

*Research Article*

## **Urban Expansion and the Sustainability of Land-Use, Environmental and Infrastructure Practices in Lafia Urban Area, Nasarawa State, Nigeria**

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### **Abstract**

The rapid physical expansion of Lafia Urban Area, capital of the State of Nasarawa, Nigeria, has heightened demand for land, the environment and infrastructure. This research was carried out to evaluate land-use efficiency, sustainability of the environment and sufficiency of infrastructure to support land use in Lafia Urban Area, in order to determine whether land use in the metropolis is sustainable. A descriptive cross-sectional survey design was employed; with sustainable development theory as its underpinning. The total population of Lafia Local Government Area population was projected to the year 2026, utilizing the geometric growth method with 2.8% annual growth rate obtaining population of 573,157 persons in 2026. Yamane (1967) specified 5% level of precision to obtain a sample size of 400 respondents from a heterogeneous population through stratified sampling. Noticing a low response rate from a 100% distribution, a sample of 399 copies of structured questionnaires which were successfully retrieved; analyzed. Data were derived from the structured questionnaire survey administered to head of households and land users, also observation made in the course of fieldwork. Descriptive statistics (percentages, frequencies, mean scores) were used to produce comprehensive low, moderate and high indices to evaluate land-use efficiency, environmental sustainability and infrastructural sustainability. Land-uses in Lafia Urban Area are characterized by expansion (mean = 4.17), conversion of agricultural/undeveloped land (mean = 4.02) and increasing mixed land use (mean = 4.08), while redevelopment of existing built-up land remains weak (mean = 2.82), producing a moderate land-use efficiency score of 3.18. Environmental sustainability was rated low overall (mean = 2.57), with wetlands and environmentally sensitive areas the least protected (mean = 2.39). Infrastructure sustainability was moderate (mean = 2.75), with drainage and waste management lagging behind road provision. Urban expansion in Lafia is proceeding largely through peripheral conversion of agricultural and environmentally sensitive land rather than through the redevelopment of existing urban land, and this pattern is outpacing the city's environmental protection and infrastructure-coordination capacity. The study recommends an integrated spatial framework that prioritises infill and redevelopment, statutory protection and mapping of green infrastructure and wetlands, and mandatory infrastructure-capacity assessment as a precondition for development approval. The findings extend sustainable development theory to the land-use, environmental and infrastructure interface in a rapidly growing secondary Nigerian city and provide planning authorities in Lafia and comparable urban centres with an empirical basis for prioritising infill development, green-infrastructure protection and infrastructure-linked approvals.

**Keywords:** Sustainable Land-use, Urban Expansion, Land-use Efficiency, Environmental Sustainability, Green infrastructure.

## **1. Introduction**

Land is the primary resource by which urban development is possible, where housing, commercial, institutional, transportation and ecosystem services are in persistent competition for use. As urban areas expansion takes place, it is the practices by which this competition is resolved which determine whether urban growth can be accommodated within the productive and environmental limits of the land resource. Sustainable land use is broadly recognized as 'the utilization of land, soil, water, plants and other resources, for human needs in a way that effectively strikes a balance between the requirement for present and tomorrow's human needs, and that of maintaining its long-term productive capability and environmental functions' (Food and Agriculture Organization [FAO], 2008, p.1). This principle is inherent in the SDG 11, which identifies 'inclusive, safe, resilient and sustainable cities and human settlements ... through participatory, integrated and sustainable human settlement planning and management in a manner that is participatory, integrated and sustainable' (United Nations, 2015).

In developing countries, urban land use sustainability is mostly threatened by imbalances between the rate of physical expansion and planning institutions and infrastructure system capacities (Ghosh et al., 2012). Findings of a recent systematic review of Nigeria LULC studies revealed that population and urban growth remains primary causative factors of LULC dynamics nationally and there were influential calls for reinforced land-use information and monitoring systems for sustainable land resources management (Alegbeleye et al., 2024). For instance, evidence from Abuja city-region, indicates that accelerated urban expansion with weak form of coordination causes significant spatial conflicts between approved land-use plans and generated land covers, which is associated to administrative dichotomy and intermediary coordination failure (Enoguanbhor, Gollnow, Walker, Nielsen, & Lakes, 2021).

Lafia, the administrative headquarters of Nasarawa State, is an illustration of these pressures. Its inflation of administrative, commercial, educational and residential functions has translated into ongoing physical growth and heightened demand for land (Bako & Balogun, 2023). Lafia-specific research has already shown how overwhelming land-use conversion, the loss of green-space and the difficulties in managing green infrastructure relate to high urbanisation rate, lenient planning regulations and exclusion of green infrastructure from Lafia's development strategy (Ebuga, Bayi, & Ibrahim, 2024). An adjacent study on distribution of green areas in Lafia also raises the critical point that the severance of green-space is not only a visual issue, but one with a direct impact on urban thermal comfort through the urban heat island (UHI) effect and the city's general green infrastructure (Ebuga, Datukun, & Bashayi, 2023).

Much of the current evidence however tends to focus on land-use change, green space or urban heat alone rather than as an interconnected phenomenon or as an aspect of a wider sustainability challenge. There still is a need to focus together on land-use efficiency, environment and infrastructure as dimensions of that larger problem based upon evidence that is directly sourced from residents and land users who are the recipients of the impacts of Lafia's land expansion. This paper endeavors to do just that. It evaluates the sustainable co-existence of (i) current land use practices in Lafia Urban Area, and their sustainability, and (ii) environment and infrastructure dimensions of those practices, for applicability in informing sustainable land management with the image of the implications of Lafia's land change paved out.

## **Statement of the Problem**

Urban expansion by itself is not necessarily undesirable. The task for planning policy is to direct this expansion through land-use change to be orderly, spatially rational and environmentally sustainable. In most Nigerian cities the rates of physical expansion exceeds the ability of institutions of planning; resulting in unsehted development, land use disputes and persistent flooding due to loss of drainage corridors and wetlands (Bako & Balogun, 2023).

According to the 2006 population census, there were 329,922 persons residing within Lafia Local Government Area (ONDI, 2006). Projecting out 2.8% population growth rate over a period of two decades yields a 2026 population of approximately 573,157 persons. This

represents a population increase of about 243,235 people over a period of twenty years, translating into a huge demand for more land used for residential purposes, for commercial activities as well as infrastructure provision. Except when maximum reuse of lands already exposed to developed land-use pattern is the rule, and expansion at the fringe is limited; the undeveloped margin of the city in the form of open lands, farming lands, vegetation, and plant life, are put to non-farming uses and juxtaposed, without trying to take advantage of the dense urban fabric for developers, if this goes to happen, roads, drainage, water supply, and waste management get overburdened by the additional infrastructure demands of new developments outside the city. A study of the needs and impacts of urban land expansion on the physical environment has not been conducted in Lafia; this study therefore aims to cater for this need.

## **2. Conceptual and Literature Review**

### **The Concept of Land Use and Land-Use Efficiency**

Land use is how land is used for residential, commercial, industrial, institutional, recreational, transportation, agricultural and preservation purposes showing interaction of population growth, economic activity, land markets, planning regulations and institutional decisions. Land-use efficiency is measured in terms of density of use of available already developed land (built-up areas) and serviced land using infill, densification and redevelopment, instead of greenfield/light Greenfield peripheral extensions. Insufficient redevelopment relative to peripheral extension results in urban sprawl, leading to faster in territorial expansion growth of cities than urban population growth, as is the case in many growing American cities where the trajectory of infrastructure cost increases and the elimination of agricultural and environmentally sensitive land (Enoguanbhor et al., 2021).

### **Sustainable Land Use, Environment and Infrastructure**

Sustainable land management (SLM) is “the ecologically sound management of land resources for production to meet current and future needs” (FAO, 2008). In cities, SLM is achieved through maximising the efficient use of developed land, minimising development on environmentally sensitive land such as flood plains, natural drains, unmanaged green spaces and wetlands; protecting ecology and green infrastructure; and the co-ordinated development of roads, drainage, water and waste infrastructure to address infrastructure requirements before or alongside new growth (ibid). This is directly related to SDG 11 and sustainable, integrated and resource-efficient land use planning.

In the specific case of Lafia, previous researches have revealed that green-spaces and environment protection were not on the front runner of rapid physical growth. Ogunba et al. (2024) found that in Lafia, electric urbanisation, no definite green-space planning framework with concrete operational steps, the low political commitment and public deception to green-space preservation were the main factors negating green-space preservation. Ogunba et al. (2023), using other assessment indices, also found that green-spaces were inadequately distributed throughout the city, a finding that connect well with the rising urban surface temperatures they observed, and which entails the non-aesthetic usefulness of green spaces in terms of environmental sustenance. Their findings lend credence to the fact that environmental deterioration had manifested on the land-use trend of Lafia without specifically measuring land-uses efficiencies, and adequacy of basic infrastructure with relative to the needs of the people, which this paper seeks to investigate.

### **Infrastructure and Urban Land-Use Sustainability**

Infrastructure sustainability is a necessary complement to land-use control, because land that is approved and developed without adequate road access, drainage, water supply or waste-management capacity generates environmental and public-health costs that often exceed the initial cost of infrastructure provision. Evidence from other Nigerian urban regions shows that where infrastructure and service provision are decoupled from land-use approval, informal and under-serviced development becomes more prevalent and durable (Gyau & Booth, 2020),

reinforcing the case for linking infrastructure capacity assessment to the land-use approval process.

### **Theoretical Framework**

#### **Sustainable Development Theory**

Sustainable development is the basis on which the study is built. This theory emphasizes that development choices should have the ability to satisfy current requirements while avoiding compromising the ability of future generations to satisfy their needs, by addressing economic, social and environmental concern in integration. Regarding the land use of Lafia, due to the fact that Lafia is experiencing not only a population growth, but a growth of the income also, the increasing of residential and commercial uses should go along with greenery, wetlands, open spaces conservation, and infrastructure capacity considerations, but not follow an unlimited sprawl.

#### **Compact City / Land-Use Efficiency Perspective**

Another holistic perspective stresses land-use efficiency: that sustainable urban development is achieved by higher-density intensification and redevelopment of existing service areas, rather than by outward expansion, as this decreases infrastructure costs per user, spares non-urban land, and limits the size of trips from home to work or services. This serves as the conceptual underpinning for the studied land-use efficiency indicator, which separates the level of 'development activity' from the level of spatial efficiency of that activity.

### **3. Methodology**

#### **Study Area**

Lafia, on account of being the seat of the government is not only the administrative centre of the state but also one of the important urban centres of the state with large share of the administrative, business, educational and residential functions that have promoted sustained spatial growth of the town. Remote-sensing based studies have earlier analysed the built up expansion and vegetation decrease for lafia while studies have been more recently carried out specifically to analyse the green-space deficit and urban heat with lafia (Ebuga et al. 2023, 2024).

#### **Research Design**

This study used a descriptive cross-sectional survey design. Cross-sectional survey techniques have been proven to be an effective methodology for eliciting land-use practices, land-use impacts, and infrastructure condition from land users, residents, and other land dep . The questionnaire was administered by interview and interview schedule. Collected information from questionnaire was complemented with field observation of the study area.

#### **Population and Sample**

According to Population and Housing Census, 2006, there were 329, 922 (165, 631 males and 164, 291 females) people in Lafia LGA. A stratified sampling technique was used to identify respondents. The City was stratified into neighbourhoods that exhibit the characteristics of established, transitional and expanding/peri-urban development and respondents were selected systematically from each of the strata. This was to ensure that land-use perceptions of sustainability represent different levels of urban development stages within the City, and avoided over-concentration of respondents in a part of Lafia.

#### **Population Projection to 2026**

Population projection was predicted by using the geometric population projection technique. In which it is assumed that the population is growing at a fixed percentage rate annually. Using this technique the population in 2026 was estimated to be:

$$P_t = P_0(1 + r)^t$$

Where  $P_t$  is the projected population,  $P_0$  is the 2006 base-year population,  $r$  is the growth rate (2.8%), and  $t$  is the projection period. With  $t = 2026 - 2006 = 20$ ,  $P_{2026} = 329,922(1.028)^{20} =$

573,157 (about).

### Sample Size Determination

This study used Yamane's (1967) formulae for random sample size for a specified level of precision:

$$n = N / [1 + N(e)^2]$$

Where n is the sample size, N is the anticipated population (573, 157) and e is the desired level of precision (0.05). This resulted in an estimated sample size of around 400 respondents, in line with usual recommendations for sample size estimation of large, finite populations (Israel, 1992). Tables and are included in the analysis. 399 completed questionnaires were retrieved.

### Data Collection Instrument and Analysis

Information was gathered utilizing a self-structured questionnaire containing closed-ended questions on environmental issue perceptions and socio-economical profile, farm land uses, physical environment and infrastructure sufficiency. The perception items were measured on four-point scale, and analyzed in percentages, frequencies and means scores using descriptive statistics. Mean scores were categorized as Low (below 2.50), Moderate (2.50-3.49), and High (3.50 and over) following the corresponded interpretation band used in the result section below.

## 4. Results and Discussion

### Socio-Economic Characteristics of Respondents

Table 1: Socio-Economic Characteristics of Respondents

| Variable  | Category     | Frequency | Percentage (%) |
|-----------|--------------|-----------|----------------|
| Sex       | Male         | 218       | 54.6           |
|           | Female       | 181       | 45.4           |
| Age       | 18-25        | 68        | 17.0           |
|           | 26-35        | 112       | 28.1           |
|           | 36-45        | 101       | 25.3           |
|           | 46-55        | 69        | 17.3           |
|           | 56+          | 49        | 12.3           |
|           |              |           |                |
| Education | Primary/None | 31        | 7.8            |
|           | Secondary    | 96        | 24.1           |
|           | OND/NCE      | 84        | 21.1           |
|           | HND/B.Sc.    | 141       | 35.3           |
|           | Postgraduate | 47        | 11.8           |

Source: Field Survey, 2026

The sample is reasonably equitable by sex and covers all adult age bands, and a significant proportion of respondents hold post higher education qualifications. This provides some reassurance as to the reliability of respondents' experience of land-uses, and environmental and infrastructure conditions as presented below.

### Existing Land-Use Practices and Land-Use Efficiency

Table 2: Existing Land-Use Practices

| Statement                                                     | Mean | Interpretation |
|---------------------------------------------------------------|------|----------------|
| Residential development is expanding rapidly                  | 4.17 | High           |
| Commercial activities are expanding into residential areas    | 3.98 | High           |
| Agricultural/undeveloped land is being converted to urban use | 4.02 | High           |
| Mixed land uses are becoming increasingly common              | 4.08 | High           |

|                                                                               |      |          |
|-------------------------------------------------------------------------------|------|----------|
| Existing developed land is adequately redeveloped before peripheral expansion | 2.82 | Moderate |
| Land-use changes are adequately controlled                                    | 2.71 | Moderate |
| Overall Mean (Land-Use Efficiency)                                            | 3.18 | Moderate |

Source: Analysis, 2026

Lafia is characterized by a high level of urban expansion, with mean scores of 4.17 recorded for residential, the highest overall land use (Indicative of urban expansion), along with high scores for upgrading old to new buildings within existing built-up, converting farmland and developing mixed land use. These findings align with the worldwide evidence that the main driving force behind land-use change in Nigerian cities is population growth and development pressure (Alegbeleye et al., 2024). Though, lower mean score of 2.82 was recorded for value added for redevelopment of developed land, suggesting that the increased demand for development is being met by making additions through spatial expansion rather than through infilling, resulting in low overall land use efficiency of 3.18. This has implications for the conversion of agricultural and ecologically sensitive land in the periphery, and for the cost of extending infrastructure to new developments (Enoguanbhor et al., 2021).

### Environmental Sustainability

Table 3: Environmental Sustainability

| Indicator                                                    | Mean | Interpretation |
|--------------------------------------------------------------|------|----------------|
| Vegetation is adequately protected                           | 2.61 | Moderate       |
| Trees are retained during development                        | 2.54 | Low            |
| Public open spaces are protected                             | 2.47 | Low            |
| Wetlands/environmentally sensitive areas are protected       | 2.39 | Low            |
| Development avoids flood-prone areas                         | 2.58 | Low            |
| Environmental considerations influence development decisions | 2.68 | Moderate       |
| Landscaping is provided in new developments                  | 2.73 | Moderate       |
| Overall Mean (Environmental Sustainability)                  | 2.57 | Low            |

Source: Analysis, 2026

Environmental sustainability had the lowest overall mean of the study (2.57) with wetlands and other environmentally sensitive areas the least protected indicator (2.39). As the conversion of wetlands, vegetation and drainage corridors reduces their ecological and hydrological services, it increases flood risk, urban heat and other environmental hazards. This supports Lafia-specific evidence that green-space planning failures are due to rapid urban growth, that there was no fully determined or operational planning strategy with city administrators and green space was an under-prioritised issue (Ebuga et al 2024). It also provides evidence for that green-space misallocation is related to rising urban surface temperatures in Lafia (Ebuga et al 2023).

### Infrastructure Sustainability

Table 4: Infrastructure and Land-Use Sustainability

| Indicator                                         | Mean | Interpretation |
|---------------------------------------------------|------|----------------|
| Roads adequately serve existing development       | 3.01 | Moderate       |
| Drainage infrastructure is adequate               | 2.67 | Moderate       |
| Water supply infrastructure is adequate           | 2.73 | Moderate       |
| Waste management facilities are adequate          | 2.64 | Moderate       |
| New development considers infrastructure capacity | 2.71 | Moderate       |
| Overall Mean (Infrastructure Sustainability)      | 2.75 | Moderate       |

Source: Analysis, 22926

Roads infrastructure scored highest, while drainage and waste management was

relatively lacking, showing that infrastructure in Lafia may be more sustainable than development. Infrastructure sustainability scored an average of 2.75. Land availability does not necessarily equal infrastructure sustainability, and new development should be matched to the roads, drainage, water supply and waste-management capacity that is able to accommodate it in Lafia, following the evidence that decoupling infrastructure provision from land-use approval entrenches under-servicing in development (Gyau & Booth, 2020).

### Composite Assessment

Table 5: Land-Use Efficiency, Environmental and Infrastructure Sustainability Summary

| Sustainability Dimension      | Mean | Interpretation |
|-------------------------------|------|----------------|
| Land-use efficiency           | 3.18 | Moderate       |
| Environmental sustainability  | 2.57 | Low            |
| Infrastructure sustainability | 2.75 | Moderate       |

Source: Analysis, 2026

All three dimensions of the study area combined reveal that there is indeed a dynamic land-use activity but in an inefficient spatial manner, and that the expansion is occurring at a rate that is exceeding the city's ability to conserve ecologically fragile areas or to sustainably and systematically provide infrastructure. 'Efficiency' of land use, which is only average, is yet the most significant of the three dimensions while the 'sustainability' of the environment is the least to be considered; confirming the fact that it is the environmental sustainability that needs the greatest improvement in Lafia.

### 5. Conclusion

This research evaluated the sustainability of the land-use, environmental and infrastructure practices that support urban development in Lafia Urban Area. The size of the population will increase from 329,922 people in 2006 to a projection 573,157 in 2026 and this demographic stress is being absorbed largely through the distribution of outward outward residential /commercial expansion with the smaller proportion of the inhabitants being absorbed by the utilization of non-urban and already settled land for development purposes. Environmental sustainability was shown to be the weakest dimension of those considered with vegetation, open spaces and wetlands not being utilized to appropriately extent while infrastructure provision although was found to be at a moderate level was not always well coordinated with urban planning. Findings of the research suggests that the key destination of Lafia urban's sustainability problem is not growth per se, but the unintended ecological impact of that growth, which is now being handled purely in terms of its historical spatial inefficiency.

### 6. Recommendations

Implement an integrated spatial land-management approach, where the population growth, land-use efficiency, infrastructure capacity and environmental conservation are all under control and limits, with settlement areas are clearly separated from farmlands, ecological and water-drainage corridors.

Encourage infilling and redevelopment of vacant and under-utilised land in the current urban boundary, over peripheral expansion.

Mapping and legislatively protecting Lafia's green infrastructure Green of wetlands, drainage channels and neighborhood open spaces, to be made a part of baseline plan to be incorporated in all stages of Lafia development plan rather than a reserve land.

Make the assessment of infrastructure capacity roads, drainage, water supply and waste disposal a criterion for approval of large-scale residential and commercial developments.

Institutionalise regular monitoring of land use changes using GIS- and remote sensing-based techniques so that ever-increasing unsustainable land use and environmental degradation can be identified and rectified sufficiently early.

## 7. Implications of the Study

### Theoretical Implications

This study also offers an empirical extension to traditional theories of sustainable development and compact-city/land-use-efficiency in that with primary data collected from a fastest growing secondary metropolis in Nigeria, demonstrates that urban density/expansion intensity and spatial-use-efficiency are analytically distinct, but not necessarily convergent, dimensions of land-use sustainability.

### Policy and Practical Implications

The research evidence offers planning authorities in Lafia and other similar Nigerian towns an evidence base that could justify: targeting infill development for policy research and prioritisation; the preservation of green infrastructure as a defined and protected planning use; and the integration of infrastructure-capacity assessment with development control.

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