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LAND DEGRADATION CLASSIFICATION, AND PERI-URBAN DYNAMICS' RELATIONSHIP: A STUDY OF AN AFRICAN CITY INTERFACE

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Abstract

This paper examines the relationship between land degradation and peri-urban dynamics in Eleyele, Adetokun, Alafara and Ologuneru, interface of Ibadan city, Nigeria. It provides an analysis of the environmental, economic, and social drivers that have been identified as being responsible for the observed land degradation in the study. The research was conducted through quantitative and qualitative analytical approaches for the assessment of data from both primary and secondary sources. The data revealed that land degradation was caused by a variety of factors including sand lifting, overgrazing, unplanned developments, deforestation, and construction activities. Three hundred and forty-six (346) questionnaires were administered on the four communities within Ibadan North-West and Ido Local Government Areas, Oyo State. The sampled communities are: Eleyele 70, Adetokun 148, Alafara 86 and Ologuneru 42. Only 325 were recovered, leaving 21 missing. Through satellite imagery and remote sensing capturing of the study area, the growth trend, land use classification and land degradation spots in retrospect for 2005, 2010, 2015 and 2020 were mapped out. Developed and undeveloped areas stand at 71% and 29% of the total landmass respectively. This result illustrates that there is a strong link between land degradation and peri-urban dynamics. The research concludes that land degradation has serious implications for the peri-urban area, reducing access to land resources, reducing soil fertility, and increasing soil degradation and pollution. As such, it is important for municipalities to take proactive measures to prevent land degradation and to empower the local communities in the process of sustainable land management.

Key words: *Land Classification, Land degradation, Peri-Urban Dynamics, Satellite Imagery*

Introduction

Land degradation is a pressing global issue that has far-reaching consequences for environmental sustainability, food security, and socio-economic well-being (Bhunia, 2021). (Tuan, 2022). Causes and issues relating to land degradation are numerous – drought, human actions

resulting into soil pollution, or deterioration, land use with its direct bearing on food and livelihood, and attendant influence on ecosystem goods and services. (AbdelRahman, 2023). The acceleration of land degradation was noticed during the twentieth century increased and combined yearning for agricultural and livestock production resulting into overgrazing and conversion of forest, urbanization, deforestation and changing weather events – drought, erosion and soil salinity. (Jagdish, 2023).

The interface between cities and their peri-urban areas is dynamic and characterized by complex interactions. (Gottero, 2023). Peri-urban areas are transitional spaces located on the outskirts of urban centers, experiencing rapid land-use changes that result from urban expansion, population growth, and increasing demand for resources. (Bzour, 2022). These changes can intensify pressure on natural resources and exacerbate land degradation processes. (Adenle, 2022).

Africa, in particular, faces significant challenges due to rapid urbanization and the complex relationships between urban and peri-urban areas. (Chirisa, 2010), opined that African peri-urban areas are places of possible outbreaks of deceases and disaster due to lack of institutional integration and planning. Understanding the interactions between land degradation and peri-urban dynamics in African cities is crucial for formulating effective mitigation and management strategies. (Wolff, 2021). In many African cities, the expanding urban footprint and the rapid growth of peri-urban areas often lead to encroachment on fertile agricultural land, deforestation, soil erosion, and other forms of land degradation. (Karg, 2019). This land degradation not only undermines the capacity to produce food but also threatens ecosystems, water resources, and biodiversity. African Union (2021), observed that African cities are diverse in their socio-economic, cultural, and environmental contexts, making it essential to study specific city interfaces to understand the unique dynamics and impacts of land degradation. This study focuses on an African city interface to explore the relationships between land degradation and peri-urban dynamics, shedding light on the specific challenges and opportunities within this context.

Land degradation is a complex and multifaceted issue that poses significant challenges to environmental sustainability, food security, and socio-economic well-being. (Egidi, 2020). The interface between urban and peri-urban areas in African cities is particularly susceptible to land degradation due to rapid urbanization and the associated land-use changes. (Imbrenda, 2021). Causes and Consequences of land degradation can be attributed to various factors, including deforestation, soil erosion, overgrazing, improper land management practices, and urban expansion. (Tilauhum, 2021 and Abdi, 2013). The impacts of land degradation are far-reaching, affecting food production, livelihoods, water resources, biodiversity, and ecosystem services. African countries are particularly vulnerable to land degradation due to factors such as population growth, poverty, weak governance, and climate change. (Mirzabaev, 2023). Numerous approaches to classify and quantify land degradation have been developed, including the United Nations Framework

Convention on Climate Change (UNFCCC) methodology, the Land Degradation Neutrality Framework, and the Universal Soil Loss Equation (USLE). Remote sensing techniques, such as satellite imagery and GIS, are widely used to assess and monitor land degradation processes and their impacts. (Ewunetu, 2021), (von Keyserlingk, 2023).

Fringe settlement areas experience rapid urbanization, population growth, and land-use changes, leading to encroachment on agricultural land, deforestation, and increased pressure on natural resources. (Abdulai, 2020). This has been described as peri-urban dynamics and land degradation. Urban expansion often leads to the conversion of fertile agricultural land into built-up areas, resulting in a loss of agricultural productivity and increased vulnerability to land degradation. (Coulibaly, 2020). The dynamics of peri-urban areas can exacerbate land degradation by intensifying resource extraction, contributing to pollution, and increasing the demand for natural resources. (Ortiz, 2021).

In relating socio-economic and environmental impacts of land degradation to fringe settlement areas, land degradation affects the livelihoods of local communities who rely on agriculture, leading to food insecurity, poverty, and migration to urban centres. (Zewide, 2021). Environmental consequences include soil erosion, loss of biodiversity, reduced water availability, and degradation of ecosystem services. The socio-economic and environmental impacts of land degradation in peri-urban areas are interconnected, creating a vicious cycle of degradation and vulnerability. (Adewoyin, 2023). Therefore, the strategies for mitigation and sustainable peri-urban development integrated land management approaches, including conservation agriculture, agroforestry, and sustainable land-use planning, can help to mitigate land degradation in peri-urban areas. (Coluzzi, 2022). Strengthening land governance, promoting sustainable urban planning, and engaging local communities in decision-making processes are essential for sustainable peri-urban development. Collaborative efforts among different stakeholders, including governments, researchers, NGOs, and local communities, are crucial for implementing effective mitigation strategies and promoting resilience in peri-urban areas (Halbac-Cotoara-Zamfir, 2020).

The complex relationships between land degradation, its classification, and peri-urban dynamics in African cities have been highlighted. Understanding these relationships is crucial for formulating effective mitigation and management strategies to address land degradation in peri-urban areas. Integrated approaches, involving various stakeholders and utilizing remote sensing techniques, can help monitor land degradation processes and inform sustainable peri-urban development. Ultimately, addressing land degradation in African city interfaces is essential for achieving environmental sustainability, food security, and socio-economic well-being in peri-urban areas (Barthel, 2019).

The study of land degradation and peri-urban dynamics relationships in an African city fringe settlement area is crucial for addressing the multifaceted challenges of land degradation, urbanization, and sustainable

development. It would also uncover complexities of these relationships and identifying effective strategies for mitigation and management to achieving a sustainable and resilient future for African cities and their peri-urban areas. (Seifollahi-Aghmiuni, 2022).

Methodology

A mixed-methods research approach has been employed, combining remote sensing and GIS analysis, field surveys, and interviews with key stakeholders. Both quantitative and qualitative analytical approaches were used for the assessment of various data obtained from the questionnaire administered, the semi-structured interview of the professionals and government personals in relation to the study area. The Spatial Analysis and remote sensing capturing of the satellite imagery of the study area, was embarked upon to know the land coverage, land use classifications and growth trend for 2005, 2010, 2015 and 2020 of the peri-urban settlements in the study area.

The choice of the case study method is to capture the in-depth investigation, relationship between the phenomena and to understand the perspectives of the participants' interviewed. Through the mixed method approach, comparison of the available phenomenon including their theoretical evolution in the peri-urban areas in the two local government councils study area was made.

Sample and Sampling Techniques

The research work was carried out in selected fringe settlement areas of Ibadan metropolis. The peri-urban interface of Ibadan North West and Ido Local Government Areas were specifically researched upon. The selected areas are; Eleyele and Adetokun communities on one part, Alafara and Ologuneru on the other part. The former are in Ibadan North West while the later are in Ido Local Government area respectively.

These four locations comprise of 26 number communities, 74 number Community Developments Associations (CDAs) and 1,826 Housing Units out of which 346 of them were sampled, using Systematic Random Sampling Technique to allow a selection of population members at regular interval. In this regard, 5 houses interval was randomly chosen in the selected 26 settlement clusters to which 346 questionnaires were administered. The unit of population in the 26 clusters are derivatives of the 1,826 housing units that represents the larger population (Table 1).

Table 1: Verification of Returned Questionnaire for Completions

SN	Settlements	No of Housing Units	Returned Questionnaire	Missing Questionnaire
1.	Eleyele	70	64	6
2.	Adetokun	148	141	7
3.	Alafara	86	81	5
4.	Ologuneru PIU	42	39	3
	Total	346	325	21

Geographical Information System/Satellite Imagery Acquisition

Through GIS, the areas are marked from the google earth map and further subjected to satellite imagery acquisition of the portion. The total land mass of the study areas stands at 3,600 hectares while the growth trend for a 20-year period – 2005, 2010, 2015 and 2020 was downloaded (Table 2, and Figure 1).

Table 2: Overview of Growth Trend over Years

Land use Category	Year (Percentage)			
	2005	2010	2015	2020
Developed Area	32%	57%	63%	71%
Undeveloped Area	68%	43%	37%	29%
Total	100%	100%	100%	100%

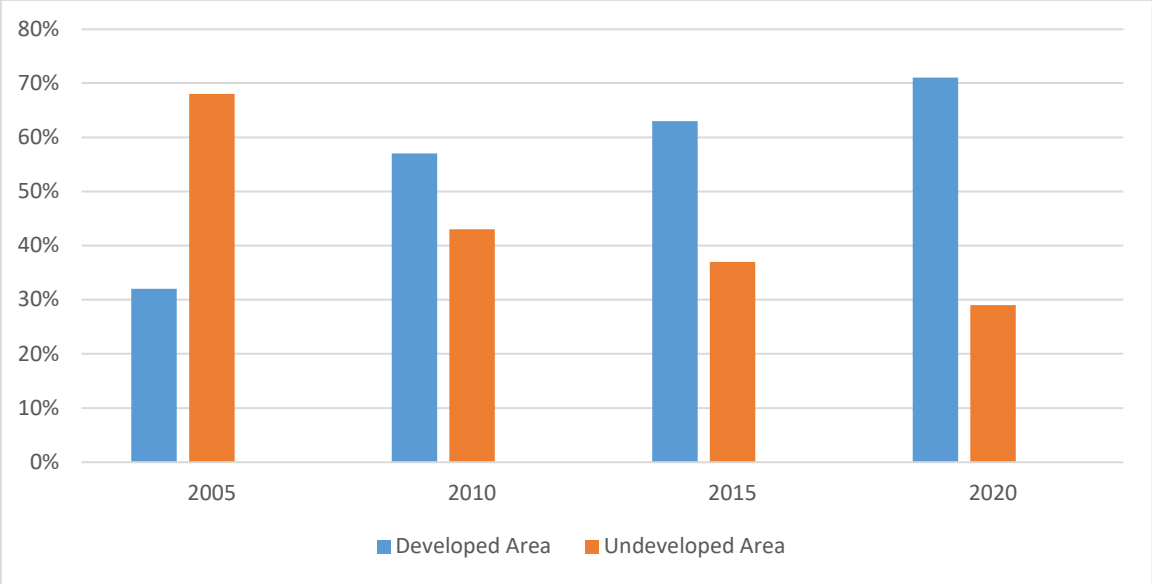

Fig. 1: Growth Trend of the Study Area

Satellite Image Acquisition

The area of interest (study area) was gridded into 165 tiles for the purpose of image acquisition. The size of each tile ranges from 700 to 1000 meters. Each tile serves as guide for image acquisition. The image dates span from 2005, 2010, 2015 to 2020. The historical images are acquired (downloaded) from Google Earth. After the acquisition of the whole images, they are later mosaicked to form single entity for each year as it is required by the study.

The technology is referred to as remote sensing. It detects and monitors physical features of an area by measuring its reflected and emitted radiation at a distance from a satellite with the aid of special cameras which assists the researcher to ''sense'' things in the earth surface. (USGS, 2023), (Mellentine, 2022). Three major software employed in carrying out this exercise include Google Earth Pro - used to acquire (downloaded) the images, QGIS – was used to geo-referenced, processed and mosaicked the images and lastly, ArcGIS- used to

digitized and carry out spatial analysis of the land area.

Vectorisation

This is the process of converting rasters into vectors useful for land use mapping and terrain modeling. The images are digitised based on their available features with aide of shape-files. The shape-files basically used are polygon, as the study is more of area based inquiry. The digitisation was carried by grouping the features on the images to either be developed or undeveloped.

Preprocessing satellite imagery involves image preparation and processing operations embarked upon before analysis to correct image distortions from imaging systems, sensors, and observing conditions. In the process, the electromagnetic energy reflects off the surface of the earth and up to the satellite sensor, which collects and records information about the energy. (NESDIS, 2020). The acquired satellite imagery is as contained in fig. 2 below.

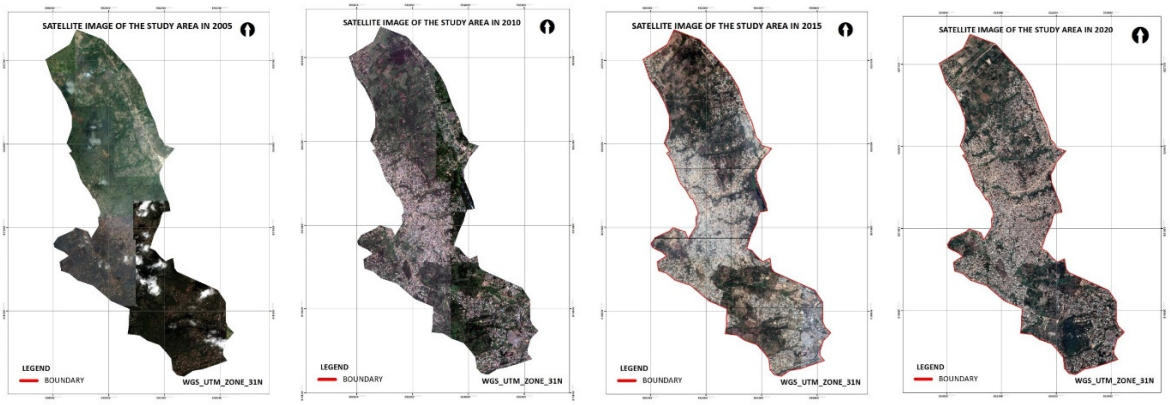

Fig. 2: Satellite Image, of the Study Area for Year 2005, 2010, 2015 & 2020

Discussion

This assessment of the socioeconomic characteristics of residents in the Eleyele, Adetokun, Alafara and Ologuneru areas of Ibadan, includes an analysis of gender, age distribution, income levels, occupational status, household numbers and ownership status to gain a comprehensive understanding of the socioeconomic profiles of the respondents. While analysis of growth trend and land use classification of the area were obtained from using the satellite imagery capturing, participant residents, through interviews and observatory inspection assisted in identifying major land degradation spots in the study.

This GIS analysis highlights the importance of satellite imagery and land use classification in understanding the impacts of land degradation on the peri-urban dynamics, especially on health of the dwellers in the study area of Eleyele, Adetokun, Alafara and Ologuneru, in Ibadan. The assessment of land use changes over time, identification of land degradation hotspots, and analyzing the relationship between land degradation and peri-urban interface dynamics were found essential necessitating satellite imagery acquisition for a 20-year period.

Land Use Classification and Land Use Changes

Generally, land can be classified based on ownership (private and Public) or

developmental (developed and un-developed) (LaGrojr, 2005). Specifically, classification was made from the acquired (downloaded) images based on the extracted features on it. Two criteria were used for this classification exercise: developed and undeveloped. Developed area refers to any part of the study area where developmental activities had taken place as a result of human activities and or alterations which may either, have positive or negative impact on the land formation components. Undeveloped area is referred to as any part of the study area where the natural land-cover has never been altered by either, human or natural occurrences, thereby not having negative impact on the land formation components. However, the classification in this study relates to land use changes in the peri-urban areas of Eleyele, Adetokun, Alafara and Ologuneru over a 20-year period. Basically, the results from this exercise are maps, graphs, and statistical analysis illustrating the trends and magnitudes of land use changes for the period starting from 2005, 2010, 2015 and 2020. This limitation was because of what is obtainable from the GIS earth google search and download otherwise, it would have been up till 2023. Figures 3, below shows the land use classification for the 20-year period under review.

Identification of Land Degradation Hotspots

Land degradation is the persistent reduction in land production capacity, leading to soil erosion, loss of biodiversity, and deforestation. (Bhunia, 2021). These components occur in the study catchment area, but identification of land degradation hotspots is attached to developed areas through land use and land cover changes as contained in the land use classification maps below Figures 3. Specific areas with significant degradation based on land use classifications and associated changes contained in the satellite imagery are identified with observatory schedule inspections to the communities in the study area (figs 4 and 5).

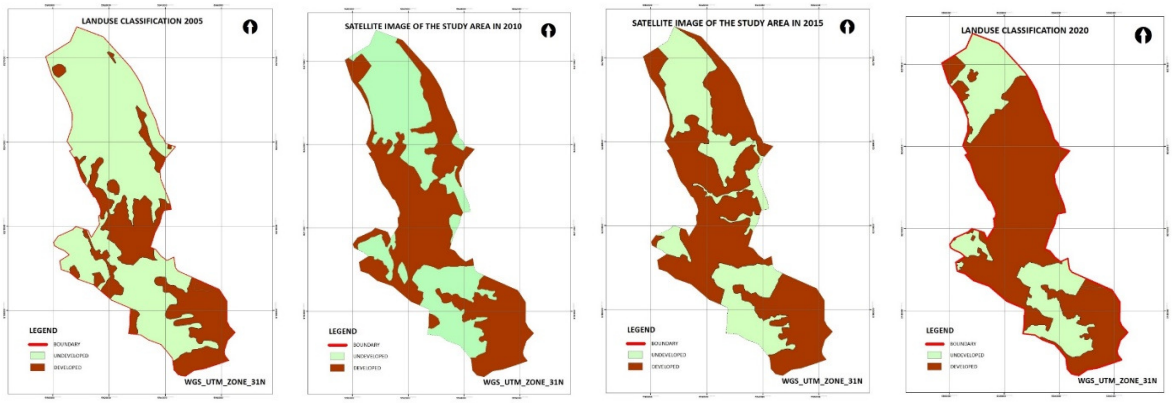

Fig. 3: Land Use Classification, Year 2005, 2010, 2015 & 2020

It must be noted that, from the extracted maps from the google earth for the period of 2005 to 2020, the study has been able to explore the connections between land degradation and peri-urban dynamics, such as population growth, urban expansion, and agricultural practices. It also assists to identify the potential drivers and impacts of land degradation on the peri-urban interface

areas. Also, the implications of land degradation on peri-urban areas, including ecological, social, and economic consequences, the potential risks and challenges associated with land degradation and its relevance for sustainable development.

Through observatory schedule visits and participants interviewed, it has been established that the contributing factors of land degradation in the study areas, include unsustainable land management practices, land-use conflicts, and ineffective policies and regulations. Therefore, as a policy recommendation and intervention strategy aimed at mitigating and preventing further land degradation in the study areas, emphasizes should be placed on the importance of sustainable land management practices and stakeholder engagement. As part of the limitations in the study, constraints related to data availability and quality, scale and scope, potential selection bias, and challenges were encountered during data collection.

Fig. 4: Land Degradation in Alafara as a Result of Sand Lifting/Informal Developments

Fig. 5: Land Degradation through Deforestation Activity in Ologolo Area

Spatial Analysis

Land areas of the digitized portion are generated automated. The land areas are simplified based on the established criteria. Thereafter, tables, pie chart and bar charts are generated for proper interpretation. The analysis was done showing growth trend in each year. These are hereby analysed below. Table 3, and Figure 6 contains the land use classification information for the year 2005. It shows that the developed part of the entire study area was 1,155.23 hectares which amounted to 32% of the 3,632.04 Hectares. The undeveloped part was as at the same year 2005 stands at 2,476.9 hectares translating to 68% of the landmass.

Table 3: Land Use Classification 2005

Land Use Category	**Area (Hectare)**	**Percentage**
Developed Area	1155.23	32%
Undeveloped Area	2476.90	68%
Total	**3632.13**	**100%**

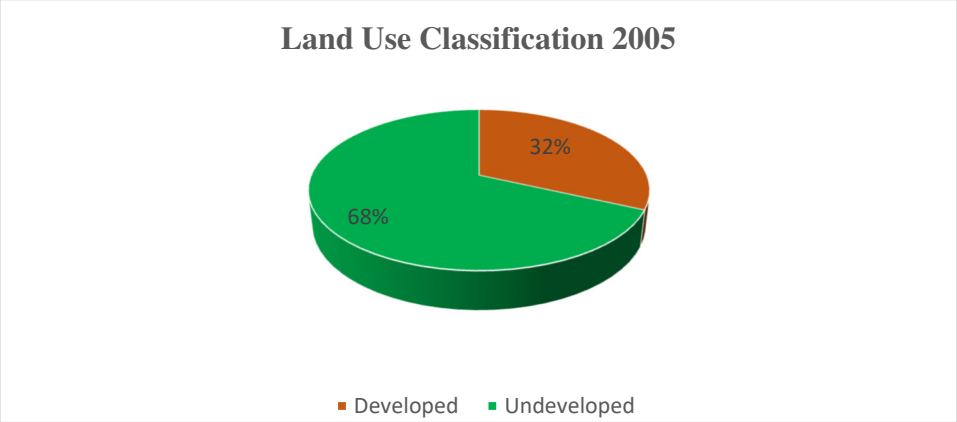

Fig. 6: Land Use Classification Chart

In the year 2010, the developed land classification rose from 32% to 57% translating to 2,085.31 hectares while undeveloped portion was reduced from 68% in 2005 to 43% in 2010 standing at 1,546.88 hectares of the entire study area. This is contained in table 4, and figure 7 below.

Table 4: Land Use Classification 2010

Land use Category	**Area (hectare)**	**Percentage**
Developed Area	2085.31	57%
Undeveloped Area	1546.88	43%
Total	**3632.19**	**100%**

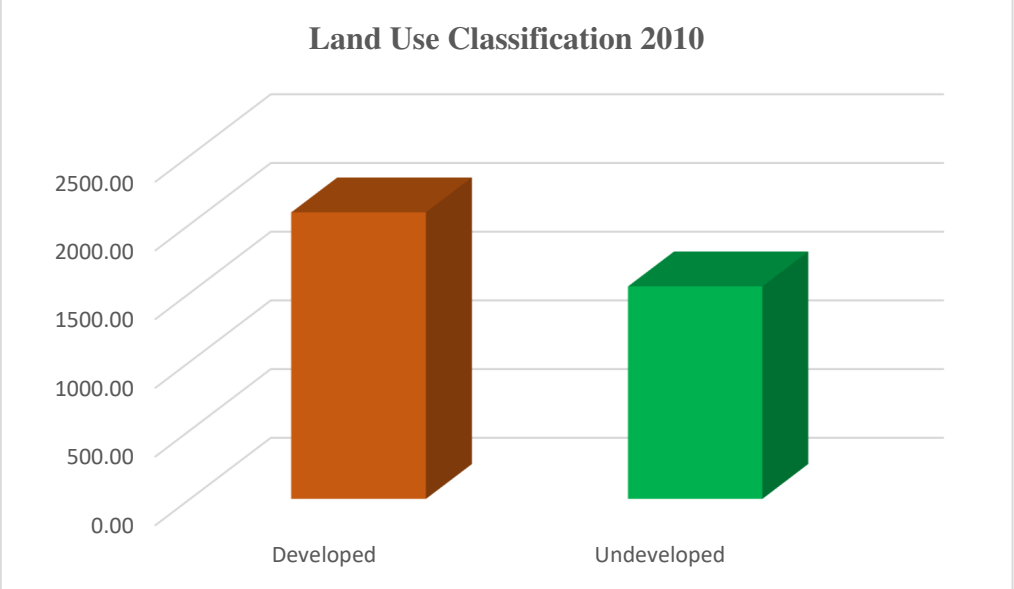

Fig. 7: Land Use Classification 2010 Chart

In year 2015, the developed land classification rises to 63% of the entire study area at 2,288.73 hectares of land. On the other hands, the undeveloped land use reduced to 37% at 1,343.53 hectares. See Table 5, and Figure 8 below.

Table 5: Land Use Classification 2015

Land use Category	**Area (hectare)**	**Percentage**
Developed Area	2288.73	63%
Undeveloped Area	1343.53	37%
Total	**3632.26**	**100%**

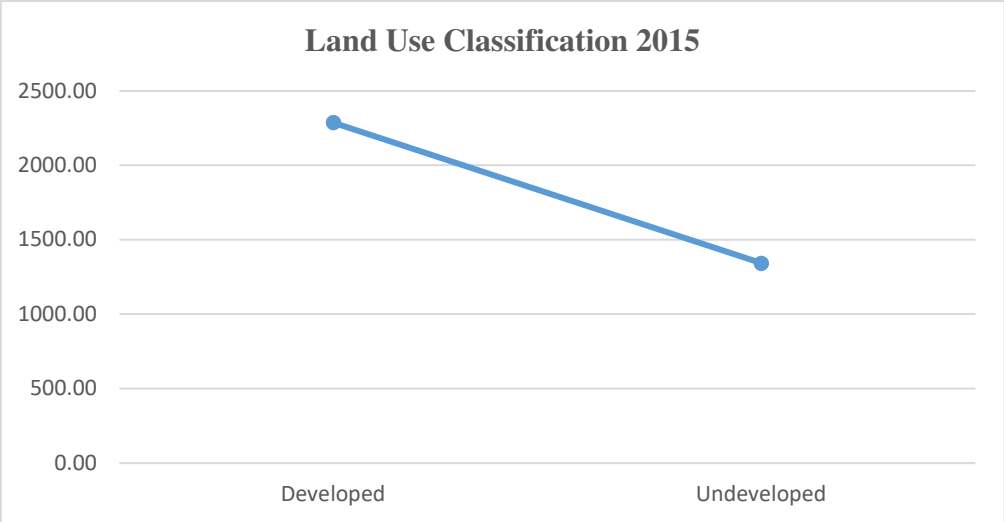

Fig. 8: Land Use Classification 2015 Graph

Table 6, and Figure 9 contains the land use classification analysis for year 2020. The developed portion of the study area, as at the period stands at 2,570.41 hectares against undeveloped land of 1,061.64 hectares which represents 71% and 29% respectively.

Table 6: Land Use Classification 2020

Land use Category	**Area (hectare)**	**Percentage**
Developed Area	2570.41	71%
Undeveloped Area	1061.64	29%
Total	**3632.04**	**100%**

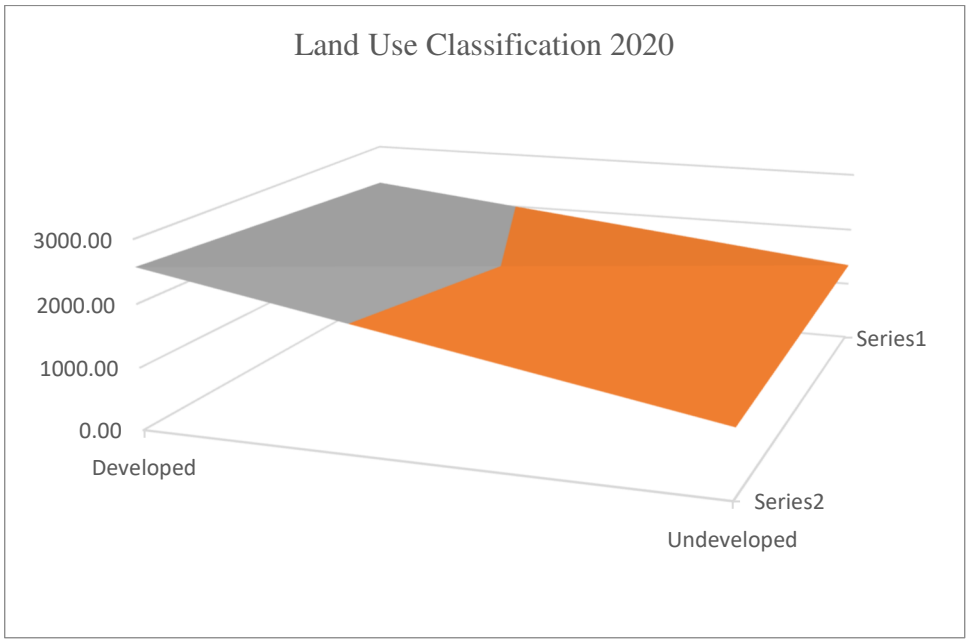

Fig. 9: Land Use Classification 2020 Chart

Table 7 below gives an overview of the spatial analysis of the percentage of land use changes for the last 20-years under classification of developed and undeveloped. As the development land percentage increases from year 2005 to 2020, while in opposite is the undeveloped land in the study area.

In 2005, the developed land stands at 32% of the total landmass of 3,632.04 hectares of land. For the year 2010, it was 57%, 2015, 63% and in 2020, 71% which is 2,570.41 hectares. For the undeveloped land classification, it stands at 68% in 2005, 43% in 2010, 37% in 2015 and 29% in 2020.

Table 7: Overview of Growth Trend over Years

Land use Category	**Year (Percentage)**			
	2005	2010	2015	2020
Developed Area	32%	57%	63%	71%
Undeveloped Area	68%	43%	37%	29%
Total	**100%**	**100%**	**100%**	**100%**

Conclusion

The study on the relationship between land degradation and peri-urban dynamics in an African city interface highlights the vital interconnectedness between urban expansion and environmental degradation. Through the thorough examination of the case study in an African city, which in this case is Ibadan City, it becomes evident that rapid urbanization and population growth in peri-urban areas have contributed significantly to land degradation. (Seifollahi-Aghmiuni, 2022).

The findings of this study reveal that the expansion of cities often encroaches upon agricultural lands and natural habitats, leading to soil erosion, deforestation, and loss of biodiversity. Additionally, the conversion of land for housing and infrastructure development further exacerbates the degradation process. (Schulze, 2021).

The study also emphasizes the importance of proactive urban planning and management strategies to mitigate land degradation. It highlights the need for policymakers and urban planners to adopt sustainable land management practices, such as reforestation, sustainable agriculture, and integrated land-use planning. These measures can help address the socio-economic and environmental challenges posed by urban expansion and prevent further degradation of peri-urban areas. (Falegan, 2023).

Furthermore, this research underscores the significance of strengthening the coordination and collaboration between different stakeholders, including government agencies, local communities, and non-governmental organizations. By working together, it is possible to implement effective measures to promote sustainable development, protect natural resources, and improve the overall quality of life in peri-urban areas.

In summary, the study on land degradation and peri-urban dynamics in an African city interface highlights the urgent need for holistic approaches to tackle the complex issues arising from urban expansion. By integrating sustainable land management practices, engaging stakeholders, and incorporating long-term planning strategies, it is possible to strike a balance between urban development and environmental conservation. This will contribute to the creation of healthy, thriving peri-urban areas that can meet the needs of the growing urban population without further degradation of the surrounding environment.

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