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Data on Land Use Land Cover Changes of Urban and Peri-Urban Areas: The Case of Mwanza City in Tanzania

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Abstract

Lack of detailed data on the dynamics of land use and land cover (LULC) changes in urban and peri-urban areas is a key problem in Tanzania, resulting in poor urban development. Most of the decisions made on land use management have always been reactive, with negative impacts on the livelihoods of people, the environment, ecosystem services, and biodiversity. The purpose of this study is to identify the spatiotemporal land use and land cover changes in urban and peri-urban Mwanza City in Tanzania for sustainable urban development. Using QGIS 3.8 Zanzibar, the Landsat Thematic Mapper (TMs) and Operational Land Imager images were generated. Six land use and land cover types under supervised classifications were produced. The dynamics of each land use and land cover type and the direction of change over 20 years (1999-2019) were determined. The overall accuracy of land use and land cover change maps was 93%, 96%, and 93% for 1999, 2009, and 2019, respectively. The calculation of the change in each land use and land cover type was done, and the results show that between 1999 and 2019, built-up area increased by 350% and grassland, woodland, and bareland decreased by 68%, 56%, and 30%, respectively. The cultivated area showed some ups and downs during the same time period. Also, in the period between 1999 and 2019, the wetland area increased by 11%. This was due to an increase in surface runoff resulting from increased paved surfaces in upstream lands because of the built-up environment. The findings of this study have shown that the capture of spatiotemporal data on the dynamics of land use and land cover will enable the Mwanza City authority to make better-informed decisions for sustainable urban development.

Keywords

Land Use/Cover, Urban Expansion, Urbanisation, Remote Sensing, GIS,

Tanzania

1. Introduction

Today, the world is urban; whereby, 56% of the world population, or 4.4 billion people, reside in cities (UN DESA, 2022). Urbanisation, the gradual change of human residence from rural to urban regions, coupled with the natural increase in urban population, will add 2.5 billion more people to the world's urban population by 2050, whereby 7 out of 10 individuals will be living in cities (Mahendra & Seto, 2019). Nearly 90% of this increase will occur in Asia and Africa (UN DESA, 2018).

Though, Africa is the least urbanised region in the world with 43% of the population living in urban areas (UN DESA, 2018), the continent has experienced the highest urban growth rate of 4.6 over the last ten years (UN DESA, 2022). As a result of rapid urban population growth and rural-urban migration (Muchelo, 2018), it is anticipated that by 2025, more than half of the people of Africa will live in urban areas (UN DESA, 2018). However, urban sprawl is becoming a critical issue for urban planners and academic research as African nations increasingly urbanise, especially in major cities (Bhanjee & Zhang, 2018).

Generally, urbanisation is beneficial as it accounts for more than 80% of the world's GDP in cities, especially when it is managed well, as it supports sustainable growth through improved productivity and innovation (UNDP, 2018). This is due to the fact that urbanisation has the potential to be a formidable enabler of development, structural economic reform, and cost-effective service delivery (Tanzania Urbanisation Laboratory (TULab), 2019).

However, if the urbanisation is not managed well, it can lock up the land use patterns and physical form of the city once it is built up, which is difficult to undo. But also, urban population expansion is the main cause of the excessive rate of urban sprawl in cities in the global south (Shao et al., 2020). Unchecked and unplanned urbanisation can lead to negative externalities such as land degradation, pollution, the spread of disease, and higher levels of crime and congestion (Hossain & Huggins, 2021). Unfortunately, most of the urbanisation in the Sub-Saharan Africa region is unplanned, is far from efficient regularisation, and is unjust (Wasonga et al., 2022).

It is estimated that 141% of city land area expansion will occur in low-income countries over the next five decades from 2020 levels due to urbanisation. This growth is projected to be highest in Africa, where it is estimated to almost double (UN-Habitat, 2022). Nevertheless, according to UN-Habitat (2018), the rapid spatial expansion of most cities in Africa has already resulted in inequalities, inadequate provision of urban basic services, exclusion, displacement of people, insecurity, urban poverty, and low capital investments to finance urban growth. But it also places significant pressure on environmental resources and quality

(Mahendra & Seto, 2019).

Hence, it calls for the need to have effective urban and territorial planning ahead of such expansion that can mitigate the negative impact (UN-Habitat, 2022). According to the World Bank (WB, 2009), "if urbanisation is done properly, it can help development more in Africa than anywhere else." However, the lack of spatial data has made it difficult to do quantitative and qualitative study on urbanisation, particularly in poor nations in Asia and Africa (Murayama et al., 2021). As most of the land use and land cover change is thought to be significantly influenced by urbanisation (Rana & Sarkar, 2021).

In that respect, many scholars are now focusing on the availability of urban spatial data as a key to sustainable urban development (Shao et al., 2020; Murayama et al., 2021). Keith et al. (2023) advocate for the need to capture the spatial-temporal variation of urbanisation trends, as it can help to have better implementation of sustainable urban planning in emerging nations. Subsequently, the advent of remote sensing and geographical information systems (GIS) technologies in spatiotemporal data acquisition and analysis in the recent past has enabled the detection of land use and land cover dynamics for sustainable urban development (Murayama et al., 2021). By using satellite imagery over a certain period of time, remote sensing methods can be employed to analyse land use and land cover dynamics (Mawenda et al., 2018).

Tanzania, like other Sub-Saharan African countries, is also urbanising rapidly. The urban population (36.7%) with an urbanisation rate of 4.9%, driven mainly by urban population growth, has been growing by 5.2% per year over the past decade, and it is projected that over half of the population will be living in urban areas by 2050 (Tanzania Urbanisation Laboratory (TULab), 2019). Tanzania is now listed among the top 8 countries in the world that will have the greatest contribution to global population growth, both in its rural and urban areas, by 2050 (UN-Habitat, 2022).

At present, however, most cities' urban expansions in the country are taking place without any clear urban policy in place. As a result, cities are unplanned and uncoordinated, leading to sprawl, congestion, and low economic multipliers (Tanzania Urbanisation Laboratory (TULab), 2019). However, among the most affected urban centres in the country is Mwanza City, the second-largest city in Tanzania after Dar-es-Salaam. Seventy-five percent (529,839 out of 706,453) of the population in the city lives in unplanned settlements (UN-Habitat, 2022).

Mwanza is a significant city on Lake Victoria and a thriving commercial centre for the Great Lakes region and the larger East African community. The centre has strategic significance (Mwanza City Socio-economic Profile, 2022). With an annual urban population growth rate of 6% (**Table 1**) and an urban population projected to grow to 2.4 million people by 2035 (Worrall et al., 2017), this calls for concerns as much of this growth has numerous implications. Currently, the city's rapid urbanisation is putting strain on critical urban infrastructure and services, including health care, drinking water, housing, and roads (MCC, 2023).

Table 1. Mwanza city population growth, 1967-2022.

Population					
1967	1978	1988	2002	2012	2022
34,861	110,553	172,287	385,810	706,453	1,104,521
Growth rate (% per annum)					
1967-78	1978-1988	1988-2002	2002-2012	2012-2022	
11	5	6	6	5.2	

Source: Summarised from national census records for 1967, 1978, 1988, 2002, 2012 and 2022.

However, despite the fact that numerous studies on land use and land cover changes in Tanzania have been conducted (Mnyali & Materu, 2021; Kitalika & Mlengule, 2021), in-depth research on changes in cities is still lacking. According to Mulugeta et al. (2017) lack of spatial information is hampering effective economic and environmental planning due to ill-informed policy implementation. Thus, addressing the challenges of urbanisation in Mwanza City requires a clear understanding of land use and land cover dynamics.

This study, therefore, using Landsat satellite images, attempted to quantify and analyze the land use and land cover changes of urban and peri-urban Mwanza City in Tanzania. The aim of the paper is to provide data that informs on the status of urban and peri-urban Mwanza City land use and land cover dynamics. The data is helpful to Mwanza City urban planners, managers, and policymakers to make informed decisions in the management of land use for sustainable urban development. This is in line with urban sustainable development goal 11, which cherishes cities and human settlements that are inclusive, safe, resilient, and sustainable.

2. Materials and Methods

2.1. Study Area

Mwanza City is situated on the southern shores of Lake Victoria in the northwest of Tanzania. It is located between latitudes 2˚15'S and 2˚45'S and between longitudes 32˚45'E and 33˚05'E (**Figure 1**). It is located at an elevation of 1140 metres above sea level and has a total area of roughly 1337 km^2, of which 437 km^2 (or 32% of the total area) is dry land and 900 km^2 (or 68%) is water (MCCR, 2017). About 86.8 km^2 of the 437 km^2 of dry land are urbanised; the other portions are made up of valleys, agricultural plains, forested land, grassy areas, and undulating rocky mountainous areas (MCCR, 2017). As a colonial economic and administrative hub for cotton production and gathering in the Lake Region, Mwanza was first created in 1892. As a town council in 1953, a municipal council in 1980, and a city council in 2000, it has advanced in terms of standing administratively (MCCR, 2017). Through the local government Act No. 7 of 1982, the Mwanza City Council was divided into two entities on October 1, 2012,

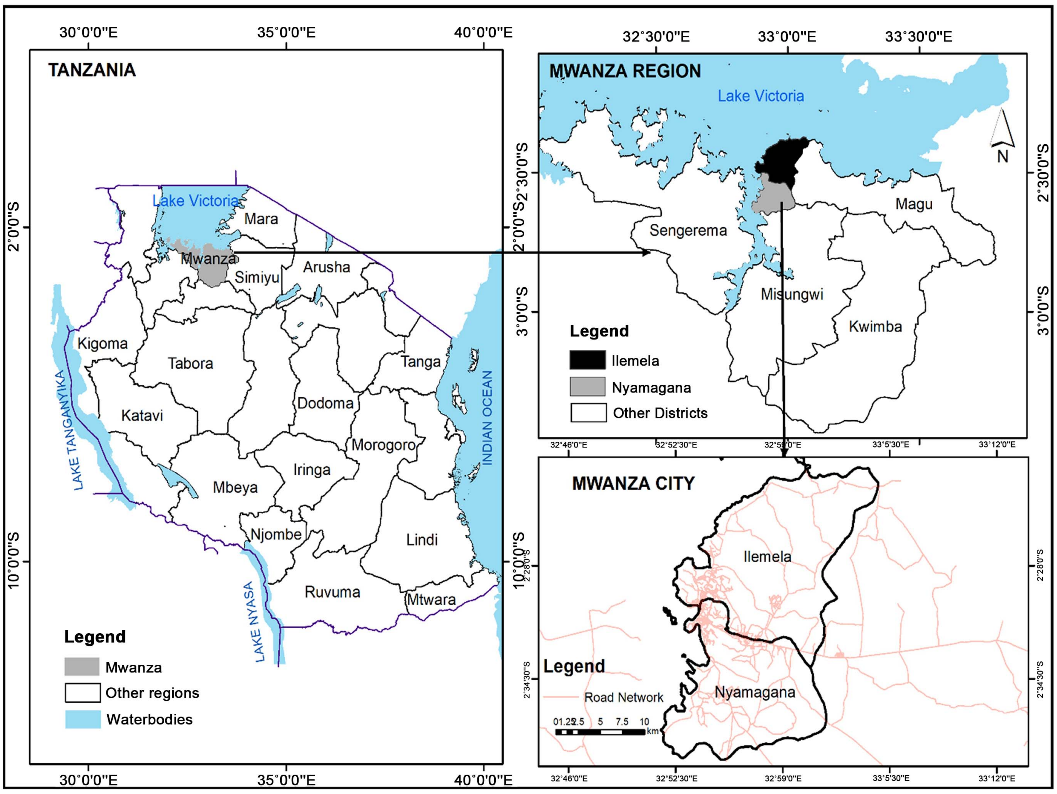

Figure 1. Map of Mwanza city, Tanzania.

notably the new Mwanza City Council (Nyamagana) and the Ilemela Municipal Council (Ilemela). The Nyamagana District (MCC) and the Ilemela District (IMC) are the two administrative districts that make up Mwanza City (MCCR, 2017).

2.2. Sources of Data

The study used the Landsat 5 TM (thematic mapper) and 8 OLI (operational land imager) satellite images to classify and analyse the land use and cover classes (**Table 2**). The satellite images were downloaded from the United States Geological Survey's (USGS) Earth Explorer (https://earthexplorer.usgs.gov/). The year 1999 was selected to correspond to the dawn of urban changes and development in Tanzania (Peter & Yang, 2019), and the year 2019 was selected because it was during the time period when most urban activities slowed down due to COVID 19.

2.3. Methodology

2.3.1. Image Pre-Processing and Classification

The QGIS 3.8 Zanzibar version was employed for pre-processing and processing of image data. This was done through the Semi-Automatic Classification plugin tool. First, images were geometrically corrected and georeferenced using the Datum ARC 1960 and the UTM zone 36S coordinate systems. Then the

Table 2. Description of the landsat satellite images used in the study.

Landsat Images	Sensor	Path/row	Date of acquisition	Spatial resolution	Source
Landsat 5	TM	171/62	9th July 1999	30 m	USGS
Landsat 5	TM	171/62	18th June 2009	30 m	USGS
Landsat 8	OLI	171/62	2nd July 2019	30 m	USGS

supervised classification approach under the Maximum Likelihood Classification (MLC) method was adopted to create six land use and cover classes, namely woodland, grassland, cultivated land, wetland, built-up area, and bareland (**Table 3**). The MLC method was used because it is quick, simple to use, and allows for a straightforward interpretation of the findings (Jiménez et al., 2018).

2.3.2. Accuracy Assessment of Classification

The accuracy assessment was done to quantify the efficiency with which pixels were classified into the appropriate feature classes in the area under study. The accuracy testing compares the classified outputs to presumed-true geographically referenced data (ground truth) (Mawenda et al., 2018). The classified images for 1999, 2009, and 2019 were tested for accuracy using the error matrix method (**Table 6**) in QGIS 3.8 Zanzibar using the accuracy assessment tool embedded in the Semi-Automatic Classification plugin. Ground truth polygons for each land cover and land use were collected from high-resolution satellite images in the Google Earth platform. Both ground truth polygons and the classified images were supplied to the accuracy assessment tool as reference data.

The computation of kappa coefficient, overall accuracy, producer accuracy, and user accuracy was done from the classified images. The kappa coefficient displays the degree of similarity between a set of control polygons and the classified image, while the overall accuracy represents the proportion of pixels that have been correctly identified. On the other hand, the producer's accuracy displays the proportion of a certain land use change in the image that is accurately identified. Meanwhile, the user accuracy is the proportion of a land use class in the image that matches the class that relates to the land (**Table 6**). The kappa coefficient is computed by the following formula

$$k = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}\left(x_{i+} \times x_{+i}\right)}{N^2 - \sum_{i-1}^{r}\left(x_{i+} \times x_{+i}\right)} \qquad \text{Equation (1)}$$

where,

k = kapa coefficient

r = number of rows in the error matrix

x_{ii} = number of observations in row 1and column 1

x_{i+} = marginal totals of row 1

x_{+i} = marginal totals of column 1

N = total number of observations

Table 3. Description of land use/cover classes.

	Land use/cover classes	Land Use/Cover Description
1	Woodland	Forest covers including tree cover
2	Grassland	Land covered with pastures
3	Cultivated land	Land covered with crops & crop fields
4	Wetland	Rivers, streams, reservoirs & swamps
5	Built-up area	Buildings and all other man-made structures
6	Bare land	Outcrop rock & bare ground/vacant land

Between classification categories, a Kappa value of more than 0.80 indicates excellent agreement, a value between 0.4 and 0.80 suggests moderate agreement, and a value lower than or equal to 0.4 indicates poor agreement (Mawenda et al., 2018).

In this case the kappa coefficients for:

a) 1999 was

$$k = \frac{16,377(15,277) - 83,158,434}{(16,377)^2 - 83,158,434} = 0.90$$

b) 2009 was

$$k = \frac{21,267(20,479) - 180,019,140}{(21,267)^2 - 180,019,140} = 0.93$$

c) 2019 was

$$k = \frac{22,043(20,531) - 160,958,353}{(22,043)^2 - 160,958,353} = 0.89$$

2.3.3. The Rates of Change

The calculations were made to determine the amount of change in land use and cover in hectares and the percentage change across ten-year intervals (**Table 4**). The rate of change in percent was calculated by the following formula.

$$\%\Delta = \left(\frac{\text{final} - \text{initial}}{\text{initial}}\right) \qquad \text{Equation (2)}$$

where,

$\%\Delta$ = percentage of change, initial = earlier year, final = later year.

2.3.4. Land Use and Land Cover Change Detection

The gross gains, gross losses, and persistence were used to examine the amount of land use and land cover change by category. The maps of 1999 with 2009 and 2009 with 2019 were overlain to create a matrix that shows the land use and land cover regions by categorical transition between the two points in time. The on-diagonal entries represent the persistence of categories, whilst the off-diagonal entries represent the proportions of the land that underwent transition from one kind to another. The column totals at the bottom show the percentage of the

Table 4. Proportion of land use/cover change in urban and peri-urban Mwanza city, 1999-2019.

Land use/cover type	1999		1999-2009	2009		2009-2019	2019		2019-1999
	Area (ha)	Area (%)	Rate of Change (%)	Area (ha)	Area (%)	Rate of Change (%)	Area (ha)	Area (%)	Rate of Change (%)
Woodland	1821.42	4	−40	1099.26	3	−28	795.03	2	−56
Grassland	8972.46	20	−60	3632.83	8	−20	2909.96	7	−68
Cultivated Land	24864.84	57	18	29406.43	68	−10	26345.31	61	6
Wetland	492.66	1	10	543.36	1	0.3	544.8	1	11
Built-up Area	2039.04	5	107	4218.94	10	118	9176.47	21	350
Bare land	5286.33	12	−13	4575.93	11	−19	3705.18	9	−30
Total	**43476.75**	**100**	-	**43476.75**	**100**	-	**43476.75**	**100**	-

Source: Extracted from analysis of Lands at images of 1999, 2009 and 2019; **ha = hectare*.

landscape by category in 1999 and 2009. The row totals on the right show the percentage of the landscape by land use/cover category in 2009 and 2019 (Table 5).

To determine the gross gains and gross losses by categories, the cross-tabulation matrix of 1999, 2009, and 2019 is extended. The persistence is subtracted from the column total to calculate the gross gain for each category, and the persistence is subtracted from the row total to calculate the gross loss.

3. Results and Discussion

3.1. Land Use and Land Cover Changes in Urban and Peri-Urban Mwanza City, 1999-2019

In this study, land use and land cover changed from one category to another at some point in the period of 20 years. Figure 2 shows the classified land use and land cover maps, whereby the built-up area, which is represented in red, increased significantly from 1999 to 2019. Similarly, wetland (blue colour) increased slightly during the same time period. On the contrary, the grassland (light green colour), woodland (green colour), and bareland (dark colour) decreased significantly during the same time period. However, the cultivated portion (pink colour) shows that it increased from 1999 to 2009 and decreased from 2009 to 2019 (Figure 2). The subsequent statistics results in Table 4 indicate an increase in built-up area of 350% from 1999 to 2019. In the period between 1999 and 2009, the built-up area increased by 2179.9 hectares (107%), whereas between 2009 and 2019, it increased by 4957.53 hectares (118%) (Table 4). On the other hand, between 1999 and 2019, the grassland, woodland, and bareland decreased by 6062.5 hectares (68%), 1026.12 hectares (56%), and 1581.15 hectares (30%) (Table 4).

3.2. Cross-Classification Analysis Results

The cross-classification analysis maps, when interpreted visually, show that all

Table 5. Land use/cover transition matrix for1999-2019 (in hectares).

		2009						
		Woodland	**Grassland**	**Cultivated land**	**Wetland**	**Built up area**	**Bare land**	**Total**
2019	Woodland	516.01	35.64	186.4	62.91	118.31	40.48	795.03
	Grassland	34.83	1605.26	1355.76	22.95	686.46	13.59	2909.96
	Cultivated land	74.3	1246.36	25435.62	97.83	189.96	0.84	26345.31
	Wetland	29.07	11.16	90.09	394.59	9.87	52.02	544.8
	Built-up area	222.82	1900.64	2300.89	19	3252.94	1500.17	9176.47
	Bare land	222.49	10.9	1.05	8.98	957.43	1930.15	3705.18
	TOTAL	1099.26	3632.83	29406.43	543.36	4218.94	4575.93	43476.75
		1999						
		Woodland	**Grassland**	**Cultivated land**	**Wetland**	**Built up area**	**Bare land**	**Total**
2009	Woodland	925.53	125.76	537.82	24.72	163.35	44.24	1099.26
	Grassland	68.22	2175.69	6158.52	16.92	551.79	1.32	3632.83
	Cultivated land	78.26	1316.81	22684.97	73.44	706.7	4.66	29406.43
	Wetland	27.25	12.61	22.23	422.04	7.38	1.15	543.36
	Built-up area	712.5	728.7	728.9	3.42	2,032.22	3.4	4218.94
	Bare land	0	1.96	2.89	2.82	757.5	4521.16	4575.93
	TOTAL	1821.42	8972.46	24864.84	492.66	2039.04	5286.33	43476.75

Source: Cross-tabulation analysis.

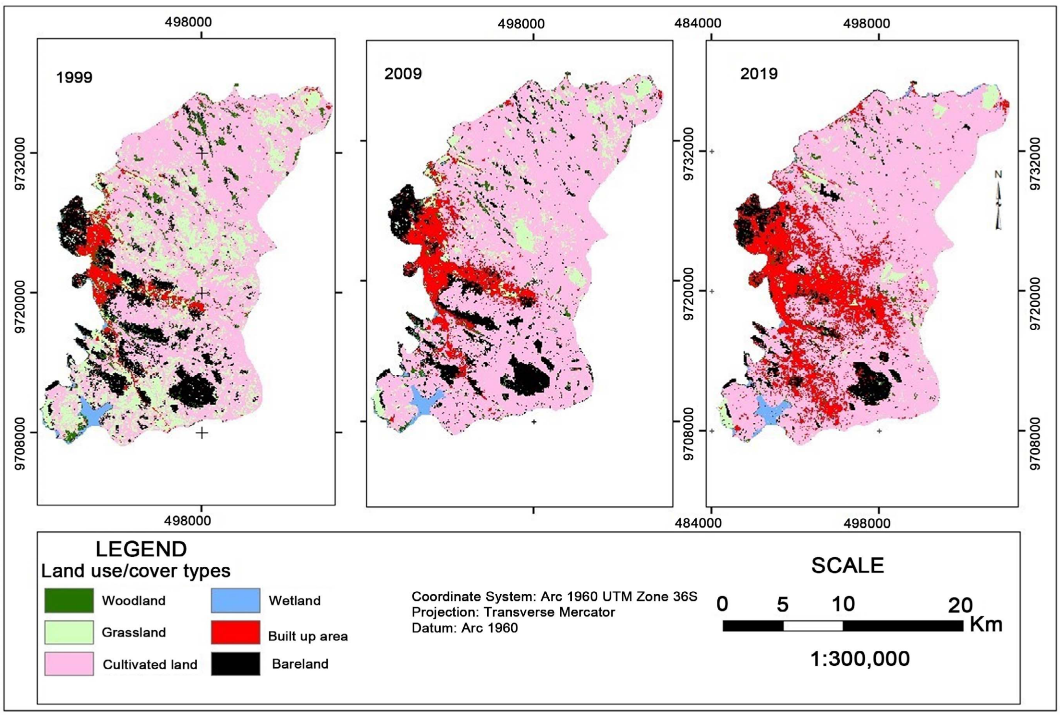

Figure 2. Land use and land cover maps of 1999, 2009 & 2019.

land use and land cover had their portions altered from one type to another in all periods from 1999 to 2009 and 2009 to 2019. The locations of alteration for each unique land use and land cover from one type to another are depicted by the colours used in the map legend of each map (**Figure 3** & **Figure 4**).

The information in **Figure 3** & **Figure 4** is supplemented with the cross-tabulation analysis results in **Table 5**, which show the fractions of alteration for each land use and land cover quantitatively. For instance, in the year 1999, the total land use and land cover of the built-up area was 2039.04 hectares, and it expanded to 4218.94 hectares in the year 2009 because of additional land acquired from other land uses and land covers. This increase was contributed by woodland (712.5 hectares), grassland (728.7 hectares), cultivated land (728.9 hectares), wetland (3.42 hectares), and bareland (3.4 hectares) (**Table 5**). On the other hand, in the year 2019, the total land use and land cover of the built-up area expanded to 9176.47 hectares, due to the acquisition of land from woodland (222.82 hectares), grassland (1900.64 hectares), cultivated land (2300.89 hectares), wetland (19 hectares), and bareland (1500.17 hectares) (**Table 5**).

The findings show that there was a rapid expansion of the built-up area compared to urban population growth. The built-up area grew by a rate of 350% compared to an overall average growth rate of 5.2% urban population in Mwanza City in the 20-year-time period (UN DESA, 2022). This growth was associated with the encroaching of 2630 hectares of grassland into built-up areas (**Table 5**) during the same time period. Since the majority of the peri-urban residents of Mwanza City are of the Sukuma ethnic group who are traditionally cattle herders, the conversion of grassland to a built-up area affected their livelihood as the land was used to graze livestock (Kaganga, 2023).

Also, between 1999 and 2019, 935 hectares of woodland were lost to built-up areas (**Table 5**), depriving the majority of urban and peri-urban residents of the cheapest source of energy, charcoal and firewood. This is because 90% of households in Tanzania were using either charcoal (21%) or firewood (69%) as their source of energy for cooking as of 2017 (Doggart et al., 2020). Not only that, but also, livestock keepers lost wood that was used to construct traditional animal kraals (Kaganga, 2019).

Between 1999 and 2019, bareland lost 1715 hectares to built-up area (**Table 5**). Much of the bareland surfaces affected by urbanisation are rock outcrops (inselbergs). Mwanza City is known as "The Rock City" because of its gently sloping granite and granodiorite physiography with isolated rock inselbergs (UN-Habitat, 2018). However, rapid urbanisation has increased demand for construction materials, especially in the housing sector; thus, rocks are being quarried to serve that purpose. But also, most of the slums are mushrooming on top of the rocks as much of the land is unplanned (UN-Habitat, 2018), hence, reducing surfaces under bareland.

The area under cultivation varied from time to time. It rose by 18% (4542 hectares) between 1999 and 2009, and then declined by 10% (3061 hectares)

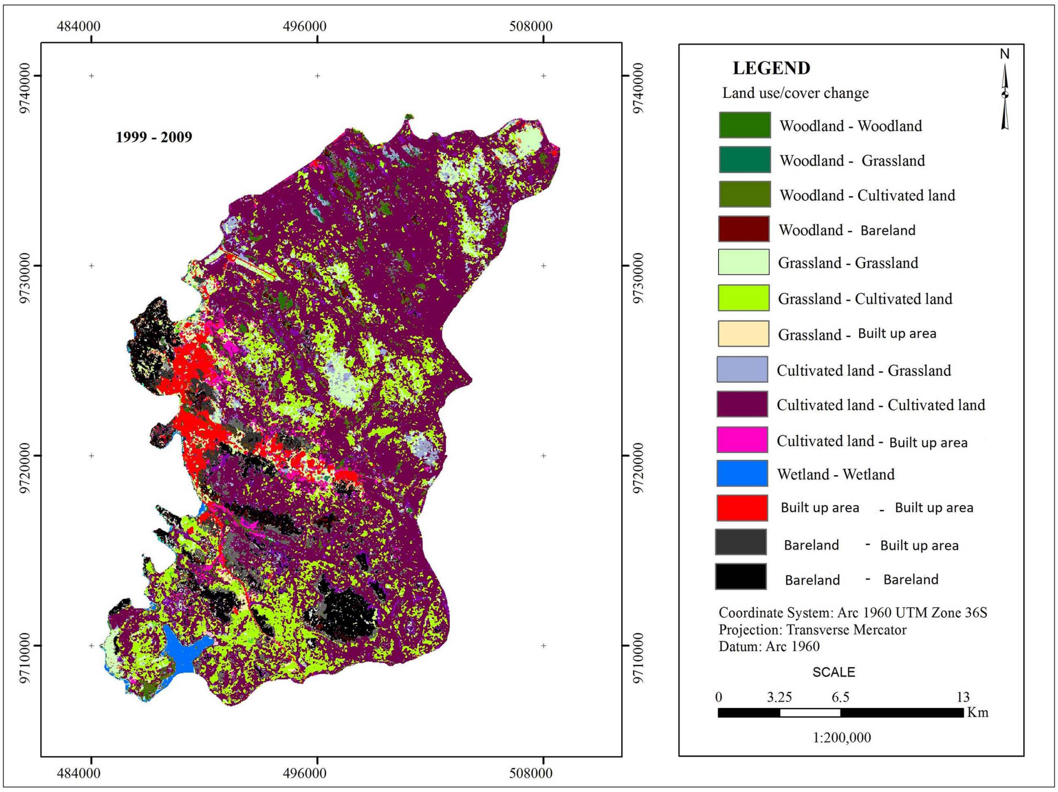

Figure 3. Cross-classification Map 1999-2009.

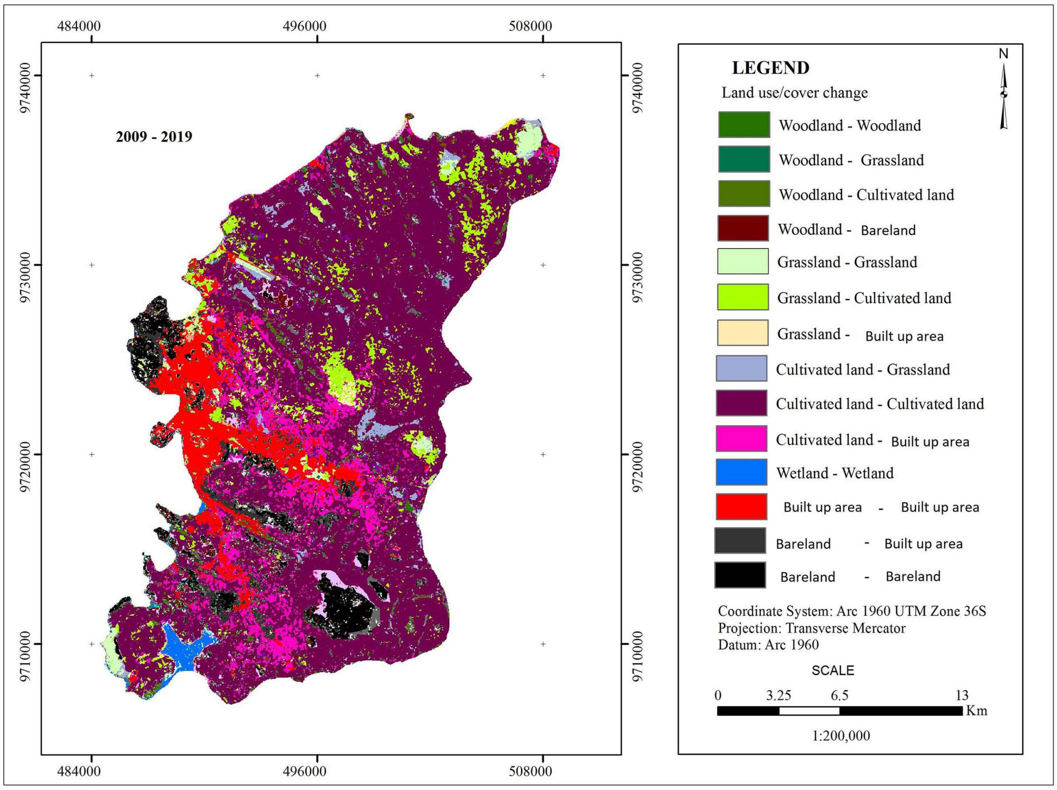

Figure 4. Cross-classification Map 2009-2019.

between 2009 and 2019. Overall, the cultivated area increased by 6% between 1999 and 2019 (**Table 4**). The expansion of cultivated land coincides with the period of exponential economic growth in Mwanza City brought on by the Nile Perch processing industries, trade, and commerce, which attracted migrants, increased food demand, and increased the amount of land available for agricultural use (urban agriculture) in the peri-urban area of the city (Kaganga, 2019). Urban agriculture, the practice of growing crops and raising small livestock on land within the boundaries of cities and towns for domestic consumption or sale in urban markets, is becoming a significant source of food for middle- and low-income families in Sub-Saharan Cities (Vidal et al., 2021). Much of the land in Buhongwa and Buswelu Wards was turned into intensive agriculture, both upland and valley bottoms, in order to feed the burgeoning population in Mwanza City.

On the other hand, the relocation of the Ilemela District headquarters (one of the municipalities that make up Mwanza City) 17 km from the city centre in 2012 attracted a tremendous growth in population and developments in the peri-urban area, leading to the conversion of agricultural land into a built-up environment (Kaganga, 2019). The analysis suggests that 2301 hectares were gained from cultivated area between 2009 and 2019 (**Table 5**). The increase in built-up area is similar to other studies conducted in developing countries' cities, including Nairobi City in Kenya (Macharia, 2018) and Blantyre City in Southern Malawi (Mawenda et al., 2018).

In the period between 1999 and 2019, the wetland area increased by 11% (52 hectares) (**Table 4**). This might be due to an increase in surface runoff resulting from increased paved surfaces (impervious surface areas) in upstream lands due to the increased built-up environment. This is because urbanisation tends to create higher surface runoff and river discharge rates, resulting in an increase in floodplain areas (Feng et al., 2021).

3.3. Accuracy Assessment Report

Table 6 shows the accuracy assessment results, whereby the overall accuracy of the classified images for 1999, 2009, and 2019 was 93%, 96%, and 93%, respectively, with kappa coefficients of 0.90, 0.93, and 0.89. The Kappa coefficients are acceptable as they are rated excellent agreement (Mawenda et al., 2018). Consequently, the classified images were considered appropriate for the study.

4. Conclusion

As the rapid physical expansion of cities becomes central to most developing countries, it is imperative to quantify and detect the extent of change from time to time. The paper identified the spatiotemporal land use and land cover changes in urban and peri-urban Mwanza City in Tanzania for a period of 20 years. The paper shows that land use and land cover changed between 1999 and 2019. Generally, the built-up area expanded rapidly as woodland, grassland, and bareland

Table 6. Accuracy assessment of the land use land cover classification.

	1999		2009		2019	
LULC	Producer's accuracy (%)	User's accuracy (%)	Producer's accuracy (%)	User's accuracy (%)	Producer's accuracy (%)	User's accuracy (%)
Woodland	73	95	78	95	81	82
Grassland	88	86	87	90	82	85
Cultivated land	97	93	98	97	97	92
Wetland	98	100	97	96	97	98
Built-up area	98	95	97	99	89	99
Bare land	86	99	98	91	98	75
Overall accuracy	**93%**		**96%**		**93%**	
Kappa Coefficient	**0.90**		**0.93**		**0.89**	

decreased significantly. The area under cultivation varied from time to time, while the wetland area increased in a small proportion. It is, therefore, suggested that some initiatives be taken by the Mwanza City authority to manage urbanisation for sustainable urban management. This can be done by making use of remote sensing and geographical information technologies to get spatiotemporal information in a timely manner.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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