Published by the University of KwaZulu-Natal
https://journals.ukzn.ac.za/index.php/JICBE

Journal of Inclusive cities and Built environment. Vol. 4 Issue 7

How to cite: S. Medayese, E. Mutsaa, H.H. Magidimisha and L.Chipungu., 2024. Spatial Consumption Patterns in South African Coastal Cities: A Comparative Land Use and Land Cover Analysis of Cape Town and Durban. *Journal of Inclusive cities and Built environment.* Vol. 4 Issue 7, Pg 15-28.

SPATIAL CONSUMPTION PATTERNS IN SOUTH AFRICAN COASTAL CITIES: A COMPARATIVE LAND USE AND LAND COVER ANALYSIS OF CAPE TOWN AND DURBAN

By S. Medayese, E. Mutsaa, H.H. Magidimisha and L. Chipungu

Published 8 November 2024

ABSTRACT

Urban landscapes constantly evolve, reflecting the complex interplay between anthropogenic activities and the natural environment. Land use and land cover (LULC) changes are critical indicators of urban dynamics, environmental sustainability, and socio-economic development. Understanding these indicators and dynamics is essential for fostering sustainable urban development in rapidly growing cities. This study conducts a comparative analysis of LULC changes in two major coastal cities of South Africa: Cape Town and Durban. These cities, characterized by distinct geographical, climatic, and socio-economic contexts, have undergone significant transformations since the end of apartheid in 1994. By employing advanced remote sensing techniques and geographic information systems (GIS), this research analyzes satellite imagery over a 30-year period to track changes in urban built-up areas, vegetation, water bodies, and bare land. The study reveals notable differences in urban expansion patterns, driven by factors such as population growth, economic development, and policy changes. Cape Town with its unique biodiversity and conservation efforts, faces challenges in balancing urban growth and environmental protection. Durban on the other hand, deals with rapid informal settlement growth and integration of peri-urban areas. Additionally, both cities are impacted by climate change, influencing land use decisions and urban planning strategies. The findings underscore the legacy of apartheid spatial planning, which continues to shape urban form and land use patterns, resulting in persistent spatial disparities. The comparative analysis highlights the effectiveness of post-apartheid spatial transformation policies and offers insights into urban sustainability strategies. The study provides a comprehensive understanding of the drivers of LULC changes in these coastal cities, by integrating socio-economic data and policy analysis. The results aim to inform urban planners, policymakers, and researchers, contributing to the broader discourse on sustainable urban development in rapidly urbanizing regions.

KEY WORDS Land Use Land Cover Change, Urban Dynamics, Remote Sensing, Sustainable urban development, Post-apartheid spatial planning

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1. INTRODUCTION

Land use and land cover (LULC) changes are critical indicators of environmental dynamics and socio-economic transformations in urban areas. Over the past few decades, rapid urbanization, population growth, and economic development have significantly influenced LULC patterns, particularly in major cities. Understanding these changes is essential for urban planning, resource management, and environmental conservation. In South Africa, a country characterized by rapid urbanization and complex historical legacies, understanding these changes is paramount for effective urban planning and management. This research focuses on a comparative analysis of LULC changes between two of South Africa's major coastal cities: Cape Town and Durban.

Cape Town and Durban are among South Africa's largest and most economically significant cities, each with unique geographical, environmental, and socio-economic contexts. Cape Town, located in the Western Cape Province, is renowned for its scenic landscapes, biodiversity, and cultural heritage. Conversely, Durban, situated in the KwaZulu-Natal Province, is a major port city with a subtropical climate and diverse ecosystems. Both cities have experienced substantial growth and transformation since the end of apartheid in 1994, making them ideal case studies for examining urban LULC dynamics in post-apartheid South Africa (Turok, 2014).

The process of urbanization in these cities has been influenced by a range of factors, including population growth, economic development, and policy changes. Cape Town, known for its unique biodiversity and natural beauty, faces challenges in balancing urban expansion with conservation efforts. The city's urban edge policy, aimed at containing sprawl and protecting natural areas, has had significant implications for land use patterns (Sinclair-Smith, 2014). Durban, on the other hand, has grappled with rapid informal settlement growth and the integration of its expansive peri-urban areas into the urban fabric (Sutherland et al., 2016).

The historical context of apartheid spatial planning continues to shape urban form and land use patterns in both cities. Racial segregation and unequal development have resulted in persistent spatial disparities, which current urban policies aim to address. Analyzing LULC changes in this context provides insights into the effectiveness of post-apartheid spatial transformation efforts (Turok, 2016). Climate change adds another layer of complexity to LULC dynamics in these coastal cities. Both Cape Town and Durban are vulnerable to sea-level rise, changing precipitation patterns, and extreme weather events. These environmental pressures influence land use decisions and urban development strategies, necessitating adaptive approaches to urban planning (Roberts et al., 2016).

Recent studies have employed advanced remote sensing techniques and geographic information systems (GIS) to quantify and map LULC changes in urban areas. For instance, Musakwa and Van Niekerk (2013) used multi-temporal satellite imagery to assess urban growth patterns in Cape Town, highlighting the city's expansion into previously agricultural and natural areas. Similarly, Pillay and Scott (2018) analyzed LULC changes in Durban's peri-urban areas, revealing complex patterns of formal and informal urban expansion. Comparative analyses of LULC changes between cities offer valuable insights into the diverse trajectories of urban development within a national context. Such comparisons can reveal how different local factors, policies, and historical contexts shape urban growth patterns. For example, a study by Govender et al. (2020) compared vegetation cover changes in several South African cities, including Cape Town and Durban, demonstrating varying trends in urban greening and loss of natural vegetation.

This research aims to build on these previous studies by conducting a comprehensive comparative analysis of LULC changes in Cape Town and Durban over the past three decades. The study seeks to uncover the underlying drivers of change and their implications for sustainable urban development, by examining similarities and differences in LULC trends between these cities. The analysis employed a multi-temporal approach, utilizing satellite imagery from different periods to track changes in various land use categories, including urban built-up areas, vegetation, water bodies, and bare land. Advanced image classification techniques such as object-based image analysis (OBIA) and machine learning algorithms, were used to ensure accurate LULC mapping (Phiri & Morgenroth, 2017). Furthermore, the research integrates socio-economic data and policy analysis to contextualize the observed LULC changes. This interdisciplinary approach allows for a nuanced understanding of how factors such as population dynamics, economic shifts, and urban policies have influenced land use patterns in each city.

In comparing LULC changes between Cape Town and Durban, this study aims to contribute to the broader discourse on urban sustainability in South Africa and other rapidly urbanizing regions. The findings provide valuable insights for urban planners, policymakers, and researchers, informing strategies for balanced urban growth, environmental conservation, and spatial transformation in diverse urban contexts.

2. THEORIZING LULC TRANSFORMATIONS

Recognizing the complex interplay between social, economic, and environmental factors in shaping urban landscapes, this research is grounded in urban ecology and political ecology. Urban ecology emphasizes the city as a socio-ecological system, where human activities and natural processes are inextricably linked (Pickett et al., 2016). This perspective is particularly relevant in the context of Cape Town and Durban, where rapid urbanization intersects with unique biodiversity and environmental challenges. Political ecology provides a lens through which to examine the power dynamics and historical legacies that influence LULC changes. The apartheid legacy in south Africa has profoundly shaped urban spatial structures, and the post-apartheid policies continue to grapple with these historical inequalities (Parnell & Robinson, 2012). This framework allows for a critical analysis of how political decisions, economic interests, and social dynamics drive land use changes in Cape Town and Durban.

The concept of urban resilience also informs this research, particularly in the context of coastal cities facing climate change impacts. Urban resilience emphasizes the adaptive capacity of urban systems to respond to environmental and socio-economic pressures (Meerow et al., 2016). For Cape Town and Durban, this involves examining how LULC changes reflect adaptation strategies to challenges such as water scarcity, sea-level rise, and extreme weather events. Urban growth theories, including the urban sprawl model and compact city concept, provide additional theoretical underpinning. These theories help explain patterns of urban expansion and intensification observed in both cities. The urban sprawl model, characterized by low-density outward expansion, contrasts with the compact city concept promoted in post-apartheid urban policies (Horn, 2019). Analyzing LULC changes through these lenses reveals the effectiveness of spatial planning policies in shaping urban form.

The study also draws on the concept of urban ecosystem services, which highlights the benefits that natural and semi-natural areas provide within urban environments (Haase et al., 2014). This framework is particularly relevant for understanding the implications of vegetation loss or gain in Cape Town and Durban, both of which are situated in biodiversity hotspots. Theories of urban political economy further inform the analysis by emphasizing the role of economic forces in shaping urban landscapes. In the South African context, this involves examining how global economic integration, local economic development strategies, and informal economic activities influence LULC patterns (Turok, 2014). Lastly, the comparative urbanism approach provides a theoretical basis for analyzing similarities and differences between Cape Town and Durban. This perspective encourages a nuanced understanding of urban processes that goes beyond simplistic generalizations, recognizing the unique historical, geographical, and socio-economic contexts of each city (Robinson, 2016).

By integrating these theoretical perspectives, this study provides a comprehensive framework for understanding LULC changes in Cape Town and Durban. This multifaceted approach allows for a rich analysis that considers the complex interplay of social, economic, political, and environmental factors shaping urban landscapes in post-apartheid South Africa.

3. METHODOLOGY

The goal of this research is to conduct a comparative land use/land cover change analysis of the Cities of Cape Town and Durban. This was to aid in the evolution of the cities maps over a 30-year time frame (1994-2024). This period was selected based on the fact that it encompassed both the pre-millennium and millennium periods. The "Terra Incognita" application, a program for downloading web source maps or local file maps for various programs or Global Positioning System (GPS) devices, was used to acquire the high-resolution satellite photos ("quick bird") required with a 15-metre resolution (Castro et al., 2019). For this study, the platform was changed to backdate the imageries for Ten-year intervals; from the 1994 to 2004; 2004 to 2014, 2014 to 2024. A total of eight imageries were acquired from this platform". Spatio-temporal analysis was performed on these images, and conclusions were made from the results. A multi-temporal analysis of the imageries of the cities of Cape Town and Durban between 1994 and 2024 using a 10-year interval, was conducted, using global thematic mapper.

3.1. Selection of the Study Period

Remote sensing (RS), spatio-temporal analysis of spatial metrics, and statistical models all play a role in detecting land use changes over time, quantifying and tracking urban growth patterns, analyzing trends, and predicting future changes based on available data in the selection process. FRAGSTATS 4.2 takes the built-up area from the classified images as input data (McGarigal et al., 2012).

3.2. Selection of the Study Area

The rapid urbanization in South African cities, driven by rural-to-urban migration, has led to significant land use and urban growth challenges, particularly in major cities like Cape Town and Durban. These cities have experienced unplanned expansion, making them ideal case studies for analyzing urban dynamics, the impacts of migration, and land use changes over the past three decades. Therefore, the selection of these cities allows for a comprehensive examination of how national and international events have influenced urbanization patterns.

3.3. Identification of study zones using gradient model

An effective way to show the differences between urban and rural areas is to use a gradient model. This research looked at how cities in South Africa have grown both geographically and chronologically. In order to accomplish this, remote sensing and GIS data were combined to perform buffer gradient analysis.

3.4. Mapping and Monitoring of Land Cover Change

The land cover change information can be achieved from the RS data by applying a range of visual interpretations, land cover classification, and change detection. Generally, the applied methodology is illustrated in Figure 1.

Figure 1: A classification scheme for land cover mapping. Source: Yuan et al. (2005)

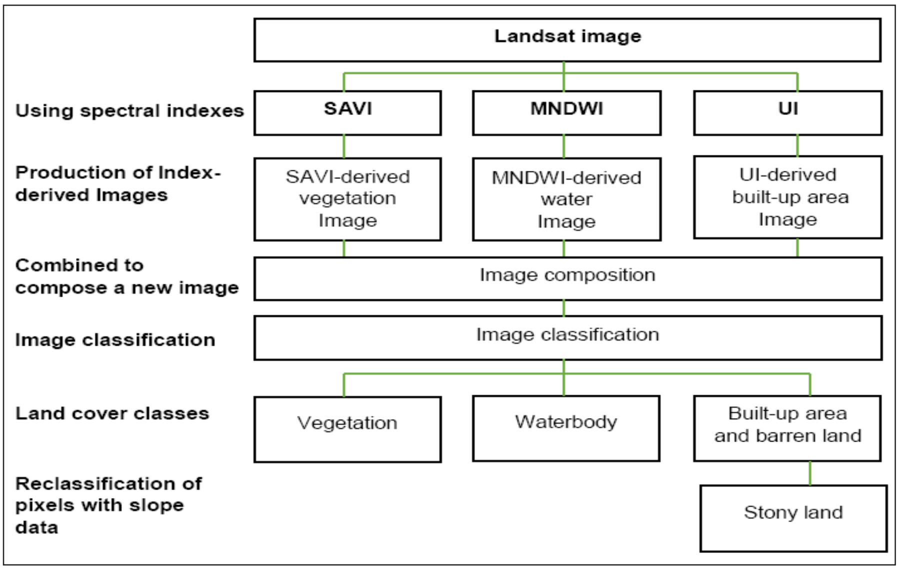


Image classification

In the urban or built-up land category, human activities have impacted the landscape in a significant way. As the name suggests, “vegetation” encompasses all land and structures that are primarily used to grow food. The term “water body” refers to any area that is occasionally submerged under water. Developed in the United States, Anderson’s classification system has since become a global standard. Rock faces, rockslides, and cliffs are all included in the new Land class we’ve created in this research. Table 1 shows the exposed types, many of which have thick moss and lichen coverings.

Table 1: Land Cover Classification System

Land cover categories	Sub-categories
Urban or built-up Land	Complexes of industrial and commercial buildings, as well as residences, businesses, and services, Other urban or built-up land, as well as land that is mixed with the former
Vegetation	Pasture and farmland, Orchards, groves, vineyards, nurseries, and ornamental horticultural areas are all included in this category. Confinement of the feeding process, Other farmland is available. land covered in deciduous trees Forests with a mix of evergreens and deciduous trees
Water body	
Barren Land	Streams and canals, Lakes, Reservoirs, Bays, and estuaries are included. Beaches and other sandy areas that aren’t beaches Rockslides, cliffs, and mountain peaks with rock faces

Source: Author’s Analysis based on Anderson in (Yuan et al., 2005).

Different land cover classes can be contained within a single Landsat pixel due to the medium spatial resolution of the imagery. Spectral characteristics can be difficult to distinguish between different types of land cover (Ji and Jensen, 1999). Land cover maps derived from satellite imagery are widely acknowledged to be woefully inadequate for actual-world use. When multiple materials are combined in a single pixel, spectral indexes can be used to determine the land cover. Land that has been developed, devoid of vegetation, and open water are all examples of urban covers. Low-vegetation areas with exposed soil surfaces can have their vegetation index values influenced by light reflectance in the red and near-infrared spectra (Huete, 1988). High NIR reflectance (TM band 4) and red light pigment absorption (TM band 3) allow SAVI to take advantage of these characteristics (Jensen, 2005). SAVI was used instead of NDVI in this study because of its superiority over NDVI in areas with low vegetation cover, such as urban areas. NDVI is well-known to remote sensing experts. NDVI can only be used on plants cover levels greater than 30% in order to be effective, whereas SAVI can work with as little as 15% plant cover (Herold et al.,2015).

The Soil-Adjusted Vegetation Index (SAVI) is expressed as follows:

$$SAVI = \frac{(TM_4 - TM_3) \times 1 + I}{TM_4 + TM_3 + I} \quad (1)$$

Where:

TM4: Reflectance value of band 4 (near-infrared) of TM sensor.

TM3: Reflectance value of band 3 (red) of TM sensor.

I: is a correction factor ranging from 0 for very high densities to 1 for very low densities.

The study area has an intermediate density of vegetation, so a value of 0.5 was used to produce a better image of the vegetation. Vegetation can be distinguished from built-up or barren land if the SAVI range expands. Using SAVI, the vegetation image was created, and then the built-up land image was created by using the Urban Index (UI) and the equation below:

$$UI = \frac{TM_7 - TM_4}{TM_7 + TM_4} \quad (2)$$

Where:

TM4: Reflectance value of band 4 (near-infrared) of TM sensor.

TM7: Reflectance value of band 7 of TM sensor.

For the purpose of distinguishing between developed and undeveloped land, UI values derived from multi-temporal images were used. As opposed to using the Normalized Difference Built-up Index (NDBI), this was used because UI's urban features are more distinct. Instead of using band 5, try band 7 for the best results (Bouhennache et al., 2015; Pratibha et al., 2014). Vegetation can be distinguished from built-up or barren land by increasing the SAVI range.

Multi-temporal images were used to derive the Modified Normalized Difference Water Index (MNDWI), which was able to distinguish water from a land-dominated background. According to Xu (2005), the MNDWI outperformed the Normalized Difference Water Index in comparison. According to McFeeters (1996) the modified NDWI is expressed as follows:

$$MNDWI = \frac{Green - MIR}{Green + MIR} \quad (3)$$

It is possible to see a greater contrast between water and built-up land using middle infrared bands, such as band 5, than with NDWI because water features have higher positive values and built-up land has lower negative values (Hu, 2007). The three new SAVI images, the MNDWI images, and the UI images were used as bands to create an entirely new image dataset. Reduced inter-band correlation is achieved by transforming a seven-band multispectral image into a three-band image with a single central theme. The three new bands were combined to create the new image. The supervised classification method was used to extract land cover features from the new images, which contained three thematic bands. The supervised classification was performed using an algorithm based on the signatures of training regions.

SAVI and MNDWI have been identified as the four primary urban land cover classes, as have the built-up area (UI) and barren land (which are well-separated). Stone and barren land are separated by large verticals in the study. Those areas with a slope of more than 15 degrees were predicted to have stony land in them. Slop data was used to identify the “stony” land. The error matrix is the most commonly used method for verifying the accuracy of remote sensing land cover maps. The data was then compared to a reference image class-by-class.

4. ANALYSIS

This research attempts a comparative analysis of land use/land cover (LULC) between two cities in South Africa which are the City of Cape Town and the City of Durban. These coastal cities hold significant historical importance in both Apartheid and Post-Apartheid South Africa. These Cities are examined in this research based on four significant attributes which are the Vegetation, Bare grounds, Water bodies and Built-up areas. The analysis period considered is a 30-year-period with a 10-year interval from 1994 to 2024. The general outlook of the analysis shows that there were significant changes in the LULC compositions of these cities within these period.

5. COMPARATIVE SPATIAL ANALYSIS OF CAPE TOWN AND DURBAN CITIES IN 1994

The LULC analysis of the City of Durban shows that the City had a spatial extent of 720.56Ha and the City of Cape Town had a spatial extent of 1559.82Ha. Both cities have four significant spatial attributes which are; Built-up areas, vegetation, bare ground and water bodies. The breakdown of the spatial attributes of the City of Durban shows that Built-up area covered 202.7ha (28.13%), Water Body 140.52ha (19.50ha), Vegetation 233.7ha (32.43%) and Bare ground 140.52ha (19.50%). On the contrary however, the city of Cape Town in 1994 had Built-up area 1014.5ha (65.04%), no water body was noticeable at the time of image acquisition resulting in the total absence of water body, Vegetation 146ha (9.36%) and Bare ground makes up 399.2ha (25.59%).

Figure 2 shows the land use distribution of the two cities and Table 2 shows a breakdown of the land use analysis of the two cities.

Figure 2: Land Use Outlook of Durban and Cape Town in 1994. Source: SARChI Chair for Inclusive-Cities Modification of Landsatt Imageries, 2024

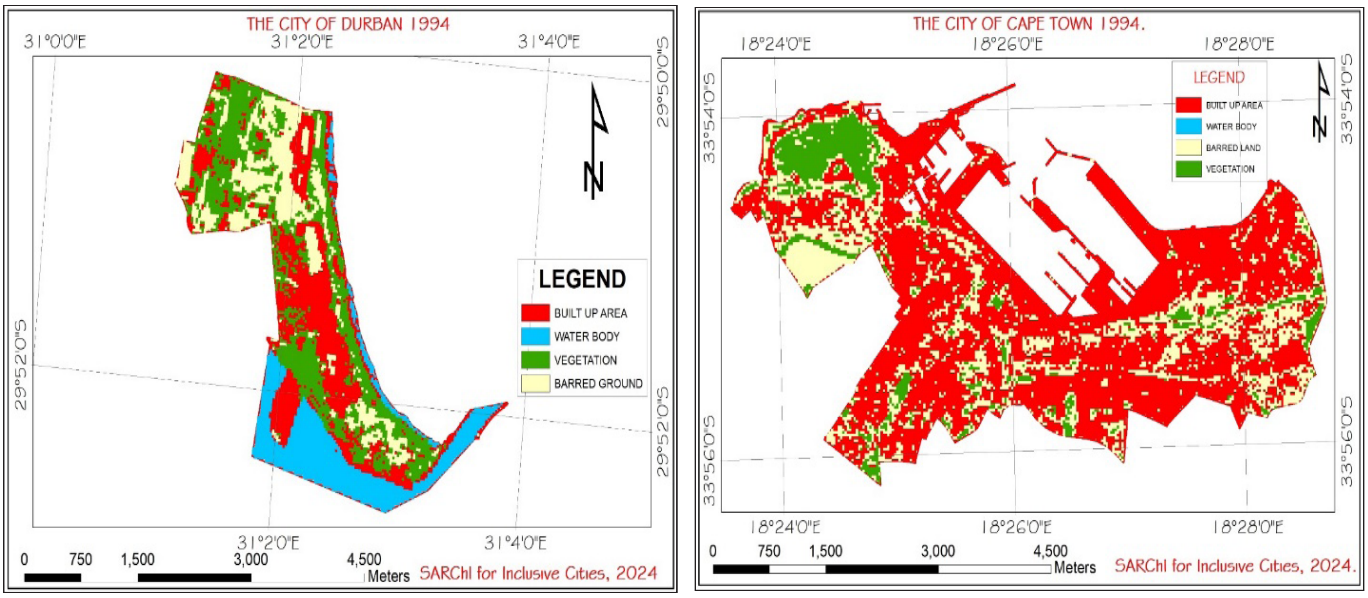


Table 2: Comparative Land Use analysis of the cities in 1994

Attribute	City of Durban	Percentage Coverage	City of Cape Town	Percentage Coverage
Built Up Area	202.7	28.13	1014.5	65.04
Water Body	140.52	19.50	----------	0.00
Vegetation	233.7	32.43	146	9.36
Bare ground	140.52	19.50	399.2	25.59
Total	**720.56 Ha**	**100.0**	**1559.82 Ha**	**100.0**

6. COMPARATIVE SPATIAL ANALYSIS OF CAPE TOWN AND DURBAN CITIES IN 2004

The breakdown of the spatial attributes of the City of Durban shows that Built-up area covered 331.7ha (46.03%), Water Body 103.8ha (14.41%), Vegetation 139.5ha (19.36%) and Bare ground 145.6ha (20.21%). On the contrary however, the city of Cape Town in 1994 had Built-up area 1353.3ha (86.76%), no water body was noticeable at the time of image acquisition, Vegetation 144.4ha (9.26%) and Bare ground makes up 62.42ha (4.00%). Figure 3 shows the land use distribution of the two cities and Table 3 shows a breakdown of the land use analysis of the two cities.

Figure 3: Land Use Outlook of Durban and Cape Town in 2004. Source: SARChI Chair for Inclusive-Cities Modification of Landsatt Imageries, 2024

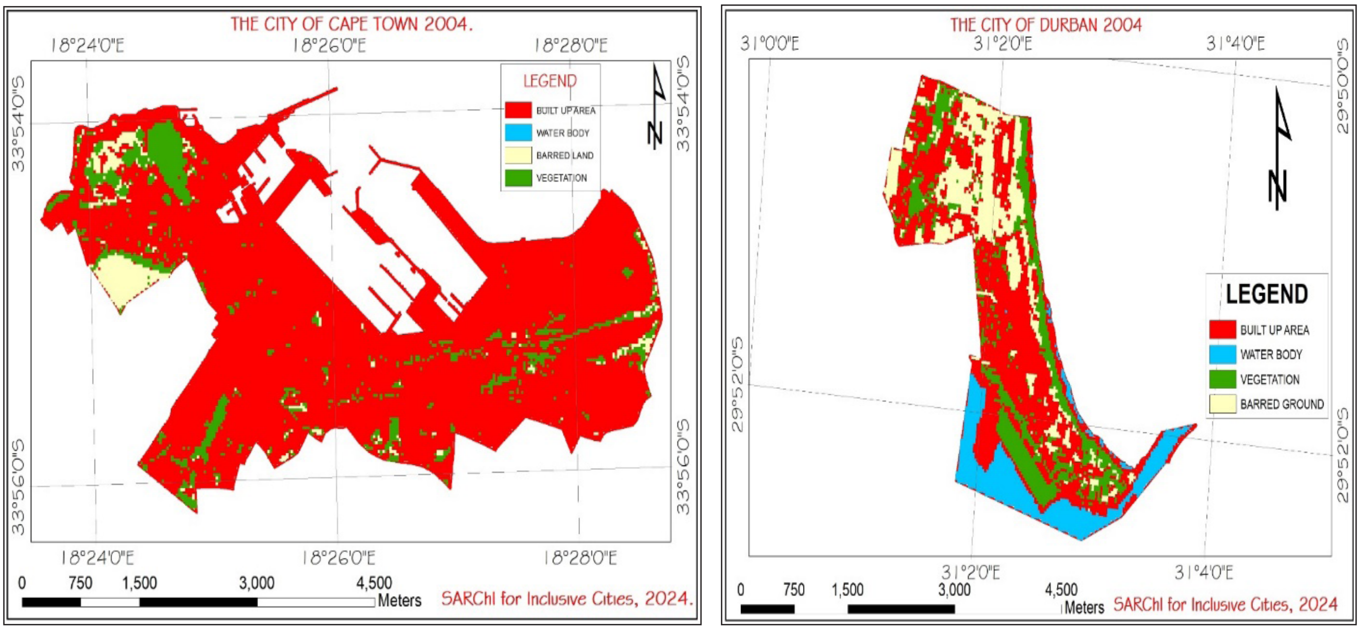


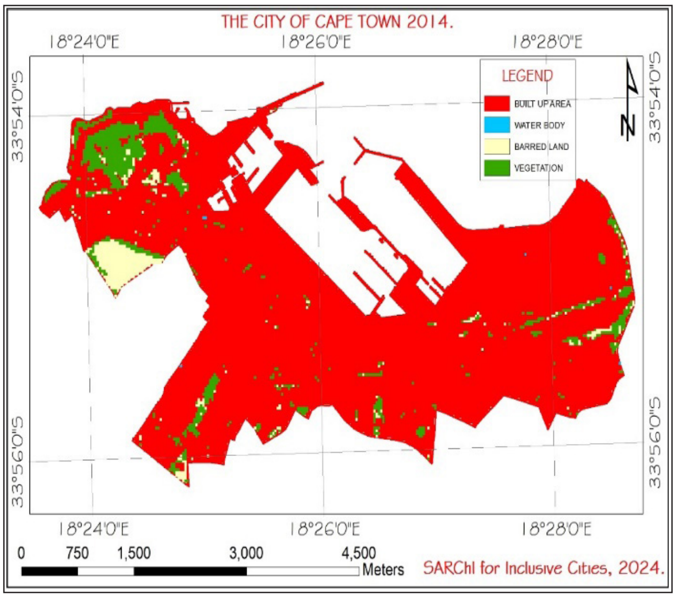
Table 3: Comparative Land Use analysis of the cities in 2004

Attribute	City of Durban	Percentage Coverage	City of Cape Town	Percentage Coverage
Built Up Area	331.7	46.03	1353.3	86.76
Water Body	103.8	14.41	--------------	-----------
Vegetation	139.5	19.36	144.4	9.26
Bare ground	145.6	20.21	62.42	4.00
Total	**720.56 Ha**	**100.0**	**1559.82 Ha**	**100.0**

7. COMPARATIVE SPATIAL ANALYSIS OF CAPE TOWN AND DURBAN CITIES IN 2014

The breakdown of the spatial attributes of the City of Durban shows that Built-up area covered 438ha (60.79%), Water Body 113.7ha (15.78%), Vegetation 115.6ha (16.04%) and Bare ground 53.60ha (7.44%). On the contrary however, the city of Cape Town in 1994 had Built-up area 1403.8ha (90.00%), water body had a spatial extent of 0.54ha (0.035%), Vegetation 107.9ha (6.92%) and Bare ground makes up 47.58ha (0.031%). Figure 4 shows the land use distribution of the two cities and Table 4 shows a breakdown of the land use analysis of the two cities. These represented the spatial outlook of these cities in 2014.

Figure 4: Land Use Outlook of Durban and Cape Town in 2014. Source: SARChI Chair for Inclusive-Cities Modification of Landsatt Imageries, 2024



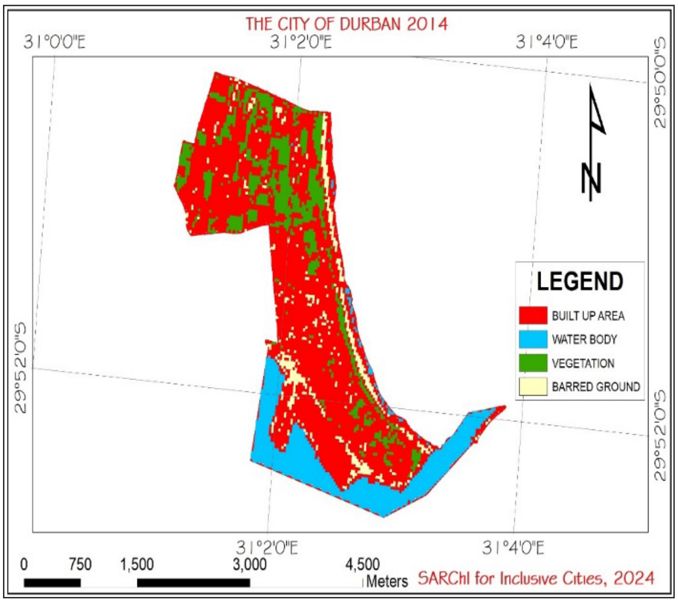


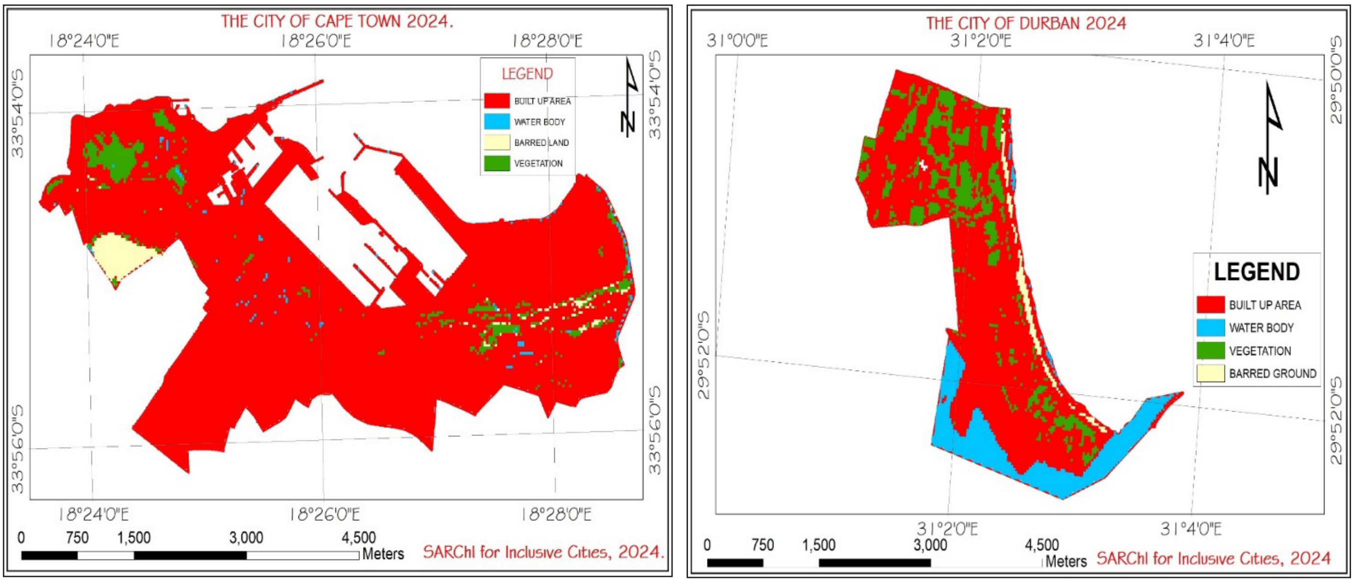
Table 4: Comparative Land Use analysis of the cities in 2014

Attribute	City of Durban	Percentage Coverage	City of Cape Town	Percentage Coverage
Built Up Area	438	60.79	1403.8	90.00
Water Body	113.7	15.78	0.54	0.035
Vegetation	115.6	16.04	107.9	6.92
Bare ground	53.60	7.44	47.58	0.031
Total	**720.56 Ha**	**100.00**	**1559.82 Ha**	**100.00**

8. COMPARATIVE SPATIAL ANALYSIS OF CAPE TOWN AND DURBAN CITIES IN 2024

The comparative LULC analysis of Durban and Cape Town Cities is presented in Table 5 and the Figure 5. The breakdown of the spatial attributes of the City of Durban shows that Built-up area covered 484.2ha (67.20%), Water Body 103.1ha (14.31%), Vegetation 116.2ha (16.13%) and Bare ground 17.57ha (2.44%). On the contrary however, the city of Cape Town in 1994 had Built-up area 1444ha (92.57%), water body had a spatial extent of 12.02ha (0.77%), Vegetation 67.2ha (4.31%) and Bare ground makes up 40.6ha (2.60%).

Figure 5: Land Use Outlook of Durban and Cape Town in 2024.



Source: SARChI Chair for Inclusive-Cities Modification of Landsat Imageries, 2024

Table 5: Comparative Land Use analysis of the cities in 2024

Attribute	City of Durban	Percentage Coverage	City of Cape Town	Percentage Coverage
Built Up Area	484.2	67.20	1444	92.57
Water Body	103.1	14.31	12.02	0.77
Vegetation	116.2	16.13	67.2	4.31
Bare ground	17.57	2.44	40.6	2.60
Total	**720.56 Ha**	**100.00**	**1559.82 Ha**	**100.00**

9. MAGNITUDE OF THE SPATIAL CHANGES IN DURBAN AND CAPE TOWN SOUTH AFRICA BETWEEN 1994 AND 2024

This research therefore further analysed the spatial changes and the magnitude of these changes that have occurred in each of these cities between 1994 and 2024. The analysis of the spatial changes between Durban and Cape Town cities between 1994 and 2004 a period of ten years interval indicated that the various spatial land uses showed a considerable change in their extent. The Built-up area in Durb-an increased in its spatial extent by 129ha, while Cape Town on the other hand had the Built-up area increased by 338.8ha. The water body in Durban city decreased by 36.72ha while the situation of water body in Cape Town was unchanged between 1994 and 2004. The Vegetal cover in Durban lost about 94.2ha between the period from 1994 to 2004 while, the city of Cape Town lost about 1.6ha within the period in review. Finally, bare ground in Durban increased by 5.08ha while the bare ground in Cape Town lost 336.78ha, this analysis is shown in Table 6.

Table 6: Spatial changes in the Cities between 1994 and 2004

Attribute	City of Durban			City of Cape Town		
	1994	2004	Change	1994	2004	Change
Built Up Area	202.7	331.7	129	1014.5	1353.3	338.8
Water Body	140.52	103.8	-36.72	----------	--------------	--------
Vegetation	233.7	139.5	-94.2	146	144.4	1.6
Bare ground	140.52	145.6	5.08	399.2	62.42	-336.78
Total	**720.56 Ha**	**720.56 Ha**		**1559.82 Ha**	**1559.82 Ha**	

The analysis of the spatial changes between Durban and Cape Town cities between 2004 and 2014 a period of ten years interval indicated that the various spatial land uses showed a considerable change in their extent. The Built-up area in Durban increased in its spatial extent by 106.3ha, while Cape Town on the other hand had the Built-up area increased by 50.5ha. The water body in Durban city decreased by 9.9ha while the situation of water body in Cape Town moved from a state where it was previously unnoticed in 2004 to a marginal increase of 0.54ha in 2014. The Vegetal cover in Durban lost about 23.9ha between the period from 2004 and 2014 while, the city of Cape Town lost about 36.5ha within the period in review. Finally, bare ground in Durban lost 92.0ha while the bare ground in Cape Town lost 14.84ha.

Table 7: Spatial Changes in the Cities between 2004 and 2014

Attribute	City of Durban			City of Cape Town		
	2004	2014	Change	2004	2014	Change
Built Up Area	331.7	438	106.3	1353.3	1403.8	50.5
Water Body	103.8	113.7	9.9	--------------	0.54	0.54
Vegetation	139.5	115.6	-23.9	144.4	107.9	-36.5
Bare ground	145.6	53.60	-92.0	62.42	47.58	-14.84
Total	**720.56 Ha**	**720.56 Ha**		**1559.82 Ha**	**1559.82 Ha**	

The analysis of the spatial changes between Durban and Cape Town cities between 2014 and 2024 ten years intervals indicated that the various spatial land uses showed a considerable change in their extent. The Built-up area in Durban increased in its spatial extent by 46.2ha, while Cape Town on the other hand had the Built-up area increased by 40.2ha. The water body in Durban City decreased by 10.6ha while the water body in Cape Town increased by 11.48ha between 2014 and 2024. There was a marginal increase in the spatial extent of the vegetal cover in Durban by 0.6ha between the periods from 2014 to 2024 while the city of Cape Town lost about 40.7ha within the period in review. Finally, bare ground in Durban lost 36.03ha while the bare ground in Cape Town lost 6.68ha. This analysis is shown in Table 8.

Table 8: Spatial Changes in the Cities between 2014 and 2024

Attribute	City of Durban			City of Cape Town		
	2014	2024	Change	2014	2024	Change
Built Up Area	438	484.2	46.2	1403.8	1444	40.2
Water Body	113.7	103.1	-10.6	0.54	12.02	11.48
Vegetation	115.6	116.2	0.6	107.9	67.2	-40.7
Bare ground	53.60	17.57	-36.03	47.58	40.6	6.98
Total	**720.56 Ha**	**720.56 Ha**		**1559.82 Ha**	**1559.82Ha**	

10. DISCUSSION AND INSIGHTS

10.1. Land Use-Land Cover Changes between 1994 and 2024

According to King (2015), spatial changes in the selected cities have been driven by different factors ranging from colonial influence, population growth, and advancement in technology, while, Cohen (2004) had argued earlier that although the recently released United Nations' publication World Urbanization Prospects is an invaluable resource for those interested in studying urban change, the data in the report are somewhat deceptive in their apparent completeness and beyond the narrow confines of technical demography, there is a great deal of misunderstanding and misreporting about what these data mean and how they should be interpreted. For example, while the scale of urban change is unprecedented and the nature and direction of urban change is more dependent on the global economy than ever before, many aspects of the traditional distinction between urban and rural are becoming redundant. This highlights the complexities of interpreting urbanization data, which is crucial when analyzing urban growth in Cape Town and Durban. Understanding these nuances allows for a more accurate assessment of how global economic factors and blurred urban-rural distinctions influence land use and urban dynamics in these cities.

The LULC analysis of the City of Durban (with a spatial extent of 720.56Ha) and the City of Cape Town (spanning 1559.82Ha) reveals four key spatial features: built-up areas, vegetation, bare ground, and water bodies. Our analysis showed significant urban expansion in both cities, driven primarily by increasing built-up areas, with Cape Town experiencing a higher degree of urbanization due to its larger spatial extent. Specifically, in Durban, built-up areas have expanded considerably along the peripheral settlements, indicating not only urban growth but also pressures on green spaces and natural ecosystems. This observation aligns with the findings of Otunga, *et al.,* (2014), who also noted urban expansion at the cost of green spaces over a twenty-two-year period in Durban through the use of land-cover change models and Markov chain analysis.

In Cape Town, the LULC patterns revealed a more consolidated urban growth within city boundaries, with a noticeable intensification of land use compared to Durban. This urbanization is consistent with studies such as van Vliet et al. (2019), which emphasize the correlation between built-up areas and population density. Comparing the proportions of built-up areas between both cities highlights Cape Town's higher rate of urban densification, reflecting significant infrastructure development and land use intensification.

In terms of vegetation cover, the analysis showed that Durban retains more extensive vegetative areas, particularly in the peripheral regions, compared to Cape Town. This finding is crucial for understanding biodiversity and ecosystem services in the region. According to De Carvalho & Szlafsztein (2019), the presence of urban vegetation directly contributes to environmental quality and the provisioning of ecosystem services. In **Cape Town**, urban greening initiatives have contributed to isolated pockets of greenery, particularly in public parks and conservation zones, but the overall vegetation cover is lower, likely due to the rapid urban expansion in recent years. These changes are reflected in the study by Demuzere et al. (2014), which associates urban vegetation loss with higher temperatures and reduced biodiversity.

The presence of bare ground in both cities signals areas of concern for land degradation and potential soil erosion. Our findings indicate that Durban, in particular, shows more bare ground in regions undergoing rapid urban sprawl and informal settlement growth, aligning with Mazeka, Phinzi & Sutherland (2021), who highlighted the environmental challenges in these areas. Cape Town, on the other hand, exhibited less bare ground, but the patches observed are associated with ongoing construction projects, suggesting an active phase of urban infrastructure development, as noted in the work of Magidi (2018).

Lastly, the analysis of water bodies in both cities underscores their importance for urban planning and ecological health. Durban's proximity to rivers and coastal areas makes water bodies more prominent in its spatial layout compared to Cape Town, which has fewer inland water bodies but a significant coastal region. Monitoring the extent and quality of these water bodies is essential for sustainable water resource management, as highlighted by Prasad et al. (2002) and Koop & van Leeuwen (2017). Both cities face challenges with water resource management, particularly in light of climate change, but Durban's integration of water bodies into its urban fabric shows a closer relationship between urban planning and ecological conservation.

10.2. Magnitude of the spatial changes in Durban and Cape Town South Africa between 1994 and 2024

The spatial changes in the selected cities have been driven by different factors ranging from colonial influence, population growth and advancement in technology. The research therefore further analysed the spatial changes and the magnitude of these changes that have occurred in each of these cities between 1994 and 2024. The construction of new roads, highways, airports, ports, and other infrastructure projects in Durban resulted in the conversion of undeveloped land covers into transportation corridors, industrial zones, and urban developments, altering the land use patterns in the city. The growth of commercial, industrial, and business sectors in Durban led to the conversion of agricultural lands, open spaces, and green areas into commercial complexes, industrial estates, and business hubs, transforming the land use dynamics of the city. These are the factors which influences land cover changes in Durban causing the Built-up area in Durban to increase in its spatial extent by 129ha between 1994 and 2004, while Land use planning decisions, zoning regulations, development policies, and urban growth strategies implemented by local authorities, government agencies, and private developers influenced the transformation of land covers in Cape Town, shaping the urban form, spatial layout, and environmental quality of the city of Cape Town with the Built-up area increasing by 338.8ha.

The population growth in Durban during this period resulted in increased demand for housing, commercial spaces, and urban amenities, leading to the conversion of open spaces and natural habitats into developed areas to meet the needs of the expanding population and reducing the water body in Durban city by 36.72ha while the growth of tourism, leisure activities, and recreational facilities in Cape Town led to the development of hotels, resorts, entertainment venues, and coastal amenities, transforming coastal areas, natural landscapes, and open spaces into tourist attractions and recreational zones. The situation further decrease the spatial extent of water body in Cape Town between 1994 and 2024. Climate change effects, such as sea-level rise, flooding, and extreme weather events, influenced land use decisions and development patterns in Durban, leading to changes in land cover types, urban expansion, and infrastructure adaptation measures to mitigate climate risks and impact Vegetal cover in Durban leading to loss of vegetal cover between 1994 to 2024 while, the city of Cape Town lost about a considerable level of its vegetal cover between 1994 and 2024 as a result of the rapid urbanization of Cape Town leading to the conversion of natural land covers, such as forests, grasslands, and agricultural areas, into built-up areas, residential developments, and infrastructure projects to accommodate the growing population and economic activities. Finally, bare ground in Durban also decreased within the periods while combined factors of socio-economic trends, governance practices, climate influences, and land management practices, contributed to the land use and land cover changes observed in the city of Cape Town between 1994 and 2024, reflecting the complex interplay between human activities, urban development dynamics, and environmental impacts.

11. RECOMMENDATIONS AND CONCLUSION

The comparative analysis of land use and land cover (LULC) changes between Cape Town and Durban reveals both commonalities and distinctions in urban development patterns, highlighting the complex interplay of historical, socio-economic, and environmental factors shaping these coastal cities. The findings underscore the ongoing challenges of addressing spatial inequalities inherited from apartheid while pursuing sustainable urban growth in the face of climate change and biodiversity conservation imperatives.

Based on the analysis, several recommendations emerge for policymakers and urban planners. Firstly, there is a need for more integrated and adaptive urban planning approaches that balance development pressures with environmental conservation. This could involve refining urban edge policies and implementing green infrastructure strategies to enhance urban resilience (Schäffler & Swilling, 2013). Secondly, addressing informal settlement growth requires innovative land use management strategies that prioritize in-situ upgrading and improved service provision, rather than relocation (Sutherland et al., 2016). Thirdly, both cities should strengthen their climate adaptation planning, particularly in coastal areas vulnerable to sea-level rise, by incorporating LULC change projections into long-term urban development strategies (Roberts et al., 2016).

In conclusion, while Cape Town and Durban face unique challenges, both cities demonstrate the need for context-specific, yet holistic approaches to urban land use management. The comparative analysis reveals that successful urban sustainability initiatives must be tailored to local conditions while addressing broader national goals of spatial transformation and environmental stewardship. Future research should focus on developing more nuanced models of urban growth that incorporate informal dynamics and ecosystem services valuation. Ultimately, the findings of this study contribute to a growing body of knowledge on urban sustainability in the Global South, emphasizing the importance of comparative urban research in informing policy and practice for more equitable and resilient cities (Parnell & Robinson, 2012).

12. ACKNOWLEDGMENT

We gratefully acknowledge the support of the SARChI Chair for Inclusive-Cities for her invaluable support and guidance throughout this research. Her commitment to advancing urban studies and promoting inclusive, sustainable development has been instrumental in enabling this comparative analysis of land use and land cover changes in Cape Town and Durban. The insights and resources provided through her support have been instrumental in shaping our understanding of urban dynamics in post-apartheid South Africa and significantly contributed to the depth and rigor of this study.

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