

Assessing Spatial Deficiency in Design Response: Evidence-Based Spatial Strategies for Low-Rise Multi-Family Housing in Peri-Urban Nigeria

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Abstract

Rapid growth along the Abuja–Keffi corridor has pushed housing in Greater Karu towards multi-storey construction, yet many completed low-rise schemes still show rigid layouts, poorly placed storage and weak passive cooling. This exploratory case study paired measured spatial metrics with interviews of residents and built-environment professionals across four local developments. Four indicators, Net-to-Gross Ratio, Circulation Factor, Floor Area per Person and Wall-to-Floor Ratio, were calculated for each case and read alongside the qualitative findings. Fragmented circulation, poor vertical access, uneven room sizes and a mismatch between standard kitchens and local cooking habits recurred across the sample. These findings shaped a design proposal built around dual protected stair cores, a modular grid with adaptable partitions, consolidated wet-wall servicing, distributed storage and a hierarchical waste strategy. As the prototype has not been built, its calculated performance is offered as a design target rather than a validated outcome. Given the small qualitative sample, the findings are presented as evidence from four specific cases rather than a claim about the wider corridor, though they suggest useful directions for revising local spatial standards in peri-urban multi-storey housing.

Keywords: Space Optimisation; Low-Rise Multi-Family Housing; Peri-urban Housing; Post-Occupancy Evaluation; Nasarawa State; Passive Design; Modular Partitioning

1. Introduction

Housing is more than shelter. It has to work structurally, sit comfortably in its climate, and support the day-to-day rhythm of a household over years of use (UN-Habitat, 2022). Peri-urban zones under land pressure have responded to this demand by building upward, and Greater Karu, in Nasarawa State, is a clear example. Its position next to the Federal Capital Territory has drawn sustained in-migration, and settlements that were once peripheral have grown into dense residential corridors within a short span of years (Rikko & Shola, 2013; Rikko et al., 2019). Local assessments of Karu itself confirm the strain this growth places on basic services and living conditions (Junaid et al., 2021; Mutaka et al., 2023). Because Nasarawa State restricts residential buildings to four storeys including the ground floor, the low-rise condominium has become the main formal answer to scarce land.

Vertical density on its own, though, does not guarantee a liveable home. Many completed schemes in Karu and the surrounding corridor share the same faults. Rooms are fixed into rigid divisions that cannot flex as a household grows or its routines change. Storage is treated

as an afterthought and ends up crowding corridors or bedrooms instead of sitting where it is needed. Orientation, cross-ventilation and solar shading are frequently ignored, leaving interiors uncomfortably hot for much of the year. Services are often added once the building shell is finished rather than planned alongside it, which creates both maintenance difficulty and visible clutter. Nigerian studies confirm both strands of this failure: energy performance is rarely designed in from the outset (Ochedi & Taki, 2022), and poor maintenance planning shortens a building's working life well before it reaches old age (Obarisiagbon et al., 2026). Both findings are drawn from single-context research, Ochedi and Taki's framework was developed for Lokoja rather than Karu, and Obarisiagbon et al.'s maintenance survey is not specific to Nasarawa State, so their relevance here is inferred rather than demonstrated. Taken together, these problems mean that many of these buildings hold more residents than their layouts were ever designed to support comfortably, and residents absorb that cost daily. Growth in Greater Karu has consistently outpaced the capacity of formal planning, producing a mix of properly built multi-storey blocks and semi-formal extensions built with little guidance. With no locally developed design standard to work from, developers tend to do one of two things: copy plan types from metropolitan Abuja, or improvise layouts that squeeze in extra lettable rooms at the cost of circulation, storage and comfort. What results is a stock of housing that meets density targets on paper while residents keep raising the same complaints, of overcrowding and of being unable to adapt their homes as circumstances change. Affordability pressure pushes many households towards exactly this kind of compromise (Tyonum & Gogo, 2025), and residents often alter their units without professional input once official channels fall short (Ale et al., 2026). Closing this gap needs more than borrowing space-saving techniques from elsewhere. It needs a proper diagnosis of what is failing locally, followed by design responses that can actually be built, afforded and accepted within a North-Central Nigerian context.

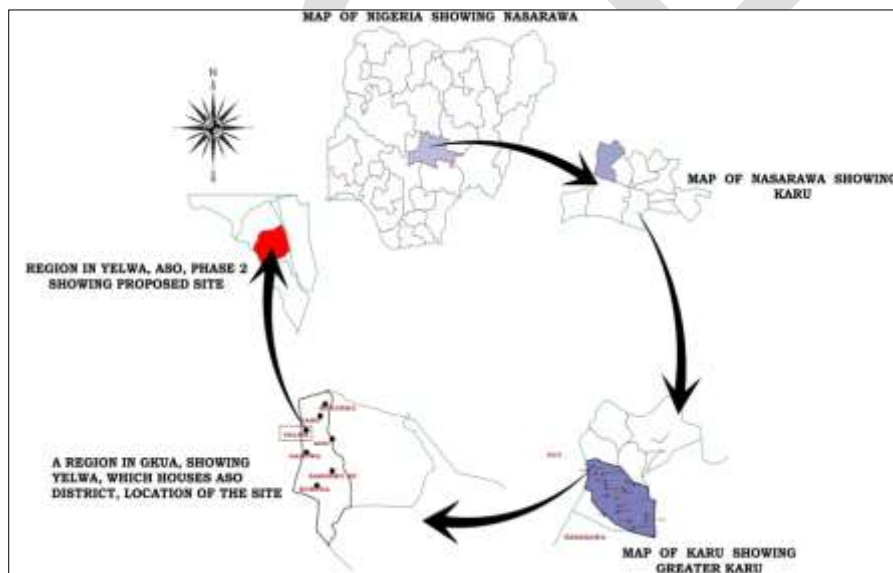


Figure 1: Map Showing the Location of the Site for the Proposed Design

Source: Drafted by Author

Most published research on space-efficient multi-family housing looks at high-rise examples from Asia and Europe. Secondary cities and peri-urban settlements in Nigeria have had far less attention, leaving both designers and regulators short of locally grounded evidence. Comparable work exists elsewhere: tall building typologies have been benchmarked for space

efficiency across a large international sample (Ilgin & Aslantamer, 2024), shared public space has been reworked through modular strategies (Shi et al., 2025), communal space design in high-rise apartments has been reviewed with attention to layout and resident use (Wu & Ge, 2020), and communal layout has been linked to resident interaction in low-income high-rise housing in Hanoi (Nguyen et al., 2026). These studies agree that spatial layout measurably shapes efficiency and social outcomes, which supports this study's own approach, but each is set in high-rise construction and a different climate, income structure or regulatory regime, so they offer a comparison point rather than a standard that transfers directly. None examine low-rise peri-urban Nigeria directly. Post-occupancy evaluation has been applied to Nigerian public housing (Ibem et al., 2023), but not yet to the peri-urban low-rise typology this study addresses. This article works from that gap. It reports a research-through-design study that began by assessing spatial and functional performance in existing low-rise developments, and then carried that evidence into a context-specific design proposal. The central claim is a modest one: density and a comfortable home are not naturally opposed. They become compatible once design decisions respond properly to local climate, construction methods and the way households actually use domestic space.

Five research questions, carried over from the thesis this article is drawn from, guided the study:

1. What architectural strategies are relevant to optimising space and functionality in multi-storey residential developments?
2. What spatial and functional limitations exist within current multi-storey developments?
3. How do residents experience space adequacy and functionality in existing condominium and multi-storey units?
4. Which architectural design approaches from similar contexts effectively optimise space and functionality in multi-storey housing?
5. How can these strategies be incorporated into a prototype design to improve spatial utilisation and functionality in future condominium developments in Karu?

The article proceeds in five further sections. Section 2 sets out the theoretical framework. Section 3 describes the research design and how cases were selected. Section 4 reports the empirical findings, grouped under spatial efficiency, circulation and privacy, and environmental and cultural adaptation. Section 5 introduces the concept and evaluates its calculated performance against the same four metrics. Section 6 discusses what the findings mean and closes with recommendations for architects, developers, regulators and future research.

2. Theoretical and Conceptual Framework

Three theoretical lenses shape the analysis. Habraken's Supports and Infill theory (1972) separates permanent shared structure from the adaptable, resident-controlled fit-out; where the two are fused, households cannot adjust their layout as family size or livelihood changes (see Figure 2). Alexander's Pattern Language (1977) contributes two practical criteria: every room should receive light from two sides, and circulation should follow an intimacy gradient from public to private space. A room lit and ventilated from only one side, deep in the plan, tends to trap heat, and this becomes acute during the dry season when daytime temperatures regularly increase (see Figure 3).

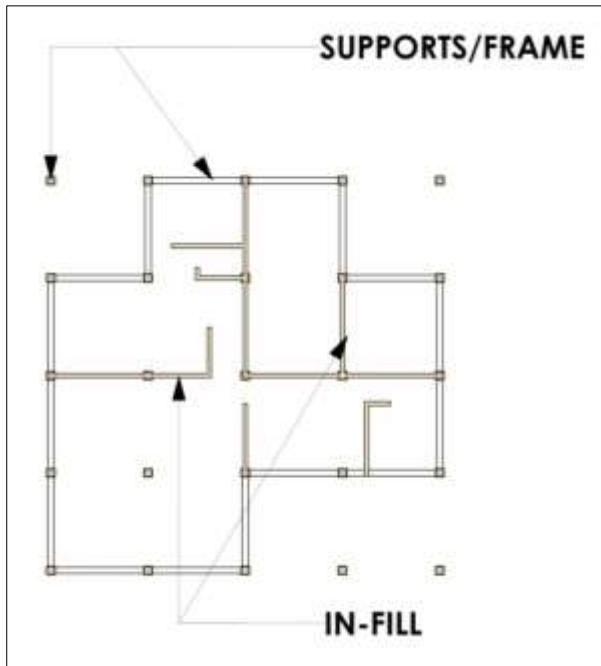


Figure 2: Habraken's Support and Infill Theory in Design
Source: Drafted by Author

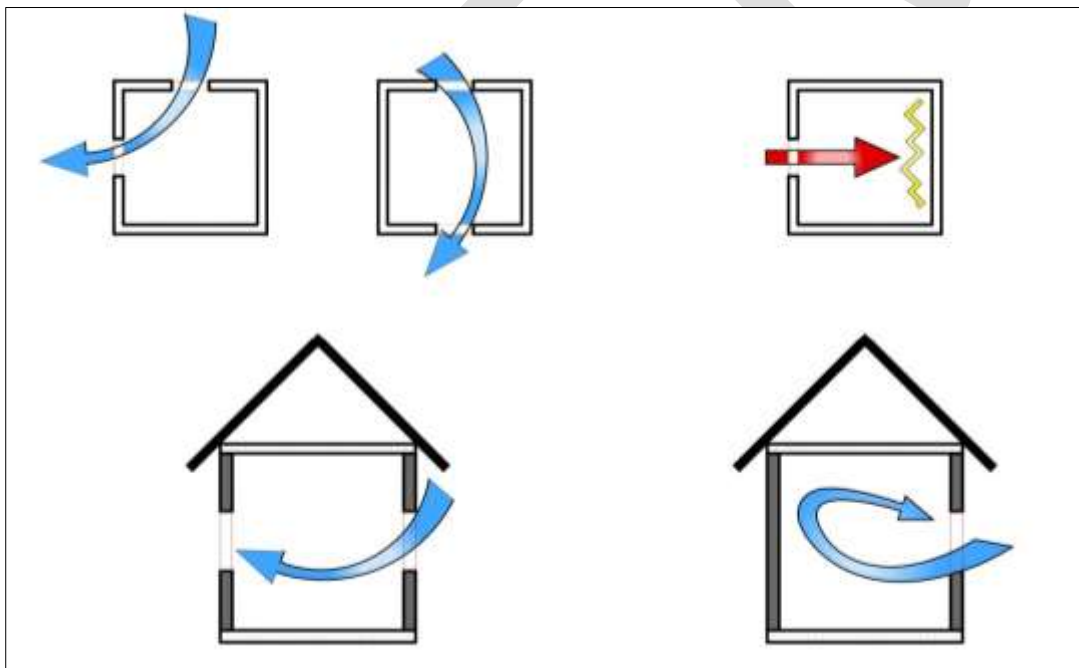


Figure 3: Alexander's Pattern Language Depicting the Principle of Light from Two Sides Arrangement against a Single Aspect Arrangement
Source: Drafted by Author

Rapoport's environment-behaviour theory (1969) argues that domestic space cannot be judged by dimensions alone. Cultural convention, household routine and the small adaptations residents make when a design lets them down are just as much a measure of performance. Nigerian domestic life often keeps 'wet' cooking activity apart from cleaner preparation and storage areas, uses transitional outdoor space for gathering, and absorbs

multi-generational or fluctuating household sizes. Where a design ignores these patterns, residents adapt informally in ways that can compromise safety, comfort or the building fabric itself. This lens is what directed attention, later in the fieldwork, towards the wall demolitions, outdoor cooking and room-swapping that residents described, treated here as evidence rather than as anomalies.

Together, these three frameworks set a dual standard for any optimisation strategy: it has to be measurably efficient, and it has to sit comfortably with how people actually live. Four benchmarks, Net-to-Gross Ratio, Circulation Factor, Floor Area per Person and Wall-to-Floor Ratio, were used alongside the qualitative account of how space is used and modified. Net-to-Gross Ratio shows the share of gross floor area that is actually usable; Circulation Factor isolates the proportion given to movement rather than habitable use; Floor Area per Person checks occupancy against established minimums; and Wall-to-Floor Ratio indicates how heavily a plan is partitioned. Used together, they allow the case studies to be assessed against ranges established in the literature rather than by impression alone.

3. Research Approach

This is an exploratory multiple-case study, aimed at depth of understanding within four specific developments rather than statistical generalisation across the wider corridor. A convergent parallel mixed-methods case study design combined two strands of evidence. The qualitative strand recorded how residents and professionals actually experienced space adequacy, circulation, storage, comfort and adaptability. The quantitative strand measured spatial indicators from surveyed floor plans. Both were collected over a six-week fieldwork period and brought together at the interpretation stage. Data collection continued until thematic saturation was reached: recurring concerns, tight communal stairs, undersized kitchens and a lack of storage, stopped generating new themes by the later resident interviews, with subsequent conversations confirming and refining what had already emerged rather than introducing new material. Given the focused nature of the inquiry, spatial and functional performance within a specific housing typology, saturation was considered achieved within the four selected developments. Four local developments were selected against explicit criteria: low-rise, multi-storey typology; occupied status; variation in unit configuration; visible evidence of either spatial inefficiency or good practice; and practical access for measurement and interview. The sample comprised a four-storey, high-density block in Garki Area 2 (Uromi Close), a two-storey development in the Nyanya–Karu corridor, a three-storey compact development on Bendel Street, Garki, and a three-storey communal-model development on Igbodo Road, Karu. A limitation of this design is that household income, family size and the standard of building maintenance were not controlled for across the four cases, and each is likely to have shaped how residents experienced and adapted their units independently of the architectural layout itself. Measuring these systematically was beyond the scope of a Master's-level fieldwork period, and the findings below should be read with that constraint in mind. Sixteen participants took part through stratified purposive sampling: ten residents with at least twelve months of occupancy, drawn across two-, three- and four-bedroom units, and six built-environment professionals with a minimum of five years' experience in the design, construction or management of low-rise residential projects in the Abuja–Nasarawa corridor. Given this sample size, the qualitative findings are treated here as evidence from four specific cases rather than as a claim that can be generalised across the wider urban corridor. Semi-structured interviews were paired with structured observation, using a checklist that rated seven spatial elements, living room, kitchen, bedrooms, circulation (corridors and stairs), bathrooms/WC, storage and the unit

overall, against criteria including space adequacy, natural lighting and ventilation, privacy, storage accessibility, ease of movement, fixture provision and adaptability, each scored on a five-point scale with supporting remarks (Table 1). Residents are identified in Table 1 by case-linked codes: RES-01-GARKI and RES-02-GARKI (Uromi Close, Garki); RES-01-NYANYA-KARU to RES-03-NYANYA-KARU (Nyanya–Karu); RES-01-GARKI2 and RES-02-GARKI2 (Bendel Street, Garki); and RES-01-KARU to RES-03-KARU (Igbodo Road, Karu). Measured drawings supplied the dimensional data behind the four spatial metrics.

Table 1

Aggregate Post-Occupancy Evaluation Scores by Spatial Element (n = 10 residents)

S/N	Spatial Element	Performance Criterion	Mean Rating (1–5)	Remarks Summary
1	Living Room	Adequacy of space for activities	3.4	Rated adequate to good (range 2–5); lowest score from RES-03-NYANYA-KARU.
		Natural lighting quality	3.3	Range 2–4 across units; no scores below 2.
2	Kitchen	Efficiency of work triangle (movement)	3.2	Range 2–5; kitchen movement rated inconsistently across cases.
		Storage adequacy	2.5	Lowest-rated criterion in the instrument (range 1–5); several 1s and 2s recorded.
		Ventilation and thermal comfort	3.6	Highest-rated kitchen criterion (range 3–5).
3	Bedrooms	Privacy level	3.4	Range 2–5; one low score (RES-03-NYANYA-KARU, 2).
		Space adequacy	3.2	Range 2–5, clustered mainly at 3.
		Natural lighting and ventilation	3.4	Range 2–4, clustered at 3–4.
4	Circulation (corridors, stairs)	Ease of movement	3.3	Range 2–4, evenly split between 3 and 4.
		Space efficiency (no wasted space)	3.3	Range 1–5; one notable low score (RES-03-NYANYA-KARU, 1).
5	Bathrooms/WC	Functional layout	3.2	Range 2–4.

		Adequacy of fixtures and fittings	3.3	Range 3–4, generally favourable.
6	Storage spaces	Availability and accessibility	2.2	Weakest overall score in the table, range 1–4.
7	Overall unit	Space optimisation (overall efficiency)	3.3	Range 2–4, generally consistent across units.
		Adaptability / flexibility of spaces	2.9	Widest spread of the Overall Unit criteria (range 1–4).
		Overall user satisfaction	3.2	Range 2–4, mid-range satisfaction overall.

Note. Mean ratings are drawn from ten completed observation checklists (n = 10).

Braun and Clarke's (2021) reflexive thematic analysis structured the qualitative work, guided by a codebook built deductively from the concepts of spatial integration, circulation efficiency and modular adaptability. Practising architects reviewed the instruments for content validity, and both instruments were piloted in comparable residential settings before use. Instrument development moved in stages. Early question themes came from the literature on space adequacy, circulation and environmental performance. Draft instruments went through review by the research supervisor and by practising architects familiar with the regional construction context, checking that the technical language and parameters held up. A pilot conducted with residents in Federal Housing Nyanya and Garki Area 2 led to extra probes on informal spatial adaptation, matching the research question on how occupants perceive and modify their units. An audit trail covering transcripts, coding decisions and calculation spreadsheets supported dependability, and the same architectural formulae were applied consistently across every case to keep the quantitative side reliable.

Table 2 sets out the formula, purpose and benchmark applied to each metric. Three of the four draw on published good-practice benchmarks; no external published benchmark exists for internal Wall-to-Floor partitioning in this context, so that row instead reports a study baseline target derived from the lowest-performing case (Uromi Close). The resulting figures for each case are reported in Table 3.

Table 2
Quantitative Spatial Metrics Evaluated

Spatial Metric	Formula / Measurement Method	Purpose / Indicator of Performance	Target or Good-Practice Benchmark
Net-to-Gross Ratio	Net Usable Floor Area (excluding lobbies, stairs, lifts, structural walls, service ducts)/Gross Floor Area x 100%	Measures spatial efficiency and usable space yield per block.	75% – 85%
Circulation Factor	Horizontal & Vertical Circulation Area/Gross Floor Area x 100%	Evaluates space lost to corridors and stairwells.	15% – 20%
m² per person	Usable Unit Area/Number of Occupants	Assesses liveability, personal space allocation, and crowding.	≥11m ² /person
Wall-to-Floor Ratio	Total Internal Wall Area/Total Floor Area	Assesses structural efficiency and thermal mass exposure (dimensionless ratio of wall area to floor area).	Study Baseline Target (Uromi Close): ≤2.20 not a published good-practice benchmark; see note.

Note. Only the Wall-to-Floor Ratio benchmark is internally derived; the other three are drawn from published literature. This study measures internal wall area against floor area, since the research question concerns partitioning density and modifiability rather than envelope cost. No established benchmark exists for this internally focused formulation in the Nigerian or wider Sub-Saharan African context; the target adopted here is therefore drawn from the lowest value recorded among this study's own case studies (Uromi Close), pending the development of a context-specific published benchmark.

The geographic scope centred on Karu Local Government Area and comparable isoclimatic zones within the Abuja corridor, which allowed bioclimatic performance to be read consistently across cases. The investigation was limited to low-rise buildings of one to four storeys, and excluded high-rise construction, purely commercial buildings, and detailed structural or cost-quantity analysis. These boundaries kept the study focused while still covering the typological range most relevant to current regulatory and market conditions in the study area.

4. Empirical Insights from the Case Studies

4.1 Spatial Efficiency and Structural Rigidity

Performance varied noticeably across the four cases. The three-bedroom units at Uromi Close reached a Net-to-Gross Ratio of around 75% and a generous floor area per person under standard occupancy assumptions, showing that habitable-area economy is achievable within local resource constraints. Built-in wardrobe storage in each bedroom and a self-contained master suite supported both storage and privacy. The same development, though, recorded a circulation factor well below the recommended 15–20% building-scale range. That shortfall coincided with more than inconvenience: neighbouring households had knocked down internal walls to add bedrooms or absorb balcony space into habitable rooms, and one household had enclosed an external escape stair for storage. Household income and family size, not systematically measured in this study, may also have shaped these decisions: RES-01-GARKI described a multi-generational household of variable size (parents, siblings and occasional extended family), a size that plausibly drove some of the space pressure reported here independently of the unit's design. That last adaptation preceded a fire-safety incident in which a neighbour escaped only through another unit. High Wall-to-Floor ratios and permanent masonry partitions further limited long-term adaptability; in Habraken's terms, structure and infill had been fused, leaving residents no sanctioned way to reconfigure their homes.

The Nyanya–Karu units fell below benchmark on both Net-to-Gross Ratio and circulation factor at once. Fragmented transitional spaces, an entrance, an anteroom and several lobbies, used up wall footprint without giving a coherent sense of privacy. Actual occupancy sat well below design capacity, which inflated floor-area-per-person figures and masked the underlying inefficiency of the plan; RES-01-NYANYA-KARU, a newly married resident sharing the unit only with her husband, reported the same fragmentation despite this low occupancy, suggesting the failure lies in the layout itself rather than in crowding. Residents had moved cooking onto undersized kitchen verandas because the enclosed kitchen could not cope with heat and smoke. At site level, a generator placed next to habitable openings blocked what could have been a useful cross-ventilation path, and sparse planting reduced whatever microclimatic benefit shaded ground cover might otherwise have offered.

The Igbodo Road development recorded the lowest Net-to-Gross Ratio and the highest Wall-to-Floor Ratio of the four Nigerian cases. It used broadly the same construction technology as the better-performing Uromi Close units, yet four separately partitioned bedrooms and three separate bathrooms packed into a constrained footprint produced substantial spatial inefficiency. Its shared 900 mm stair, serving two mirrored units per landing, did not register in the unit-level circulation factor at all, yet it was the single most consistently reported problem among residents there. That finding makes a methodological point on its own: metrics measured within a unit's envelope cannot capture how well shared vertical access performs, and it set a concrete lower bound that the prototype's stair width had to exceed.

4.2 Circulation, Privacy and Vertical Access

Bendel Street showed the sharpest failure of entry sequence. Its stairwell landing opened straight into the living room, with no buffer between shared circulation and private domestic space. Residents described a persistent loss of privacy as a result, and said cross-ventilation felt like 'a war', with some bedrooms becoming 'complete ovens' by afternoon. The unit's high Wall-to-Floor Ratio, relative to its compact floor area, tracked closely with these thermal complaints. Across the sample as a whole, undersized shared staircases came up as a complaint independent of unit-level circulation figures. At Igbodo Road, several residents

separately named the 900 mm winding stair, serving two units per landing, as too narrow for comfortable movement or for carrying goods, a complaint sharpened for RES-01-KARU, whose household runs a home baking and tailoring trade alongside civil-service work and so moves goods through that stair daily. This confirms that a circulation factor calculated only within a unit's own envelope misses how well a shared vertical core actually performs, a limitation that matters directly for any low-rise strategy built around semi-private stair clusters.

4.3 Environmental Adaptation and Cultural Mismatch

Thermal discomfort drove several forms of behavioural adaptation. Some residents moved between rooms through the day to escape heat building up in living areas; others shifted cooking outdoors entirely. Storage placed in marginal rooms or inside escape-stair enclosures sat largely unused, while belongings piled up instead in kitchens and dining areas. These patterns support Rapoport's argument that a design has to be judged against the domestic routine it is meant to serve. What mattered was not how much storage existed but where it sat relative to the activity generating the need for it. In the same way, kitchens that ignored the heat and smoke of everyday cooking simply pushed activity outdoors or trapped odours inside, confirming a real mismatch between standard enclosed-kitchen layouts and local culinary practice. This pattern of residents altering standard layouts to fit real use is consistent with wider findings on user-initiated modification in Nigerian apartment buildings (Ezeokoli et al., 2022).

Four themes ran through the qualitative material drawn from the sixteen participants. First, structural inflexibility against domestic need: both residents and professionals pointed to permanent load-bearing partitions as a barrier to the reconfiguration that a growing household or a change in livelihood demands. Second, environmental adaptation through spatial reallocation: cooking, sleeping and storage activity shifted routinely in response to thermal and spatial pressures the original design had not anticipated. Third, modular shortfalls that waste material: practitioners repeatedly named the absence of a standard dimensional grid as a source of construction inefficiency and a barrier to cost-effective, prefabricated partitioning. Fourth, vertical access as a distinct and under-measured constraint: shared stair performance surfaced as a complaint independent of unit-level metrics and needs its own design attention. Read together, these themes point to one conclusion: the most serious failures were not simple shortages of floor area, but mismatches between how a design was organised and how households actually live in and adapt the space. Table 3 below sets these patterns against the measured figures, comparing all four case studies with the proposed prototype across the same four metrics.

Table 3

Comparative Spatial Metrics across the Four Case Studies and the Proposed Prototype

Case	Net-to-Gross Ratio	Circulation Factor	Floor Area	Wall-to-Floor Ratio
Part A: Measured Case Studies (Empirical Field Data)				
Uromi Close (3-bed)	75.1%	6.6%	16.0 m ² /persons	2.20
Nyanya–Karu bed and 2-bed)	(3- 72.6% (3-bed) – 71.2% (2-bed)	9.9% (3-bed) – 11.7% (2-bed)	10.0 m ² /person (3-bed) – 12.2 m ² /person (2-bed)	2.33 (3-bed) – 2.27 (2-bed)
Bendel Street (2-bed)	66.1%	6.6%	14.35 m ² /person	2.86
Igbodo Road (4-bed)	62.58%	8.13%	9.63 m ² /person	3.65 (highest)
Part B: Proposed Prototype (Calculated Design Targets)				
Proposed Prototype (2-bed)	71.94%	9.5%	11.7 m ² /person (smallest room selected) (exceeds 11 m ²)	3.67 (declines with size)
Proposed Prototype (3-bed)	75.42%	8.4%	12.5 m ² /person (smallest room selected) (exceeds 11 m ²)	3.36 (declines with size)
Proposed Prototype (4-bed)	80.39%	10.4%	12.4 m ² /person (smallest room selected)(exceeds 11 m ²)	2.78 (declines with size)

Note. Part A rows (Uromi Close, Nyanya–Karu, Bendel Street, Igbodo Road) report figures measured from surveyed floor plans of occupied buildings. Part B rows (the three Proposed Prototype configurations) report figures calculated from architectural drawings for a design that has not been built or post-occupancy tested; these are design targets, not measured outcomes. Case-study floor area per person uses design-capacity occupancy (two persons per bedroom); prototype figures use each bedroom's own area per single occupant, so the two sets are not directly comparable.

5. Prototype Development: A Design Proposition

This section presents the Diffused Compound as a design proposition rather than a tested outcome. It translates the problems diagnosed in Section 4 into a spatial strategy for a 2.9-hectare site in the Aso District of Greater Karu, evaluated below through calculated projections rather than post-occupancy measurement. The Diffused Compound reinterprets the traditional Nigerian compound typology, spreading the familiar public-to-private hierarchy across the whole site rather than containing it within a single walled enclosure.

Across the residential cultures that have shaped housing in the North-Central zone, the compound has historically organised domestic life through a sequence of thresholds: a public forecourt, a semi-public reception court, a family quarter shared among household members, and an innermost private realm of sleeping and personal space. The Diffused Compound keeps that logic while adapting it to multi-household, multi-storey conditions.

At site scale, public amenities sit on the perimeter, recreational facilities consisting of a park and basketball court to the north, acting as the public zone, while residential clusters occupy the more protected interior. Circulation now runs through two separate vehicular accesses instead of one shared route: a service entrance to the north-east and a main entrance to the east, with cars exiting through a dedicated gate to the south. This contributes to the easing of movement between the public edge and the residential core. Two retention pools have also been added to the site, cooling the microclimate and cutting down on storm water runoff. At block scale, each cluster is organised around a semi-private courtyard that works both as a social threshold and as the pressure-difference zone driving cross-ventilation through the surrounding wings. Access to each forecourt is limited to that cluster's own residents, which supports neighbourly familiarity without forcing intimacy. At unit scale, the intimacy gradient runs from general entry through an entrance lobby and open-plan living-dining space towards the more private sleeping zones, buffered by bathroom and storage space.

5.1 Unit Organisation and Modular Coordination

Three unit types, two-, three- and four-bedroom, sit on a consistent 3750 mm structural grid with 1875 mm sub-modules, calibrated to a 230 mm stabilised mud block module. The unit mix favours two-bedroom dwellings (about 57% as drawn, from a 60% baseline), reflecting market demand and financial viability in the lower-middle-income segment, with three-bedroom units next and four-bedroom units least represented. Load-bearing elements sit on the perimeter, freeing internal partitions for adaptability. Non-load-bearing 150 mm masonry partitions let households adjust secondary room boundaries without structural work, putting Habraken's support-infill distinction into practice. Wet zones align along shared service walls to shorten pipe runs, cut potential leak points and simplify long-term maintenance. Built-in storage sits next to kitchen and dining areas, where fieldwork repeatedly showed belongings actually accumulate, rather than in peripheral rooms that tend to go unused. With two exceptions, the 3-bedroom general WC/bath (3.53 m² against 3.7 m²) and the 4-bedroom balcony width (1,080 mm against 1,200 mm), every room meets or exceeds the Nasarawa State Urban Development Board minimum, a baseline that existing stock misses on bedroom, bathroom and balcony dimensions (Tables 4 and 5).

Table 4
 Standard Floor Area of Rooms/Spaces, Compared Against Case Study Averages

Space Definition	NUDB Min.	Floor Min. Side (mm)	Dimension	Case Avg.	Study
Living Room	11.15 m ²	3,000		14.76 m ²	
Dining	7.5 m ²	2,500		8.11 m ²	
Bedroom	10.8 m ²	3,000		10.42 m ²	
Kitchen	6.0 m ²	1,800		6.72 m ²	
Toilet (WC/Bath)	3.7 m ²	1,500		2.73 m ²	
Toilet (WC only)	1.5 m ²	1,000		3.3 m ²	
Communal Corridors(width)	1,200 mm	—		2,220 mm	

Head Room (height)	2,500 mm	–	2,750 mm
Balcony (width)	1,200 mm	–	1,100 mm
Riser	150mm	–	165.75 mm
Tread	250mm	–	287.5 mm

Table 5

The Proposed 2-, 3- and 4- Bedroom Units Compared against Case Study Average Benchmark

Room type	Case average (benchmark)	Study	Proposed 2-Bedroom	Proposed 3-Bedroom	Proposed 4-Bedroom
Living Room	14.76 m ²		28.61m ² (combined Living Room and Dining)	29.91m ² (combined Living Room and Dining)	29.91m ² (combined Living Room and Dining)
Dining	8.11 m ²				
Bedroom	10.42 m ²		11.74m ²	12.59 m ²	12.59 m ²
Kitchen	6.72 m ²		14.97m ²	12.41 m ²	12.40m ²
Toilet (WC/Bath)	2.73 m ²		4.28m ²	3.53m ²	3.73m ²
Toilet (WC only)	3.3 m ²		2.40m ² (Visitor's WC)	1.92m ² (Visitor's WC)	2.05m ² (Visitor's WC)
Communal Corridors(width)	2,220 mm		4,200 mm	7,320 mm	7,170 mm
Head Room (height)	2,750 mm		3,000 mm	3,000 mm	3,000 mm
Balcony (width)	1,100 mm		1,200 mm	1,870 mm	1,080 mm
Riser	165.75 mm		150 mm	150 mm	150 mm
Tread	287.5 mm		300 mm	300 mm	300 mm

5.2 Circulation, Egress and Environmental Performance

Each floor plate is served by a primary stair and lift core shared by two mirrored units, with a separate fire-rated escape stair at the opposite end of the floor. Escape routes sit behind alarmed access doors and are excluded from any unit's storage allocation, addressing directly the informal enclosure seen in the field. The dual-core arrangement keeps travel distance from any unit to a protected exit within permissible limits and stops a unit's primary circulation being compromised by service or refuse routes. Unit layout and dual-aspect fenestration support cross-ventilation: east-facing living spaces catch morning light while service zones buffer the harsher western and southern exposures. Overhangs and balcony projections provide solar control without depending on mechanical cooling, which sits beyond the means of the target demographic. High-level roof openings allow buoyancy-driven stack ventilation, pulling cooler air in low as warm air escapes at the top of each block. Accessibility runs across every movement system. Lift cores sit within each block's circulation design, backed up by ramps wherever ground level changes between the parking surface and the building entrance. Pedestrian paths on site are step-free, distinguished from vehicle surfaces by paving material and sized for a wheelchair or pram. Where pedestrian and

vehicle routes cross, raised platforms improve visibility and slow vehicles naturally. Balconies keep enough distance from neighbouring units to prevent direct sightlines, protecting residents' privacy.

5.3 Material, Construction and Services Strategy

Stabilised mud blocks form the primary wall material. Soil excavated below the topsoil layer is dried, sieved and proportioned to around 70–75% sand content, then stabilised with 7–12% cement and 1–2% lime, compacted by manual press and cured for at least ten days, parameters consistent with published cement- and lime-stabilised earth block research (Walker, 1995; Nagaraj et al., 2014). Cured blocks are wet-compression tested against a 3.5 MPa minimum before use. The material carries lower embodied energy than an equivalent reinforced-concrete frame, better thermal mass that moderates internal surface temperatures, and a cost profile that favours local labour over imported materials. The modular grid cuts material waste and supports repetitive formwork and block-laying sequences. Foundations are conventional strip footings with a 450 mm plinth above finished ground level. Plumbing follows the wet-wall principle, stacking kitchens and bathrooms vertically between floors, and service ducts and refuse chutes stay clear of escape routes. The site falls steeply westward, so surface water runs down the slope towards a low stream channelled through a nearby culvert (see Figure 4). Hierarchical waste management runs from unit-level separation through screened block-level bin stores to central estate collection bays, conveyed manually, addressing the unmanaged refuse at the Bendel Street entry and informal collection at Igbodo Road.



Figure 4: Path of Water Discharge on the Site

Source: Author's Fieldwork, 2026

5.4 Performance against the Evaluative Metrics

Applying the four-metric framework to the completed drawings suggests that the three- and four-bedroom units are calculated to meet or exceed the 75% Net-to-Gross threshold (75.4% and 80.4% respectively), while the two-bedroom unit falls marginally short at 71.9%, a pattern consistent with the higher proportional overhead of structure and services in smaller

footprints. Unit-level circulation factors are deliberately kept below the building-scale benchmark of 15–20% (ranging from 8.4% to 10.4%): allocating that share of a single household's floor area to internal movement would shrink room sizes without a matching benefit, and the benchmark applies more sensibly to shared corridors, fire stairs and lift lobbies serving multiple units. Floor area per person, calculated on one occupant per bedroom using each bedroom's own area, is projected to exceed the 11m² minimum across all unit types. Wall-to-Floor Ratios decline as unit size increases (3.67, 3.36 and 2.78), but all three exceed the ≤ 2.20 study baseline, and the two-bedroom value is close to the 3.65 recorded at Igbodo Road. The prototype therefore does not improve on the local precedents on this metric, a trade-off accepted for the flexibility, privacy and passive performance noted below. In exchange, the design is intended to offer more flexibility, better privacy, stronger passive performance and a closer cultural fit, the qualities fieldwork suggested matter most in everyday living. As the prototype has not been built, these figures should be read as design targets calculated from the drawings, not as measured, validated outcomes.

5.5 Implementation, Considerations and Barriers

The dual-stair arrangement and movable partition system respond directly to the privacy and adaptability failures identified in the fieldwork, though each carries a cost. A second protected stair core adds structural volume and land take beyond a single shared stair; this study treats that as a necessary fire-safety cost, consistent with the near-miss at Uromi Close, rather than quantifying it. The modular partition system needs approval from the Nasarawa State Urban Development Board under its Development Control Standards and Regulations (4th ed., 2021), which demand full architectural and structural drawings but do not explicitly prohibit non-load-bearing internal systems. Stabilised mud blocks, specified against a 3.5 MPa minimum wet-compression strength, offer lower embodied energy and favour local labour over imported materials; a full cost comparison against conventional sandcrete construction falls outside this study's scope and would need separate costing before the design is built. Long-term success also depends on estate-level enforcement against the informal stair enclosure already observed in the case studies, since no partition strategy substitutes for ongoing management.

6. Discussion, Conclusions and Implications

The case studies show that spatial efficiency and long-term adaptability are separate goals, not one that follows automatically from the other. One local precedent reached a strong Net-to-Gross Ratio within ordinary construction constraints, yet its permanent masonry partitions still blocked any legitimate route to reconfiguring the home. Circulation analysis added a further nuance: a low unit-level circulation factor can signal either genuine economy or a dangerous shortfall in shared stair provision, and only resident testimony told the two apart. The prototype's separation of permanent support from adaptable infill responds directly to this, putting Habraken's framework into practice under the material and regulatory conditions of the study context. The cultural and climatic findings show why optimisation strategies have to be grounded in local domestic practice rather than abstract dimensional targets. Kitchens that fail to handle the heat and smoke of everyday cooking either push cooking outdoors or trap odours inside. Storage that is dimensionally adequate but badly placed goes unused. Passive design measures that ignore generator placement or site microclimate are easily undone by external conditions. The prototype's semi-open kitchen loggia, fitted with dedicated extraction, and its storage distributed near points of accumulation, respond directly to these mismatches. Landscape design and courtyard permeability matter just as much to

microclimatic performance, confirming that environmental strategy cannot stop at the building envelope. For policy, the current regulatory focus on minimum room sizes and gross internal area is necessary but not sufficient. Guidance on internal flexibility, protecting escape routes from informal modification, kitchen and service-zone layout, and shared vertical-access performance would help emerging schemes reach genuine habitability rather than paper compliance. Nasarawa State's lack of enforceable design codes for vertical residential housing leaves compliance and benchmarking loosely defined; the metric framework and interview evidence developed here offer one starting point for that guidance.

6.1 Limitations

The geographic focus on Karu and selected Abuja corridor sites limits how far these findings generalise, though they should transfer reasonably to comparable peri-urban contexts with similar climate, culture and regulatory conditions. Household income, family size and building maintenance standards were not controlled across the four cases. These are rival explanations that this study cannot rule out: reported storage adequacy, unauthorised modification and overall satisfaction may reflect differences in income and family size between the four developments at least as plausibly as differences in spatial configuration, and the associations reported in Section 4 should be read as correlational rather than causal on this basis. Household composition also varies considerably across regions: Reall (2022) found that mean household size among Nigeria's urban bottom-40% income group ranges from 2.7 in Lagos State to 4.6 in the Federal Capital Territory, with earners per household showing a similar spread (1.6 in Lagos versus 2.1 in the FCT). Nasarawa State is one of the states profiled in the same dataset, situating the present study's household context within a documented range of urban Nigerian variation rather than a single national norm.

Household composition was recorded incidentally, not systematically, during interview and is noted alongside the relevant findings in Section 4 where it plausibly bears on the result; it should not be read as a representative profile of the sample. Controlling for such variables within a Master's-level fieldwork window remains a recognised constraint of practice-based post-occupancy research more widely (Hay et al., 2018), not a gap specific to this study. Reliance on privately developed sites narrowed case diversity, and voluntary participation raises the possibility of self-selection bias, though the qualitative sample reached saturation within the scope of a Master's-level design. Wall-to-floor ratios were calculated from residual wall footprints and assumed thicknesses (225 mm for the case studies; 230 mm external and 150 mm partition walls for the prototype); they are useful for relative comparison but should not be read as precise absolutes. The prototype itself has not been built or post-occupancy tested, so its calculated performance is a well-evidenced design proposal rather than a validated outcome, and the sample of ten resident interviews across four sites supports conclusions about those four cases rather than the wider urban corridor.

Poor spatial and functional performance in Greater Karu's low-rise multi-storey housing does not follow inevitably from density. It comes from identifiable, correctable design decisions. Clear circulation hierarchies, courtyard-based passive ventilation, adaptable partitioning and culturally consistent service zones are well established in the literature and in-built precedent, yet remain rarely applied here. Residents experience their absence as a real constraint on adaptability, privacy and comfort. This prototype sets out one way of translating those priorities into a low-rise, resource-constrained peri-urban setting, even though its performance remains, for now, a calculated projection rather than a proven result.

For architectural theory, the study reaffirms the value of reading Habraken, Alexander and Rapoport together rather than separately: the support-infill distinction, the intimacy gradient

and the insistence that a design match the routines of the household who use it, taken together, form a workable evaluative and generative framework for multi-storey housing in developing urban contexts. For practice, it offers evidence-based principles and a proposed prototype relevant to architects, developers and planning authorities working in comparable peri-urban Nigerian settings: a modular structural grid calibrated to local block sizes, a movable partition system, a dual protected stair arrangement, consolidated wet-wall servicing and a hierarchical waste strategy, each a transferable design move addressing a failure diagnosed directly in the field. These moves rest on different strengths of evidence, set out below.

Table 6
Design Moves Mapped to Supporting Evidence

Design move	Supporting evidence	Strength
Dual protected stair, separated escape route	Documented near-miss fire-safety incident at Uromi Close; corroborated by resident complaints about the shared 900 mm stair at Igbodo Road.	Strong
Modular structural grid (3750 mm)	Repeated practitioner complaints, across all four cases, about the absence of a standard dimensional grid.	Moderate
Adaptable, non-load-bearing partitions	Wall demolition at Uromi Close; residents and professionals on rigid walls limiting adaptation.	Moderate
Semi-open kitchen loggia with extraction	Kitchen-to-veranda cooking migration observed at Nyanya-Karu; consistent with the wider cultural mismatch reported across cases.	Moderate
Consolidated wet-wall servicing	Drawn from practitioner interviews on construction and maintenance efficiency; no resident complaint named service layout directly.	Tentative
Hierarchical, screened waste management	Near-total absence (or unmanaged communal waste as in the cases of Igbodo Road and Bendel Street) provision observed.	Moderate

Note. Strong indicates a single documented incident directly demonstrating the problem; moderate indicates a pattern repeated across two or more cases; tentative indicates a recommendation drawn mainly from professional interviews rather than resident-reported evidence.

6.2 Recommendations

Architects should separate permanent structural supports from adaptable internal infill, and settle circulation planning and staircase placement early, before room layouts are fixed. Developers and estate managers should consider adaptable partitioning to extend a single unit typology across a wider range of households and life stages, and should put screened, hierarchical communal waste provision in place from the outset. Planning and regulatory authorities should review minimum spatial standards for multi-storey residential development in peri-urban local government areas against both national building-code minimums and the lived experience evidence gathered here, and should consider supplementary guidance on internal flexibility, escape-route protection and shared vertical-access performance. Future researchers should extend the case-study sample beyond Karu and Abuja to test how far these findings travel under different climatic and cultural conditions, control for household income and family size where the study design allows it, and, should the prototype be built, subject it

to a proper post-occupancy evaluation.

Within these limits, the research supports one clear proposition: density and a comfortable home can be made compatible through deliberate, context-sensitive design. The proposed design is not offered as a universal template, but as a demonstration that the tension between density and liveability identified at the outset can be resolved when design decisions are grounded in both measured spatial performance and the lived experience of the households who will inhabit the resulting space.

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