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Assessing Landscape Design Deficiencies and Their Effects on Crowd Management, Spatial Navigation, And Emergency Evacuation at Caleb University Imota, Lagos.

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Abstract- ***University campuses require well-planned landscape environments to ensure safety, functionality, and user comfort. However, deficiencies in landscape design such as poor pathway organization, inadequate signage, improper vegetation placement, and limited open space coordination can negatively affect movement patterns and safety performance. This study assesses landscape design deficiencies at Caleb University, Imota, Lagos, and examines their effect on crowd control, spatial navigation, and emergency evacuation efficiency. The research evaluates how existing outdoor spatial arrangements influence pedestrian flow, wayfinding clarity, and response during peak usage and emergency situations. Using field observations, user surveys, and spatial analysis, the study identifies critical design gaps and their implications on safety and accessibility. Findings aim to propose strategic landscape improvements that enhance circulation, reduce congestion, and support effective emergency management within the university environment.***

Keywords: Landscape design, crowd management, wayfinding system, emergency evacuation, campus planning

I. INTRODUCTION

The contemporary university campus is more than an educational facility; it is a complex urban microcosm that necessitates sophisticated spatial planning to ensure the safety and comfort of its diverse population. Caleb University, located in Imota, Lagos, operates within one of the world's fastest-growing metropolitan areas, where the pressures of urbanization often outpace the development of supporting infrastructure (Ogunnaike et al., 2025; Cengizet al., 2018). As the campus expands, the design of its landscape—including walkways, plazas, and open spaces—becomes critical to its functional success. Landscape design deficiencies, ranging from structural flaws like narrow paths and steep slopes to perceptual issues like poor lighting and ineffective signage, represent significant latent hazards (Li et al., 2025; Huang et al., 2022). These deficiencies do not only impede daily movement but can also lead to catastrophic outcomes during emergency evacuations, where congestion and panic can result in stampedes and injuries (Shao et al., 2019; Cilenti, 2019). While recent research in Nigeria, led by scholars such as Ogunnaike et al. (2025), has explored modular construction and spatial layouts in retail and hotel settings, there remains a critical gap in the systematic assessment of landscape safety on institutional campuses in Lagos (Ogunnaike et al., 2025; Ibrahim et al., 2017; Adekunle et al., 2016). This study aims to bridge this gap by identifying the specific landscape design deficiencies that affect crowd management, spatial navigation, and emergency evacuation. By focusing on Caleb University, the research provides a framework for institutional self-assessment and the implementation of evidence-based design interventions.

II. LITERATURE REVIEW

2.1 Physical and structural landscape deficiencies

The physical configuration of the landscape is the most direct determinant of pedestrian flow and safety. Literature consistently highlights several structural features that, when poorly designed, become deficiencies.

2.1.1 pathway dimensions and gradients:

Quantitative studies have established that street or passage widths narrower than approximately 2.0 meters create high-risk zones where pedestrian density can reach critical levels, leading to flow

stagnation (Li et al., 2025). Furthermore, slopes exceeding 4° are shown to materially slow movement, particularly for downhill evacuation, where the risk of falling increases (Li et al., 2025).

2.1.2 Bottleneck geometry:
Bottlenecks at entrances, exits, and corners are the most frequent sites of "pedestrian clogging" and stampede events (Shao et al., 2019; Hassan et al., 2014). Recent research into funnel-shaped bottlenecks suggests that an angle of 26.6° is the most efficient for promoting smooth egress, whereas more acute or obtuse angles can impede flow (Tavana et al., 2019).

2.1.3 Pathway circuitousness and turning angles:
Path layouts that involve sharp turns or circuitous routes are inherently less efficient. Turning angles of 60° or greater have been shown to significantly reduce flow rates and velocities even under orderly conditions, suggesting they pose a severe hazard during high-speed emergency evacuations (Dias et al., 2014).

2.1.4 Obstacles and encroachments:
The improper placement of urban furniture (seating, bollards, planters) can obstruct intended flow lines. Studies of university campuses have noted that even when furniture is present, it is 2 often insufficient in quantity or poorly maintained, further degrading the utility of the landscape (Cengiz et al., 2018).

2.2 Environmental and perceptual deficiencies
Beyond structural dimensions, the perceptual quality of the landscape plays a vital role in how users navigate and respond to the environment.

2.2.1 Lighting and visibility:
Poorly illuminated settings and "places to hide" significantly reduce the perceived and actual safety of a campus. Deficiencies such as plants blocking viewsheds and dark, shallow alleys limit natural surveillance and can facilitate crime or cause accidents (Huang et al., 2022).

2.2.2 Legibility and signage:
A lack of environmental legibility—the ease with which the layout of a space can be recognized and organized into a coherent pattern—leads to disorientation (Oyelola,2014). Ineffective or absent directional and escape-route signs are frequently cited as major contributors to misnavigation during emergencies (Brombilla et al., 2020; Huang et al., 2022).

2.2.3 Surface conditions:
Uneven road surfaces, slippery materials, and a lack of tactile flooring for visually impaired users represent significant navigation hazards. In Nigeria, poor construction quality using low cement-sand ratios has been observed to cause crevices and structural failure in campus walkways (Simon et al., 2014).

2.3 Effects on crowd management and flow dynamics
The interaction between landscape design and human behavior determines the effectiveness of crowd management strategies.

2.3.1 Local density hotspots:
High local dynamic densities can occur at "critical points" like merging passages or T junctions, even if the overall average density of a space appears safe (Cilenti, 2019). These hotspots are where physical pressure builds, leading to injuries (Ibrahim et al., 2019).

2.3.2 Surge and panic mitigation:
Inadequate planning of attraction locations (e.g., event stages or food courts) can cause localized crowd surges. Adjusting the spatial layout of these features has been shown to reduce surge incidents by up to 34%, enhancing overall safety (Zhang et al., 2023).

2.3.3 Behavioral heterogeneity:
The presence of risk-seeking individuals within a crowd can amplify the negative effects of design deficiencies. When the proportion of such agents increases, average crowd pressure and injury rates rise exponentially (Ibrahim et al., 2019).

2.4 Effects on spatial navigation and wayfinding
Navigational efficiency is critical for both routine operations and time-sensitive evacuations.

2.4.1 Decision time and cognitive load:
Poor orientation cues increase the cognitive load on users, lengthening the time required to make navigational decisions. Information overload from poorly designed maps can also inhibit spatial cognition (Oyelola, 2014).

2.4.2 Reliance on prior knowledge:
When signage is dysfunctional, users tend to rely on their prior knowledge of the space. While this may be effective for regular users, it leaves visitors and new students vulnerable, especially if their known routes are blocked during an emergency (Brombilla et al., 2020).

2.4.3 Social interactions:
In emergency scenarios, social behaviors—such as the tendency to follow the crowd— can either assist or hinder navigation. If the lead individuals are misnavigating due to poor design, the entire group is at risk (Al-Sharaa et al., 2022).

2.5 Effects on emergency evacuation performance
The culmination of design deficiencies is often seen in the performance of evacuation systems.

2.5.1 RSET VS. ASET:
The Required Safe Egress Time (RSET) must be less than the Available Safe Egress Time (ASET). Deficiencies like narrow paths and steep slopes lengthen RSET, narrowing the safety margin (Li et al., 2025).

2.5.2 Software simulation utility:
Modern simulation tools allow designers to test "what-if" scenarios. Architectural adjustments based on these simulations have been shown to reduce evacuation times by over 90% in some contexts (Shiwakoti et al., 2013).

2.5.3 Campus as shelter:
Universities are increasingly being evaluated for their dual use as city-level emergency shelters. Deficiencies in the campus landscape directly impact its capacity to serve as a safe haven for the broader community (Xin et al., 2025).

2.6 The Nigerian context: case studies and local realities
Research in Nigeria highlights unique challenges that exacerbate landscape design deficiencies.

2.6.1 Maintenance and finance:
Studies at Ekiti State University (EKSU) indicate that inadequate finance and a lack of maintenance culture are major barriers to effective campus landscaping (Adekunle et al., 2016). This leads to the misuse and mismanagement of open spaces.

2.6.2 Vehicular interference:
At Covenant University, Ota, loose coordination in spatial structure has led to continuous interference between vehicular traffic and pedestrians, resulting in noise, pollution, and increased accident risks (Simon et al., 2014).

2.6.3 Drainage and flooding:
In metropolitan Lagos, urban development often restricts natural runoff, leading to the blockage of drainage channels. For a campus like Caleb University, inadequate landscape drainage can lead to localized flooding, making paths impassable and increasing slip hazards (Ogunnaike et al., 2025).

III. METHODOLOGY

To systematically assess the landscape design deficiencies at Caleb University, Imota, the following two-pronged methodological framework is proposed.

3.1 site auditing and spatial analysis
A physical audit of the Caleb University campus landscape is the foundational step. This involves:

i. Measurement of Circulation Paths: Precise measurement of walkway widths and gradients using digital tools.
ii. Geometric Mapping: Identifying all merging passages, T-junctions, and funnel-shaped bottlenecks, with a focus on their interior angles and transition zones.
iii. Signage and Lighting Inventory: A comprehensive count and evaluation of the visibility and legibility of all directional and safety signs, alongside a nighttime assessment of illumination levels.

3.2 human factors and perception assessment

Understanding how the Caleb University community interacts with the landscape requires:

i. User Surveys: Questionnaires targeting students, faculty, and visitors to gauge their perceptions of safety, comfort, and navigational ease.
ii. Wayfinding Exercises: Controlled experiments where participants are asked to find specific locations on campus, with researchers tracking their decision points and any instances of confusion.

IV. FINDINGS AND RESULT

This chapter presents the analysis of data collected on the effect of landscape design deficiencies on crowd management, spatial navigation, and emergency evacuation in Caleb university. A total of 100 questionnaires were administered and analyzed using descriptive statistics.

4.1 Data presentation and analysis

A total of 100 respondents participated in the study, comprising 78% students, 15% staff, and 7% visitors, with the majority (60%) having spent more than one year on campus, indicating a high level of familiarity with the environment. Findings revealed that 50% of respondents rated walkway widths as inadequate or very inadequate, while only 32% considered them adequate, highlighting significant limitations in pedestrian capacity. In terms of congestion, 50% reported experiencing it frequently (15% always and 35% often), particularly around lecture areas (65%), junctions (55%), campus entrances (52%), worship centers (48%), and hostels (40%), indicating critical pressure points within the circulation network. Additionally, 62% confirmed the presence of walkway obstructions, further reducing effective movement space. Regarding bottlenecks, 70% of respondents acknowledged their existence, with 50% rating them as severe or very severe, demonstrating a major constraint in pedestrian flow efficiency. In terms of spatial navigation, only 40% found movement easy, while 40% reported difficulty, and 58% admitted to having gotten lost or confused on campus, which correlates with the finding that 54% rated campus signage as inadequate or very inadequate. Lighting conditions were also identified as problematic, with 45% rating walkway lighting as poor or very poor and 40% of respondents expressing feelings of being unsafe or very unsafe at night. Furthermore, only 35% of respondents were aware of emergency evacuation routes, while 65% were not, and 50% disagreed or strongly disagreed that the campus design supports effective emergency evacuation. Overall, these findings clearly indicate that deficiencies in walkway design, presence of obstructions, inadequate signage, poor lighting, and lack of emergency awareness significantly hinder crowd management, spatial navigation, and safety within the campus environment.

4.2 Discussion of findings

The findings from this study clearly demonstrate that landscape design deficiencies have a significant impact on movement efficiency and safety within the campus environment. The high percentage of respondents who reported inadequate walkway widths and frequent congestion indicates that existing pedestrian infrastructure is not sufficient to handle peak period movement. This is further compounded by the presence of obstructions and bottlenecks, which reduce effective walkway capacity and create points of delay and crowd build-up. In terms of spatial navigation, the results show that a significant number of users experience difficulty in finding their way around the campus. This is directly linked to inadequate signage and poor environmental legibility, which contribute to confusion and disorientation, especially for new users and visitors. The fact that more than half of the respondents have gotten lost at some point emphasizes the need for a more structured and intuitive wayfinding system. The study also reveals that lighting conditions on campus are not adequate, with a substantial proportion of respondents rating them as poor. This negatively affects both visibility and perceived safety, particularly during nighttime movement. The high percentage of users who feel unsafe at night highlights the importance of proper lighting in enhancing security and comfort. Finally, the results indicate a low level of awareness of emergency evacuation routes and a general lack of confidence in the campus's ability to support quick and safe evacuation. This suggests that current landscape

design and planning do not adequately support emergency response, which could pose serious risks in critical situations. Overall, these findings align with existing literature that emphasizes the role of physical design, spatial organization, and environmental clarity in ensuring effective crowd management and safety.

V. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 introduction

This chapter presents the summary of the study, the conclusion drawn from the findings, and recommendations for improving landscape design in Caleb university.

5.2 Summary of findings

The study examined the effect of landscape design deficiencies on crowd management, spatial navigation, and emergency evacuation. The findings revealed that walkways are generally inadequate, congestion is frequent, bottlenecks are common, signage is poor, lighting is insufficient, and awareness of emergency routes is low.

5.3 Conclusion

The study concludes that landscape design deficiencies have a significant negative impact on movement and safety. Poorly designed walkways, inadequate signage, and insufficient lighting reduce efficiency and increase risk, particularly during emergencies.

5.4RECOMMENDATIONS

i. Walkways should be widened and properly designed
ii. Bottleneck areas should be redesigned
iii. Clear and consistent signage should be provided
iv. Lighting should be improved across the campus
v. Obstructions should be controlled
vi. Regular maintenance should be ensured
vii. Emergency awareness programs should be introduced

5.5 Contribution to knowledge

This study highlights the importance of landscape design as a key factor in campus safety and functionality.

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