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GREEN COVER DYNAMICS IN RESOURCE CONSTRAINED URBAN PLANNING CONTEXTS IN PUBLIC HOUSING ESTATES IN ENUGU METROPOLIS, NIGERIA

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ABSTRACT

The rapid urban development in Enugu metropolis has brought about heightened residential construction within formally established housing estates, which has different effects on vegetation retention and landscape design. While it is expected that public housing projects will incorporate useful green components, it remains uncertain how thoroughly green cover is integrated into the layouts of these estates. This study presents a comparative assessment of urban green cover in selected public housing estates in Enugu metropolis using a case study approach supported by satellite imagery and descriptive spatial analysis. Five estates were examined, focusing on defined residential clusters to ensure spatial precision. The visual proportional assessment was utilized to assess the extent, distribution, and structural integration of vegetation in each estate. The

results indicate a noticeable variation in greenery across the estates. High-density layouts were characterized by limited and dispersed vegetation, predominantly found within private properties. Conversely, larger plot estates revealed a moderate level of greenery, but this was mainly driven by individual plot development rather than collective community organization. The estate adjacent to major vegetated corridor showed the highest green continuity due to its spatial relationship with the surrounding landscape. Across all cases, green infrastructure was predominantly private and weakly structured within estate-wide planning frameworks. Vegetation presence appeared to depend more on plot allocation and adjacency conditions than on deliberate ecological design. The study highlights the need for structured green infrastructure integration within residential layout standards. By demonstrating the effectiveness of accessible satellite-based visual assessment, the research provides a practical framework for monitoring green cover dynamics in resource-constrained urban planning contexts.

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1.0 Introduction

In recent decades, Nigeria's cities have experienced swift growth as more and more individuals migrate in search of economic opportunities (Mugo, 2024, Jegede, O. O et al, 2024, Opoko, A. P and Oluwatayo 2014). Enugu metropolis, being the capital of Enugu State in south-eastern Nigeria, is a prime example of this trend. Originally developed around coal mining activities in the early 20th century, the city has evolved into a major administrative and commercial hub, with its population rising from about 505,000 in 1991 to over one million by recent estimates (Anierobi, 2023). The expansion has created greater pressure on land resources, leading to the rapid growth of housing estates in response to residential needs. Public housing initiatives, launched by government bodies such as the Enugu State Housing Development Corporation (ESHDC), strive to offer organized living environments, but they frequently neglect the importance of including sufficient green spaces, which are vital for both ecological health and the well-being of residents.

Urban green spaces, such as trees, lawns, and recreational parks in built environments, play a crucial role in tropical cities like Enugu. They help to control microclimates by lowering ambient temperatures through shading and evapotranspiration, which helps alleviate the urban heat island effects, which can make densely populated areas uncomfortable (Adegun et al., 2021, Abdulkadir, I. F et al, 2020 and Bowler, D. E et al, 2010). In addition, green cover supports biodiversity by providing habitats for local flora and fauna, improves air quality by absorbing pollutants, and enhances storm water management to prevent flooding, a recurrent issue in Enugu due to its hilly terrain and seasonal heavy rains (Okwuosa et al., 2024, Bununu, Y. A et al, 2023). Studies in similar to Nigerian contexts, such as Lagos, have shown that residents value these spaces for recreation and social interaction, and with preferences influenced by accessibility and maintenance levels (Dipeolu et al., 2021). It is deeply concerning that rapid urbanization often results in the loss of green spaces, as they are transformed into concrete structures and roads, which ultimately disrupts the vital services our ecosystems provide and increases susceptibility to climate-related challenges (Agbelade, A. D., Ojo, O. A., & Adesuyi, A. A.,2025)..

In Enugu State, the transformation of natural landscapes into urban fabric has been particularly evident since the post-colonial era. Historical records indicate that the expansion of the city included nearby villages and woodlands, yet there was a lack of adequate measures to preserve green spaces. Public housing estates, which were established to tackle housing deficits, exemplify this issue. For example, estates constructed through state programmes frequently favour higher density over environmental concerns, resulting in limited greenery

and dependence on residents for informal planting (Faisal Koko, A., Han, Z., & Alolabi, H., 2021, Anierobi, C. M., 2023). This situation is made more complex due to challenges like restricted funding for landscaping, insufficient enforcement of planning rules, and societal beliefs about land utilization that prioritize construction over green areas (Agboeze & Nwankwo, 2023). The lack of sufficient green spaces in these areas not only detract visual charm but also raise health worries, such as breathing difficulties due to poor air quality and mental strain from a scarcity of natural environments.

The necessity to evaluate urban green cover in the public housing estates of Enugu State arises from wider national and global requirements. Although Nigeria's National Housing Policy acknowledges the significance of sustainable urban development, there are still challenges in implementing it, especially when it comes to incorporating green features into affordable housing (World Bank, 2023, Federal Ministry of Works and Housing, 2012). Internationally, frameworks like the United Nations Sustainable Development Goals (SDGs), specifically Goal 11 on sustainable cities and communities, underscore the role of green spaces in fostering resilient urban environments. In African contexts, where urbanization rates are among the highest globally, studies using satellite imagery have revealed declining green cover in cities like Dakar and Johannesburg, attributing it to unplanned expansion (Cissé et al., 2024; Gidey, 2025). Enugu State faces similar dynamics, with informal settlements and estate extensions eroding vegetated areas, as observed in biodiversity assessments that link urbanization to species loss (Ogbuene et al., 2018).

This study focuses on five selected public housing estates in Enugu metropolis: Trans-Ekulu Housing Estate, Liberty Estate, Golf Course Estate, Zoo Estate, and WTC Estate. These were chosen for their representation of diverse developmental phases and their digital footprints, including online documentation from government sources and media, which facilitate comparative analysis. Trans-Ekulu, one of the older estates, spans multiple phases and reflects mid-20th-century planning with some retained natural features. Liberty Estate, located in Independence Layout, emphasizes low-density housing but shows signs of green degradation due to resident modifications. Golf Course and Zoo Estates in the Government Reserved Area (GRA) benefit from proximity to recreational zones, potentially offering higher green densities. WTC Estate, more centrally positioned, highlights challenges in high-traffic urban cores. All these estates have been referenced in state housing reports and online platforms, confirming their relevance and data availability (Enugu State Housing Development Corporation, 2024; Agboeze et al., 2023).

The methodology adopts a case study approach, supplemented by satellite imagery from ArcGIS for visual assessments and descriptive comparisons. This avoids complex metrics like the Normalized Difference Vegetation Index (NDVI), opting instead for straightforward evaluations of green extent, types (e.g., trees versus lawns), and conditions through high-resolution imagery. Such methods have proven effective in African urban studies for identifying green cover patterns without requiring extensive fieldwork (Metzler et al., 2025; Karan et al., 2025). Data collection involves reviewing estate layouts, analysing temporal changes in imagery, and incorporating stakeholder insights where available. The comparative framework examines variations across estates, linking them to factors like age, management, and socio-economic profiles of residents.

The objectives are in threefold: first, to document the current status of green cover in the selected estates; second, to identify factors contributing to differences in green space quality and quantity; and third propose policy recommendations for enhancing green integration in future housing developments. By doing so, the study addresses a gap in localized research on Nigerian urban green spaces, where much existing work focuses on larger cities like Lagos or Abuja (Olukoya & Olukoya, 2023; Bununu et al., 2023). It also contributes to the discourse on sustainable urbanization in the Global South, emphasizing practical assessments that can inform planning without advanced technical resources.

The significance of this research lies in its potential to guide Enugu's urban policy toward more environmentally friendly housing. With Nigeria projected to have over 200 million urban dwellers by 2050, preserving green cover in estates could mitigate climate risks and improve quality of life (United Nations, 2018). For Enugu State, where flooding and erosion are prevalent, enhanced green spaces could bolster resilience. Moreover, the findings may extend to other south-eastern Nigerian cities facing similar urbanization pressures.

2.0 Literature Review

The importance of urban green cover, including trees, lawns, shrubs, parks, and other vegetated spaces in built environments has been gaining significant scholarly focus in Nigeria and the wider African context. This study brings together existing knowledge about the gains of urban green spaces, the challenges faced in their creation and upkeep, assessment methods that are suitable for resource-limited environments, and particular insights from Nigerian cities, especially those linked to public housing estates. The discussion is based on peer-reviewed studies, many of which emphasize the tropical urban conditions that are typical of Enugu metropolis.

2.1 Benefits of Urban Green Spaces in Tropical Urban Environments

Urban green spaces deliver a range of ecosystem services that support environmental stability and human well-being in tropical cities. They regulate microclimates by providing shade and facilitating evapotranspiration, which reduces ambient temperatures and counters the urban heat island effect common in densely built areas (Agbelade, A. D., Ojo, O. A., & Adesuyi, A. A. 2025, Adegun et al., 2021). In Nigerian settings, field measurements have shown that tree canopies lower air temperatures by 5–10 °C during dry and wet seasons, depending on species density and height (Enete et al., as cited in Adegun et al., 2021). Such cooling is particularly valuable in cities like Enugu, where seasonal heat and humidity intensify thermal discomfort. Beyond thermal regulation, green cover improves air quality by absorbing pollutants and supports storm water management by reducing runoff and erosion risks in hilly terrains (Okwuosa et al., 2024). Biodiversity conservation benefits arise as these spaces serve as habitats for local species amid habitat fragmentation from urbanization (Ogbuene et al., 2018). Socially, accessible green areas foster recreation, social interaction, and psychological relief, with residents in Lagos expressing preferences for parks and gardens that enhance connectedness to nature (Dipeolu et al., 2021). In tropical African cities, these spaces also contribute to food security through home gardens and urban agriculture, though economic returns remain modest (Adegun et al., 2021). Provisioning services, such as fruits and medicinal plants from domestic gardens, align with cultural practices, while cultural benefits include aesthetic enhancement and community cohesion (Dipeolu & Taiwo, 2024). Overall, these functions position green infrastructure as a nature-based solution for sustainable urban development in rapidly growing Nigerian cities.

2.2 Challenges to Urban Green Space Provision and Maintenance in Nigeria

Despite recognized benefits, urban green cover in Nigeria faces persistent decline due to multiple pressures. Rapid urbanization converts vegetated land into impervious surfaces for housing and infrastructure, often without adequate compensatory planning (Anierobi, 2023). In Enugu, historical growth incorporated surrounding forests and villages, yet provisions for green preservation were insufficient, leading to sparse vegetation in many estates (Eze, 2021). Public housing estates exemplify these issues, where density priorities overshadow environmental considerations, resulting in reliance on informal resident planting (Agboeze & Nwankwo, 2023). Factors such as limited funding for landscaping, weak enforcement of regulations, and cultural preferences for built development exacerbate degradation (Adegun et al., 2021). In Lagos and other cities, encroachment, poor maintenance, and competing land uses contribute to loss, with similar patterns observed in Enugu's estates (Okwuosa et al.,

2024). Broader challenges include institutional weaknesses, fragmented governance, and low political priority for green infrastructure (Bununu et al., 2023). In African urban contexts, these lead to inequities in access, particularly affecting lower-income groups (Muhoza & Cobbinah, 2024). Studies noted that without integrated policies, green spaces risk becoming marginalized, undermining their potential contributions to resilience against flooding and heat in places like Enugu (Okwuosa et al., 2024; Eze, 2021).

2.3 Methods for Assessing Urban Green Cover: Focus on Visual and Satellite-Based Approaches

Assessing urban green cover in resource-limited settings often relies on accessible tools like satellite imagery and visual interpretation, avoiding advanced indices such as NDVI when data or expertise is constrained. Google Earth imagery, with its high-resolution historical views, supports straightforward visual assessments of green extent, distribution, and condition (Gaikadi, 2024, Aliyu, A., Muhammad, I., & Sani, A., 2025). Threshold-based reclassification of pixel values from Google Earth has achieved overall accuracies exceeding 90% in distinguishing trees, lawns, and other vegetation types in various cities (Gaikadi, 2024). In African urban studies, such methods effectively identify patterns without fieldwork-intensive requirements (Metzler et al., 2025). Comparative analyses using temporal imagery reveal changes linked to urbanization, as seen in Lagos where satellite data tracked green space decline (Owoeye & Ibitoye, 2016, as referenced in related works). Visual assessments complement descriptive comparisons, enabling evaluation of management influences and resident impacts in housing estates (Karan, 2025). These approaches suit Nigerian contexts, where free tools like Google Earth facilitate localized studies without sophisticated software, though validation through ground trothing enhances reliability (Oloke, O. C., and Ajayi, O. ,2023, Alegbeleye et al., 2024).

2.4 Urban Green Cover in Nigerian Public Housing Estates: Insights and Gaps

Literature on green cover specifically in Nigerian public housing estates remains limited but points to consistent challenges. In Enugu metropolis, estates often exhibit inadequate green integration due to planning oversights and maintenance gaps (Okwuosa et al., 2024). Residents' value accessible spaces for recreation, yet degradation from informal expansions reduce benefits (Agboeze et al., 2023). Comparative studies in similar contexts, such as Lagos, show preferences for well-maintained green features in housing areas, influenced by accessibility and quality (Dipeolu et al., 2021). Enugu's estates, varying in age and location, reflect disparities: older ones retain some natural features, while newer or central ones face higher pressures (Anierobi, 2023). Broader Nigerian reviews highlight domestic gardening

and public parks as key, but estate-specific data is sparse (Adegun et al., 2021). This gap underscores the need for localized assessments using accessible methods to inform policy, particularly in south-eastern cities like Enugu where hilly topography amplifies erosion and flooding risks without sufficient green cover (Okwuosa et al., 2024). The reviewed literature establishes urban green spaces as essential yet threatened in Nigerian urban settings. Benefits span environmental regulation and social well-being, while challenges stem from urbanization and governance limitations. Assessment via visual satellite methods offers practical pathways forward. These insights frame the current study's focus on comparative visual evaluation in Enugu's selected estates.

2.5 Policy and Institutional Frameworks for Urban Green Spaces in Nigeria

Nigeria's policy landscape for urban green spaces remains fragmented, with limited integration into housing and urban development frameworks. The National Housing Policy (Federal Ministry of Works and Housing, 2012) acknowledges sustainable development principles, including environmental considerations in housing provision, but implementation has been inconsistent, particularly in public estates where green elements are often deprioritized in favour of density and cost efficiency (Agboeze & Nwankwo, 2023 Enoguanbhor, E. C. et al, 2021). At the state level, initiatives like Enugu State's on-going urban green campaigns emphasize tree planting and open space enhancement, yet these efforts face challenges in enforcement and funding (Enugu State Government initiatives, as referenced in recent policy discussions).

Broader national policies, such as those aligned with the United Nations Sustainable Development Goals (SDG 11), promote resilient cities through green infrastructure, but gaps persist in translating these into actionable guidelines for housing estates (Adegun et al., 2021). Institutional weaknesses, including overlapping responsibilities between federal, state, and local authorities, hinder coordinated green space management. In south-eastern Nigeria, including Enugu, local planning authorities often lack resources to enforce landscaping standards in public housing developments (Okwuosa et al., 2024). Studies highlight that while policies recognize the value of green spaces for flood mitigation and thermal comfort, critical in Enugu's hilly and rainy terrain, practical application remains weak due to inadequate monitoring and community involvement (Bununu et al., 2023). Recent calls for stronger institutional mechanisms, such as dedicated green infrastructure units within housing corporations, aim to address these shortcomings and ensure sustained provision in estates (Muhoza & Cobbinah, 2024).

2.6 Comparative Insights from Other Nigerian Cities and African Contexts

Comparative analyses from other Nigerian cities reveal patterns relevant to Enugu's public housing estates. In Lagos, residents in public schemes express preferences for accessible, well-maintained green spaces, with satisfaction linked to proximity and quality rather than mere presence (Dipeolu et al., 2021). However, joint-owned green areas often suffer from poor maintenance compared to individual unit-adjacent spaces, a trend observed in Lagos and Abuja public housing (Jegede et al., 2024, Ideki et al, 2025). Similar disparities appear in Kaduna, where urban greenery positively influences perceived quality of life, including environmental beauty and recreational value, though high-density areas show lower satisfaction (Shamang et al., 2024). In Kano metropolis, contingent valuation approaches indicate residents' willingness to pay for preserved green spaces, underscoring economic potential despite low current cover (Abubakar, 2025). These findings align with Enugu's context, where older estates like Trans-Ekulu retain some natural features, while central or newer ones face degradation from informal uses (Anierobi, 2023). Across African cities, studies in South Africa and Ethiopia highlight how varying satellite imagery resolutions affect green space mapping accuracy, with higher-resolution sources like Google Earth improving detection of fine-scale vegetation in housing areas Cardenas-Ritzert et al., 2025). In sub-Saharan contexts, urban expansion often erodes green cover unequally, affecting lower-income estates more severely (Muhoza & Cobbinah, 2024). These insights suggest that Enugu's estates could benefit from targeted, localized assessments to inform equitable green interventions.

2.7 Research Gaps and Justification for the Current Study

Existing literature on urban green cover in Nigeria predominantly focuses on larger cities like Lagos and Abuja, with limited attention to south-eastern contexts such as Enugu (Olukoya & Olukoya, 2023; Bununu et al., 2023). While reviews cover benefits, challenges, and general practices (Gumel, I. A., Ebeh, R. E., & Muhammad, A., 2020, Adegun et al., 2021), estate-specific comparative studies remain scarce, particularly those using simple visual methods from accessible satellite imagery. Gaps include insufficient documentation of green cover variations across public housing estates of different ages and locations, and limited exploration of management practices' influence on vegetation quality in resource-constrained settings (Karan, S. K., 2025, Okwuosa et al., 2024). Few studies avoid advanced indices like NDVI, opting instead for practical visual assessments suitable for local planners without specialized tools (Gaikadi, 2024). This study addresses these gaps by conducting a descriptive comparative assessment of green cover in five selected Enugu estates namely Trans-Ekulu, Liberty, Golf Course, Zoo, and WTC, using Arches (Foxpoi) imagery for visual

evaluation. It builds on prior work emphasizing the need for green integration in Enugu housing (Okwuosa et al., 2024) and contributes localized evidence to support policy enhancements in similar Nigerian urban settings. The reviewed literature collectively underscores the multifaceted value of urban green spaces, persistent implementation challenges, and the utility of accessible assessment methods. These elements provide a strong foundation for the empirical focus of this research on comparative green cover dynamics in Enugu's public housing estates.

3.0 Methodology

This study adopts a qualitative case study approach to examine urban green cover in five selected public housing estates within Enugu metropolis. The method combines visual analysis of satellite and street-level imagery obtained through Foxpoi 3D with descriptive spatial comparison. This method allows for a systematic assessment of the size, spread, and visible state of green spaces, without the need for complex vegetation indices or specialized GIS tools. It focuses on being user-friendly, making it possible to evaluate green areas at an estate level using freely accessible digital platforms. Such visual approaches have been recognized as valid within urban and environmental studies where the objective is spatial configuration analysis rather than spectral quantification (Gaikadi, 2024; Karan, 2025).

3.1 Study Area

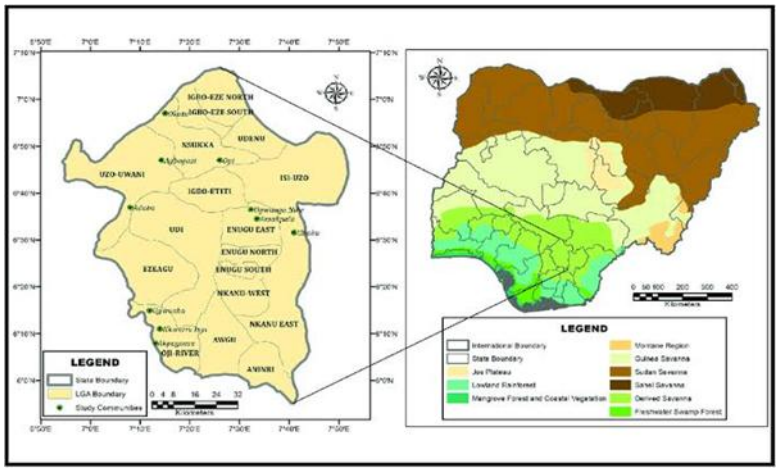

Fig 1: Map of the study Area, Enugu State

Enugu metropolis is located in south-eastern Nigeria and serves as the capital of Enugu State. The city lies at the foot of the Udi-Nsukka Plateau, with an elevation of approximately 180 metres above sea level. It experiences a tropical climate characterized by distinct wet and dry

seasons, with significant rainfall influencing vegetation growth patterns and urban drainage systems (Anierobi, 2023). Administratively, the metropolis comprises Enugu East, Enugu North, and Enugu South Local Government Areas. Urban growth over the past decades has resulted in expansion of formal housing estates across these districts, accompanied by varying levels of vegetation retention and landscape modification (Adegun et al., 2021; Agboeze & Nwankwo, 2023). Five estates were selected to reflect different planning histories, socio-economic profiles, and morphological structures. To ensure spatial precision and comparability, each estate is represented by a clearly defined residential cluster with identifiable internal road boundaries.

The selected case study clusters are:

- Trans-Ekulu (CBN Quarters Cluster): A defined institutional housing segment within the broader Trans-Ekulu estate, characterized by rectilinear block layout and consistent plot typology.
- Golf Course Estate (Upper GRA Core Residential Segment): The structured residential core adjacent to the former golf layout corridor within the Government Reserved Area.
- WTC Estate (Original Residential Housing Block Section): The primary organized housing blocks within the estate, excluding peripheral commercial or informal expansions.
- Liberty Estate (Central Residential Core): The internal loop-road residential segment with consistent plot sizes and observable communal pockets.
- Zoo Estate (Planned Residential Core off Zoo Road): The structured housing segment excluding irregular transitional extensions.

These estates were selected due to their prominence in formal housing development within Enugu metropolis and the availability of high-resolution digital imagery that allows consistent visual interpretation (Okwuosa et al., 2024; Enugu State Housing Development Corporation, 2024).

3.2 Data Sources and Collection

Primary data were obtained through Foxpoi 3D, a web-based digital mapping platform providing high-resolution ARCGIS satellite imagery and street-level visualization. The platform allows dynamic navigation across estate road networks and provides oblique and horizontal viewing angles for observing vegetation distribution within plots and along corridors. Imagery from 2015 to 2025 was reviewed where available in order to observe

temporal consistency and possible landscape changes. Particular attention was given to dry-season imagery to enhance vegetation clarity and minimize distortion caused by cloud cover. Street-level perspectives were used to corroborate satellite observations, especially in assessing tree maturity and canopy spread, setback vegetation, plot-level paving and encroachment into green spaces. Supplementary contextual information was obtained from state housing documentation and relevant planning literature describing estate characteristics (Okwuosa et al., 2024; Agboeze & Nwankwo, 2023). No physical field survey was conducted. The reliance on digital visual interpretation aligns with cost-effective urban research practices in resource-constrained contexts and remains appropriate for estate-scale spatial assessment (Gaikadi, 2024; Karan, 2025).

3.3 Data Analysis

Analysis followed a structured visual assessment protocol applied consistently across all five case study clusters.

Boundary Confirmation: Each residential cluster was delineated using identifiable internal roads and block configurations visible within Foxpoi 3D. Peripheral transition zones were excluded to maintain spatial consistency.

Vegetation Identification: Vegetation types were identified through observable colour contrast, canopy texture, and shadow patterns. Elements assessed included mature roadside trees, plot-level trees and shrubs, lawns and grass strips and communal vegetated pockets

Green Cover Estimation: Green cover extent was estimated visually using proportional comparison between vegetated and impervious surfaces. A qualitative classification scale was applied:

- Low: Less than 20% visible vegetated surface
- Moderate: Approximately 20–40%
- High: Greater than 40%

The estimation relied on consistent visual judgment across blocks rather than pixel-based measurement.

Distribution Pattern Assessment: Vegetation arrangement was categorized as linear (along roads), clustered (within communal spaces), scattered (plot-dependent), fragmented (interrupted by paving or infill development)

Temporal Observation: Where historical imagery was available, visible changes in vegetation continuity and building footprint expansion were noted descriptively.

3.4 Limitations

The methodology relies on visual interpretation and is therefore subject to observational bias. Absence of field verification limits assessment of vegetation health beyond visible canopy density. Additionally, image resolution and update frequency vary across estates. However, the combination of satellite and street-level imagery strengthens interpretive reliability by allowing cross-verification of canopy structure and plot-level modifications. The approach remains appropriate for comparative estate-scale assessment within an architectural and planning research framework, where emphasis is placed on spatial configuration rather than spectral modelling.

4.0 Results

High-resolution satellite imagery from Foxpoi 3D enabled visual interpretation of vegetation extent within the selected residential clusters to be analysed. Green cover proportions presented here represent visual approximation ranges derived from comparative assessment of vegetated surfaces relative to total land area within clearly defined estate boundaries. These values are indicative rather than GIS-derived measurements.

Distinct differences were observed across the five estates.

4.1 Central Bank of Nigeria (CBN) Quarters Cluster (Trans-Ekulu)

The CBN Quarters cluster exhibits a compact, repetitive block arrangement with shallow setbacks and extensive exposed soil between building rows. Vegetation is present but spatially limited. Tree cover appears concentrated along selected building edges and small courtyard spaces, with minimal canopy continuity across the cluster.

Fig 2: Satellite image of CBN Quarters Cluster (Trans-Ekulu) using Foxpoi ArcGIS.

There are significant areas within the internal space that are quite bare or only have a little vegetation, which diminishes the overall presence of greenery. It is also apparent that there is no distinct communal green infrastructure evident within the area. From what can be seen, the extent of green cover seems to be in the low to lower-moderate range, roughly around 20 to 25%. The vegetation seems more of an afterthought rather than something that has been thoughtfully incorporated into the estate design.

Fig 2i: 3D street view of CBN

4.2 WTC Estate

In WTC Estate, the layout is relatively dense, organized around a circular internal street system. Most of the land area is occupied by buildings, with vegetation mainly found in private spaces.

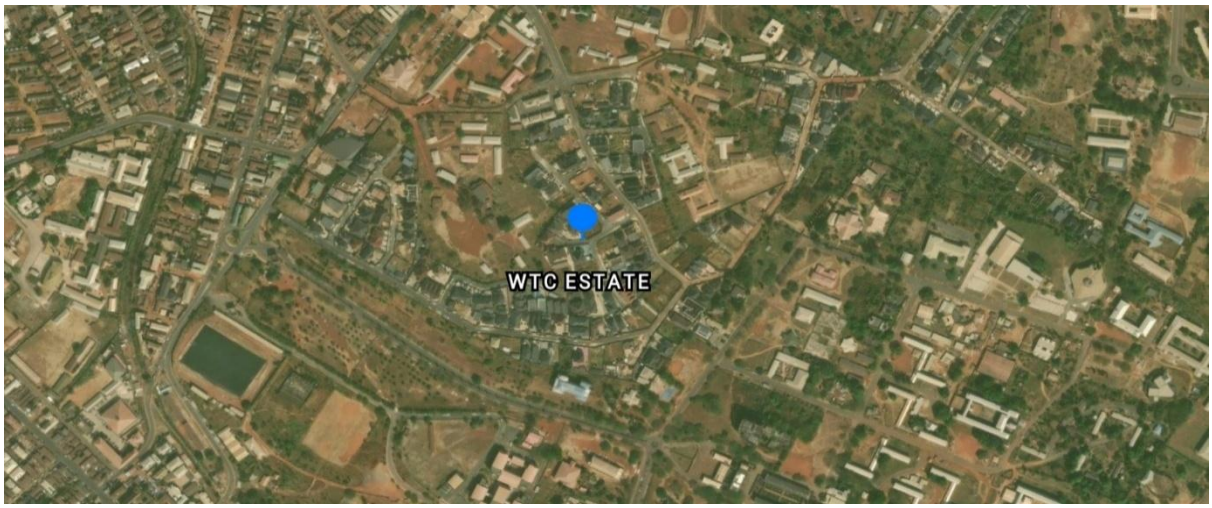

Fig 3: Satellite image of WTC Estate

The spread of the tree canopy is quite limited, and the alignment of trees along the roadside is not very strong. There is a noticeable dominance of bare soil and hard surfaces in the visual landscape. Unfortunately, there appears to be no central green space or connected landscape corridor. A rough visual assessment suggests that green cover is on the lower end, around 15 to 20%, which means WTC Estate has the least vegetation among the areas we looked at.

4.3 Liberty Estate (Independence Layout Core)

Liberty Estate demonstrates comparatively larger plot sizes and more generous setbacks. Vegetation is more visible across individual compounds, including lawns and ornamental planting. Tree presence is moderate and dispersed.

However, green distribution remains largely plot-based rather than collectively structured. No prominent public green spine or central park is evident within the study boundary.

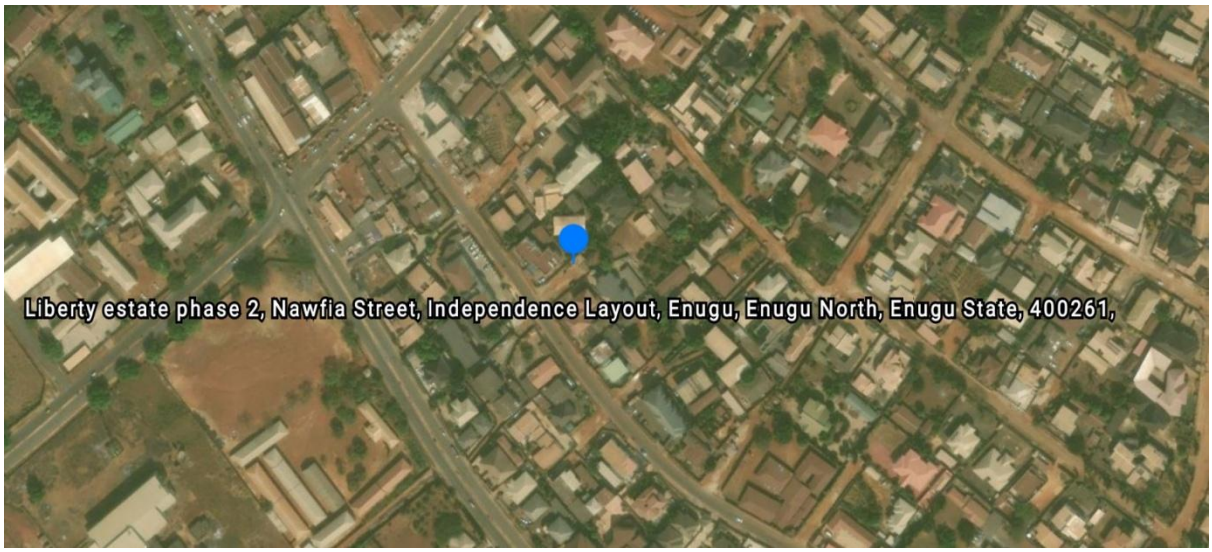

Fig 4: Satellite image of Liberty Estate

Fig 4i: Street view of Liberty Estate

Visual proportional interpretation suggests green cover falls within the moderate range (approximately 20-30%).

4.4 Zoo Estate (Ekulu East Residential Cluster)

Zoo Estate features greater spacing between plots and more distinct separation between buildings when compared to the WTC and CBN clusters. There is a more consistent presence of vegetation throughout the compounds, with well-kept lawns, shrubs, and mature trees that contribute to the landscape. The distribution of trees seems more uniform than in Liberty Estate, although it remains largely private in nature. Within the chosen boundaries, there does not appear to be a designated communal park.

Fig 5: Satellite image of Zoo Estate

Estimated green cover falls within the moderate to moderately high range (approximately 25–45%), reflecting improved spatial integration of vegetation relative to denser estates.

Fig 5i: Street view of Liberty Estate

4.5 Golf Course Estate (Residential Cluster Adjacent to Golf Corridor)

Being adjacent to the expansive golf field allows the Golf Estate to enjoy significant benefits, including a beautiful, continuous vegetated border. The residential area features spacious plots, and the landscaping is impressively uniform. The tree canopy coverage is more pronounced, and the greenery benefits from being near the golf corridor. This connection creates a richer landscape framework that is not found in other estates.

Fig 6: Satellite image of Golf Estate

Visual estimation indicates green cover within the highest range (approximately 40-50%), particularly when the contiguous golf vegetation is considered part of the estate's environmental setting.

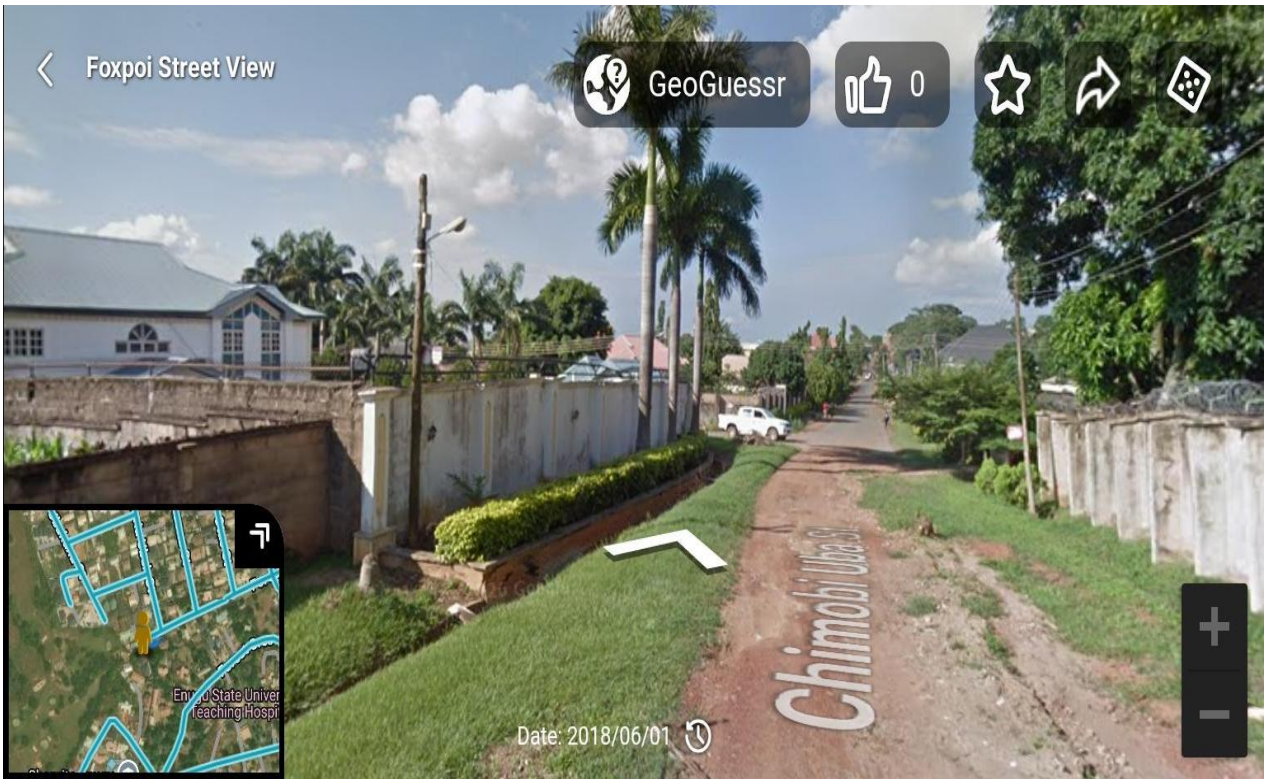

Fig 6i: Street view of Golf Estate

4.6 Comparative Overview of the selected estates

In most scenarios, green spaces are mostly private instead of being shared by the community. There is limited structured public green infrastructure within the layouts of internal estates. The differences in the presence of greenery seem closely linked to factors such as density, plot size, and proximity to external vegetated areas. A clear gradient emerges across the estates: While WTC estate revealed the lowest green proportion, the CBN Quarters manifested low but organized cluster greenery and Liberty Estate showed moderate plot-driven greenery. On the other hand, Zoo estate exhibited moderately high detached-lot greenery while Golf Course estate revealed the highest integrated greenery in the study area.

5.0 DISCUSSION

The comparative evaluation shows a noticeable structural link between estate density, planning history, and the level of visible greenery throughout the specific housing areas in Enugu metropolis. Even though all five estates are recognized as formally planned residential zones, the spatial principles that guide their development seem to affect the integration of vegetation in remarkably different ways. In various instances, the green cover tends to be more focused on individual plots rather than being part of a wider system. This observation aligns with the findings from housing research in Nigeria, where it appears that landscape features in numerous planned estates are often viewed as leftover or decorative elements

instead of being integrated infrastructure within the overall layout (Adegun et al., 2021; Nnam, V. C., Okeke, F. I. , 2022Okwuosa et al. and 2024 Karan, S. K.,2025). In the present study, vegetation rarely forms a continuous public network. Instead, it is concentrated within private compounds, reinforcing the notion that greenery in many estates functions as a household amenity rather than collective environmental infrastructure.

5.1 Density and Green Distribution

The reduced green spaces seen in the WTC Estate and the CBN Quarters area indicate a greater concentration of buildings and shallower setbacks. In these locations, the prominence of building footprints and visible lateritic surfaces shapes the overall visual appeal. Similar patterns have been documented in rapidly urbanising Nigerian cities, where increasing land value and demand for compact development often reduce green allocations within residential layouts (Anierobi, 2023; Adegun et al., 2021). The CBN cluster serves as a noteworthy example, as its repetitive block design leads to predictable internal courtyards while restricting canopy growth to only narrow gaps. Although there is some vegetation present, it doesn't grow enough to impact the broader environmental character of the estate. This observation aligns with research indicating that mid-density staff housing designs frequently favour building efficiency rather than ecological planning (Shandas, V., and Voelkel, J., 2013, Van den Bosch, M. and Sang, Å. O, 2017 and Okwuosa et al., 2024). In contrast, Zoo Estate and Liberty Estate demonstrate how larger plot sizes and lower density indirectly increase green presence. Greater setbacks create opportunities for lawns, shrubs, and canopy trees to establish. However, the study shows that this increased greenery remains fragmented at the compound level. The absence of central parks or linked green corridors limits environmental continuity; reinforcing findings that private greening alone does not substitute for structured urban green systems (Adegun et al., 2021; Gaikadi, 2024).

5.2 Planning Intent and Landscape Integration

Golf Course Estate is unique due to its location next to the golf corridor. The large green field serves as an ecological anchor, positively impacting both the perceived and actual greenery in the residential area. This supports claims in spatial planning literature that being close to extensive green spaces greatly benefits the environmental quality of a neighbourhood, even when the landscaping within the estate is quite simple (Karan, 2025, Sa'ad, A., Muhammad, I., & Sani, A.,2026). The key distinction is not merely the quantity of vegetation but its structural integration. Where green areas are contiguous and visually dominant, they contribute to microclimatic moderation and landscape coherence. Where vegetation is scattered, its impact is limited. Research on urban thermal environments consistently shows

that canopy continuity, rather than isolated planting, is more effective in moderating surface temperatures (Adegun et al., 2021).

The findings therefore suggest that estate-level greening in Enugu metropolis is shaped more by market positioning and plot allocation standards rather than ecological planning principles. Higher-income estates display greater vegetation presence, not necessarily because of deliberate green policy but due to spatial allowance and larger land parcels.

5.3 Socio-Economic Context and Landscape Outcomes

Socio-economic differentiation appears to intersect with green outcomes. Zoo Estate and Golf Estate typically regarded as higher-value residential environments, show stronger vegetation presence than WTC and the CBN cluster. This reflects broader patterns in urban studies where environmental quality often correlates with income stratification (Eze, P. N., 2021; Oduwaye, L., and Ogundele, J. A., 2021 and Anierobi, 2023).

However, it would be reductive to attribute green variation solely to affluence. The results indicate that layout configuration and adjacency conditions are equally significant. WTC Estate, despite being centrally located and modern in development character, exhibits the lowest green proportion due to compact planning and limited residual open space. This reinforces the argument that design structure may outweigh age or prestige in determining ecological outcomes (United Nations, 2018, Oduwaye, L., and Ogundele, J. A., 2021 and World Bank, 2023).

5.4 Public versus Private Green Infrastructure

A common issue observed in all estates is the insufficient availability of communal green spaces. None of the estates within the chosen area features a designated central park or an organised green corridor. Even in areas where there is some vegetation, it tends to be largely confined to private properties. This issue echoes the worries expressed in Nigerian architectural studies about the slow decline of communal green areas in residential developments (Adegun et al., 2021; Oloke, O. C., and Ajayi, O.,2023). When greenery is privatised, the shared environmental advantages it brings are compromised. This results in streetscapes that miss the continuity of canopies, reduced comfort for pedestrians, and inconsistent microclimatic buffering. The study advocates for a more intentional incorporation of green infrastructure into estate planning frameworks instead of depending on optional landscaping within compounds. Visual data gleaned from satellite images indicates that in the absence of structured design regulations, vegetation tends to be left as an afterthought.

5.5 Implications for Urban Housing Planning in Enugu

The comparative pattern indicates three important considerations for planning. Firstly, managing density has a direct impact on ecological capacity; as plot coverage grows, there are fewer chances for significant vegetation to thrive. Urban housing authorities might want to rethink setback regulations and ensure that new developments include a minimum percentage of landscaping (Nnam, V. C., and Okeke, F. I., 2022, Meerow, S. et al 2016). Secondly, being close to larger ecological resources greatly boosts environmental performance. Whenever feasible, residential designs should aim to maintain and integrate existing vegetated corridors instead of breaking them up (Seto, K. C. et al, 2012, Gidey, E. T. 2025). Lastly, estate planning needs to emphasize practical green infrastructure and evolve from merely focusing on attractive landscaping. Research consistently correlates well-organised vegetation networks with enhanced environmental resilience (Adegun et al., 2021; Karan, 2025). The present findings indicate that such integration remains limited in the selected Enugu estates.

5.6 Methodological Reflection

Relying on visual interpretation of satellite data has shown to be quite effective in spotting structural variations and how vegetation is distributed (Mugo, R., Odera, P., and Ongoma, V., 2024). Similarly, visually based methods have also proven to be effective and reliable in urban green mapping, particularly when advanced spectral analysis is limited by available resources (Gaikadi, 2024; Karan, 2025).

Unfortunately, without ground verification, it's challenging to fully assess the health of vegetation and the diversity of species. Consequently, the results of this study mainly reflect spatial configuration instead of the ecological quality.

Concluding Interpretation

The overall analysis highlights that the green cover in certain public housing estates in Enugu is inconsistent and largely influenced by layout density, plot size, and proximity to other areas. The vegetation present is mainly private, fragmented, and not well integrated into community planning frameworks. There is a greater correlation between the amount of green cover and the available space than with intentional environmental design strategies. This indicates that upcoming estate developments in Enugu should incorporate green infrastructure into their layout planning instead of relying on individual homeowners' choices. This discussion places the identified spatial patterns within the wider context of urban housing in Nigeria, emphasizing the importance of structured, system-oriented green planning in new residential projects.

6.0 Conclusion and Recommendations

This study conducted a comparative visual analysis of the green spaces in five chosen public housing estates within Enugu metropolis, utilizing satellite imagery and descriptive spatial methods. The results reveal distinct differences in the amount and distribution of vegetation among the estates, with the presence of greenery significantly affected by factors such as layout density, plot size, and proximity to larger vegetated areas. WTC Estate and CBN Quarters cluster show low levels of greenery, marked by closely arranged buildings and little continuity in the tree canopies while Liberty Estate and Zoo Estate have a moderate amount of vegetation, mostly found within private gardens rather than in shared community areas. In contrast, Golf Course Estate stands out with its abundant greenery, significantly attributed to its proximity to the adjoining golf course, which enriches the environmental quality of the area. In all instances, the vegetation is mainly private and fragmented. None of the estates within the designated study area showcases a consciously designed internal green network or a shared green infrastructure. The presence of greenery seems to arise more from available space rather than from thoughtful ecological planning. Consequently, the results indicate that although housing estates in Enugu maintain different levels of vegetation, there is no consistent integration of green infrastructure within the layout of these estates. As urban development continues and land demands grow, this trend could diminish ecological capacity further unless the standards of planning improve.

The study shows that visual satellite assessment offers an effective and justifiable approach for evaluating green spaces on an estate scale, particularly in research settings with limited resources. While exact quantitative measures were not produced, consistent comparative observations enabled dependable classification of green dominance patterns. Based on the findings, several planning and policy implications are proffered:

- **Integration of Structured Green Infrastructure in Estate Design**

Future residential estate layouts in Enugu should move beyond discretionary compound landscaping. Planning authorities and housing developers should incorporate structured green systems at the layout stage, including, defined communal parks, Linear green corridors along internal roads, Minimum canopy coverage standards and Embedding green infrastructure within design regulations to prevent reliance on individual household initiative.

- **Density-Sensitive Green Standards**

Estate density should be directly linked to mandatory landscape allocation thresholds. Where higher plot coverage is permitted, compensatory green measures such as shared open spaces

or roadside canopy planting should be required. This approach would balance land efficiency with ecological function.

- **Protection of Adjacent Ecological Assets**

The case of Golf Course Estate demonstrates the environmental value of adjacency to large vegetated corridors. Urban development frameworks in Enugu should identify and preserve natural or recreational green buffers as integral components of residential planning, rather than treating them as surplus land.

- **Retrofitting Existing Estates**

For established estates such as WTC and CBN clusters, retrofitting strategies may include, street tree planting programs, community-managed pocket parks, incentives for compound greening, enforcement of un-built setback areas, incremental landscape enhancement can improve microclimatic conditions without major structural redesign.

- **Policy and Monitoring Framework**

Urban planning agencies in Enugu State should develop monitoring guidelines for green cover within housing estates. Periodic satellite-based assessments can provide cost-effective evaluation of vegetation trends over time. Such monitoring would support evidence-based planning adjustments.

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