The main land use classes of Mumbai are Built-up, Open land/vacant spaces, Dense vegetation/Forest, Sparse vegetation/scrub land, cropland, water bodies, green spaces, coastal features, barren land, Mangroves, Mudflat, Saltpan, Sand, wetland, reclaimed land, quarries (Kamini et al., 2006; Rahaman et al., 2021; Sansare & Mhaske, 2018, 2020; Shahfahad et al., 2021; Vijay et al., 2020; Vinayak et al., 2021; Zope et al., 2015, 2017). Techniques: The investigators of this study have observed that three studies have used the on-screen digitisation technique for LULC classification of satellite imageries (Chaudhry et al., 2015; Kamini et al., 2006; Zope et al., 2016, 2017) see table 2. In on-screen visual interpretation, an interpreter classifies, identifies and quantifies objects or regions of the aerial photographs or other digital senor images through their fundamental elements like values of brightness across the scene, tone, texture, shadows, patterns, and contextual attributes(Read & Torrado, 2009). Perhaps supervised and unsupervised classifications are primarily used automated classification methods. Supervised classification requires the analyst's prior knowledge of the study area to operate the classification process to obtain the proper training sites in the form of some sample pixels in an image representing specific classes. The analyst then directs to image processing software to utilise these training sites as the references for classifying every pixel in the image (Egorov et al., 2015).On the other hand, in the unsupervised classification, there is no need for an analyst's knowledge regarding the study area in advance. It requires less human intervention in comparison to supervised classification. This type of classification is also called 'clustering'. It classifies the satellite imagery data into multispectral feature space and extracts the information regarding the land cover. One study has used supervised classification(Rahaman et al., 2020). Studies using unsupervised classification techniques are (Sansare & Mhaske, 2018)(Sansare & Mhaske, 2020). One study that has utilised digitisation cum supervised method is (Zope et al., 2015). Maximum Likelihood classification is a type of supervised algorithm. It is a widely used supervised classifier that presumes normal or near-normal spectral distribution for each feature of interest and the same prior probability through the classes. It is based on the likelihood that a pixel pertains to a particular category. It considers the variability of classes by utilising the covariance matrix (Li et al., 2017). The maximum likelihood classification technique is used by two studies (Shahfahad et al., 2021; Vinayak et al., 2021). One study has used a particular LULC classification, i.e., Object- Based Image Analysis (OBIA)(Vijay et al., 2020). OBIA has become an acceptable way to analyse satellite images with high spatial resolution. This method groups many pixels into shapes and represents the objects meaningfully (Hossain & Chen, 2019).

Land use dynamics:

Table 3, Lulc dynamics in different classes of the study area

S. no.	Study Area	Land use classes	Total area sq.km		Net change sq.km	References
			Year_1991	year_2018		
1.	Mumbai	Dense vegetation/Forest	215.8	129.27	-86.53	(Shahfahad et al., 2021)
		Sparse vegetation/scrub land	71.96	64.08	-7.88	
		Open land	80.57	33.78	-46.79	
		Built up	173.09	346.02	172.93	
		Crop land	35.17	10.32	-24.85	
		Water body	27.19	20.31	-6.88	
		Total	**603.78**	**603.78**		

2.	Mumbai	Green space	**year_1988**	**year_2018**		(Rahaman et al., 2021)
			292.6062	168.1427	-124.4635	
3.	Mumbai		**year_1992**	**year_2011**		(Vinayak et al., 2021)
		Urban	494.52	922.93	428.41	
		Forest	874.08	598.36	-275.72	
		Water	139.27	137.5	-1.77	
		Crop land	237.19	194.48	-42.71	
		Agricultural/Sparsely Vegetated and Barren	1089.51	981.31	-108.2	
		Total	**2834.57**	**2834.58**		
4.	Oshiwara River Basin, Mumbai		**year_1966**	**year_2009**		(Zope et al., 2016)
		Built-up	4.73	8.27	3.54	
		Vegetation	5.6	8.72	3.12	
		Open land	14.84	8.49	-6.35	
		water body	0.5	0.19	-0.31	
		Total	**25.67**	**25.67**		
5.	Poisar River basin		**year_1966**	**year_2009**		(Zope et al., 2017)
		Built-up land	3.36	8.9	5.54	
		Vegetation	7	9.25	2.25	
		Open land	8.7	1.49	-7.21	
		Water body	1.13	0.55	-0.58	
		Total	**20.19**	**20.19**		
6.	Mumbai		**year_1973**	**year_2018**		(Zope et al., 2015)
		Built-up	139.26	231.307	92.047	
		Forest	114.55	90.32	-24.23	
		Bare land	84.55	54.02	-30.53	
		Water and wetland	132.78	95.48	-37.3	
		Total	**471.14**	**471.127**		
7.	Mithi river basin, Mumbai		**Year_1966**	**year_2009**		(Zope et al., 2015)
		Open land	18.64	29.76	11.12	
		Built-up area	14.97	16.99	2.02	
		Water body	30.05	18.19	-11.86	
		Vegetation and forest	6.92	5.64	-1.28	
		Total	**70.58**	**70.58**		
8.	Mumbai		**year_1973**	**year_2018**		(Vijay et al., 2020)
		water	29.74	23.47	-6.27	
		Forest	131.93	100.21	-31.72	
		Built-up	166.95	285.89	118.94	
		Open land	61.55	10.87	-50.68	
		Wetland	80.9	50.67	-30.23	
		Total	**471.07**	**471.11**		
9.	Urban Mumbai		**1973**	**2018**		(Sansare & Mhaske, 2018)
		Built-up	13	32	19	
		Reclaimed land	0	1.6	1.6	
		Airport area	3.43	4.93	1.5	
		Open spaces/vacant land	10	1.25	-8.75	
		River/stream	1.94	0.92	-1.02	
		Lakes/Tanks	2	1	-1	
		Mudflats	4.47	1.5	-2.97	
		other (vegetation, quarries, barren land)	11.16	3.1	-8.06	
		Total	**46**	**46.3**		

The results of studies that we have included in this review paper highlighted the status of LULC dynamics in Greater Mumbai, Maharashtra, from the last 16 years (2006-2024). These studies are (Kamini et al., 2006; Rahaman et al., 2021; Sansare & Mhaske, 2018, 2020; Shahfahad et al., 2021; Vijay et al., 2020; Vinayak et al., 2021; Zope et al., 2015, 2017). These studies found that the primary land use classes (see table 3) experienced drastic changes in the study region. It has been found that the vegetation cover of Mumbai has decreased significantly. It was 215.8 sq. km in and reduced to 129.27 sq. km in 2018. Thus, a decrease of 86.53 sq. km within 26 years. While during the same period, area under built-up dramatically increased from 173.09 sq. km to 346.02 sq. km(Shahfahad et al., 2021) . Another study has revealed that the urban green space in Mumbai was 292.60 Sq.km in 1988, and in 2018 it decreased to 168.14 sq.km., a decrease of 124.46 (Rahaman et al., 2021). From 1992 to 2011, the built-up area in Mumbai expanded at a high pace and was just 494.52 sq. km in 1992, and in 2011, it increased to 922.93 sq.km, an increase of 428.41sq.km. While during the same period, the forest area in the region diminished to 275.72 sq. km. The other LULC classes, like water bodies, cropland, and sparse vegetated/barren land, have also shown a decreased trend. It has also been predicted that by 2050, the urban land use class will constitute 46.87% (1328.77 sq. km) of Greater Mumbai. On the other hand, the agriculture/ sparsely vegetated and barren land will reduce by(Vinayak et al., 2021). In another study, it has been analysed that over 45 years, the areas under open land, wetland and forest have shrunk by 36%, 28% and 21%, respectively, concerning the total catchment area of Mumbai. In comparison, the region's built-up area has risen to 66 % between the period of 1973 to 2018 (Sansare & Mhaske, 2020). In the Mithi river catchment basin area, the built-up area has increased from 18.6 sq. km to sq. km between 1966 and 2009. There is a decrease in open space and water body area from 18.64 sq. km to sq. km and 30.05 sq. km to 18.19 sq. km, respectively, over 43 years(Zope et al., 2015). Creeks are one of the vital coastline features and act as a funnel that links rivers to seas and plays a significant role in ecological phenomena, processes, and material transfer. A study has found that in Manori and Thane creeks, the area under mangroves has risen from 8 sq. km to 25.2 sq. km and 50.7 km2 to 57.6 sq. km, respectively. It has also been predicted that more creek width will be reduced by 2025 and 2050 (Vijay et al., 2020).

LULC dynamics and Environment of the study region:

Increasing the built-up area and decreasing green spaces and vegetation in Mumbai significantly increased the intensity of urban heat islands (UHI). In both the zones of UHI and Non-UHI, the minimum and mean Land surface temperatures (LST) temperature display an increasing trend, i.e., 1.94 °C (minimum) and 2.2 °C (mean) in UHI and 5.99 °C (minimum) and 1.98 °C in non-UHI. On the other hand, the maximum LST has decreased in the zones of UHI. It has also been analysed that the Normalised difference vegetation index (NDVI) (in Mumbai has reduced from 1988/1991 to 2018, and during the same time gap, the Normalised Difference Built-up Index (NDBI) has increased considerably in the city mainly due to increases in a built-up area (Rahaman et al., 2021; Shahfahad et al., 2021). Increasing urbanisation and encroachment along the poisar river banks halt water flow and become one of the critical causes of flooding(Zope et al., 2017). In a similar study, the flood hazard analysis found that the high-intensity flood hazard zone area has increased significantly due to the LULC changes along oshiwara River Basin, Mumbai; the high-intensity flood hazard zone area has increased considerably by about 64%. While on the other hand, the areal extent of low-intensity hazard zone decreased to 32% between 1966 and (Zope et al., 2016). From 1973 to 2018, it has been observed that the peak discharge has increased by 36 %, and the drastic changes in LULC resulted in the increase of peak discharge and the waste that results the choking of drains. Thus, flood or water logging cases occur most frequently in Mumbai (Sansare & Mhaske, 2020; Zope et al., 2015). Reduction of Land use classes like Water bodies, vegetation, and mudflats and expansion of built- up results in the increase of sewage, solid wastes and siltation that subsequently leads to the growth of mangroves into the creeks. Such ecological degradation may cause many catastrophes like water escalation in the urban areas of Mumbai, blockade of the drainage system, property loss etc. (Vijay et al., 2020). It has also been predicted that if the rate of LULC change in Mumbai increases at the same pace, then it may lead the severe repercussions on the processes of the climate and environment of the region (albedo, leaf area index, and sky view factor) which may amend the regions micro-metrology by interrupting the land-atmosphere interaction (Vinayak et al., 2021).

Drivers of LULC:

In the cities like Mumbi, rapid LULC changes are taking place. Thus, it is important to know the driving forces or reasons for such change. After scrutinising all ten relevant studies on LULC change of study area (Kamini et al., 2006; Rahaman et al., 2021; Sansare & Mhaske, 2018, 2020; Shahfahad et al., 2021; Vijay et al., 2020; Vinayak et al., 2021; Zope et al., 2015, 2017)., the investigators have reached to the conclusion that urbanisation and increasing population growth are two main pivotal drivers responsible for LULC dynamics in the study region. It is very important to note down, that though climate change is one of the important factors of LULC changes. However, after analysing all ten papers that we have utilized to review the LULC changes in the region, we didn't find any single paper that has included climate change as the important driver for LULC changes in the region. Thus, in the following paragraphs, we will only discuss population and urbanization in a detailed manner. Increasing Population: Population severely impacts limited resources, especially in third-world countries like India, Pakistan, and Bangladesh. Unsustainable management of the resources, especially of land assets, leads an unhealthy competition between the increasing population and their settlement and infrastructural needs in these developing countries and transforms the LULC surface to fulfil their growing land demands and results in the degradation of ecological, climatic and hydrological processes of the region (Dutta et al., 2019). Thus, it has been observed that there is a strong correlation between population change and LULC dynamics (Genet, 2020). Studies that have analysed population growth as one of the important factors of LULC change in the study area are(Kamini et al., 2006; Rahaman et al., 2021) (Shahfahad et al., 2021)(Vinayak et al., 2021). Urbanisation: Increasing urbanisation, particularly in developing countries, is considered one of the important factors of global change in the present time that affects the different human facets (Sui & Zeng, 2001). Studies that have found urbanisation as the prime driver for the LULC dynamics in the study region are (Kamini et al., 2006; Rahaman et al., 2021; Sansare & Mhaske, 2020; Zope et al., 2015, 2016, 2017).

Conclusion

In this study, a systematic review of already available literature was done to know the status of LULC in Greater Mumbai, Maharashtra. The important conclusions that the authors of this study have found are as under: Over the last few decades, increasing urbanization has resulted in a dramatic rise in the built-up area in the study region while green spaces, other vegetation cover and water body area have significantly reduced. An increase in built-up and a decrease in green spaces and other vegetation cover enhanced the intensity of Urban Heat Island and thus increased the city temperature. The LULC changes in the region also results in a significant increase and decrease in NDBI and NDVI respectively. LULC changes have also accelerated the intensity of floods in the study region. It has also been projected that if the rate of LULC change in the region remains the same, it will significantly affect the study area's climatic and environmental processes. Finally, it has been analyzed that increasing population and urbanization are the two main drivers responsible for the LULC dynamics in the study region. Unsustainable and unplanned LULC changes have more disadvantages and may have a few temporary positives. In our study area also, investigators of this study found that haphazard LULC dynamics have created many problems. If the pace of changes continues, it will cause many catastrophizes in the future. Thus, there is an urgent need for the government to develop a LULC policy to control this blind land transformation. Moreover, this review paper will act as a tool for the local people and policymakers for the efficient and sustainable management of land resources in the study area.

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