South African Journal of Geomatics, Vol. 15. No. 1, February 2026

Dynamics of Urban Sprawl in Dar es Salaam: a Three-decade Analysis using Remote Sensing and Landscape Metrics

Olipa Simon[a]*, Zakaria Ngereja [b]

[a]Institute of Resource Assessment, University of Dar es Salaam, P.O. Box 35097, Dar es Salaam, Tanzania - simon.olipa@udsm.ac.tz

[b]Department of Geospatial Sciences and Technology, Ardhi University, P.O. Box 35176, Dar es Salaam, Tanzania - zakaria.ngereja@aru.ac.tz

*Corresponding author's e-mail address: simon.olipa@udsm.ac.tz

DOI: https://dx.doi.org/10.4314/sajg.v15i1.2

Abstract

Dar es Salaam, the largest city in Tanzania, has undergone rapid population growth over recent decades. This surge in population has been accompanied by inadequate enforcement of urban planning regulations. The combination of these factors has led to extensive urban sprawl with far-reaching environmental and socio-economic consequences. Environmentally, the unchecked spread of the city has contributed to the loss of natural habitats, increased flooding risk, heat stress, and the degradation of vital ecosystems. Socio-economically, urban sprawl has placed considerable strain on public infrastructure, reduced access to essential services, and exacerbated inequalities within the city. Overall, the lack of effective planning has intensified the challenges associated with rapid urbanisation in Dar es Salaam.

This study integrated remote sensing and landscape metrics to assess urban sprawl dynamics over three decades (1995–2024). Thereby, it sought to highlight the phenomenon of peri-urban expansion and its associated risks (e.g., flooding, heat stress, and vegetation loss). Multi-temporal Landsat imagery was processed by using the random forest supervised classification, accuracy assessment, and post-classification change detection methodologies. To quantify spatial patterns, fragmentation, and connectivity, the landscape metrics package was used to compute R for the landscape metrics, namely, percentage of landscape (PLAND), number of patches (NP), patch density (PD), total edges (TE), and aggregation index (AI).

The results reveal a dramatic increase in built-up areas from 73 km² (4.41%) in 1995 to 131 km² (7.92%) in 2009 and 409 km² (24.73%) in 2024, reflecting a 20.31 percentage point rise. Urban expansion into peri-urban zones has displaced agricultural land and the natural vegetation, creating hotspots of environmental vulnerability characterised by the threat of increased flooding, vegetation loss, and heat stress. Fragmentation was found to intensify, with NP rising from 5,432 to 26,368 and TE increasing by more than sixfold, whereas declining AI values indicated weakened patch connectivity.

This study shows how urban growth threatens natural ecosystems, infrastructure, mobility, and green spaces. Unlike recent socio-economic studies, it offers a spatially explicit assessment of growth, fragmentation, and directionality. The findings provide vital insights for developing sustainable land-use policies and planning to promote the resilience of Dar es Salaam, while contributing to the global sustainability goals, (SDG 11, 13, and 15).

Keywords: *Landscape Fragmentation, Remote Sensing Techniques, GIS Analysis, Land Cover Change Detection, Urban Growth Metrics, Sustainable Urban Planning*

1. Introduction

Urban sprawl is a global phenomenon that has gained prominence in recent decades, particularly in rapidly growing cities, where population growth and urban expansion have intensified. Currently, more than half of the world's population resides in urban areas, with projections indicating that this figure will rise from 55% to 68% by 2050, with 90% of this growth expected to be concentrated in the less-developed nations (Gu *et al*., 2021; Nyongesa *et al*., 2022). As of 2022, 57% of the global population resided in urban areas, underscoring the ongoing trend of urbanisation (Demographia, 2022; United Nations, 2019). Sub-Saharan Africa is expected to play a pivotal role in global growth, and it is projected to account for over 50% of the global population increase by 2050, with the main countries being the Democratic Republic of the Congo, Nigeria, and Tanzania (Abramova, 2022; Pison and Poniakina, 2024).

Unprecedented urbanisation in developing countries is driving significant changes in land use and land cover (LULC), thereby posing complex challenges to regional cities (Merem *et al*., 2019; Sumari *et al*., 2020). Rapid population growth intensifies pressure on natural resources and public infrastructure, resulting in habitat loss, increased carbon emissions, reduced agricultural land, and higher overland runoff. These changes exacerbate the risks of flooding, water scarcity, and pollution, while straining housing and public infrastructures (Magidi and Ahmed, 2019; Tewabe and Fentahun, 2020). In sub-Saharan Africa, high birth rates and rural-to-urban migration have accelerated urbanisation, often exceeding the government's capacity to manage growth and complicating efforts to achieve sustainable urban development (Igun and Williams, 2018; Ramuhulu, 2021). As cities expand into rural areas, fragmented and unplanned development has become pervasive, necessitating a balance between urban growth and sustainable environmental practices.

While urbanisation can boost economic development and living standards, unplanned urban sprawl frequently results in fragmented landscapes, the loss of agricultural and natural land, and overburdened urban infrastructures (Merem *et al*., 2019). These challenges are particularly acute in cities such as Dar es Salaam, where rapid population growth and inadequate enforcement of urban planning regulations have led to widespread informal settlements (Lupala, 2021). Such unregulated growth intensifies environmental problems, including deforestation, flooding, and the urban heat island effect, while limiting equitable access to essential services (Nuhu *et al*., 2023).

Despite these challenges, research on urban sprawl in Dar es Salaam remains limited. Most studies have focused on socio-economic factors, population density, or transport systems, with few employing spatially explicit methods or quantitative landscape metrics to systematically assess the spatial structure, its fragmentation, and the directional growth of urban sprawl (Mkalawa and Haixiao, 2014; Mnyali and Materu, 2021).

This study addresses this gap by integrating multi-temporal Landsat imagery with landscape metrics, computed in R, to assess urban sprawl over the past three decades. By quantifying spatial structure, fragmentation, and peri-urban expansion hotspots, our findings provide critical insights for sustainable land-use planning, policy formulation, and resilience strategies for rapidly urbanising cities.

2. Materials and methods

2.1. Description of the Study Area

This study focuses on Dar es Salaam Metropolitan City, Tanzania's largest and most populous urban centre, strategically located along the East African coast (Figure 1). Covering approximately 1,493 square kilometres, Dar es Salaam serves as the country's primary economic hub and port, with an estimated population of 6 million, projected to rise to 15.6 million by 2050 (Simon *et al.*, 2022; United Republic of Tanzania, 2022). This rapid growth, combined with geographic constraints, such as the Indian Ocean and a tropical climate with distinct rainy seasons, presents significant challenges for urban planning and infrastructure (Kibassa and Shemdoe, 2016). Flooding in low-lying and informal areas disrupts livelihoods, whereas unplanned urban sprawl threatens ecosystems such as mangroves and wetlands, exacerbating the urban heat island effect and increasing the risk of flooding (Nuhu *et al*., 2023; Simon *et al*., 2024).

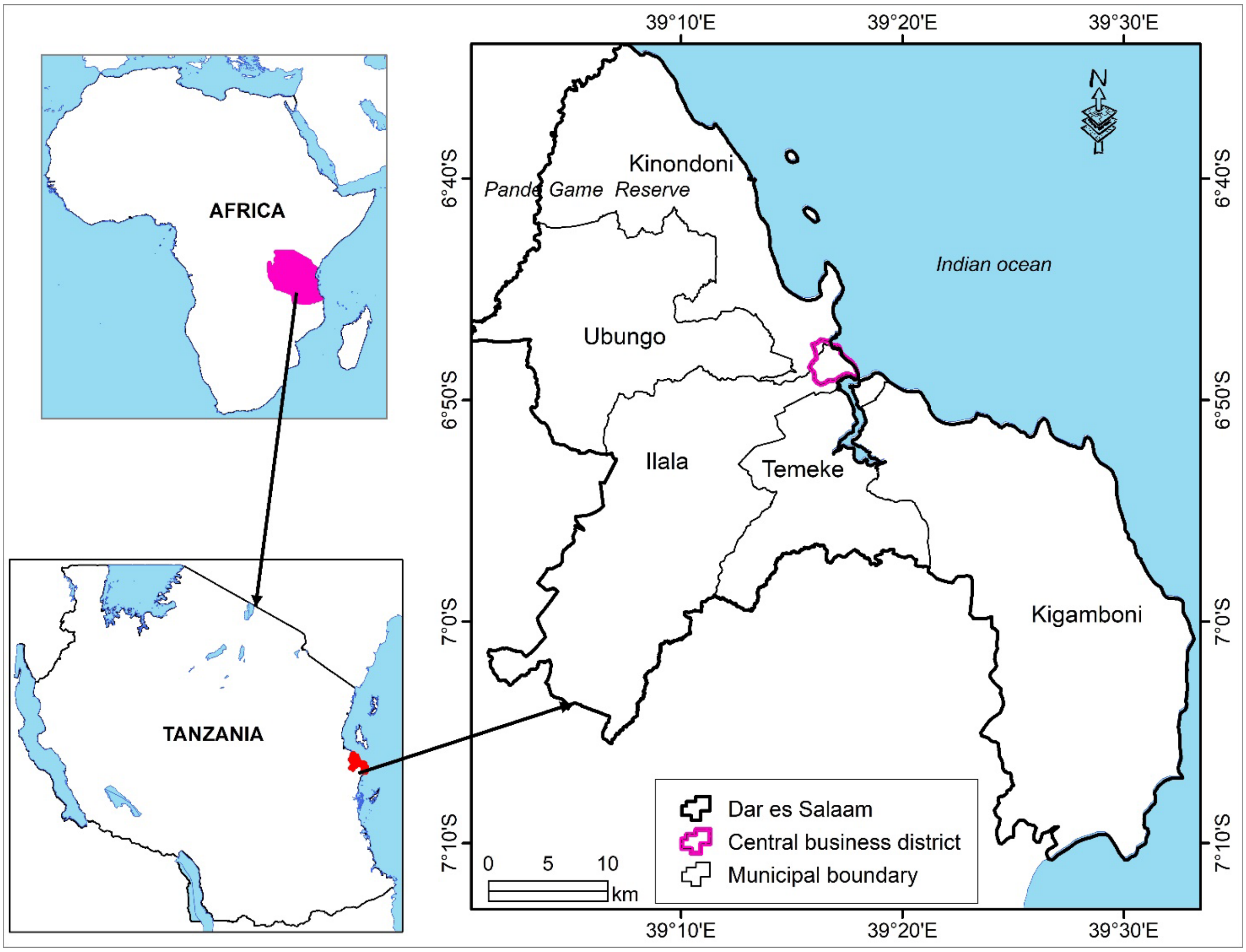

Figure 1: Location of Dar es Salaam Metropolitan City

2.2. Data Collection Methods and Tools

2.2.1. Data collection and processing

The study used the multi-temporal Landsat satellite imagery (30m resolution) of Dar es Salaam Metropolitan City from 1995 to 2024 to examine land cover changes and evaluate the features of urban sprawl. Landsat images with less than 10% cloud cover were obtained from the United States Geological Survey (USGS) via the Google Earth Engine (GEE) Code Editor. Image preprocessing was carried out in GEE using open-source algorithms for cloud and shadow masking. The study used the open-source code of the Google Earth Engine for cloud, shadow, and snow masking during image preprocessing. This exercise included stacking individual spectral bands, cloud masking, gap filling, radiometric correction, and the clipping of the study area. The characteristics of the selected satellite images are summarised in Table 1.

Table 1: Description of Landsat satellite images used in the study (1995, 2009, and 2024)

Year	Sensor Type	Date of acquisition	Season	Spatial Resolution (m)	Spectral Bands
1995	Landsat 5 Thematic Mapper (TM)	25 June	Dry	30	7
2009	Landsat5 Thematic Mapper (TM)	01 July	Dry	30	7
2024	Landsat 8 Operational Land Imager (OLI)	03 June	Dry	30	11

Source: USGS, 2024

2.2.2. Image classification and accuracy assessment

Image classification

Supervised image classification was performed using the Random Forest algorithm in R (version 4.3.2) to create land cover maps. Land cover change detection was conducted using ArcGIS Pro (Simon et al., 2024). The study used higher-resolution imagery from Planet, Bing Maps, Esri, and Google Earth to supplement the limited spatial resolution of the Landsat imagery. Training signatures for each land use and land cover (LULC) class were created using QGIS plugins, resulting in five categories: agriculture, built-up area, vegetation (including bushland, forest, and grassland), waterbody, and bare soil. The land cover categories and their descriptions are presented in Table 2.

Table 2: Land cover categories and descriptions

Land cover category	Description
Agriculture with scattered settlements	The land actively used for agriculture includes agroforestry, as well as wooded and grain crops.
Bare Soil	Bare land, beach sands, and areas without any form of construction
Built-up	Urban areas, including residential, commercial, and industrial settlements
Vegetation	Vegetation encompasses various plant types, including bushland, forest, and grassland.
Waterbody	Inland waterbodies and the Indian Ocean

Accuracy assessment

To ensure reliability, the study evaluated the accuracy of the land cover maps by considering the overall accuracy (OA) index and the Kappa coefficient (κ). It validated the information by using ground-truth data, including field observations, Google Earth imagery, and GPS data. ERDAS Imagine 2014 software was used for accuracy analysis, with at least 166 systematically collected ground points for each classified image, stratified across all five LULC classes (agriculture, built-up area, vegetation, waterbody, and bare soil). For each image, a confusion matrix was generated by comparing the classified classes with the referenced data. From the confusion matrix, the study calculated the overall accuracy, producer's accuracy, user's Accuracy, and the Kappa coefficient for each class and for the entire classification, basing this exercise on the methods recommended by Elmi et al. (2022). This approach allowed for a robust and consistent evaluation of the classification performance across the study period, thereby ensuring a reliable quantification of urban expansion and land use/ land cover (LULC) change dynamics.

2.2.3. Measuring Urban Sprawl with Spatial Metrics

To analyse urban sprawl in Dar es Salaam, the study computed landscape metrics for the built-up land use class for the years 1995, 2009, and 2024. Thirteen landscape metrics were calculated using the "landscapemetrics" package in R (v.4.1.3). These included percentage of landscape (PLAND), number of patches (NP), and patch Density (PD), as detailed, amongst others, in Table 3. These metrics provide insights into the structure and extent of urban sprawl.

Table 3: Class metrics and descriptions (Elif *et al*., 2018; Nyongesa *et al*., 2022)

Metric	Metric Description
Percentage of Landscape (PLAND)	Percentage of the landscape occupied by a specific patch type
Number of Patches (NP)	Total number of patches of a particular type
Patch Density (PD)	Number of patches per unit area for a specific type
Largest Patch Index (LPI)	Area of the largest patch relative to the total landscape area
Total Edge (TE)	Sum of the edge lengths of all patches in the landscape
Edge Density (ED)	Edge length per unit area of the landscape
Landscape Shape Index (LSI)	Standardised measure for patch-shape complexity
Class Area (CA)	Total area occupied by a specific patch type
Total Core Area (TCA)	Combined core area of all patches of a particular type
Fractal Dimension (PAFRAC)	Measure for patch-shape complexity based on perimeter and area
Simpson's Diversity Index (SIDI)	Diversity of land cover types within the landscape
Aggregation Index (AI)	Degree of clustering for each patch type within the landscape
Shannon's Evenness Index (SHEI)	Measure for the even distribution of land cover types across the landscape

3. Results

3.1. Accuracy Assessment

The accuracy assessment of the LULC classification for Dar es Salaam from 1995 to 2024 (Table 4) highlights variations in performance, reflecting the dynamic nature of land cover changes. The overall accuracy was 83.5% in 1995, peaked in 2009 (95.8%), and declined to 84.9% in 2024, indicating increased classification challenges in a more heterogeneous landscape. The Kappa statistics supported the reliability of the classification process, demonstrating strong, moderate, and weak agreement across the respective periods.

Table 4: Accuracy assessment of land use and land cover (LULC) classification for Dar es Salaam Metropolitan City

LULC classes	1995		2009		2024	
	PA	UA	PA	UA	PA	UA
Agriculture	68.4%	89.0%	96.97%	88.9%	68.9%	91.2%
Bare Soil	69.2%	90.0%	100%	90.0%	78.6%	91.7%
Built-up	94.6%	84.1%	84.0%	100.0 %	94.9%	82.4%
Vegetation	92.8%	77.6%	97.3%	100.0%	93.6%	80.7%
Waterbody	90.9%	100%	100%	88.24%	100.0%	100.0%
Overall accuracy		83.5%	95.8%		84.9%	
Kappa coefficient		0.77	0.94		0.79	

Note: PA—Producer's Accuracy, UA—User's Accuracy

3.2. Land Cover Change Detection and Urban Growth Analysis

The LULC analysis from 1995 to 2024 (Figures 2 and Table 5) revealed significant shifts in land cover, particularly in urban expansion, reduction of agricultural land, and loss of vegetation. Built-up areas showed substantial expansion, increasing from 4.41% of the total area in 1995 to 24.73% by 2024, marking a more than five-fold increase. This trend aligns with the overall urban growth in Dar es Salaam. Conversely, vegetation cover decreased from 69.17% in 1995 to 55.32% in 2024, highlighting the loss of natural habitat owing to developmental pressures.

Table 5: Summary of the results for the change in each LULC class for Dar es Salaam

LULC classes	1995		2009		2024		Change (%)
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	
Agriculture	397	24.00	435	26.30	283	17.11	-6.89
Bare Soil	17	1.03	29	1.75	25	1.51	0.48
Built-up	73	4.41	131	7.92	409	24.73	20.31
Vegetation	1,144	69.17	1,032	62.39	915	55.32	-13.85
Waterbody	24	1.45	26	1.57	21	1.27	-0.18

Total	1,654	100	1,654	100	1,654	100

Agriculture exhibited a net decline over the study period, decreasing from 397 km² (24.0%) in 1995 to 283 km² (17.11%) in 2024, representing a 6.89% reduction. Despite an interim expansion to 435 km² in 2009, substantial conversion to other land-use classes occurred thereafter, predominantly to urban uses. Vegetation experienced the most significant overall loss, shrinking from 1,144 km² (69.17%) in 1995 to 915 km² (55.32%) in 2024, a decline of 13.85%, primarily driven by conversion to built-up and agricultural areas. Waterbodies remained relatively stable over the study period. Figure 2 illustrates the spatial dynamics of these land cover classes from 1995 to 2024.

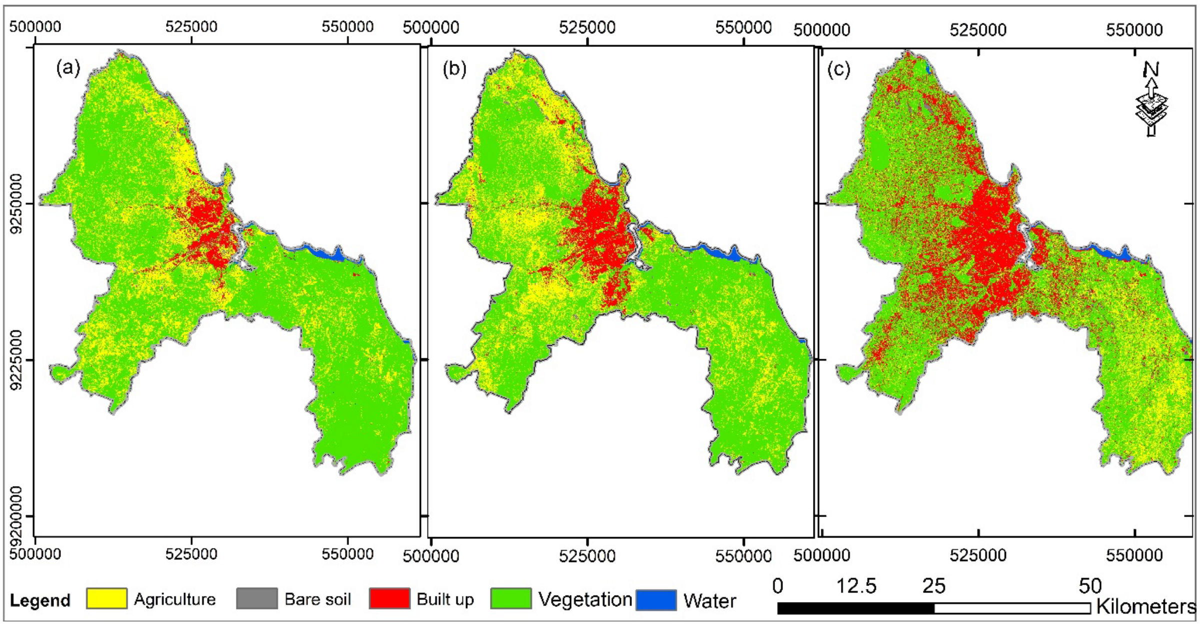

Figure 2: Land cover dynamics of the main land use/land cover classes in Dar es Salaam: (a) 1995, (b) 2009, and (c) 2024

3.3. Urban Sprawl Analysis using Landscape Metrics

The landscape metrics analysis (Figure 3 and Table 6) highlights significant urban growth and fragmentation patterns in Dar es Salaam over the study period from 1995 to 2024.

Table 6: Landscape Metrics for Built-up Area of Dar es Salaam (1995–2024)

Class metrics	1995	2009	2024
Class Area (CA, ha)	7153.2897	12,940.6269	40,336.2484
Edge Density (ED, m/ha)	15.1201	20.6466	93.4028
Number of Patches (NP, count)	5,432	6,288	26,368
Largest Patch Index (LPI, %)	3.0142	5.9644	12.1046
Percentage of Landscape (PLAND, %)	4.3895	7.9422	24.7737
Landscape Shape Index (LSI, dimensionless)	73.1021	74.2775	190.0460
Aggregation Index (AI, %)	74.4879	80.7394	71.8965
Fractal Dimension (PAFRAC, dimensionless)	1.5168	1.4964	1.53015
Patch Density (PD, patches/100 ha)	3.33	3.86	16.1874
Simpson's Diversity Index (SIDI, dimensionless)	0.4622	0.5345	0.6028
Shannon's Evenness Index (SHEI, dimensionless)	0.5240	0.6110	0.6798
Total Core Area (TCA, ha)	3,511	7,623	17,245
Total Edge (TE, m)	2,464,006	3,364,045	15,211,345

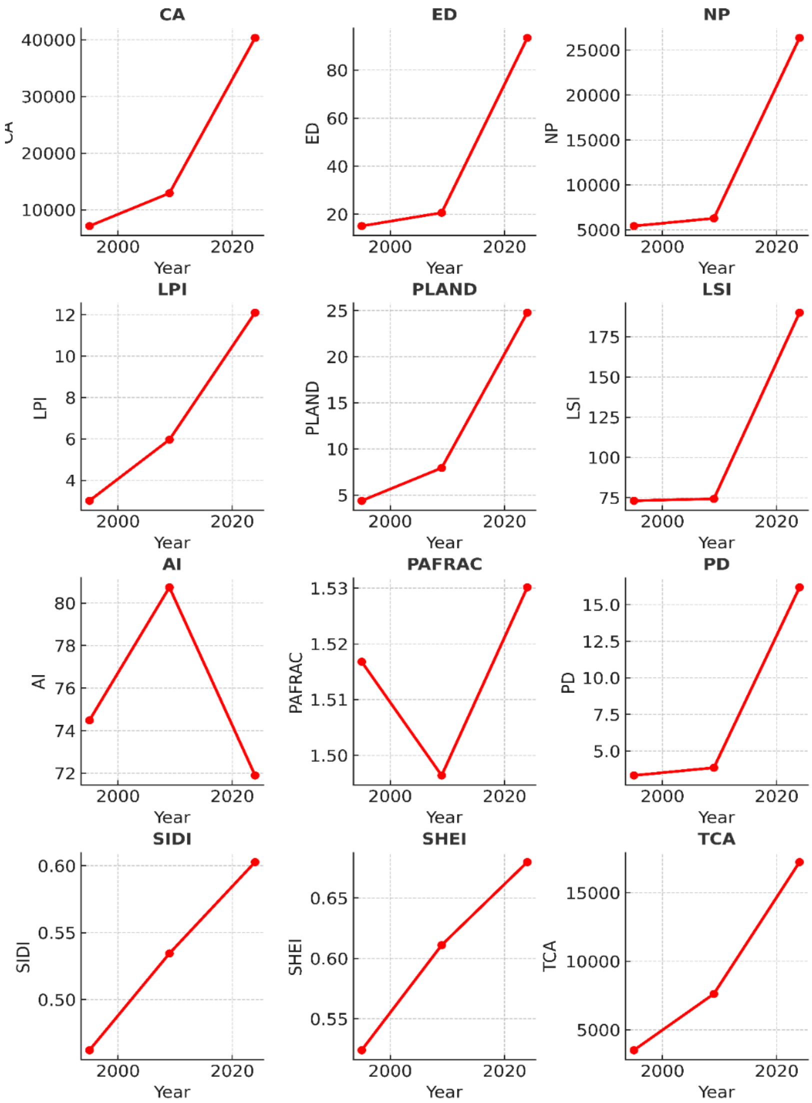

Figure 3: Temporal trends in urban metrics for Dar es Salaam from 1995 to 2024

Figure 3 illustrates the temporal changes in the key metrics for Dar es Salaam, capturing the shifts in urban structure and complexity between the years 1995, 2009, and 2024. Metrics such as CA, ED, NP, and LPI vividly demonstrate the evolving patterns of urban growth and fragmentation, thereby postulating the challenges of managing unplanned urbanisation in a rapidly expanding city.

The Class Area (CA) of built-up land increased dramatically, from 7,153 ha in 1995 to 40,336 ha in 2024, reflecting extensive urban expansion. Similarly, the Percentage of Landscape (PLAND) rose from 4.39% to 24.77%, underscoring the rapid transformation of the city. This growth was accompanied by a marked increase in the Number of Patches (NP), from 5,432 to 26,368, and in Patch Density (PD), from 3.33 to 16.19 patches per 100 ha, indicating greater fragmentation of urban patches.

The LPI increased from 3.01% to 12.10%, indicating the development of more significant, contiguous built-up areas, alongside the proliferation of smaller patches. TE increased substantially from 2,464,006m in 1995 to 15,211,345m in 2024, whereas ED rose from 15.12 to 93.40 m/ha, indicating more complex urban boundaries as unplanned growth spread outwards. In contrast, AI, which measures the cohesion of built-up patches, peaked at 80.74% in 2009 before declining to 71.90% by 2024. This decline suggests a shift toward more scattered and less cohesive urban development.

Diversity and evenness metrics also increased over the study period. Simpson’s Diversity Index (SIDI) demonstrates that the landscape became more diverse with the introduction of new patch types. At the same time, Shannon’s Evenness Index (SHEI) indicates that patches became more evenly distributed across the landscape. Together, these trends highlight a dual pattern in Dar es Salaam’s urban structure: macro-scale consolidation of major urban hubs, as reflected in LPI, alongside micro-scale fragmentation and dispersion of peripheral patches, as reflected in NP, PD, and SHEI. This combination underscores the city's unstructured, rapid expansion.

3.4. Spatial Directionality and Constraints

The analysis of urban sprawl in Dar es Salaam (Figure 4) reveals a dynamic transformation of land cover across the metropolitan area between 1995 and 2024. To better understand these changes, the city was divided into eight directional zones radiating from the Central Business District (CBD): Northwest (NW), North (N), Northeast (NE), East (E), Southeast (SE), South (S), Southwest (SW), and West (W).

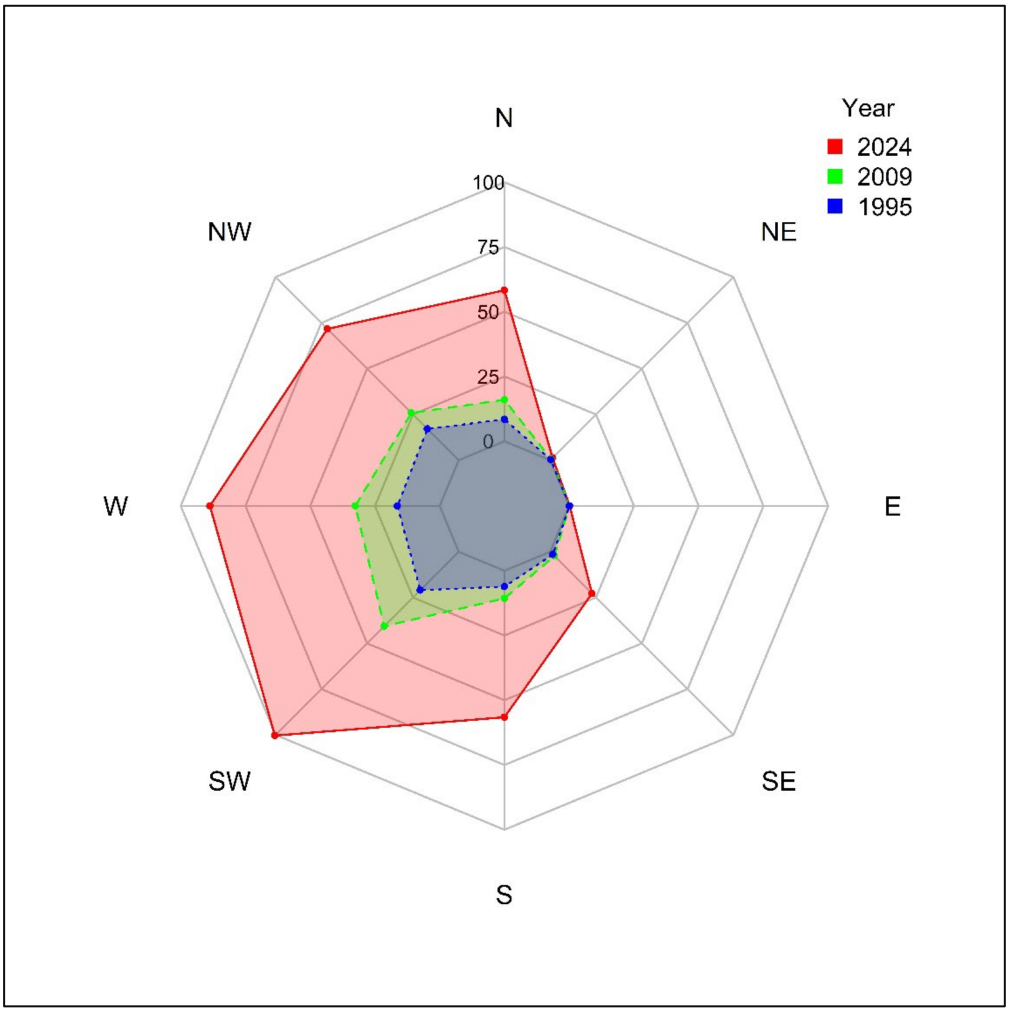

Figure 4: Radar chart illustrating urban expansion in Dar es Salaam from 1995 to 2024

Over the study period, the most pronounced expansion occurred in the W, SW, and NW zones, reflecting a strong westward and southward push of urban growth. This trend is driven mainly by the availability of developable land and ongoing infrastructure projects, which have shifted development away from the crowded city centre. As a result, peri-urban areas—particularly those located 10–20 km from the CBD—have seen accelerated urbanisation. Expansion to the east is limited by the Indian Ocean, naturally channelling growth toward the inland zones. By 2024, these areas had become hotspots of urban sprawl, generating increased pressure on infrastructure, public services, and the surrounding environment.

4. Discussion

4.1. Drivers of Urban Sprawl

The observed patterns of urban sprawl in Dar es Salaam align with the broader urbanisation trends documented in previous studies. Population growth, driven by natural increase and rural-to-urban migration, has been identified as a primary catalyst for urban expansion in Dar es Salaam (Simon *et al*., 2024). Economic development further accelerates this growth by increasing the demand for housing, infrastructure, and services, as observed in other rapidly growing cities such as Accra and Addis Ababa (Mensah *et al*., 2020). Furthermore, weak enforcement of urban planning regulations and gaps in policy implementation have facilitated unchecked growth, particularly in peri-urban areas, where informal settlements have proliferated, as highlighted by Lupala (2021) and Nuhu *et al*. (2023). Similar trends have been observed in Kampala, where inadequate governance frameworks have allowed unregulated sprawl to flourish (Bidandi and Williams, 2020). These drivers have collectively contributed to the fragmented and sprawling urban landscape characteristics of Dar es Salaam.

While previous studies have primarily described these drivers qualitatively, this study offers new insights by quantifying the spatial and temporal dynamics of urban sprawl over three decades using landscape metrics. This approach connects demographic, economic, and governance drivers to measurable changes in the urban landscape, illustrating how these factors collectively generate the fragmented and sprawling urban forms typical of Dar es Salaam.

4.2. Environmental Implications

Urban sprawl in Dar es Salaam has significant environmental consequences, with trends that mirror the challenges identified in other studies focused on the city. The loss of vegetation and green spaces has reduced ecological resilience, increasing the city's vulnerability to environmental risks such as flooding and heat stress (Nuhu *et al*., 2023; Simon *et al*., 2023). The proliferation of impervious surfaces, including roads and buildings, has disrupted natural drainage systems in the city's main sub-catchments-Msimbazi (265.5 km^2), Kizinga (247.1 km^2), and Mzinga (686.4 km^2) - exacerbating flooding risks during rainy seasons, particularly in low-lying and informal settlement areas (Kibassa and Shemdoe, 2016; Kibugu *et al*., 2022; Mzava *et al*., 2021). The intensification of urban heat islands has been documented as a growing concern, driven by the reduction of vegetation and the expansion of built-up areas. Studies have shown that increased impervious surfaces contribute to elevated surface temperatures, compounding heat-related challenges for urban residents (Simon *et al*., 2022). Additionally, the fragmentation of green spaces in Dar es Salaam threatens biodiversity and reduces the city's ability to provide critical natural ecosystems services, such as air purification and climate regulation (Magina *et al*., 2020; Nuhu *et al*., 2023).

4.3. Limitations

It is important to note that owing to the limited availability of data on the metropolitan scale, sprawl patterns cannot be directly validated against zoning or town planning schemes. Incorporating such datasets in future research would provide a more comprehensive understanding of the alignment between planned and actual urban growth and inform more effective urban planning strategies.

4.4. Future Research Recommendations

Future research should aim to develop a more comprehensive urban sprawl index than the one used in this study, capturing multiple dimensions of expansion such as density, fragmentation, connectivity, and environmental impacts, with parameters tailored to the regional context of Dar es Salaam. Additionally, alternative methods for assessing spatial dispersion and the directional patterns of urban growth should be explored. Indices such as Simpson's Diversity Index or other spatial metrics could provide complementary insights, improving our understanding of urbanisation dynamics and informing more effective, sustainable planning and policy interventions.

5. Conclusion

This study highlights the urgent need for targeted planning and policy measures to effectively manage the rapid urbanisation in Dar es Salaam. Quantifying the spatial and temporal dynamics of urban sprawl over three decades using landscape metrics provides novel insights into how demographic, economic, and governance factors drive fragmented urban growth, thereby complementing previous qualitative studies.

The findings emphasise the importance of compact urban development, the preservation of green infrastructure, and the improvement of infrastructure and service delivery in peri-urban areas to curb the growth of informal settlements. In the Tanzanian context, rapid urbanisation has outpaced existing urban planning and regulatory frameworks. Planned infrastructural projects, such as formal road networks, urban upgrading initiatives, and housing developments, have partially guided growth and improved accessibility. Still, unplanned settlements in peri-urban zones continue to drive fragmented and irregular urban expansion. These dynamics highlight gaps in policy implementation and underscore the need for integrated governance approaches that combine formal planning, zoning enforcement, and support for informal settlement management.

Apart from the insights offered by this study into urban sprawl and the challenges issuing therefrom, the study also directly supports the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 15 (Life on Land). By analysing the impacts of urban sprawl on land use, green space, and settlement patterns, it demonstrates how effective planning, governance, and landscape management can enhance resilience, promote inclusive and safe cities, and conserve terrestrial ecosystems. Understanding the differential impacts of planned *versus* unplanned development provides actionable insights for Tanzania's urban policies, enabling more equitable service delivery, reduced environmental risk, and sustainable urban growth. Future research should further explore the long-term ecological and social impacts of urban sprawl, including biodiversity, ecosystem services, and housing affordability, to guide sustainable development in rapidly growing cities. Future research should develop more comprehensive urban sprawl indices and explore alternative measures of spatial dispersion to better understand urban expansion patterns and support sustainable planning strategies in Dar es Salaam and other rapidly growing cities.

5.1. Data availability

The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

6. References

Abramova, I.O., 2022. The Population of Africa under the Conditions of Transformation of the World Order. *Herald of the Russian. Academy of Science.* 92(Supp.14), S1306–S1315. https://doi.org/10.1134/S1019331622200023

Bidandi, F., Williams, J.J., 2020. Understanding urban land, politics, and planning: A critical appraisal of Kampala's urban sprawl. *Cities*. 106, 102858.

Demographia, 2022. Demographia world urban areas – built-up urban areas or world agglomerations, *Demographia*.

Elif, S., Topaloglu, H., Sallib, B., Algan, I.Y., 2018. Comparison of landscape metrics for three different level land cover/use maps generated from SPOT6/7 images and an object-based classification approach, in: *GEOBIA 2018 - from Pixels to Ecosystems and Global Sustainability*.

Elmi, M., Rouhani, A., Keshavarz, E., 2022. Landscape metrics for urbanization and urban land-use change monitoring from remote sensing images: A case of Shiraz Metropolis, Iran. *International Journal of Earth Science Knowledge Applications*. 4, 43–50

Gu, D., Andreev, K., Dupre, M.E., 2021. Major trends in population growth around the world. *China CDC Weekly*. 3, 604–613

Igun, E., Williams, M., 2018. Impact of urban land cover change on land surface temperature. *Global Journal of Environmental Science Management*. 4, 47–58. https://doi.org/10.22034/gjesm.2018.04.01.005

Kibassa, D., Shemdoe, R., 2016. Land cover change in urban morphological types of Dar es Salaam and its implication for green structures and ecosystem services. *Modern Environmental Science and Engineering*. 2, 171–186

Kibugu, C.P., Munishi, S., Kongo, V., 2022. Impacts of Land Cover Change caused by Urbanization on the Flood Regime of Msimbazi Catchment in Dar es Salaam, Tanzania. *Tanzanian Journal of Engineering and Technology*. 41.

Lupala, J., 2021. Exploring unbalanced urban spatial expansion in sprawling cities. Case study of Kimara Matangini, Kibululu and Dovya settlements in Dar es Salaam City, Tanzania. *Central European Journal of Geography and Sustainable Development*. 3, 62–84.

Magidi, J., Ahmed, F., 2019. Assessing urban sprawl using remote sensing and landscape metrics: A case study of City of Tshwane, South Africa (1984–2015). *Egyptian Journal of Remote Sensing: Specialized Science*. 22, 335–346. https://doi.org/10.1016/j.ejrs.2018.07.003

Magina, F.B., Kyessi, A., Kombe, W., 2020. The urban land-nexus challenges and opportunities of regularising informal settlements: The case studies of Dar es Salaam and Mwanza in Tanzania. *Journal of African Real Estate Resources*. 5, 32–54.

Mensah, C., Atayi, J., Kabo-Bah, A.T., Švik, M., Acheampong, D., Kyere-Boateng, R., Prempeh, N.A., Marek, M. V., 2020. Impact of urban land cover change on the garden city status and land surface temperature of Kumasi. *Cogent Environmental Science*. 6, 1–16. https://doi.org/10.1080/23311843.2020.1787738

Merem, E.C., Twumasi, Y., Wesley, J., Alsarari, M., Fageir, S., Crisler, M., Romorno, C., Olagbegi, D., Hines, A., Mwakimi, O.S., Nwagboso, E., Leggett, S., Foster, D., Purry, V., Washington, J., 2019. Analyzing Land Use and Change Detection in Eastern Nigeria using GIS and Remote Sensing. *American Journal of Geographic Information Systems*. 8, 103–117. https://doi.org/10.5923/j.ajgis.20190802.06

Mkalawa, C.C., Haixiao, P., 2014. Dar es Salaam City: temporal growth and its influence on transportation. *Urban, Planning. and Transportation Resources*. 2, 423–446.

Mnyali, E.T., Materu, S.F., 2021. Analysis of the current and future land use/land cover changes in peri-urban areas of Dar es Salaam City, Tanzania, using remote sensing and GIS techniques. *Tanzanian Journal of Science*. 47, 1622–1636.

Mzava, P., Valimba, P., Nobert, J., 2021. Quantitative analysis of the impacts of climate and land-cover changes on urban flood runoffs: A case of Dar es Salaam, Tanzania. *Journal of Water and Climate Change.* 12, 2835–2853. https://doi.org/10.2166/wcc.2021.026

Nuhu, S., Munuo, N., Mngumi, L., 2023. Governance challenges of regularisation of informal settlements in peri-urban Tanzania: perspectives from local stakeholders. *International Journal of Urban Sustainable Development*. 15, 35–47. https://doi.org/10.1080/19463138.2023.2167821

Nyongesa, S.K., Maghenda, M., Siljander, M., 2022. Assessment of Urban Sprawl, Land Use and Land Cover Changes in Voi Town, Kenya, using Remote Sensing and Landscape Metrics. *Journal of Geography, the Environment and Earth Sciences: International*. 26, 50–61. https://doi.org/10.9734/jgeesi/2022/v26i430347

Pison, G., Poniakina, S., 2024. The Population of the World (2024). *Population and Society*. 626, 1–8.

Ramuhulu, T.C., 2021. The prospectus and challenges of rural urban migration in South African cities: perceptions from integrated development plans.

Simon, O., Lyimo, J., Gwambene, B., Yamungu, N., 2024. Unveiling the Transforming Landscape: Exploring Patterns and Drivers of Land Use/Land Cover Change in Dar es Salaam Metropolitan City, Tanzania. *African Geographical Review*. https://doi.org/10.1080/19376812.2024.2309405

Simon, O., Yamungu, N., Lyimo, J., 2023. Influence of Urban Land Use / Land Cover Changes on Land Surface Temperatures in Dar es Salaam Metropolitan City, Tanzania : The Use of the Geospatial Approach 49, 356–368.

Simon, O., Yamungu, N., Lyimo, J., 2022. Simulating land surface temperature using biophysical variables related to building density and height in Dar es Salaam, Tanzania. *Geocarto International*. 88, 1–18. https://doi.org/10.1080/10106049.2022.2142971

Sumari, N.S., Cobbinah, P.B., Ujoh, F., Xu, G., 2020. On the absurdity of rapid urbanization: Spatio-temporal analysis of land-use changes in Morogoro, Tanzania. *Cities*, 107, 102876. https://doi.org/10.1016/j.cities.2020.102876

Tewabe, D., Fentahun, T., 2020. Assessing land use and land cover change detection using remote sensing in the Lake Tana Basin, Northwest Ethiopia. *Cogent Environmental Science*. 6, 1–21.

United Nations, D. of E. and S.A. and P.D., 2019. World Population Prospects 2019: Highlights (ST/ESA/SER.A/421), *World Population Prospects*, 2019. New York: United Nations.

United Republic of Tanzania, 2022. 2022 Population and Housing Census - Preliminary Report in Swahili Language.