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Urbanization Effect on Socio-Spatial Landscape of Lodwar Municipality, Turkana, Kenya.

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Abstract:

Background

Urbanization is a global phenomenon whose effect and influence on socio-spatial landscape of urban areas cannot be discounted. This paper focuses on urbanization effect on the socio-spatial landscape of Lodwar municipality from 1999 to 2019. The study outcome is critical in providing spatial evidence necessary to support urban governance and land use planning for sustainable urban areas developments.

Method

This study adopted a mixed research design and employed varied data collection techniques such as land cover analysis and spatial statistical methods. The paper undertook land use/land cover analysis by aid of ArcGIS to reveal effect of urbanization on socio-spatial landscape of Lodwar municipality from 1999 to 2019 at interval of 10 years. Getis-Ord Gi* statistical analysis was applied to measure changes and intensity of spatial concentration of built-up area within Lodwar municipality.

Results

The empirical findings in this study reveal that Lodwar municipality has experienced significant population growth between 1999 and 2019, with almost double population growth between 2009 and 2019.Rapid population growth, and subsequent urbanization effect in Lodwar municipality signifies ***spatial tipping point*** for arid and semi-arid areas which are predominantly communal grazing land. Conversion from community land predominantly for nomadic-pastoralism use to administrative and commercial use, ultimately structures differently socio-spatial landscape of the municipality. This is observed through unplanned developments with only 10% planned, built areas expansion from the core urban area to the community grazing fields and increased encroachment to the riparian reserves of River Turkwel and Kawalase. Land cover analysis showed increase in built-up areas; 0.126% in 1999, 1.207% in 2009, and 2.516% in 2019. Vegetation cover decreased significantly from 17.97% in 1999 to 13.41% in 2009, indicating a shift from a natural rural landscape to a more urbanized landscape. The Getis-Ord Gi* statistic showed high concentration near the CBD in 2009 and a more dispersed patterns in 2019, with high z-scores (+1.97 to + 2.29) with p-values below 0.05. Indicating statistically significant hot spots, which reveals significant effect of urbanization on socio-spatial landscape of Lodwar between 1999 and 2019.

Conclusion

Urbanization has had a significant effect on the socio-spatial landscape of Lodwar municipality. The findings provide insights to governments and planning authorities to adopt comprehensive land use planning strategies to achieve sustainable urban development and better managed urban areas.

Key words: Urbanization, Socio-spatial landscape, Land use plan, built area, human settlement patterns.

1.0 Introduction

The world has been urbanizing rapidly over time, with Sub-Saharan Africa being the fastest urbanizing region between 1960 and 2021(Combes, 2023; *The World Bank. (2020). Data: Total Population . Retrieved May 22, 2022, from Https://Data.Worldbank.Org/Indicator/SP.POP.TOTL*, 2022). This manifest global population increase and shift from rural to urban areas which defines urbanization - presenting significant demographic and physical change of the 21st century. In 2009, approximately 3.4 billion people lived in urban areas, accounting for 50% of the world population(Nations, 2009; UNDESA, 2018). In 2019, approximately 4.3 billion people, accounting for approximately 55% of the global population lived in urban areas(UN-Habitat, 2022; UNDESA, 2018). It is projected that, by 20230, global urban population will reach 5 billion people which represent 60%, while about 70% of the world population will be living in urban areas, by 2050(UN-Habitat, 2022; UNDESA, 2018).

Pronounced majority of the population contributing to urban growth is taking place in Asia at 50% and Africa 43%(Nations, 2009; UN-Habitat, 2022; UNDESA, 2018). Based on the upward trend population growth rate recorded globally and rapidity growth in Sub-Saharan Africa, implies that, more housing and land would be required to accommodate and meet the increasing urban population demand. The rapid urbanization trend observed especially in Sub-Saharan Africa where Kenya is part, brings with it socio-economic and environmental impact to a region in which more than 1/3 of the population is documented to be living with insufficient infrastructure with extreme poverty recorded in 2019(Combes, 2023). The outcome of urbanization ultimately, influences infrastructural and socio-spatial landscape of rapidly growing towns and cities.

The population increase and shifts from rural to urban area is used in this paper to describe urbanization. Urbanization is characterized by increased population density which may occur as a result of either natural population increase within the urban area or rural to urban migration. Urbanization is also used in this paper to reflect physical expansion of urban area and land uses(Kumar & Manegar, 2019). The interconnectedness between social and geographical spaces within the built environment in the context of this research is referred to as the socio-spatial landscape(Mughal, 2023).

In Kenya, urbanization impact on infrastructure and services, alongside its far-reaching effect on socio-spatial landscape of most urban centers in Kenya, can be traced back to British colonial period. According to Kakuma etal. (2007), during colonial period, the urban centers and cities like Nairobi grew up as administrative centers or stop over posts along the Mombasa – Uganda railway line, popularly known as 'lunatic line' (Akumu & Olima, 2007). During the colonial period between 1890, and before Kenya independence in 1963, most of the urban centers along the railway line – like the case of Nairobi experienced spatial segregation based on racial and ethnic lines, a spatial segregation concept which was reinforced by planning laws and zoning regulations (Akumu & Olima, 2007)– which created tripartite spatial structure plan that zoned European, Asian and African into separate residential zones in Nairobi(Akumu & Olima, 2007). The social stratification of human settlement along racial groupings, ethnicity and economic status(Akumu & Olima, 2007) informed the socio-spatial landscape of Nairobi and most urban areas as currently constituted. This colonial concept of stratification has been exacerbated by rapid urbanization, with outcome reflected in the mushrooming informal settlements which served as the source of labor for high income residential zones(Akumu & Olima, 2007). According to the Kenya National Bureau of Statistics(KNBS) and Government of Kenya reports(GoK), approximately 60% of urban population in Kenya live in informal settlements(GoK, 2015; Kenya National Bureau of Statistics, 2019).

A similar trend is mirrored in Lodwar Municipality- where urban growth and developments have surpassed the Land use Plan for Lodwar. Consequently, the human settlement areas within the municipality are characterized with 'dual- city' structures made of formal and informal settlements, inadequate infrastructure and related services such as water and access roads, social stratification based on economic ability to acquire land for residential use, which further creates distinct settlement patterns areas. These challenges can be attributed to urban governance related policies and land use laws which have failed to match land use planning with population growth which subsequently influence socio-spatial landscape of urban areas(GOK, 2016 ;(World Bank, 2016)GoK, 2015; *REPUBLIC OF KENYA KENYA COUNTRY*

REPORT ON PROGRESS IN THE IMPLEMENTATION OF, 2022). Interestingly, this colonial spatial planning influence continues to define the socio-spatial landscape of modern Kenyan urban areas, coupled with rapid urbanization process and the dictates of increased poverty even after 56 years of independence.

The promulgation of the Constitution of Kenya 2010, and enactment of the Urban Areas and Cities Act, 2011, however, shifted the focus and management of urban areas from the single prime city of Nairobi to 47 counties based decentralized - urban headquarters(Republic of Kenya, 2011). Upcoming urban centers like Lodwar municipality have transformed from simple administrative center to County headquarter and commercial hub(World Bank, 2016). The frontier urbanism effect experienced among other factors is driven by devolution impact stemming from the enactment of the Constitution of Kenya 2010, active Non-governmental organization programs and LAPSSET corridor related projects(Muhumed, 2016). Subsequently, the socio-spatial landscape is continuously being shaped up by the effect of urbanization manifested by increased land commodification demand, encroachment into riparian and conversion of community land into private built up environment(CIDP, 2018, 2023)

Sari et al. (2023), study findings reveal that Arnavutköy municipality in Istanbul, was reshaped by an airport and highway developments(Hale et al., 2016; Sari et al., 2023). Similarly, Lodwar municipality and urban areas along the LAPSSET transport corridor in Kenya is continuously being reshaped by the LAPSSET transport corridor developments(Mkutu & States, 2021; Mugendi et al., 2019). Reshaping of the spatial landscape by such mega projects' developments, which rapidly consumes existing pasture, often influence configuration of socio-spatial landscape of an area (Mughal, 2023). Destruction of existing vegetation and land cover of Arnavutköy municipality due to urban growth and expansion, to a greater extend, mirrors fragmentation of Lodwar municipality which was predominantly pastoralist grazing land, but currently undergoing spatial reorganization due to urban developments. The use of landscape matrix measurements which is GIS enabled, resonates with this study's use of GIS technology in analyzing; (a) land use /landcover changes from 1999 & 2019 (b) urbanization growth and extend of urban concentration/expansion using Getis-Ord Gi∗statistic analysis -in order to establish urbanization effect on socio-spatial landscape of Lodwar municipality in two decades between 1999 and 2019.

The study seeks to analyze extend of urbanization effect on socio-spatial land scape with critical assessment on critical components such as; land use /land cover changes, human settlement patterns, social-stratification, environmental impact, and how these shape up physical and social fabric of Lodwar municipality. This is important in managing urbanization effects on socio-spatial landscape of rapidly growing and developing urban areas. Despite existence of comparable studies on the subject matter in the prime cities like Nairobi and other parts of the world, there are no specific study's findings on; **urbanization effect on socio-spatial landscape of Lodwar municipality**. It is therefore, expected that, the findings of the study would contribute to the glaring gaps in the literature, provide insights to governments and planning authorities to adopt comprehensive land use planning strategies and policies to achieve sustainable urban development and better managed urban areas. The remaining sections of the paper is organized as follows: section 2 methodology and materials used in the study, section 3 results and discussion of the study analysis, section 4 conclusion and recommendation arising from the study.

2.0. Methodology and Materials

2.1. Study area location

The study was carried out in Lodwar Municipality covering total area of 799 km^2. The study focus was on the core urban township and peri-urban settlement wards of Nakwamekwi, Kanamkemer/Nawoitorong. The municipality is located in Turkana County in the Northwest part of Kenya with total area of 77,000 km^2, situated along the Kitale-Lokichogio-Juba (South Sudan) route at E 35^0 64′ and N 2^0 53' as indicated in figure 1 below. The Lodwar municipality serves as an administrative headquarters in Turkana County. The area falls under arid and semi-arid zones with high temperatures between 20^0 - 40^o centigrade and receives low rainfall of less than 250 mm per year ((CIDP, 2018; GoK, 2015)

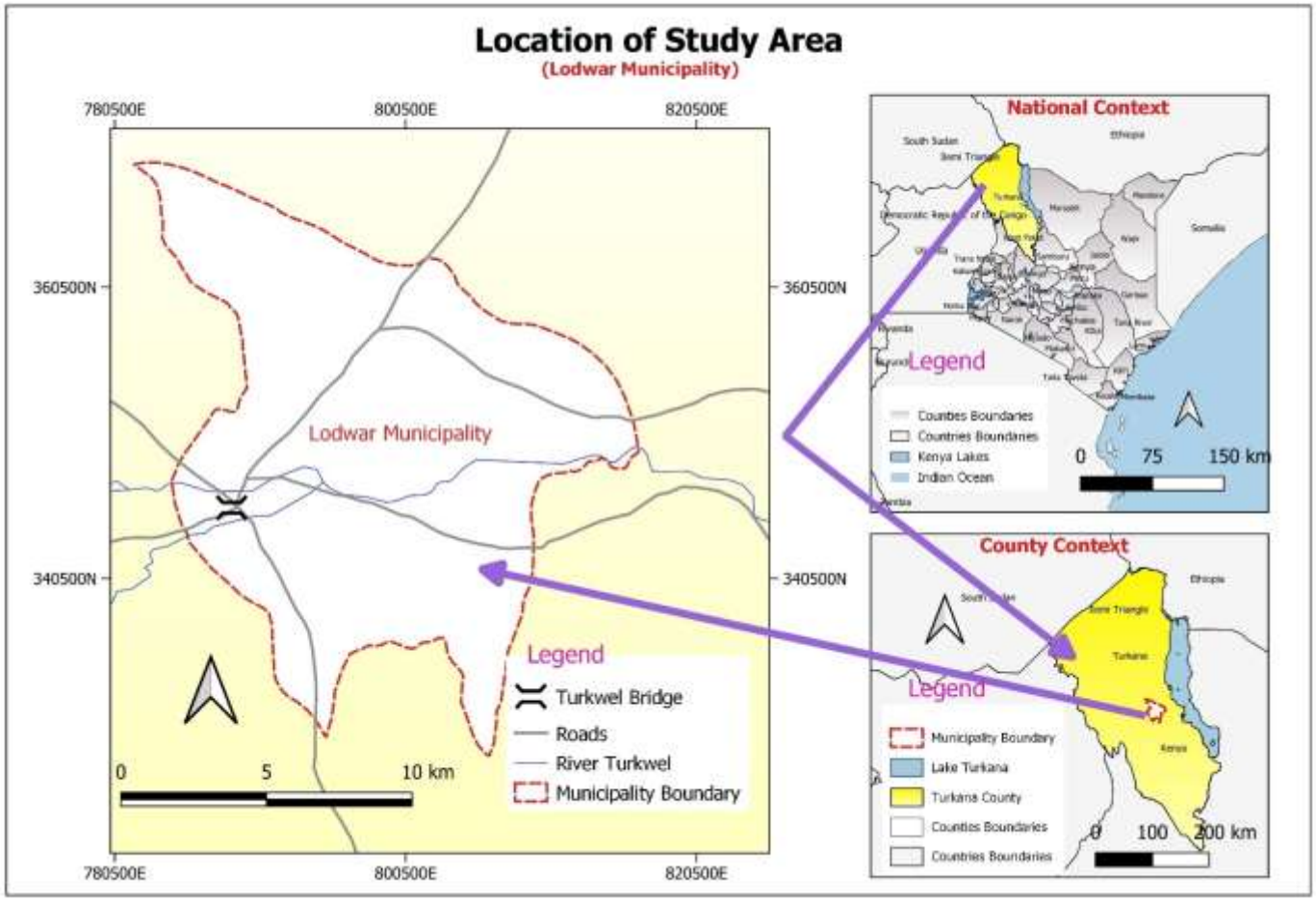


Figure 1: Lodwar Municipality Location in National, Regional and County Context
Source: (Research, 2026 based on KNBS,2009 and 2019

2.1.1 Physical condition and drainage

Lodwar Municipality is located on a plain, surrounded by hills to the northwest, dotted with inselbergs in an arid and semiarid environment with scattered shrubs. The Landscape generally slopes towards Lake Turkana with an average of 500 m above sea level (CIDP, 2018; GoK, 2015)

The main Lodwar Municipality Central Business District (CBD) is located between Turkwel and Kawalase Rivers which influence human settlement. The Turkwel River is the only permanent river originating from the Cherangani Hills to the South and the slopes of Mt. Elgon to the far south. The Kawalase River is seasonal and originates mainly from the Moru-a-Ngisinger hills, the Pelekech Range, and parts of Loima ranges located west of the municipality ((CIDP, 2018; GoK, 2015) Despite its location between the two rivers, a greater percentage of residents of Lodwar municipality are not accessible to portable water(CIDP, 2018).

2.2 Research design, sampling and data analysis procedure

This study adopted a mixed-methods search design. The research design was appropriate for the study because it was cost-effective and allowed the use of a multi-data gathering method that provided strengths that offset the weakness of each research method be it quantitative or qualitative method(Creswell, J. W., & Plano Clark, 2017; Zohrabi, 2013). Quantitively, land use/land cover changes from 1999-2019 was analyzed using ArcGIS, while the information obtained through field observations, key informants and household interviews was qualitatively analyzed to provide insight on urbanization effect on socio-spatial landscape.

The target population of the study involved interviews with sampled households and resource persons within the urban settlement wards of the Lodwar municipality. According to the Kenya Population and Housing Census of 2019, Lodwar municipality had three wards, with a total urban population of 114,031 with 22,174 households. This study focuses on built-up areas, targeting all three urban wards with five urban settlements. Two urban settlements in the township core urban/Central Business District (CBD) were sampled to examine and understand the impact of urbanization on the socio-spatial landscape within the Lodwar municipality. The remaining three urban settlements at the peripheries of the CBD namely; Nakwamekwi on the West, Kanamkemer on the South, and Nawoitorong on the Eastern part of the CBD, were also sampled to examine effect of urbanization on physical and socio-spatial dynamics in the urban settlements within Lodwar municipality as demonstrated in Table 1.

2.3 Sampling Procedure

The sampling procedure adopted the size of the household survey results from the Kenya Population and Housing Census, 2019. Therefore, the number of questionnaires administered to the household heads was calculated based on the 2019 population census results for each of the three urban settlement wards. Household questionnaires were randomly administered to the sampled population in the five villages within the three urban settlement wards, as shown in Table 1. To determine the sample size for the household surveys, the following simplified formula by Yamane (1967) was applied.

According to Yamane (1967) , **Sample size;** $n=N/1+N(e)^2$ where n= sample size, N= Population size, e= level of precision (0.05), with confidence level of 95% (Yamane Taro, 1967) . Since the three urban settlement wards have 21,058 households, our **Sample size (n)** is calculated as

$n= 21{,}058/1+21058(0.05)^2 =21058/53.65=$**393**

To determine the proportion of questionnaires to be administered to household respondents per urban settlement village, sampled settlement households were divided by total target population households multiplied by sample size (n).

Table 1:Sampling Distribution

Sub-County	**Ward Urban centers**	**Urban settlements/ Villages**	**Population & Households (2019, Kenya Population & Housing Census)**	**Proportion No. of questionnaires to be administered to HHs**
Turkana Central	Kanamkemer (Southern part of the municipality)	Kanamkemer	Population 29,965 HHs=6,630	6,630/21058x393=124
		Nawoitorong	Population 14,995 HHs =3,334	3,334/21058x393=62
	Lodwar township (Central area)	Township	Population 16,931 HHs= 4,301	4,301/21058x393=80
		Napetet	Population 13,681 HHs= 2,779	2,779/21058x393=5
	Nakwamekwi (Western part of the municipality)	Nakwamekwi	Population 18,408 HHs= 4,014	4,014/21058x393=75
Total			**21,058**	**393**

2.4 Data collection methods

This study relied on both secondary and primary data sources. The secondary sources of data included reviews and analysis of data and information from existing literature, journals, case studies, land use maps, and satellite imagery analysis. The primary data comprised the data obtained from household surveys through administration of questionnaires and key informants'/resource person's interviews, physical observations, and photography.

2.4.1 Pre-test and administration of Household Questionnaire

A pre-testing exercise for household questionnaires was conducted on 393 households, randomly selected from the five urban settlement villages one week before the actual administration of household questionnaires was carried out. The purpose of conducting the pilot study was to test the reliability and validity of household questionnaires in relation to how urbanization has impacted the socio-spatial landscape in the Lodwar municipality. A pilot study was conducted to test the content validity of the questionnaire in terms of the sequence of questions and wording.

2.4.2 Resource persons and Institution Interviews

To draw experiences specific to the chronology of events leading to the urban growth of Lodwar and its corresponding effect on socio-spatial landscape, key resource persons and institutions heads were interviewed. Four resource persons– a politician, retired teacher, Turkana elder, Turkana County Government Physical Planning officer, and other technical officers–were interviewed separately, and their ideas were put together, compared, and analyzed in order to understand how urbanization has influenced the socio-spatial landscape of the municipality between 1999 to 2019.

2.4.3 Land use mapping and satellite imagery analysis

Quantitatively, land use and land cover satellite imagery analysis overtime (1999,2009 &2019) was undertaken using ArcGIS to establish the effect of urbanization on the socio-spatial landscape of the Lodwar municipality. GIS-aided Getis-Ord Gi∗ statistical analysis, which is a spatial analysis method, was further applied to measure the intensity of urban growth and spatial concentration of built-up areas, as reflected by human settlement patterns in specific zones within the Lodwar municipality.

3.0. Results and Discussion

3.1 Socio-Spatial History of Lodwar Municipality

Lodwar's urban area history of establishment and subsequent urban growth dates back to1919, when Lodwar started as an army base for the British colonial government and grew to serve as a colonial administrative center for the vast northwestern Kenya region in the 1930s. Lodwar grew over time and further became a town that served as the administrative headquarters for the greater Turkana District (according to one resource person who was once a member of parliament for Turkana Central constituency, where Lodwar town was then the headquarter). "*Politically, Lodwar also owes its growth to its geographical location which is adjacent to Turkwel River". He added.* According to the politician, the bridge across Turkwel river and the 'A1'road traversing through Lodwar was used as a reference point - to determine and divide the greater Turkana District (currently Turkana County) into three constituencies with three elected members of parliament representing each constituency. The boundaries of the three constituencies namely; Turkana East, West, and South, adopted the natural landscape of River Turkwel as their political boundary reference point as demonstrated in figure 2 below. The Turkana East Constituency, had the starting point beginning from Turkwel River bridge – through the entire land on the eastern part of Lodwar-Lokichogio 'A1' road, including Lake Turkana region, Todonyang' and Lokitaung areas.

Turkana West Constituency started from the Turkwel River bridge, through the entire land on the western part of the Lodwar-Lokichogio 'A1' road, including areas of Pelekech and Lorokon. The Turkana South Constituency had a starting point beginning from the Turkwel River bridge, covering the expansive land on the southern part of the River Turkwel as demonstrated in figure 2 below.

The residents of the three constituencies, however, preferred Lodwar as their common urban center with the basic physical and social infrastructure necessary for better human living standards. The livability and secure environment in Lodwar attracted a significant population from the three constituencies to migrate and settle in Lodwar as their preferred destination for trade and commerce, formal employment, access to social services, and other opportunities associated with vibrant growing urban centetre. To date, Lodwar is a cosmopolitan urban area home to different tribes in Kenya and nationalities across the globe. The influx of people into Lodwar from the rural areas of Turkana County, other parts of Kenya, and refugees from different nationalities, immensely contribute to the burgeoning population and, therefore, urbanization in Lodwar municipality as currently experienced.

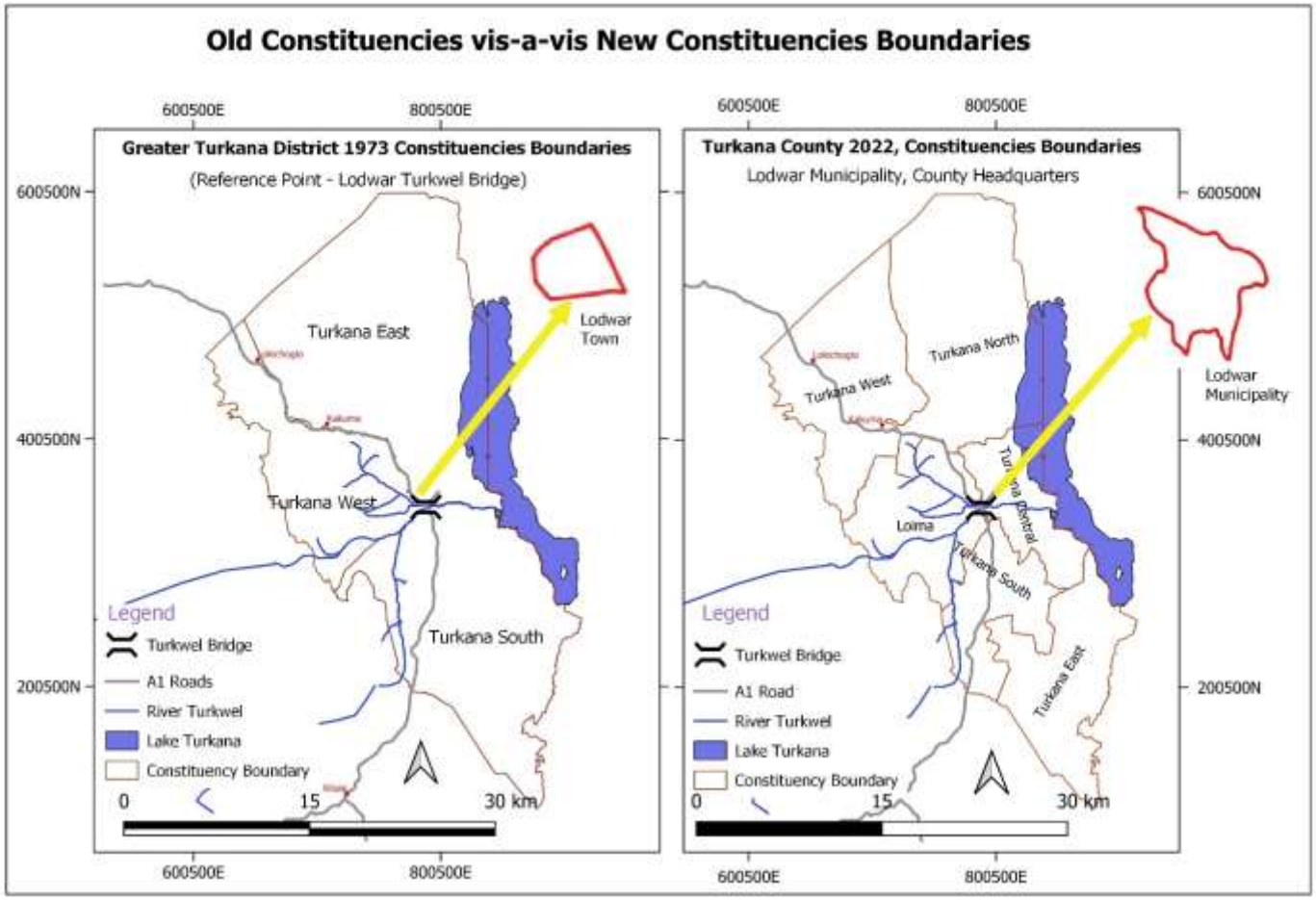


Figure *2*: Old constituencies vis-à-vis new constituencies boundaries

(Source: Research, 2026)

The second resource person who is a Turkana elder said, "*Lodwar was once a small trading centre, with countable number of buildings, surrounded with palm trees bushes and hills. It was a trading centre where nomadic pastoralists would meet to exchange their livestock and conduct barter trade with business men who were mostly of Somali origin in 1950's. It had one colonial administration building block on the hill, and only one primary school (Lodwar) serving the*

greater Turkana district (currently Turkana County)." He further added, '*one cannot imagine presently how Lodwar has extensively grown large from a small trading centre to a town and currently to a municipality hosting Turkana County headquarters with many institutions, commercial and residential buildings dotting the landscape*"

The Lodwar municipality history narrative was further reinforced by a third resource person, an elder who was once a student at Lodwar Primary School in 1956. The resource person highlighted that Lodwar developed gradually as an administrative area and military support base for the military camp at Lokitaun'g in Turkana North, where the first president of Kenya and four other political prisoners were detained by the British colonial government. The development and growth of the Lodwar Centre was influenced by the British colonial government's administration structures. According to the third resource person, the old development structures marked the initial stages of urban growth and urbanization of Lodwar, which defined the spatial layout of the present Lodwar municipality. The old infrastructure that has shaped the landscape of Lodwar municipality as presently stand include;

I) ***District Commissioner's administration offices*** **-** colonial administration offices of the 1950s–define the location of the present Turkana County National and County government administration square, Turkana County Assembly and Lodwar municipality headquarters

II) ***Lodwar air strip*** **–** the present Lodwar Airstrip which serves local flights was exclusively for colonial administration and the Northern frontier military response base. It was a battle response ground against Italian aggression from Ethiopia in 1941.

III) ***Lodwar primary school***–the only primary school in the greater Turkana District, started in 1932 around the present Tumaini clinic area within the Lodwar CBD, and later relocated to the current location (Nabute) in 1952. The school was established to provide formal primary education to the local people. The school forms the reference point for the growing educational institutions in Turkana County.

IV) ***Lodwar town CBD*** **–** The old business structures within Lodwar CBD – which has significantly contributed to the present Lodwar commercial square – essentially shaping up socio-spatial landscape of the present Lodwar municipality.

The County Physical Planning officer concurred with the Lodwar urban growth narrative and recounted that, *"Lodwar urban area grew organically without any land use plan to guide development until 1969, when first 'quickie plan' was undertaken*". The Quickie Plan refers to a plan based on very rough and unverified aerial photo information, but which provides at least some rough indication of the nature and extension of the physical development on the ground. The officer further added that," *we have other land use plans that were prepared thereafter to guide developments and bring order to Lodwar Urban area, including plans for 1976, 1982 and 2019. Land uses and settlement patterns within the planning area have been shaped majorly by the Lodwar Development Plan prepared in 1982 and Integrated Strategic Urban Development Plan (ISUDP) of 2015 which was approved in 2019. Unfortunately, spatial developments have surpassed the planned area boundary, and various land uses have haphazardly spread out to unplanned areas of the municipality without any control".*

Upon georeferencing and superimposing the 2019 Land Use Plan on Lodwar Municipality general boundary base map, the research established that, the Land use Plan for Lodwar municipality as shown in figure 3, only covered 10% of the total area of Lodwar Municipality, leaving 90% of the municipality area unplanned. This exposes the municipality to uncontrolled developments, haphazard developments, proliferation of informal settlements, encroachment into riparian reserves, and destruction of natural ecosystems.

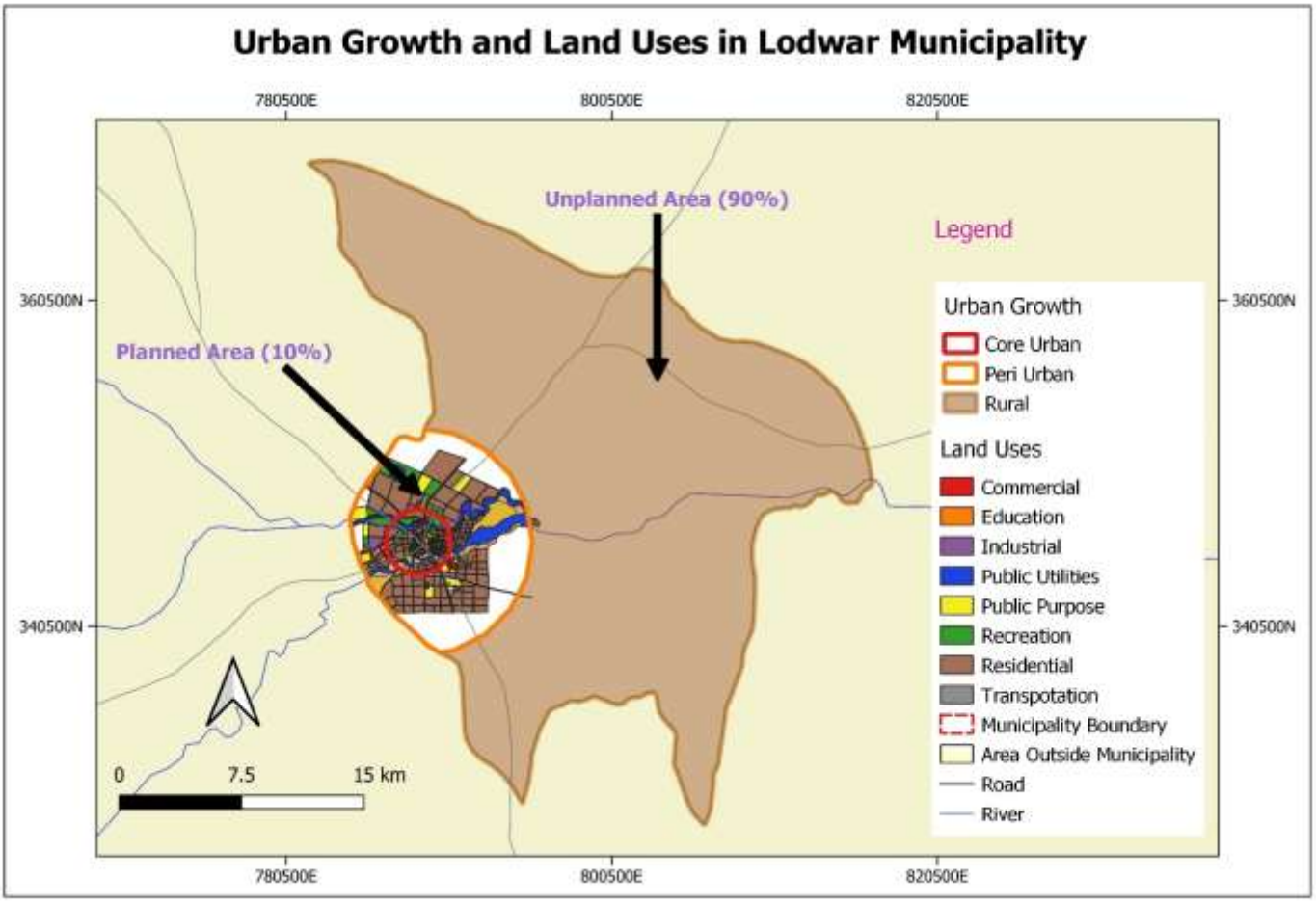


Figure *3*: Planned vis-à-vis unplanned area

Source: Research, 2026, based on Lodwar Integrated Strategic Urban Development Plan, 2019

Gaining insight from the narrative of the two resource persons and the physical planning officer's report, it is evident that Lodwar has grown over time from predominantly rural-natural landscapes to urbanized area. Natural feature landscapes, such as the Turkwel River, were used as boundary demarcation lines. It is also apparent that spatial planning has played a key role in shaping the socio-spatial landscape and settlement pattern of Lodwar municipality. Figure 4 and 5 show the spatial plans for the Lodwar urban area for 1982 and 2019, respectively.

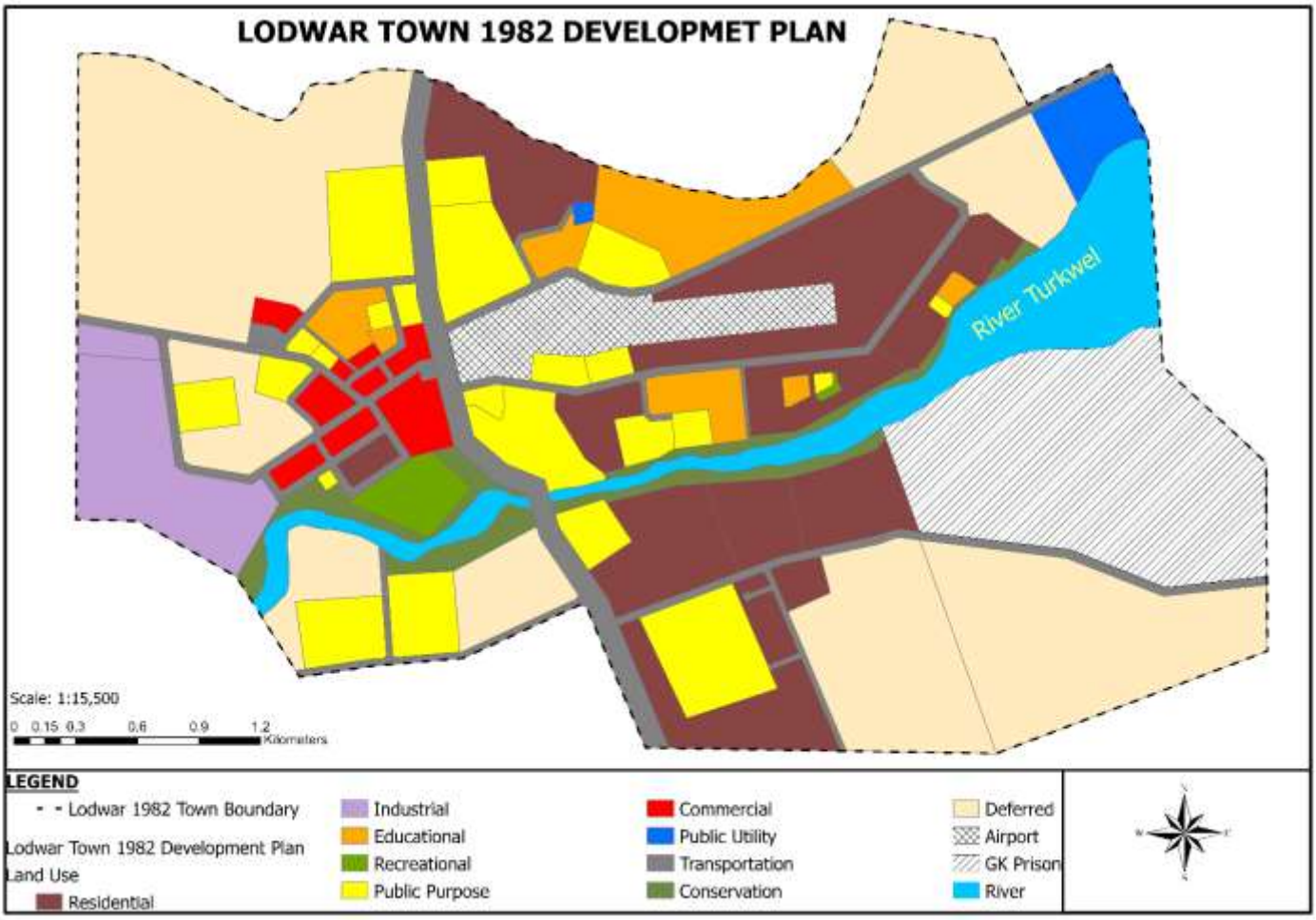


Figure 4: Lodwar town land use development plan, 1982

Source: Turkana County Government

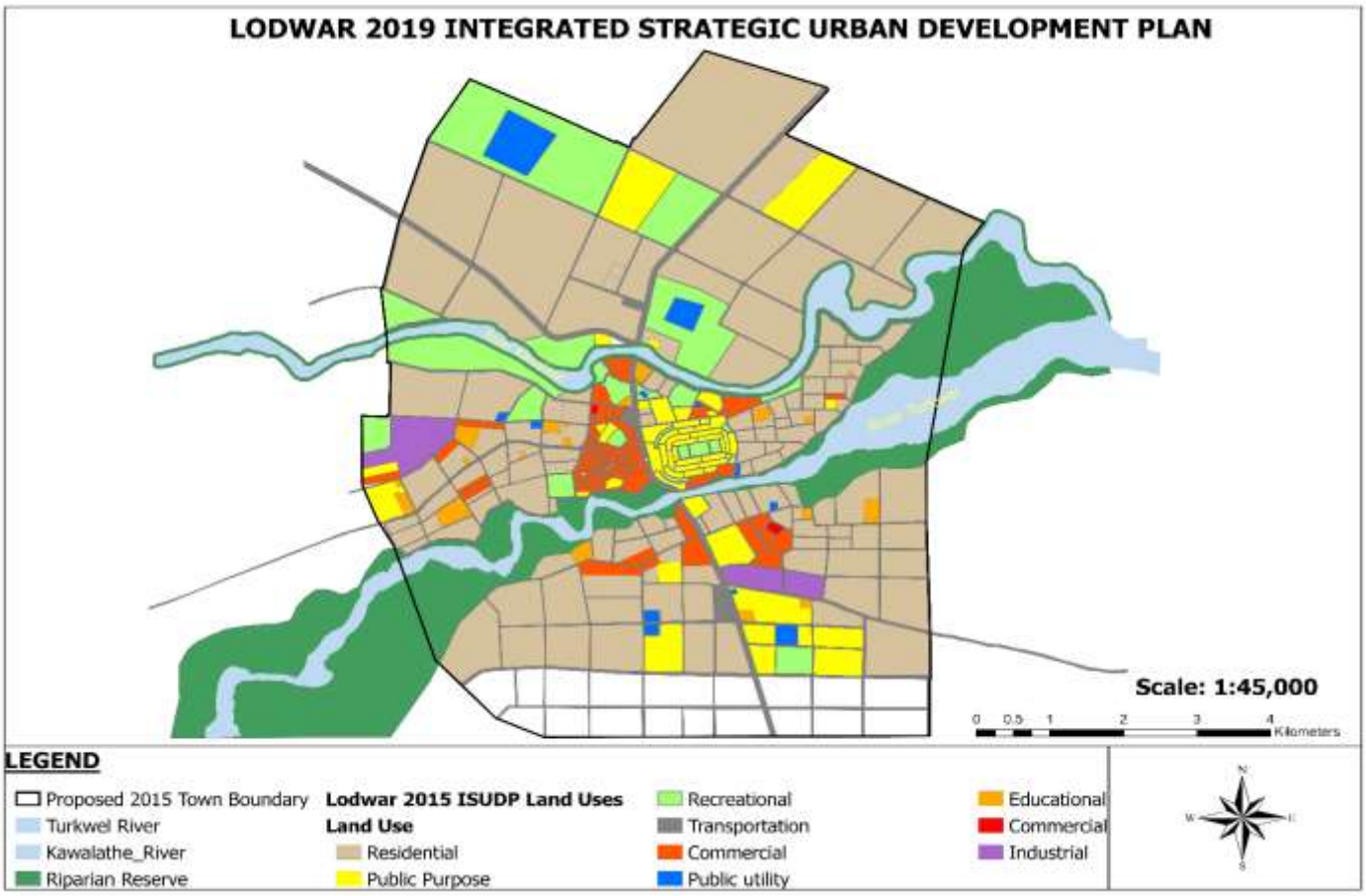


Figure 5: Lodwar Integrated Strategic Urban Development Plan, 2019

Source: Turkana County government, Physical Planning office, 2022

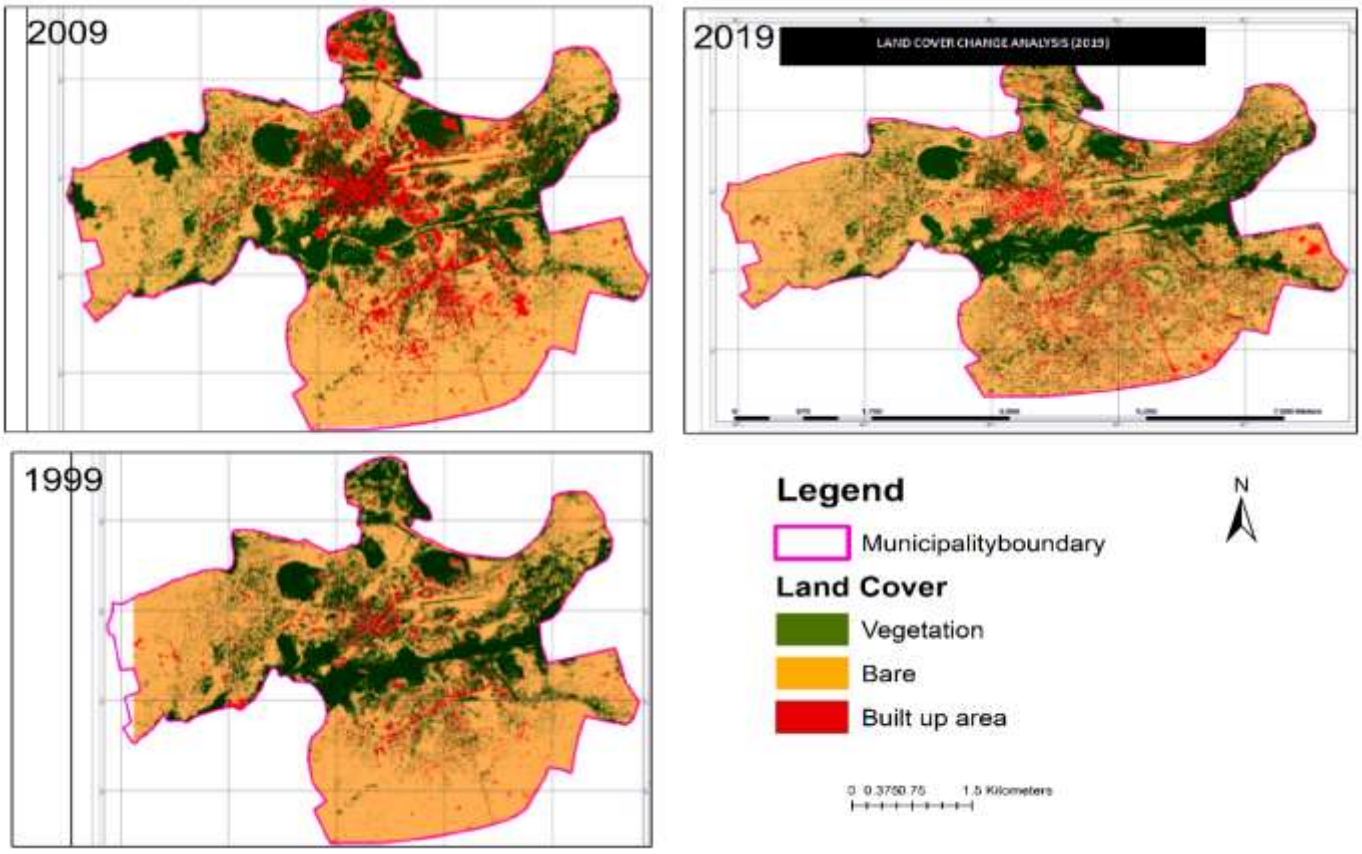
3.2 Key components of urbanization that influence socio-spatial landscape in Lodwar

Based on literature reviews, resource person interviews, and satellite imagery analysis of the study area, the following are the key components of urbanization that influence the socio-spatial landscape of an urban area in the context of this research.

3.2.1 Land Use/Land cover changes

Land use and resultant land cover changes over time were observed in the Lodwar municipality as revealed in figures 6 and table 2 below. The study findings indicate a significant increase in built-up areas over the past two decades so as to accommodate more human settlement spaces as a result of the increasing urban population. The percentage increases in built-up areas were 0.13% (1999), 1.21% (2009), and 1.25% (2019). These findings indicate a shift from the natural landscape, predominantly used for livestock grazing to human settlements. This trend indicates the impact of urbanization, which has shaped the socio-spatial landscape of the municipality, which was previously rural and natural in character and predominantly pastoral in terms of livelihood and lifestyle. On inverse, there was a significant loss of vegetation cover, at a rate of 17.97% in 1999 and 15.41% in 2019. Except for 2009, re-vegetation was observation for re-vegetation of the study area, indicating restoration of vegetation cover by 18.58%.

The land use/land cover changes signify the impact of urbanization on natural and undeveloped landscapes, which corroborates the findings of Li et al. and Roy that urbanization impacts previously vegetated land and manifests through vegetation cover loss (Li et al., 2016; Roy & Roy, 2010).



Figures 6: Land use and Land cover change, 1999,2009, 2019
Source: Research, 2026, based on satellite imagery,1999,2009 2019)

Table 2:Lodwar Municipality Land Use and Land Cover Analysis

Year	**1999**	**2009**	**2019**
Land Cover Class	**Area (Ha)/%**	**Area (Ha)/%**	**Area (Ha)/%**
Bare land	65,474.12 **81.89%**	64,121.66 **80.20%**	65,612.05 **82.07%**
Built-up	101.23 **0.126%**	965.59 **1.207%**	2,011.16 **2.516%**
Vegetation	14,371.96 **17.97%**	14,860.06 **18.58%**	12,322.10 **15.41%**

Source: Research, 2026

3.2.2 Urbanization effect on population distribution and settlement patterns

Lodwar municipality has experienced significant population growth and, thus, rapid urbanization in the past 20 years. The population of Lodwar rose from 35,919 in 1999 to 68,575 in 2009 and 114,031 in 2019(Kenya National Bureau of Statistics,2019,2009,1999). Population increases result from internal municipality population growth and migration of people from rural areas, neighboring counties, and countries into the Lodwar municipality in search of better economic opportunities and improved living standards (Kenya National Bureau of Statistics, 2019; KNBS, 2009). As a result of the urbanization effect, an increase in population density over time influenced the socio-spatial landscape and settlement pattern distribution in the Lodwar municipality, as demonstrated in figures 7,8 and 9 below.

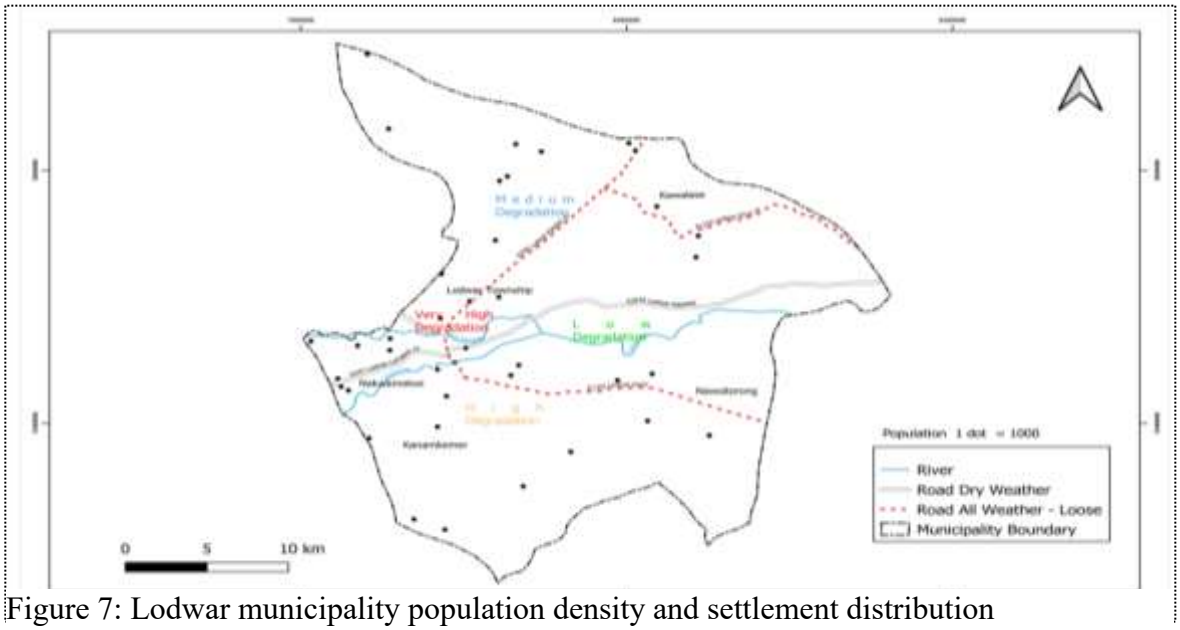


Figure 7: Lodwar municipality population density and settlement distribution patterns,1999

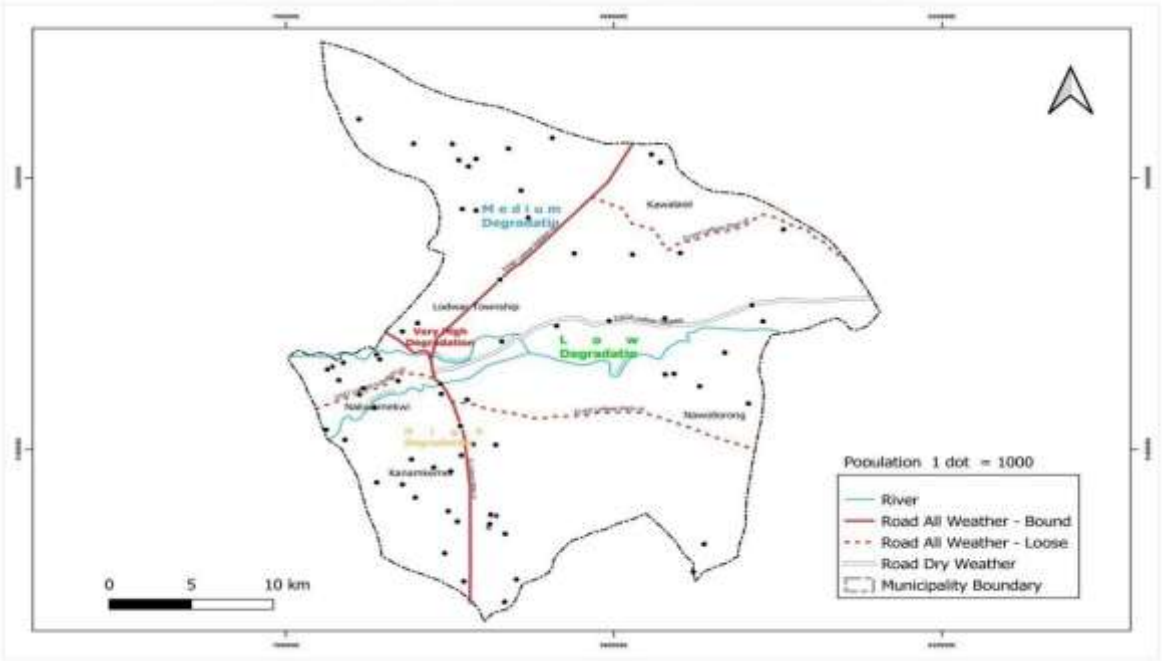


Figure 8: Lodwar municipality population density and settlement distribution patterns,2009
Source: Research, 2026 based on KNBS,2009

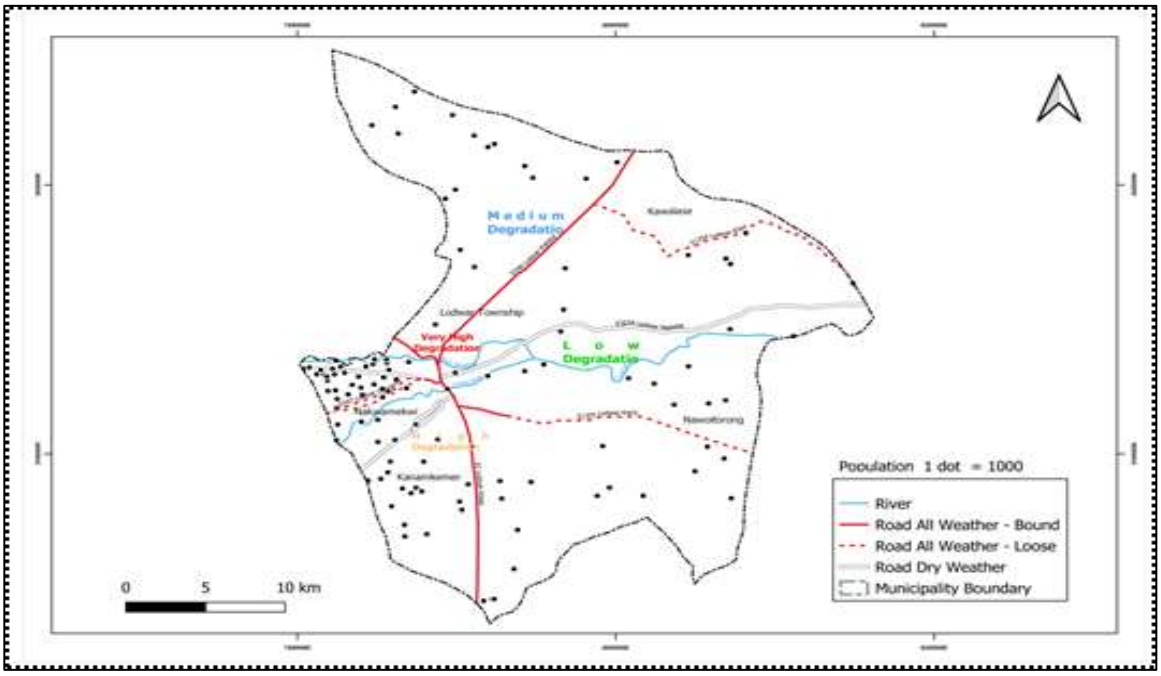


Figure 9: Lodwar municipality population density and settlement distribution patterns,2019
Source: Research, 2026 based on KNBS,2019

3.2.3 Urbanization effect on environment

A comparison analysis between population density shown in figures 7,8,9 above, and the land degradation index map in figure 10 below revealed that areas with high population density experienced a high level of degradation. The study observed that rapid urbanization has further influenced encroachment of human settlements to the riparian reserves of Turkwel and Kawalase Rivers, a phenomenon which has led to land degradation and occasional flash floods especially along the flooding risky points of both River Turkwel and Kawalase.

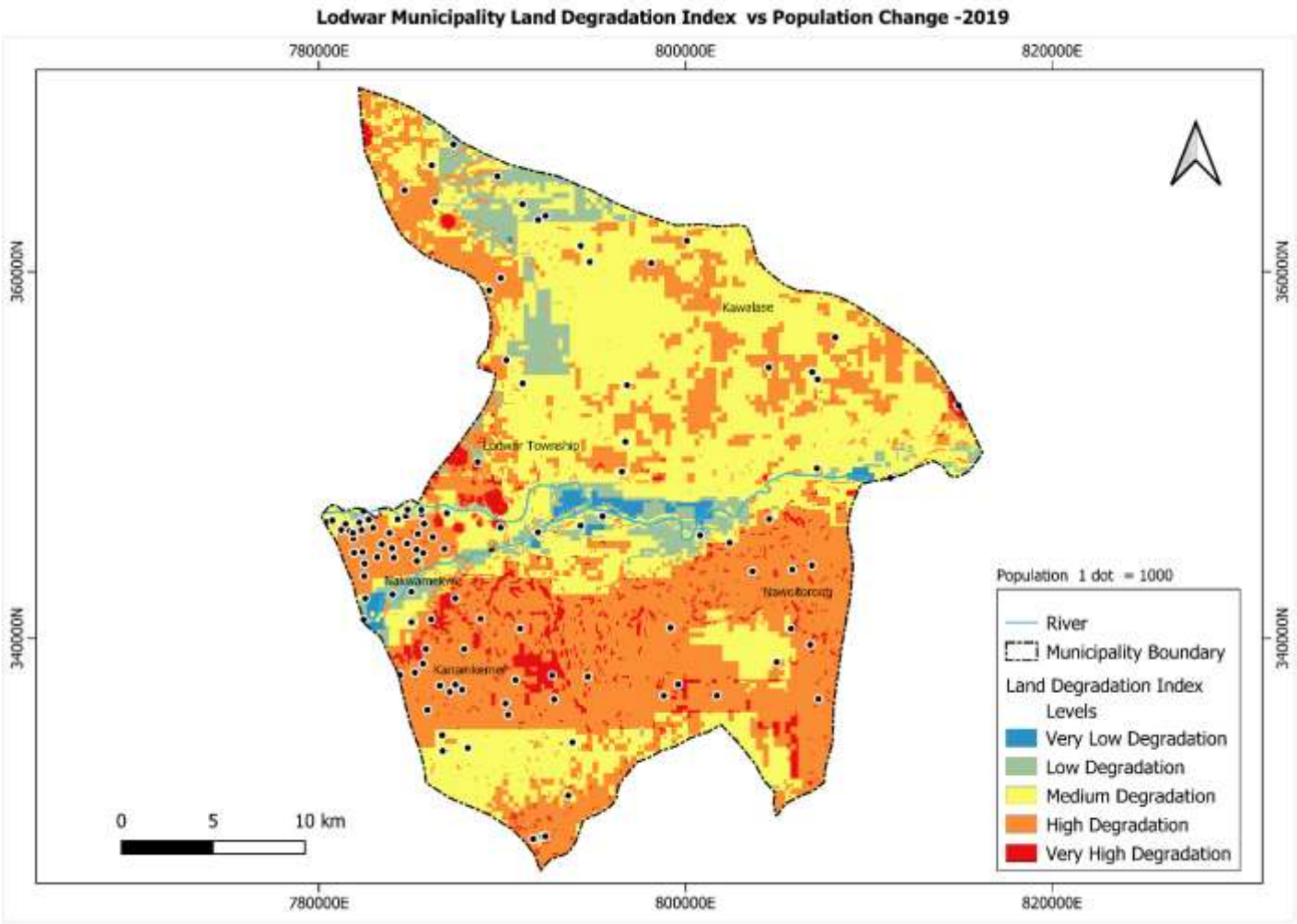


Figure 10: Land degradation index map
Source: (Research, 2026 mapping analysis, based on land degradation index mapping by Regional Centre for Mapping of Resources for Development (RCMRD) & The Global Monitoring for Environment and Security, 2019)

The land Degradation index map above categorizes Lodwar Municipality area into "Very Low Degradation" and "Very High Degradation. Very Low Degradation areas indicate minimal or no land degradation, whereas Very High Degradation areas - signify severe land degradation where the natural environment has been significantly altered or damaged (Brabant, 2010; Erickson, 1996; Li et al., 2016). The study observed that, areas with high population density (refer to figure 9) coincides with very high land degradation Index as shown in figure 10 above. This infers that there is correlation between high population growth and high land degradation index.

3.2.4 urbanization effect on social-stratification of Lodwar municipality

The social stratification of the Lodwar municipality, which had defined neighborhood settlement patterns and residential zones, was found to be stratified on the basis of individual family's income, availability of land for residential use, availability of infrastructure and services. Majority of the people who were interviewed (60%) responded that, these are the most important factors for consideration when settling in urban area such as Lodwar. The study established that these factors greatly influence the socio-spatial distribution of human settlements within Lodwar Municipality, which is spatially structured into five urban settlement zones within the CBD and peripheral urban settlements as shown in table 3 below.

Table 3: Social stratification zones and distribution of human settlement patterns in Lodwar Municipality

Urban settlement	Population density	Socio-economic status (Income)	Land use	Settlement pattern concentration
Township CBD Napetet	High (100-1000 people per hectare)	High income Low income	Commercial	Clustered /nucleated
		High income Medium	Residential Institutional (schools) Mixed use	Nucleated/clustered
Kawalase	High >250 people per Hectare)	Low income	Residential Quarrying	Clusterd
Nakwamekwi	Medium High (100-250 people per hectare)	Medium income Low income	Residential Commercial (linear) Institutional (school health)	Linear/clustered
Kanamkemer West of A1-Road	Low density Medium (10-80 people per hectare)	High income Medium income	Mixed use Commercial Institutional	Clustered/ dispersed Linear
Kanamkemer East of A1 Road	Low density (6-30 people per hectare)	High income Medium	Residential Institutional	Dispersed Clustered Linear
Nawoitorong	Low density Medium (8-70 people per hectare)	High income Medium	Residential Water aquifer Institutional Mixed	Linear Clustered

Research,2026

3.3 Measuring extend of urban growth and settlement patterns in Lodwar Municipality

In 1999, the concentration of human settlements and, therefore, urban development can be observed clustered around Lodwar town CBD between the two rivers (Kawalase and Turkwel) as shown in figure 11 below. During the same year, there were minimal dispersed settlements radiating from the CBD, approximately 0.72 km from Nakwamekwi and 1.79 km from Kanamkemer. The built area during the year covered approximately 0.126 %(*101.23Ha*) of Lodwar total area. In 2009, the human settlement patterns can be observed from 2009 satellite imagery sparsely expanding out to 0.89 km from the nucleated CBD to Kawalase area, 2.1 km from CBD to Kanamkemer and 3.89 km from CBD to Nakwamekwi settlement areas as revealed in figure 12 below. The built area during the year covered approximately 1.207% (*965.59Ha*) of the total area, indicating an increase in urban built-up area by 1.081 %, thus indicating urban growth.

In *2019*, the settlement pattern formation in the Lodwar municipality exhibited a concentric pattern, with settlements clustered and concentrated around the Lodwar CBD and Kanamkemer areas (see figure 13). Increasingly, there was extension of settlement patterns and therefore, built up area spreading outwards the CBD, approximately 1.86 km,5.92 km, 6.87 km towards Kawalase in the North, Kanamkemer in the South and Nakwamekwi to the West direction

respectively. The built-up area during this period was approximately 2.516% *(2011.16Ha)* of the Lodwar total area, indicating further increase in urban built-up area by approximately 1.309 %, which showed significant expansion of built-up area and, therefore, urban growth of the Lodwar municipality in two decades as a result of urbanization. From these findings, it is evident that urbanization influences the shaping of human settlement patterns, and therefore, the socio-spatial landscape of an urban area such as the Lodwar municipality.

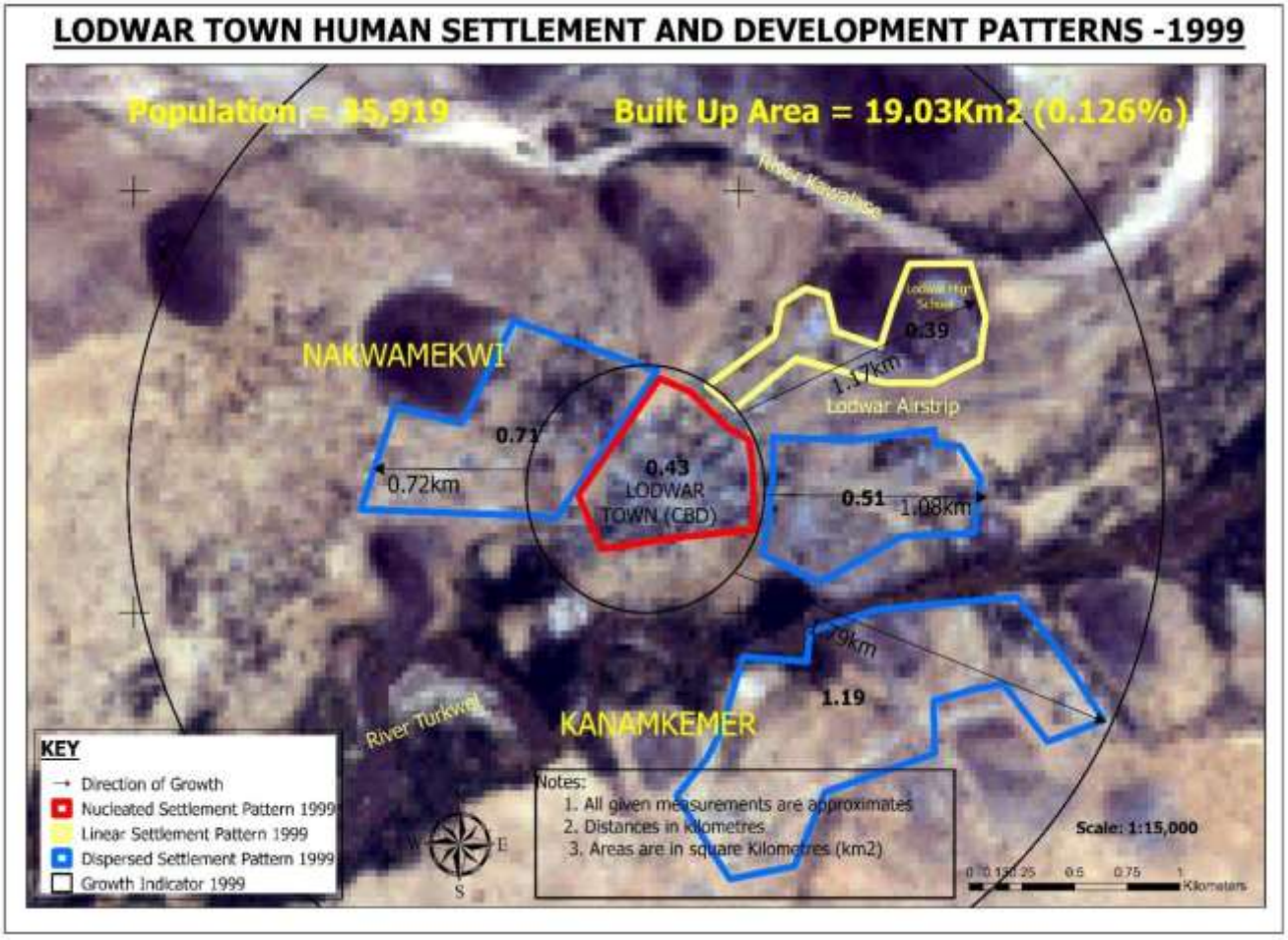


Figure *11*: Lodwar Municipality settlement patterns and urban development,1999

Source: Research, 2026, based on 1999 satellite imagery

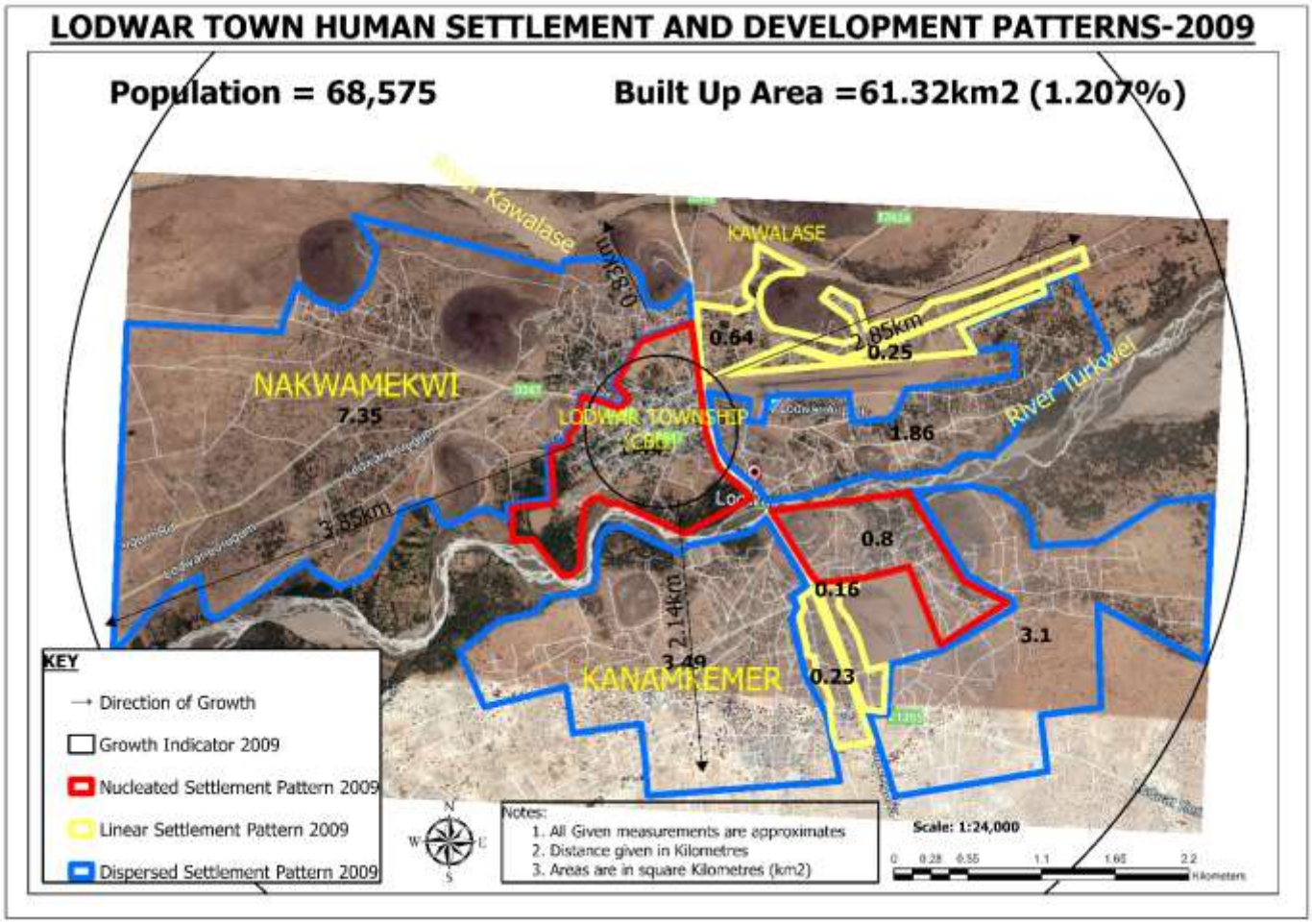


Figure 12: Lodwar Municipality settlement patterns and urban development, 2009

Source: Research, 2026, based on 2009 satellite imagery

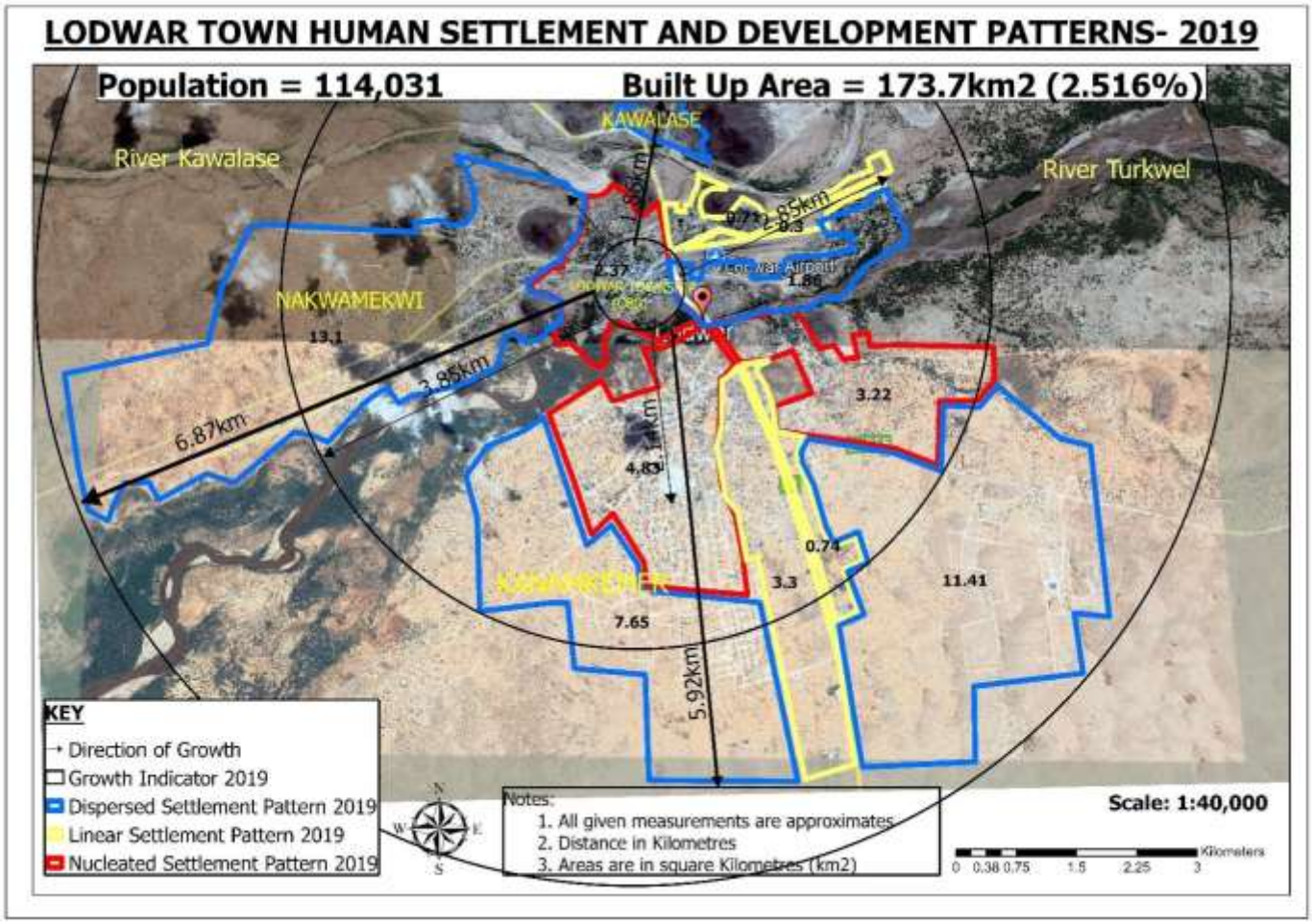


Figure 13: Lodwar Municipality settlement patterns and urban development,2019

Source: Research, 2026, based on 2019 satellite imagery

3.3.1 The Getis-Ord Gi∗statistic analysis results of urban concentration and resultant effect on socio-spatial landscape of Lodwar municipality.

The figures 14 and 15 below show the urban concentration of the Lodwar municipality in 2009, and 2019, with increased built-up areas. The two mapped patterns demonstrate urban growth outwards the CBD, with the intensity of blue and red clusters in 2009, and 2019 respectively, decreasing as the distance from the center increases, following a concentric ring or zone pattern. Getis-Ord Gi∗ statistics(Ord & Getis, 1995) which is a spatial pattern analysis tool, which make use of spatial structures data/ spatial clusters points in the landscape - which help in calculating Z-scores and p-values used to measure urban growth and the intensity of concentration in specific zones in an urban area(Ord & Getis, 1995). The analysis provides insights into which areas have experienced the most significant increase in built-up areas, as a result of urbanization, leading to spatial configuration of human settlements, consequently, shaping up the socio-spatial landscape of the urban area such as the Lodwar municipality. This method calculates a **Z**-score and P- values for each point or area within the Lodwar municipality, which helps identify statistically clusters of high values (hotspots) or low values (cold spots). High z-scores indicate areas with intense urban growth, while low scores indicate areas with less or no growth(Ord & Getis, 1995).

In 1999, the concentration was primarily around the Lodwar township CBD, with a limited extension. By 2009, urban growth had spread, covering more areas in the surrounding zones, especially Kanamkemer and Nakwamekwi. The Getis-Ord Gi∗ statistical analysis shows a high concentration near the CBD over the years, with a broader spread in 2019,

suggesting that urbanization has expanded outwards (urban sprawl), forming new "hot" zones around the original core, as demonstrated figure 14 below.

The Getis-Ord Gi∗ statistical analysis results below provide z-scores for each spatial data point, with specific analysis for 2009 and 2019. The 1999 spatial data clustering was small and was limited to a small CBD.

Positive z-scores indicate clustering of high values (hot spots), with higher z-scores representing a higher intensity of urban growth; negative z-scores indicate clustering of low values (cold spots); z-scores near zero indicate no significant clustering. Typically, z-scores beyond ±1.96 (at a 95% confidence level) or ±2.58 (at a 99% confidence level) indicate statistically significant hot or cold spots

The Getis-Ord Gi∗statistic analysis results for 2009

Compared with 1999, there was a notable increase in the extent and number of high-intensity clusters (hot spots) around the Lodwar township area. This indicates growth in built-up areas and urban development, showing that urbanization is spreading outward (a dispersed pattern of urban intensity) from the CBD as revealed in figure 14 below.

Table 4: Getis-Ord Gi*2009 Sample Output Values

Output Values			
GiZScore	**GiPValue**	**Neighbors**	**GiBin**
1.970308164	0.048803063	37	0
1.970308164	0.048803063	37	0
1.417433821	0.15635613	37	0
1.417433821	0.15635613	37	0
1.417433821	0.15635613	37	0
1.417433821	0.15635613	37	0
2.523182508	0.011629803	37	0
2.523182508	0.011629803	37	0
2.523182508	0.011629803	37	0
2.523182508	0.011629803	37	0
1.417433821	0.15635613	37	0
1.417433821	0.15635613	37	0
1.417433821	0.15635613	37	0
1.417433821	0.15635613	37	0
2.523182508	0.011629803	37	0

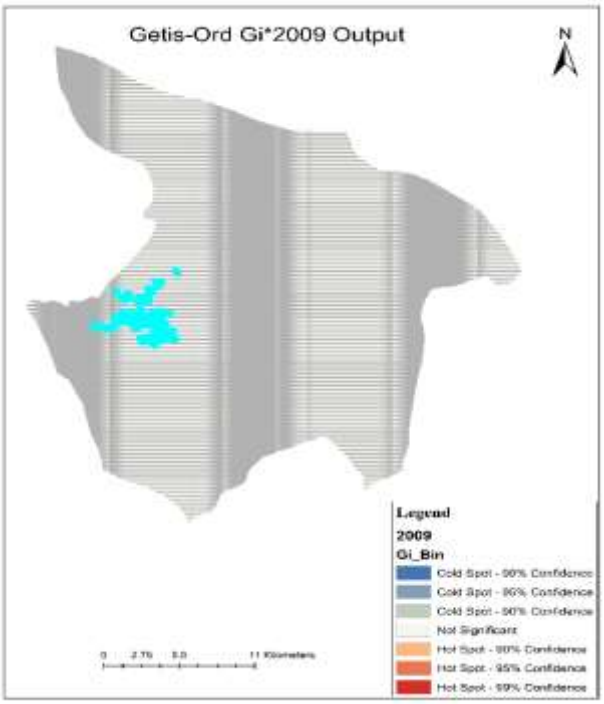


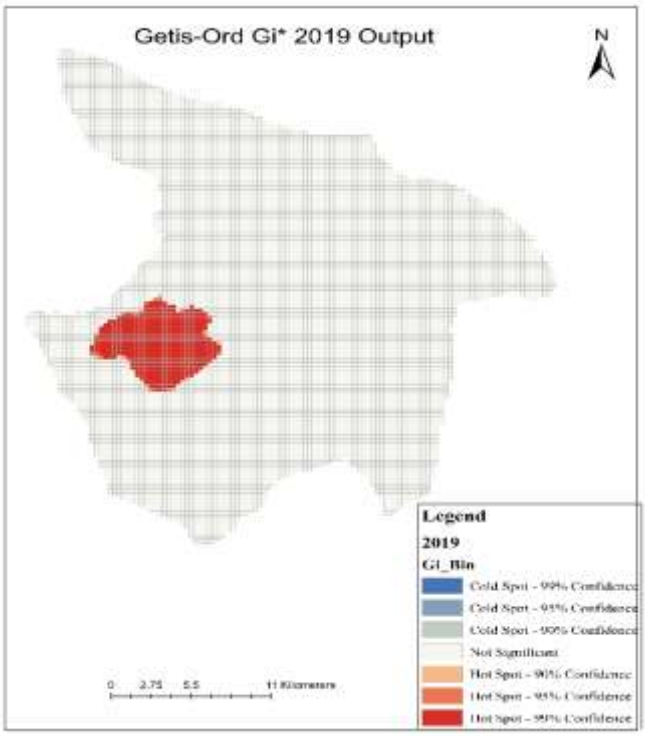
Figure *14*: Lodwar Municipality urban concentration analysis map, 2009

Source: Research, 2026, based on Land Use/Land Cover Dataset analysis for Lodwar municipality ,2009

The Getis-Ord Gi∗statistic analysis results for 2019

In 2019, there were more extensive clusters (multiple hotspot) around CBD, with additional clusters extending outwards. Urban concentration covered a broader area, with hot spots distributed over a larger region, indicating outward urban expansion of built-up area, and therefore, increased human settlement patterns, as revealed in figure 15 below.

Table 5: Getis-Ord Gi*2019 Sample Output Values



Output Values			
GiZScore	**GiPValue**	**Neighbors**	**GiBin**
1.97070326	0.048757827	37	0
1.97070326	0.048757827	37	0
1.979530382	0.047756322	37	0
2.023665991	0.04300453	37	0
2.050147357	0.040350053	37	0
2.076628722	0.03783584	37	0
2.103110088	0.035456147	37	0
2.103110088	0.035456147	37	0
2.103110088	0.035456147	37	0
2.129591453	0.033205357	37	0
2.191381306	0.028424211	37	0
2.235516916	0.025383432	37	0
2.261998281	0.02369751	37	0
2.270825403	0.02315755	37	0
2.297306768	0.021601276	37	0

Figure *15*: Lodwar Municipality urban concentration analysis map, 2019

Source: Research, 2026, based on Land Use/Land Cover Dataset analysis for Lodwar Municipality ,2019

From the Getis-Ord Gi∗statistic analysis output results above, the z-scores indicate clustering of high values (hot spots), with higher z-scores between + 1.97 to +2.29 representing a higher intensity of urban growth, with corresponding P-values <0.05. Indicating statistically significant hot spots which implies that urbanization has significantly affected the socio-spatial landscape of Lodwar Municipality between 1999 and 2019. This is consistent with Peripheralization theory, where rapid population increase from rural areas have led to concentrated high density settlements and urban expansion(Güneralp & Seto, 2013) – which outstrip Lodwar spatial plan and therefore, provision of prerequisite infrastructure.

4. 0 Conclusion and Recommendation

Conclusion

The empirical findings in this study reveal that Lodwar municipality has experienced significant population growth between 1999 and 2019, with almost double population growth between 2009 and 2019.Rapid population growth, and subsequent urbanization effect in Lodwar municipality signifies ***spatial tipping point*** for arid and semi-arid areas which are predominantly communal grazing land. Conversion from community land predominantly for nomadic-pastoralism use to administrative and commercial hub, ultimately structures differently socio-spatial landscape of the municipality,

as observed through uncontrolled developments with only 10% planned, expansion of the built-up areas from the core urban areas to the communal grazing fields and increased encroachment to the riparian reserves.

There was significant increase in built up areas in Lodwar municipality between 1999 and 2019. The increase in built-up area was recorded at 0.13% (1999), 1.21% (2009), and 1.25% (2019). On inverse, there was a significant loss of vegetation cover, at a rate of 17.97% in 1999 and 15.41% in 2019. Except for 2009, the study observed re-vegetation of the study area, indicating restoration of vegetation cover by 18.58%.

The study established that, in 1999, the concentration of built-up area/urban settlement was primarily around the Lodwar township CBD with limited extension. The Getis-Ord Gi∗ statistical analysis shows a high concentration near the CBD with a broader spread of patterns in 2019, suggesting that urbanization has expanded outward, forming new "hot" zones around the original core. There were increasingly high **z**-scores of between 1.97 & 2.29 (at 95% confidence level) and corresponding **p**-values of between 0. 02 and 0.05 in 2019. Statistically, this indicates a significant effect of urbanization on the socio-spatial landscape of the Lodwar municipality over the last 20 years.

Recommendation

The County government of Turkana should proactively undertake comprehensive Land use planning for the entire Lodwar Municipality to cover 90% of the un-planned Municipality area. This is critical in enhancing urban order, development control, and mitigation of the negative effect of urbanization on human settlements, and therefore, the sustainable positive impact of the socio-spatial landscape of the Lodwar municipality. If urbanization effect in the municipality continues uncontrolled with little land use planning as it were, then Lodwar municipality risk institutionalizing informal settlements and therefore, '***infrastructure deserts***. Increased vulnerability to climatic disasters like flash floods and increased heart intensity from uncontrolled developments will be among the challenges to be encountered by the municipality residents.

2.4.1 Pre-test and administration of Household Questionnaire

A pre-testing exercise for household questionnaires was conducted on 393 households, randomly selected from the five urban settlement villages one week before the actual administration of household questionnaires was carried out. The purpose of conducting the pilot study was to test the reliability and validity of household questionnaires in relation to how urbanization has impacted the socio-spatial landscape in the Lodwar municipality. A pilot study was conducted to test the content validity of the questionnaire in terms of the sequence of questions and wording.

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Author Contributions

Mark Ewesit Ewoi, Conceptualized research topic, undertook data collection, analysis and wrote the manuscript with supervision of Prof. Caleb Mireri and Dr. Christine Majale

Data availability and Supplementary materials

The data supporting research findings and analysis will be available in https://www.doi.org/10.55041/IJSREM57440

Compliance with ethical standards and conflict of interest

There are no relevant financial or non-financial competing interests in this research.
This research approval was granted by NACOSTI license No, NACOSTI/P/21/12932.

Ethical Consideration

The study was approved by the Graduate School committee of Kenyatta University and National Council for Science and Technology under License Number NACOSTI/P/21/12932(attached). The consent was obtained from participants in Lodwar municipality before the start of the interview as indicated at the introductory part of the questionnaire (attached), with a disclaimer statement that read, 'the information collected during this survey is purely for academic purposes and will not be divulged to any other person in whatever circumstance'. The request for interview consent was read verbally to the respondents who cannot read or write, besides presenting them with a copy of research approval license number NACOSTI/P/21/12932(attached). The head of institutions and departments who formed majority of key informants and respondents to this research accepted the interview as evidenced in the attached correspondences between them and the researcher. The interview engagement ensured that participants fully understood the nature and purpose of the study before voluntarily accepting to be interviewed.

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