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Spatio-Temporal Analysis of Ilorin Airport on the Land-Use of Ilorin Metropolis, Southwestern Nigeria

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Abstract

This study investigates land-use patterns and changes in the vicinity of Ilorin Airport in Southwestern Nigeria using spatio-temporal analysis. Geographic information systems (GIS) and remote sensing techniques are employed to analyze land use dynamics from 1972 to 2018, and make a projection to 2078. Satellite images obtained from the United States Geological Survey and primary data collected through GPS serve as the main sources of information for the analysis. The findings reveal significant shifts in land use over the study period. A marked increase in built-up areas indicates urban expansion, while grassland areas experience a corresponding decrease. These changes are attributed to the development and growth of the airport and ongoing urbanization processes in the region. The results provide valuable insights into the impact of airport development and urbanization on land-use patterns in the study area. The study highlights the importance of employing GIS and remote sensing techniques in monitoring and analyzing land-use dynamics, enabling informed decision-making and planning processes. The research contributes to the existing knowledge on land-use changes associated with airport development and urbanization. It provides a foundation for further research in the field of land-use management and spatial planning. The outcomes of this study can inform policy and decision-makers, urban planners, and other stakeholders in developing strategies for sustainable land-use practices and mitigating the potential adverse effects of airport development and urban expansion.

Keywords: Land-Use Patterns, Land-Use Changes, Ilorin Airport, Spatio-Temporal Analysis, Geographic Information System (GIS), Remote Sensing

1. Introduction

The land is central to human existence and development (Barlowe, 1963). However, the concept of land varies among different disciplines within the social sciences and environmental sciences, such as economics, geography, urban and regional planning, and estate management. Each discipline offers its unique perspective on land and its use and management (Barlowe, 1963). In a geographical context, Vink (1975) provides a comprehensive definition of land as a specific area of the Earth's surface. This definition encompasses various attributes of the biosphere, including the atmosphere, soil, rocks, topography, water, and plant and animal populations. Tanimowo (2004) explains that transportation land use refers to the activities that facilitate the physical movement of goods and people from one place to another. It serves as an auxiliary to trade, supporting the transportation of raw materials to production sites and the distribution of finished products for consumption. These activities are carried out by transporters who move raw materials, finished products, and passengers between different locations (Tanimowo, 2004).

The establishment of Ilorin Airport in 1975 can be attributed to factors such as urbanization and the strategic location of Ilorin as a node city between Nigeria's northern and western zones. The airport was necessary to facilitate transportation between these two zones. However, the airport's creation has significantly impacted the surrounding land use. It has led to unprecedented growth and uncontrolled development, resulting in poor housing, inadequate layout, insufficient waste management systems, and substandard sanitary conditions, among other environmental problems (Tanimowo, 2004). Mandal (1990) defines land use as utilizing both developed and vacant land at a specific time. It encompasses human activities directly related to the land. On the other hand, land cover refers to the vegetational and artificial constructions that cover the land surface (Burley, 1961).

The Food and Agricultural Organization (FAO) concept emphasizes that land use is determined by human activities that utilize or impact land resources. The focus is on managing land to meet human needs (FAO, 1995). Thapa and Murayana (2000) conducted a study in Kathmandu, which revealed that the rapid changes in land use since the 1970s were driven by urbanization processes. The urban built-up space expanded outward from the city core and main roads to the city fringes. Housing units occupied lands adjacent to ring roads, and even valley areas with complex mountainous terrain experienced development due to population pressure. This led to landscape fragmentation and heterogeneity (Thapa & Murayana, 2000).

Satterthwaite (2005) defines urbanization as the population concentration resulting from spatial movement and redistribution of the human population, resources, and industries in a landscape. Agboola (2005) defines sub-urbanization as a dynamic process whereby rural areas close to urban centres and adjacent open spaces transform into extended metropolitan regions. With its ongoing urbanization, Ilorin has entered a significant development phase. The city has experienced population growth, expansion of land uses, and increased commercial activities. One of the key factors contributing to the urbanization of Ilorin is the migration of people from nearby towns, such as Offa, Ogbomosho, and Patigi, in search of employment and trading opportunities. Additionally, Ilorin's status as the state capital attracts many government workers (Agboola, 2005).

Different types of land use require standards, and they can be categorized into traditional land use and land use intensity. Traditional land use types include residential, commercial, industrial, recreational, public and semi-public, transportation, agricultural land uses, and open space (Lawal, 2017). Airports are vital in facilitating business and industrial growth within a community. They provide air access for companies to meet supply demands, expand marketing areas, and stimulate economic development. Communities with airports or good air services need more capacity for economic growth. Moreover, airports often bring about housing development in the communities where they are located (Abdullahi, 2014). Various factors influence the location of airports, and significant development projects must undergo environmental impact assessments, as mandated by the Nigeria Urban and Regional Planning Law (1992).

Clawson and Stewart (1965) emphasize the significance of accurate and meaningful data on land use in dynamic situations. Reliable information is essential for public agencies and private organizations to understand ongoing trends and make informed plans for the future. Geographic Information Systems (GIS) play a crucial role in obtaining accurate and reliable data on land use, enabling classification, analysis, and projection of land use patterns from the past to the present and future. Various scholars have successfully utilized GIS for environmental management purposes. For instance, Kamaruzaman and Manaf (1995) employed an image processing system to assess deforestation in the Sungai Buloh Forest Reserve in Peninsular Malaysia. Their study identified land conversion from forest to agriculture, mining, dam construction, and water reservoir development as the significant causes of deforestation (Kamaruzaman & Manaf, 1995).

The spatio-temporal analysis of land use in the vicinity of Ilorin Airport can provide insights into the impact of airport development and urbanization on land-use patterns. By analyzing historical data and projecting future trends, this study aims to contribute to effective land-use management in the study area.

2. Materials and Methods

The data for this study will be obtained from both primary and secondary sources.

2.1 Primary Data

This involves data collected from satellite images as they are direct observation images. The coordinates of Ilorin Airport will also be collected using the Global Positioning System (GPS).

Table 1. Dataset and Sources

S/N	Data	Specification	Sources
1	Satellite Image	I90/054	United States Geological Survey
2	Ilorin Airport Spatial Data	Decimal, Degree	Garmin Etrex 20 Global Positioning System (GPS) receiver

Source: Authors' compilation, 2018

2.2 Secondary Data

This involves data on land use and land-use change. These were sourced from textbooks, relevant journal articles and research publications. The method of analysis employed in this research was based primarily on Geographic Information System (GIS) and Remote sensing techniques. Descriptive statistics were also used to corroborate the GIS analysis. The satellite images were subjected to several processing stages to correct, rectify and subset the study area. This was done for the images of different years under study, the images were classified using the supervised classification method, and the statistics of land use losses and gains were calculated and presented in tables, charts and graphs. The future extent of land cover was projected using the Markovian prediction Model of the IDRISSI software.

3. Study Area

The study area for this research is Ilorin Airport and its environs (Figures 1.1 and 1.2). The airport is located in the Fili area of Ilorin, about 9km South-West of Ilorin town. It is on latitude 80 26' 15.59" N and longitude 40 29' 23.99" E of the Ilorin Emirate, which is made up of Ilorin West, Ilorin East, Ilorin South, Asa and Moro Local Government Areas of Kwara State. The airport was commissioned on February 16, 1978 (FAAN, 2016).

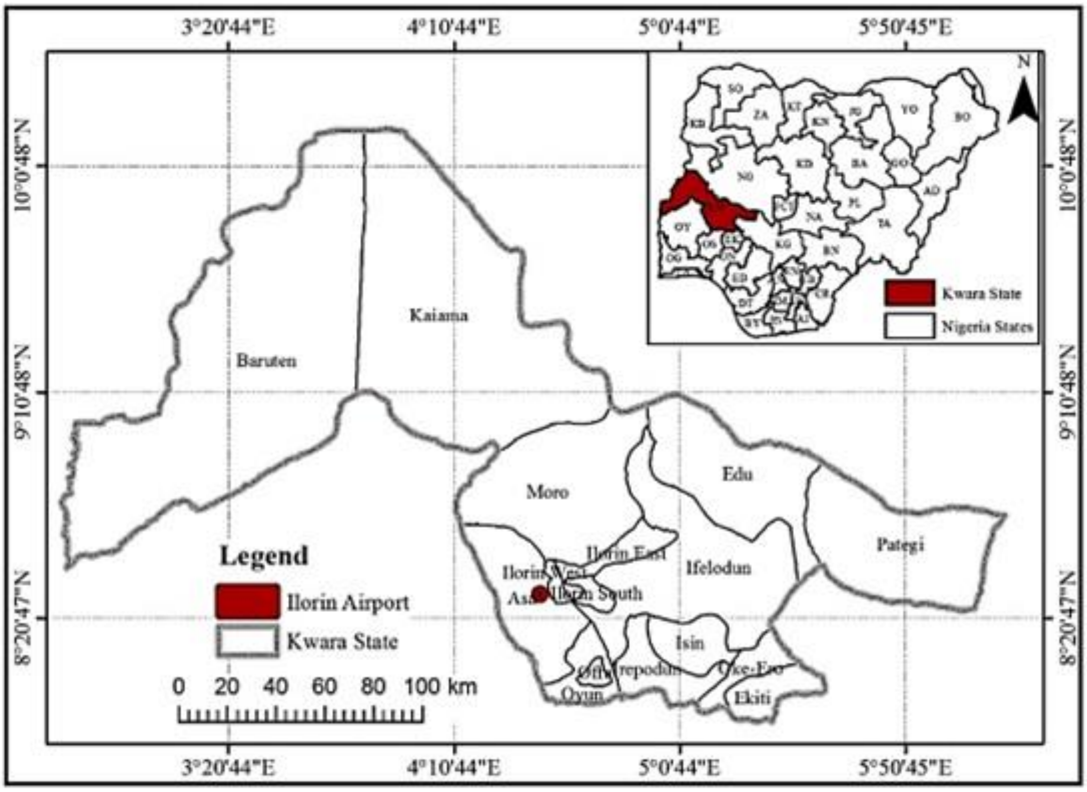

Figure 1. Kwara State, Showing Ilorin Airport
Inset: Nigeria, Showing Kwara State
Source: Generated from Map Library, 2018.

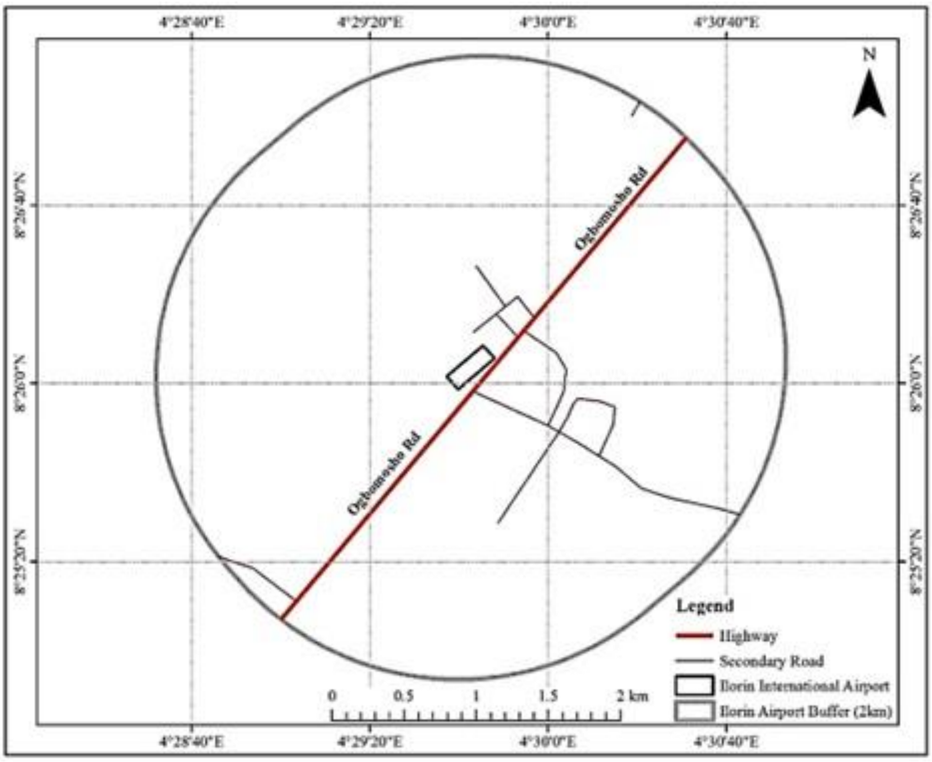

Figure 2. Ilorin International Airport (2km radius)
Source: Generated from Map Library, 2018.

4. Results and Discussions

4.1 Land-use Pattern of Ilorin Airport and Environs for 1972

The land-use pattern in Ilorin Airport and Environs (2km radius) for 1972 was analyzed in this section. This intends to ascertain what the land-use pattern was before the establishment of the airport in the year 1978. The total area covered is 14.299 Km2. Four land-use parameters were used: build-up areas, bared surfaces, grassland and dense vegetation.

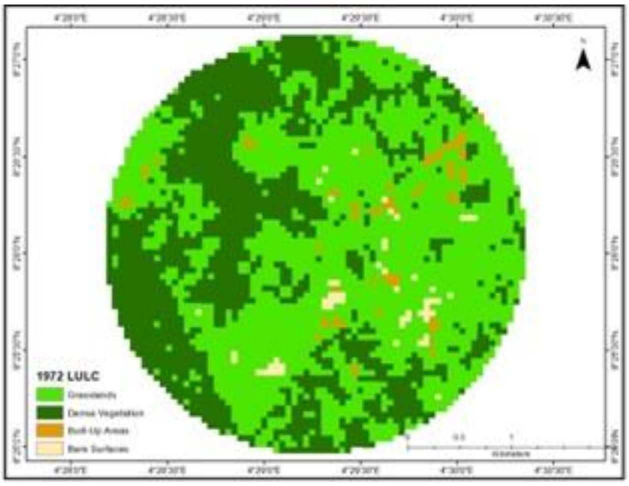

Figure 3. Land-use analysis for 1972
Source: Author's GIS Analysis, 2018.

The results of the land-use classification for the year 1972 showed that grassland accounted for 57.33% (8.197 km2), the most prominent land use for that year. This is followed by dense vegetation - at 39.36% (5.629), built-up areas - at 1.81% (0.259 km2), and bare surfaces at 1.50% (0.214 km2). This is shown in table 2 and figure 3.

Table 2. Land-use Change 1972

S/N	Land-use 1978	LULC (Km^2)	LULC (%)
1	Built-Up Areas	0.259	1.81
2	Bare Surfaces	0.214	1.50
3	Grasslands	8.197	57.33
4	Dense Vegetation	5.629	39.36
	Total	**14.299**	**100**

Source: Author's Analysis, (2018).

4.2 Land-use Pattern of Ilorin Airport and Environs for 1978

The results of the land-use classification for the year 1978 showed that grassland accounted for 45.36% (6.486 km2), the most significant land use for that year. This is followed by dense vegetation, built-up areas, wetlands/barren lands and bare surfaces with 37.77% (5.401 km2), 8.21% (1.174 km2), 7.13% (1.020 km2), and 1.53% (0.218 km2) shares respectively as shown on table 3 and figure 4. However, it was observed that there were significant changes in the land use of the area in 1978 compared with what was obtainable in the year 1972 before the establishment of the airport.

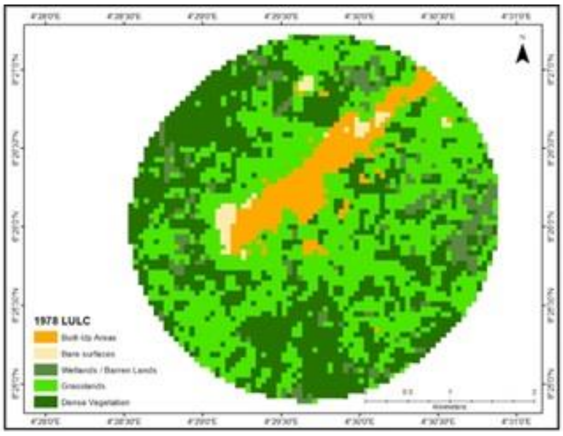

Figure 4. Land-use analysis for 1978
Source: Author's GIS Analysis, 2018.

Table 3. Land-use Change 1978

S/N	Land-use 1978	LULC (Km^2)	LULC (%)
1	Built-Up Areas	1.174	8.21
2	Bare surfaces	0.218	1.53
3	Wetlands / Barren Lands	1.020	7.13
4	Grasslands	6.486	45.36
5	Dense Vegetation	5.401	37.77
	Total	**14.299**	**100**

Source: Author's Analysis, (2018).

4.3 Land-use Pattern of Ilorin Airport and Environs for 1988

The results for the land-use classification of 1988 imagery showed that the grasslands accounted for 39.39% (5.633 km2), dense vegetation 25.91% (3.705 km2), wetlands/barren lands 17.8% (2.547 km2), built-up areas 13.23% (1.891 km2), and bare surfaces 3.66% (0.523 km2). It was observed that there was an increase in built up areas, bared surfaces and wetlands/barren lands while grasslands and dense vegetation reduces as compared to what we have in the year 1978. This is shown on table 4 and figure 5.

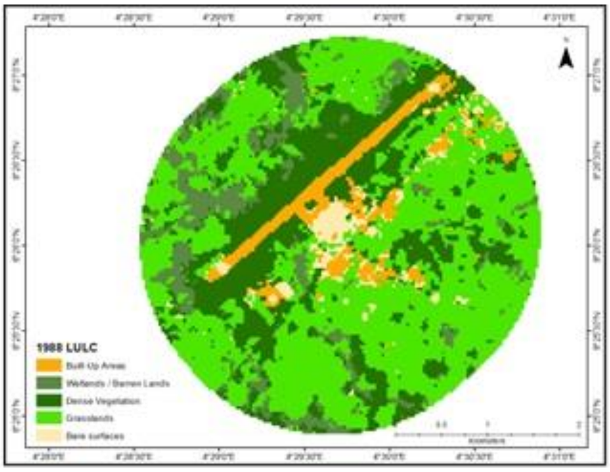

Figure 5. Land-use analysis for 1988
Source: Author's GIS Analysis, 2018.

Table 4. Land-use change 1988

S/N	Land-use 1988	LULC (Km^2)	LULC (%)
1	Built-Up Areas	1.891	13.23
2	Bare surfaces	0.523	3.66
3	Wetlands / Barren Lands	2.547	17.81
4	Grasslands	5.633	39.39
5	Dense Vegetation	3.705	25.91
	Total	**14.299**	**100**

Source: Author's Analysis, (2018).

4.4 Land-use Pattern of Ilorin Airport and Environs for 1998

Figure 6 and table 5 showes the results for the classification of 1998 imagery. It was observed that the built-up areas increased from 1.891 km2 in 1988 to 2.182 km2 in 1998 and grassland increased from 5.633 km2 in 1988 to 7.622 km2 in 1998 while bare surfaces, wetlands/barren lands and dense vegetation from 0.523 km2 to 0.244 km2, 2.547 km2 to 2.464 km2 and 3.705 km2 to 1.786 km2 respectively.

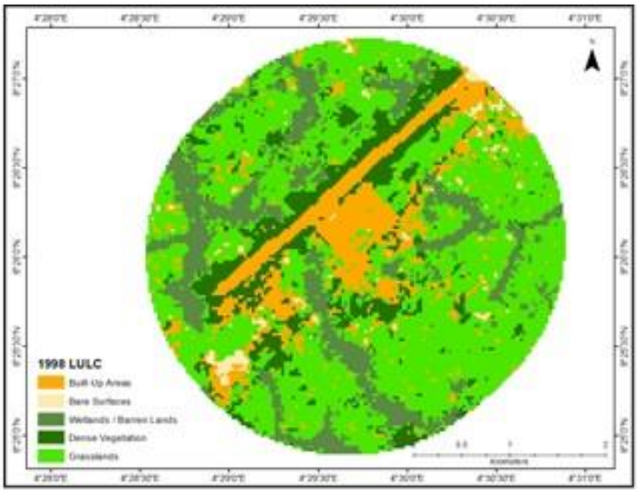

Table 5. Land-use change 1998

S/N	Land-use 1998	LULC (Km^2)	LULC (%)
1	Built-Up Areas	2.182	15.26
2	Bare surfaces	0.244	1.71
3	Wetlands / Barren Lands	2.464	17.23
4	Grasslands	7.622	53.30
5	Dense Vegetation	1.786	12.49
	Total	**14.299**	**100**

Source: Author's Analysis, (2018).

4.5 Land-use Pattern of Ilorin Airport and Environs for 2008

The result for the land-use classification of 2008 showed drastic decrease in dense vegetation from 12.49% (1.786 km2) in 1998 to 8.25% (1.180 km2) in the year 2008. Bare surfaces experienced a drastic increase from 1.71% (0.244 km2) in 1998 to 10.13% (1.449 km2) in the year 2008, while there was a little increase in wetlands/barren land - 17.23% (2.464 km2) in the year 1998 and 18.80% (2.688 km2) in the year 2008. The built-up areas increase to 28.84% (4.123 km2) in 2008 as against 15.26% (2.182 km2) that it was in 1998. Grasslands also decreased from 53.30% (7.622 km2) to 33.98% (4.858 km2) in the year 1998 and 2008 respectively. This is shown in table 6 and figure 7.

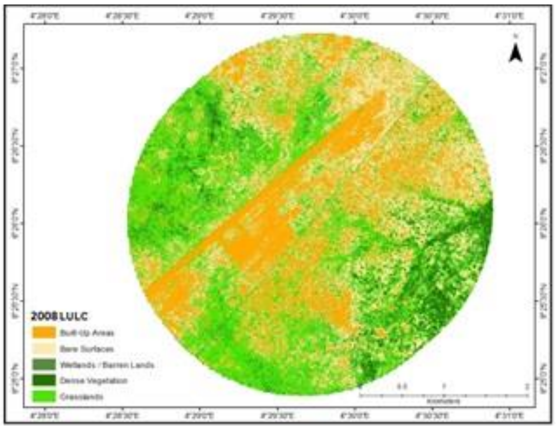

Figure 7. Land-use analysis for 2008
Source: Author's GIS Analysis, 2018.

Table 6. Land-use change 2008

S/N	Land-use 2008	LULC (Km^2)	LULC (%)
1	Built-Up Areas	4.123	28.84
2	Bare surfaces	1.449	10.13
3	Wetlands / Barren Lands	2.688	18.80
4	Grasslands	4.858	33.98
5	Dense Vegetation	1.180	8.25
	Total	**14.299**	**100**

Source: Author's Analysis, (2018).

4.6 Land-use Pattern of Ilorin Airport and Environs for 2018

The result for the land-use classification showed that the build-up areas over doubled from the year 2008 to 2018. It was 28.84% (4.123 km2) in the year 2008 and 51.32% (7.338 km2) in the year 2018. Other land-use classifications (bare surfaces, wetlands/barren lands, grasslands, and dense vegetation) experienced decreased over the years under study. This is shown in table 7 and figure 8.

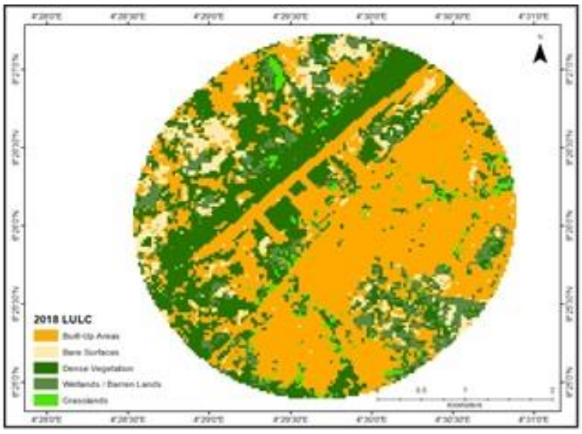

Figure 8. Land-use analysis for 2018
Source: Author's GIS Analysis, 2018.

Table 7. Land-use Change 2018

S/N	Land-use 2018	LULC (Km^2)	LULC (%)
1	Built-Up Areas	7.338	51.32
2	Bare surfaces	1.066	7.46
3	Wetlands / Barren Lands	1.356	9.48
4	Grasslands	4.172	29.18
5	Dense Vegetation	0.367	2.56
	Total	**14.299**	**100**

Source: Author's Analysis, (2018).

4.7 Land-use Change Analysis for 1978 – 2018

This set objective tends to measure the rate at which the land use of the study is changing, i.e., how fast or how slow the land use in the surrounding areas is affected due to the airport's location. As revealed in table 8, grassland that accounted for 45.36% (6.486 km2) in 1978 has decreased drastically to -2.31325km2 in 2018; other land uses were not left out in this; in 1978, dense vegetation, built-up areas, wetlands/barren lands and bare surfaces with 37.77% (5.401 km2), 8.21% (1.174 km2), 7.13% (1.020 km2), and 1.53% (0.218 km2) have all been affected as shown in figure 9.

Table 8. Land-use change 1978 - 2018

S/N	Changes (1978 - 2018)	Area (Km^2)	% Change
1	Built-Up Areas	6.164173	43.10852
2	Bare surfaces	0.84806	5.930821
3	Wetlands / Barren Lands	0.33554	2.346565
4	Grasslands	-2.31325	-16.1775
5	Dense Vegetation	-5.03452	-35.2084

Source: Author's Analysis, (2018).

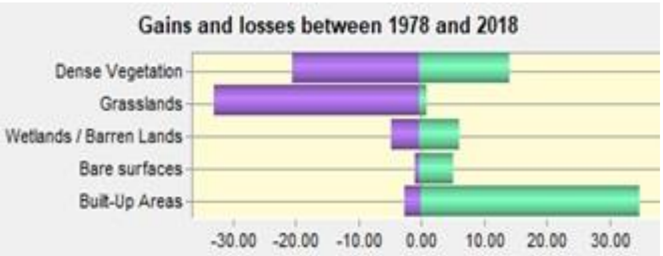

Figure 9. Gains and losses between 1978 and 2018
Source: Author's Analysis, (2018).

4.8 Projected Land-use Change (2018 – 2078)

This subsection will be juxtaposed with the year under study in line with the available baseline of the study area prior to establishing the airport in 1978 to give a clearer perspective and empirically backed findings. The projected land-use change for 2018 to 2078 is displayed by the figures 10 to 13.

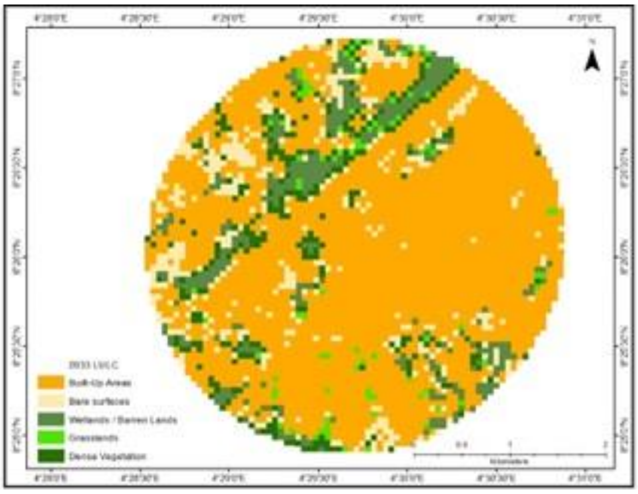

Figure 10. Projected Land-use Change for 2033
Source: Author's GIS Analysis, 2018.

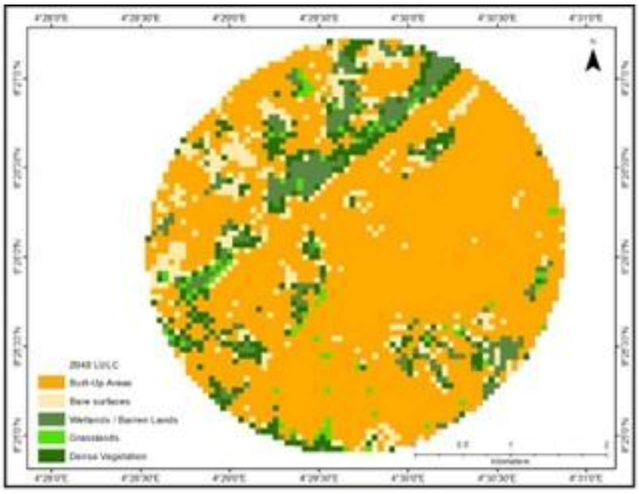

Figure 11. Projected Land-use Change for 2048
Source: Author's GIS Analysis, 2018.

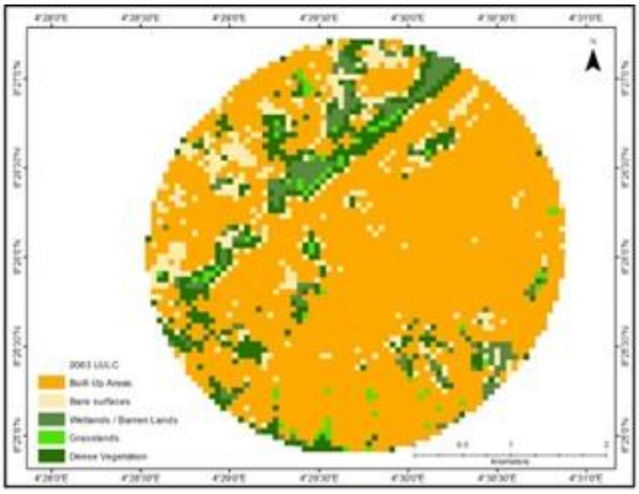

Figure 12. Projected Land-use Change for 2063
Source: Author's GIS Analysis, 2018.

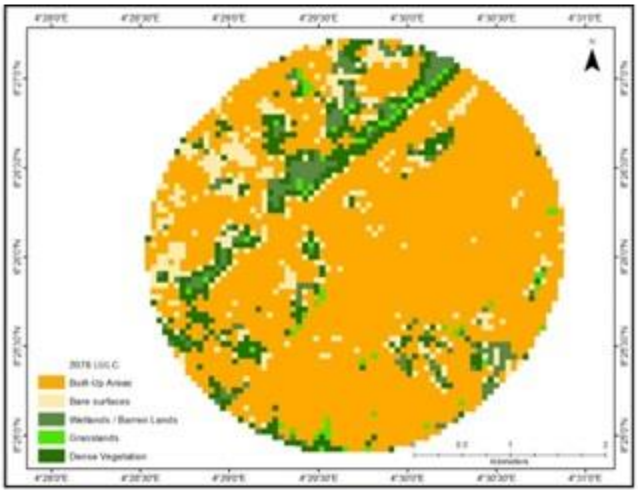

Figure 13. Projected Land-use Change for 2078
Source: Author's GIS Analysis, 2018.

Table 9. Projected Landuse table

S/N	Land-use	2033 LULC (Km²)	2033 LULC (%)	2048 LULC (Km²)	2048 LULC (%)	2063 LULC (Km²)	2063 LULC (%)	2078 LULC (Km²)	2078 LULC (%)
1	Built-Up Areas	10.202	71.35	10.303	72.05	10.476	73.26	10.49	73.36
2	Bare surfaces	1.505	10.52	1.487	10.4	1.451	10.15	1.454	10.17
3	Wetlands / Barren Lands	1.303	9.11	1.127	7.88	0.778	5.44	0.781	5.46
4	Grasslands	0.317	2.22	0.295	2.06	0.252	1.76	0.248	1.74
5	Dense Vegetation	0.972	6.8	1.087	7.6	1.343	9.39	1.325	9.26

Source: Author's GIS Analysis, 2018.

As shown in Table 9, built-up areas have expanded to 10.202km2 against what it was in 1978; it was 1.174km2 when the airport was established. Dense vegetation, which was 5.401 km2 in 1978, will be reduced to 0.972 km2 in 2033 (figure 10), going by the rate at which the land use changes in the study area, the percentage of built-up areas increased from 71% in 2033 to 72% in 2048, with a land area of 10.303 km2. This is in tandem with the assertion of Thapa and Murayana (2000) on the urbanization process. See figure 11 for the land-use map of the study area in 2048. The built-up areas are on a steady increase from the preceding years under-study. As shown in table 9, the built-up area increased arithmetically from 72% in 2048 to 73.26% in 2063. Dense vegetation, which was 37.77% of the land-use area in 1978, has shrunk significantly to as low as 9.39% in 2063. Bare surfaces, wetlands and grassland had their fair share of the changing rate in the land use of the study area due to the establishment of the airport.

The year 2078 recorded marginal change in the built-up areas; grassland is almost entirely lost in the study area. It has been taken over or converted to other forms of land use; in 1978, it was 6.486 km2, while in 2078, it was 0.248 km2. The loss in grassland is a gain for bare surfaces and other land uses; bare surfaces were as low as 0.218 km2, and it has gained coverage of 1.454 km2 in 2078.

5 Summary

The siting of Ilorin Airport around Fili has led to significant changes in the settlement arrangement and social class distribution within the study area. This change can be attributed to the increased demand and higher land cost in the airport vicinity. It deviates from the proposed pattern by Homer Hoyt, which suggests that classes of residence radiate from the central business district (CBD) around the Oja Oba area. Despite being within the designated built-up area, according to the Ilorin master plan, the classes of settlers have become mixed, causing a shift in the expected residential patterns. The land-use pattern in the study area has undergone significant transformations. The built-up class has experienced substantial growth, increasing from 1.81% in 1972 to 8.21% in 1978 and further rising to 13.23% in 1988. By 2018, the built-up class accounted for 51.52% of the land area, reaching 7.338 km². Conversely, the grassland land-use class has experienced the highest losses to the built-up class during this period, as depicted in figure 8.

The land-use projections for future years indicate a continued increase in the land area occupied by the built-up class, surpassing other land-use categories. By 2033, the built-up class is expected to cover 10.2 km², representing 71.35% of the total land area and gaining dominance over other land uses. In subsequent years, the built-up class is projected to occupy 10.303 km² in 2048, 10.476 km² in 2063, and 10.490 km² in 2078. The slight increase in projected built-up land use can be attributed to the nearing saturation point of available land for development within the study area. Consequently, future development will likely concentrate on new areas outside the current study site.

These findings highlight the ongoing changes in the settlement arrangement and land-use patterns surrounding Ilorin Airport. Policymakers and urban planners must consider these dynamics and develop appropriate strategies for sustainable land-use management. By understanding the evolving land-use patterns and anticipating future trends, stakeholders can guide development processes, mitigate potential challenges, and ensure the effective utilization of land resources.

6 Conclusion

This study contributes to the knowledge of land-use changes associated with airport development and urbanization. The research emphasizes the need for comprehensive land-use planning and management strategies to address the evolving land-use patterns in the study area. By understanding land use dynamics, policymakers, urban planners, and other stakeholders can develop strategies for sustainable land-use practices and mitigate the potential adverse effects of airport development and urban expansion. The use of remote sensing and GIS techniques has been, of no doubt, helpful in observing and predicting the land use change pattern; the land use within the area under study, like every other area, is dynamic and changes continuously, responding to factors of change, majorly the influence of man's activities.

7 Recommendations

Land use changes are a continuous process that results from man's activities in ensuring the use of available land to meet their needs will continue to take place. To ensure effective land-use management and address challenges associated with airport development and urbanization near Ilorin Airport, key recommendations include;

i. **Develop a comprehensive land-use plan** to guide the orderly and sustainable growth of the area surrounding Ilorin Airport, taking into account factors such as population growth, infrastructure requirements, and environmental considerations.

ii. **Enhance infrastructure and transportation connectivity** by investing in road networks, public transportation systems, and pedestrian-friendly infrastructure to support efficient movement within the region and reduce dependence on private vehicles.

iii. **Implement sustainable urban design principles** that promote mixed land-use development, compact and walkable neighborhoods, green spaces, and energy-efficient buildings to create vibrant and environmentally friendly communities.

iv. **Strengthen environmental conservation measures** by protecting and restoring natural habitats, promoting green spaces, and implementing sustainable water management practices to preserve the ecological integrity of the area.

v. **Foster community engagement** through participatory planning processes, public consultations, and collaboration with local residents and stakeholders to ensure their voices are heard and their needs are incorporated into decision-making processes related to land use and development.

By implementing these recommendations, Ilorin Airport and its surrounding areas can achieve sustainable land-use management, promote economic growth, enhance environmental quality, and improve the overall quality of life for the local community.

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