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Intra-urban dualism and development control in land-use transformation: Geospatial insights from Kisii town, Kenya

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Abstract

Urbanisation across sub-Saharan Africa is transforming the spatial structure of secondary towns, often generating uneven and fragmented growth. A key manifestation of this process is intra-urban dualism, where well-planned, affluent neighbourhoods coexist with densely populated, poorly regulated settlements. This spatial divide undermines orderly growth, deepens inequality, and places pressure on urban infrastructure. In Kenya, intra-urban dualism is increasingly evident, yet limited research has explored how it influences land-use transformation and sustainable development. Addressing this research gap is essential to understand how spatial inequalities shape urban growth trajectories and to guide equitable planning interventions. This study examines intra-urban dualism and land-use transformation in Kisii town, western Kenya, focusing on the contrasting neighbourhoods of Milimani (a low-density planned area) and Jogoo (a high-density unregulated settlement). Land-use and land-cover changes from 2005 to 2024 were analysed and projected to 2044, using ArcGIS Pro and QGIS. Building density, plot size compliance, and coverage ratios were quantified and validated through a one-sample t-test. Results show that Milimani has largely retained its planned form, whereas Jogoo has undergone rapid, unregulated densification driven by weak development control and fragmented land ownership. The study recommends data-driven, geospatially informed development control supported by adaptive zoning, participatory monitoring, blockchain-based permitting, and resilience audits to promote sustainable, inclusive, and transparent urban growth.

Keywords: Intra-urban dualism, land-use transformation, development control, geospatial analysis, Kisii town, Kenya, urban inequality, spatial planning, informal settlements, urban resilience, sustainable urban development

INTRA-STEDELIKE DUALISME EN ONTWIKKELINGSBEHEER IN GRONDGEBRUIKSTRANSFORMASIE: KISII-DORP, KENIA

Verstedeliking in sub-Sahara-Afrika verander vinnig die ruimtelike struktuur van sekondêre stede en lei dikwels tot ongelyke groei. Hierdie studie ondersoek intra-stedelike dualisme en grondgebruikstransformasie in Kisii, 'n stad in Wes-Kenia, met fokus op die kontras tussen Milimani en Jogoo. Deur gebruik van ArcGIS Pro en QGIS is veranderinge in grondgebruik en grondbedekking van 2005 tot 2024 ontleed. Die bevindings toon dat Milimani sy beplande vorm grotendeels behou het, terwyl Jogoo vinnige, ongereguleerde verdigting ervaar het weens swak ontwikkelingsbeheer. Die studie beveel 'n data-gedrewe, geospatiaal-ingeligte benadering tot ontwikkelingsbeheer aan, ondersteun deur aanpasbare sonering, deelnemende monitering en blockchain-gebaseerde vergunning om volhoubare, inklusiewe en deursigtige stedelike groei te bevorder.

KA HARE HO LITOROPO TSE PELI LE TAOLO EA NTS'ETSOPELE PHETOHONG EA TŠEBELISO EA MOBU: TEROPO EA KISII, KENYA

Boikopanyo bo ntseng bo eketseha ka tlase ho Sahara Afrika bo fetola libaka tsa litoropo tse mahareng, bo baka kholo e sa lekanyeng. Thuto ena e hlahloba boikarabello bo habeli ka hare ho toropo le phetoho ea tšebeliso ea mobu toropong ea Kisii, Kenya e ka Bophirima, e shebane le libaka tsa Milimani le Jogoo. Ho sebelisitsoe ArcGIS Pro le QGIS ho sekaseka liphetoho tsa tšebeliso le sekoaelo sa mobu ho tloha 2005 ho isa 2024, 'me liphetho li bontša hore Milimani e bolokile sebopeho se hlophisitsoeng ha Jogoo e ntse e hola ka potlako ntle le taolo e hlakileng. Thuto e khothalletsa taolo ea nts'etsopele e thehiloeng ho lintlha, ho hlophisa bocha libaka, le tšebeliso ea mahlale a blockchain ho khothaletsa kholo e tšoarellang le e kenyeletsang ea litoropo.

1. INTRODUCTION

Global population dynamics and urbanisation trends are pivotal in shaping future socio-economic and environmental landscapes. As of 2025, the global population stands at approximately 8 billion and is forecasted to reach 9.7 billion by 2050, with a peak of 10.4 billion in the 2080s before a gradual decline (United Nations, 2024: 12). Growth is concentrated in sub-Saharan Africa, which is expected to double its population by 2050 (United Nations Population Fund, 2024: 17). Simultaneously, urbanisation is accelerating. In 2020, 56% of the global population lived in urban areas, a figure anticipated to rise

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to 68% by 2050 (United Nations, 2024: 1). This trend is most evident in developing countries, where urban centres rapidly expand. For example, less developed countries' urban population is predicted to increase by 1 billion, reaching 2.5 billion by 2040 (National Intelligence Council, 2021: 19). The interface between population growth and urbanisation presents challenges. Rapid expansion fuels unplanned settlements, strains infrastructure, exacerbates disparities, and intensifies environmental pressures, with urban areas contributing up to 40% of global greenhouse gas emissions (UN-Habitat, 2024: 27). The expansion is not only demographic, but also spatial. Between 2000 and 2030, global urban land cover is projected to increase by over 200%, while the urban population will grow by over 70% (Seto, Güneralp & Hutyra, 2012: 16083). This shows that land consumption is outpacing population growth, creating challenges such as sprawl. Such trends promote a dualistic land-use pattern marked by modern developments alongside informal settlements. As cities expand, housing and service demand outpace the formal sector's capacity to provide infrastructure. Consequently, informal settlements emerge to absorb migrants seeking opportunities. These areas lack planning and services, contrasting sharply with well-developed zones. This disparity reflects spatial inequalities and challenges to sustainable development (UN-Habitat, 2003: 4; Seto *et al.*, 2013: 412). Applying development control instruments such as zoning regulations, land-use plans, building codes, permits, and enforcement can mitigate dualism, promote sustainability, and ensure equitable growth. This includes new construction, land subdivisions, extensions, and changes in land or building use (Etuk, Raphael & Isok, 2023: 53).

This article explores the implications of intra-urban dualism on land-use development control through a comparative geospatial analysis of two residential neighbourhoods in Kisii town, Kenya, namely Jogoo and Milimani. Section 56(a) of the Physical and Land Use Planning Act (Republic of Kenya, 2019b: 640) empowers the County Government of Kisii (CGOK) to control land use and development for orderly growth. This study examines whether planning standards enforced through development control instruments, specifically minimum plot size and building coverage ratio (BCR), are applied uniformly across the two neighbourhoods. It addresses a knowledge gap on enforcing development control in urban areas and provides insights for policymakers, by demonstrating the importance of consistent regulation. The spatial analysis spans 2005 to 2024, using the two neighbourhoods as case studies.

2. LITERATURE REVIEW

2.1 Theoretical justification of development control

This study applies the theory of regulatory compliance (TRC), advanced by Fiene (2016: 2), to justify adherence to rules and regulations. TRC shapes laws and standards developed by planning authorities, providing a framework to understand enforcement and rationale (Andersen & Pløger, 2007: 1349). Compliance ensures alignment with development control principles of safety, access, compatibility, and efficiency. Enforcement is influenced by regulatory design, incentives, deterrence mechanisms, and public attitudes. Agencies use fines, legal action, and orders to deter violations of zoning, building codes, and environmental rules (Asamoah *et al.*, 2025: 81). Applied to this study, TRC underpins why the CGOK must enforce planning standards uniformly across neighbourhoods. In Kisii town, balancing strict legal mechanisms with participatory governance promotes adherence. Urban areas integrating clear rules, transparent enforcement, and community engagement achieve better compliance and sustainable development (Deep, 2023: 1634).

2.2 Intra-urban dualism, development control, and planning standards

Intra-urban dualism refers to the coexistence of contrasting land uses within metropolitan areas, where high-value, formal, and planned land uses exist alongside informal, low-value, and unplanned regions (Pacione, 2009: 48). These areas may be geographically close yet reveal stark contrasts in living standards and urban development. Wealthier sections benefit from quality infrastructure and essential services, whereas informal settlements face inadequate housing, poor sanitation, and limited utilities (Mugah & Letema, 2025: 3). This duality appears in residential commercial distinctions or the disparities between affluent and impoverished neighbourhoods (Chen, Long & Liao, 2020: 7). Development control regulates land use and physical works to ensure conformity with spatial plans, policy guidelines, and standards. Its objectives include promoting orderly development, optimising land use, implementing approved plans, conserving the environment, safeguarding health, ensuring safe building, and protecting national security (Republic of Kenya, 2019b: 639). Planning standards define the minimum space requirements for facilities, infrastructure, and land uses, set by planning authorities to guide and control development (Omollo, 2020a: 96; Olujimi, 1993: 116).

2.3 Urban dualism in a global context

A growing body of literature shows that dualism is a common phenomenon in urban development. Rodrigue and Behrends (2018: 3) demonstrate this, by examining freight distribution between central urban areas and suburban regions in New York, highlighting functional and operational differences. Drivers of this dualism included city logistics strategies such as tolls and off-peak deliveries, urban land-use designs guided by smart growth, and e-commerce. These factors deepened dualism, creating divergent distribution channels, operations, and modes depending on whether logistics occurred in central or suburban areas. Similarly, Filas-Zając and Kwiatkowski (2024: 96) analyse dualism in urban design, emphasising tensions between urban modernisation and rural or less-developed spaces. They noted challenges in balancing growth with the preservation of traditional landscapes. Understanding such dualities provides insights into the evolution of urban spaces and supports planning strategies that reconcile competing demands in contemporary urban environments.

Depending on its implementation, a compact city model can both mitigate and exacerbate urban dualism. Bibri, Krogstie & Kärrholm (2020: 6) highlight that compact planning approaches such as mixed-use development, public transport integration, and green infrastructure can reduce carbon footprints and improve quality of life. However, they caution that compact growth also raises social equity and economic concerns, requiring balanced policies. In a comparative study of Barcelona and Rotterdam, Kain *et al.* (2022: 7) advocate integrated approaches prioritising sustainability, liveability, and resilience but critique the persistent dualism between environmental sustainability and social equity. Harmonising these elements is vital to create practical compact city models delivering both ecological and social benefits. Fan and Chapman (2022: 2) examine whether compact cities reinforce dualism and analyse links with carbon emissions, arguing that high-density, mixed-use cities can lower emissions through shorter travel distances, increased public transport use, and improved resource efficiency. Practical implementation challenges mean that effective policy frameworks are essential. Benkő (2010: 50) extends the debate, by analysing closed and open spaces, where buildings' enclosed facades contrast with open public areas, shaping urban aesthetics and social interaction.

From a sustainability perspective, Talen and Brody (2005: 687) highlight the tension between urban development and natural ecosystems. They argue that cities often prioritise infrastructure and growth over ecological preservation, undermining sustainability. Their research calls for policies encouraging green spaces, resource conservation, and biodiversity protection to achieve ecological balance. Income inequality is a major driver of urban land-use dualism. Nijman and Wei (2020: 9), studying United States of Amercia metropolitan areas, show how disparities in housing, employment, and resource access marginalise communities and intensify inequalities between affluent and disadvantaged populations. They call for re-engineering urban planning and policy to remedy structural inequalities, advocating inclusive economic models that promote equitable growth and reduce segregation. Dualism is also evident in governance. Andersen and Pløger (2007: 1340) examine Danish urban policy, noting tensions between participatory, welfare-oriented strategies targeting deprived districts and top-down, market-driven planning emphasising large-scale renewal projects. While the former aspires to inclusivity and empowerment, the latter often sidelines community voices, prioritising economic growth. This policy duality reflects Denmark's ongoing debate about balancing grassroots participation with development objectives.

2.4 Urban dualism in Africa: Dynamics and policy implications

Like other regions, Africa and specifically Kenya are not immune to land-use dualism. Barau *et al.* (2023: 14) observe how children and adults in Kano City, Nigeria, share a small 0.5-hectare public space, reflecting a dualistic relationship between the two groups. Despite its limited size and dense population, both groups developed a harmonious way to use the space, demonstrating how public areas can promote collaborative consumption of scarce urban resources. In contrast, Musakwa and Van Niekerk (2015: 12) analyse urban sprawl in Stellenbosch, South Africa, confirming dualism between rapid, unplanned expansion and sustainable development. Sprawl undermines environmental sustainability, equitable resource distribution, and efficiency, deepening spatial and socio-economic inequalities. Similarly, Maina and Waiganjo (2024: 385) show how urban sprawl in Kenya drives economic growth and infrastructure development, while depleting farmland and ecological zones. They emphasise the dualism of progress versus preservation, highlighting the need for integrated policies to harmonise urban expansion with sustainable land use. Mwaura and Odera (2021: 66) highlight how rapid urbanisation, population growth, and weak planning frameworks drive Nairobi's expansion beyond planned boundaries, encouraging informal settlements alongside planned neighbourhoods and exemplifying land-use dualism. Sprawl intensifies inequalities between serviced formal areas and underserved informal ones. Ayonga (2019: 1661) notes that dualistic planning laws create contradictions, prioritising urban development, while marginalising rural areas, and that separate urban-rural frameworks fuel uncoordinated growth. Ng'ayu (2015: 414) adds that peri-urban areas reflect this dualism, with farmland converted to mixed formal and informal uses, disrupted by unclear tenure systems and weak planning policies. Ren *et al.* (2020: 1) identify land-use dualism as central to Nairobi's urban structure, with informal settlements exhibiting high density, poor conditions, and limited services. K'oyoo (2024) links dualism to colonial planning, which segregated cities, and notes that weak governance and private interests sustain it. K'Akumu and Olima (2007: 87) affirm that colonial and post-colonial policies entrenched dualism, where the formal sector benefits from state-backed planning, while informal settlements operate outside legal frameworks, often neglected by authorities.

K'Akumu and Olima (2007: 88) link dualism to colonial policies, echoed by Syagga (2019: 8), who shows that it persists between state-controlled legal frameworks and informal land management, marginalising certain populations. Formal areas serve affluent groups; informal areas house the poor. K'oyoo (2024: 95) stresses that urban policies should balance progress and community identity. Mwangi (2016: 142) highlights housing disparities: the formal sectors offer high-standard rentals, while informal settlements offer substandard housing. Policies favouring high-end developments further marginalise vulnerable groups, leaving them in overcrowded areas with inadequate water, sanitation, and healthcare. Owuor and Mbatia (2008: 3) show that Nairobi's urbanisation features formal and informal land uses, creating stark disparities. The World Bank (2017: 26) validates that Kenya's informal sectors coexist with the formal city but fail to integrate effectively. Formal housing remains unaffordable, while informal settlements expand without infrastructure. Mukolwe, Badurdeen and Khamis (2024: 65) note that land-use dualism in Kwa-Bulo, Mombasa, produced unplanned housing, inadequate infrastructure, and land conflicts, contributing to poor living conditions. Laji *et al*. (2017: 332) recommend planning approaches that balance formal and informal developments for equitable access to transport, services, and housing amid rapid urbanisation. The literature reveals that land-use dualism in Kenya stems from unplanned urban expansion into adjoining rural land, driven by ineffective development control and inadequate rural planning. Kioko, Mwendwa and Imteyaz (2022: 197) show how urbanisation displaces agricultural and rural land uses, creating inefficiencies and conflicts. Planning often fails to align with rural-urban interactions. Kimtai, Mabonga and Wasike (2023: 1341) call for integrated policies balancing urban growth with agricultural preservation and environmental sustainability. Sakketa (2023: 2) highlights how rapid urbanisation encroaches on rural areas, displacing agriculture and degrading ecosystems. This dualism causes inefficient land allocation, with urban expansion lacking infrastructure, while rural regions lose vital resources. Legislation is also crucial. Willy (2018: 180) examines the potential of Kenya's Community Land Act No. 27 of 2016 to secure community land rights, but finds that weak implementation, bureaucratic processes, and competing interests significantly undermine its effectiveness.

The literature review offers valuable insights into debates on urban land-use dualism from global and Kenyan perspectives. A recurring theme is that dualism encourages unequal spatial development, undermining liveable urban environments. In Africa, particularly Kenya, the issue often arises when urban development sprawls into unplanned rural areas, causing inadequate infrastructure and land-use conflicts. While this study builds on prior research, the influence of weak enforcement of planning standards on dualism in urban residential neighbourhoods and land-use change remains underexplored. Guided by a positivist paradigm, this article investigates this issue through spatiotemporal analysis in Kisii town, Kenya.

2.5 Geospatial analysis as a diagnostic tool for development control

Geospatial analysis has emerged as a diagnostic tool for urban planning and development control, enabling accurate monitoring of land-use and land-cover changes across diverse contexts. Studies across Africa, Asia, and Europe show that rapid urban expansion often exceeds regulatory capacity, leading to encroachment on agricultural, forest, and ecologically sensitive lands (Mwaura & Odera, 2021: 67; Rotich & Opiyo, 2022: 2447; Munywoki & Singh, 2018: 46). Geospatial analysis facilitates real-time assessment, allowing authorities to detect unauthorised development, monitor zoning compliance, and enforce regulations. Wagh and Auti (2025: 101), as well as Omollo (2018) demonstrate that geospatial analysis identifies areas of non-conformance, whereas Abubakar *et al*. (2025: 56) emphasise its role in strengthening enforcement in Nigeria. International studies also confirm the predictive power of geospatial tools. CA-Markov modelling in Lagos (Gilbert & Shi, 2024: 100) and urban growth node identification in Surat, India (Sheladiya & Patel, 2023: 97) enable proactive interventions before sprawl occurs.

Furthermore, geospatial analysis supports evidence-based decision-making, by integrating temporal and spatial data to evaluate environmental and infrastructural impacts (Jiménez-Espada, Martínez García & González Escobar, 2023: 122; Ouchra, Belangour & Erraissi, 2022: 15). In Mangaluru and Mizan Aman City, geospatial monitoring exposed that built-up expansion outpaced agricultural and forested areas, due to weak enforcement, highlighting its potential to guide corrective planning measures (Dhanaraj & Angadi, 2022: 1133; Bikis *et al.,* 2025: 12014). Despite these advantages, challenges remain. Institutional fragmentation, limited technical capacity, and data gaps can reduce geospatial effectiveness (Abubakar *et al*., 2025: 56; Munywoki & Singh, 2018: 45). Nonetheless, adopting geospatial analysis as a diagnostic tool provides planning authorities with pragmatic evidence, enabling them to monitor development compliance, enforce zoning, and promote sustainable urban growth, thus transforming development control from a reactive to a proactive process (Slimani & Raham, 2023: 17; Dhanaraj & Angadi, 2022: 1133). Although the reviewed literature acknowledges that integrating GIS and remote sensing into development control enhances oversight through land-use change detection, compliance monitoring, and support for sustainable urban management, there remains a research gap in demonstrating how geospatial analysis can be applied to study intra-urban dualism, which warrants further research.

3. CASE STUDY AREA

Kisii town, located in south-western Kenya (Figure 1), is the capital of Kisii County, one of the country's 47 counties. It lies approximately 300km west of Nairobi and 120km south of Kisumu, near the equator (0.683°S, 34.767°E) at an elevation of 1,700 meters, which supports its agriculture-friendly climate (Omollo, 2020b: 97). According to the 2019 census, Kisii had an urban population of 112,417 and ranks third in population density nationally, at 34,066 people/km² (Republic of Kenya, 2019a: 38).

The study focuses on two contrasting residential neighbourhoods, namely Milimani and Jogoo, both in the south-eastern part of Kisii town. Milimani, a low-density, high-income area, hosts government-built residences on public land for senior officials, along with landmarks such as the Kisii State Lodge and Christa Marianne Hospital. Jogoo, zoned for high-density development, is a mixed-use area with institutions such as Kisii National Polytechnic and the Agricultural Training Centre. Properties in Jogoo are mostly private freehold. These neighbourhoods were selected due to their contrasting land tenure and planning densities. Milimani's public land is defined under Article 62(b) of the Constitution, while Jogoo's private land falls under Article 64 (Republic of Kenya, 2010: 42). The study examines land-use change in both areas and assesses the uniformity of planning standards and development control by the CGOK.

4. METHODS

4.1 Research design

This study adopts a case study design to understand land-use and land-cover (LULC) change and densification in Jogoo and Milimani within their real-life context (Crowe *et al.*, 2011). It examines how the CGOK enforces planning standards across these contrasting neighbourhoods. Guided by the positivist paradigm, the study uses quantitative methods for objective, measurable observations, favouring empirical data-collection and analysis (Omollo, 2020b; Tubey, Rotich & Bengat, 2015: 224). It quantifies LULC change and evaluates compliance with CGOK's standards of minimum plot size and building coverage ratio (BCR). Such quantitative research enhances reliability, reduces bias, and allows replication, making findings credible across urban contexts (Creswell & Creswell, 2023: 48).

4.2 Population and sampling

Cluster sampling was used to investigate the implications of intra-urban dualism in Kisii town, ensuring a representative selection of buildings. This method suited the study's focus on two distinct neighbourhoods, namely Milimani (planned, low-density) and Jogoo (unregulated, high-density), which naturally represent clusters of intra-urban dualism. Localised contrasts are best captured through cluster sampling, allowing analysis of land-use transformation and planning compliance while generating generalisable insights (Creswell & Creswell, 2023: 125; Etikan & Bala, 2017: 216). The target population comprised all buildings in both neighbourhoods. Google Earth Pro satellite imagery obtained in January 2025 was used to map all structures, while participatory mapping with local Assistant Chiefs was used to delineate neighbourhood boundaries. Buildings were digitised as vector points to create a complete attribute table. Once the sampling frame was established, the sample size for each neighbourhood cluster was determined, using Krejcie and Morgan's (1970) Sample Size Determination Table. Since Milimani had 50 buildings and Jogoo 360 buildings, proportional samples were drawn from each cluster, resulting in 44 buildings selected from Milimani and 185 from Jogoo. Random sampling ensured unbiased selection, giving each building equal selection probability, reducing bias, and improving statistical validity (Creswell & Creswell, 2023: 28).

4.3 Data-collection and analysis

This study first assessed the extent of LULC change and building densification in the Milimani and Jogoo neighbourhoods of Kisii town between 2005 and 2024. The objective was to determine whether these changes influence compliance with planning standards – specifically, minimum plot size and BCR – and whether this contributed to urban dualism between the two areas. Spatial and temporal data were sourced from high-resolution Google Earth imagery for the years 2005 and 2024. The suitability of Google Earth Pro for urban land-use mapping is well documented, with Malarvizhi, Kumar and Porchelvan (2016: 1840) demonstrating its effectiveness in similar studies in Vellore, Tamil Nadu, India. This study applied geospatial analysis because it offers objective, spatially explicit, and temporally comparable detection of land-use change. Wagh and Auti (2021: 101) affirm that it enhances real-time monitoring, early detection of unauthorised development,

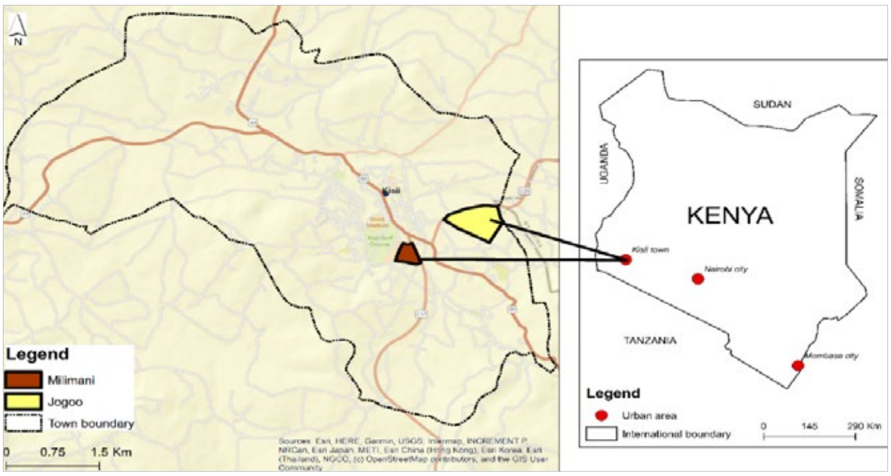

Figure 1: Location of Milimani and Jogoo neighbourhoods in Kenya and Kisii town

Source: Drawn from ArcGIS Pro StreetMap, 2025 verifies zoning compliance, and ultimately strengthens enforcement decision-making. The images were analysed using ArcGIS Pro and the QGIS MOLUSCE plugin through the following steps:

1. Georeferencing the 2005 and 2024 satellite images using the Arc 1960/UTM Zone 36S projected coordinate system.
2. Clipping each image using the delineated neighbourhood boundaries, established through participatory mapping with local Assistant Chiefs.
3. LULC classification of the clipped images, using ISO Cluster Unsupervised Classification, chosen for its efficiency in handling large data sets without the need for labelled training samples. Four LULC categories were derived, guided by Anderson *et al.* (1976: 4):
    - Trees: Closely growing vegetation forming canopies.
    - Transitional areas: Temporarily bare land, due to cessation or change of use.
    - Grassland: Areas covered by natural grasses or bushes.
    - Built-up land: Areas occupied by structures such as buildings and roads.

1. Accuracy assessment was conducted, using 250 stratified ground sample points per image, comparing classified maps to ground-truth data to ensure the integrity and reliability of the geospatial classifications.
2. Calculation of LULC areas (in hectares), detection of changes between classifications, and mapping of building development density per neighbourhood.
3. Transition probability matrices were generated, and 20-year LULC forecasts for each neighbourhood (up to 2044) undertaken, using the Cellular Automata-Artificial Neural Network (CA-ANN) model, using QGIS MOLUSCE plugin.

Following the spatial analysis, field data were collected to assess compliance with approved planning standards (summarised in Table 1), using a structured observational checklist. Buildings were categorised as *conforming* or *non-conforming* based on whether they adhered to the standards. For BCR compliance, the building footprint area (m²) was measured, divided by the plot area (m²), and multiplied by 100 to yield the percentage. To verify compliance with minimum plot size, Registry Index Maps (RIMs) were obtained from the Kisii County Survey Office. These maps provide plot boundaries and dimensions for sampled properties in Jogoo and Milimani. Field measurements were then compared against the recommended standards, with results recorded systematically.

A one-sample t-test in SPSS Statistics was used to assess whether observed building sizes and coverage ratios deviated from recommended planning standards. Kernel density estimation evaluated spatial development patterns, identifying clusters and uneven growth, and providing insights into urban form and development intensity (Brandão, Correia & Paio, 2018: 1). Comparisons across two clusters quantified intra-urban dualism in planning and development control, while a structured cluster sampling approach captured variations in urban growth, compliance, and development densities across the neighbourhoods.

4. RESULTS

4.1 Land-use and land-cover change, 2005-2024

a) Milimani

The study adopts 2005 as the baseline year for assessing LULC change in the Milimani neighbourhood up to 2024. The spatial analysis begins by examining the LULC status in 2005, which consisted of 4 hectares (39%) grassland, 4 hectares (38%) transitional land, 2 hectares (16%) tree cover, and 1 hectare (7%) built-up land. As illustrated in Figure 2, built-up areas were sparsely

Table 1: Approved BCR and minimum plot size per neighbourhood

Neighbourhood cluster	Permitted development	Maximum BCR (%)	Minimum plot size (Ha)	Maximum density
Jogoo	Mixed developments (multiple dwelling residential units, maximum four floors)	65	0.05	High density (70 dwellings per ha)
Milimani	Residential, single-dwelling units	50	0.2	Low density (10 dwellings per ha)

Source: County Government of Kisii, 2013

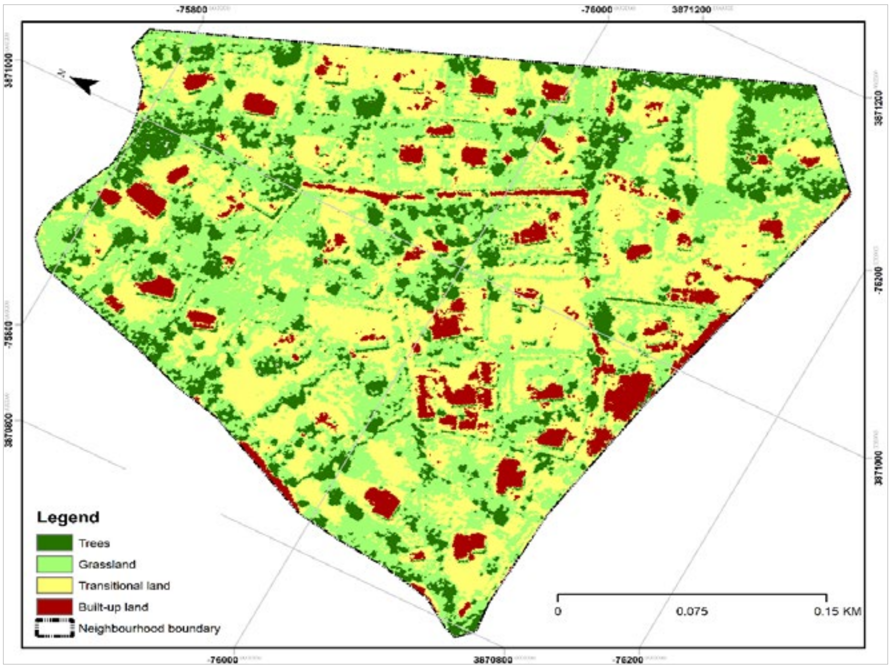

Figure 2: Milimani LULC, 2005

distributed at the time, reflecting a low development density and a distinctive urban form within the neighbourhood.

Accuracy assessment evaluates the reliability and precision of classified remote-sensing images, ensuring that the information derived is valid and suitable for informed decision-making (Congalton & Green, 2019: 23). The study conducted an accuracy assessment for the 2005 LULC classification of Milimani and the results are presented in Table 2 as a confusion matrix. Built-up land and transitional areas recorded the highest producer's accuracies at 100%, while tree cover and grassland registered lower accuracies of 75% and 61%, respectively. These lower values correspond to one pixel and seven pixels that were incorrectly omitted from the tree and grassland classes.

Table 2 shows that trees and built-up land achieved the highest user accuracy at 100%. In contrast, transitional areas recorded the lowest user accuracy of 58.82%, primarily due to misclassification of grassland pixels as transitional land, resulting from their similar spectral signatures. The overall classification accuracy was 80%, meeting the threshold recommended by Anderson *et al*. (1976: 5). In addition, the Kappa coefficient of 72% indicates strong agreement between the classified data and reference information. Figure 3 employs the Kernel Density hotspot analysis to illustrate building development density in 2005, the baseline year. This study links non-compliance with planning standards to the rapid changes in LULC and building density, identifying these factors as key drivers of intra-urban dualism within the study area.

Figure 3 illustrates Milimani's low population density in 2005, characterised by the dispersed spatial distribution of buildings and clusters, with large areas classified as low-density. At that time, high-density development accounted for only 11% (1 hectare) of the neighbourhood, while medium-density and low-density areas covered 37% (4 hectares) and 53% (5 hectares), respectively. Building on this spatial pattern, Figure 4 examines whether

Table 2: Confusion matrix for the 2005 LULC classification, Milimani

Classified data (2005 LULC)	Reference data (2005 satellite image)						Kappa
	Trees	Grassland	Transitional areas	Built-up land	Total	User accuracy	
Trees	3	0	0	0	3	100.00	
Grassland	1	11	0	0	12	91.67	
Transitional areas	0	7	10	0	17	58.82	
Built-up land	0	0	0	8	8	100.00	
Total	4	18	10	8	40	-	
Producer accuracy	75.00	61.00	100.00	100.00	-	80.00	
Kappa							0.72

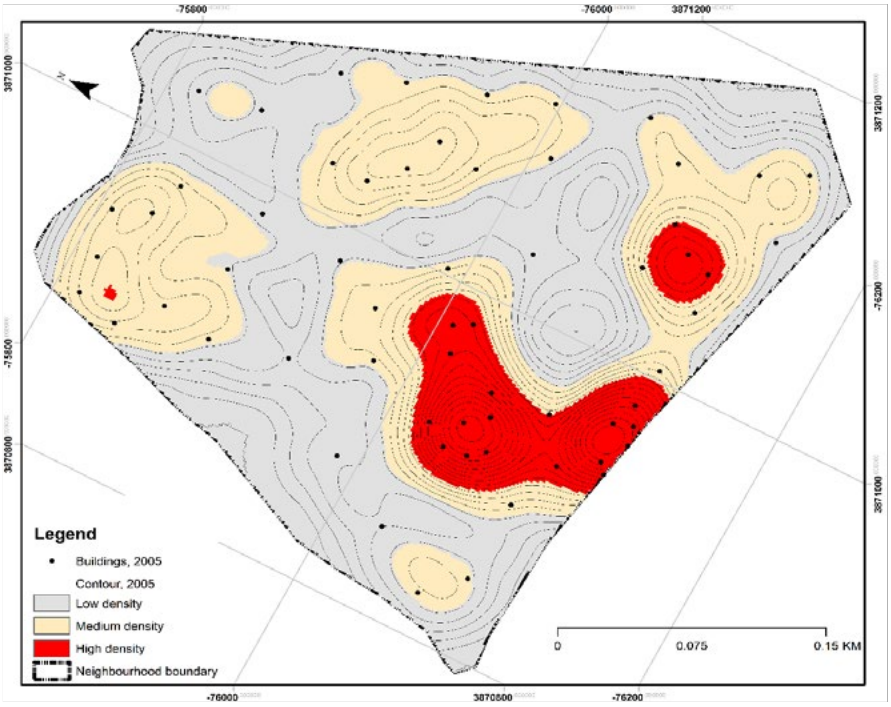

Figure 3: Milimani development density, 2005

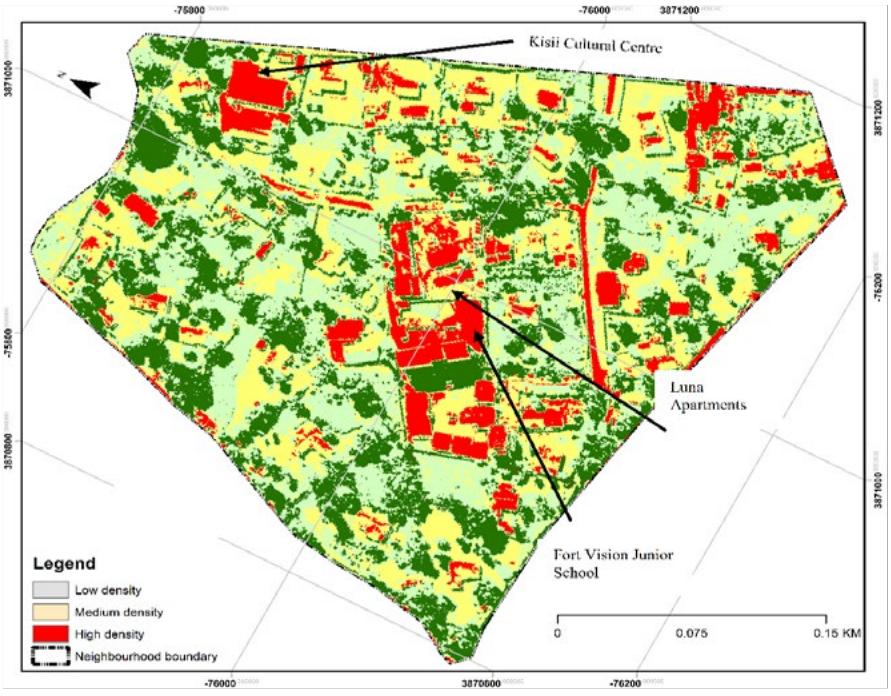

Figure 4: Milimani LULC, 2024

the LULC observed in 2005 had significantly changed by 2024.

In comparison to 2005, grassland significantly increased in 2024, becoming the dominant land-use type in Milimani, covering 4 hectares (36%). This was followed by tree cover at 3 hectares (29%), and built-up land at 1 hectare (10%). The red areas in the central and north-western parts of the map represent recent developments – including Fort Vision Junior School, Luna Apartments, and the Kisii Cultural Centre – that were established between 2018 and 2019. These structures, absent in 2005, now serve as key landmarks in the neighbourhood. Table 3 presents the accuracy assessment results for the 2024 LULC classification using a confusion matrix.

Although the overall accuracy of 67.50% fell below the 80% threshold recommended by Anderson *et al*. (1976: 15), it is noteworthy that user accuracies for key classes – particularly built-up areas – were high at 100%. Given that the study primarily focused on the dualistic implications of built-up development, the achieved accuracy and a Kappa coefficient of 57% were deemed sufficient for investigating the research problem.

The transitional land class recorded the lowest user accuracy at 20%, largely due to misclassification with grassland and built-up areas caused by overlapping spectral signatures. Rusted corrugated iron sheet roofs, in particular, shared reflectance characteristics with transitional areas, leading to confusion during classification. Similar misclassification occurred between grassland and built-up land, with grassland pixels being incorrectly labelled as built-up. Regarding producer accuracy, built-up land reached only 52.63%, as the classifier excluded several relevant pixels by misassigning them to grassland and transitional categories. Grassland achieved a 60% producer accuracy, with four pixels omitted, due to spectral similarities with transitional areas.

The LULC classification from 2005 was compared to that of 2024 (see Figure 4 and Table 4) to assess significant spatial transitions. Tree cover notably increased from 1.55 hectares in 2005 to 2.79 hectares in 2024, an 80% rise, suggesting improvements in vegetation cover possibly due to afforestation, conservation, or natural regrowth, which may enhance biodiversity, air quality, and climate resilience.

Grassland declined by 11%, from 3.79 to 3.37 hectares, likely reflecting conversion to other land uses such as tree planting or urban development. Transitional land decreased by 30%, from 3.81 to 2.65 hectares, indicating a shift toward more permanent land uses, including built-up development and reforestation. Built-up land increased by 43%, from 0.79 to 1.13 hectares, largely due to the establishment of Fort Vision Junior School, Luna Apartments, and the Kisii Cultural Centre between 2018 and 2019.

Despite these changes, built-up land in the rest of Milimani remained relatively stable, suggesting limited overall urban expansion. This stability is likely due to controlled development by the CGOK, particularly as the neighbourhood houses many government officials.

Building on the insights from Figures 4 and Table 4, Figure 5 illustrates the spatial distribution of building development densities in Milimani as of 2024. The map reveals distinct variations in density, with red areas indicating high-density zones and lighter shades representing lower densities. The dispersed pattern of buildings across most of the neighbourhood suggests well-spaced developments, contributing to an overall low-density settlement character.

High-density clusters are concentrated in the central, southern, and north-eastern parts of Milimani. As noted in Figure 4, this pattern is primarily driven by developments such as Fort Vision Junior School, Luna Apartments, and the Kisii Cultural Centre, which were established between 2018 and 2019. Despite broader urbanisation trends in Kisii town, Figure 5 indicates that much of Milimani has retained its low-density profile. This is largely attributed to the neighbourhood's role as a residential area for senior national and county government officials, which has resulted in the strict enforcement of building development control standards.

The sparse distribution of buildings visible in Figure 5 further affirms the low building development density in Milimani as of 2024. Further analysis, presented in Table 5, highlights the LULC transitions in Milimani between

Table 3: Confusion matrix for the 2024 LUC classification, Milimani

Classified data (2024 LULC)	Reference data (2024 satellite image)						Kappa
	Trees	Grassland	Transitional areas	Built-up land	Total	User accuracy	
Trees	9	0	0	1	10	90.00	
Grassland	0	6	0	4	10	60.00	
Transitional areas	0	4	2	4	10	20.00	
Built-up land	0	0	0	10	10	100.00	
Total	9	10	2	19	-	-	
Producer accuracy	100.00	60.00	100.00	52.63	-	67.50	
Kappa							0.57

Table 4: LULC change (hectares) in Milimani, 2005-2024

LULC	2005	2024	% change
Trees	1.55	2.79	80
Grassland	3.79	3.37	-11.1
Transitional land	3.81	2.65	-30.4
Built-up land	0.79	1.13	43

2005 and 2024. The results show that grassland experienced conversions of 1.03 hectares each into tree cover and transitional areas, while 0.38 hectares transitioned into built-up land. Tree cover declined, with 0.44 hectares reverting to grassland, 0.70 hectares becoming transitional land, and 0.10 hectares converted into built-up land. Transitional areas underwent significant shifts: 1.38 hectares changed to grassland, 0.53 hectares to trees, and 0.18 hectares to built-up land. Built-up land saw minor reversions: 0.16 hectares to grassland, 0.35 hectares to trees, and 0.15 hectares to transitional areas. However, a substantial portion (3.52 hectares) of built-up land remained unchanged, indicating a level of developmental stability over the study period.

Over the next 20 years, LULC in Milimani is expected to continue evolving. The transition probability matrix for the period 2024 to 2044, presented in Table 6, illustrates the likelihood of various land-cover changes occurring over time. Tree cover has a 42.1% probability of remaining unchanged. However, it is more likely to transition into grassland (28.5%) or transitional land (21.4%), with 8% expected to be converted into built-up areas – an indication of ongoing deforestation and urban expansion. Grassland has a 39.7% chance of remaining stable, while a 33.1% probability of transitioning to tree cover suggests potential natural regeneration. Nonetheless, 20.7% of the grassland is projected to become transitional land, and 6.6% is likely to be developed into built-up areas, reflecting moderate urbanisation pressure within the neighbourhood.

Transitional land has a 33.3% probability of remaining unchanged by 2044. However, a significant portion is projected to convert to grassland (34.3%), suggesting potential land recovery. In addition, 20.5% is likely to transition into tree cover, while 11.9% is expected to become built-up, indicating growing urban influence on previously undeveloped or temporarily used areas. Built-up land is projected to exhibit the highest level of stability, with a 38.4% probability of remaining developed. Its expansion is expected to come primarily from transitional land (33.6%), followed by grassland (14.9%) and tree cover (13.1%), reflecting a steady but moderate increase in built-up areas over time. Taken together, Table 7 and Figure 6 suggest that Milimani will likely experience an increase in tree cover, a decline in transitional land, and a modest expansion of built-up areas. These trends will largely depend on existing development patterns and the effectiveness of development control and conservation measures. This projection assumes that current

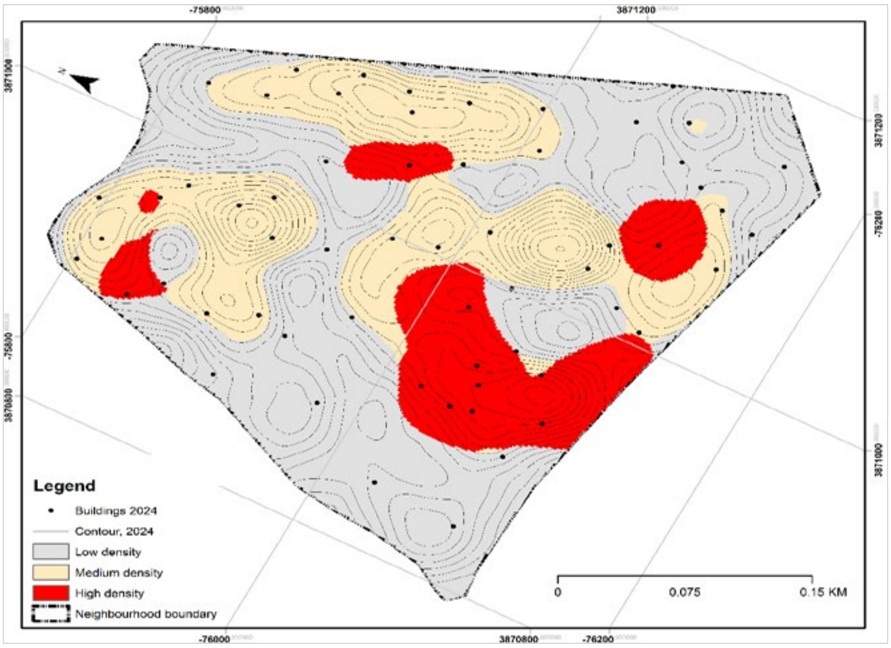

Figure 5: Milimani development density, 2024

Table 5: LULC transition in Milimani, 2005-2024

From 2005 LULC	To 2024 LULC	Area (Ha) changed
Grassland	Trees	1.03
	Transitional areas	1.03
	Built-up land	0.38
Trees	Grassland	0.44
	Transitional areas	0.70
	Built-up land	0.10
Transitional areas	Grassland	1.38
	Trees	0.53
	Built-up land	0.18
Built-up land	Grassland	0.16
	Trees	0.35
	Transitional areas	0.15
No change	No change	3.52

Table 6: Milimani LULC transition probability matrix, 2024-2044

LULC	Trees	Grassland	Transitional land	Built-up land
Trees	0.421	0.285	0.214	0.080
Grassland	0.331	0.397	0.207	0.066
Transitional land	0.205	0.343	0.333	0.119
Built-up land	0.131	0.149	0.336	0.384

Table 7: Prediction of LULC change in Milimani, 2024-2044

LULC	Area (Ha), 2024	Predicted area (Ha), 2044	Remarks
Trees	2.79	4.0	Continued increase
Grassland	3.37	2.9	Gradual decline
Transitional land	2.65	1.5	Further reduction
Built-up land	1.13	1.7	Low expansion

trends continue in the absence of major external influences such as policy changes or large-scale infrastructure projects.

Based on the observed LULC trends in Milimani from 2005 to 2024, the projections shown in Figure 6 suggest that the neighbourhood is likely to maintain its low development density over the next 20 years (2024-2044). As noted previously, Milimani is a preferred residential area for affluent national and county government officials, resulting in strict enforcement of development control regulations to preserve its low-density character. The only notable exceptions to this pattern are Fort Vision Junior School and Luna Apartments, located centrally within the neighbourhood, and the Kisii Cultural Centre, situated in the northeastern part (see Figure 4). These developments represent the few high-density features within an otherwise low-density urban fabric.

Given Milimani's consistent low-density profile, a comparative analysis of LULC change in Jogoo – including notable contrasts in land-use patterns, densification, and compliance with BCR and minimum plot sizes – would provide further evidence of intra-urban dualism between the two neighbourhoods.

b) Jogoo neighbourhood

As with Milimani, the LULC assessment in Jogoo used 2005 as the base year. Figure 7 illustrates notable land-use patterns during this period. Built-up areas (red) are primarily concentrated along the periphery, indicating early signs of urban expansion. The neighbourhood exhibited a blend of natural and developed land, with grassland (light green) being the dominant category, covering 50% (20 hectares) – reflecting the presence of substantial open space.

Transitional land (yellow) accounted for 24% (9 hectares), suggesting active land conversion processes, while tree cover (dark green) made up 18% (7 hectares), contributing to environmental benefits such as improved air quality and erosion control. Built-up land, at only 9% (3 hectares), was the smallest LULC category, indicating that much of the neighbourhood was still in an early stage of urban development.

Overall, Jogoo in 2005 was characterised by a transitional landscape, balancing natural spaces with increasing urbanisation. The northern part of the neighbourhood contained the majority of the built-up areas. These patterns suggest a trajectory of continued urban growth leading into 2024 and potentially through to 2044, while still retaining a notable degree of green cover.

The user accuracy values presented in Table 8 assess the reliability of the 2005 LULC classification for Jogoo. Trees and built-up land achieved perfect user accuracy (100%), indicating that all classified pixels accurately represented their actual land-cover categories. In contrast, grassland and transitional areas recorded lower user accuracy (60%), suggesting misclassification, particularly where some grassland areas were incorrectly identified. Producer accuracy further reveals that trees were classified with complete accuracy (100%), while

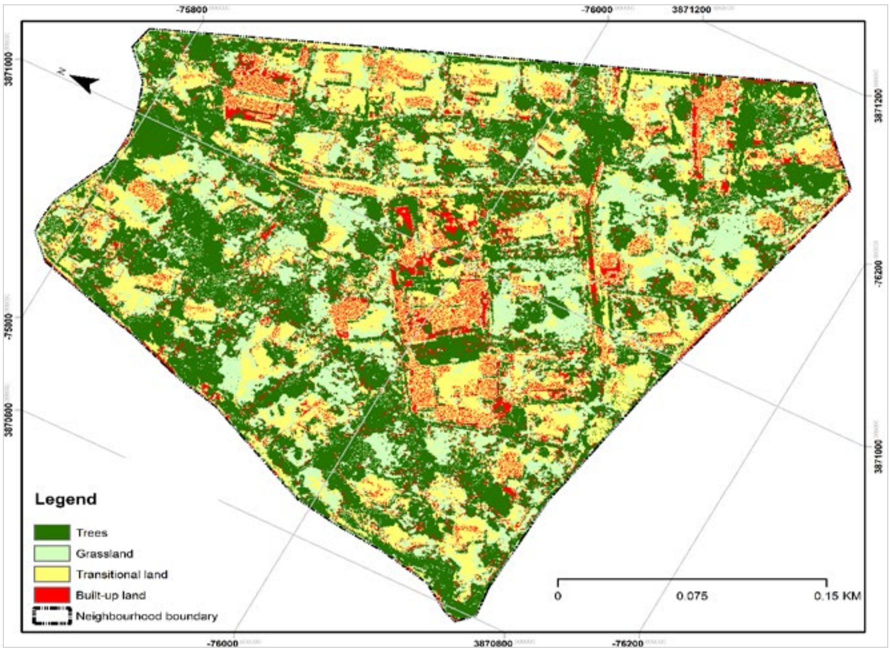

Figure 6: Predicted LULC in Milimani by 2044

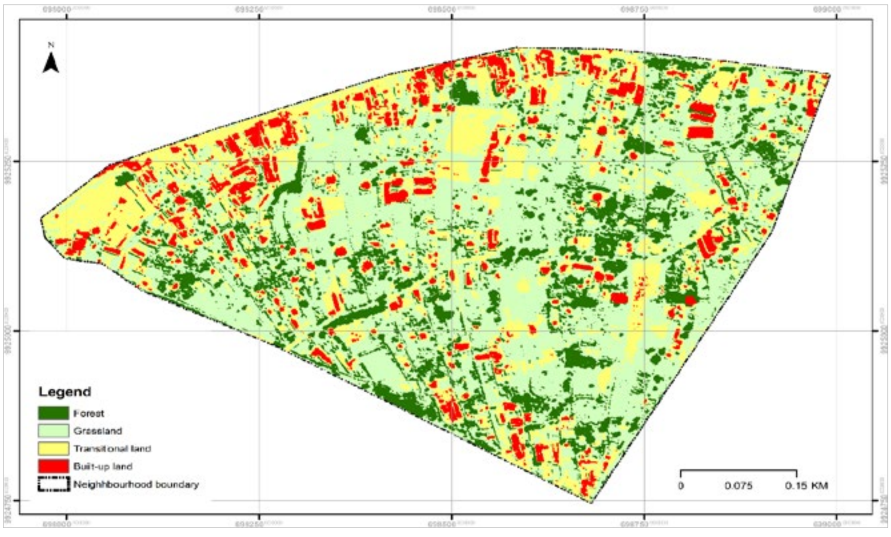

Figure 7: LULC in Jogoo, 2005

grassland and built-up land achieved reasonably good results (80% and 76.92%, respectively). However, transitional areas exhibited the lowest producer accuracy (60.00%), reflecting difficulties in differentiating them from grassland and built-up areas, likely due to similar spectral characteristics. The overall Kappa coefficient of 0.72 indicates a substantial level of agreement between the classified results and the reference data, although some degree of misclassification persists. These findings suggest that, while tree and built-up land classifications are highly reliable, accurately distinguishing grassland from transitional areas remains a challenge, likely due to the fluid nature of transitional land cover in urbanising environments.

Figure 8 illustrates the spatial distribution of building density in Jogoo for 2005, using contour lines and colour-coded density levels to visualise land use intensification across the neighbourhood. Black dots represent individual buildings, while contour lines indicate variations in density. High-density zones, shown in red, are concentrated primarily in the western part of Jogoo around Jogoo Primary School, reflecting intense urbanisation with closely spaced structures. Medium-density areas, depicted in yellow, indicate moderate development, likely comprising a mix of residential and commercial properties. Low-density zones, represented in grey, correspond to sparsely developed or undeveloped land scattered throughout the neighbourhood, with some moderate clustering. This pattern reveals uneven growth with a dense urban core surrounded by less developed areas, suggesting potential for further expansion.

Building on this, Figure 9 presents a comparative LULC assessment for 2024. Grassland remains dominant, covering 20 hectares (50%), indicating substantial open space potentially used for grazing or left undeveloped. Transitional land occupies 9 hectares (24%), highlighting ongoing land-use changes such as conversion from vegetation to built-up areas. Tree cover accounts for 7 hectares (18%), contributing to environmental benefits such as carbon sequestration and biodiversity support. Built-up land is the smallest category, covering 3 hectares (9%) and reflecting limited urban expansion.

The accuracy assessment for the 2024 LULC classification in Table 9 demonstrates strong performance. Producer accuracy is perfect (100%%) for trees, grassland, and transitional areas, indicating that all reference pixels were correctly classified. Built-up land has a lower producer accuracy (66.67%), suggesting some misclassification. User accuracy is high overall, with grassland and built-up land achieving 100%, while trees and transitional

Table 8: Confusion matrix for the 2005 LULC classification, Jogoo

Classified data (2005 LULC)	Reference data (2005 satellite image)						Kappa
	Trees	Grassland	Transitional areas	Built-up land	Total	User accuracy	
Trees	10	0	0	0	10	100.00	
Grassland	0	8	4	1	13	61.54	
Transitional areas	0	2	6	2	10	60.00	
Built-up land	0	0	0	10	10	100.00	
Total	10	10	10	13	43	-	
Producer accuracy	100.00	80.00	60.00	76.92	-	79.07	
Kappa							0.72

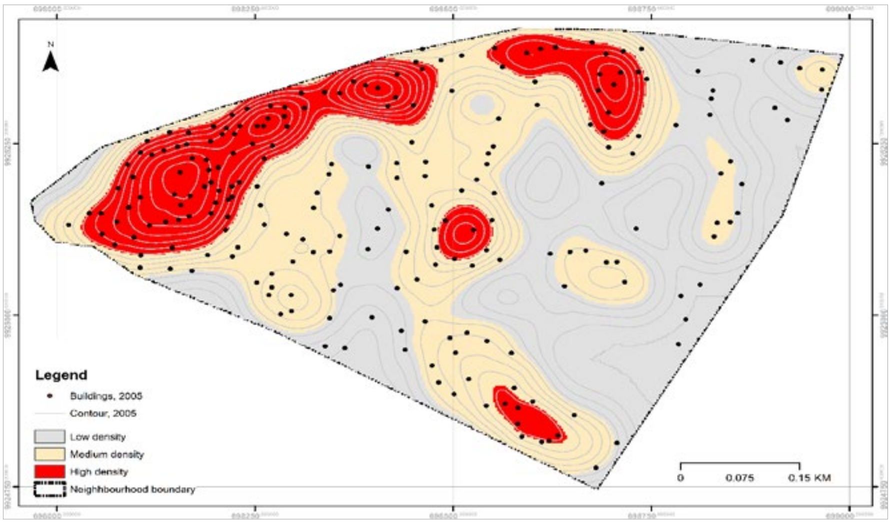

Figure 8: Jogoo development density, 2005

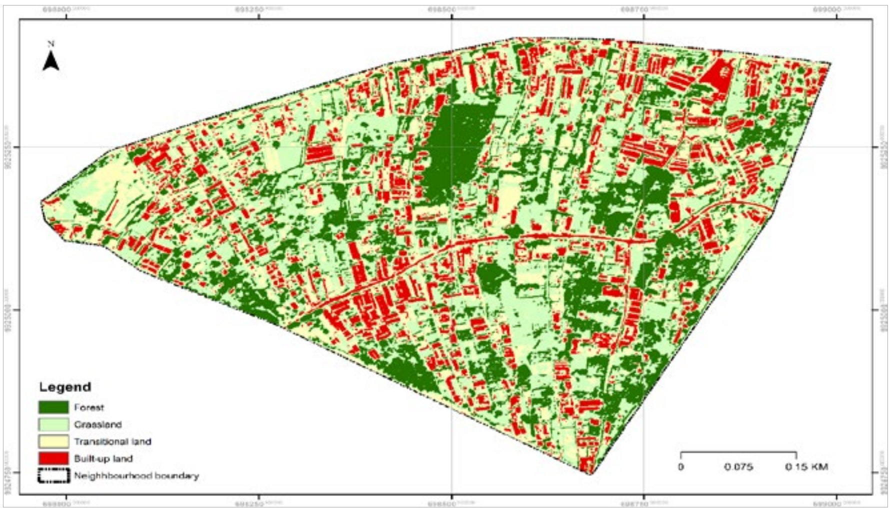

Figure 9: LULC in Jogoo, 2024

areas record slightly lower values (70% and 80%, respectively), reflecting minor classification errors. The overall Kappa coefficient of 0.83 indicates substantial agreement between classified data and reference imagery, confirming the classification's reliability. However, misclassification in the built-up category points to opportunities for improvement, such as refining classification algorithms or employing higher-resolution imagery.

Over the years, unlike Milimani, Jogoo has undergone substantial changes in LULC (see Table 10 and Figure 9). Between 2005 and 2024, tree cover increased by 43%, rising from 7 to 10 hectares, signalling possible afforestation initiatives or conservation efforts. In contrast, grassland declined by 30%, from 20 to 14 hectares, likely due to urban expansion or intensified agricultural use. Transitional land remained stable at 9 hectares, suggesting a consistent level of land undergoing conversion. The most significant change occurred in built-up land, which doubled from 3 to 6 hectares, a 100% increase. This sharp rise reflects rapid urbanisation and infrastructure development, resulting in increased land use density. However, this growth has occurred at the expense of environmental sustainability and liveability, placing the neighbourhood under strain.

As illustrated in Figure 10, land-use densification in Jogoo by 2024 reflects growing urban pressures, with previously underdeveloped or sparsely populated zones transformed into densely built-up areas. This intensification has increased demand for housing and services, putting considerable pressure on existing infrastructure, including roads, water supply, and sewage systems. Overcrowding and service deficiencies are emerging concerns. In this context, effective physical and land-use planning is essential to manage Jogoo's urban transformation. Without it, continued densification could undermine environmental sustainability and the quality of life. Proper regulation and strategic development are required to ensure that the neighbourhood remains liveable, functional, and resilient despite growing urban pressures.

The high-density areas in Jogoo represent the neighbourhood's most developed and populated zones. These are concentrated in compact clusters rather than being spread uniformly, suggesting that factors such as accessibility and topography have influenced their spatial distribution.

Based on the observed trends in LULC change and intensifying densification, Table 11 presents the transitions in land cover in Jogoo

Table 9: Confusion matrix for the 2024 LULC classification, Jogoo

Classified data (2024 LULC)	Reference data (2024 satellite image)						Kappa
	Trees	Grassland	Transitional areas	Built-up land	Total	User accuracy	
Trees	7	0	0	3	10	70.00	
Grassland	0	10	0	0	10	100.00	
Transitional areas	0	0	8	2	10	80.00	
Built-up land	0	0	0	10	10	100.00	
Total	7	10	8	15	40	-	
Producer accuracy	100.00	100.00	100.00	66.67	-	87.50	
Kappa							0.83

Table 10: LULC change (hectares) in Jogoo 2005-2024

LULC	2005	2024	% change
Trees	7	10	43
Grassland	20	14	-30
Transitional land	9	9	0
Built-up land	3	6	100

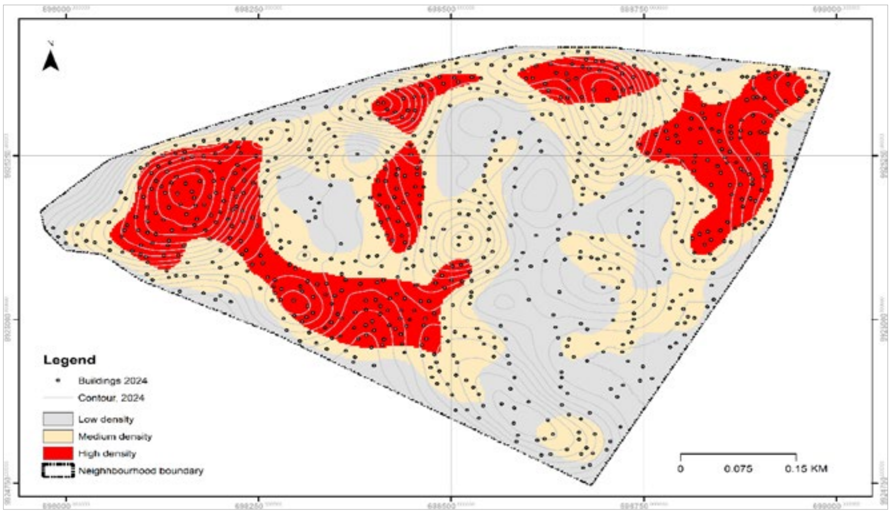

Figure 10: Jogoo development density, 2024

Table 11: LULC transition in Jogoo, 2005-2024

From 2005 LULC	To 2024 LULC	Area (Ha) changed
Grassland	Trees	2.05
	Transitional areas	1.21
	Built-up land	1.00
Trees	Grassland	0.21
	Transitional areas	0.11
	Built-up land	0.55
Transitional areas	Grassland	3.44
	Trees	2.02
	Built-up land	1.75
Built-up land	Grassland	0.83
	Trees	0.39
	Transitional areas	1.29
No change	No change	

between 2005 and 2024. This pattern contrasts sharply with Milimani, where the 2024 LULC (see Table 4) indicates a persistently low population density during the same period.

The most notable reductions occurred in grassland, which lost 2.05 ha, transitioned to tree cover, 1.21 ha to transitional land, and 1.00 hectares to built-up areas. These patterns suggest simultaneous urban expansion and ecological interventions such as afforestation. A small area under tree cover changed to grassland (0.21 hectares), likely due to deforestation, with a further 0.11 hectares changing to transitional areas, suggesting impacts of logging or cultivation.

Transitional land remained stable overall, but internally underwent redistributions, including 3.44 hectares reverting to grassland, 2.02 hectares becoming tree cover, and 1.75 hectares converted into built-up land. These shifts suggest that previously unstable or converted land is increasingly being reclaimed for vegetation or absorbed by urban expansion.

Built-up land experienced the most significant expansion, primarily through conversions from transitional areas (1.75 hectares), grassland (1.00 hectares), and tree cover (0.55 hectares). Minor reversions to vegetation occurred from built-up land, including 0.83 hectares to grassland, 0.39 hectares to trees, and 1.29 hectares to transitional areas.

To assess potential future changes, Table 12 presents a transition probability matrix projecting LULC shifts from 2024 to 2044. The values along the diagonal indicate the likelihood of each category remaining unchanged or transitioning into others.

Grassland is the most stable land cover, with a 38.8% probability of remaining unchanged, although 28.2% may change to tree cover, 18.6% to transitional land, and 14.4% to built-up areas, showing pressure from ecological succession and urbanisation. Tree cover has a 34.2% chance of remaining, while 34.4% may transition to grassland, 17.4% to transitional land, and 14.0% to built-up areas. Transitional land is highly dynamic: 26.7% remains, 36.0% may become grassland, 21.2% tree cover, and 16.1% built-up land. Built-up areas are comparatively stable: 25.6% remains, 34.2% may convert to transitional land, 27.4% to grassland, and 12.8% to tree cover, indicating potential greening. Grassland shows the highest stability; transitional land shows the most dynamic change. Built-up land significantly drives transformation, particularly towards transitional land. Figure 11 predicts Jogoo's 2044 LULC distribution based on these transition probabilities.

Figure 11 reveals that Jogoo will likely experience sustained urban growth, reduced grasslands, and increased tree cover, with transitional land maintaining a steady balance unless important policy interventions occur within the next 20 years. As confirmed in Table 13, tree cover has increased from 6.95 hectares in 2005 to 10.38 hectares in 2024, showing a positive growth trend. If this continues, tree cover may expand to approximately 13 hectares by 2044, driven by afforestation efforts or conservation policies.

In the interim, grassland has decreased from 19.78 hectares in 2005 to 14.8 hectares in 2024, indicating a decline. If this trend persists, it could shrink to around 10 hectares by 2044, likely due to urbanisation, agricultural activities, or new infrastructure developments. The area of transitional land slightly changed from 9.39 hectares to 8.56 hectares, suggesting an almost balance between land conversion and regeneration. Unless significant land-use policies change, transitional land will likely remain stable in the next two decades. Built-up land has doubled from 3.42 hectares in 2005 to 6.21 hectares in 2024, reflecting

Table 12: LULC transition probability matrix for Milimani, 2024-2044

LULC	Trees	Grassland	Transitional land	Built-up land
Trees	0.342	0.344	0.174	0.140
Grassland	0.282	0.388	0.186	0.144
Transitional land	0.212	0.360	0.267	0.161
Built-up land	0.128	0.274	0.342	0.256

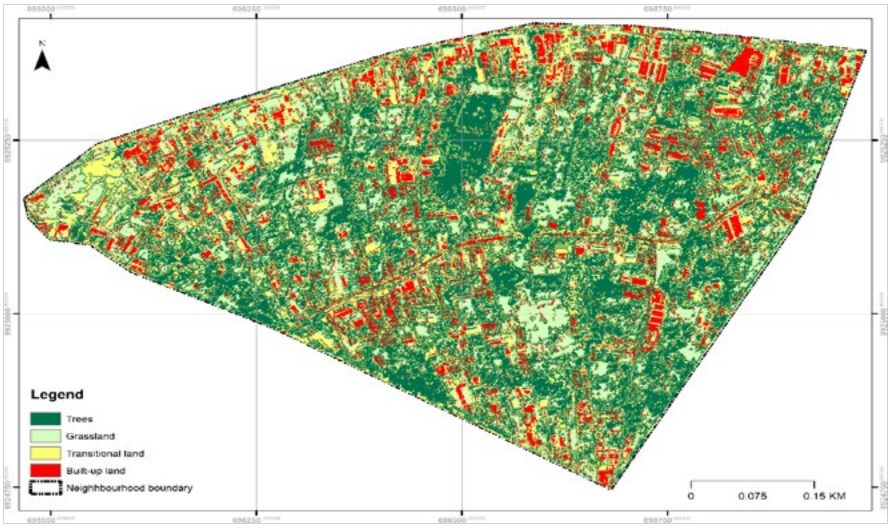

Figure 11: Predicted LULC in Jogoo by 2044

Table 13: Predicted LULC in Jogoo, 2044

LULC	Area (Ha) 2005	Area (Ha) 2024	Change (Ha)	2005%	2024%	Change (%)	Predicted Area (Ha) 2044	Trend
Trees	6.95	10.38	3.44	17.57	26.26	8.69	13	Increasing
Grassland	19.78	14.38	-5.40	50.03	36.37	-13.66	10	Decreasing
Transitional land	9.39	8.56	-0.83	23.75	21.66	-2.09	9	Stable
Built-up land	3.42	6.21	2.79	8.65	15.71	7.07	12	Increasing

rapid urbanisation. If this continues, built-up land could expand to approximately 12 hectares by 2044, driven by population growth, urban expansion, and economic activities.

4.2 Dualistic implication of LULC changes in Milimani and Jogoo

The spatial analysis identifies a contrasting LULC change between Milimani and Jogoo from 2004 to 2024. In Milimani, the built-up environment covered 1 hectare in 2005. It increased by 10% to 1.1 hectares in 2024, with projections indicating growth to 1.7 hectares by 2044. Despite this increase, development density has remained fairly low. In contrast, Jogoo's built-up land expanded from 3.42 hectares in 2005 to 6.21 hectares in 2024, marking a 100% increase, with projections suggesting that it will increase to 12 hectares in 2044. Strict regulations control development in Milimani, because it accommodates many senior county and national government officials. However, development in Jogoo remains uncontrolled, as the neighbourhood sits on private land, creating intra-urban dualism in land-use planning. Given this background, further analysis (Table 14) examines whether this observation contributes to non-compliance with planning standards for minimum plot size and BCR.

As shown in Table 14, one sample t-test analysis evaluates whether observed plot sizes in Milimani conform to the recommended standard of 0.2 hectares. The results show that the mean plot size (M = 0.21659, SD = 0.08012, N = 44) slightly exceeds the threshold, suggesting general conformity, since the mean is close to 0.2 hectares. A further analysis in Milimani examined compliance with the BCR standard of 50%. The results (M = 51.93, SD = 5.77, SE = 0.87, N = 44) show that the mean BCR slightly surpasses the threshold. However, given the mean's proximity to 50%, the findings indicate general adherence to the standard. Comparatively, a one-sample t-test analysis also assessed whether plot sizes in Jogoo conform to the standard of 0.02 hectares. The sample included 185 plots, with a mean plot size of 0.01283 hectares (SD = 0.006156). These results indicate that the average plot size falls significantly below the recommended standard, suggesting widespread non-conformity and high land fragmentation. A further analysis in Jogoo examines compliance with the BCR standard of 65%. The results show a high mean BCR of 76.77% (SD = 23.75), indicating considerable variation in adherence. Figure 12 presents the dualistic nature of compliance with BCR and minimum plot size in Jogoo and Milimani.

5. DISCUSSION OF THE FINDINGS

The findings reveal that intra-urban dualism is a defining feature of land-use transformation in Kisii town. The comparative geospatial analysis between Milimani and Jogoo neighbourhoods showed stark spatial and regulatory contrasts that illustrate the uneven enforcement of development control standards. While Milimani has largely maintained a regulated, low-density urban form, Jogoo has experienced rapid and uncoordinated densification, underscoring the influence of land tenure and governance structures on urban morphology. These findings align with Pacione (2009) and Mugah and Letema (2025), who argue that spatial inequalities within cities often emerge from institutional weaknesses and uneven policy enforcement.

The results show that between 2005 and 2024, built-up land in Jogoo doubled from 6 to 12 hectares, while Milimani's built-up area increased only marginally from 1 to 1.13 hectares. This indicates a higher rate of land-use conversion in privately owned weakly regulated neighbourhoods compared to government-controlled zones. The findings are consistent with Mwaura and Odera (2021), who observed similar patterns in Nairobi, where unregulated developments proliferated in areas with limited oversight. The contrast between Milimani and Jogoo demonstrates how development control mechanisms such as BCR and minimum plot size regulations play a decisive role in shaping urban form. In Milimani, where planning standards are strictly enforced, the mean plot size (0.216 ha) and mean BCR (51.9%) closely match the approved standards. In contrast, Jogoo's mean plot size (0.013 ha) and BCR (76.8%) reveal extensive non-compliance,

Table 14: Comparison of plot sizes and BCR in Milimani and Jogoo, 2024

Area	Spatial variable	N	Mean	Std. deviation	Std. error mean
Milimani	Observed minimum plot size (Ha)	44	0.21659	.080115	.012078
	Observed BCR (%)	44	51.9318	5.77242	.87022
Jogoo	Observed minimum plot size (Ha)	185	.01283	.006156	.000453
	Observed BCR (%)	185	76.7676	23.74743	1.74595

Figure 12: Controlled low-density development and BCR in Milimani (right) *versus* uncontrolled high-density development and BCR in Jogoo (left)

Source: Extracted from Google Earth Pro (2025) illustrating that weak enforcement fosters land fragmentation and unplanned densification. These disparities confirm that intra-urban dualism is not merely a spatial phenomenon, but also a governance and regulatory challenge. According to Andersen and Pløger (2007), urban governance dualism arises when top-down regulatory regimes coexist with informal, market-driven development systems. In Kisii town, the County Government's selective enforcement of planning standards stricter in Milimani and lax in Jogoo reflects such governance dualism. This pattern perpetuates spatial inequality, by concentrating public investment and infrastructure in planned neighbourhoods, while neglecting informal settlements. The resulting uneven development undermines sustainable urban growth, echoing the findings of K'Akumu and Olima (2007) and K'oyoo (2024), who attribute such disparities to the colonial legacy of segregated planning systems and post-colonial policy inconsistencies.

The results suggest that private landownership and speculative development exacerbate non-compliance with planning standards. Ayonga (2019) made similar observations, noting that unregulated private development in Kenyan towns often occurs without adherence to approved spatial plans. In Jogoo, the absence of effective monitoring has enabled property owners to subdivide land into substandard plots and exceed permissible BCRs, resulting in overcrowding and infrastructure strain. This supports the theory of regulatory compliance (Fiene, 2016), which posits that adherence to regulations depends on institutional design, deterrence mechanisms, and societal attitudes toward rules. In Kisii town, weak deterrence and limited institutional capacity appear to have diminished compliance motivation among developers.

The study also revealed that, while Milimani's land-use pattern is projected to remain relatively stable up to 2044, Jogoo is likely to continue experiencing unregulated expansion. This trajectory mirrors broader urbanisation trends in sub-Saharan Africa, where rapid population growth and limited planning enforcement drive informal urban expansion (UN-Habitat, 2003; Musakwa & Van Niekerk, 2015). The geospatial predictions suggest that, without intervention, intra-urban inequalities will deepen, leading to environmental degradation and declining urban liveability. Such findings reaffirm the argument by Talen and Brody (2005) that uncontrolled urban growth compromises both social equity and ecological sustainability. Overall, this study highlights that intra-urban dualism in Kisii town is a manifestation of uneven development control and planning enforcement. The duality between Milimani and Jogoo reflects broader institutional weaknesses in urban governance, where formal planning systems coexist with informal development practices. Although based in Kenya, these findings apply broadly to rapidly urbanising cities in the Global South that experience similar weaknesses in development control.

6. CONCLUSION

Major LULC and development density changes are occurring in Kisii town, particularly in the Milimani and Jogoo neighbourhoods. Jogoo has experienced substantial building growth compared to Milimani, driven by landownership and regulatory enforcement differences by the CGOK. Milimani, home to senior government officials, has maintained low-density development, while Jogoo, dominated by private landowners, doubled built-up areas from 6 hectares in 2005 to 12 hectares in 2024. Buildings in Milimani comply with BCR and minimum plot size, unlike Jogoo, which largely flouts standards. This confirms intra-urban land-use dualism, with Jogoo facing increasing infrastructure pressure. Without proper planning interventions, dualism will likely widen, leading to unsustainable neighbourhood development. Differences in LULC change, densification, and plot compliance validate this dualism. Overall, the study highlights the spatial and temporal impacts of intra-urban dualism and the need for balanced strategies to ensure sustainable growth, infrastructure efficiency, and quality of life. It advances development control practice, by demonstrating the practical use of geospatial analysis to monitor land-use conformity and enforce planning standards. Weak enforcement of BCR and minimum plot sizes contribute to unregulated growth and spatial inequality. The study promotes evidence-based, geospatial-supported monitoring to strengthen regulatory oversight. It highlights the need for uniform application of development control tools and inclusive planning policies to achieve orderly, equitable, and sustainable urban development in Kisii town and similar contexts.

7. RECOMMENDATIONS

The findings underscore the urgent need to rethink development control as a strategic tool for achieving spatial equity and sustainable urban transformation in Kisii town. First, the CGOK should reconceptualise development control from a purely regulatory exercise to a framework for spatial justice, ensuring that all neighbourhoods, whether planned or informal, receive equitable access to infrastructure, services, and environmental amenities. To institutionalise this vision, the County should establish an Urban Geospatial Intelligence Unit equipped with drone surveillance, remote sensing, and AI-assisted mapping tools to enable real-time detection of non-conforming developments and evidence-based enforcement. Secondly, planning inclusivity should replace exclusionary regulatory approaches. Informal neighbourhoods such as Jogoo require adaptive zoning mechanisms that integrate flexibility into standards, allowing incremental upgrading rather than punitive enforcement. The County should adopt performance-based development control, where compliance is measured not only by plot size or BCR, but also by contributions to sustainability, affordability, and liveability. Further, participatory urban governance is essential. A citizen-led spatial monitoring platform could enable residents to report unapproved developments or environmental degradation through digital mapping tools, promoting transparency and civic responsibility. In addition, the County should introduce blockchain-enabled permitting systems that link development approvals to spatial databases, ensuring traceability and preventing unauthorised alterations to approved plans.

Finally, the study recommends that CGOK institutionalise urban development resilience audits to periodically evaluate how planning compliance enhances infrastructure efficiency, environmental sustainability, and disaster preparedness. A deliberate policy of inter-neighbourhood equity should guide resource allocation between high- and low-density areas to counter intra-urban dualism. Collectively, these measures can transform development control into a proactive, data-driven, and socially responsive governance instrument, positioning Kisii town as a model for sustainable secondary city growth in s-Saharan Africa. Given that this study focused only on compliance with BCR and minimum plot size standards, future research should examine intra-urban dualism in the implementation of other planning standards such as floor area ratio, pedestrian footpaths, and residential building setbacks, because these standards equally influence spatial equity, densification patterns, neighbourhood habitability, and differentiated development outcomes across urban spaces. Exploring them will, therefore, broaden understanding of how dualism manifests across multiple regulatory dimensions beyond the two assessed in this study.

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