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Levels of Infrastructure Development in Peri-urban Areas of South-South Nigeria

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Abstract

Peri-urban settlements exhibit varying levels of infrastructure development, yet systematic classification of these areas remains limited in Nigeria. This study classified peri-urban settlements in South-South Nigeria according to their levels of infrastructure development to provide an empirical basis for equitable planning and resource allocation. Sixty peri-urban settlements were assessed using thirteen infrastructure indicators comprising telecommunications, electricity, educational facilities, health facilities, water supply, roads, police stations, waste management, courts, recreational facilities, and markets. An Infrastructure Index was computed by averaging the infrastructure scores for each settlement, and the resulting index values were subjected to hierarchical cluster analysis. The agglomeration schedule and dendrogram were used to determine the optimal number of settlement clusters. The analysis identified three distinct categories of peri-urban settlements. Cluster 1 comprised 14 highly developed settlements with infrastructure indices ranging from 0.69 to 0.92, Cluster 2 contained 19 moderately developed settlements with indices between 0.54 and 0.62, reflecting partial but uneven infrastructure provision, while Cluster 3 consisted of 27 least developed settlements with infrastructure indices ranging from 0.23 to 0.46. The hierarchical clustering procedure confirmed clear structural differences among the three categories of settlements. The study demonstrates that the combination of an infrastructure index and hierarchical cluster analysis provides a robust framework for classifying peri-urban settlements according to infrastructure development. The findings reveal substantial spatial disparities in infrastructure provision across peri-urban areas of South-South Nigeria and provide a practical basis for evidence-based planning, targeted infrastructure investment, and policies aimed at promoting equitable and sustainable peri-urban development.

Keywords: Peri-urban, Infrastructure development, infrastructure index, Hierarchical cluster analysis

1. Introduction

Peri-urban areas are transitional zones situated between urban areas and rural landscapes (Etim, Ivo, and Attah, 2024). The rapid expansion of urban areas has transformed peri-urban regions into highly dynamic spaces characterised by complex interactions between urban and rural systems. These transitional environments are increasingly becoming focal points of population growth, economic transformation, and physical development, yet they exhibit considerable spatial variation in the provision of infrastructure and public services.

Consequently, peri-urban settlements differ significantly in their levels of development, functional capacity, and degree of integration into regional systems. Such spatial heterogeneity presents a major challenge for regional planning, where effective policy formulation and infrastructure investment depend on a clear understanding of settlement characteristics. Infrastructure is widely recognised as one of the most reliable indicators of settlement development because it reflects accessibility, service availability, economic potential, and overall quality of life (UN-Habitat, 2016; World Bank, 2020). Consequently, classifying settlements according to their infrastructure development provides an objective basis for understanding spatial disparities and guiding evidence-based regional planning.

Settlement classification is a fundamental component of regional planning because it simplifies complex spatial systems into meaningful categories that support analysis, comparison, and policy intervention. A sound classification scheme should be objective, mutually exclusive, collectively exhaustive, reproducible, and sufficiently flexible to accommodate variations in settlement characteristics. Furthermore, it should produce internally homogeneous and externally heterogeneous groups, ensuring that settlements within the same class share similar attributes while remaining clearly distinguishable from those in other categories (Everitt et al., 2011). Such classifications enable planners to establish settlement hierarchies, identify infrastructure-deficient communities, prioritise public investment, and monitor spatial transformation over time. Rather than treating settlements as homogeneous entities, infrastructure-based classification recognises the differentiated nature of regional development and provides a practical framework for promoting spatial equity and balanced territorial development.

From a regional planning perspective, classifying settlements according to their level of infrastructure development serves multiple purposes. It reveals the spatial distribution of development opportunities and infrastructural deprivation, supports equitable allocation of public resources, strengthens regional investment programming, and provides a basis for monitoring progress towards balanced territorial development (Imikan and Udofia, 2016). Infrastructure-based classification also enables planners to identify settlements requiring immediate intervention while recognising areas capable of functioning as regional growth centres. Such evidence-based approaches are essential for reducing spatial inequalities and promoting sustainable regional development, particularly in rapidly urbanising countries where infrastructure provision often lags behind settlement expansion (OECD, 2017; UN-Habitat, 2016).

Despite the increasing importance of peri-urban areas in Nigeria's urbanisation process, relatively few studies have developed objective frameworks for classifying peri-urban settlements according to their overall level of infrastructure development. Existing studies have largely focused on descriptive analyses of infrastructure provision or individual sectors without producing comprehensive settlement typologies capable of informing regional planning decisions. This study addresses this gap by integrating an Infrastructure Index with hierarchical cluster analysis to classify peri-urban settlements in South-South Nigeria according to their levels of infrastructure development. The resulting classification provides an empirically derived framework for identifying spatial disparities, prioritising infrastructure investment, and supporting evidence-based regional planning aimed at achieving more balanced, equitable, and sustainable territorial development.

Theoretical Framework

This study is principally anchored on core–periphery theory proposed by John Friedmann, with insights drawn from spatial justice theory to strengthen the interpretation of infrastructure disparities among peri-urban settlements. Core–periphery theory explains regional development as an inherently uneven spatial process in which economic activities, infrastructure, investment, and institutional functions become concentrated within core regions, while peripheral regions experience relatively lower levels of development. According to Ebong (2006), cumulative processes of investment, innovation, and accessibility reinforce the developmental advantages of core areas, whereas peripheral regions often remain characterised by weak infrastructure, limited economic opportunities, and reduced institutional capacity. Friedmann (1959), believes that because deviation-amplifying forces in the regional process, inequality between the core and periphery will increase, unless events are deliberately controlled. Between these extremes are transitional or semi-peripheral areas that exhibit intermediate levels of development and gradually integrate into the regional economy. Consequently, regions become differentiated according to their infrastructure endowment, accessibility, and functional roles within the broader spatial system.

While core–periphery theory explains the processes that generate spatial inequalities, spatial justice theory provides the normative perspective for interpreting these inequalities within the context of regional planning. Spatial justice argues that development should not merely be assessed by its spatial distribution but by the fairness with which infrastructure, public services, and development opportunities are allocated across geographic space (Ebong, 2006). In regional planning this principle is essential as marginalized communities often require more attention or targeted intervention to achieve comparable access to opportunities (Coleman, 2023). Since planning decisions creates both winners and losers, the question of who gets what, where and why, becomes fundamental to evaluating justice in spatial terms (Atser, 2026). A key dimension of spatial justice is equity which contrast sharply with equality: equality assumes uniform treatment but equity recognizes differences in needs and capacity ensuring that disadvantaged groups are given adequate attention relative to their spatial characteristics (Etim, 2026).

The integration of these theoretical perspectives provides a comprehensive explanation for the classification of peri-urban settlements according to their level of infrastructure development. Core–periphery theory explains why settlements exhibit varying degrees of infrastructure development as a consequence of uneven regional growth, whereas spatial justice theory underscores the planning imperative of addressing these disparities through equitable infrastructure provision.

Methods

South-South Nigeria is made up of six states, out of these three states, namely Akwa Ibom, Cross River and Rivers States, were randomly using a table of random numbers. Subsequently, Uyo, Calabar and Port Harcourt, the respective state capitals, were purposively selected as the metropolitan centres whose peri-urban areas constituted the study setting. Based on previous studies identifying 36 peri-urban settlements in Uyo, 25 in Port Harcourt and approximately 18 in Calabar, 75% of the identified peri-urban settlements in each metropolis were selected, resulting in 27 settlements in Uyo, 19 in Port Harcourt and 14 in Calabar, giving a total of 60 settlements.

In this study, the infrastructure index was employed as one of the analytical methods used to assess the level of infrastructure development across the sampled communities before carrying out the hierarchical cluster analysis. The index provided a quantitative basis for evaluating and comparing the infrastructural performance of each community. It was derived by summing the scores of the selected infrastructure variables, such as roads, electricity, water supply, education, and health facilities, for each settlement and dividing the total by the number of variables considered (Imikan and Udofia, 2016). The variables captured the availability of key infrastructure and services across the sampled peri-urban settlements. These variables provide a structured basis for assessing and comparing the levels of infrastructure development of the peri-urban settlements and for subsequent classification. It should be noted that using the infrastructure index allowed for classification based on levels as against inputting the variables directly which will give the pattern of infrastructure development.

Mathematically, the infrastructure index is expressed as:

$$\text{Infrastructure Index} = \frac{\sum X1, X2, X3, X4\cdots, Xn}{N} \qquad \text{Equation 1}$$

Where Sigma (Σ) represents the summation of the infrastructure variable scores, X1, X2, X3,.. Xn denotes the individual infrastructure variables, and N is the number of variables employed in the computation.
The infrastructure index served as the input data for the clustering process. Through the use of similarity measures, the method grouped the 60 peri-urban areas into three clusters showing infrastructural disparity, distinguishing well-developed settlements from those with lower levels of infrastructure provision. The resulting dendrogram (Appendix II) provided a visual, tree-like representation of these relationships, allowing the understanding of how settlements are hierarchically related and to identify regional variations that require policy intervention.

Results

The infrastructure index of each peri-urban area was calculated using the formulae presented previously as Equation 1. Based on this index (Table 1), settlements were categorized into three clusters.

Table 1: Table Showing the Infrastructure index of each Peri-Urban Area

S/N	Settlement	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1.	Choba	1	1	1	3	1	1	1	1	0	1	0	0	1	12	0.92
2.	Rumuokparali	1	1	0	2	0	0	1	0	0	0	0	0	0	5	0.38
3.	Akpo-Ozuoba	1	1	0	1	0	1	1	0	0	0	0	0	0	5	0.38
4.	Ozuoba	1	1	1	2	0	1	1	1	0	0	0	1	1	10	0.77
5.	Aluu	1	1	1	1	0	2	1	1	0	0	1	0	1	10	0.77
6.	Igwurata	1	1	1	2	0	0	1	2	0	0	0	0	1	9	0.69
7.	Igwurata-Ali	1	1	0	2	0	1	1	0	0	0	0	1	0	7	0.54
8.	Enenka	1	1	2	1	0	1	1	1	0	0	0	0	2	10	0.77
9.	Iriebe	1	1	1	3	0	1	1	1	0	0	0	1	1	11	0.85
10.	Rumuolumeni	1	1	0	1	0	1	1	0	1	1	0	0	0	7	0.54
11.	Chokota	1	1	0	2	0	1	1	0	0	0	0	0	0	6	0.46

12.	Akpajo	1	1	1	2	0	1	1	1	1	0	0	1	1	11	0.85
13.	Okuru-Ama	1	1	1	1	0	1	1	0	0	0	0	1	1	8	0.62
14.	Ozuboko	1	1	1	1	0	1	1	1	0	0	0	0	1	8	0.62
15.	Omuoko	1	1	1	1	0	1	1	0	0	0	0	0	1	7	0.54
16.	Umuebulu 1	1	1	1	1	0	1	1	0	0	0	0	0	1	7	0.54
17.	Mbodo	1	1	1	2	0	1	1	0	0	0	0	1	1	9	0.69
18.	Rumuekini	1	1	1	2	1	0	1	0	0	0	0	0	1	8	0.62
19.	Ikot Nkebre	1	1	1	0	0	1	1	0	0	0	0	0	1	6	0.46
20.	Obot Okoho	1	1	1	1	0	1	1	0	0	0	0	0	0	6	0.46
21.	Nassarawa	1	1	1	1	0	0	1	1	1	0	0	0	1	8	0.62
22.	Adiabo	1	1	1	1	0	1	1	1	1	0	0	1	1	10	0.77
23.	Bacoco	1	1	1	0	0	0	1	0	0	0	0	1	0	5	0.38
24.	Ikot Ekpo	1	1	2	0	0	1	1	0	0	0	0	0	0	6	0.46
25.	Omin	1	1	1	0	0	0	1	1	0	0	1	0	1	7	0.54
26.	Ikot Mbo	1	1	1	1	0	0	1	0	0	0	0	0	0	5	0.38
27.	Ikot Enebong	1	1	1	1	0	1	1	1	0	0	0	0	1	8	0.62
28.	Akim Akim	1	1	0	1	0	1	1	0	0	0	0	0	1	6	0.46
29.	Ikot Anwatim	1	1	1	0	0	1	1	0	0	0	0	0	0	5	0.38
30.	Akai Efa	1	1	1	1	0	1	1	1	0	1	1	0	1	7	0.54
31.	Lemna	1	1	1	1	0	1	1	0	0	0	0	1	0	7	0.54
32.	Ikot Efanga	1	1	1	1	0	1	1	1	0	1	0	1	1	9	0.69
33.	Ikot Emian	1	1	1	0	0	0	1	0	0	0	0	0	0	4	0.31
34.	Ifa Ikot Akpan	1	1	0	1	0	0	1	0	1	0	0	1	0	6	0.46
35.	Nung Ikono Ufok	1	1	1	0	0	1	1	0	0	0	1	0	0	6	0.46
36.	Ibiaku Isshiet	1	1	2	1	0	1	1	0	0	0	0	0	1	8	0.62
37.	Mbak Etoi	1	1	1	2	1	1	1	0	1	0	1	0	1	11	0.85
38.	IbiakuUruan	1	1	2	1	0	1	1	0	0	0	0	0	1	8	0.62

39.	Ibaku	1	1	1	0	1	0	1	0	0	0	0	0	0	5	0.38
40.	Nduetong	1	1	0	1	1	0	1	0	0	0	0	0	1	6	0.46
41.	Ikot Akpan Abia	1	1	2	0	0	1	1	2	1	1	1	0	1	9	0.69
42.	Afaha Ikot Obio Nkan	1	1	1	1	0	0	1	0	1	0	0	0	2	8	0.62
43.	Afaha Etok	1	1	1	0	0	1	1	0	0	0	0	0	2	7	0.54
44.	Afaha Atai	1	1	1	0	0	0	1	0	0	0	0	0	0	4	0.31
45.	Ikot Oduot	1	1	1	0	0	0	1	0	0	0	0	0	0	4	0.31
46.	Ikot Obio Offiong	1	1	1	0	0	0	1	0	0	0	0	0	0	4	0.31
47.	Ikot Obio Odongo	1	1	1	0	0	0	1	1	0	0	1	0	0	6	0.46
48.	Nung Ukana	1	1	1	0	0	0	1	0	0	0	0	0	0	4	0.31
49.	Ibiaku Obio Ndobo	1	1	1	2	1	0	1	1	0	0	0	0	0	8	0.62
50.	Ikot Akpa Ekang	1	1	1	0	0	0	1	0	0	0	0	0	1	5	0.38
51.	Ifa Ikot Akpabio	1	1	0	1	0	0	1	0	0	0	0	0	0	4	0.31
52.	Ifa Ikot Abia Ntuen	1	1	0	0	0	0	1	0	0	0	0	0	0	3	0.23
53.	Ifa Ikot Idang	1	1	0	0	0	0	1	0	0	0	0	0	1	4	0.31
54.	Ikot Inyang Idung	1	1	1	0	0	0	1	0	0	0	0	0	0	4	0.31
55.	Nung Oku Uruan	1	1	1	1	0	0	0	0	0	0	0	0	0	4	0.31
56.	Obio Etoi	1	1	1	2	0	0	2	0	1	1	0	1	0	11	0.85

57.	Ikot Ambang	1	1	1	0	0	2	1	1	0	1	0	0	1	9	0.69
58.	Ikot Asukpong	1	1	1	0	0	1	1	0	0	0	0	0	0	5	0.38
59.	Ikot Ekpuk	1	1	1	1	0	1	1	1	1	1	1	0	1	8	0.62
60.	Mbiabam	1	1	1	1	0	1	1	0	0	0	0	0	1	7	0.54

A= telecommunication, B= Electricity, C= Primary school, D= Secondary school, E = Tertiary Schools, F= Health facilities, G= Water sources, H= police station. I= Tarred Internal Roads, J= Waste receptacles, K= courts, L= Recreational areas, M= Market, N=infrastructure score, 0=infrastructure index.

The classification of peri-urban settlements into three groups was justified using the agglomeration schedule (Appendix I) derived from hierarchical cluster analysis based on the infrastructure index. The coefficients in the schedule remained very low (0.000) through the early stages, indicating strong homogeneity among settlements, but began to rise sharply from Stage 52 onward, reaching 1.000 at Stages 52–55, 2.154 at Stage 56, 3.078 at Stage 57, and peaking at 20.294 at Stage 59. This sharp increase signified a clear structural break, marking the point where further merging would combine settlements with distinctly different infrastructural characteristics. Thus, the appropriate cut-off point was established around Stage 56–57, resulting in three distinct groups representing highly developed, moderately developed, and less developed peri-urban areas. This three-cluster solution effectively reflects the varying levels of infrastructural development across the settlements in South-South Nigeria.

The dendrogram (Appendix II) using average linkage (between groups) presents a hierarchical classification of the 60 peri-urban settlements in South-South Nigeria, based on their mean infrastructure index scores. The dendrogram clearly delineates three major groups corresponding to the clusters identified in the quantitative analysis.

Settlements with high infrastructure index values, including Choba, Ozuoba, Aluu, Iriebe, and Enenka, are closely linked at the lower branch, forming Cluster 1 – highly developed peri-urban areas. These areas exhibit strong infrastructural endowment, characterised by efficient utilities, extensive road networks, and accessible social and civic amenities.

The middle section of the dendrogram comprises settlements such as Okuru-Ama, Rumuekini, Ibiaku Uruan, Ibiaku Obio Ndobo, and Lemna, which recorded moderate infrastructure index scores. These were classified as Cluster 2 – Moderately developed peri-urban areas, reflecting intermediate levels of infrastructural provision where essential services and physical infrastructure exist but are inconsistently distributed or inadequately maintained.

At the upper section of the dendrogram (Appendix II), settlements such as Ikot Nkebre, Obot Okoho, Chokota, Ikot Ekpo, Bacoco, and Ikot Mbo form distinct groupings with low infrastructure index values, corresponding to Cluster 3 – Least developed peri-urban areas. These settlements are characterised by limited access to basic services, weak physical infrastructure, and minimal educational and civic facilities.

The dendrogram (Appendix II) confirms that the classification of peri-urban settlements was primarily driven by their infrastructure index scores, which summarised the relative adequacy of infrastructural components. The resulting three-tier hierarchy, highly developed, moderately developed, and least developed, illustrates the uneven spatial distribution of infrastructure across the South-South region and underscores the existence of developmental disparities among peri-urban settlements.

Table 2: Cluster 1 – Highly developed peri-urban areas in South-South, Nigeria

S/N	Settlement	Infrastructure Index
1	Choba	0.92
2	Iriebe	0.85
3	Akpajo	0.85
4	Mbak Etoi	0.85
5	Obio Etoi	0.85
6	Ozuoba	0.77
7	Aluu	0.77
8	Enenka	0.77
9	Adiabo	0.77
10	Igwurata	0.69
11	Mbodo	0.69
12	Ikot Efanga	0.69
13	Ikot Akpan Abia	0.69
14	Ikot Ambang	0.69

Cluster 1 represents the highly developed peri-urban areas within the South-South region, characterized by elevated infrastructure indices ranging from 0.69 to 0.92 (Table 2). These settlements, such as Choba, Iriebe, Akpajo, Ozuoba, Aluu, and Enenka, are zones where infrastructural investment and service provision are substantially advanced compared to other clusters. The relatively high infrastructure indices indicate balanced growth across multiple dimensions of development, particularly in access to essential services, paved road, and educational and civic infrastructure.

The profile of Cluster 1 demonstrates that highly developed peri-urban areas exhibit multidimensional infrastructural advancement, though not without internal variation. The predominance of positive loadings across most categories supports sustainable growth and liveability. The concentration of educational, utility, and civic infrastructure in these settlements underscores their role as transitional urban nodes, bridging the urban core and rural hinterlands.

Table 3: Cluster 2 – moderately developed peri-urban areas in South-South, Nigeria

S/N	Settlement	Infrastructure Index
1	Okuru-Ama	0.62
2	Ozuboko	0.62
3	Rumuekini	0.62
4	Nassarawa	0.62
5	Ikot Enebong	0.62
6	Ibiaku Uruan	0.62
7	Ibiaku Obio Ndobo	0.62
8	Ikot Ekpuk	0.62
9	Afaha Ikot Obio Nkan	0.62

10	Ibiaku Isshiet	0.62
11	Igwuruta-Ali	0.54
12	Rumuolumeni	0.54
13	Omuoko	0.54
14	Umuebulu 1	0.54
15	Omin	0.54
16	Lemna	0.54
17	Afaha Etok	0.54
18	Mbiabam	0.54
19	Akai Efa	0.54

Cluster 2 represents the group of moderately developed peri-urban settlements, characterised by a transitional level of infrastructural development that lies between the highly developed and less developed categories (Table 3). The 19 settlements in this cluster, with an average infrastructure index of 0.58, demonstrate a mixture of progress and deficiency across different infrastructural components. The settlements within Cluster 2 display a moderate level of infrastructural development, characterised by partial access to essential services, uneven physical infrastructure, and selective educational and institutional presence. Cluster 2 epitomises transitional peri-urban environments where urban influence is gradually transforming rural landscapes, but infrastructural provision remains inconsistent. The observed disparities suggest that infrastructural development in these areas is influenced by locational advantages, planning priorities, and proximity to metropolitan centres. Targeted interventions aimed at improving road connectivity, expanding educational and health facilities, and integrating peripheral settlements into existing utility networks would therefore be essential for achieving balanced and sustainable peri-urban development in the region.

Table 4: Cluster 3 – Least- Developed Peri-Urban Areas in South-South, Nigeria

S/N	Settlement	Infrastructure Index
1	Ikot Nkebre	0.46
2	Obot Okoho	0.46
3	Chokota	0.46
4	Ikot Ekpo	0.46
5	Akim Akim	0.46
6	Ifa Ikot Akpan	0.46
7	Nung Ikono Ufok	0.46
8	Nduetong	0.46
9	Ikot Obio Odongo	0.46
10	Rumuokparali	0.38
11	Akpo-Ozuoba	0.38
12	Bacoco	0.38
13	Ikot Mbo	0.38
14	Ibaku	0.38

15	Ikot Akpa Ekang	0.38
16	Ikot Asukpong	0.38
17	Ikot Emian	0.31
18	Afaha Atai	0.31
19	Ikot Oduot	0.31
20	Ikot Obio Offiong	0.31
21	Nung Ukana	0.31
22	Ifa Ikot Akpabio	0.31
23	Ifa Ikot Idang	0.31
25	Ikot Inyang Idung	0.31
26	Nung Oku Uruan	0.31
27	Ifa Ikot Abia Ntuen	0.23

Cluster 3 represents the least developed peri-urban settlements within the study area, characterised by generally low infrastructural indices (Table 4). The settlements within this cluster exhibit an average infrastructure index ranging between 0.23 and 0.46, indicating limited access to essential services, poor physical conditions, and minimal institutional presence. This cluster embodies the peripheral nature of peri-urban expansion, where infrastructural investment remains inadequate despite growing population pressures and spatial proximity to urban centres. Settlements within Cluster 3 typify low infrastructural development and weak urban integration. They are marked by poor access to basic services, inadequate physical infrastructure, limited educational and recreational facilities, and minimal institutional influence. These deficiencies collectively reflect systemic disparities in infrastructural investment and spatial planning.

Test of hypotheses

HO1: There is no significant variation in the level of infrastructure development across peri-urban areas in South-south Nigeria.

To determine whether there is a significant variation in the level of infrastructural development across the three clusters of peri-urban settlements, an ANOVA (Table 5) was conducted using the infrastructure index as the dependent variable.

Table 5: ANOVA of level of infrastructural development across peri-urban settlement clusters

ANOVA					
level of Infrastructure	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1.496	2	.748	121.268	.000
Within Groups	.352	57	.006		
Total	**1.848**	**59**			

The results revealed a statistically significant difference in infrastructural development among the clusters (F = 121.268, p = 0.000). This indicates that the level of infrastructure provision and accessibility varies considerably across the three categories of peri-urban areas, highly developed, moderately developed, and least developed.

The very high F-value and the significance level below 0.001 suggest that the observed differences are not due to random variation but reflect genuine disparities in infrastructural development levels. In other words, the clusters represent distinct groups with varying degrees of infrastructural advancement, aligning with the earlier classification based on the infrastructure index. Therefore, the null hypothesis (H_0), that there is no significant difference in levels of infrastructural development among the clusters, is rejected. This confirms that peri-urban settlements in South-South Nigeria differ significantly in their infrastructural development status, supporting the validity and robustness of the three-cluster model used in the study.

Discussion

The classification of peri-urban settlements in South-South Nigeria into three distinct clusters provides an empirically grounded reflection of infrastructural inequalities and confirms many of the insights highlighted in the literature. As Lumpala's epistemic approach to classification suggests, settlements can be understood in terms of their shared properties, and in this study, infrastructure index provided a reliable basis for distinguishing development patterns. The 60 peri-urban settlements were classified into three clusters, consistent with the results of Akpan (1992), Ofem (2010), and Atser and Ujene (2016).

Settlements in Cluster 1 have higher levels of infrastructure development, characterised by access to healthcare facilities, security formations, tertiary institutions, courts, and good waste management, in addition to the basic ones such as electricity, primary schools and potable water supply. These areas function are mostly positioned close to urban cores, confirming the findings of studies such as Anríquez and Stamoulis (2007) and Ikejiofor et al. (2011), which highlighted the spatial advantage of peri-urban areas that benefit from urban spillover effects. This pattern reinforces the conceptual position advanced by Rapoport (2001) that settlements evolve into distinct categories as they adopt more complex infrastructural arrangements, with those closer to urban centres demonstrating stronger integration into metropolitan systems (Simon et al., 2004). These findings therefore mirror global experiences reported in China and India, where peri-urban zones proximate to cities tend to outperform peripheral counterparts in infrastructural development and socio-economic connectivity (Kundu, 2011; Tian, 2015)

Cluster 2 settlements represent moderately developed areas with access to electricity, basic schools, and sometimes health services, but lacking higher-order facilities and consistent service delivery. This cluster can be described as peri-urban communities in transitional states of development, where basic infrastructure exists but institutional support and investment remain insufficient. This cluster highlights a structural reality whereby most peri-urban areas occupy an intermediate position in the development hierarchy, suggesting gradual integration rather than complete neglect or full transformation.

Cluster 3 provides further nuance by demonstrating settlements with patchy or transitional infrastructure. These areas possess some facilities, often limited to primary schools and electricity, but are marked by gaps in transportation, health, and security provision. This profile resonates with studies in India and sub-Saharan Africa, which have shown that peri-urban settlements frequently exhibit partial integration where certain infrastructures arrive earlier than others. This phenomenon supports the view that peri-urbanisation is not linear but differentiated, with infrastructural expansion occurring unevenly due to political, economic, and geographic factors. The results also align with the assertion of Ebong and Animashaun (2009) that infrastructural development in Nigeria is often fragmented, reflecting the absence of coordinated planning and governance.

The three-cluster solution derived in this study therefore not only confirms theoretical expectations but also provides an applied demonstration of how classification methods can disentangle spatial inequalities. The agglomeration schedule and dendrogram substantiate the methodological robustness of the classification, in line with advances in settlement studies where clustering has been employed to reveal meaningful distinctions in development patterns. By cutting the dendrogram prior to the sharp increase in coefficients, the study ensured that internal homogeneity was maintained within clusters while preserving distinctions across groups, thereby reflecting best practice in hierarchical clustering as outlined by Everitt et al. (2011). This methodological decision strengthens the comparability of findings with earlier studies that employed cluster analysis to identify settlement typologies. The results highlight the persistence of spatial disparities in infrastructural development in South-South Nigeria, reflecting broader global patterns but also underscoring the contextual realities of Nigerian peri-urbanism. While highly developed clusters benefit from proximity to urban centres and stronger governance presence, the majority of settlements remain only moderately served, and a significant minority are trapped in infrastructural deprivation. These findings resonate with the literature's emphasis on peri-urban inequalities but extend it by demonstrating, through empirical classification, the precise distribution of infrastructural levels across a large sample of settlements. In policy terms, this classification gives a practical framework for targeted interventions, as clusters with low and moderate development can be prioritised for investment to promote more balanced and sustainable regional growth.

Conclusion

This study demonstrates that peri-urban settlements in South-South Nigeria exhibit substantial differences in infrastructure provision and therefore require differentiated regional planning responses. Infrastructure investment should be guided by the spatial characteristics, infrastructure deficits and developmental potential of individual settlements, with priority given to low-infrastructure areas and strategic upgrading of moderately developed settlements. This calls for a co-ordinated regional governance framework that brings together state agencies, local governments and other stakeholders to establish shared infrastructure priorities and investment programmes, thereby shifting planning from equal allocation to equitable allocation. Peri-urban settlements should also be re-conceptualised as future vibrant urban centres, with infrastructure and services planned ahead of growth through a shared regional spatial framework that coordinates transportation, housing, education, healthcare, markets and utilities across administrative boundaries.

At the same time, peri-urban areas with strong agricultural advantages should be protected from indiscriminate urban encroachment through agricultural preservation zones and controlled urban expansion. Such an approach would enable regional planning to accommodate urban growth while safeguarding food security, environmental sustainability, spatial equity and long-term regional resilience. The study has some limitations: its focus on 60 selected peri-urban settlements, its emphasis on infrastructure availability rather than quality, functionality and accessibility, and its cross-sectional design, which captures conditions at a particular point in time and cannot establish temporal changes in infrastructure development or peri-urban transformation. Future studies should therefore adopt longitudinal approaches, broaden geographical coverage, and integrate infrastructure quality, accessibility and spatial-temporal dynamics to provide stronger evidence for anticipatory regional planning and the sustainable transformation of Nigeria's emerging peri-urban urban system.

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Appendix I: Cluster Procedure for the 60 Peri-urban Areas in South-South Nigeria

Agglomeration Schedule						
Stage	**Cluster Combined**		**Coefficients**	**Stage Cluster First Appears**		**Next Stage**
	Cluster 1	**Cluster 2**		**Cluster 1**	**Cluster 2**	
1	43	60	.000	0	0	17
2	41	59	.000	0	0	19
3	50	58	.000	0	0	10
4	36	57	.000	0	0	24
5	37	56	.000	0	0	23
6	54	55	.000	0	0	7
7	53	54	.000	0	6	8
8	51	53	.000	0	7	9

9	48	51	.000	0	8	12
10	39	50	.000	0	3	21
11	38	49	.000	0	0	22
12	46	48	.000	0	9	14
13	42	47	.000	0	0	18
14	45	46	.000	0	12	15
15	44	45	.000	0	14	16
16	33	44	.000	0	15	52
17	31	43	.000	0	1	28
18	40	42	.000	0	13	20
19	30	41	.000	0	2	29
20	35	40	.000	0	18	25
21	29	39	.000	0	10	30
22	27	38	.000	0	11	32
23	32	37	.000	0	5	27
24	21	36	.000	0	4	38
25	34	35	.000	0	20	26
26	28	34	.000	0	25	31
27	22	32	.000	0	23	37
28	25	31	.000	0	17	34
29	12	30	.000	0	19	46
30	26	29	.000	0	21	33
31	24	28	.000	0	26	35

32	18	27	.000	0	22	41
33	23	26	.000	0	30	36
34	16	25	.000	0	28	43
35	20	24	.000	0	31	39
36	3	23	.000	0	33	51
37	9	22	.000	0	27	48
38	17	21	.000	0	24	42
39	19	20	.000	0	35	40
40	11	19	.000	0	39	54
41	14	18	.000	0	32	45
42	6	17	.000	0	38	55
43	15	16	.000	0	34	44
44	10	15	.000	0	43	47
45	13	14	.000	0	41	53
46	1	12	.000	0	29	56
47	7	10	.000	0	44	53
48	8	9	.000	0	37	49
49	5	8	.000	0	48	50
50	4	5	.000	0	49	55
51	2	3	.000	0	36	54
52	33	52	1.000	16	0	57
53	7	13	1.000	47	45	58
54	2	11	1.000	51	40	57

55	4	6	1.000	50	42	56
56	1	4	2.154	46	55	59
57	2	33	3.078	54	52	58
58	2	7	7.138	57	53	59
59	1	2	20.294	56	58	0

Appendix II

Dendrogram Using Average Linkage (Between Groups)