

LAND USE AND LAND COVER (LULC) OF BANGALORE CITY -A GEOSPATIAL APPROACH

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Abstract

Land-use and land-cover change (LULCC); is a general term for the human modification of Earth's terrestrial surface. *Bangalore City is one of the rapidly growing city in India as well as in Asia. The Growth of the Bangalore city took its speed after 1996-97, because of Real Estate, Globalization and its policies. Bangalore city is the part of Bangalore Urban District, the city has 709 KM² Geographical area but the urban district has 2196KM². The population of the study area crosses over 105 million in 2017. The Population and the City growth mainly affected the LULC of the area. Land Use and Land Cover look like similar words but while studying deeply we can understand LULC concept easily. For the study purpose only Urban and Urban influence area have been taken. The major aim of the research paper is to show the changes occur in the LULC of Bangalore City using Remote Sensing Technology. Multi-Spectral Satellite Imageries are used to know the development and changes taken in Land Use and Land Cover. GIS and ERDAS Technologies are used to do mapping and analysis. The research paper mainly concentrating on City and BBMP region but some packages of land have been used to understand the influencing zone of Urban and Rural.*

Keywords: LULC, Multi-Spectral, BBMP, Real Estate.

Introduction

Land-use and land-cover change (LULCC); is a general term for the human modification of Earth's terrestrial surface. Though humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of LULCC are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales. These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soil and air. Monitoring and mediating the negative consequences of LULCC while sustaining the production of essential resources has therefore become a major priority of researchers and policymakers around the world.

Although the terms land cover and land uses are often used interchangeably, their actual meanings are quite distinct. Land cover refers to the surface cover on the ground, vegetation, urban infrastructure, water, bare soil or other. Identifying, delineating and mapping land cover is important for global monitoring studies, resource management and planning activities. Identification of land cover establishes the baseline from which monitoring activities (change detection) can be performed. It provides the ground cover information for baseline thematic maps.

In the analysis of land use and land cover change, it is first necessary to conceptualize the meaning of change to detect it in real world situations. At a very elementary level, land use and land cover change means (quantitative) changes in the areal extent (increases or decreases) of a given type of land use or land cover, respectively. It is important to note that, even at this level, the detection and measurement of change depends on the spatial scale; the higher the spatial level of detail, the larger the changes in the areal extent of land use and land cover which can be detected and recorded.

Study Area

Bangalore city has a colorful past and begin life as the “village of the half-baked gram”.At the beginning of 20th century, Bangalore city had many sobriquets like “Pensioner’s paradise”, since retired army officers preferred to settle in Bangalore in big sprawling houses; the “Garden City” with the green and beautiful maintained Lalbagh and Cubbon Parks in the heart of the city, and the “air-conditioned city” because of its pleasant climate. However today, it is known as the “Fastest growing city in Asia”, the city of 21st century for the potential investors from abroad and the “Silicon Valley of India” for the global electronic and computer giants. The study area forms a major part of the Bangalore Urban and Rural district, which was carved out as a separate district from the original Bangalore district in 1986, to differentiate its urban and rural components. The study area covers the areas of Bangalore Urban districts, 4 taluks namely Bangalore North, Bangalore South, Bangalore East and Anekal. Bangalore rural districts, Part of Hoskote, Devanahalli and Nelamangala. Within these districts study area covers 198 BBMP Wards. The absolute location of the study area is Top left corner $77^{\circ}25'49.399''$ E and $13^{\circ}11'24.17''$ N, Bottom right corner $77^{\circ}47'49.534''$ E and $12^{\circ}51'13.526''$ N, the absolute location of the seed point in Bangalore city is $77^{\circ}34'34.307''$ E and $12^{\circ}58'21.103''$ N. The total geographical study area is **1500** sq km.

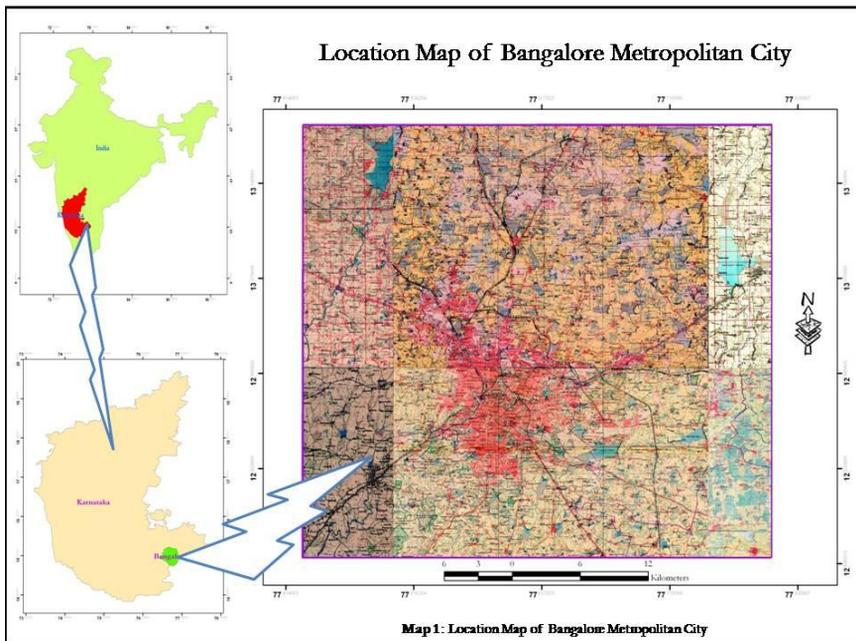


Figure 1. Location Map

Table 1. Population Growth in Bangalore.

Growth of Population in Bangalore Metropolitan		
Census Year	Persons	Area in Sq. Km
1901	1,63,000	NA
1941	4,10,000	NA
1981	29,21,751	365.65
2001	56,86,844	531.00
2011	84,99,399	710.00

Objectives

We all know that Bangalore is the city where we can see all type of peoples from different corners of the world. The major objective of this research paper is to demarcate and understand the Land Use and Land Cover changes occurred over the period of time in Bangalore city and its surrounding regions. The changes are common in city and its geographical area, but as a researcher we should understand the changes are happen for positive or negative approach.

Data Sources

Data source is one of the important elements for the any research work, researcher has gather data's from survey of India, National Remote Sensing Agency and Regional Remote Sensing Centre of Karnataka. The data used for land use and land cover mapping are as follows: Survey of India Toposheets, IRS-1D Satellite Imagery, IRS-P4 Satellite Imagery, IRS-P6 Satellite Imagery, Carto Sat-I Satellite Imagery.

Methodology

Geospatial technologies have been used for this research paper. For map making and editing ARC GIS software and for processing the satellite imageries ERDAS software used. Supervised classification is the major option used to calculate the changes occurred in the urban area.

Result and Discussion

The land use / land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense anthropogenic pressure. Hence, information on land use/land cover and possibilities for their 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. Land use effects land cover and land cover affects land use. Land use change, as one of the main driving forces of global environmental change, is central to the sustainable development debate. The types of land use are distinguished as land cover conversion, i.e., the complete replacement of one cover type by another, and land cover modification, i.e., more subtle changes that affect the character of the land cover without changing its overall classification.

Table 2: Level I and Level II Class of LULC.

Sl No	Level I	Level II
1	Built Up	Built Up (Urban), Built Up (Rural)
2	Agricultural Land	Crop Land, Fallow, Plantation, Tree Groves
3	Forest	Evergreen, Semi, Deciduous, Scrub, Grassland, Mangrove etc.
4	Natural / Semi Natural Grassland and Grazing Land	Alpine, Tropical, Manmade Grassland
5	Wastelands	Salt-affected land, Scrub land, Sandy areas, Mine dumps, Industrial dumps, stony wastes.
6	Wetlands	Inland Wetland, Coastal Wetland
7	Water Bodies	River, Canal, Lakes, Reservoir
8	Others	Mining, Quarry, Bricks Kilns, snow covered or Glacial area

This classification cannot be performed using medium and low resolution satellite imageries. So based on the availability, first order classification done using the below table. If the satellite imagery is Multi-Spectral, based colour we can easily classify the images. Otherwise we need to see the digital number and perform the classification process.

Table 3. Land use and land cover classification based on research work and available satellite imagery.

Classes of LULC		
Sl No	Classification	Including
1	Built-up Areas	Residential, Commercial, Transportation and other built up areas
2	Water-body Areas	Natural and Manmade Lakes
3	Greenery Areas	Agricultural land, Forests, Scrubs and Grasslands
4	Other Areas	Vacant land, non-usable for agriculture and other purpose, dumping yards, masked areas if any, quarry etc.

In Bangalore Metropolitan City area, Land use change changed rapidly since last decade that from 2000 to 2009 period. In this research Land use change has been studied through the satellite imageries. I have used 2001, 2007 and 2015 satellite imageries for the understand Land use pattern. There are two approaches for the land-use classification. Both are based on the principle that a land cover class can be described by a unique spectral reflectance profile which has already been seen in the previous chapter. The first approach we will look at is called an **unsupervised classification**. The second approach is called **supervised classification**. The land use class have been taken from NRSC /ISRO Table.

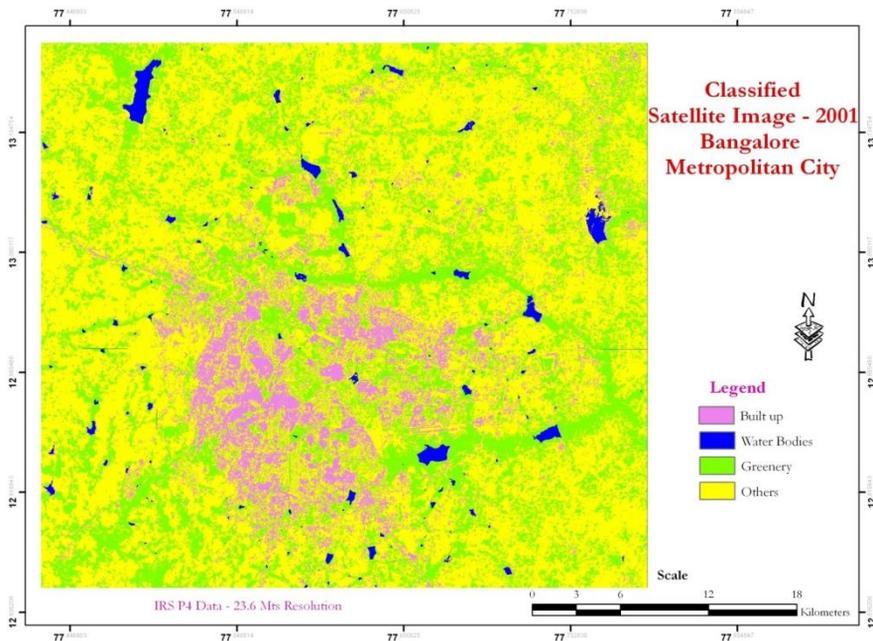


Figure 2. 2001 Classified Satellite Imagery.

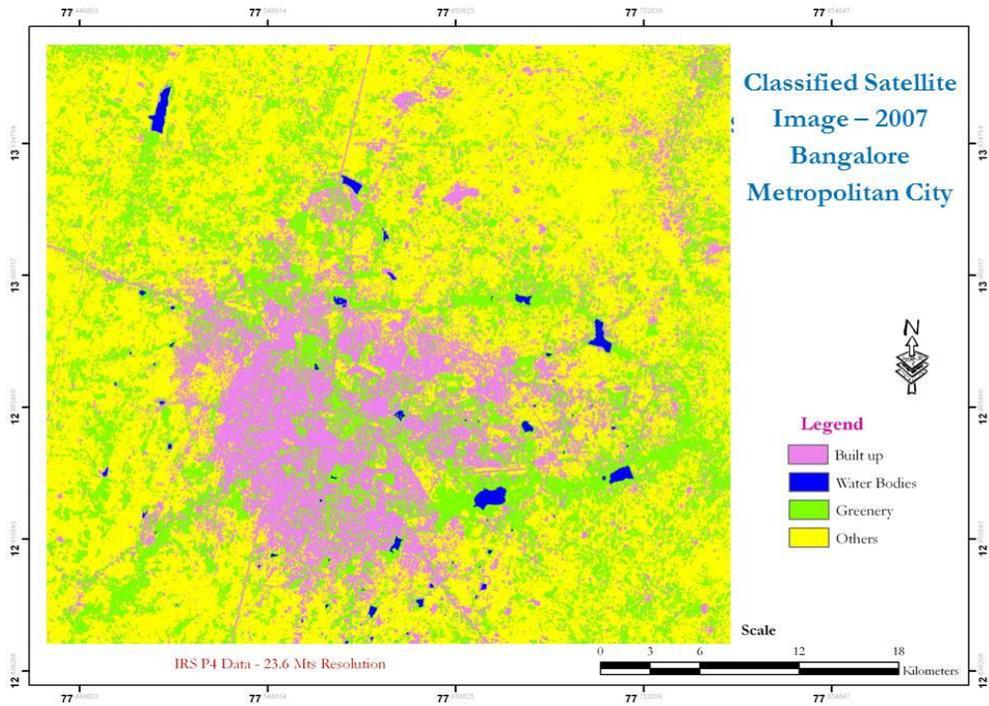


Figure 3. 2007 Classified Satellite Imagery.

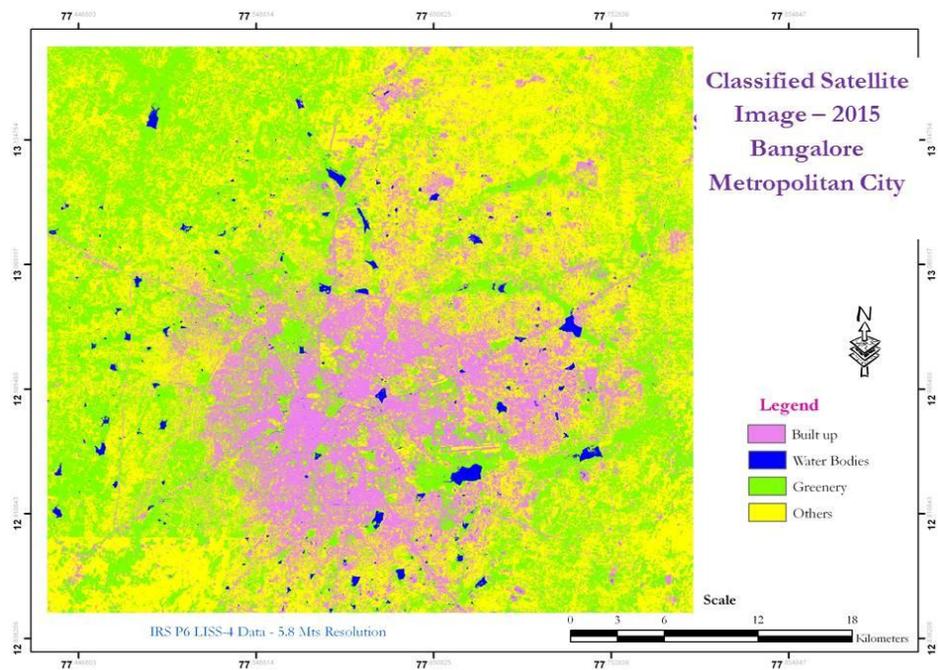


Figure 4. 2015 Classified Satellite Imagery.

Data is based on the classification of Satellite imagery, used IRS 1C/1D for 2001 having the resolution of 23.6 mtr. For 2007 IRS P4 Data resolution is 23.6 mtr. and for 2015 IRS P6 LISS 4 Data having 5.8 mtr resolution. The below tables explains the Land Use classes and geographical area represent against each class. The total Geographical area of the research is 1500 KM² including BBMP and influence region of the city, including some sprawl and fringe villages. We can see that since 1995 to 2015 Bangalore LULC has changed drastically. Every frequent interval Built-up areas is increasing at the same time waterbody, Green Patches and part of agriculture land is decreasing. Vacant area, open area and non-usable area for agriculture had been used for developmental purposes.

Table 4. Temporal Land Use Classification (The Total Geographical Area of under study is 1500 sq km)

Land Use Type	1995		2001		2007		2015	
	Area in Sq Km	%						
Built-up Areas	163	10.86	225	15.00	320	21.33	524	34.93
Waterbody Areas	41	2.73	35	2.33	28	1.86	17	1.13
Greenery Areas	633	42.20	595	39.66	540	36.00	408	27.20
Other Areas	663	44.21	645	43.01	612	40.81	551	36.74
Total	1500	100	1500	100	1500	100	1500	100

Table 5. Temporal Land Use Classification, Area in Hectare and Acre

Land Use Type	1995		2001		2007		2015	
	Area in Hectare	Area in Acre						
Built-up Areas	16300	40278	22500	55598	32000	79073	52400	129483
Waterbody Areas	4100	10130	3500	8648	2800	6918	1700	4200
Greenery Areas	63300	156417	59500	147027	54000	133436	40800	100819
Others Areas	66300	163830	64500	159382	61200	151228	55100	136153
Total	150000	370655	150000	370655	150000	370655	150000	370655

Land-use 2001 of Bangalore Metropolitan City

The land-use in the year 2001 for study area is dominated by the Greenery and Other Areas. Greenery includes Agricultural land, Forestry, Scrubs and Grasslands. The other class includes open land, waste land, stone-quarry and dumping-yards. There were increasing components of built-up area in the metropolitan city.

Built-up Areas: Areas of human habitation developed due to non-agricultural use an that which has a cover of buildings, transportation and communication, utilities in association with

water, vegetation and vacant lands are classified as built up. The study area covers Bangalore Metropolitan City and surrounding villages. The total built-up land measures to 225 sq km in 2001, this has great increase since the 1995, in the year 1995 has 163 sq km.

Waterbody Areas: This class comprises of surface water either impounded in the form of ponds, lakes and reservoirs or flowing as rivers. The effect of urbanizations has taken some heavy toll on the beautiful lakes in Bangalore. The lakes in the city have been largely encroached for urban infrastructure and as a result, in the heart of the city only 17 good lakes exist as against 51 healthy lakes in 1985. Urban development has caused 16 lakes getting converted to bus stands, Golf courses, play grounds and residential colonies, and few tanks were breached under the malaria eradication programme. Lake Development Authority has been governed in 2002, before that many lakes vanished due to encroachment and construction activity for urban infrastructure expansions. The city once had 280-285 lakes of which 7 cannot be traced, 7 are reduced to small pools of water, 18 have been unauthorized encroached by slums and private parties, 14 have dried up and are leased out by the Government. 28 lakes have been used by the Bangalore Development Authority to distributes sites and build extensions for residential areas. Over the years Bangalore city losing its one type of land use class because of the rapid urbanizations.

Greenery Areas: It constitutes Agricultural land, forest, grassland and other type of land covered by vegetation. Out of geographical area of the city the share of the greenery was 633 sq. km in the year 1995, but it is decreased to 595 sq km because of the lifting green belt in to yellow belt. The converted areas used for the new layouts and many industrials built up. Many IT Companies were established in period in the boundaries of the urban areas. Bangalore is known for its green space and has a good ecology. The increasing urbanization has posed a serious threat on the spatial distribution of the forests area as well as in the quality / health of the forest. In Bangalore Metropolitan City some of the areas where natural vegetation is dominated by grasses or grass like plants and non-grass like herbs. Lands exclusively used for farming grasses are called meadows and pastures. Such grass land is found in the North and South West corner of the study area. **Other Areas:** The land use class named other constitutes vacant land, non-usable for agricultural purpose, dumping yards and quarry. These are more common sloping land where they are developed by the action of concentrated runoff. Such kinds of lands are found in the East and Northern Part of the Bangalore Metropolitan City. These lands are characterized by exposed massive rocks, sheet rocks, stony pavements or lands with excessive surface accumulating of stones that render them unsuitable for producing any green biomass. Above tables shows the gradually decrease in the other class of land use classification.

Land-use in Bangalore Metropolitan City - 2007

The land use in 2007 saw an increasing loss of Agricultural land and a heavy shoot up of built-up land. There was also an increasing loss to the water body areas and greenery areas. Thereby reading the overall statistics of the land use 2007, considerable amount of ecological space loss can be identified and accounted.

Built-up Areas: Tremendous increase in all the categories of the built up area was noticed in the year 2007. Area occupied by village and urban built up increased rapidly. Many new projects in commercial and apartments has been took place. Many IT Industries were constructed outside the Central Business District, and this routs the improvement of the

Transportation and Communication. Good number of roads was constructed and government approved core roads and outer ring roads and many flyovers and underpasses. This creates the good transportation infrastructure to the Bangalore Metropolitan City.

Waterbody Areas: There was a tremendous decrease in the all area cover of water bodies in the year 2007. The water body area 28 sq km decreased by 35 sq km. the number of living tanks were decreased to 78 in numbers.

Greenery Areas: The main category in Greenery is belongs to Agricultural land, there was a steady loss of agricultural land in 2007. 380 sq km was no more agriculture area compared to land use of 2001. Many land holders converted agriculture land in to built-up land because the influence of the real estate. And they created many private layouts of their own, all over the Bangalore Metropolitan City. Bangalore Metropolitan City lost 35 sq km of Forest area in last 7 years.

Other Areas: The classified class other also decreased because of the fulfillment of Urbanization. Many land areas used for the built up areas, and some of the areas used for the dumping waste of the cities.

Land-use in Bangalore Metropolitan City-2015

Urban and Rural Fringe changing its characteristics every day. The type of land use also changes every day, and converting Bangalore into one of the Biggest and Largest city in the modern world. Bangalore Metropolitan City and the Peri-urban attract rural peoples to enjoy the urban life. Since the last decade we can see the dramatic changes and growth in the Bangalore Metropolitan City Land use patterns.

Built-up Areas: In the period of 2007 to 2015 Bangalore Metropolitan City grew very drastically. In CBD and also in the Peri-urban region many shopping malls were established, the important ones are Phoenix Market City, Gopalan Signature Mall, Meenaki Innovative Mall, Mantri Mall and Squares, Orioan Mall and others. Big apartments were constructed in the fringe of the city, example Whitefield, Yelahanka, Marathahalli, J. P. Nagar, Kengeri, VidyanayanaPura. Many connectivity roads were constructed to connect and save the time of the commuters. IT Industries like Manyatha Embassy Business Park, Adarsh Tech Park, Global Technology Park, Bagmane World Technology Center and other Business centers were established. Built up area increased up to 28% in the Bangalore Metropolitan City.

Waterbody Areas: The land use of water bodies decreased since 2001 to 2015, at the end of the decade it has only 18 sq km. Many lakes were converted into commercial hubs, and some lakes were privatized. Now we have only few lakes in Bangalore Metropolitan City, those are also not in the good conditions. Lake development authority and Pollution Control Board taking some measures to save lakes.

Greenery Areas: Agricultural land in and around the Bangalore Metropolitan City converting into yellow zone and again converting into Layouts. This leads to the development of the satellite towns, and the urban expansion finally results the Peri-urbanization. Hesaraghatta forest and Banneraghatta are the some patches of forest available in Bangalore Metropolitan City. LalBagh, Cubbon Park, Indian Institute of Science is the some of the Green Patches available in heart of the city.

Other Areas: These vacant land, Land not use full for the agricultural purpose, Stones quarry, dumping yards, percentage is also decreasing every year because of the commercial importance of the land uses. The points of Industrial waste and mining waste also increasing but that is not affected the Other Class of land use patterns.

The comparison of land use between 2001 to 2015 shows drastic changes especially in terms of Greenery loss and water bodies' loss. There is a massive transformation of Agriculture loss and considerable loss of the lakes which had attributed to the increase of concrete structures of the Bangalore Metropolitan City. The agricultural land has decreased more than two fold, the lake area has decreased by one fold and there is a considerable forest area loss can also be noted here. But the built up has increased more than two fold and there is a notable increase in the waste lands too. After understanding all these phenomena Bangalore Metropolitan City can be compared with the Multiple Nuclei Model. The below table express the Index of Increase and Decreases in each LULC classes.

Table 6. Comparison between Land use 2001, 2007 and 2015

Land Use Type	2001		2007		2015		Increase and Decrease Index	
	Area in Hectare	%	Area in Hectare	%	Area in Hectare	%	2001 and 2007	2007 and 2015
Built-up Areas	22500	15.00	32000	21.33	41000	27.33	↑	↑
Waterbody Areas	3500	2.33	2800	1.86	1800	1.20	↓	↓
Greenery Areas	59500	39.66	54000	36.00	51500	34.33	↓	↓
Other Areas	64500	43.01	61200	40.81	55700	37.14	↓	↓
Total	150000	100	150000	100	150000	100	↔↔↔	↔↔↔

Dynamics of Land-use in Bangalore Urban

A trend catching on around the city is the fast-developing business hubs and the resulting demand for residential spaces in the vicinity. Connectivity and accessibility are the two most significant factors behind this trend. On the one hand, the Metro connectivity is augmenting accessibility for many localities, and on the other, the slew of road development projects is leading to the emerging commercial hubs.

Malleswaram - Tumkur Road: A case in point is the Malleswaram – Tumkur Road belt. The seamless connectivity that has come about with the grade separators along the Chord Road on one side and the up-gradation of connectivity from Malleswaram, and of late, the opening of the flyover to opening of the flyover to Nelamangala, at the other end, has led to this belt emerging as a commercial hub. The grade A office spaces available in the belt, the presence of major hotels and civic infrastructure make the belt a complete business hub. With the Metro connectivity set to change things further shortly, it is no wonder the belt is turning a potential commercial hub for property investors too given the convenience of commuting to it and the residential spaces in close proximity offering a variety of options.

IT in South: In a way, this trend began with the city's first IT hub in the south. The development of the belt from Whitefield to Hosur Road into an IT corridor created a similar micro market that fuelled the development of many localities along the way. Here, it was primarily the availability of large land parcels that drew many IT majors, especially those looking at campus developments. The Electronic City and many IT facilities in the belt were just the infrastructure these IT majors needed.

Outer Ring Road: The Outer Ring Road (ORR) has been a major micro market for some time now. The seamless connectivity coming about now and the availability of quality Grade

A spaces along the corridor are the major fundamentals pushing the case for this micro market. Another distinctive advantage this belt offers is the easy connectivity to even relatively further residential localities. ORR's IT growth corridor story commenced in early 2000s with land acquisition and allotment efforts by Karnataka Industrial Areas Development Board (KIADB) to promote IT developments. To facilitate prompt developments, KIADB acquired large land parcels along ORR and ensured conversion of the same for industrial hi-tech use. Further, single window clearance system adopted by Karnataka Udyog Mitra (KUM) supported KIADB's initiative. With the completion of ORR in 2002, a new growth corridor opened up for IT development in Bangalore. With the commencement of Bangalore International Airport (BIA) in 2008 in Devanahalli, the ORR stretch: Hebbal to Silk Board Jn. Gained importance as it serves as the main artery between BIAL and major IT hubs of Bangalore i.e. – Whitefield and Electronic City.

Conclusion

The land use / land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense anthropogenic pressure. Hence, information on land use/land cover and possibilities for their 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. Land use affects land cover and land cover affects land use. Land cover can be altered by the forces other than anthropogenic. Natural events such as flooding, fire, climatic fluctuations and ecosystem dynamics can also initiate modifications upon land cover. Globally, land cover today is altered principally by direct human use, livestock raising, forest harvesting and management and urban and suburban construction and development. Land use change, as one of the main driving forces of global environmental change, is central to the sustainable development debate. The types of land use are distinguished as land cover conversion, i.e., the complete replacement of one cover type by another, and land cover modification, i.e., more subtle changes that affect the character of the land cover without changing its overall classification. Land use change occurs at every Spatio-temporal scale. The Three duration satellite imageries given the clear cut feature, and identified that Built-up area is increasing, because of Privatization, Globalization and other government policies. To create infrastructure in-side the city and out-side the city other classes of lands were disturbing. Day by day waterbody and Greenery are decreasing. This is directly or indirectly affected the Climate, Pollution and life style of the peoples. It is difficult to control or stop the conversion of LULC but some measures can be taken to face the fore coming consequences.

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