Characterization of Streetscape Elements in Aba Residential Area, Abia State: A Sub-Sahara African City

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Abstract
There is a dire need for a systematic analysis of the characterisation of streetscape elements in residential urban areas of Aba, Abia State. This is because there is limited research examining categorisation of streetscape elements in residential urban areas. This study therefore assesses the characterisation of Streetscape Elements in Aba residential area, Abia State with a view to providing evidence-based recommendations for sustainable urban design and neighbourhood planning. A descriptive cross-sectional survey research design was adopted in the study on areas with streetscape elements (e.g, trees, sidewalks, buffers, etc). Using the Taro Yamane sample size determination formula, households from 351 housing units were sample from the sample frame of 1,565. A multistage sampling technique combining stratified, systematic and simple random sampling approaches was employed. Primary data were collected through structured questionnaires. Data were analyzed using descriptive statistics, Weighted Mean Score (WMS) and Principal Component Analysis (PCA), The result of the study shows that the characterization of the major streetscape elements/components in the study area are dimensioned in seven components and these are Pavement & Movement (33.090%), Street Furniture (20.136%), lighting & Signage (11.884%), Landscape & Green Infrastructure (11.162%), Utilities & Technical Elements (8.156%), Parking & Curb Management (6.763%) and Safety & Accessibility. (4.608%). The study recommends adoption of the seven streetscape dimensions as the official framework and design guidelines for streetscape development, establishing a monitoring and evaluation

framework for streetscape performance and prioritizing the upgrading of existing non-streetscape neighbourhoods

Keywords: *Streetscapes; Residential; Design; Elements; Dimensioned*

1. Introduction

Sustainable streetscape elements have emerged as an effective approach to mitigate these challenges. This approach focuses on integrating specific natural and built features, such as vegetation, permeable surfaces, street furniture, lighting, and green infrastructure, into urban streets to enhance environmental performance and community livability (Kumar & Puri, 2020; Metwally, 2026). Key elements include green infrastructure like bioswales and rain gardens for stormwater management and improved water quality (Pauleit, Liu & Kaczynski, 2019), tree canopies and native plants to boost biodiversity and lower maintenance costs (Haq, 2011), permeable pavements, multifunctional public spaces, street lighting, seating, and pedestrian pathways. Access to these elements, particularly greenery, positively impacts mental and physical health, reducing stress, improving mood, and promoting physical activity (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Kumar & Khanna, 2017). Well-integrated sustainable streetscape elements foster pleasant environments, pedestrian accessibility, community cohesion, and healthier lifestyles (Lindsay, 2017; Fachrudin, 2024). These synergistic benefits make sustainable streetscape elements essential considerations for urban planners. In recent years, the concept of sustainable streetscape design has gained prominence in urban planning and environmental design. Streetscape elements have been arguably alluded to having the propensity to significantly contribute to environmental quality by improving microclimatic conditions, reducing urban heat island effects, filtering air pollutants, mitigating stormwater runoff, reducing noise levels, and enhancing visual and psychological comfort. (Turner-Skoff & Simpson, 2019; Johansson, 2024). It can also be argued that pedestrian-friendly walkways and well-designed public spaces can enhance social interaction and improve residents' perception of environmental quality.

The streetscape constitutes an important component of the urban environment because it represents the interface between transportation infrastructure, buildings, public spaces, commercial activities, vegetation and the everyday activities of urban residents. Beyond its transportation function, the quality and configuration of streetscape elements influence the visual character, environmental quality, safety, accessibility, pedestrian experience and overall liveability of cities. Consequently, understanding the composition and spatial characteristics of streetscape elements is essential for effective urban design, planning and development management. Aba is one of the major commercial and industrial cities in southeastern Nigeria, with a highly active urban environment characterised by intensive commercial activities, substantial pedestrian movement, vehicular traffic and rapid physical development. The expansion and intensification of urban activities have resulted in considerable changes in the physical appearance and functional characteristics of major streets within the city. Elements such as roadways, sidewalks, drainage channels, street furniture, street lighting, trees and other vegetation, utility infrastructure, signage, building frontages, advertising structures, parking spaces, pedestrian facilities and informal commercial activities occur along the streets to varying degrees and in different configurations. However, the presence and arrangement of these streetscape elements appear to be largely heterogeneous and, in some locations, poorly coordinated. Encroachment of commercial activities and informal uses into pedestrian and road spaces, inadequate pedestrian facilities, indiscriminate parking, poorly

integrated drainage infrastructure, visual clutter from advertising and signage, limited or poorly maintained vegetation, and inconsistent building frontage treatments may contribute to a fragmented streetscape character. These conditions can affect pedestrian movement, traffic operations, environmental quality, visual amenity, urban safety and the general experience of users of the streets. However, observations show that in many neighbourhood in Aba residential areas, streetscapes are often poorly designed, inadequately maintained, or entirely neglected. These are obvious in routes and streets like Port Harcourt Road, Ngwa Road, Asa Road, Azikiwe Road, Opobo Road, New Umuahia Road, Obohia Road, Emelogu Street Okigwe Road, Faulks Road, and Osusu Road, to mention but few. Rapid urbanization, weak planning enforcement, and inadequate infrastructure provision have resulted in streets that lack adequate greenery, pedestrian facilities, drainage infrastructure, and proper spatial organization. These deficiencies contribute to environmental problems such as flooding, heat stress, air pollution, and reduced visual quality within residential neighbourhoods.

Despite growing awareness of sustainable urban design, many Nigerian cities still lack adequate empirical studies that examine the characterization of streetscape elements mainly from the perspective of residents. Notwithstanding the importance of these elements to urban functionality and character, there is limited systematic documentation and empirical characterisation of the major streetscape elements that constitute the streets of Aba. Most existing studies (Mokhtar, Mohamed, & Saad, 2019; Cohen, McKenzie, & Ghosh,, 2016) focus on infrastructure provision or urban mobility, while limited attention has been given to categorization or dimensioning of streetscape design/element. Despite these established benefits and ongoing urban renewal efforts in Aba. This knowledge gap creates difficulties for urban planners, designers and development-control authorities in establishing appropriate streetscape improvement strategies and design standards for Aba. Without a systematic understanding of the existing streetscape characteristics, interventions may be fragmented, reactive and inadequately responsive to the specific physical and functional conditions of different streets. This study consequently seeks to identify and characterise the major streetscape elements present in Aba, thereby providing empirical information that can support evidence-based urban design, streetscape management and sustainable improvement of the city's major streets. The study further hypothesized that the streetscape elements present in the study area cannot be significantly patterned and characterized. This study would deliberately choose routes/streets in Aba that has major streetscape intervention. The outcome of the study would help identify key streetscape elements that contribute to improved environmental conditions, and thus provide practical recommendations for enhancing thermal comfort, reducing pollution, improving drainage, and creating aesthetically pleasing neighbourhoods.

2. Literature Review

The systematic documentation of streetscape elements, what is present in the street environment, where, and in what condition, has evolved considerably over the past two decades, driven by both the recognition of streetscape's role in urban quality of life and the dramatic expansion of data collection technologies available to researchers. Early streetscape characterisation relied heavily on direct observational audits, trained researchers systematically recording the presence, condition, and distribution of streetscape elements along predefined street segments using structured audit instruments. These approaches, exemplified in the work of Pikora et al. (2002) and subsequently

adapted by numerous researchers, provided reliable and contextually sensitive data but were labour-intensive, geographically limited, and subject to inter-rater reliability concerns.

The proliferation of street-view imagery platforms, most notably Google Street View, launched in 2007, transformed the landscape of streetscape characterisation research by making large-scale, georeferenced, street-level visual data available to researchers without the need for field data collection. This enabled study of streetscape conditions at city, regional, and even national scales that would previously have been impractical. Ogawa et al. (2024), working in Sapporo, Japan, demonstrate the methodological potential of street-view imagery-based approaches, using machine-learning algorithms to segment and quantify streetscape visual components, greenery ratio, sky openness, building proportion, and pavement coverage — and correlating these computationally derived measures with subjective quality assessments from survey respondents. Their study demonstrates that computationally derived streetscape characteristics can explain a substantial proportion of variance in residents' perceptual ratings, establishing the validity of remote-sensing approaches as proxies for field-based streetscape assessment.

More recent work has deployed deep learning techniques, convolutional neural networks trained on large labelled image datasets, to extract increasingly fine-grained information about streetscape visual quality from street-view imagery. Lu et al. (2025), in a study of Changbai Island in Shenyang, China, used a multi-dimensional deep learning framework to assess the influence of streetscape-built environment characteristics, including building facade condition, greenery proportion, sky openness ratio, pedestrian space quality, and enclosure index, on human perceptions of environmental quality. Their analysis identified building facade condition and greenery ratio as the most influential variables, together explaining a larger proportion of the variance in perceived quality than any other pair of variables tested. The study also revealed that the influence of individual streetscape variables was non-linear: greenery ratio, for example, had a strong positive effect on perception up to a threshold level, beyond which additional greenery contributed less marginal improvement. This non-linearity finding has important methodological implications for studies that use linear regression models to assess streetscape influences, suggesting that such models may understate the importance of threshold effects.

Guo et al. (2025), applying a deep learning quality assessment framework to old residential communities in Wuchang district, Wuhan, provide a fine-grained spatial analysis of streetscape quality variation within a single urban area. Their study reveals that streetscape quality is highly heterogeneous even within small geographical areas, with neighbouring streets sometimes differing dramatically in their machine-assessed quality scores. This spatial heterogeneity finding challenges research designs that treat the neighbourhood as the unit of analysis and assume that all streets within a neighbourhood share similar quality characteristics, a challenge directly relevant to the design of the present study, which must grapple with the considerable variation in streetscape conditions within, as well as between, the study neighbourhoods in Aba.

Liu et al. (2025), in a study of post-renewed neighbourhoods in Chengdu, China, examine how different streetscape visual components affect public perception following urban renewal interventions. Using Google Street View imagery combined with semantic segmentation and machine learning analysis, they find that green vegetation coverage and pavement quality are the dominant determinants of perceived streetscape quality in post-renewal contexts, significantly outweighing the contribution of building facades, utility infrastructure, and street furniture. This finding has a particular resonance for the Aba context, where urban renewal interventions, when

they occur, have historically prioritised road resurfacing over the broader integration of greening and pavement improvements that the evidence suggests are most important for perception.

Elizabete & Kristin (2020) evaluated recent innovations in streetscape design in the district of Columbia, with the aim of ascertaining how the city's Vision Zero has been effective in informing the planning and design outcomes of three selected street transformation projects and compared them to three case studies of global best practices using a mixed methodology. This study showed that the technical design of the analyzed street improvement projects complied with well-recognized and widely used street design guides, despite the recent global recognition of streets in the New Urban Agenda 2030 and the SDG as drivers of prosperity and sustainable development.

Mehta. (2022) advance the field further by constructing predictive models of streetscape quality preferences using deep learning techniques across different street types, commercial, residential, and mixed-use, in Taichung City, Taiwan. Their key methodological contribution is demonstrating that the predictive model's accuracy is substantially improved when street type is incorporated as a moderating variable, suggesting that the determinants of perceived streetscape quality differ systematically between street types. For residential streets specifically, Ou et al. find that greenery proportion and spatial enclosure are the strongest predictors of preference, followed by pavement condition and absence of visual clutter, a finding consistent with both the Kaplans' informational model and Prospect-Refuge Theory, and directly relevant to the present study's focus on residential streets. Adegun (2021) provides the most comprehensive overview available of urban green infrastructure, a critical component of streetscape quality, in Nigerian cities. His systematic review of forty-five studies documents a consistent finding across Nigerian urban contexts: urban green infrastructure is critically underinvested, unevenly distributed, and most deficient in the low- to middle-income residential areas that house the majority of the urban population. Green space provision in Nigerian cities falls far below the World Health Organization's recommended minimum of nine square metres of green space per urban resident, and street trees, one of the most accessible and cost-effective forms of urban greening, are largely absent from residential streets outside of GRA and high-income estate developments. Adegun's review also documents that the characterisation of green infrastructure deficits in Nigerian cities has relied predominantly on remote sensing and GIS-based methods, which can capture the quantity of urban greenery but provide limited information about its quality, distribution at the street level, or relationship to residents' perceptions and well-being. Reid er al. (2015) also studied sustainability issues in urban streetscapes: a case study of Abeokuta, Nigeria with the aim to examine the state of the urban streetscapes of Abeokuta, Ogun State and identify the poverty-environment nexus (as well as other dynamic factors) that precipitated their present condition and suggest solutions to their improvement. The study concluded that the urban streetscapes must efficiently facilitate easy vehicular movement but not at the expense of human inhabitants, hence the walkability of the streets should be enhanced. The study recommended that state governments make efforts to improve the aesthetics of the major streets in Abeokuta, through the process of consultative and interactive (multimedia-assisted) communication. Afinowi et al. (2025), in a systematic review of urban sustainability indicators for African cities, raise a broader methodological concern that is directly relevant to streetscape characterisation in the Aba context. They argue that the conventional urban indicators developed primarily in the Global North context, including most of the streetscape quality metrics reviewed above, fail to capture the distinctive spatial, institutional, and social dimensions of urban life in African cities. The informal occupation of street space for trading, the prevalence of self-built boundary treatments of varying quality, the dominance of

motorcycle and minibus transport over pedestrian movement in many Nigerian cities, and the significance of communal gathering spaces within residential streets are all features of the Nigerian urban streetscape that do not register adequately in frameworks designed for managed, formally regulated urban environments. This observation suggests that the present study's approach of combining a structured survey instrument with contextually informed field observation is more appropriate for characterising streetscape conditions in Aba than the application of off-the-shelf deep-learning or remote sensing assessment tools calibrated for different urban contexts.

Han et al. (2023) conducted a methodological study examining the validity of immersive virtual reality (VR) as a streetscape evaluation method, comparing VR-based assessments with assessments based on on-site experience in residential areas. Their finding, that VR and on-site assessments produce broadly comparable results but with some systematic differences in the salience of specific attributes, has important implications for the growing use of virtual and photographic methods in streetscape research. It suggests that while such methods offer significant practical advantages (particularly in terms of scale and experimental control), they may not capture all dimensions of the lived streetscape experience that are relevant to residents' environmental quality perceptions. For the present study, this finding reinforces the value of a questionnaire-based approach in which residents assess their actual street environments from their own direct experience, rather than photographic or virtual-reality stimuli.

Feng et al. (2022) propose an integrated approach combining multi-source data (street-view imagery, environmental sensor data, and survey ratings) with deep learning analysis for the visual evaluation of urban streetscape design, applied to a Chinese urban context. Their multi-source approach addresses a significant limitation of single-method studies: the tendency for image-based methods to capture visual attributes of the streetscape well but to miss non-visual dimensions (noise, thermal comfort, air quality) that are also important to residents' environmental perceptions. This methodological insight is relevant to the present study's operationalisation of environmental quality as a multi-dimensional construct encompassing not only visual and aesthetic dimensions but also safety, cleanliness, accessibility, and noise, dimensions that require a survey-based approach to capture residents' integrated assessments. Adejumo (2016) studied street side space resources and urban aesthetics in metropolitan Lagos. with the aim to examine the composition of street-side resources in metropolitan Lagos using baseline research. This revealed that the foundation of the prevailing aesthetic shortcoming in Lagos is rooted in the non-conformity of the streets to designed standards. The study concluded that the attempt to specify street design parameters in the 1986 Building Plan Regulation of Lagos State Town and Country Planning Law is limited to building setbacks. The study recommended an interrelated six-step solution including a futuristic street philosophy that accommodates the opinions of key stakeholders in the street enterprise. A critical gap that emerges from the review of streetscape characterisation methods is the near-complete absence of studies employing systematic characterisation of streetscape conditions in Nigerian or West African urban contexts. The deep-learning approaches reviewed above require large, georeferenced datasets of street-level imagery that are not available at adequate coverage or resolution for most Nigerian cities through platforms like Google Street View. Field-audit approaches, while methodologically appropriate for the Nigerian context, have been applied only rarely and without the kind of systematic, large-scale deployment that would enable city-wide assessment of streetscape conditions. This absence of baseline characterisation data represents a significant gap in the evidence base and underscores the need for the kind of primary, field-based research that the present study undertakes.

3. Methodology

The research design adapted in the study is a cross-sectional survey. The choice of this research design was due to the objective of the study and the nature of the subject matter being investigated. The approach involves eliciting information from residents' perceptions in areas with streetscape elements in Aba. Data on Routes/areas with streetscape elements /intervention was sourced from studio Report of URP 652(Masters), on Tourism in Abia conducted by Masters students, URP Department, accessed through the library holdings of Abia State University (Uturu) Abia State and Geo-reference information, 2025**.** Structured field observation is employed as the primary method for obtaining objective, first-hand data on the physical condition and character of streetscape elements along the study streets in Aba. Unlike unstructured observation, which records phenomena in a free-form and potentially inconsistent manner, structured observation uses a pre-designed, standardised recording instrument, the observational checklist, that ensures all observers record the same set of variables in a consistent format, enabling reliable comparison of conditions across streets and segments. The questionnaire is administered face-to-face by the researcher rather than through self-completion. Face-to-face administration is adopted because it maximises response rates and minimizes missing data in a field context where literacy levels and familiarity with formal survey instruments vary across the study population.

The target human research population of this study consists of all adult residents (above 18 years) (primarily household residents, road users, shop owners along residential streets and pedestrians/regular street users) living along or within the immediate selected study streets/routes in the study area. The non-human research population are the residential houses along the selected streetscape routes/roads in the study area. The sampling frame include all housing units located on selected streets and they are 1,565 housing units. The sample size for the questionnaire survey was determined using the Yamane (1967) formula for estimating a sample from a finite population, which is widely applied in descriptive survey research in the Nigerian urban planning and environmental quality literature (Ilesanmi, 2012). The Yamane formula yields a minimum required sample of 333 respondents at a 5% margin of error and a 95% confidence level. This constitutes the statistically derived minimum sample size for the study. Although the minimum calculated sample size for the study was 333, to accommodate incomplete and invalid copies of questionnaires, 360 copies of the questionnaire were administered in the study. A total of 360, representing 8% of the calculated sample size was added to accommodate for non-responses, invalid or lost copies of questionnaires. This was similar to previous works (Keene, 2016, Iwemi, 2010) where the researchers added extra 8% and 10% respectively to the calculated sample size. Thus a total of 360 copies of questionnaires were administered in the study area.

The study employed a multi-stage sampling technique to ensure adequate representation of different streets within the residential area in the study area. For the stage One, stratified random sampling was used to stratify the study area – Aba metropolis into the two administrative Local government area that made up of the Aba Metropolis, these are Aba North and Aba South LGA. All the major registered routes/streets in these two local government areas were listed, this information was elicited from a Newsletter from the Ministry of Housing,(2025) on the list of major routes/roads in Aba urban area. The second stage was the selection of houses, houses along each selected street were sampled using systematic sampling. Prior to this, goggle satellite imaginary was used to get the number of houses in each routes. Geo–Eye Image of Aba urban was sourced from google earth. Image 'on-screen' digitizing was performed through ArcView GIS version 3.2a windows operating environment. Onscreen Digitizing of features such as roads and

buildings in the selected routes was carried out as line and polygon features respectively. The Google image was used to update the analogue maps and to identify the residential housing units in the study area. The researcher with three trained students of Abia State University (Department of Urban & Regional Planning – who served as research assistants) crosschecked and marked residential buildings in the selected routes since previous studies used only residential buildings (Wolf, 2003, Adegun, 2021). Systematic sampling technique was used to select the buildings in each of the selected route. The first building in each street/route was selected by casting of dice (1^{st} -6^{th}) and any number that appears in that dice was picked as the first house to start, then systematically, subsequent units selected at every 4^{th} residential building sequel to the listing of building based on street numbering system and centering of buildings were houses were not numbered. Housing units not occupied by house adults were dropped and next buildings occupied by adults were selected

Furthermore, the researcher with the robust assistance of the research assistants filled the Observational Checklist. The observational checklist covers categories of streetscape elements: road surface, drainage, lighting, boundary treatments, street trees, medians, verges, signage, utility poles, bus stop seating, pedestrian walkways, crossings, waste management facilities, traffic calming features, visual enclosure, and is applied to successive 100-metre segments along the full length of each study street. Each element is rated on a four-point condition scale (1 = Absent/Very Poor to 4 = Good), and quantifiable elements such as tree count and walkway width are measured and recorded numerically. The observation exercise is conducted by the researcher and two trained research assistants. Prior to the commencement of main data collection, all three observers participated in a two-day training and calibration exercise on a street outside the study sample, during which each observer independently completed checklist ratings for the same segments and the ratings were compared and reconciled to establish consistent interpretation of the rating criteria. The observation exercise is conducted during daylight hours to ensure consistent and adequate visibility of all streetscape elements. The research assistants were engaged in the counting and administration of the questionnaire in each of the selected routes/streets and helped to interpret the content of the questionnaire to the very few residents who were not able to read and write. The period of data collection was from February 1st to April 24^{th}, 2025. The questionnaires were administered using the face-to –face method to the respondents

The various elements identified as possible streetscape element in the study area from literatures reviewed were 33 in number and are listed in Table 1. They were included in the questionnaire as the possible streetscape elements in the study area.

Table 1: The 33 possible streetscape elements in the study area

No	Streetscape elements
1	- Loading zones and curb cuts
2	- Bus shelters and transit stops
3	- Accessible parking markings
4	- Reflectors, road markings, speed humps
5	- Newspaper stands and vending carts
6	- Green walls or vertical planting
7	- Curb ramps / wheelchair access
8	- Directional and wayfinding signs
9	- Public toilets / kiosks

10	- Benches and seating
11	Crosswalks and pedestrian crossings
12	- Street trees and canopy cover
13	- On-street parking bays
14	- Trash and recycling receptacles
15	- Taxi stands / drop-off points
16	-Surveillance cameras
17	- Guardrails and handrails
18	- Planters, shrubs, groundcover
19	- Bike lanes and cycle tracks
20	- Traffic signals and pedestrian countdowns
21	- Bollards and protective barriers
22	- Medians and traffic islands
23	Sidewalks / footpaths
24	- Banners, flags, interpretive panels
25	- Manhole covers and utility access lids
26	- Streetlights and pedestrian-scale lighting
27	- Parking meters and pay stations
28	- Pavers, asphalt, concrete finishes
29	Curbs and gutters
30	- Regulatory signs (speed limits, parking, etc.)
31	- Fire hydrants
32	- Street poles (lighting, signage, CCTV)
33	- Tree grates, guards, and planting beds

Source: Literatures and pilot survey

The Principal Component Analysis (PCA) was used to compress the 33 primary streetscape elements in the study area into definite pattern. This PCA was used to test whether the streetscape elements present in the study area can be significantly patterned and characterized. The data was elicited only from the streets/routes that have had streetscape elements in the study area. Weighted Mean Score (WMS) was equally applied when the mean weight of the various variables were scored. Data processing and analysis for this study were performed using the Statistical Package for Social Sciences (SPSS) 22 for windows for statistical analysis of the quantitative data.

4. Results

The examination of the characterization of the major streetscape elements/components present in the study area was done using two determination approaches. The first approach was using the ranking of the mean major streetscape elements/components present in the study area and the second approach was the use of the Principal Component Analysis to compress the 33 identified variables into manageable factors. While the ranking of the mean major streetscape elements/components present approach, the responses from the respondents on each of the 33 identified variables were weighed according to presence or otherwise of identified major streetscape elements/components present in the residential unit as were answered from the questionnaire. This ranking of the mean major streetscape elements/components present in the

individual residential unit analysis was done aggregately for the entire selected neighbourhoods. The second approach used the PCA to compress the 33 identified variables into manageable factors and this was determined for the neighbourhoods in the study area

The study have a tabular analysis on how the 351 sampled respondents responded on the presence or otherwise of major streetscape elements/components on their individual residential units in the study area. The analysis which was presented in table 2 shows the presence or otherwise of major streetscape elements/components, this was followed by the ranking and the remarks. The ranking gives details on the predominance of these streetscape elements/components, Further analysis was done in terms of the streetscape elements that had high occurrence (those that had average percentage presence/occurrence between were graded between 60%-100%, those that had moderate occurrence (those that had average percentage presence/occurrence between 40-59% and those that had little or no presence (those that had average or no percentage presence/occurrence were graded between 0-39%. This ranking and presentation were similar to previous study done by Mohamed, & Saad, (2019); Cohen et al (2016)

Table 2: Possible streetscape elements in the study area N=351

	Streetscape elements	**% Present**	**% Absent**	**Rank**	**Remark**
1	- Loading zones and curb cuts	75	25	8th	High
2	- Bus shelters and transit stops	61	39	14th	High
3	- Accessible parking markings	55	45	17th	Moderate
4	- Reflectors, road markings, speed bumps	62	38	13th	High
5	- Newspaper stands and vending carts	49	51	18th	Moderate
6	- Green walls or vertical planting	85	15	4th	High
7	- Curb ramps / wheelchair access	32	68	21st	Little
8	- Directional and wayfinding signs	86	14	3rd	High
9	- Public toilets / kiosks	52	48	17th	Moderate
10	- Benches and seating	72	28	10th	High
11	Crosswalks and pedestrian crossings	35	65	20th	Little
12	- Street trees and canopy cover	78	22	7th	High
13	- On-street parking bays	87	27	2nd	High
14	- Trash and recycling receptacles	56	44	16th	Moderate
15	- Taxi stands / drop-off points	73	27	9th	High
16	-Surveillance cameras	37	63	19th	Little
17	- Guardrails and handrails	20	80	25th	little
18	- Planters, shrubs, groundcover	78	22	7th	High
19	- Bike lanes and cycle tracks	10	90	27th	little
20	- Traffic signals and pedestrian countdowns	85	15	4th	High
21	- Bollards and protective barriers	24	76	23rd	Little
22	- Medians and traffic islands	79	21	5th	High
23	Sidewalks / footpaths	64	36	12th	High

24	- Banners, flags, interpretive panels	62	38	13th	Little
25	- Manhole covers and utility access lids	``81	19	5th	High
26	- Streetlights and pedestrian-scale lighting	73	27	9th	High
27	- Parking meters and pay stations	66	37	11th	High
28	- Pavers, asphalt, concrete finishes	80	20	6th	High
29	Curbs and gutters	88	12	1st	High
30	- Regulatory signs (speed limits, parking, etc.)	78	22	7th	High
31	- Fire hydrants	25	75	22nd	little
32	- Street poles (lighting, signage, CCTV)	72	38	10th	High
33	- Tree grates, guards, and planting beds	88	12	1st	Moderate

Source: Researcher's survey, 2025

The result as shown in table 6.9 presents a picture that the 20 out of the 33 streetscape elements were rated to have high level of availability in the study area, of course, observation shows that these elements are mainly present at the areas with streetscape interventions. Two of the most significant streetscape elements available in the study area was the presence of trees, guards and planting beds (88% present and was ranked: 1st) as well as the prevalence of kerbs and gutters in the area. (88% present and was ranked: 1st). This highlights the prevalence of trees and shrubs in the study area. The prevalence of on-street parking bays and directional and wayfinding signs were other streetscape elements that were most available in the study area with the ranking of 2nd and 3rd respectively. Other highly available streetscape elements in the study area where street trees and canopy cover, benches an seating, green walls or vertical planting, road reflectors, Loading zones and curb cuts and bus shelters and transit stops (ranked 14th). However, the study recognized that streetscape elements such as wheelchair ramps (32% present), crosswalks and pedestrian crossing (35% present) and existence of fire hydrants elements were among the streetscape elements that were least in its availability in the study area.

However, further detailed and statistical analysis of the characterization of the major streetscape elements/components present in the study area using inferential statistical technique (Principal component analysis) which have a more robust and reliable presentation was done. This was because the rankings were merely non parametric analysis in simple term. In other to examine the characterization of these major streetscape elements/components present in the study area using a more robust statistical and empirical dimension, the Principal Component Analysis (PCA) was implored to compress the 33 identified primary variables to fewer dimensions. These dimensions derived formed the secondary variables (factors) that characterize major streetscape elements/components in the study area

The Principal component analysis (PCA) output showed that 7 components (factors) expressed the bulk of the common variance among the 33 primary variables. These seven dimensions (factors) were continually referred to as the dimensions of the characterization of the major streetscape elements/components present in the study area. Each of the dimensions was given a component name.

For clarity, each of the factors was named to match the variables that were found in them.

Factor 1 - Pavement & Movement
Factor 2 - Street Furniture
Factor 3 - Lighting & Signage

Factor 4 - Landscape & Green Infrastructure
Factor 5 - Utilities & Technical Elements
Factor 6 - Parking & Curb Management
Factor 7 - Safety & Accessibility

In other to have a clearer understanding of the output, Table 3 showed those primary dimensions that made up each component with their factor loadings as well as their percentage variance and eigen values. In summary, the PCA result patterned and dimensioned the predominant factors that characterization of the major streetscape elements/components in the study area into 7 components that explained 95.799 percent of observed variation in characterization variables. The identified dimensions that made up characterization of the major streetscape elements/components in the study area that accounted for the explained percentage variations were as follows: Pavement & Movement (33.090%), Street Furniture (20.136%), lighting & Signage (11.884%), Landscape & Green Infrastructure (11.162%), Utilities & Technical Elements (8.156%), Parking & Curb Management (6.763%), Safety & Accessibility. (4.608%). This table 3 shows the factors and the corresponding variables that make up each of them. Further explanations of the table and its contents were discussed subsequently.

Table 3: Rotated Component Matrix for streetscape elements

	Component						
	1	2	3	4	5	6	7
sidewalks	.972						
curbs	.972						
crosswalks	.972						
curbramps	.972						
bikelanes	.972						
medians	.810						
pavers	.810						
benches		.940					
busshelter		.839					
trashrecept		.719					
bollards		.636					
parkingmeter		.621					
publictoilet		.591					
newspaperstand		.536					
streetlight			.950				
trafficsignals			.950				
directionsign			.920				
regulatorysigns			.854				
banners			.724				
streettrees			.	.915			
treegates				.813			
planters				.813			
greenwalk				.603			

manholecover					.874		
firehydrants					.846		
streetpoles					.846		
onparkingbay						.985	
loadzone						.984	
accessparking						.845	
taxistand						.784	
guardrails							.863
reflector							.667
survillancecamera							.667

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

These factors were further explained individually.

Factor 1: Pavement & Movement

This was highly and positively loaded on 7 variables out of the 33 variables in the study. One of the highest variables in this factor was sidewalks and pedestrian pathways with the factor loading of 0.972. Other variables in this factor include curbs, gutters, and edge treatments with factor loading of .972, crosswalks, zebra stripes, pedestrian refuge islands, curb ramps and tactile warning strips, bike lanes, cycle tracks, shared-lane markings, medians, traffic islands, and channelizers, pavement materials (concrete, brick, asphalt) and surface textures with factor loading of .810. This Factor 1 with an Eigen value of 10.920, explains 33.090% of the characterization of the major streetscape elements/components present in the study area. Factor 1 is therefore the most significant characterization of the major streetscape elements/components in the study area contributing to 33.090% of the factors. Factor 1 as defined by pavement & movement **is** therefore identified and classified as the greatest factor that characterized the major streetscape elements/components in the study area.

Factor 2: Street Furniture

This was highly and positively loaded on 7 variables out of the 33 variables in the study. The striking variable in this factor was presence of benches, seats, ledges with the factor loading of 0.940. Other variable in this component was bus shelters, transit signage, real-time displays (0.839), Trash cans, recycling bins, cigarette receptacles (0.719), Bollards, planter guards, low fences (0.636) parking meters/ charging posts, (0.621) public toilets, kiosks, phone booths (0.591) and newspaper stand (0.536). This Factor 2 with an Eigen value of 6.645, explains 20.136% of the characterization of the major streetscape elements/components in the study area. Factor 2 is therefore the second most significant characterization of the major streetscape elements/components in the study area contributing to 20.136% of the factors. Factor 2 as defined by street furniture is therefore identified and classified as the second factor that characterized the major streetscape elements/components in the study area

Factor 3: Lighting & Signage

This was highly and positively loaded on 5 variables out of the 33 variables in the study. The striking variable in this factor was roadway and pedestrian-scale streetlights with the factor loading of 0.950. Other variables in this factor include traffic signals, (0.950) pedestrian countdown timers, regulatory signs (speed, parking, loading), wayfinding and directional signs (0.0854), banners, flags, interpretive panels, public art, murals, sculptures with factor loading of .724. This Factor 3 with an Eigen value of 3.922, explains 11.884% of the characterization of the major streetscape elements/components present in the study area. Factor 3 is therefore the third most significant characterization of the major streetscape elements/components present contributing to 11.884% of the factors. Factor 3 as defined by Lighting & Signage is therefore identified and classified as the third factor that characterized the major streetscape elements/components in Aba

Factor 4: Landscape & Green Infrastructure

This was highly and positively loaded on 4 variables out of the 33 variables. The defining variable in this factor was street trees, tree pits, grates, guards with the factor loading of 0.915. Other variables in this component were tree gates (0.813), planters, shrubs, ground cover, flower beds (0.813), and Green walls, trellises, hedges (0.603). This Factor 4 with an Eigen value of 3.683, explains 11.162% of the characterization of major streetscape elements/components present in the study area. Factor 4 is therefore the fourth most significant characterization of the major streetscape elements/components present in the study area contributing to 11.162% of the factors. Factor 4 as defined by landscape & green Infrastructure is therefore identified and classified as the fourth greatest factor that characterized major streetscape elements/components in Aba

Factor 5: Utilities & Technical Elements

This was highly and positively loaded on 3 variables out of the 33 variables. The defining variable in this factor was manhole covers, catch basins, storm grates with the factor loading of 0.874. Other two variables in this group were fire hydrants and standpipes (0.854) and street poles (0.846). This Factor 5 with an Eigen value of 2.692, explains 8.156% of the characterization of the major streetscape elements/components present in the study area. Factor 5 is therefore the fifth most significant characterization of the streetscape elements/components present in the study area contributing to 8.156% of the factors. Factor 5 as defined by utilities & technical elements factor is therefore identified and classified as the fifth major factor that characterized the major streetscape elements/components present in Aba

Factor 6: Parking & Curb Management

This was highly and positively loaded on 4 variables out of the 33 variables in the study. The striking variable in this factor was on-street parking spaces, curb markings with the factor loading of 0.985. Other variables in this factor include loading zones, taxi stands, drop-off areas g with factor loading of 0.984, accessible parking and associated signage (0.845) and taxi/bus stands (0.784). This Factor 6 with an Eigen value of 2.232, explains 6.763% of the characterization of major streetscape elements/components present in the study area. Factor 6 is therefore the sixth most significant characterization of streetscape elements/components present in the study area contributing to 6.763% of the factors. Factor 6 as defined by parking & curb management is therefore identified and classified as the sixth major factor that characterized the major streetscape elements/components present in the study area

Factor 7: Safety & Accessibility

This was positively loaded on 3 variables out of the 33 variables. The defining variable in this factor was the guardrails, handrails, anti-climb panels with the factor loading of 0.863. Other variable was road markings, lane delimiters, reflectors with the factor loading of .667 and surveillance camera (0.667). This Factor 7 with an Eigen value of 1.521 explains 4.608% of the characterization of major streetscape elements/components present in the study area. Factor 7 is therefore the least most significant characterization of the major streetscape elements/components present, contributing to 4.608% of the factors. Factor 7 as defined by safety & accessibility is therefore identified and classified as the least factor that characterized the post-occupancy modification of outdoor spaces in the study area

5. Discussion

The study used the ranking as well as the Principal Component Analysis (PCA) for the examination of the characterization of the major streetscape elements/components present in the study area. Fortunately, the two analyes gave the same findings, thus the PCA analysis which gave more robust findings would be adopted in this discussion. The Principal Component Analysis (PCA) revealed that the 33 observed streetscape variables could be reduced into seven underlying dimensions that collectively explained 95.799% of the total variance. This exceptionally high cumulative variance indicates that the extracted components adequately captured almost all the information contained in the original variables. In urban design and environmental perception research, a cumulative variance above 60% is generally considered satisfactory, while values exceeding 80% indicate a highly reliable factor solution (Hair et al., 2019). Consequently, the 95.799% variance obtained in this study demonstrates a strong and stable component structure, suggesting that the seven extracted factors effectively represent the principal physical characteristics defining streetscape composition within the study area. The reduction of numerous physical streetscape variables into seven meaningful dimensions is consistent with the theoretical assumptions underlying Principal Component Analysis, which seeks to identify latent constructs that explain relationships among correlated variables (Jolliffe & Cadima, 2016). From an urban design perspective, the findings equally support the proposition of Lynch (1960) that urban environments are not perceived as isolated physical objects but rather as integrated systems of interconnected environmental elements that collectively shape the imageability and functionality of cities. Similarly, the findings resonate with the principles of Complete Streets, which emphasize that streets should be designed as multifunctional public spaces accommodating mobility, safety, accessibility, environmental sustainability, and social interaction rather than merely serving vehicular traffic (National Complete Streets Coalition, 2015).

The predominance of the Pavement and Movement component, accounting for 33.090% of the total variance, indicates that pedestrian and vehicular movement infrastructure constitutes the most influential characteristic defining the streetscape of the study area. The very high factor loadings recorded for sidewalks and pedestrian pathways, curbs and gutters, crosswalks, curb ramps, bike lanes, medians, and pavement materials suggest that movement-related infrastructure forms the structural backbone of the urban streetscape. This finding reflects the growing recognition that mobility infrastructure determines not only transportation efficiency but also environmental quality, accessibility, and urban livability. Jacobs (1961) argued that vibrant streets depend fundamentally on continuous pedestrian activity supported by safe and comfortable walking environments. Likewise, Gehl (2010) maintained that cities become more liveable when pedestrian

movement receives greater priority in street design. The prominence of movement infrastructure observed in this study therefore confirms that the physical organization of circulation systems remains the primary determinant of streetscape quality. Empirical evidence from previous studies supports this observation. Ewing and Handy (2009) identified sidewalks, pedestrian crossings, pavement quality, and street connectivity as among the strongest predictors of perceived urban design quality. Similarly, Southworth (2005) found that well-designed pedestrian infrastructure significantly enhances walkability and promotes greater public use of urban streets. In developing countries, studies by Adedeji and Fadamiro (2018) and Ahmed et al. (2020) similarly reported that deficiencies in sidewalks, pedestrian crossings, and pavement quality constitute the most visible indicators of deteriorating urban streetscapes. The present findings therefore reinforce the international consensus that movement infrastructure remains the most fundamental component of effective streetscape design. The second component, Street Furniture emerged as the second most influential streetscape dimension. The high loadings associated with benches, bus shelters, waste receptacles, bollards, parking meters, kiosks, and public toilets indicate that supporting amenities substantially contribute to the functional and social quality of streets. Street furniture transforms transportation corridors into public places by encouraging comfort, rest, social interaction, and convenience. This finding strongly aligns with the urban design philosophy advanced by Gehl (2010), who emphasized that the success of public spaces depends largely on the availability of human-scale amenities that encourage people to stay rather than simply pass through. Carmona et al. (2010) similarly argued that appropriately designed street furniture enhances environmental quality, strengthens place identity, and improves user satisfaction. Previous empirical studies provide considerable support for this finding. Mehta (2014) demonstrated that seating facilities, bus shelters, public conveniences, and pedestrian amenities significantly increase street vitality and encourage social interaction. Likewise, Ewing et al. (2013) identified street furniture as a major contributor to pedestrian comfort and overall streetscape attractiveness. Within African cities, Fair (2018) observed that deficiencies in street furniture reduce the usability of public streets despite adequate road infrastructure. The present study therefore confirms that street furniture constitutes an indispensable dimension of contemporary streetscape character. The third component, Lighting and Signage highlights the importance of visual communication and nighttime functionality in shaping streetscape character. The dominant variables—including street lighting, traffic signals, pedestrian countdown timers, regulatory signs, directional signage, banners, murals, and public art—collectively represent the informational and aesthetic functions of the urban environment. Street lighting enhances visibility, improves pedestrian confidence, reduces crime opportunities, and contributes to nighttime economic activities. Simultaneously, signage facilitates orientation, traffic regulation, and environmental legibility. The significance of this component strongly reflects Lynch's (1960) concept of imageability, which emphasizes that environmental elements such as landmarks, signs, and visual cues improve people's ability to navigate and mentally organize urban environments. Appleton's Prospect–Refuge Theory (1975) also suggests that well-lit environments enhance users' perception of safety by increasing visibility and reducing uncertainty. Empirical studies by Nasar (1998) and Painter (1996) found that improved street lighting significantly enhances perceptions of safety and urban attractiveness, while Wayfinding Theory similarly emphasizes the importance of environmental signage in facilitating navigation and reducing cognitive stress. The current findings therefore support both theoretical and empirical literature emphasizing lighting and signage as critical determinants of urban environmental quality.

The fourth component, Landscape and Green Infrastructure underscores the ecological dimension of streetscape quality. The strong factor loadings for street trees, tree guards, planters, shrubs, flower beds, hedges, and green walls demonstrate that vegetation constitutes an essential structural component of the urban streetscape. Green infrastructure performs multiple ecological functions, including improving thermal comfort, reducing urban heat island effects, enhancing biodiversity, mitigating stormwater runoff, and improving air quality. Beyond ecological benefits, landscape elements also improve aesthetic appeal and psychological well-being. This finding is highly consistent with Biophilia Theory (Wilson, 1984), which argues that humans possess an inherent affinity for natural environments. Kaplan and Kaplan's Attention Restoration Theory (1989) further suggests that exposure to vegetation enhances mental restoration, reduces stress, and improves cognitive functioning. Numerous empirical studies reinforce these theoretical perspectives. Wolf (2003) found that tree-lined streets significantly increase public preference and commercial activity. Similarly, Ulrich (1984) demonstrated that natural environments positively influence psychological health and environmental satisfaction. More recent studies by Chen. (2023) concluded that integrating green infrastructure into urban streets contributes substantially to climate resilience and sustainable urban development. The emergence of this factor therefore reflects increasing recognition of environmental sustainability within contemporary streetscape planning. The fifth component, Utilities and Technical Elements, accounted for 8.156% of the explained variance. Although often overlooked in conventional streetscape evaluations, technical infrastructure—including drainage systems, manhole covers, fire hydrants, and utility poles—forms the hidden operational framework that supports urban functionality. Their clustering into a distinct component demonstrates that respondents recognized these facilities as important physical elements contributing to streetscape character. Carmona et al. (2010) argued that successful public spaces require both visible urban design features and efficient underlying infrastructure systems. Similarly, urban infrastructure theory emphasizes that effective service delivery depends upon the integration of engineering infrastructure with urban design principles (UN-Habitat, 2020). The present findings therefore highlight the importance of balancing aesthetic improvements with technical infrastructure provision in comprehensive streetscape planning. For the sixth component, Parking and Curb Management, although it contributes a smaller proportion of variance, the exceptionally high loadings for parking spaces and loading zones indicate a highly coherent factor. Parking management has increasingly become an essential element of sustainable urban mobility because poorly organized curb spaces frequently generate congestion, pedestrian conflicts, and inefficient land use. Shoup (2005) argued that effective parking management significantly improves urban accessibility while reducing traffic congestion. Similarly, Litman (2020) demonstrated that integrated curb management enhances transportation efficiency and supports multimodal mobility. The emergence of this factor suggests that parking infrastructure represents a distinct functional dimension within the streetscape character of the study area.

6. **Conclusion and Recommendation**

The seven dimensions identified through the PCA—Pavement and Movement, Street Furniture, Lighting and Signage, Landscape and Green Infrastructure, Utilities and Technical Elements, Parking and Curb Management, and Safety and Accessibility—should be adopted by the Abia State Government as the standard framework for planning, designing, implementing, and evaluating streetscape projects. This framework provides an evidence-based model for ensuring that future streetscape developments are comprehensive rather than fragmented. The seven-factor

framework generated by this study should serve as the empirical basis for developing official streetscape design guidelines for Aba. Such guidelines should establish minimum design standards, technical specifications, maintenance requirements, and performance indicators for streetscape infrastructure. Standardized guidelines would promote consistency, improve project quality, and facilitate effective monitoring of future streetscape interventions. In other words, The seven streetscape dimensions identified through the Principal Component Analysis—Pavement and Movement, Street Furniture, Lighting and Signage, Landscape and Green Infrastructure, Utilities and Technical Elements, Parking and Curb Management, and Safety and Accessibility—should serve as the basis for developing a standardized streetscape design manual for Aba. Such a manual would provide technical guidance for planners, engineers, architects, and developers while ensuring consistency in future streetscape interventions. More so, since pavement and movement emerged as the most influential streetscape dimension, urban road development projects should prioritize the provision of continuous sidewalks, pedestrian crossings, bicycle lanes, curb ramps, tactile paving, medians, and high-quality pavement materials. Road infrastructure projects should shift from a vehicle-centred approach toward a people-centred design philosophy that promotes walkability, accessibility, and sustainable mobility. The study established that Street Furniture is the second most significant determinant of streetscape character. Consequently, every road construction and urban renewal project should include adequate provision of benches, bus shelters, public waste bins, bollards, kiosks, public toilets, bicycle parking facilities, and other pedestrian amenities. These facilities should be strategically located to enhance user comfort, encourage social interaction, and improve the functionality of public spaces. Again, given the emergence of Landscape and Green Infrastructure as a major streetscape dimension, future urban development policies should emphasize the integration of street trees, landscaped medians, bioswales, flower beds, hedges, green walls, and other forms of urban vegetation into road projects. Such interventions will improve thermal comfort, reduce urban heat island effects, enhance biodiversity, improve air quality, and strengthen climate resilience within Aba.

The study established that the characterization of major streetscape elements/components in the study area is multidimensional rather than dependent on isolated physical features. The successful reduction of the original 33 observed streetscape variables into seven distinct and interpretable components (Pavement and Movement, the emergence of Street Furniture, Lighting and Signage, Landscape and Green Infrastructure , Utilities and Technical Elements, Parking and Curb Management and Safety and Accessibility) demonstrates that the physical composition of urban streets is structured around coherent functional dimensions. Collectively, these seven components explained **95.799%** of the total variance, indicating that they provide a comprehensive representation of the physical attributes that define streetscape character within the study area. This exceptionally high explanatory power confirms the robustness of the component structure and suggests that the identified dimensions adequately capture the essential characteristics of the urban streetscape. Taken together, the seven-component solution demonstrates that the streetscape of the study area is characterized by an integrated system of mobility infrastructure, public amenities, environmental features, technical services, traffic management, and safety provisions. The findings reinforce contemporary urban design theories that conceptualize streets as multifunctional public spaces serving transportation, environmental, economic, and social purposes simultaneously. From a planning perspective, the results suggest that improvements to streetscape quality should adopt a holistic rather than sectoral approach. Urban renewal initiatives should prioritize the coordinated provision of pedestrian infrastructure, public amenities, lighting systems,

green infrastructure, technical services, parking management, and safety facilities because these dimensions operate collectively to define overall streetscape character. Focusing exclusively on road expansion or beautification without addressing these interconnected components is unlikely to produce sustainable improvements in urban environmental quality. Collectively, the seven extracted dimensions provide a comprehensive framework for understanding the physical composition of streetscapes within Aba. The findings demonstrate that effective streetscape planning requires an integrated approach in which transportation infrastructure, environmental design, public amenities, green infrastructure, utility services, parking management, and safety facilities are planned and implemented simultaneously. Consequently, the study concludes that sustainable streetscape development cannot be achieved through isolated infrastructure provision but requires coordinated urban design strategies that address multiple functional, environmental, and social objectives. Furthermore, the PCA model provides a validated empirical framework for future streetscape planning, assessment, and policy formulation in Aba and other rapidly urbanizing Nigerian cities. The identified dimensions may therefore serve as measurable indicators for evaluating existing streetscapes, prioritizing infrastructure investment, and monitoring urban renewal programmes aimed at improving environmental quality, walkability, public safety, and sustainable urban development.

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