GEOGRAPHICAL ANALYSIS

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Analysis of the Spatial Transformation Process of the Inner-City Slums in Ibadan Between 1990 and 2020

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Abstract

This study examines the spatial transformation of inner-city slums in Ibadan, Nigeria, from 1990 to 2020, focusing on land use and land cover (LULC) changes, changes in population and their urban planning implications. Rapid urbanization, driven by population growth, rural-urban migration, and infrastructural expansion, has led to the densification of built-up areas, gentrification, and the displacement of natural vegetation and water bodies motivated this study. Both primary and secondary data were used, and multi-staged sampling technique was adopted in determining the size. Using techniques such as Random Forest classification, spatial indices, and intensity analysis, the study provides insights into these dynamic shifts. The transformation that is prevalent is in the areas of land use /land cover and great change in the population size spatio-temporally. Results revealed that between 1990-2000 the land mass increased from 17,451,392.4 m^2 to 43,277,488.4 m^2 (148%) while the population also increased by 36.4% (1,685,894 to 2,298,923). Findings show that the continuous proliferation of built-up areas signifies urbanization within slums, presenting both redevelopment opportunities and environmental vulnerabilities. Further analysis reveals that between 1990-2030, there would have been an increase in population from 1,685,894 to 5,388,608 (220%) while built up areas would have also increased from 17,451,392.9 m^2 to 69,054,640.07m^2 (296%) this is due to several factors such as haphazard growth, capitalist investments, infrastructure focus and participatory limitations amongst other identified reasons. The study highlights the need for integrated urban regeneration, resilient infrastructure, sustainable housing policies, land banking to curb speculation, socioeconomic shifts through community-based economic programs, prioritizing environmental restoration and compact development, integrate smart urbanism principles in infrastructure projects and adaptive zoning regulations to balance modernization with environmental conservation. As Ibadan undergoes continuous transformation, these insights can help policymakers address socio-economic disparities, informal settlements, land fragmentation, and ecological degradation linked to slum transformation.

Keywords: Inner-City Slum; Spatial Transformation; Sustainable Urban Planning; Inclusive development; Urbanization

1 Introduction

Increased population over time has led to more people living in informal settlements generally known as slums. Today, more than half of the world's population resides in urban areas. The early studies of Ricardo (1978)[1] are linked to current attempts to comprehend urban transformation and land uses, which have a major influence on housing production, density, and spatial growth. Additionally, Hurd (1903)[2] created the theory of bid rent functions in response, while Ratcliffe (1949), Alonso (1964)[3], Mills (1967)[4], and Muth (1969)[5] later developed the main points. In order to depict the relationships and interdependence between land value, land use, average density, and their rates of change among cities, they embraced the neoclassical marginalist models to organize their understanding of urban spatial process and pattern.

There has been an age-long argument on whether expansion of cities should be allowed or resisted, that is, if intensification of the existing developed areas should be fostered. It is essential to comprehend what intensification and spawl mean, at least from the standpoint of this study, before delving more into the discussion. Previous studies[6-9] conceptualized sprawl as a multidimensional phenomenon that necessitates distinct sets of measurements for each dimension. Growth rates, density, accessibility, spatial geometry, and aesthetic measures were the five categories of scatter measures proposed[6, 9].

Ibadan, the capital of Oyo State, is a significant city in Nigeria, with a rich history and significant role in the nation's cultural and political development[10]. Established in the 19th century as a war camp for the Yoruba people, it quickly grew into a significant urban center known for its military prowess and strategic importance[10]. Ibadan became the headquarters of the Yoruba Empire and played a key role in resisting colonial encroachment[11]. As it became a center of administration, commerce, and education during the colonial era, it hosted the first television station in Africa and is now one of the largest cities in sub-Saharan Africa. Despite challenges such as the expansion of inner-city slums and informal settlements, it remains a vital economic and cultural center with a vibrant market economy, diverse population, and rich cultural heritage[12].

Ibadan's inner-city slums are overcrowded, poorly ventilated, and poorly managed, resulting in limited access to clean water, inefficient waste management, and narrow, unpaved roads[13]. Despite these challenges, these communities are vibrant with complex social networks, engaging in informal economic activities like petty trading and small-scale farming. They are located in some of the oldest parts of the city, representing the historical evolution of urbanization. These slums are home to a large proportion of Ibadan's population, particularly low-income residents who cannot afford formal housing. And therefore, the informal economy thrives within these areas, providing employment and income for many residents. They also serve as entry points for rural migrants seeking better opportunities. The dense population and lack of infrastructure strain the city's resources, making it difficult to implement effective urban development strategies. Globally, these slums are often associated with social issues like crime, poverty, and health problems, which require comprehensive planning and investment in infrastructure[14]. Despite their physical and socio-economic challenges, the inner-city slums are centers of cultural and social activity, with festivals, traditional ceremonies, and communal activities playing a crucial role in maintaining the social fabric[15]. As Ibadan grows, the spatial dynamics of these slums influence the overall urban landscape, requiring understanding for sustainable urban development policies which has necessitated this study[16].

Urban slums, especially in rapidly growing cities like Ibadan, are complex environments where spatial transformation processes significantly impact the lives of millions of residents[17]. Understanding these processes is crucial for urban planning and policy development, as it provides critical data for urban planners and policymakers. By analyzing these processes, policymakers can design targeted interventions to improve living conditions in slums, such as upgrading infrastructure, providing affordable housing, and improving access to services like water, sanitation, and electricity.

Understanding vulnerability in urban slums helps identify areas of extreme vulnerability, promoting inclusive development and ensuring marginalized communities are not left behind in the broader urbanization process[18]. Studying spatial transformations in slums can help manage urban sprawl, mitigate negative impacts, and integrate sustainable practices in slum areas[19]. Cultural and social dynamics are also important, as understanding how slums transform spatially helps preserve cultural heritage and foster social cohesion and community building[20]. By studying spatial transformations, health authorities can better plan for and address public health challenges in slum environments, reducing disease spread and improving overall health and well-being[21]. Understanding spatial dynamics in slums contributes to global knowledge on managing urban growth, helping to create more sustainable and equitable urban futures[22].

There are many challenges associated with inner-city slums, such as overcrowding, poor infrastructures and socio-economic issues. Therefore, the objectives of this study are to analyze the spatial transformation of inner-city slums in Ibadan from 1990 to 2020 and also to examine the factors driving these changes and their implications for urban planning and policy. This study would contribute significantly to the existing literature on urbanization, slum development, and spatial analysis which will be relevant to policymakers, urban planners, and stakeholders involved in urban development in Ibadan and other similar cities.

1.1 Socio-Spatial Dynamics Influence, the Living Conditions and Community Structures within the Inner-City Slums

Socio-spatial dynamics exert a profound influence on the living conditions and community structures within the inner-city slums. These dynamics encompass the intricate interplay between social and spatial factors that shape the environment in which residents navigate their daily lives. The spatial distribution of resources, amenities, and infrastructure within the slums, combined with the social fabric of the community, contributes significantly to the overall quality of life for inhabitants. For instance, unequal access to essential services, such as education and healthcare, can be spatially determined, impacting residents' well-being and perpetuating socio-economic disparities. According to Issa, (2021), the physical layout and spatial organization of the inner-city slums also play a pivotal role in shaping community structures. Limited space and overcrowded conditions often characterize these areas, influencing social interactions, community cohesion, and the formation of support networks. Additionally, the spatial arrangement of housing and public spaces may contribute to the emergence of distinct sub-communities or social divisions within the slums. Understanding these socio-spatial dynamics is crucial for developing targeted interventions that address the root causes of challenges faced by residents and promote more equitable community development[23].

Furthermore, socio-spatial dynamics in inner-city slums can impact residents' ability to engage in economic activities and access employment opportunities. The spatial proximity to commercial centers, markets, and potential job hubs can influence the socio-economic mobility of individuals within the community. Consequently, an in-depth exploration of these dynamics is essential for policymakers, urban planners, and community leaders to implement effective strategies that enhance living conditions, foster community resilience, and promote sustainable socio-economic development within the inner-city slums of the Ibadan metropolis.

1.2 Prevailing Habitat Conditions In the Inner-City Slums and How They Impact the Health and Well-Being of Residents

Adewale et. al., (2020) opined that the prevailing habitat conditions within the inner-city slums constitute a critical factor that significantly influences the health and well-being of residents. Often characterized by substandard housing, inadequate sanitation facilities, and limited access to clean water, these habitat conditions pose substantial challenges to the overall health of individuals within the community. Overcrowded living spaces and insufficient ventilation contribute to the spread of infectious diseases, and the lack of proper sanitation infrastructure exacerbates hygiene-related issues, impacting the well-being of residents[24]. Access to clean water, a fundamental component of a healthy living environment, is often compromised in inner-city slums[25]. Limited infrastructure and inadequate water supply systems contribute to waterborne diseases and hygiene-related challenges. Residents may face difficulties securing sufficient and safe water for daily consumption and sanitation needs, leading to increased vulnerability to waterborne illnesses. Understanding the direct correlation between habitat conditions and health outcomes is crucial for developing targeted interventions that address water and sanitation deficiencies to improve the overall health of inhabitants in the inner-city slums[26].

Housing quality within inner-city slums is another dimension of prevailing habitat condition that significantly influences residents' health and well-being. Substandard housing structures, often constructed with materials that provide insufficient protection against environmental elements, contribute to respiratory issues and exposure to extreme temperatures[27]. Additionally, the lack of proper waste management systems within these habitats can lead to environmental pollution, further impacting the health of residents. Addressing these habitat-related challenges requires a holistic approach that integrates improved housing conditions, enhanced sanitation infrastructure, and increased access to clean water to uplift the health and well-being of individuals residing in the inner-city slums of the Ibadan.

1.3 Environmental Conditions: Contribution To or Mitigating the Challenges Faced By Inhabitants of Inner-City Slums

Environmental conditions play a pivotal role in either exacerbating or mitigating the challenges faced by inhabitants of inner-city slums. The air and water quality in these areas are often compromised due to factors such as industrial pollution, inadequate waste management, and densely populated living conditions[28]. Poor air quality can lead to respiratory illnesses, while contaminated water sources contribute to waterborne diseases, significantly impacting the health of residents. Understanding the contribution of these environmental factors to health challenges is essential for developing effective interventions that address pollution sources and enhance overall environmental quality[29].

Waste management is a critical aspect of environmental conditions within inner-city slums. Inadequate disposal systems and limited access to waste collection services often result in the accumulation of solid waste in and around residential areas. This not only poses aesthetic concerns but also increases the risk of the spread of diseases. Implementing sustainable waste management practices, such as recycling initiatives and community clean-up programs, can mitigate these challenges, fostering a healthier and more habitable environment for slum residents. The availability of green spaces within inner-city slums can also contribute to residents' well-being by offering recreational areas, promoting mental health, and providing a respite from the dense urban environment. However, these spaces are often limited or neglected in slum areas. Recognizing the importance of green spaces and incorporating them into urban planning initiatives can positively impact the overall environmental conditions within inner-city slums, contributing to a more sustainable and health-promoting living environment for the residents.

1.4 Government Intervention and Slum Dwellers Participation in Slum Transformation

Most of the reoccurring problems facing Nigerian cities are the inadequacies of urban infrastructure and the dilapidated state of the urban environment. Recently, the government of Nigeria has adopted a few strategic approaches aimed at urban environmental infrastructure development. These are the technocrat state provider model, private provision model and international and stakeholder approaches. The most used of these approaches in Nigerian cities is that of state-led infrastructure development[30]. Benin-City one of the major cities and the capital of Edo State in Nigeria is a good example of a state who adopted this approach, but all happen to be an illusion now due to lack of continuity of development policies and change of government. It witnessed three stages of urban development which is related to outward growth from the core to the periphery, just like in the case of Ibadan.

The Sustainable Cities Programme is an international cooperation of UN_HABITAT and the United Nations; it works at the city level in connection with partners at local levels in a view to achieving strengthened capacities for environmental planning and management which is more of participatory in nature thereby encouraging good governance. The programme emphasises proper planning and management as a propeller to quick human development with good governance playing a pivotal role. The Sustainable Cities Programme stresses that properly planned and managed cities hold the key to faster human development in a safer environment. Good Urban Governance is the key to this outcome. Sustainable Cities Programme views environmental dilapidation as unavoidable. Many cities are suffering from very serious environmental and economic decadence, which is a resultant effect of urban growth, urban governance, better planning, and effective and efficient urban development activities alongside the human environment.

In the participatory approach, NGOs, CBOs and international agencies have high roles-initiated strategies to promote stakeholder participation in urban development and management. The Sustainable Ibadan Programme (SIP) is an offspring of this initiative. This programme was aimed at improving infrastructural services in Ibadan via participation partnership of communities, and private and public sectors. The city is facing serious environmental issues relating to its high rate of urbanisation accompanied by an acute shortage of water supply and poor management of solid and liquid wastes. This programme focused on the city core of Ibadan and acted upon priority issues that emerged from the city consultations. Their priorities were waste management, water supply and institutionalising Environmental Planning Management (EPM) of Bodija market with little or about concerns on slum upgrading.

Among the Sustainable Cities Programmes in Nigeria, only that of Ibadan got to the strategic development stage.

Strategies were prepared to achieve the highlighted priorities on waste management, water supply and environmental improvement. The Oyo State water Corporation made sure pipe-borne supply is on regular basis while the development programme constructed hygienic boreholes as an alternative source of water supply same with the other identified priorities. And yet the gap is still widened as the people and authorities did not fully accept this alternative to the water supply. There is, therefore, a need for a sustainable approach to the city's development. The UN_HABITAT suggested "how a clear overview of costs and benefits could help to bridge the existing gap between Sustainable Ibadan Programme and its supporting organisations".

2 Materials and Methods

2.1 Study Area

Ibadan, the capital of Oyo State, Nigeria, is the largest traditional urban center in the Southwest Sahara with an estimated population of five million. The city is characterized by a tropical wet and dry climate with alternating wet and dry seasons. The wet season lasts from April to October, while the dry season spans between November and March. The mean yearly precipitation varies between 1225 mm and 1260 mm, with an annual average temperature of about 26.5˚C and average humidity of about 80%. The vegetation of the study area falls within the moist lowland rainforest, occupied by evergreen hydrophytic plants of great diversity. The northern portion of the city is characterized by derived savanna vegetation with characteristic short grasses, scattered trees, and dense undergrowth. However, a significant proportion of the natural vegetation has been transformed by impervious surfaces due to the ever-increasing population and rapid urbanization. The city's elevation ranges between 180 m and 210 m above sea level, with remarkable landform features such as quartzite ridges and gneissic inselbergs. The city is characterized by four principal drainage systems: the Ona, Ogunpa, Kudeti, and Ogbere river basins. Ibadan serves residential, administrative, commercial, and education functions, contributing to its rapid development rate and net immigration. The land use pattern is characterized by a mix of residential, educational, administrative, agricultural, and recreation land uses.

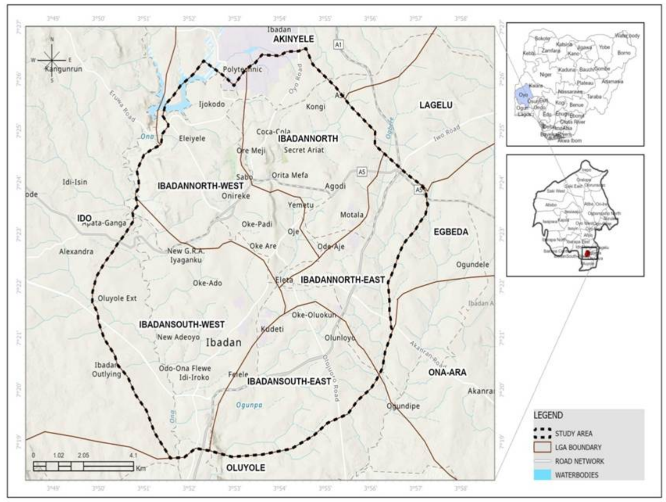

Fig. 1: Map of the Study Area [*Source: Author (2024)*]

2.2 Data and Methods

The study adopted the use of both primary and secondary data. The primary data were collected through the reconnaissance and socioeconomic survey from residents of the slums, while the secondary data were obtained from geospatial data acquired from remotely sensed sources, Geographical Information System Laboratory in Obafemi Awolowo University (OAU) and Department of Urban and Regional Planning Osun state University and Ministry of Lands and Physical Planning, Ibadan. Multi-stage sampling technique was used in the sampling procedure. First stage involved the stratification of the Ibadan into major Local Government Areas where slums are prevalent. The second stage considered the stratification of the selected LGAs into communities of the slum areas. The third stage adopted purposive sampling technique; this was necessitated to reducing the sample size to homogeneous population. And lastly, the fourth stage of the multi-stage sampling technique employed the selection of 2% of the identified streets in the communities according to the Slovin's sample size principle; hence the appropriated 2% equivalents of the streets were identified in Ibadan North IBN (460), Ibadan North East IBNE (336), Ibandan North West IBNW (460), Ibadan South East IBSE (333) and Ibadan South West IBSW (297) as illustrated in [Table. 1]. One out of every four buildings was selected across the 5 LGAs (IBN, IBNE, IBNW IBSE and IBSW) so as to allow fairness in the course of selection making a total of 552 sampled residents. [Table. 1] shows how these residents were reached in each of the LGAs.

Table 1: Determination of Sample Frame and Size and Sampled Communities

S/N	LGAs	Slum Communities in the LGAs	Sampled Communities	Total No of Streets Identified in the Sampled Communities	2% of the Identified Sampled Communities	No Of Buildings Along the Sampled Streets	Total No of Buildings Selected (Sampled Size)
1	Ibadan North	Yemetu, Oke-are, Nalende, Ago Tapa, Bodija Districts, Ladoke Akintola Street, Agodi, Oyelade crescent, Oyo road and Sango.	Ago Tapa, Inalende, Oke-are, Sango and part of Bodija.	514	10	460	115
2	Ibadan North East	Beere, Olorunsogo, Oje, Oke-Irefin, Aperin, Agugu, Oke adu, Oja-gbo, Irefin.	Beere, Oje, Oke adu, Ode- aje, and Oja gbo.	488	9	336	112
3	Ibadan North West	Onireke, Ayeye, Dugbe, Ologuneru, Agbeni and Eleyele, Abebi, Sabo, Agbaje, Ekotedo, Olopometa and Oke padre.	Dugbe, Ekotedo, Ayeye, Agbeni and Sabo.	602	12	460	115
4	Ibadan South East	Esu-Ewele, Eleta, oke-oluokun, oja-oba, Ogunpa, owode, kobomeje, Agbongbon, Bode, and parts of Oke-ado and Idi-Arere.	Part of Oke-ado, idi-arere, Kobomeje, Ogunpa, Bode and Oja oba.	443	8	333	111
5	Ibadan South West	Isale osi, Odo-ona, Foko, Ologede, Apata, amule, Atere, Popoyemoja, Orita merin	Oke Foko,Popoyemoje, Atere, Odo-ona and Orita-Merin.	301	6	297	99
Total	5	50	25	2348	45	1886	552

Source: Author 2024.

Geospatial data were analysed where the Landsat imageries for 1990, 2000, 2010 and 2020 were resampled using the nearest-neighbour algorithm with a spatial resolution of 30 m × 30 m for all bands, including the thermal bands. Supervised classification was carried out using a random forest (RF) machine learning classifier in the Google Earth Engine (GEE) platform following the procedure of Fashae *et al.*, (2020)[31]. Following the land use classification, buffering distances were created around each slum community at a distance of 0.2 km, 0.5 km 0.8 km and 1.0 km depending on the respective sizes of the slums; this was done in the ArcGIS 10.8 environment according to Chen *et al.,* (2021)[32]. Thereafter, ecological changes in the condition of the slums around these buffer zones were evaluated by analysing the spatial and temporal trend of certain indices such as the Normalised Difference Vegetation Index (NDVI) and Normalised Difference Built Index (NDBI).

Subsequently, the spatial growth and transformation pattern of these slums were determined using the relative and absolute Shannon entropy technique. This technique was performed in the QGIS environment according to Biney and Boakye (2021)[33].

3 Results and Discussion

3.1 Socioeconomic Characteristics of the Respondents

Based on findings and as shown in [Table. 2], males (52.2%) were more than females' counterparts (47.8%) in the inner-city slum areas of Ibadan. These populations were characterised majorly of Yorubas (88.8%) who were married (79.5%). The high proportion of Yoruba resident and large household sizes (4+ persons) can be linked to cultural and spatial factors influencing social cohesion and community networks as observed by Kong *et al.*, 2020 and Issa, 2021.

Table 2: Socioeconomic Characteristics

Demographic Characteristics	Ibadan	
Age	**Frequencies**	**Percentages**
18-33	210	38.0
35-45	222	40.2
49-63	73	13.2
64 >	47	8.5
Sex		
Male	288	52.2
Female	264	47.8
Marital Status		
Married	419	75.9
Single	66	12.0
Widowed	35	6.3
Divorced	21	3.8
Separated	11	2.0
Educational Status		
No formal education	78	14.1
Primary	129	23.4
Secondary	250	45.3
Tertiary	69	12.5
Vocational education	26	4.7
Tribe		
Yoruba	491	88.8
Igbo	29	5.3
Hausa	29	4.9
Others	6	1.1
Building type		
Brazilian	392	71.0
Self-contained	69	12.5
Terraced Building	45	8.2
Duplex	14	2.5
Storey building	28	5.1
Others	4	0.7
Income		
< 30,000 (very low)	180	32.6
30,001-80,000 (low)	153	27.7
80,001-130,000 (medium)	93	16.8
130,001-180,000 (High)	75	13.6
180,001 > (very high)	51	9.2
Household size		
1-3	106	19.2

Demographic Characteristics	Ibadan	
4-6	274	49.6
7>	172	31.2
Occupation		
Artisan	114	20.7
Student	13	11.4
Farmer	16	2.9
Trader	345	62.5
Civil servant	7	1.3
Private worker	23	4.2
Unemployed	9	1.6
Retired	25	4.5
Length of stay		
< 10yrs	165	29.9
10-19yrs	127	23.0
20-29yrs	119	21.6
30-39yrs	81	14.7
40yrs >	60	10.9
Occupancy type		
Permanent	226	40.9
Temporary	326	59.1

Source: Author, 2024.

It was discovered that many of the respondents have stayed approximately from 10 to 30 years; many of whom possess temporal (59.1%) and permanent (40.9%) occupancy type. The study equally revealed that respondents that earn less than ₦30,000 (Very low), ₦30,000-80,000 (Low) and ₦80,001-130,000 (medium) dominated the study area. This shows that the inner-city slum area contains different strata of income earners which was equally noted by González-Gordon *et al*. (2023) where they linked spatial proximity to economic opportunities to the study area. The prevalence of low-income earners (<₦30,000–₦130,000) and informal occupations can be tied to limited access to commercial hubs, reinforcing socio-economic challenges.

It was inferred from the views of the sampled respondents in Ibadan that occupational status that dominated the selected LGAs were; traders (62.5%), artisans (20.7%) and retired (4.5%) individuals. This confirms the postulation of Kamath and Vijayabaskar (2014) which emphasizes the informal economy's role in sustaining slum livelihoods, despite spatial constraints as noted by González-Gordon *et al*., (2023). The study further revealed that the study area was made up of diverse level (primary, tertiary and vocational) of education certificate holders, only 14.1% of the respondents had no formal education, while majority (45.2%) of the respondents attained secondary educational level. It was revealed that the inner-city slum areas of Ibadan were characterised by young adults (35-49 years) and youths (18-34 years). The elderly population was critically low (less than one-tenths) of the total sampled population in Ibadan. The study revealed that the inner-city slum area comprises active individuals in the population who contribute significantly to the economy.

In the slum areas of Ibadan, it was revealed by the respondents that the dominant building type were the Brazillian (71.0%) type. The study indicated that majority of the households of the inner-city slum areas of Ibadan comprises 4 persons and above per household. This agrees to study of Kong *et al*., (2020) and Issa (2021) as the Brazilian building type and large household sizes reflect socio-spatial dynamics that shape community interactions and overcrowding, a common feature of slums.

3.2 Changes in Land Use/Cover in the Five Local Government Areas of Ibadan (1990-2020)

Analysis of the multi-date (1990, 2000, 2010 and 2020) Landsat images show comparative changes in the classified landuse/cover of the Ibadan inner city slums over selected study period [Fig. 2]. [Table. 3] shows the transformation in (percentages and Square metres (m^2) in the land cover that have occurred between 1990-2020, a period of 30 years. The works of Ricardo (1978), Hurd (1903), Alonso (1964), Mills (1967), Muth (1969) provided theoretical frameworks for land use and urban spatial growth. The expansion of built-up areas aligns with bid rent theory and neoclassical models, where land value and demand drive urban densification[1-5].

Table 3: Landuse/cover change between 1990 and 2020

Land use/cover type	1990		2000		Change 2010		2020	
	(%)	(m^2)	(%)	(m^2)	(%)	(m^2)	(%)	(m^2)
Built-up	12.84	17,451,392.95	31.84	43,277,488.44	31.14	42,322,404.52	36.56	49,688,522.61
Bare land/open land surface	48.43	65,824,794.40	9.66	13,128,437.96	43.07	58,548,645.71	9.66	13,131,064.86
Farmland/Short grasses/shrubs	17.43	23,694,663.50	46.50	63,202,370.54	4.87	6,614,829.54	46.32	62,956,991.46
Tree vegetation/tall grasses	19.48	26,479,065.52	11.59	15,751,832.96	20.66	28,088,884.26	7.44	10,118,388.37
Waterbody	1.82	2,475,572.17	0.42	565,358.63	0.26	350,724.49	0.02	30,521.24
Total	100	135,925,488.53	100	135,925,488.53	100	135,925,488.53	100	135,925,488.53

Source: Author (2024)

In 1990, the built-up area was 17,451,392.95 m^2 which accounts for 12.84% of the entire area, while bare land surface/open land space was 65,824,794.40 m^2 (48.43%) of the total area. Areas such as farmland or short vegetation (including shrubs) occupied 23,694,663.50 m^2 (17.43%) while tree and tall grasses vegetation was 26,479,065.52 m^2 (19.48%). Waterbodies were 2,475,572.17 m^2, occupying (1.82%). In 2000, the built-up area was 43,277,488.44 m^2which accounts for 31.84% of the entire area, while bare land surface/open land space was 13,128,437.96 m^2 (9.66%) of the total area. Areas such as farmland or short vegetation (including shrubs) occupied 63,202,370.54 m^2 (46.50%) while tree and tall grasses vegetation was 15,751,832.96 m^2 (11.59%). Waterbodies were 565,358.63 m^2, occupying (0.42%). Likewise in 2010, the built-up area was 42,322,404.52 m^2 which accounts for 31.14% of the entire area, while bare land surface/open land space was 58,548,645.71 m^2 (43.07%) of the total area. Areas such as farmland or short vegetation (including shrubs) occupied 6,614,829.54 m^2 (4.87%) while tree and tall grasses vegetation was 28,088,884.26 m^2 (20.66%). Waterbodies were 350,724.49 m^2, occupying (0.26%) and lastly in 2020, the built-up area was 49,688,522.61 m^2 which accounts for 36.56% of the entire area, while bare land surface/open land space was 13,131,064.86 m^2 (9.66%) of the total area. Areas such as farmland or short vegetation (including shrubs) occupied 62,956,991.46 m^2 (46.32%) while tree and tall grasses vegetation was 10,118,388.37 m^2 (7.44%). Waterbodies were 30,521.24 m^2, occupying (0.02%) when compared with the 135,925,488.53 m^2 (100%) total land area of the five local government areas of Ibadan.

Elderbrock, (2023) ascertained that the availability of green spaces within inner-city slums contributes to residents' well-being by offering recreational areas, promoting mental health, and providing a respite from the dense urban environment. This is contrary to the situation of the inner-city of Ibadan as there is a rapid decline in the availability of green spaces. The conversion of green spaces and bare land to built-up areas reflects multidimensional sprawl, measurable through spatial geometry and density changes[6-9]. [Table. 3] shows that while built-up area is on the increase, bare surface made a significant increase between years 1990 to year 2000. Areas covered by waterbodies; tree vegetation/tall grasses have declined. According to the study of Anthonj, et al. (2024) [24], this will definitely have a negative effect on the physical and psychological health of residents. Overcrowded living spaces and insufficient ventilation will increase the incidence of infectious diseases, impacting the well-being of residents.

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b

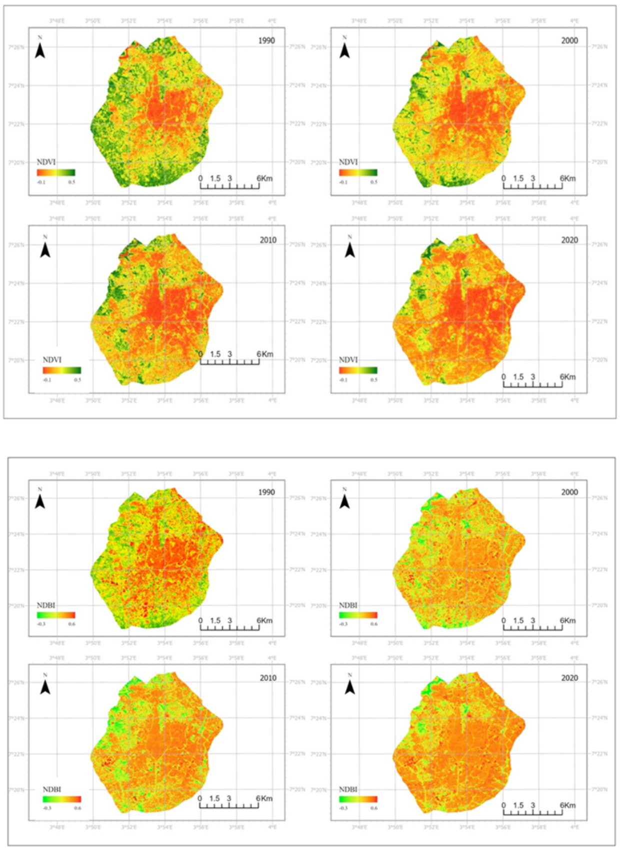

Fig. 2: a) Normalised Difference Vegetation Index (NDVI), b) Normalised Difference Built-up Index (NDBI) [*Source: Author, 2025*]. a: 1990 – Thematic Mapper (TM) sensor; b: 2000 – Enhanced Thematic Mapper (ETM+) sensor; c: 2010 – Multi-Spectral Scanner (MSS) sensor; d: 2020 – Operation Land Imager (OLI) sensor

Obviously, the area has witnessed increases in number of populations through immigration, and accompanying accommodation and facilities, following the status of Ibadan as the former western region capital city and currently the administrative and capital city of Oyo State. The increase in population and slum areas would understandably be linked with the reduction in open land surface, tree vegetation and waterbodies, especially as there are evidences of building constructions in areas that hitherto were bare surface/vegetation zones. In general, the distribution of the land area occupied by waterbodies and tree vegetation/tall grasses are most lost land cover in the study area in 2020 [Fig. 2] (**a and b**). The LULC changes underscore the urgency of sustainable planning to mitigate environmental losses[16].

The consistent expansion of built-up areas portrays a matured urbanization process within the inner-city slums, accompanied by infrastructural, population, socio-economic, and environmental transformations. This transformation is associated with the challenges and opportunities inherent to urbanization, necessitating sustainable urban planning to balance development, environmental preservation, and residents' well-being.

Therefore, the analysis of LULC trends in Ibadan reveals a remarkable evolution in the inner-city slums. The rapid expansion of built-up areas signifies the profound spatial transformation process that has occurred between the years under review, aligning with the objective of the study of the inner-city slums. These findings are crucial for understanding the challenges and opportunities faced by urban areas experiencing rapid transformation, providing valuable insights for future research and urban planning efforts.

3.3 Spatial Growth and Transformation Pattern of Built-Up Areas

The results of the analysis of the spatio-temporal variations in the landuse/landcover indicated that built-up areas have transformed increasingly over the study period. The built-up areas were concentrated towards the south-eastern (Bode, Idi-arere, Kobomeje etc.) parts in 1990 and have gradually spread to cover the north-eastern (Oje, Bere, Ode-aje, Oja-agbo etc.) parts of the study area by 2020 [Fig. 3]. Majority of the green areas (farmland/short grasses/shrubs and tree vegetation/tall trees) have been converted to bare land/open land surface and built-up over the years. When examined using hierarchical classification method with dendrogram plot [Fig. 4], the closest level of association was observed within the farmland, forest and waterbody landuse/cover classes, followed by the association between built-up areas and bare surface. The green class (farmland and vegetation) and waterbody were classified together before they became linked with the built-up area and bare land/open land surface class. The level of association represents the level of interaction and thus appear to suggest that the previously waterbody classes had changed to tree vegetation/tall grasses, which has correspondingly changed to farmland/short grasses/shrubs, on the one hand. On the other hand, the strong association between built-up area and bare land/

open land surface suggests that open spaces have been converted leading to increase in built-up areas. In either case, it is easy to link the changes that occurred to anthropogenic causes, which may have been prompted by population increase and urbanization Gasu et al., (2016) and Torrens and Alberti (2000)[6, 7]. The interpretation of the dendrogram plot is an evidence of sprawl, with bare land conversion indicating anthropogenic impacts.

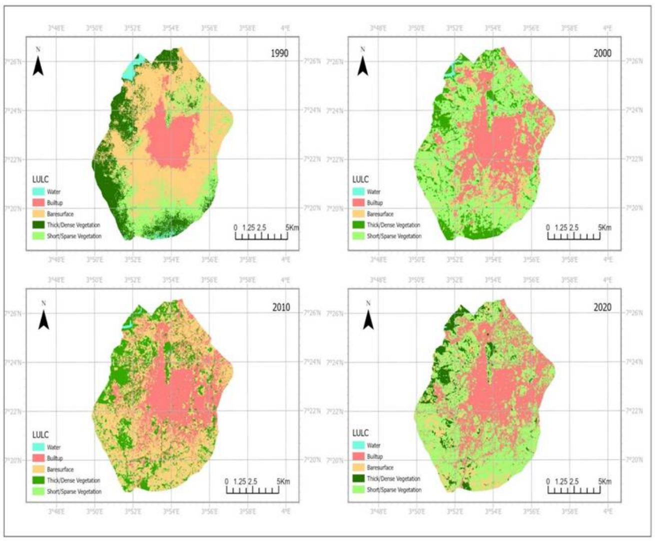

Fig. 3: Pattern and direction of temporal changes in the land use/cover over the study area in (a) 1990, (b) 2000, (c) 2010 and (d) 2020 respectively. [*Source: Author (2025)*]

Furthermore, the result of the "enter regression" that was used to examine the relationship of the growth in built-up area with other landuse/cover indicated that the bare surface/open land were more impacted than other landuse/cover types. The partial correlation of bare land/open land surface, farmland/short grasses/shrubs and waterbodies with built-up areas were observed to be strong (r = 0.91, 0.54 and -0.64, respectively) and the model is as shown in equation 4.1. This suggests that collectively they contributed insignificantly (p≥0.85) to the direct explanation of the changes in built-up areas in the study area. Swapan et al., (2017) and Niva et al., (2019)[18, 19] argue that the spatial growth patterns necessitate sustainable urban planning to address vulnerabilities and promote inclusive development.

$$y = -2.077x + 25.88\ (F = 5.808,\ p = 0.29) \qquad \textbf{Eq. (1)}$$

y = Built-up area (km^2), x = bare surface, tree vegetation/tall grasses, waterbody.

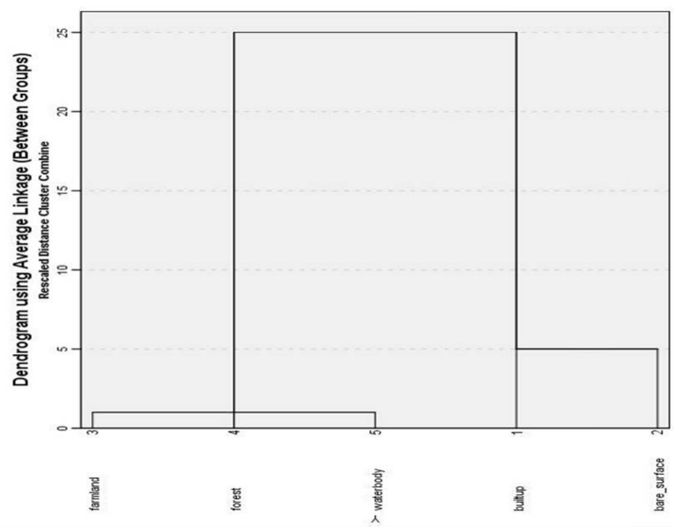

Fig. 4: Dendrogram plot showing the hierarchical classification of the landuse/cover between 1990 and 2020 in Ibadan [*Source: Author (2024)*]

[Table. 4] shows the transformations that have occurred in land use between 1990-2020 both in m^2 and population. It could be said from the results that the urban area is experiencing constant expansion which could be linked to anthropogenic factors and the brisk population growth, urbanization, education needs, housing renovations and expansion to mention a few as illustrated in [Table. 5].

Table 4: Changes in Land Use between 1990 and 2020

Land Use	Changes between 1990-2000		Changes between 2000-2010		Changes between 2010-2020	
	(m^2)	(%)	(m^2)	(%)	(m^2)	(%)
Built-up	+25,826,095.5	148	-955,083.9	-2.21	+7,366,118.1	17.40
Bare land	-52,696,356.4	-8.0	+45,420,207.8	346	-45,417,580.9	-77.6
Short Shrubs/vegetation	+39,507,707.0	166.7	-56,587,541	-89.5	+56,342,161.9	851.8
Tall Vegetation	-10,723,739.5	-40.5	+12,337,051.3	78.6	-17,970,495.9	-64
Water	-1,910,213.5	-77.2	-214,634.1	-38	-320,203.3	-91.3

Source: Author, 2024

N.B: + means increase and – means decrease.

Table 5: Analysis of Urban Expansion

Year	Built-up Areas	Change		Time Span (year)	Arithmetic Mean per Change		Period
		(m^2)	(%)		(m^2/yr)	(%/yr)	
1990	17,451,392.95	25,826,095.49	148	10	2,582,609.5	14.8	1990-2000
2000	43,277,488.44						
		-955,083.92	-2.21	10	-95,508.4	-0.22	2000-2010
2010	42,322,404.52						
2020	49,688,522.61	7,366,118.09	17.40	10	736,611.8	1.74	2010-2020

Source: Author's Survey, 2024.

3.4 Urban Population Growth

Using the population census statistics of Ibadan in 1991 (1,739,000) and 2006 (2,559,853), the population data for the years 1990, 2000, 2010 and 2020 was projected with the formula (NPC, 1990 and 2006):

$$Pr = P0\ (1+r/100)^n$$

Where Pr is the projected population, P0 the existing population (1991), r is the growth rate (3.15%) and n is the number of years, n is -1 in 1990, 9 in 2000, 4 in 2010, 14 in 2020 and 24 in 2030.

Table 6 : LULC Changes with Population Increase

Land Use	1990		2000		2010		2020		2030	
	Area (m^2)	Popn.	Area (m^2)	Popn.	Area (m^2)	Popn.	Area (m^2)	Popn.	Area (m^2)	Po
Built-up	17,451,392.95	1,685,894	43,277,488.44	2,298,914	42,322,404.52	2,897,957	49,688,522.61	3,951,703	69,054,640.07	5,3
Bare land	65,824,794.40		13,128,437.96		58,548,645.71		13,131,064.86		10,584,079.26	
Short shrubs/vegetation	23,694,663.50		63,202,370.54		6,614,829.54		62,956,991.46		41,156,008.04	
Tall Vegetation	26,479,065.52		15,751,832.96		28,088,884.26		10,118,388.37		7,560,111.05	
Water	2,475,572.17		565,358.63		350,724.49		30,521.24		10,467.06	
Total	135,925,488.53		135,925,488.53		135,925,488.53		135,925,488.53		135,925,488.53	

Source: Author's Survey, 2024.

[Table. 6] details the population growth in relationship with the land use especially the built up areas between 1990-2020 and also as projected to 2030. The land mass increased from 17,451,392.4 m^2 to 43,277,488.4 m^2 (148%) between 1990-2000 as the population also increased by (36.4%) 1,685,894 to 2,298,923. Between 2000 and 2010, the urbanized land decreased by (2.2%) from 43,277,488.4 m^2 to 42,322,404.5 m^2 while the population increased from 2,298,914 to 2,897,957 (26.1%). Also, between 2010 to 2020, the urbanized land increased from 42,322,404.52 m^2 to 49,688,522.61 m^2 (17.4%) while the population increased from 2,897,957 to 3,951,703 (36.4%). It was projected that between 2020 and 2030, the urbanized land would have increased from 49,688,522.6 m^2 to 69,054,640.07 m^2 (38%), while population would have increased from 3,951,703 to 5,388,608 (36.4%). The analysis reveals that between 1990 to 2030, there would have been an increase in population from 1,685,894 to 5,388,608 (220%) while the built up areas would have also increased from 17,451,392.9 m^2 to 69,054,640.07 m^2 (296%). It becomes obvious that the brisk increase in population invariably has a great influence on the classes of land uses resulting in urban sprawl.

However, the significant increase in Built-up without a commensurate increase in population growth between 1990-2000 and 2020-2030, can be attributed to several factors particularly in the context of urban or regional development like Ibadan's inner-city slums.

1. **Urban Sprawl and Unplanned Expansion**: Urban areas often expand due to uncontrolled development or the absence of a comprehensive master plan, leading to increased land use without proportional population growth. In Ibadan, the lack of a city master plan resulted in haphazard growth, with traditional compounds subdivided to create more residential or commercial space, even if population growth was modest. This reflects a broader trend in developing cities where land is repurposed for speculative or economic purposes[38]. Developers may clear land for future projects, expanding the urban footprint without immediate population increases.
2. **Economic and Capitalist Investment**: Capitalist investment drives land transformation to maximize profit, often prioritizing high-value uses over dense residential settlement. In Ibadan, inner-city slums are targeted for investment due to the "rent gap" between current and potential land values, leading to gentrification that expands land use but reduces population density. This aligns with global trends where economic motives reshape urban landscapes[34, 35]. Slums are replaced with commercial complexes or upscale housing, using more land but serving fewer residents.
3. **Infrastructure Development**: Large-scale infrastructure projects, such as roads or public utilities, require significant land but do not directly increase population[36]. Initiatives like the Sustainable Ibadan Programme (SIP) focused on infrastructure improvements (e.g., water supply, waste management), which involved land acquisition or reclamation, expanding the urban landmass without attracting proportional population growth. For instance, new roads or boreholes expand land use but serve existing populations or economic goals.
4. **Environmental and Spatial Reconfiguration**: Land reclamation or environmental restoration converts degraded or unused land into usable urban space, expanding landmass without population growth. In Ibadan, efforts to address environmental degradation (e.g., waste piles, stagnant water) involve clearing or repurposing land for utilities or green spaces, which do not house large populations[36]. A typical example is the creation of sanitation facilities or urban parks expands land use but serves existing residents.
5. **Socioeconomic and Cultural Shifts**: Socioeconomic changes lead to land expansion as traditional structures are modified or new settlements reflect cultural or economic aspirations[37]. The disaggregation of family compounds to accommodate economic activities (e.g., small businesses) or growing families also expands land use. However, migration or underutilization may limit population growth. Socioeconomic transformation drives compound disaggregation in the core of Ibadan. Families build larger homes or commercial spaces, increasing land use without proportional household growth.
6. **Speculative Land Acquisition**: Land speculation, where investors acquire land for future development, expands landmass without immediate population growth[34]. Speculative buying by developers or

elites, especially in areas targeted for transformation, inflates land use as plots are reserved for future projects, a common trend in rapidly urbanizing cities such as Ibadan.

4 Conclusion

The study of the spatial transformation processes of inner-city slums in Ibadan between 1990 and 2020 provides a comprehensive understanding of the urban dynamics shaping one of Nigeria's most historic cities. The analysis reveals significant changes in land use and land cover (LULC), particularly the transformation of built-up areas at the expense of green spaces and water bodies. These findings underscore the rapid urbanization occurring in Ibadan's inner-city slums, driven by population growth, rural-urban migration, and the increasing demand for housing and infrastructure.

The consistent growth of built-up areas highlights the maturation of urbanization within these slums, reflecting both the opportunities and challenges associated with this transformation. On the one hand, the expansion of infrastructure and housing supports the city's development and provides shelter for its growing population. On the other hand, this growth has led to the reduction of natural vegetation and open spaces, contributing to environmental degradation and the loss of ecological balance. The study's use of sophisticated techniques like Random Forest classification, spatial indices, and intensity analysis has provided valuable insights into these transformations, offering a detailed picture of how these slum areas have evolved over the past three decades.

Moreover, the findings emphasize the importance of sustainable urban planning and policy development in managing the growth of these slums. As Ibadan continues to transform, it is essential to strike a balance between urban development and environmental preservation. The insights gained from this study can guide policymakers and urban planners in formulating strategies that address the socio-economic and environmental challenges posed by slum expansion. This includes improving infrastructure, providing affordable housing and ensuring that urban growth does not come at the cost of environmental sustainability.

In conclusion, the spatial transformation of inner-city slums in Ibadan is a microcosm of the broader urbanization trends affecting many African cities. The rapid transformation of built-up areas and the corresponding changes in land use patterns reflect the pressures of urban growth in a rapidly developing city. The study's findings are crucial for understanding these processes, offering a foundation for future research and policy interventions aimed at creating more sustainable and livable urban environments in Ibadan and similar cities across the globe.

5 Recommendations

a. Develop and Enforce a Comprehensive Urban Master Plan

Ibadan's haphazard growth due to the absence of a city master plan, leading to inefficient land use and sprawl. A master plan can guide sustainable land expansion and prevent speculative or unplanned development. The Oyo State government, in collaboration with urban planners, should create a master plan prioritizing mixed-use zoning, green spaces, and affordable housing. This plan should regulate land subdivision and speculative acquisition to ensure land use aligns with population needs. Stakeholders should be Engaged (residents, planners, developers) through participatory workshops, as advocated in the document to ensure the plan reflects community priorities. Enforce compliance through local government oversight. If properly carried out, Controlled land expansion, reduced sprawl, and balanced development that supports both economic and residential needs will be achieved.

b. Promote Inclusive and Sustainable Community Participation

Limited resident involvement (e.g., consultation, incentives) reduced the effectiveness of slum transformation. Inclusive participation fosters ownership and ensures development meets community needs, preventing land-intensive projects that displace residents. There should be Shift from consultation-based participation to active community-led planning, involving slum dwellers in decision-making for land use and redevelopment projects. Establish community councils to co-design projects like housing or waste management facilities.

c. Regulate Capitalist Investment and Gentrification

Unregulated investment prioritizes profit over population needs, leading to low-density, high-value developments. The Oyo State government should enforce land use regulations through urban development authorities, ensuring a percentage of redeveloped land is allocated for social housing. Monitor projects to prevent displacement. Policies that regulate land acquisition and gentrification, such as taxes on speculative land purchases or mandates for affordable housing in redeveloped areas should be enforced.

d. Integrate Smart Urbanism Principles in Infrastructure Projects

Smart urbanism can optimize land use through technology and efficiency. Design infrastructure projects (e.g., water, waste systems) to minimize land use while maximizing service delivery, using technologies like compact treatment plants or vertical storage. Incorporate smart city components (e.g., smart transportation, governance) to enhance efficiency. Partner with UN-HABITAT, to adopt smart urbanism frameworks. Pilot projects in one LGA (e.g., Ibadan North) before scaling up.

e. Prioritize Environmental Restoration and Compact Development

Land reclamation for environmental projects (e.g., waste management) increases landmass but does not house populations. Compact development can address environmental degradation while conserving land. Implement compact, mixed-use developments that integrate housing, green spaces, and utilities on smaller land parcels. Restore degraded areas (e.g., stagnant water sites) for community use, such as urban farms or parks, rather than large-scale reclamation.

f. Address Socioeconomic Shifts through Community-Based Economic Programs

Socioeconomic changes, like compound disaggregation, drive land expansion for economic activities (e.g., businesses) without population growth. Community-based programs can channel these shifts into sustainable land use. Support micro-enterprises and cooperatives in slums to create economic opportunities within existing land boundaries, reducing the need for new subdivisions. Provide training and microfinance for slum dwellers.

g. Implement Land Banking to Curb Speculation

Speculative land acquisition inflates landmass use as plots remain vacant. Land banking can reserve land for public use, ensuring development aligns with population needs. Establish a state-managed land bank to acquire and hold land for future public projects (e.g., housing, schools). Restrict speculative purchases through zoning laws or higher taxes.

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