

Optimizing Circulation and Passenger Flow in Ferry Terminals: A Spatial Framework for Lagos, Nigeria

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Abstract

Ferry terminals are critical transport interchanges in coastal cities, yet many suffer from circulation inefficiencies that undermine their role in sustainable urban mobility. This challenge is acute in Lagos, Nigeria, where rapid urbanization and road congestion intensify the need for efficient water transport, but terminal designs remain inadequate. This study investigates spatial design strategies to optimize circulation and passenger flow in ferry terminals, using Lagos as a case study. A qualitative mixed-methods approach was applied, combining a systematic literature review with comparative case analysis of three international exemplars (Rotterdam, Anaheim, Salerno) and two Lagos terminals (Ikorodu, Five Cowries). Data were evaluated through five design dimensions: spatial zoning, wayfinding, multimodal integration, inclusivity, and cultural design. The results reveal significant deficiencies in the Lagos terminals, including poor zoning causing congestion, inadequate wayfinding, weak multimodal links, and a lack of inclusive design. Conversely, global cases demonstrated that integrated spatial strategies are paramount for efficiency. The study therefore proposes a Five-Pillar Framework, recommending hierarchical zoning, enhanced wayfinding, seamless multimodal integration, universal accessibility, and cultural symbolism to transform Lagos's terminals into efficient, user-centric hubs. These findings provide a transferable framework for improving ferry terminal design in rapidly urbanizing contexts globally.

Keywords: Ferry Terminal; Passenger Flow; Circulation Efficiency; Urban Mobility; Lagos

1. Introduction

Ferry terminals are critical infrastructural elements within modern transportation systems, providing essential nodes that facilitate the movement of passengers, vehicles, and goods across waterways. Beyond embarkation and disembarkation, they integrate with road, rail, and pedestrian systems to strengthen regional and urban mobility (Alonge et al., 2024; Kamińska, 2019; East & Armstrong, 1999). In global contexts such as Hong Kong, New York, and Sydney, ferry terminals have evolved into well-organized hubs where circulation, safety, and efficiency are prioritized to support sustainable mobility and enhance user experience (Cheemakurthy & Garme, 2022; Kim et al., 2022). Despite these successes, numerous ferry terminals worldwide continue to struggle with accessibility barriers, inefficient circulation patterns, and poor integration with surrounding urban systems (Izobo-Martins, 2020; Qi et al., 2023).

These challenges are particularly evident in rapidly urbanizing cities such as Lagos, Nigeria. With extensive water bodies; including lagoons, creeks, and the Atlantic Ocean, Lagos possesses significant potential for water-based transport. However, its rapid urban growth has intensified mobility pressures. Home to more than 25 million residents and projected to surpass 32 million people by 2053 (Lagos State Ministry of Economic Planning and Budget, 2022; World Bank, 2023; Bakare-Abidola et al., 2024), Lagos experiences severe traffic congestion that constrains economic productivity and quality of life. In this context, ferry transport presents a viable alternative, offering opportunities to decongest roads while promoting sustainable mobility (Franklin & Gam, 2022; Ansorena, 2022).

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Yet, existing ferry terminals in Lagos remain underdeveloped in both design and operation. Accessibility for persons with disabilities is inadequate, with limited provision of ramps, tactile guidance, and clear signage (Izobo-Martins, 2020; Babalola & Akinola, 2020). Circulation inefficiencies frequently result in overcrowding, disorganized queues, and safety risks during peak travel hours (Belema & Abbey, 2024; Najmuddin et al., 2020). Moreover, weak integration with road, rail, and pedestrian systems constrains the role of ferry terminals as part of a multimodal transport network (Dagogo & Tamunoiminabo, 2020; East & Armstrong, 1999).

Global best practices demonstrate that such challenges can be addressed through innovative spatial design approaches. Wayfinding systems, advanced ticketing technologies, and clear spatial zoning have been applied successfully in ferry terminals in South Korea, Penang, and Sydney, leading to improved circulation efficiency, reduced congestion, and enhanced user satisfaction (Kim et al., 2022; Franklin & Gam, 2022; Najmuddin et al., 2020). These international experiences underscore the importance of deliberate architectural and planning strategies that prioritize circulation and passenger flow while aligning with broader goals of accessibility, safety, and sustainability.

Despite the wealth of global evidence, Lagos ferry terminals have yet to adopt such innovations. This gap creates an urgent need for context-sensitive solutions that respond to the city's unique infrastructural and socio-cultural realities. This study therefore investigates spatial design approaches to optimize circulation in ferry terminals, using Lagos as a case study to develop context-sensitive strategies. By identifying design principles that improve passenger flow, accessibility, and multimodal integration, this research aims to contribute to both academic discourse and practical interventions in sustainable transport infrastructure.

2. Materials and Methods

This study employed a qualitative mixed-methods approach, combining a systematic literature review with a comparative case study analysis. The research was conducted in four sequential phases to ensure a structured and comprehensive inquiry into spatial design strategies for optimizing ferry terminal circulation. This dual approach enabled a comparative analysis that situates Lagos's specific challenges within a global discourse of best practice. A summary of the research design and sequential process is provided in Figure 1.

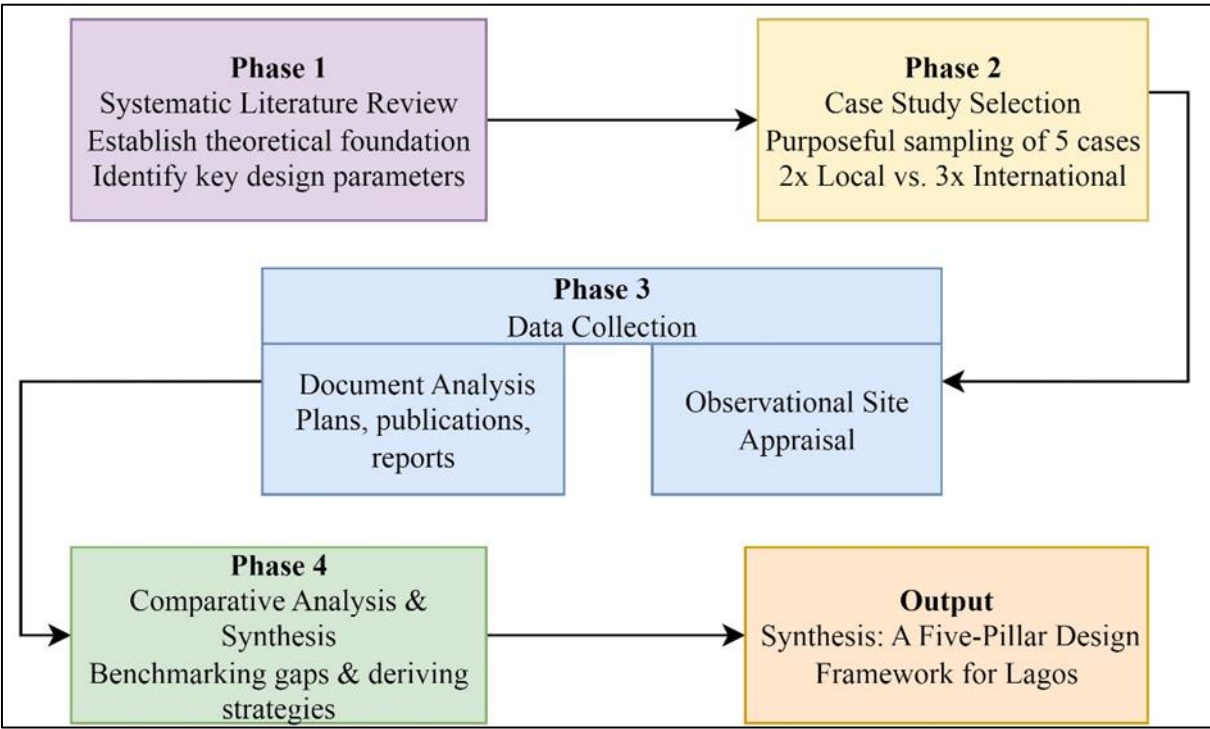


Figure 1 Research Design Workflow

2.1. Systematic Literature Review

A systematic review of existing literature was conducted to establish a theoretical foundation and identify key design parameters for ferry terminal efficiency. Peer-reviewed journal articles, books, technical reports, and architectural case

studies were sourced from academic databases including Scopus, Web of Science, and Google Scholar. The review focused on literature addressing core themes relevant to terminal design: passenger flow dynamics, spatial zoning, wayfinding, multimodal integration, accessibility, and sustainability. This phase culminated in the development of an analytical framework comprising five key dimensions for evaluation: (1) Spatial Zoning and Circulation, (2) Wayfinding and Legibility, (3) Multimodal Integration, (4) Inclusivity and Accessibility, and (5) Safety and Security.

2.2. Case Study Selection

A purposeful sampling strategy was used to select five illustrative case studies for in-depth analysis. Selection was based on two primary criteria:

- Exemplary Global Hubs: Terminals internationally recognized for innovative design and circulation efficiency, including Rotterdam Central Station (Netherlands), Anaheim Regional Transportation Intermodal Center (ARTIC) (USA), and Salerno Maritime Terminal (Italy).
- Local Nigerian Terminals: Facilities within Lagos exhibiting characteristic circulation and operational challenges, specifically the Ikorodu Ferry Terminal and the LASWA Five Cowries Terminal (Falomo).

This dual approach enabled a comparative analysis that situates Lagos's specific challenges within a global discourse of best practice

2.3. Data Collection and Site Appraisal

Data for each case study was collected through document analysis and structured observational review.

- Document Analysis: For all cases, this involved reviewing architectural plans, design publications, project reports, and secondary data to understand the intended spatial design and operational strategies.
- Observational Review: For the local Lagos cases, this was supplemented with direct site visits. Structured observational audits were conducted at the Ikorodu and Five Cowries terminals during both peak and off-peak hours. These audits focused on mapping passenger flow patterns, identifying bottlenecks, assessing the clarity of wayfinding systems, and evaluating the quality of intermodal connections.

2.4. Comparative Analysis and Design Synthesis

The collected data from both the literature and case studies was analyzed thematically using the five-dimensional framework established in Phase 1. Each case was evaluated and compared based on its performance across these dimensions. The analysis specifically benchmarked the operational deficiencies and spatial configurations observed in Lagos against the design principles and successful strategies implemented in the international benchmarks. The final phase involved design synthesis, translating the comparative findings into actionable, evidence-based spatial design recommendations and criteria tailored to the Lagos context.

3. Results and Discussion

A comparative analysis of international benchmarks and local case studies revealed significant disparities in spatial design strategies, with direct implications for circulation efficiency. The findings are structured around five key design approaches derived from the literature, providing a framework to systematically evaluate and contrast terminal performance. The core insights from this comparative analysis are summarized in Table 1.

Table 1 Comparative Analysis of Design Strategies in Ferry Terminal Case Studies

Design Approach	Global Case Studies (Rotterdam, ARTIC, Salerno)	Lagos Case Studies (Five Cowries, Ikorodu)	Derived Design Strategies
Spatial Zoning & Hierarchy	Clear separation of arrival, departure, and transfer zones; multi-level circulation to avoid flow conflicts.	Poorly defined zones; embarking/disembarking often overlap, causing congestion.	Introduce hierarchical circulation (vertical layering, separate flows).

Wayfinding & Legibility	Strong visual cues, transparent façades, centralized atriums, and intuitive signage.	Navigation depends on habitual users' mental mapping; poor visibility of signage; unclear boarding points (esp. Ikorodu).	Embed legibility in design via open sightlines, high-contrast signage, and intuitive circulation paths.
Multimodal Integration	Seamless links to rail, metro, bus, and pedestrian networks (e.g., Rotterdam's hub model).	Weak integration with road transport; lack of pedestrian/bus connectivity.	Create intermodal hubs with pedestrian-friendly pathways and bus/rail interfaces.
Inclusivity & Accessibility	Universal design: ramps, elevators, tactile paving, and accessible waiting zones.	Limited provision for persons with disabilities; access routes often obstructed.	Embed universal design principles into circulation systems for inclusivity.
Cultural & Symbolic Design	Salerno terminal uses metaphorical form to guide circulation; ARTC reflects regional identity.	Cultural expression is minimal; circulation lacks symbolic guidance.	Integrate cultural narratives and symbolic spatial cues to enhance legibility and identity.

3.1. Spatial Zoning and Hierarchical Circulation

Efficient terminals employ a hierarchical spatial structure to segregate different flows. In Rotterdam Central Station, embarking, disembarking, and transfer movements are clearly separated across multiple levels, significantly reducing conflict points (East & Armstrong, 1999). Similarly, the Anaheim Regional Transportation Intermodal Center (ARTIC) uses a central atrium to radially distribute passenger flow.

By contrast, Ikorodu and Five Cowries terminals lack deliberate zoning. Field observations indicated overlapping circulation of passengers, baggage, and waiting areas, creating chronic bottlenecks during peak boarding periods. Belema and Abbey (2024) also identified poor spatial sequencing as a primary cause of congestion in Lagos ferry nodes. These results confirm that without zoning and vertical layering, circulation efficiency remains unattainable.

3.2. Wayfinding and Legibility

Legibility is central to circulation efficiency, allowing passengers to orient and move with minimal cognitive effort. International exemplars embed this into architectural form: Salerno's metaphorical geometry directs passengers seamlessly toward embarkation, while ARTIC's transparent atrium enables orientation from any vantage point (Ryan & Imaah, 2022). These precedents illustrate that when wayfinding is integrated into spatial design rather than dependent on signage, circulation becomes intuitive and resilient to user familiarity.

In Lagos terminals, however, navigation relies heavily on commuters' prior experience. Franklin and Gam (2022) found that most Five Cowries users navigate effectively through mental mapping developed over repeated use, while first-time visitors struggle with poor signage visibility and unclear boarding points, particularly at Ikorodu. This reliance on learned familiarity compromises inclusivity, increasing hesitation, backtracking, and congestion. To optimize circulation, Lagos ferry terminals must shift from user-dependent navigation to design-embedded legibility through open sightlines, high-contrast signage, and intuitive spatial zoning.

3.3. Multimodal Integration

Rotterdam exemplifies seamless multimodal connectivity, linking ferries with rail, tram, and pedestrian routes in a continuous, weather-protected system (Pace & Ricci, 2018). Integration ensures passenger movement is uninterrupted beyond the terminal interface.

In Lagos, terminals function as isolated transport islands. At Five Cowries (Falomo), connections to buses and taxis are informal and congested, while pedestrian access is fragmented. This disconnect reduces the terminal's potential to ease urban congestion. Dagogo and Tamunoiminabo (2020) emphasize that terminal efficiency is nullified without integration into the broader transport ecosystem.

3.4. Inclusivity and Accessibility

International cases embed universal design features; ramps, elevators, tactile paving, into circulation systems, ensuring equitable access without impeding flow. These provisions demonstrate how inclusivity and efficiency can be mutually reinforcing. Lagos terminals, however, neglect accessibility. Ikorodu's stair-only chokepoints constrain not only persons with disabilities but also crowd circulation. This finding validates Izobo-Martins (2020), who asserts that inclusivity is not supplementary but foundational to efficient and equitable mobility.

3.5. Cultural and Symbolic Design

Salerno's maritime terminal illustrates how cultural metaphor can double as a circulation tool, with form symbolically directing passenger movement. Similarly, ARTIC integrates regional identity within its spatial logic, reinforcing place attachment and orientation.

In Lagos, terminals present minimal cultural cues, leading to generic environments where circulation lacks symbolic reinforcement. The absence of narrative expression diminishes legibility and weakens public engagement. This confirms Hee (2005), who argued that embedding cultural narratives strengthens both spatial coherence and user identity.

3.6. Synthesis: A Five-Pillar Design Framework for Lagos

The comparative analysis demonstrates that circulation deficiencies in Lagos terminals stem from systemic neglect of integrated design. Effective terminals treat zoning, wayfinding, multimodal integration, inclusivity, and cultural symbolism as interdependent pillars of spatial design.

This study therefore proposes a Five-Pillar Framework for Ferry Terminal Design in Lagos:

- Hierarchical Zoning – vertical and functional separation of flows.
- Legible Wayfinding – open sightlines, transparent forms, and intuitive signage.
- Seamless Integration – structured connections with road, rail, and pedestrian systems.
- Universal Accessibility – circulation inclusive of all user groups.
- Cultural Symbolism – spatial narratives reinforcing orientation and identity.

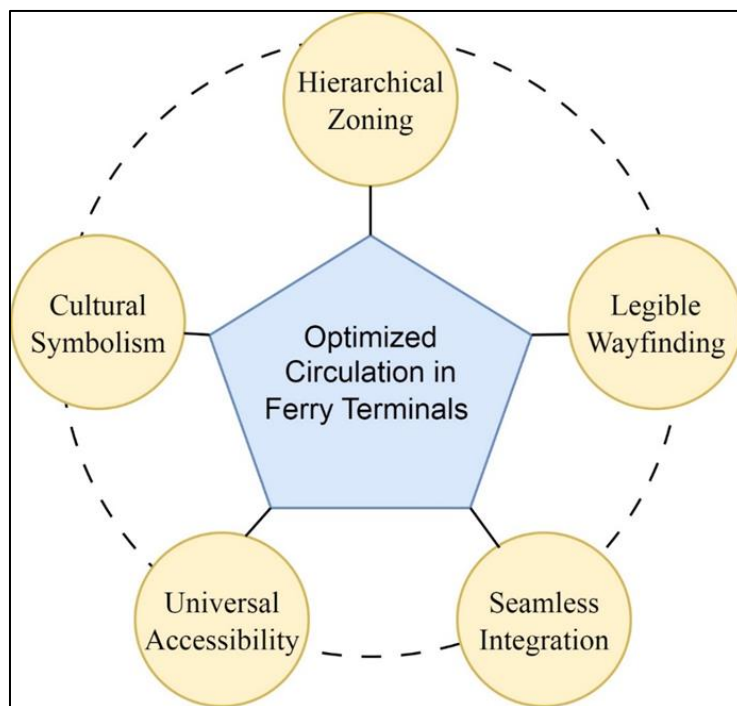


Figure 2 Conceptual diagram of the proposed five-pillar design framework for Lagos ferry terminals

Figure 2 illustrates the conceptual model of this Five-Pillar Framework, while Figure 3 applies it to Lagos terminals, showing how zoning, wayfinding, integration, accessibility, and cultural overlays can be synthesized in practice. The

framework translates into actionable strategies summarized in Table 2, which consolidates design recommendations directly addressing the observed challenges in Lagos ferry nodes.

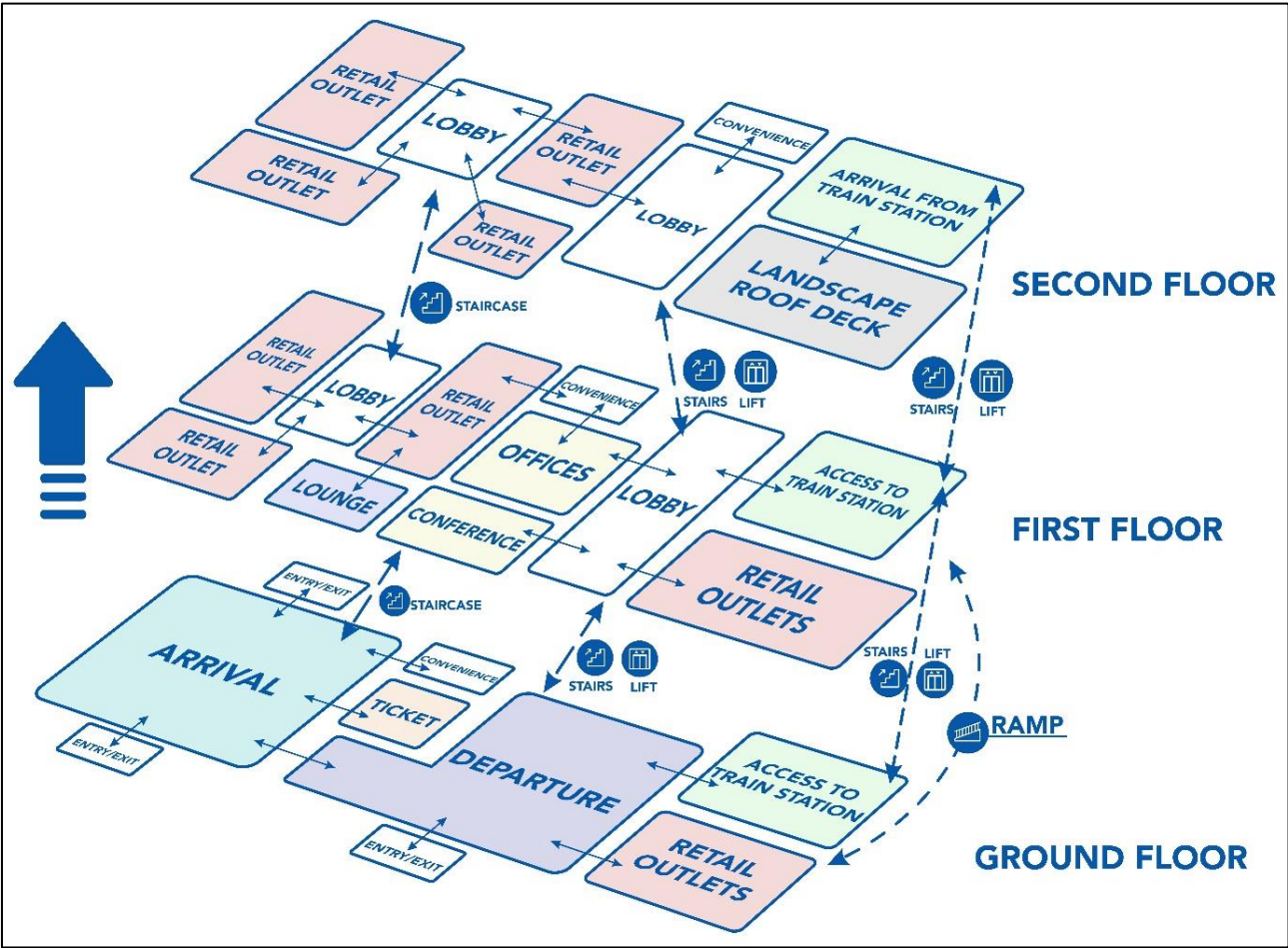


Figure 3 Applied Schematic for Circulation Optimization in Lagos Ferry Terminals

Building on the proposed framework (Figures 2 and 3), Table 2 consolidates actionable recommendations that directly address the spatial and operational challenges observed in Lagos ferry terminals

Table 2 Framework-Based Design Recommendations for Optimizing Circulation in Lagos Ferry Terminals Design

Observed Terminals)	Challenge (Lagos	Derived Design Recommendation
Overlapping flows	embarking/disembarking	Introduce hierarchical zoning with vertical and functional separation of movements.
Poor signage and path	unclear navigation	Integrate legible wayfinding through open sightlines, transparent façades, and high-contrast signage.
Weak multimodal (bus/pedestrian)	connections	Develop structured multimodal interfaces with dedicated pedestrian walkways and bus/rail linkages.
Limited accessibility provisions		Embed universal design principles; ramps, tactile paving, elevators, and unobstructed circulation routes.
Minimal cultural cues and identity		Incorporate culturally resonant motifs and spatial narratives to reinforce orientation and identity.
Inadequate safety integration		Design circulation systems with clear egress routes, passive surveillance, and defined security zones.

Optimizing circulation in Lagos requires adoption of this holistic framework rather than piecemeal interventions. The derived strategies in Table 1 and specific recommendations in Table 2 provide a direct bridge between global best practice and locally grounded design solutions.

4. Conclusion

This study developed a five-pillar spatial framework that addresses circulation deficiencies in Lagos's ferry terminals, demonstrating that integrated design strategies significantly enhance passenger flow efficiency. The implementation of this framework will benefit society by transforming ferry terminals into efficient, accessible transport hubs that alleviate urban congestion and promote sustainable mobility, while future research should explore practical implementation and quantitative validation of these design principles.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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