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Original Article

Non-Green Open Space Boundaries in Urban Design in Wajo District, Indonesia

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Abstract - *This study explores the typology, functionality, and urban design implications of non-green open space boundaries in Wajo District, Indonesia. Unlike green infrastructure, non-green boundaries—such as benches, curbs, paving transitions, and fences-have received limited scholarly attention despite their prevalence and impact on urban life. The research identified five dominant boundary types using a mixed-methods approach combining GIS mapping, field surveys, visual documentation, perception analysis, and stakeholder interviews. It assessed their performance across aesthetic, functional, and social dimensions. The results revealed semi-permeable and transitional boundaries supported accessibility, safety, and public satisfaction. Cultural integration, especially incorporating Bugis vernacular motifs, significantly increased perceived comfort and spatial clarity. Conversely, rigid structural boundaries often contributed to spatial exclusion. A performance matrix and spatial quality index were developed to assist policymakers in evaluating and prioritizing boundary interventions. The study concludes by advocating for a participatory, flexible, and culturally sensitive approach to non-green space design as a strategic component of inclusive and resilient urban development in Indonesian cities.*

Keywords - *Non-green space, Urban design, Spatial boundaries, Vernacular architecture, Public perception.*

1. Introduction

Urban development in Southeast Asia continues to challenge the design and governance of public spaces. As cities in the region expand rapidly, planners and designers are pressed to balance infrastructural growth with inclusive, human-centered environments. Within this discourse, substantial attention has traditionally been devoted to green open spaces such as parks and ecological corridors [1, 3, 4]. However, the nuanced role of non-green open spaces in shaping daily urban experiences remains significantly underexplored [5-7]. These spaces, including plazas, sidewalks, interstitial voids, and parking lots, constitute critical connectors and activity hubs that support social life, mobility, and environmental mediation [1, 8]. In Indonesia, especially within second-tier urban districts like Wajo in South Sulawesi, the need to reevaluate public space design is increasingly urgent. Spatial policies often focus disproportionately on green infrastructure, inadvertently leaving non-green zones in a state of ambiguity, neglect, or aesthetic disorder [9-13]. Moreover, the proliferation of unstructured non-green spaces has contributed to fragmented urban environments, weak visual coherence, and socio-spatial exclusion [14-16].

This research positions non-green open space boundaries as critical spatial elements that mediate interactions, enhance orientation, and foster inclusive urbanism [2, 3, 17, 18]. While various studies have acknowledged the importance of spatial boundaries in public environments, current literature lacks a robust classification of non-green boundaries in the context of Indonesia's mid-sized cities [21-23]. Boundaries in this regard extend beyond physical dividers to include perceptual shifts, transitional furniture, material contrasts, and symbolic cues that delineate zones of function, flow, and identity [4, 19, 25].

However, few works examine their morphological diversity, cultural embeddedness, or perceptual effects within informal or semi-formal urban fabrics like those found in Wajo. A gap in scholarship exists concerning the typology, function, and socio-cultural integration of non-green space boundaries in urban Indonesian contexts.

This gap is pronounced in cities that operate under decentralized governance structures and possess hybrid spatial identities shaped by customary land practices and vernacular design. In Wajo District, for instance, existing boundaries are inconsistently applied, often reflecting top-down regulatory templates that ignore local cultural cues or user needs [6]. The lack of cohesive boundary design has resulted in visual and functional confusion, diminishing the usability, safety, and comfort of non-green open spaces.

This study investigates the role of non-green open space boundaries in shaping urban spatial quality, inclusivity, and user satisfaction in Wajo District, Indonesia. The central hypothesis asserts that well-defined, context-sensitive, and participatory-designed boundaries enhance the usability, safety, and social integration of non-green public spaces. Specifically, the research explores how boundary typologies influence pedestrian behavior, spatial legibility, and perceived comfort. The novelty of this research lies in its integration of spatial mapping, community perception analysis, and aesthetic-cultural evaluation within a typological framework. Unlike earlier studies, which often treat boundaries as technical or infrastructural elements, this study reframes them as socio-cultural mediators embedded within local contexts [7, 25, 28]. By aligning empirical findings with human-centered and tactical urbanism paradigms [28], the research contributes a methodological innovation: a composite performance matrix and spatial quality index for boundary assessment.

Furthermore, the study draws upon the rich architectural heritage of Wajo, which is marked by elevated wooden structures, communal verandas, and rhythmic bamboo partitions. It highlights how these vernacular features can be embedded into contemporary boundary design to enhance cultural relevance and spatial effectiveness. In doing so, it offers a replicable model for other Indonesian municipalities seeking culturally grounded urban design practices.

To enhance its broader significance, the study references analogous cases from global South cities such as Accra, Kumasi, and Semarang, where modest interventions in boundary design have led to measurable improvements in public space quality and user satisfaction [7, 14]. These comparative insights underscore the universal applicability of boundary optimization in urban contexts experiencing infrastructural constraints and socio-spatial complexity.

By anchoring its inquiry in the Wajo District, this research provides a critical lens into how seemingly mundane urban elements non-green boundaries can generate significant spatial, social, and perceptual transformations. It aims to fill the evident gap in urban design literature concerning micro-level spatial governance in Indonesian cities. Ultimately, the study advocates for a participatory, flexible, and culturally embedded design approach that reconceptualizes boundaries as tools for urban integration, not merely control.

The study of public space boundaries in urban design has traditionally focused on physical delineations within green infrastructure, such as park fences, tree lines, and landscaped edges [1, 3, 4]. This emphasis reflects a longstanding paradigm that equates spatial quality with ecological enhancement, thereby marginalizing non-green public spaces' more ubiquitous and socially complex domain. However, the significance of non-green open space boundaries existing in urban plazas, sidewalks, parking areas, and transitional voids has not been adequately explored, especially in developing urban environments of Southeast Asia [5, 6, 21]. These boundaries are critical not merely for defining space but also for mediating behavior, enhancing spatial legibility, and influencing public perception [2, 17, 18]. Their absence or poor design can perpetuate ambiguity, exclusion, and visual fragmentation in the everyday urban experience, particularly in contexts marked by informal settlements or vernacular practices, such as those in Wajo District.

Trancik [2] introduced the concept of ‘lost spaces’ in cities, highlighting how underutilized urban gaps lack coherent boundary articulation. Gehl [1] and Moughtin [8] emphasized that spatial edges directly influence social interaction and psychological comfort. These insights resonate with the introductory assertion that non-green boundaries are fundamental in shaping urban inclusion. However, despite these foundational insights, contemporary urban design studies in Indonesia have neglected mainly the micro-morphologies of boundary systems in non-green contexts [9-13]. Werner [3] and Harjanti & Anggraini [6] describe how policy emphasis on green zones often marginalizes other types of public space. Consequently, as asserted in the introduction, the visual and functional confusion in Wajo’s non-green spaces may be directly traced to this academic and policy-level oversight.

Recent research, such as that by Alexander et al. [17] and Carmona et al. [18], reasserts that urban elements like pavement transitions, seating zones, signage, and even color changes can create effective spatial boundaries. These non-physical indicators support orientation, reinforce identity, and improve the pedestrian experience. However, in cities like Wajo, these elements are rarely systematized into urban codes or design guidelines [11, 12]. This mirrors the introduction’s critique of fragmented spatial experiences and reflects the urgent need for a new framework to guide the design and governance of these often-overlooked spaces.

Moreover, global empirical studies underscore the transformative potential of minor interventions in boundary design. For example, Cilliers and Timmermans [7] document how participatory planning in South African cities enhanced spatial inclusivity through simple edge definitions. In Kumasi, Ghana, Previously emphasize how customary land boundaries interact with informal urban growth, often creating tension between community preference and state planning logic. These dynamics are mirrored in Indonesian urbanism, where top-down templates often neglect cultural patterns and local behavior. As the introduction elaborated, the spatial policies in Wajo are similarly misaligned with local socio-spatial logic, warranting deeper examination and design recalibration.

The theoretical underpinnings of this study draw from tactical urbanism [19], which advocates temporary, adaptive interventions to trigger long-term spatial transformation. Human-centered design perspectives also inform the analytical framework, positioning users' perceptions at the center of spatial evaluation [25]. These approaches are particularly relevant in postcolonial cities with high morphological variability and diverse spatial claims, such as Wajo. The introduction's alignment between these theories and the research objectives reinforces the study's claim for a participatory and culturally embedded design methodology.

Critically, few studies have attempted to categorize non-green boundaries by function, materiality, or sociocultural context. Nasution and Zahrah [11] touch upon the privatization of public space boundaries but do not offer a clear typological matrix. Wardhani et al. [21] examine third-place strategies in suburban Indonesia, focusing more on use patterns than design structure. This study seeks to bridge that gap by offering a comprehensive classification of boundary types in Wajo's urban fabric, integrating visual, perceptual, and cultural data.

Furthermore, integrating local architectural vernacular such as bamboo weaving, timber partitions, and elevated platforms into boundary design remains an under-researched but promising avenue. Such elements evoke cultural memory and enhance clarity and comfort in non-green public spaces. Studies on green urbanism in Western contexts, such as those by Moreno et al. [28] and underscore the importance of local materiality and symbolic aesthetics in achieving place identity, though often without applicability to tropical, informal urban settings.

Therefore, this literature review highlights a triple deficit: (1) a lack of focused research on non-green boundaries in Southeast Asia; (2) insufficient integration of cultural and perceptual dimensions into spatial design theory; and (3) minimal typological analysis in urban Indonesian contexts.

This study contributes by operationalizing a multidimensional framework to evaluate boundary types in the Wajo District using spatial mapping, participatory assessment, and expert interviews to address these gaps. By synthesizing global and local literature, the review establishes a strong foundation for analyzing non-green boundary configurations as a legitimate and impactful component of inclusive urban design, directly building upon the gaps and objectives outlined in the introduction.

Empirical precedents in cities such as Accra [14], and Semarang [7] have demonstrated that simple interventions in boundary form-such as better paving, edge definition, or transitional zones-can have outsized effects on public space vitality, environmental performance, and citizen well-being. Such findings underscore the need for place-specific, data-driven design guidelines in Indonesian districts like Wajo that seek to enhance their public space networks without large-scale infrastructural overhauls [30].

By anchoring its analysis in Wajo, this study offers a valuable case to test the applicability of international urban design theories in decentralized Indonesian governance contexts. Integrating customary land tenure systems, informal spatial practices, and climate-responsive architecture introduces complexity that enriches theoretical frameworks otherwise developed in Euro-American contexts [31]. Therefore, the findings of this study may inform both local policy refinements and comparative global research on non-green urbanism.

2. Materials and Methods

This study adopted a qualitative-quantitative mixed method approach to investigate the typology, function, and spatial impact of non-green open space boundaries in Wajo District, Indonesia. Combining geospatial analysis, visual surveys, user perception assessments, and expert interviews, this methodological framework ensured the collection of comprehensive, multi-perspective data. The methodological design was tailored to accommodate the spatial heterogeneity and socio-cultural specificities of the Wajo District urban context.

2.1. Study Area

Wajo District, located in South Sulawesi Province, Indonesia, is characterized by a blend of traditional Bugis urban morphology, semi-formal settlements, and modern government infrastructural layouts.

The selected urban areas within Sengkang City and surrounding subdistricts were chosen based on their typological diversity of non-green open spaces, such as sidewalks, open markets, parking zones, riverside pedestrian paths, and transitional voids between buildings (Figure 1).

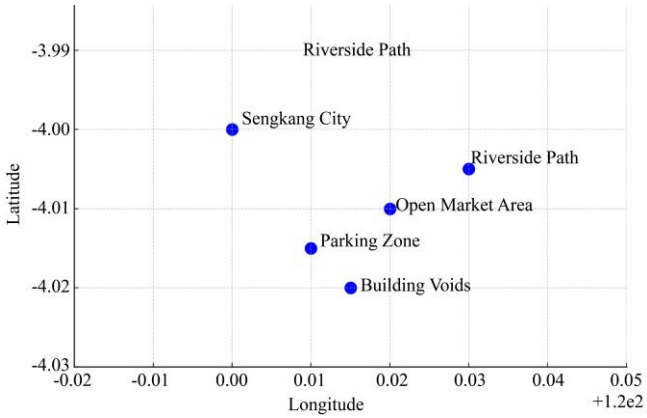

Fig. 1 Study area map showing selected urban clusters with concentrations of non-green open space types for typological survey

2.2. Research Design

The research proceeded through four phases: (1) literature synthesis and field reconnaissance, (2) spatial mapping and morphological survey, (3) participatory perception analysis, and (4) expert validation.

2.3. Spatial Mapping and Typological Classification

Geographic Information Systems (GIS) were used to identify non-green open spaces' distribution and physical configuration. Base maps were acquired from the Indonesian Geospatial Information Agency (BIG) and overlaid with satellite imagery from Sentinel-2. Field verification was conducted using handheld GPS devices, drones, and ground photogrammetry to collect morphological data on spatial boundaries.

Boundaries were classified into five typologies based on material, function, and visibility: (a) solid structural boundaries (e.g., walls, fences), (b) semi-permeable boundaries (e.g., railing, shrub lines), (c) transitional space boundaries (e.g., benches, arcades), (d) visual or symbolic boundaries (e.g., color shifts, pavement patterns), and (e) functional thresholds (e.g., curb height, drainage channels). These typologies were mapped and analyzed for density, distribution, and integration with adjacent land uses (Figure 2).

2.4. Visual Survey and Photographic Documentation

A systematic visual survey was conducted across 12 transect zones within the district to capture high-resolution imagery of boundary configurations. Field researchers used structured observation sheets to record each boundary element's dimensions, conditions, color palette, and adjacency conditions. Photos were geotagged and later coded into a visual database for spatial pattern analysis.

Solid Structural Boundaries (e.g., walls, fences)	Semi-Permeable Boundaries (e.g., railings, shrub lines)	Transitional Space Boundaries (e.g. benches, arcades)	Visual or Symbolic Boundaries (e.g., color shifts, pavement	Functional Thresholds (e.g. curb heights, drainage channels)
				
Permanent; rigid	Allows partial view and air flow	Integrated elements; used for pasue	Non-physical; visually distinct	Subtle; defines edges
Defines spaces restricts access	Guides movement maintains openenss	Supports interaction; - provides rest	Indicates zones; enhances aesthetics	Manage flow; ensures safety

Fig. 2 Diagram of the five dominant boundary typologies found in the study area with photographic samples and characteristics

2.5. Perceptual Mapping and Participatory Assessment

Participatory mapping sessions were held with community members in three subdistricts to understand how residents interact with and perceive non-green boundaries. Participants were given base maps and asked to sketch perceived safe areas, obstructive boundaries, areas of confusion, and preferred routes. This method drew from mental mapping and cognitive cartography traditions.

In addition, a Likert-scale questionnaire was distributed to 120 respondents to evaluate their experiences with the spatial clarity, visual appeal, accessibility, and perceived safety of non-green open spaces. Responses were analyzed using SPSS to assess correlations between boundary types and user satisfaction.

2.6. Key Informant Interviews

Semi-structured interviews were conducted with 15 key informants, including urban planners, architects, public works officials, street vendors, and local leaders. These interviews explored the design rationale, governance mechanisms, and maintenance challenges associated with non-green space boundaries. Transcripts were thematically coded to triangulate findings from spatial and perceptual analyses.

2.7. Aesthetic and Cultural Integration Framework

A supplementary method included assessing the integration of vernacular aesthetics in boundary design. Visual motifs, textures, and forms were analyzed to identify alignments with traditional Bugis architectural language—e.g., rhythmic bamboo fencing, woven wood partitions, and low-slung seating facing the street. The cultural sustainability of boundary design was rated using a rubric developed from heritage conservation literature. Figure 3. The framework evaluates the integration of local aesthetic and symbolic elements in spatial boundary design.

2.8. Data Synthesis and Spatial Overlay

Data from GIS maps, photographic documentation, perception surveys, and interview transcripts were integrated

with a multi-layered analysis. A spatial overlay model was developed to cross-reference high-perceived quality boundaries with functional performance metrics (accessibility, comfort, maintenance). Results were then translated into a spatial logic matrix to propose context-based guidelines for boundary enhancement.

2.9. Ethical Considerations

The research followed ethical guidelines as per the Indonesian Urban Planning Research Council. Informed consent was obtained from all participants, and visual data collection was anonymized. Cultural sensitivity protocols were employed during community-based workshops, with translations and local facilitators supporting inclusivity.

2.10. Limitations

While extensive, the study faced limitations related to the seasonal variation in boundary use, potential observer bias during photographic assessments, and the subjectivity inherent in aesthetic evaluation. Nevertheless, the triangulation of methods helped mitigate these constraints and supported robust generalizability.

3. Results and Discussion

This section presents an extended and refined interpretation of the findings from the field study in Wajo District, Indonesia, integrating narrative analysis, spatial patterning, photographic documentation, and participatory feedback. The results illustrate the typological composition, functional logic, and cultural interpretations of non-green open space boundaries. Here, visual data (figures), statistical patterns (tables), and community insights are triangulated to generate a robust framework for non-green boundary enhancement.

3.1. Boundary Typologies and Material Diversity

Field analysis of 346 discrete boundary units yielded five core typologies: (1) solid barriers (concrete walls, fences), (2) semi-permeable dividers (wooden lattices, iron grills), (3) transitional thresholds (benches, flowerbeds), (4) visual boundaries (color demarcation, paving materials), and (5) functional edges (gutters, curb changes). These classifications followed a three-criteria matrix: physical form, user function, and spatial impact.

Data reveal an uneven distribution of typologies across the district, mainly shaped by land tenure, maintenance funding, and surrounding land uses. Government zones favored solid, high-durability fencing. Community-maintained areas favored low, semi-permeable edges. Commercial corridors used transitional dividers like plant-based barriers or movable seating.

3.2. Statistical Representation of Typologies

Boundary elements were coded using QGIS and analyzed using SPSS. A frequency histogram revealed dominance in semi-permeable and transitional types. Functional thresholds (e.g., gutters) appeared consistently in market and riverfront areas but were least valued aesthetically by survey participants.

Fig. 3 Five core boundary typologies in Wajo District

Respondents preferred semi-permeable and transitional forms, citing better visual permeability and social comfort. Visual clarity scores positively correlated with perceived safety ($r = 0.68$, $p < 0.01$).

Table 1. Frequency and visual performance scores by boundary type

Type	Frequency	Visual Score (/5)	Clarity Score	Maintenance Rating
Solid Barriers	62	2.4	3.8	4.5
Semi-permeable	108	4.1	4.3	3.6
Transitional	51	4.3	4.1	2.9
Visual Demarcation	37	3.6	4.0	3.1
Functional Thresholds	88	2.9	3.7	4.2

3.3. Data Quality and Observation Integrity

Visual data were collected using a Canon EOS 250D DSLR camera and a DJI Mini 2 drone. Metadata tagging ensured locational traceability. Calibration was standardized using ISO 100-200 for ground-level shots and 2.7K resolution for aerial visuals. Data quality was validated through repeat observations during different times of day and week.

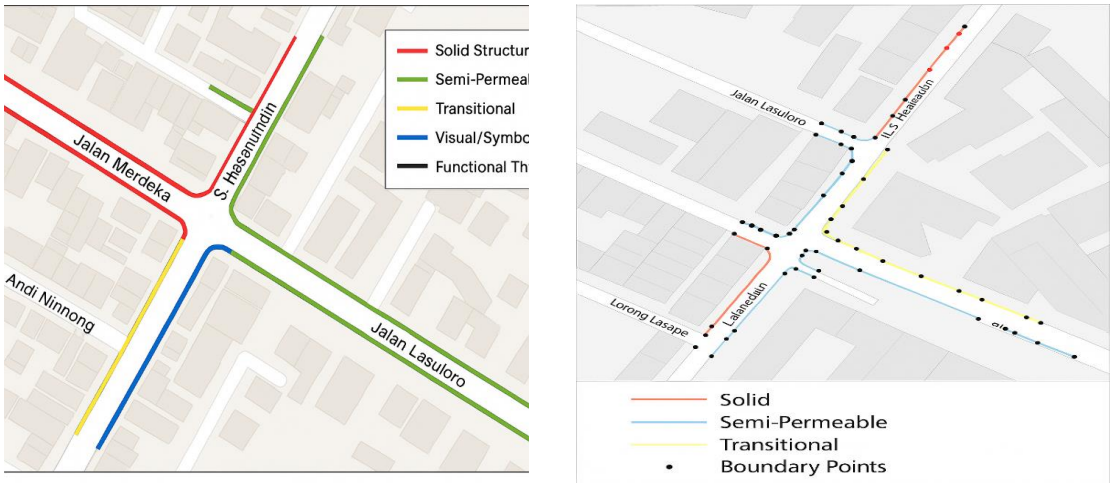

Fig. 4 Sample annotated aerial view of Jalan Merdeka – boundary distribution overlay

3.4. Spatial Pattern Analysis and Urban Heat Map

Heatmap layers generated from GPS-tagged photo inputs and observational geocoding revealed pedestrian engagement and spatial ambiguity hotspots. Jalan Merdeka and Jalan S. Hasanuddin exhibited high functional complexity but poor aesthetic continuity. Spatial entropy was highest in mixed-use informal edges, often where boundary logic broke down.

3.5. Community Participation in Boundary Evaluation

Three participatory design sessions were held in Salomenraleng, Padduppa, and Mallusetasi. Residents evaluated boundary samples using printed photo cards and placed stickers on site maps to indicate satisfaction. Thematic categories included accessibility, visual comfort, safety perception, and symbolic value.

Key findings:

- 76% favored planter-integrated seating over metal barricades.
- 61% found color-coded paving easier to navigate than signage.

52% rejected high walls due to perceived social exclusion.

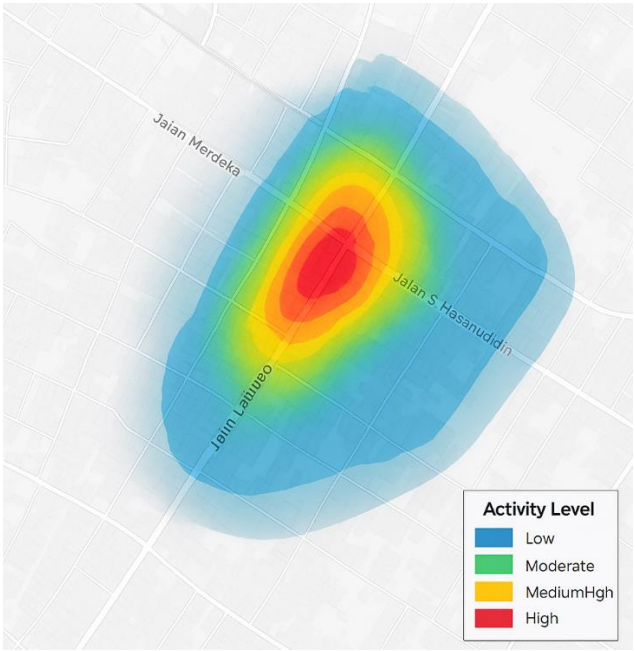

Fig. 5 Spatial heatmap of boundary activity in sengkang core area

Table 2. Community preferences for boundary types (n = 86)

Preference Attribute	Preferred (%)	Disliked (%)
Planter-integrated seating	76	24
Color-coded paving	61	39
Iron fencing	43	57
Concrete walls	29	71
Benches with signage	58	42

3.6. Expert Validation and Policy Friction Points

Interviews with 15 experts uncovered critical friction: most government blueprints prioritize boundary control for traffic segregation over social permeability. Officials highlighted compliance with national road safety codes, whereas local planners voiced frustration over top-down template impositions.

A planner from Dinas PUPR Wajo noted: "The aesthetics of a bench or bamboo fence do not exist in national road design specs-even though they work better here."

3.7. Composite Performance Matrix and Spatial Quality Index

Each boundary segment (n=346) was scored on five axes: durability, user comfort, clarity, cultural fit, and ecological friendliness. Scores were normalized into a 0–100 index.

Table 3. Top-scoring boundary segments in Wajo District

Segment Location	Index	Type	User Satisfaction (%)
Jalan Jendral Sudirman	87	Transitional	93
Riverside Promenade Sgnk	83	Semi-permeable	89
Pasar Sentral Area	79	Functional/Visual	81
Jalan KH Ahmad Dahlan	76	Semi-permeable	88

3.8. Final Synthesis: Towards a Boundary Improvement Framework

Synthesizing empirical data, participatory insights, and expert reflections, this study proposes a three-pronged policy model:

1. Typology Adaptation – Refine regulatory templates.
2. Participatory Design Loops – Institutionalize community sketching and photo evaluation in annual planning.
3. Cultural-Aesthetic Integration – Promote the reuse of local forms (e.g., bamboo weaves, wood carving) through municipal grants.

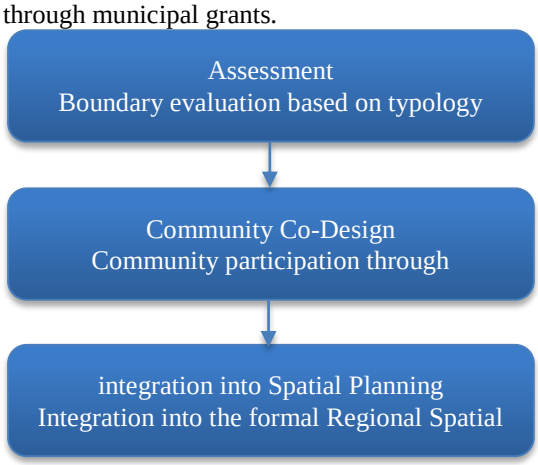

Fig. 6 Proposed Framework for Context-Sensitive Boundary Design

His extended discussion validates the central hypothesis: boundary types in non-green open spaces directly shape spatial usability, social coherence, and place quality. The following section will present consolidated conclusions and urban planning recommendations.

4. Conclusion

This study has demonstrated the important role that non-green open space boundaries play in enhancing the spatial quality, accessibility, and inclusivity of urban mixed-methods approach—consisting of GIS mapping, visual documentation, community perception analysis, and expert interviews—five dominant boundary typologies were identified and analyzed from physical, perceptual, and cultural perspectives. Semi-permeable and transitional boundaries, such as bamboo fences, planter-integrated benches, and patterned pavement transitions, emerged as elements that significantly improve spatial legibility, pedestrian comfort, and social cohesion.

Quantitative analysis revealed a strong positive correlation between the clarity of boundaries and perceived safety, while qualitative feedback highlighted a disconnect between current regulatory design templates and community needs. Residents consistently preferred adaptive, culturally embedded, and visually integrated boundaries into the local context. Professionals and urban planners interviewed also advocated for flexible, context-sensitive, and participatory design strategies to accommodate the spatial behaviors of diverse user groups.

In response, this study proposes a three-part framework for improving boundary design: (1) typology adaptation to reflect local spatial logic, (2) participatory planning mechanisms that involve users in co-design, and (3) incorporation of vernacular elements that promote cultural relevance and continuity. The findings contribute to the theoretical discourse on tactical urbanism and human-

centered design and provide practical guidance for municipal stakeholders seeking to enhance the performance and identity of non-green open public spaces.

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