GEOGRAPHICAL ANALYSIS

RESEARCH ARTICLE

Urbanization and Loss of Green Spaces in Mysuru City

S Sushmitha[1]*, **B Chandrashekara**[2]

1 *Research Scholar, DoS in Geography, University of Mysuru, Manasagangothri Campus, Mysuru, Karnataka, India*
2 *Professor, DoS in Geography, University of Mysuru, Manasagangothri Campus, Mysuru, Karnataka, India*

OPEN ACCESS

Received: 05.12.2024
Accepted: 25.12.2024
Published: 29.12.2024

Citation: Sushmitha S, Chandrashekara B. (2024). Urbanization and Loss of Green Spaces in Mysuru City . Geographical Analysis. 13(2): 34-44. https://doi.org/10.53989/bu.ga.v13i2.251

* **Corresponding author**.
shankarsushmitha@gmail.com

Funding: None

Competing Interests: None

Published By Bangalore University, Bengaluru, Karnataka

ISSN
Print: 2319-5371
Electronic: XXXX-XXXX

Abstract

With an emphasis on the loss of urban green spaces as a result of urban growth, this study examines the Land Use and Land Cover (LULC) dynamics in Mysuru City, India, over a 20-year period between 2000 and 2020. Four main LULC classes—Built-up Area, Water Bodies, Open Space, and Green Space—were examined using remote sensing and GIS techniques to evaluate the temporal and spatial variations in land cover. The objective of the study is to understand the level of greenery in urban environment of Mysuru city as Mysuru is currently subjected to increased population and unbridled urbanization. The findings raise questions about ecological health and sustainable urban development since they show a notable increase in built-up areas at the expense of green and open Spaces.

Keywords: Urban Green Space; Land Use Land Cover; Remote Sensing; GIS; Mysuru City

1 Introduction

Urbanization is the process by which towns and cities are formed and become larger as more and more people begin living and working in central areas. The urbanization takes the form of either densification of urban core or spatial expansion of urban areas outwards as urban sprawl. Densification of urban core refers to high population density and increase in the built environment (building structures) in relation to open spaces.

By the 2050, up to 70% of the world's population will live in urban areas[(1)]. Approximately 90% of urban growth happens in developing countries, and Asia will have more than 60% of the urban population of the world by 2050. Additionally, the number of megacities (with over 10 million inhabitants) will grow, especially in Asia and Africa[(2)]. Consequently, hasty growth of urban population is often triggered the urban expansion and altered urban Land Use Land Cover (LULC) patterns. Alteration of LULC pattern could breed several environmental threats[(3–7)] including changes in vegetation cover[(8)], water bodies and wetland[(9,10)], grassland and open space[(11,12)]. Therefore, LULC changes become a growing concern for urban planners to manage various environmental issues triggered by the process of urbanization[(13)]. Urbanisation and climate change require new solutions to maintain and, above all, improve the quality of life in our cities[(14)]. Significant changes in the world's land surfaces have

resulted from the increased exploitation of natural resources brought on by the quick growth of human civilization and the desire for higher living standards [15,16]. With human activities affecting over 80% of terrestrial surfaces, the degradation of Earth's natural resources, particularly land, has reached alarming proportions [17,18].

High-density areas like Mysuru City, experience severe degradation, underscoring the necessity of sustainable land management techniques to promote long-term growth in line with the Sustainable Development Goals (SDGs) [19–21].

The term "Land Use and Land Cover" (LULC) refers to the various uses of land, including agriculture, urbanization, conservation, recreation, and wildlife habitats, as well as the interactions that result between people and the environment, which are influenced by socio-economic factors and climate change [22–24]. Sustainability research relies heavily on accurate LULC data since it is crucial for tracking environmental changes at the local, regional, and global levels [25,26]. The necessity for accurate and up-to-date LULC maps to support sustainable development, good urban planning, and environmental monitoring is highlighted by changes in LULC, which are frequently caused by urbanization and population expansion [27–29].

Global researchers have shown how effective GIS and remote sensing technologies are at detecting changes in LULC over time. Zhou's integrated approach to green space analysis, for instance, showed that greening activities and increasing urbanization drastically change LULC patterns [30]. Historical assessments of LULC are made possible by remote sensing, which uses satellite photos to assess how humans have affected landscapes [31–33]. Insights from these technologies are essential for directing policy choices and encouraging sustainable urban growth.

Urban green spaces in cities of developing countries are vulnerable to the rapid transitions of land use patterns caused by population growth and economic development [34–36]. Green spaces are an integral component of the urban landscape and a foundation for the pursuit of sustainable development [37]. Green areas of the city are an inseparable element of a sustainable and smart city. In the era of intensifying climate crises, green areas are one of the elements shaping urban resilience and ecological stability [38,39].

Green spaces are required both in quantity and quality. Many scholars have analysed and suggested the area of green space needed per inhabitant in a city. Many Western countries suggest that nearly 20 m^2 per capita green space is sufficient for an urban dweller. A study conducted by countries like Germany and Japan in the 20th century suggests it to be 40 m^2 of high-quality urban green space per inhabitant or 140 m^2 of suburban forest area per capita. Recently, the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) suggested a standard of 9 m^2 of green space per city dweller. The project 'English Nature' by the Centre of Urban and Regional Ecology, Manchester, recommends at least 2 ha of accessible natural green space per thousand population should be provided to urban dwellers [40–42] .

In India, the urban population growth of 31.8 % during 2001–2011 stands in stark contrast to the simultaneous national population growth of 17.6 % (Census of India 2011). Increase in population has adversely affected the green cover in urban India where Significant decrement in the area of residential gardens has been observed in Kozhikode, Delhi and in addition, Chennai and Mumbai have a meagre 0.46m^2 and 0.12 m^2 of green space per capita, respectively during 2000–2010. Rapid urbanization and widespread urban sprawl have depleted green cover.

Mysuru is undergoing the tremendous land use and land cover change since it has become an attraction for all the investors including housing, industries and information technology hub. Significant changes in LULC have resulted from India's fast urban growth in places like Mysuru, which has important ramifications for the preservation of green spaces. Urban Green Space (UGS) in Mysuru city are heterogeneous in nature and has its own kind of functional aspects according to their character, type and location.

The objective of the study is to understand the level of greenery in urban environment of Mysuru city as Mysuru is currently subjected to increased population and unbridled urbanization. The continuous horizontal expansion has eaten away green spaces in different parts of the city. These green patches and open spaces should be evenly distributed in the city of Mysuru to function as city lungs.

Urbanization's growing conversion of green regions to populated areas threatens the city's ecological balance and standard of living. In light of these developments, this study intends to: (i) categorize Mysuru City's LULC using satellite imagery from 2000 and 2020 using remote sensing and GIS techniques; (ii) measure the degree of LULC changes over the course of the two decades; and (iii) evaluate the loss of urban green spaces and open spaces and its effects on urban environment.

2 Methods and Methodology

2.1 Study Area

Mysuru, a well-known and the second fastest growing city in Karnataka, southern India, is renowned for its extensive cultural legacy, historical significance, and thoughtfully designed urban infrastructure. Mysuru city (Mysuru city corporation ward boundary) occupies an area of 86.68 sq.km. and is located at an elevation of roughly 770 meters (2,530 feet) above sea level. The city is the administrative centre of the Mysuru district and is located at latitude 12.2958° N and longitude 76.6393° E. Mysuru is flanked to the east by the picturesque Chamundi hills and has a generally level terrain

with sporadic hills. The city is home to about 887,446 people, representing a wide range of ethnic groups and communities, according to the 2011 Census. The climate of Mysuru is tropical savanna, with distinct wet and dry seasons.

Mysuru has experienced substantial urbanization over the last 20 years, which has led to a discernible rise in built-up areas and the development of infrastructure to support the expanding population. Green spaces and open areas have been turned into residential and commercial complexes as a result of urban growth, especially along main roads and close to industrial hubs. Significant urban development is marked by increasing built-up area and decreasing green space between 2000 and 2020 which raises questions about how to maintain ecological balance and sustain urban growth (Figure 1).

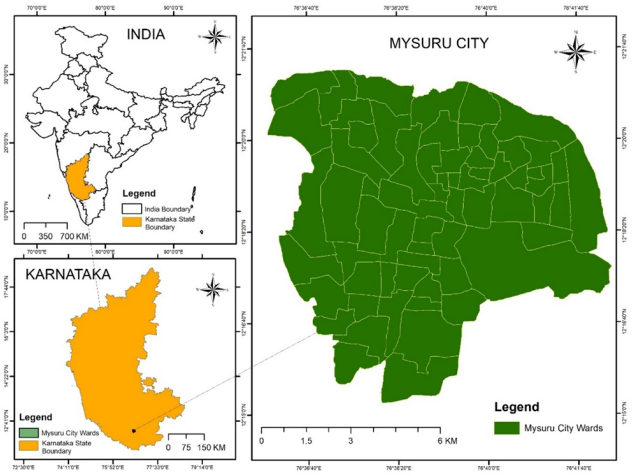

Fig. 1. Location Map of Mysuru City

Notwithstanding these developments, Mysuru is known for its parks and gardens, which offer vital leisure areas and improve urban biodiversity. Examples of these include the well-known kukkaralli lake, Karanji lake, and Chamundi hill. Urban green space evaluation is essential to sustainable urban planning and enhancing the quality of life for locals, especially when the city changes to meet environmental and demographic demands.

2.2 Methodology

The study used imagery from satellites to detect changes in LULC using a supervised classification method. The supervised classification is widely-used method for the urban LULC mapping[43]. The stages that follow describe the methodology:

2.2.1 Data Acquisition

- **Satellite Imagery:** In this study, we have used 30-m resolution Landsat satellite data set for estimation of LULC change and UGS mapping because Landsat provides a continuous sequence of data, covers most of the area of the earth and widely used by the researchers[44]. The USGS Earth Explorer portal is used to obtain Landsat satellite images of 2000 and 2020. To guarantee uniformity in data quality and coverage, Landsat-7 Enhanced Thematic Mapper Plus (ETM+) for the year 2000 and Landsat-8 Operational Land Imager (OLI) for the year 2020 are used as satellite datasets.
- **Ground Truthing:** To verify the classifications of the satellite imagery, primary data was gathered by field surveys. This will entail gathering representative samples and identifying different land use types in the field.

2.2.2 Data Preparation

Images Preprocessing: "To focus on specific bands relevant to LULC analysis, the satellite images underwent preprocessing procedures such as layer stacking and sub-setting." These procedures are designed to increase visual interpretation and spectral separability of earth surface characteristics, as well as provide improved inputs for automated image processing algorithms[45]. To improve the images' accuracy, geometric and radiometric adjustments are also made.

- **False Colour Composite (FCC):** To visually distinguish between different forms of land cover, a false colour composite is made.

2.2.3 Image Classification

- **Selection of Training Samples:** using the ground truthing data and existing information, representative training samples for LULC classes such as Built-up, Water bodies, Open Space & Green Space is found.
- **Maximum Likelihood Classification (MLC):** The satellite images are categorized into the designated LULC groups using the maximum likelihood technique. The training data for every class is assumed to be regularly distributed in this manner. The MLC is the most efficient parametric classifier based on Bayes' theorem of probability density functions (Otukei and Blaschke, 2010).

2.2.4 Confusion Matrix

The classified images are compared to ground truth data in order to evaluate accuracy. The categorization performance is assessed by calculating the accuracy of the producer and user by creating a confusion matrix.

2.2.5 Change Detection Analysis

- **Post-Classification Comparison:** To detect and measure changes in land cover, the classed LULC maps of 2000 and 2020 is compared. The following calculations are used to determine each category's degree of change:

$$C_i = L_i - B_i$$

$$P_i = \frac{L_i - B_i}{B_i} \times 100$$

where C_i is the change in class, P_i is the percentage change in the i-th class, L_i is the latest image (2020), and B_i is the base image (2000).

3 Results and Discussion

3.1 Overview of LULC classes and Changes (2000-2020)

Land Use and Land Cover (LULC) changes in Mysuru City from 2000 to 2020 highlight significant transformations driven by urbanization, population growth, and economic activity. The expansion of built-up areas has drastically reduced open and green spaces, reflecting the dynamic nature of urban growth. This shift has replaced natural landscapes with residential, commercial, and industrial zones, disrupting the city's ecological and environmental balance. These changes underscore the importance of sustainable urban planning to mitigate ecological impacts.

Water bodies in urban areas, including lakes, are landlocked water features that may be natural or artificially created. These serve multiple purposes such as recreation, water management, aesthetic enhancement, and providing wildlife habitats. Built-up areas, on the other hand, encompass land developed for residential, commercial, industrial, and infrastructural use. These areas are marked by significant human intervention, with structures, transportation networks, and pavements dominating the landscape.

Open spaces consist of areas with minimal or no greenery, such as open fields, playgrounds, and vacant lands, both private and public. Open space can be classified into two categories: green space and gray space. Green spaces, as described in [46], include areas with vegetation like trees, grass, and shrubs, occurring naturally or through planting. They encompass lush green parks, gardens, private and public green areas, and street-side trees. Urban green spaces are limited to soft lands but urban open spaces encompass all aspects of green spaces in addition to those hard land surfaces made purposely for human usage therefore urban green spaces can be said a subset of urban open spaces (Table 1) [47,48].

Table 1. Land Use and Land Cover (LULC) Changes in Mysuru City (2000–2020)

Sl. No	Classification	Area in 2000 (Sq. km)	Area in 2020 (Sq. km)	Percentage of Total (2000)	Percentage of Total (2020)	Percentage Change (%)
1	Built-up Area	36.85	61.61	42.51%	71.06%	+66.97%
2	Water Bodies	0.89	0.44	1.03%	0.51%	-50.56%
3	Open Space	26.44	7.71	30.50%	8.89%	-70.84%
4	Green Space	22.49	16.92	25.95%	19.54%	-24.74%
5	**Total**	**86.68**	**86.68**	**100%**	**100%**	-

3.1.1 Increase in Built-up Area and Urbanization

Over the past two decades, Mysuru City has witnessed a significant transformation, with built-up areas growing rapidly. In 2000, built-up regions accounted for 36.85 sq.km. (42.51%) of the city's total area. By 2020, this increased dramatically to 61.61 sq.km., making up 71.06% of the total area, marking a 66.97% rise. This growth reflects a clear shift toward residential development.

With increased in-migration and natural population growth, new residential neighbourhoods and commercial areas emerged, especially in peri-urban zones. Urban Transition Theory [49] posits that urbanization is an inevitable stage in socio-economic development, driven by population growth, industrialization, and the centralization of economic activities. It explains how increasing urbanization leads to transformations in land use, replacing agricultural or natural landscapes with built environments.

In Mysuru city, the most notable concentration of built-up areas since the year 2000 is in the central part of the city CBD (Central Business District), especially around K.R. circle, Mysuru Palace, and nearby localities like Agrahara, Lakshmipuram, Ashokapuram, Devraj Mohalla, and Mandi Mohalla. These areas show a high density of mixed-use buildings, both residential and commercial.

In contrast, the peripheral regions of the city, such as Hebbal, Vijayanagara, Sharadadevinagara, and parts of J.P. Nagar, showed lower density built-up areas which is primarily residential. These areas were less developed or had more open or green spaces in the past.

As built-up areas expanded, many of the green spaces and open spaces around the city were converted into grey spaces (developed areas) by 2020. Previously low-density built-up regions, such as Hebbal, Kumbarakoppalu, and Mahadeshwara Badavane in the northwest and Vontikoppal, Dattagalli in west and Shrirampura, J.P.Nagara in South-West, are now seeing significant urbanization.

Areas that were once open or green spaces have gradually transformed into high-density residential or commercial zones. Residential roads in some parts of the city, like Chamaraja double road, Apollo hospital road, and Vontikoppal main road, have been converted into commercial areas in 20 years further contributing to the growth of built-up regions.

Several residential areas in the north, east, and southeast of the city, such as, Kesare, Rajivnagara, Udaygiri and Vidyaranyapuram**,** have seen substantial growth in built-up areas. These areas, once either green or open spaces, are now rapidly urbanizing.

Mysuru's built-up areas have expanded significantly, with the central regions experiencing the most concentrated development, especially for mixed-use purposes (residential and commercial). On the other hand, the peripheral areas**,** once characterized by open spaces or low-density development, are also witnessing rapid urbanization. This growth has led to the transformation of previously green and open spaces into high-density built-up zones, with a noticeable shift towards residential and commercial development. The pace of change suggests that these trends will continue in the coming years, further reshaping the city's landscape.

The Figure 2 shows the Land Use Land Cover of Mysuru city 2000 to 2020. The growth of built-up regions is the most notable shift that Mysuru City has seen in the last 20 years, where 36.85 sq.km. or 42.51% of the city's total area, were made up of built-up areas in 2000. This number increased significantly by 2020, reaching 61.61 sq.km. or 71.06% of the total area, an increase of almost 66.97%.

The city's status as a regional economic center and the resulting demand for residential and commercial space are the reasons for this rapid growth. Bengaluru, the capital of Karnataka, is close to Mysuru, which has aided in population expansion and industrial development, raising the demand for infrastructure. In addition to speeding up infrastructure expansion projects, Mysuru's status as a "Smart City" attracted additional commercial investments. The loss of green and open spaces, which are essential for preserving urban biodiversity and ecological health, is a clear result of this fast urbanization.

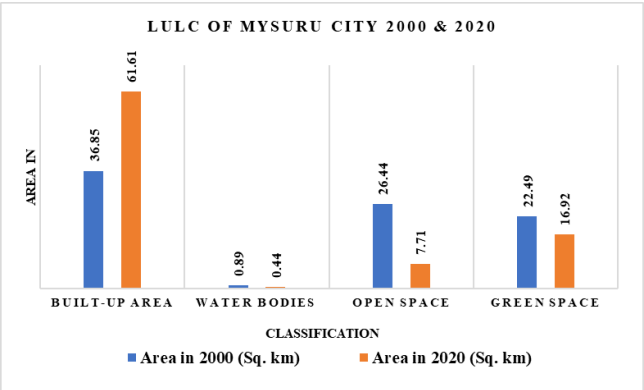

Fig. 2. LULC of Mysuru city 2000 & 2020

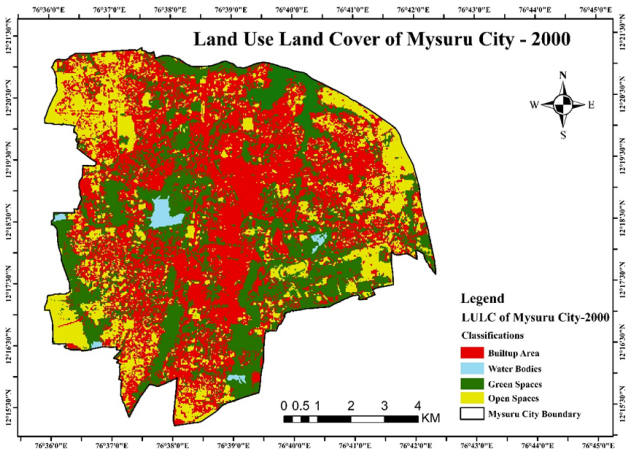

Fig. 3. Land Use Land Cover of Mysuru city 2000

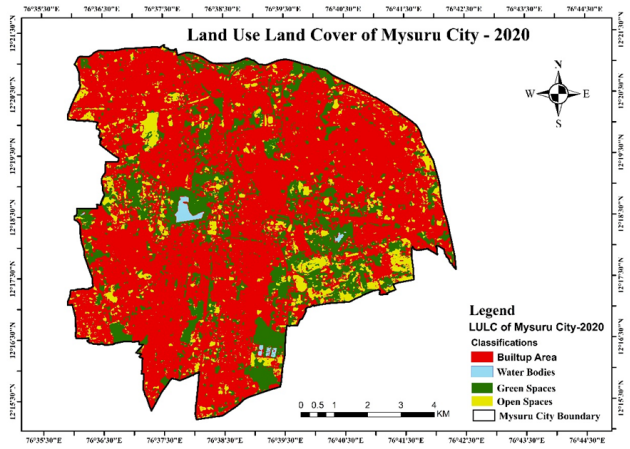

Fig. 4. Land Use Land Cover of Mysuru city 2020

3.1.2 Water Bodies: Shrinking Resources

Mysuru's water bodies have drastically declined, shrinking from 0.89 sq. km. (1.03% of the total area) in 2000 to 0.44 sq. km. (0.51%) in 2020, a 50.56% loss. Of the eight lakes, Kukkarahalli and Karanji are the most prominent. Kukkarahalli lake, located in the city's heart near landmarks like the University of Mysore and CFTRI, was created in the early 19th century as a percolation tank for drinking water. Similarly, Karanji lake, over 100 years old and adjacent to the Mysuru Zoo, served as a percolation tank before becoming part of the zoo in 1976. The now-defunct Doddekere tank, east of Mysuru Palace, was used a century ago but has been converted into an exhibition ground.

The lakes face severe challenges, including sewage discharge, garbage dumping, silt inflow, land encroachment, illegal construction, and runoff diversion. Cutting of foreshore trees has caused soil erosion, while pollution and eutrophica-

tion have reduced their size. Many areas around the lakes have turned into swamps, breeding insects and degrading their ecological value. Revitalizing these lakes is crucial to restoring their environmental and recreational significance.

3.1.3 Decline in Green Spaces and open space at the cost of urbanization

Green spaces in Mysuru have seen a significant reduction over the past two decades. In 2000, green spaces covered 22.49 sq.km. representing 25.95% of the city's total area, but by 2020, this dropped to 16.92 sq.km., or 19.52% of the total area.

A relevant theoretical framework addressing the relationship between urbanization and the loss of urban green space is Ecological Modernization Theory which suggests that environmental degradation, including the reduction of green spaces, often results from rapid urban growth and industrialization but can be mitigated through proactive policy, technological innovation, and sustainable urban planning.

These green spaces were distributed unevenly across the city, with the northwestern and western parts, particularly around Kukkarahalli lake, University of Mysore (UOM) campus, and the CFTRI campus, having ample green cover. Residential areas such as Gokulam, Yadavgiri, Jayalakshmipuram, Vontikoppal, Gangotri Layout, Saraswathipuram, and Kuvempunagara had good amounts of parks and avenue trees. Similarly, the southeastern parts of the city, including Vidyaranyapuram, Chamundipuram, Ittigegudu, and Gayatripuram, benefited from proximity to Karanji lake and the Mysuru Zoo, as well as the foot of Chamundi hill. The northern parts, like Kesare, Bannimantap HUDCO, and Metgalli, had large green patches, though they were mostly unplanned. These areas, along with the regions surrounding Kukkarahalli and Karanji lakes, acted as "Mini Lungs" for the city.

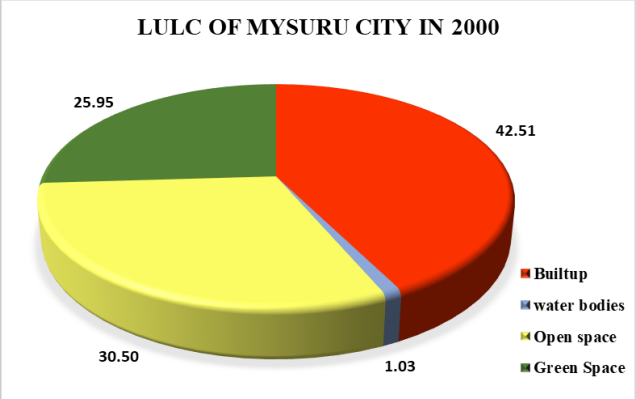

Fig. 5. LULC of Mysuru city 2000

However, over time, green spaces in Mysuru have drastically decreased, with satellite data revealing that only 19.5% of urban Mysuru remains covered by green spaces, which include parks, gardens, and green patches, both systematically and randomly grown. The distribution of green spaces is highly uneven, with the northern, western, and south-eastern parts retaining more green areas, while other regions have lost significant portions due to urban expansion. Notably, areas like Metgalli, Bannimantap, Kesare, and Rajivnagar in the north have seen thick green patches vanish for residential development.

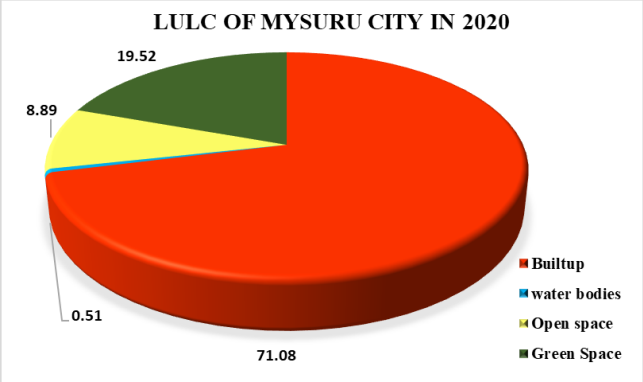

Fig. 6. LULC of Mysuru city 2020

Similarly, green spaces in the southwest around Sharadadevinagara and Dattagalli have been overtaken by built-up areas. In the southern parts of the city, green spaces in Srirampura, Jayanagara, Arvindanagara, and Kuvempunagara have been reduced due to residential development and road construction, which has also led to widespread tree felling.

The south-eastern part, despite seeing some loss due to the expansion of built-up areas, still retains more green spaces compared to other parts, largely due to its proximity to Karanji lake and Chamundi hill. However, even areas like Yerganahalli in the eastern limit and neighbourhoods such as Udayagiri, Sathyanagara, Gousiyanagara, and Shanthinagara in the north-east have been entirely deprived of significant green spaces due to high-density urbanization. The overall trend clearly shows a sharp decline in green spaces across the city as urban growth, particularly residential development, continues to consume the available green cover.

The open spaces in Mysuru have significantly decreased over the past two decades, dropping from 26.44 sq.km. (30.50% of the total area shown in Figure 5) in 2000 to just 7.71 sq.km. (8.89% of the total area shown in Figure 6) in 2020. These open spaces, which are scattered across the city, are mostly found away from the center of the city and in the north-western, south-western, and southern parts, areas that are largely unbuilt and hold potential for future development.

While open spaces like vacant residential plots, playgrounds, sports grounds, and public properties are still present, many of these spaces are gradually being converted into built-up areas as the city expands. In the northwest, areas like Vijayanagara 1st and 2nd stage contain open spaces,

mainly vacant plots, and sports grounds, while in the west, the Mysuru University campus, Kukkarahalli lake parks, and the Oval grounds represent significant open spaces.

The south-western and southern parts of the city, while still having some parks and playgrounds (un-maintained with peripheral vegetation) are dominated by residential areas, with vacant plots adding to the open space but often remaining barren. The southern part, particularly areas like Srirampura, Jayanagara, and J.P. nagara, has limited open spaces, insufficient compared to the surrounding built-up areas.

In the south-eastern part, Vidyaranyapuram and Chamundipuram still retain some open spaces, but their distribution is uneven and often unplanned.

The eastern part of the city, particularly Ittigegudu and Gayatripuram has vast open and green spaces, close to Chamundi hill and Karanji lake making it a "mini lung space" of the city.

In contrast, the north-eastern part of the city, including areas like Yaraganahalli, Sathgalli, and Rajivnagar, suffers from high-density built-up areas with very little open space. Other areas like Gousiyanagara, Udaygiri, Kalyangiri, and Shantinagara also face a shortage of open spaces, which is concerning as it affects public health and well-being.

The northern parts, such as Kesare and Bannimantap, have some open spaces, but they are still inadequate compared to the expanding built-up areas, with Metgalli and Hebbal showing a shift towards residential and industrial development, further reducing open spaces.

The core/central parts of the city, including areas like K.R. circle, City bus stand, and Devaraja Mohalla, has negligible open spaces. This high-density area, primarily commercial and residential, is facing an acute shortage of open spaces, highlighting a pressing issue of rapid urbanization in Mysuru.

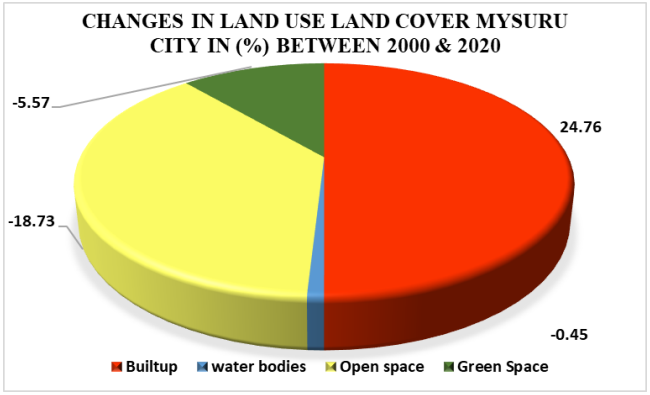

Fig. 7. Changes in Land Use Land Cover of Mysuru City between 2000 & 2020 in (%)

Between 2000 and 2020, the amount of green space, a crucial component of the urban environment decreased dramatically from 22.49 sq.km. to 16.92 sq.km. The area of vegetative spaces has decreased by 24.74%.

Compact Cities: Sustainable Urban Forms for Developing Countries model advocates for high-density, mixed-use urban development to limit urban sprawl and protect green spaces within city limits.[50] Concerns regarding the city's environmental sustainability have been raised by the ongoing conversion of green spaces into residential or commercial sectors. Because they enhance air quality, control temperature, promote biodiversity, and give locals access to recreational opportunities. Green spaces are vital to metropolitan environments but their disappearance restricts the amount of area available for leisure and physical activity in addition to having an effect on the ecological balance plans for development.If left unchecked, this trend may have a negative impact on Mysuru's general livability and public health.

3.2 Confusion Matrix: Accuracy Assessment Report for LULC of the Year 2000 and 2020

The accuracy assessment for the 2000 and 2020 Land Use Land Cover (LULC) maps was conducted using the ArcGIS Accuracy Assessment Tool, comparing classified maps with ground truth data. Metrics including overall accuracy (OA), producer's accuracy (PA), user's accuracy (UA), and the kappa coefficient (κ) were calculated. The 2000 map achieved an OA of 86% and a κ of 0.806, with PA ranging from 82.4% to 100% and UA from 81.3% to 91.7%. The 2020 map showed improved performance, with an OA of 88%, κ of 0.834, PA ranging from 83.3% to 93.3%, and UA from 83.3% to 93.8%, indicating enhanced classification accuracy and consistency.

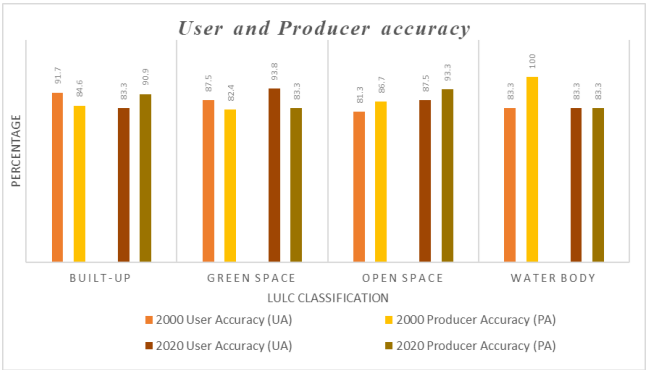

Fig. 8. User and Producer Accuracy of LULC classification for 2000 and 2020

The accuracy assessment process in ArcGIS software involved generating stratified random accuracy points using the *Create Accuracy Assessment Points tool*. These points were exported to Google Earth for reference class assignment based on high-resolution imagery, then re-imported into ArcGIS. The *Confusion Matrix tool* was used to calculate

the metrics, providing a comprehensive evaluation of classification performance and guiding map refinement.

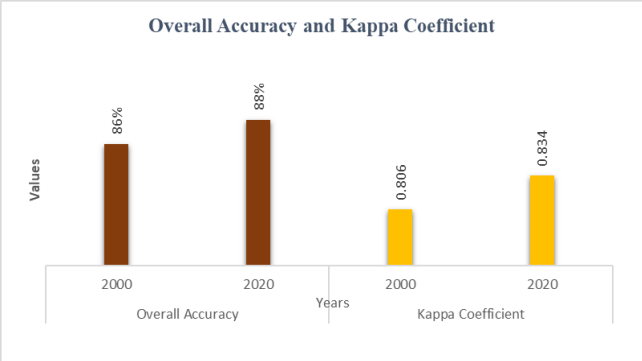

Fig. 9. Overall Accuracy and Kappa Coefficient of LULC classification for 2000 & 2020

3.3 Discussion of Ecological and Social Implications

Significant ecological and societal ramifications are suggested by the observed alterations in Mysuru city's LULC patterns. Urbanization presents problems for ecological balance, public health, and social well-being even while it is good for economic growth.

The lack of urban green spaces leads to increased urban surface temperatures, biodiversity loss, and diminished ecosystem services. Socially, it exacerbates health issues, reduces community cohesion, and limits recreational opportunities, negatively impacting the overall quality of life for urban dwellers[51,52].

Increased grey surfaces and poor water absorption heighten the risk of urban flooding, as seen in recent years when unprecedented rainfall temporarily inundated low-lying areas, particularly the CBD region and low-lying neighbourhoods households. The city's development pattern has led to a reduction in overall green coverage. This decrease in vegetation exacerbates the Urban Heat Island (UHI) effect by limiting shade and evapotranspiration, natural processes that help cool the environment[53]. Residents' access to recreational areas is restricted due to the loss of green and open spaces in the areas of high population density and low-income communities live. It has affected on their mental and physical health lowering the quality of life and potentially widening inequalities, especially for underserved neighborhoods. Economically, it can drive up healthcare costs and reduce property values, while culturally, Mysuru's heritage appeal and community identity may erode.

Green Infrastructure Theory , which draws from ecological principles highlights the role of interconnected green spaces in managing stormwater, reducing urban heat, and improving biodiversity. The sustainable management, conservation and restoration of green and open spaces must be given top priority in future planning initiatives by incorporating green infrastructure, could offer practical methods for boosting sustainable development and urban resilience in Mysuru.

4 Recommendations for Sustainable Urban Planning for greening the city

Biophilic Urbanism, introduced by[54] emphasizes the integration of nature into urban environments to promote sustainability, improve well-being, and enhance ecological resilience. Beatley's work advocates for cities designed with abundant green spaces, urban forests, and natural elements that contribute to environmental health and social benefits.

The estimated population of Mysuru city is around 1.4 million and it is advised that city planners in Mysuru use sustainable urban design techniques that give ecological preservation first priority in light of the LULC findings. Strict zoning laws must be put in place to safeguard the remaining green and open areas and lakes.

The environmental effects of urbanization may be mitigated by putting regulations into place that support green infrastructure and the incorporation of vegetated areas into urban development projects.[55] *Green Infrastructure: Linking Landscapes and Communities* stress the multifunctionality of green spaces in creating sustainable and livable urban environments.

The commercial streets like Irwin road, Sayyaji Rao road, Devraj URS road, K.T street, Shivarampete road etc., absolutely lacks in avenue trees. At the same time density of population in these areas specially in the heart of the city in and around CBD is high where greens are essential.

Trees two or three in number anywhere in a city are not adequate as it cannot perform the function of a large green space in an urban environment. Even the open spaces like a vacant land or a ground is not equal to a lush green space as the soil reflects more heat causing thermal discomfort but green spaces lower the ambient temperature and keeps it naturally cool.

Alternative greening strategies for Mysuru city should focus on innovative and sustainable solutions to enhance urban greenery. Vertical gardens and green walls can optimize limited space, while rooftop gardens provide insulation and increase greenery in densely built areas. Miyawaki forests, which involve planting dense, fast-growing native trees, can transform small urban patches into thriving ecosystems. Urban agriculture initiatives, like community gardens, promote green spaces while supporting food security. Permeable pavements and bioswales can integrate greenery into infrastructure while aiding water management. Additionally, abandoned or underutilized spaces such as former industrial sites, railway tracks, and parking lots can be transformed into green spaces and creating pocket parks can enhance accessi-

bility to green spaces for residents across the city.

These methods, coupled with public participation and policy support, can help Mysuru to maintain its ecological balance and improve urban living. Furthermore, encouraging community involvement and raising awareness of the value of green spaces can encourage local stewardship and support for conservation efforts. To prevent urban sprawl and protect the natural environment, policymakers should also think about creating urban green belts or buffers surrounding the metropolis.

5 Conclusion

The study reveals that Mysuru city has undergone significant urbanization over the past two decades, with built-up areas increasing from 42.51% of the city's total area in 2000 to 71.06% in 2020 a remarkable 66.97% growth. This rapid development, fueled by population expansion, economic activity, and the city's proximity to Bengaluru, has led to a substantial reduction in green and open spaces. Green spaces declined from 25.95% in 2000 to 19.52% in 2020, while open spaces experienced an even sharper reduction, dropping from 30.50% to 8.89% over the same period.

High-density built-up areas are predominantly concentrated within 3 sq. km. of the city's core and northeastern part, where there is a severe lack of green and open spaces. The northwestern and southern parts are also becoming densely built-up, with scattered green spaces that are insufficient to meet the demands of population growth and to mitigate urban heat island effects.

In contrast, the western and eastern parts of Mysuru retain significant green and open spaces, particularly near areas like Chamundi hill and Karanji lake, which act as a "mini lung space" for the city. However, this uneven distribution of green spaces exacerbates ecological imbalances, leaving densely populated and congested areas, such as the Central Business District (CBD), critically deficient in green infrastructure.

While it is challenging to create large green spaces in the CBD and other compact settlements, interventions like linear parks, pocket parks, green roofs, and green walls can provide localized cooling and improve ecological health, making sustainable urban greening a viable possibility even in high-density zones.

6 Limitation of the study

This study on the changes in Land Use and Land Cover (LULC) in Mysuru City offers valuable insights, though there are a few areas for further refinement. While satellite data may sometimes present limitations in terms of precision, particularly for historical imagery, the study utilizes the best available resources to minimize any potential errors in classification. The classification of water body is significantly influenced by seasonal fluctuations in rainfall and varying summer temperatures. These variations were cross-verified using Google Earth, based on the imagery date. The research acknowledges that smaller features, such as narrow roads, small open spaces, or individual trees, may be challenging to capture; however, the methodology used aims to address these by refining classification techniques. Additionally, while this study provides a broad overview of LULC trends, integrating socio-economic factors, policy impacts, and human-environment interactions by future researches would offer a deeper understanding of the driving forces behind these shifts.

Acknowledgment

We would like to express our sincere gratitude to everyone who contributed to the successful completion of this research paper. We are also thankful to the University of Mysore for providing access to essential resources and data. Our appreciation goes to the officials at Mysuru City Corporation (MCC) and Mysuru Urban Development Authority (MUDA) for their support and for sharing valuable information that enhanced the depth of this study.

We would also like to acknowledge the contributions of our peers and colleagues, whose valuable suggestions and constructive criticism helped in improving the quality of our research.

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