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Spatio-Temporal Land Use Change Analysis at Dutse International Airport Using Google Earth Imagery

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Abstract: This study discusses spatial-temporal land use change around Dutse International Airport, Nigeria, using high-resolution Google Earth imagery of 2012, 2018, and 2023. Change was triggered by the development of an airport in 2014 and has brought about phenomenal changes, including urbanization and agricultural and vegetated land cover loss. With supervised classification in ArcGIS, aided by geometric correction and accuracy measurements (confusion matrix, user and producer accuracy, kappa coefficient), quantitative estimation of land use change over time is ascertained in the study. Findings reveal the steep decline of agricultural land from 452.41 ha in 2012 to 116.01 ha in 2023, and loss in vegetation from 278.33 ha to 104.42 ha. In contrast, cover of settlement expanded from 97.21 ha to 346.42 ha and road infrastructure expanded from 172.54 ha to 296.54 ha. The result indicates natural and agricultural landscape pressure induced by infrastructure-based development. The research suggests land use planning through zoning policy, ecological buffer zones, and remote monitoring to harmonize development and conservation of peri-urban ecosystems.

Keywords: Dutse international Airport, Google Earth imagery, Spatial-temporal changes, Land Use, Nigeria

INTRODUCTION

Land cover and use are seen as two of the most important indicators for environmental change, reflecting the dynamic interaction between people and natural ecosystems (Selmy et al., 2023). Over recent decades, urbanization has accelerated across the world with increasing population and economic growth, leading to huge LULC changes across the globe (Zhong et al., 2023). In Nigeria, urban expansion has been particularly pronounced, with cities experiencing rapid growth that often encroaches upon agricultural and natural lands, resulting in ecological degradation and loss of biodiversity (Farrell, 2018). Dutse is the capital of Jigawa State in Nigeria and use has seen quite a lot of changes, especially with the establishment of Dutse International Airport. Dutse International Airport was chosen based on its recent development (2014) and strategic position in stimulating peri-urban development in Northern Nigeria and relative to older airports in Lagos or Abuja, Dutse is a new urban node in which land changes induced by the airport can be examined at an embryonic stage of development, it is therefore a fascinating case study through which to examine infrastructure-led urbanization in less-studied secondary cities (Ajayi et al., 2022). It has not only enhanced ease of transportation and economic activities but triggered urban sprawl affecting the land use around it and in this respect, construction work at the airport followed by operational activities at the airport have surged the residential, commercial, and industrial demand for land leading to the alteration of the spatial pattern of the area (Zangina et al., 2019). Accessibility factors, such highways, have a substantial impact on land usage. As time goes on, these changes become more complex and affect wetland losses, forest land, and ecological land (Li et al., 2020). In Jigawa state, the Dutse International Airport was constructed in 2014. Airport growth is aided by the land usage of Dutse International Airport, including roads, open space, farming, vegetation, and urbanization in the context of the change in land use from rural to urban in Dutse, it represents the general trend in Nigeria, which has been noted to grow about 5.8% yearly within the urban areas (Rane et al., 2023).

Remote sensing technologies, particularly Google Earth imagery, provide valuable tools for monitoring and analyzing LULC changes over time. These technologies enable researchers to capture high-resolution images that facilitate the assessment of land use dynamics and the identification of trends in urban expansion (Putri & Wibowo, 2023). With these images applied to the instance of Dutse International Airport, it is possible to appreciate with detail how city growth is changing the urban landscape and what that would imply for local ecosystems and communities (Angel, 2023).

In this respect, understanding the variations in land usage over time and space around Dutse International Airport is at the core of effective urban planning for sustainable development. This, therefore, has shown a real need for comprehensive data on changing land use while the towns and cities grow explosively (Tavares et al., 2012).

Google Earth views to perform an object-based land use analysis for a case study in Wuhan City, China, Google Earth imagery was chosen. A close-up of the unique tract shows its current mix of park and institutional land use, and the area at fine spatial resolution clearly demonstrates that it was dominated by a few institutional structures, which a little investigation identifies as a medical school (Wibowo et al., 2016). The Google Earth imagery was chosen for a case study in Wuhan City to conduct an object-based land with 570 validation points, Google Earth achieved a classification accuracy of 78.07%, which demonstrated an effective way of land use/cover mapping (Hu et al., 2013).

The research examines the variations in land usage over time and space around Dutse International Airport. It utilizes imagery from Google Earth to add to the ever-increasing volume of literature available on the topic of urbanization in Nigeria but also provides a basis on which further research in similar settings may be premised.

METHODS

Data collection and extraction begin with Google Earth satellite photography data that has been downloaded as a resource (Figure 1). Because of Google Earth software's ability to directly influence events on the ground, media academics, political theorists, and geographers have started to take Google Earth data into consideration (Liang et al., 2018).

As a geographic information system application, Google Earth offers a satellite image with great spatial resolution that is used in the research to inform the land use change analysis (Li et al., 2020). But at the national level, Google Earth Imagery only offers a small dataset (Uddin et al., 2024).

Geometric Correction of Imagery

We also conducted hand geometric correction in ArcGIS by georeferencing all the satellite images (2012, 2018, and 2023) to stable, identifiable features such as road intersections and public buildings. This created spatial consistency across all the time layers, a requirement for change detection and area estimation accuracy (Ma et al., 2020).

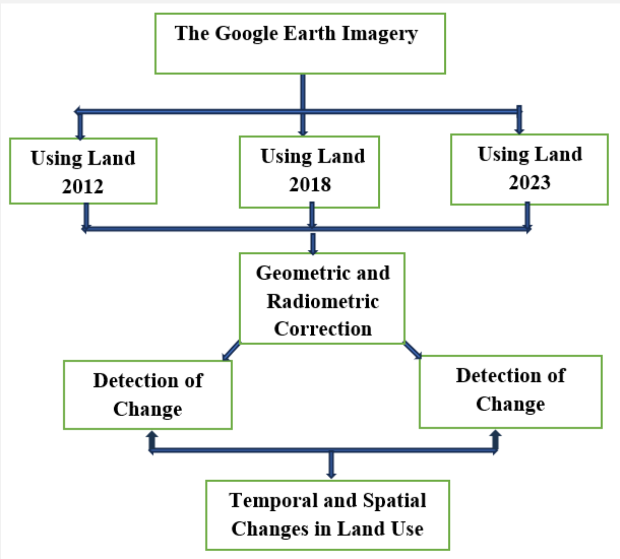

Figure 1. Research Methodology Flowchart.

Dutse International Airport is situated between longitudes 9°18'33"E and 9°24'24"E and latitudes 11°38'31"N and 11°46'16"N (Figure 2). Birnin Kudu Local Government Area borders Dutse Local

Government Area to the north, Ringim and Jahun Local Government Area to the south, and Kiyawa and Gaya Local Government Areas to the east and west, respectively (Zangina et al., 2019).

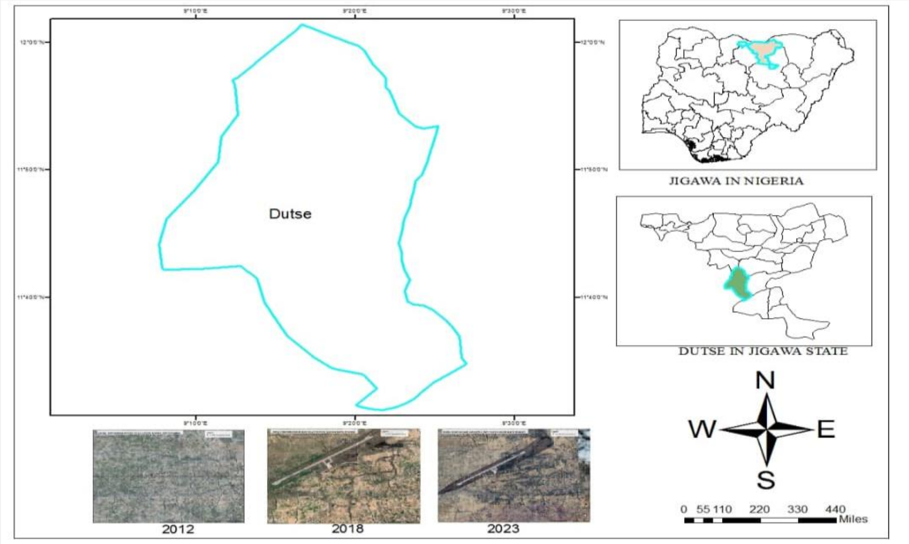

Figure 2. Map of the Study Area.

Using Google Earth imagery, three land use maps from 2012, 2018, and 2023 are available on various dates for analysis with differences in land use change during those years at the Dutse International Airport (Figure 3). Google Earth imagery, although allowing high-resolution visual interpretation, is limited by factors like heterogeneous temporal coverage and heterogeneous image quality. For example, there was no usable image available for the year 2017. To guard against the same, land use classes were cross-validated with 80 training samples per class and cross-validation results with Landsat data and field references where possible (Okeke & Eze, 2025). Land use changes in 2012, 2018, and 2023 were examined using ArcGIS and Google Earth.

Figure 3. Dutse International Airport in 2012, 2018 and 2023 based on Imagery from Google Earth.

RESULTS & DISCUSSION

Imagery from Google Earth

The need to create more outdoor areas for inhabitants' leisure and recreation activities is highlighted by the rapid rate of urban growth in tropical cities. A visual representation of high-resolution data is Google Earth imagery (Junker-Köhler et al., 2025). A quick and effective method for identifying changes in land use for various satellite imagery periods is to use Google Earth imagery (Hu et al., 2013).

Land use change in Dutse international Airports could be viewed with Google Earth imagery in 2012, 2018, and 2023. To determine the various Types of land usage on Google Earth Data, the Dutse International Airport image from 2012 to 2018 is spaced six years apart and Five years ago, from 2018 to 2023, Google Earth Data provided the most recent image of this research.

This study employed temporally preserved Google Earth data from 2012 to 2023 to sample data from the area around the new Dutse international Airport. This data took five years to obtain diverse land use types, however in 2017, Google data was not available in the archive; Rather, in 2018, it was transformed into Google Earth data. The territory used for the Dutse international airport is depicted below and consists of roads, vegetation, farms, and settlements. Google Earth data served as the basis for this visualization of land use statistics. Maps were all created with ArcGIS following the same color coding for Settlement, Farmland, Vegetation, and Roads. Legends, north points, and scale bars are also provided for ready interpretation and year-to-year comparison (García-Ontiyuelo et al., 2024). From 2012, which clearly shows the land use was vegetation and farmlands before the construction of the Airport in the year 2014 (Figure 4).

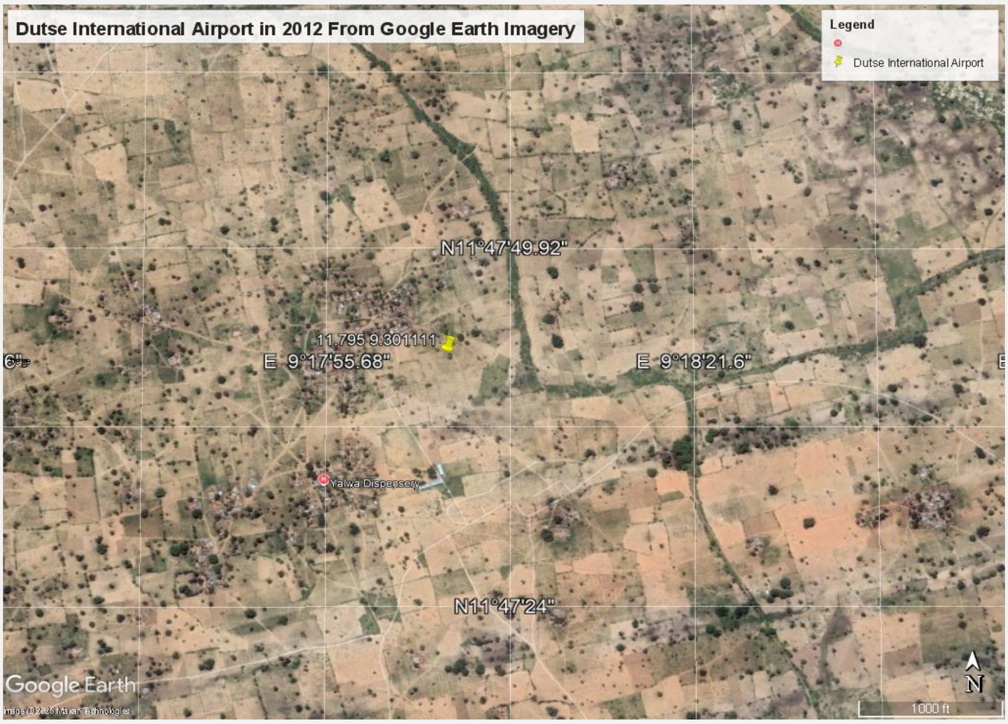

Figure 4. Google Earth Data 2012.

Figure 5 shows that, after the construction of the airport in the year 2014, the land use type changed to administrative, roads, vegetation, and other urban land use. This land use information representation is from the 2018 Google Earth Data archive (12/06/2018). There were differences in the land use types between Google Earth data from 2012 and 2018.

Figure 6 below makes it clear that in 2023, the land used in the area was changed to a government official, road, building, and other land use types. Based on the 2023 Google Earth Data archive (11/7/2023), this representation of land use data includes information that differs from that of Google Earth Data from 2012 and 2018.

Figure 5. Google Earth Data 2018.

Figure 6. Google Earth Data 2023.

Changes in Land Use Using Google Earth Images

Data on Changes in land usage can be obtained from satellite photography(Acuña-Alonso et al., 2022). Changes in certain locations and periods can be examined using Google Earth imagery (Tesfaye et al., 2024). Dutse international Airport's land use shift can be determined by looking at the land use types in 2012, 2018, and 2023. The three Dutse international Airport photos from 2012, 2018 and 2023 that were derived using Google Earth data.

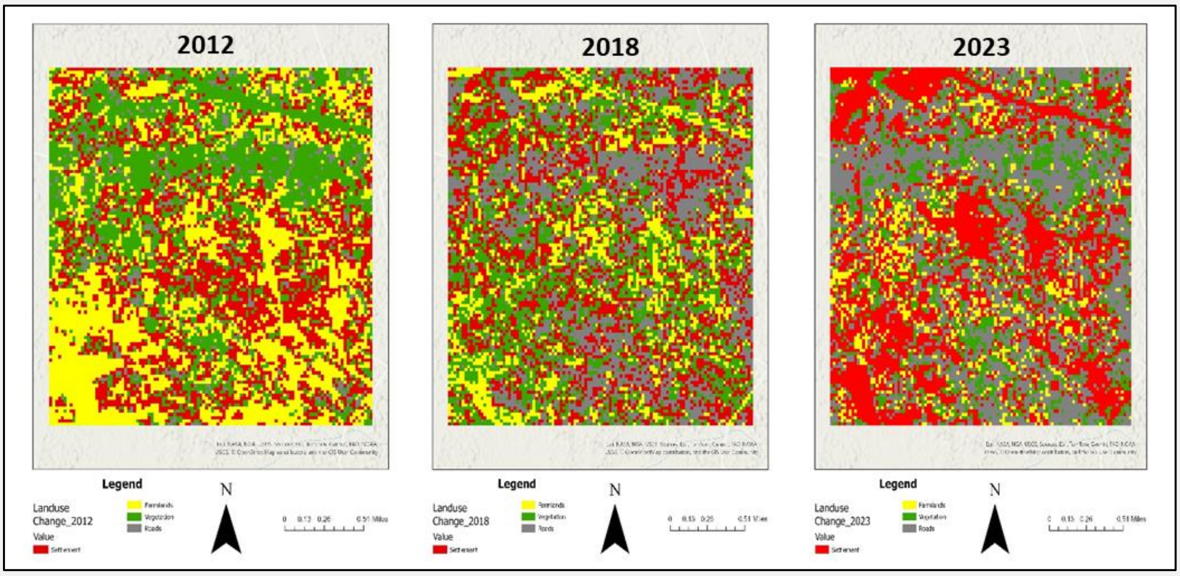

Figure 7. Change Detection at Dutse International Airport in 2012, 2018, and 2023 by Google Earth Data.

Using Google Earth data, information for 2012, 2018, and 2023 regarding substantial land usage and land use types are available at five-year intervals for the Dutse International Airport. The major socio-economic drivers of the land use change are intensified migration founded on perceived employment opportunities within the airport zone, subsidization of urban development by the government, and heightened transport connections and these drivers are consistent with those under similar circumstances in Nigeria (Kuijpers et al., 2016). Land use maps of 2012, 2018, and 2023 have been reclassified based on the same legend where settlements are red, farmlands yellow, vegetation green, and roads dark grey. Classification (Figure 7) shows a huge change over the years. For instance, the land use plots mapped as farmland in 2012 (yellow) were mostly changed to bare land and road infrastructure in 2018 and 2023. Vegetation areas (green) reduced significantly and were substituted with settlement or built-up land in 2023. Road infrastructure (dark grey) grew significantly, especially in areas initially mapped as vegetation and farmland. Residential zones (red) also expanded, particularly around transportation and administrative concentrations, echoing the city expansion due to the airport expansion.

Table 1. Confusion Matrix and Accuracy Assessment for 2012

Class value	Settlement	Farmlands	Vegetation	Roads	Total	User's. Accuracy
Settlement	4	2	1	0	7	0.61
Farmlands	3	42	1	0	46	0.91
Vegetation	1	10	30	1	42	0.71
Roads	0	1	1	3	5	0.60
Total	8	55	33	4	100	
Producer's Accuracy	0.50	0.76	0.90	0.75		
Overall Accuracy	0.79					
Kappa Coefficient	0.75					

As shown in Table 1, the overall land use map accuracy of 2012 is good with 75% and Kappa coefficient 0.75, which indicates substantial agreement between classification data and reference data. Farmland and Vegetation were classified best among all with 0.91% and 0.71% user's accuracy and 90%,76% producer's accuracy for each, which is excellent agreement to accurately classify these two land cover classes.

The poorest performance was that of the Road class at 0.60% user accuracy and significant 75% producer's accuracy, with considerable confusion with other classes, due to its limited area extent and spectral confusion with the urban class. Settlement also did not fare well with 61% user accuracy and 50% producer's accuracy, with some confusion with the background farmland and vegetated land. Overall, the result indicates that the classification method is successful in the classification of general land cover categories.

Table 2. Confusion Matrix and Accuracy Assessment for 2018

Class value	Settlement	Farmlands	Vegetation	Roads	Total	User's. Accuracy
Settlement	38	0	0	11	49	0.77
Farmlands	0	17	1	0	18	0.94
Vegetation	0	5	15	1	21	0.71
Roads	1	1	0	10	12	0.83
Total	39	23	16	22	100	
Producer's Accuracy	0.96	0.73	0.93	0.5		
Overall Accuracy	0.80					
Kappa Coefficient	0.72					

The 2018 land use class (Table 2) is also better than the previous years with 73% overall accuracy and 0.72 Kappa value, indicating high agreement with reference data. The best mapped class was the settlement class with 77% user's accuracy and 96% producer's accuracy, where high potential for mapping built-up areas is obvious. The agricultural fields were also perfectly accurate with 94% of users' and 93% producer's accuracy because they have a distinctive spectral signature along with a spatial pattern.

Vegetation and Road classes were comparatively poorer but reasonable. Vegetation was 71% user's accuracy and 50% producer's accuracy with some confusion with the adjacent land cover classes like Farmlands. Road class was 83% user's accuracy and 80% producer's accuracy, much better than the previous results. Perhaps because of increased differentiation and greater spatial resolution of input images. Overall, 2018 classification results show consistent land use identification, most notably for urban land and agriculture.

Table 3. Confusion Matrix and Accuracy Assessment for 2023

Class value	Settlement	Farmlands	Vegetation	Roads	Total	User's. Accuracy
Settlement	43	0	0	0	43	1
Farmlands	0	5	1	0	6	0.83
Vegetation	1	0	4	1	6	0.67
Roads	13	1	1	30	45	0.66
Total	57	6	6	31	100	
Producer's Accuracy	0.75	0.83	0.67	0.96		
Overall Accuracy	0.82					
Kappa Coefficient	0.70					

The land use 2023 class (Table 3) yielded high performance figures with overall accuracy of 82% and Kappa value of 0.70, indicating incredibly good agreement between ground truth data and classified output. Settlement class was correctly classified by 100% with user's and producer's accuracies of 100%, indicating particularly good urban settlement identification, perhaps because of unique spectral properties and extensive development in the study area.

Vegetation Classes and Farmlands classes were moderately accurate. Farmlands achieved 83% user is and 67% producer's accuracy, and Vegetation achieved 67% user is and 75% producer's accuracy because of some seasonal variation of vegetation misclassification. Road class presented moderate performance with 66% user is and 96% producer's accuracy because of likely spectral confusion with adjacent built-up or exposed surfaces.

Supervised classification area estimation supplied total coverages of Settlement, Farmland, Vegetation, and Road classes in 2013, 2018, and 2023. While area differences were noted in some classes like Vegetation, classification accuracy (producer and user accuracy, and kappa coefficient) was computed separately and reflects the quality of pixel-level classification, and not the proportion of area in each class.

Land Use Changes Analysis

As a result of a recent shift in airport land usage, the new Dutse international Airport in Jigawa state was constructed in 2014. Between 2012 and 2023, the new Dutse international Airport Area's land use changes were documented. The research of land use type in 2012, 2018, and 2023 can be revealed by utilizing Google Earth imagery to describe and analyze the spatial temporal land use change at a Dutse international airport. The land use changes at the proposed Dutse International Airport from 2012 to 2023.

Table 4. 2012, 2018 and 2023 Changes in Land Use

Type of Land Use	2012 (hectare)	2018 (hectare)	2023 (hectare)	Changes (hectare)
Settlement	97.21	203.21	346.42	+249.21
Farmlands	452.41	223.30	116.01	–336.40
Vegetation	278.33	135.04	104.42	–173.91
Road	172.54	267.53	296.54	+124.00

Land use transformation from 2012 to 2023 (Table 4) in Dutse International Airport shows remarkable transformation. The built-up urban population increased from 97.21 ha to 346.42 ha with an increment of +249.21 ha due to residential, administrative, and commercial growth. The farmlands reduced dramatically from 452.41 ha in 2012 to a minimum of 116.01 ha in 2023 by –336.40 ha. Density classes of vegetation also declined by –173.91 ha, an indication of environmental stress on the green cover. Road infrastructure increased from 172.54 ha to 296.54 ha by +124.00 ha, an indication of improved accessibility and transportation development for airport facilities.

The findings capture the spatial and temporal induced infrastructural consequences of urbanization. The growth of built-up land, agricultural land, and vegetated cover captures the imperatives of adopting sustainable land use plan in rapidly transforming peri-urban towns such as Dutse. One advantage of land use changes is that the area around the new airport is transformed into a zone for economic growth. The evolving discourse acknowledges the socio-economic benefits such as job creation, increase in land values, and urban development. These were weighed against environmental expenses through biodiversity loss and vegetation degradation (Adenugba et al., 2024). New airports reduce vegetation halt of farming activities, which can result in erosion and a loss of biodiversity in the area, and this is a negative effect of land use change.

CONCLUSION

This research takes changes in land use across space and time in the Dutse International Airport, showing quite a transformation process influenced by growth. The result reflects that while there has been development with the airport, farmland and vegetation decrease drastically and a remarkable increase reflects on the road network. This conversion from agricultural land to urban symbolizes the socio-economic pressures allied to rapid urbanization, hence posing significant questions relating to ecological sustainability in this region. The last part brings forth pragmatic suggestions: zoning policy, dynamic ecological buffers, remote sensing monitoring at regular intervals, and encouraging agro-urban land-use planning for sustainable development. It is, therefore, one single, invaluable contribution in the light of urban studies regarding the strategic need for urban planning in which environmental considerations are included. Besides bringing economic development and accessibility, the airport certainly poses a serious threat to the local ecosystem and biodiversity. This, however, calls for further research being directed toward land-use strategies in such a way that it provides for sustainable, well-balanced urban growth with ecological preservation, considering long-term changes in community well-being and environmental health.

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