

Quantifying Urban Street Transformation: Integrating Informal Economic Activity Intensity (IIAEI) and Spatial Occupation Ratio (SOR) in Medan City

I Gede Wyana Lokantara^{1*}, Rafika Hilmi Nasution¹, and Lia Liswati²

¹Architecture Study Program, Faculty of Engineering, Universitas Negeri Medan, Medan, Indonesia

²Department of English Language and Literature, Faculty of Languages and Arts, Universitas Negeri Medan, Medan, Indonesia

*Corresponding author, email: wyana@unimed.ac.id

ABSTRACT

Informal economic activities significantly influence the spatial and functional transformation of urban street corridors; however, their quantitative impact has not been examined in depth. This study analyzes the restructuring of street space by informal activities by integrating spatial pattern analysis (linear, spot, and mixed) with two quantitative indicators: the Informal Economic Activity Intensity Index (IIAEI) and the Spatial Occupation Ratio (SOR), where $IIAEI = \frac{A_i}{L}$ and $SOR = \frac{A_o}{A_t}$. Empirical data from three urban corridors in Medan City demonstrate that street space transformation occurs systematically through the interaction between activity intensity and spatial distribution. The findings indicate a non-linear relationship between activity intensity and spatial occupation, with SOR reaching up to 100 percent in several corridor segments. Concentrated activities result in high spatial pressure even at lower intensity levels, whereas dispersed activities lead to lower pressure despite higher activity counts. This interaction yields three distinct corridor typologies: high-pressure corridors, concentration-based hotspots, and transitional corridors. This study introduces a novel quantitative framework that operationalizes the relationship between informal economic activities and street space transformation by integrating IIAEI and SOR, enabling a measurable and comparative assessment of spatial pressure. The integration of IIAEI and SOR enables an objective, comparative assessment of spatial pressure. The results underscore the need to transition from control-oriented policies to integrative, data-driven approaches, thereby positioning urban street space as an adaptive and inclusive socio-economic environment.

Keywords: Activity intensity; Informal economy, Spatial distribution, Spatial occupation, Urban street space.

INTRODUCTION

The transformation of urban street space in developing cities is increasingly influenced by the intensity of informal economic activities, which occur in dynamic and recurring patterns [1]. This shift not only signifies a shift from mobility corridors to productive economic spaces but also reveals complex spatial restructuring at the operational level of the city [2]. In the Global South, street space functions as a primary arena for

interactions between formal systems and informal practices, where street-based economic activities develop in the absence of adequate spatial management frameworks. Consequently, urban streets should be understood not merely as mobility infrastructure but as hybrid spaces continuously shaped by the interplay of social, economic, and physical processes. In Indonesia, this phenomenon is particularly pronounced along highly accessible urban corridors. Informal economic activities, including street vendors, roadside services, and informal parking, actively appropriate sidewalks, road shoulders, and even portions of carriageways, rather than merely occupying residual spaces [3]. This situation poses several spatial challenges, including reduced road capacity, deterioration of pedestrian infrastructure, increased user conflicts, and declining environmental quality [4]. The primary issue, however, is not solely the presence of informal activities but the limitations of current planning approaches in understanding how variations in activity intensity and spatial distribution generate different levels of spatial pressure and unevenly transform street space [5].

Medan, one of Indonesia's major metropolitan cities, exemplifies this phenomenon with significant intensity. Preliminary observations along key corridors indicate that informal economic activity can exceed 80 percent in certain segments, particularly on sidewalks and road edges. This finding indicates that, in some areas, the mobility function of street-edge space has been substantially diminished and supplanted by dominant economic uses. These recurring activities create structured spatial patterns, including linear, clustered, and mixed configurations, which directly influence the spatial organization of street corridors. In many instances, streets no longer function optimally as mobility systems but instead evolve into hybrid spaces marked by high spatial pressure [6].

Although this phenomenon has been widely examined, existing studies are predominantly descriptive or qualitative and have not systematically explained the relationship between the intensity of informal economic activities and measurable spatial transformation [6], [7]. Most research does not integrate activity density and spatial occupation within a unified operational and comparative analytical framework. As a result, there remains a lack of analytical models capable of quantifying variations in spatial pressure across street corridors, as well as a limited understanding of the spatial mechanisms by which informal economic activities differentially shape street space [8]. To address this limitation, the present study introduces a corridor-based analytical approach that integrates the measurement of informal activity intensity using the Informal Economic Activity Intensity Index (IIAEI) and spatial occupation using the Spatial Occupation Ratio (SOR). The combination of these two indicators facilitates the identification of spatial pressure levels and elucidates the relationship between activity intensity, spatial distribution, and the transformation of street corridor characteristics [9], [10]. This approach enables both

quantifying activity density and a clearer understanding of how these activities physically alter urban space, thereby allowing comparison across corridors [11].

The primary contribution of this study is the development of an analytical framework that explains the spatial mechanisms of urban street transformation through the interaction between activity intensity and spatial occupation at the corridor scale [12]. Notably, the findings indicate that the distribution of activities exerts a more significant influence than the absolute number of activities in shaping spatial pressure and street character, a dimension not explicitly addressed in previous research [13]. Accordingly, this study introduces a more operational quantitative approach and contributes conceptually to understanding the production of urban street space in the context of informal economies, while providing an analytical foundation for more adaptive, contextual, and data-driven corridor planning [14].

To address these limitations, this study aims to develop a quantitative and operational framework to analyze the transformation of urban street space based on the interaction between informal economic activity intensity and spatial occupation. Accordingly, this study is guided by the following research questions: (1) How does the intensity of informal economic activities influence spatial occupation along urban street corridors? (2) How does the interaction between activity intensity and spatial distribution generate varying levels of spatial pressure? (3) What types of spatial transformation emerge from this interaction? This study is based on the analytical proposition that spatial pressure is more strongly influenced by the spatial distribution and occupation patterns of activities than by their absolute number.

MATERIALS / DATA DESCRIPTION / METHODS

Analytical Framework

The analysis is organized in sequential stages to connect empirical data with both measurable and conceptual outputs. An integrative approach combines quantitative measurement of informal economic activities with spatial interpretation of changes in urban street space [14], [15]. This analytical framework captures the spatial mechanisms linking activity intensity, spatial occupation, and corridor transformation, ensuring that the findings are operational and comparable across different study locations rather than merely descriptive.

Field observations were carried out along selected urban street corridors in Medan City during peak activity periods, specifically in the afternoon and evening (approximately 16:00 to 21:00), when informal economic activities are most prevalent. Data collection spanned multiple days to enhance consistency and reliability. Spatial data collection and mapping utilized digital tools, such as Google Earth and GIS-based analysis, to accurately delineate corridor boundaries, activity distribution, and spatial occupation patterns. Occupied

space (A_o) and total available street space (A_t) were measured using digital techniques. Spatial dimensions were determined through on-screen digitizing and scaling from satellite imagery, ensuring consistency and comparability across all corridor segments.

Study corridors were selected using a purposive sampling approach to ensure representation of varying levels of informal economic activity intensity and diverse spatial characteristics. Three urban street corridors in Medan City were chosen according to the following criteria: (1) High accessibility and connectivity within the urban network; (2) Presence and variation of informal economic activities; and (3) Observable differences in spatial occupation and activity distribution patterns. This approach facilitates comparative analysis across corridors with distinct spatial conditions, providing a more comprehensive understanding of how variations in activity intensity and distribution influence spatial pressure and street-space transformation.

To enhance clarity and reproducibility, a set of variables and indicators is defined and consistently applied throughout the analysis, as detailed in the following table.

Table 1. Research Variables and Indicators

Variable	Indicator	Operational Definition	Unit
Activity Intensity	Number of activity units (A_i)	Total number of informal economic activities per corridor segment	Units
Spatial Occupation	Segment length (L) Occupied area (A_o) Total space (A_t)	Length of the observed corridor segment Area occupied by informal economic activities Total available street space	Meters m^2 m^2
Spatial Transformation	Space function Spatial fragmentation Mobility disruption Spatial pattern	Dominance of mobility or economic use Discontinuity of pedestrian pathways Occupation of roadway space Linear, clustered (spot), or mixed	Qualitative Qualitative Qualitative Category

Analysis of Informal Economic Activity Intensity (IIAEI)

The initial stage involves quantifying the intensity of informal economic activities to establish a foundation for analyzing activity pressure along street corridors [16]. A quantitative-spatial methodology is employed, conceptualizing informal economic activities as measurable entities distributed spatially. Here, intensity is defined not only by the number of activities but also by their density relative to corridor length, thereby capturing spatial concentration. To operationalize this concept, the Informal Economic Activity Intensity Index (IIAEI) is introduced and formulated as follows:

$$IIAEI = \frac{\sum A_i}{L} \dots \dots \dots (1)$$

The application of the IIAEI formula is based on the measurement of the total area occupied by informal economic activities within each corridor segment. In this context, $\sum A_i$ represents the aggregated area of all informal activity units, obtained by measuring the

spatial footprint of each activity through field observation and digital mapping. The length of the corridor segment (*L*) is measured in meters using digital tools based on satellite imagery and GIS analysis to ensure consistency across all observed locations. The resulting IIAEI value represents the intensity of informal economic activities per unit length of the street corridor, enabling standardized comparison across segments with different spatial scales.

The IIAEI values are further classified into four categories, low, medium, high, and very high, using a quantile-based distribution approach derived from empirical observations. The classification thresholds are defined based on quartile values (Q1, Q2, and Q3), as presented in Table 2.

Table 2. Classification of IIAEI Values

Category	Range (IIAEI)
Low	≤ Q1
Medium	Q1 – Q2
High	Q2 – Q3
Very High	≥ Q3

This classification ensures that the categorization reflects the actual spatial variation of informal economic activity intensity across the observed corridors.

Analysis of Spatial Occupation and Spatial Pressure (SOR)

The second stage assesses the extent to which informal economic activities physically occupy and alter street space. This is quantified using the Spatial Occupation Ratio (SOR), which indicates the proportion of total available street space occupied by informal activities:

$$SOR = \frac{A_o}{A_t} \times 100 \dots \dots \dots (2)$$

where *A_o* represents the area occupied by informal activities, and *A_t* denotes the total available street space within each corridor segment.

The value of *A_o* is obtained by measuring the spatial footprint of informal economic activities through field observation and digital mapping techniques. Each activity unit is identified, and its occupied area is delineated using GIS-based tools and satellite imagery. The total available street space (*A_t*) is defined as the effective usable space within the corridor, including carriageways, sidewalks, and other accessible public areas, excluding permanent built structures.

Measurements are performed using digital scaling and on-screen digitizing to maintain consistency and comparability across corridor segments. The resulting SOR value

quantifies the percentage of street space occupied by informal activities, facilitating comparative assessment of spatial occupation levels.

Higher SOR values correspond to greater spatial occupation and reduced available space for mobility functions. In this study, spatial pressure is conceptualized as the outcome of the interaction between activity intensity (IIAEI) and spatial occupation (SOR)

This approach underscores that spatial pressure depends not only on the number of activities but also on their spatial distribution and the extent of space they occupy [17]. The relationship between IIAEI and SOR is analyzed comparatively across corridors, as detailed in section 4, facilitating the identification of spatial conditions such as high-pressure corridors, over-occupied segments, and uneven spatial distributions.

Analysis of Spatial Transformation and Corridor Typology

The third stage analyzes the transformation of urban street space by integrating IIAEI and SOR results with field-based spatial observations. Transformation is identified using key indicators such as shifts in space function from mobility to economic use, levels of spatial fragmentation, degrees of mobility disruption, and forms of spatial adaptation. This comparative analysis examines how variations in activity intensity and spatial occupation produce distinct spatial configurations [18]. Based on this integration, a typology of street corridors is developed to reflect the study's empirical findings. The typology includes high spatial pressure corridors, concentration-based hotspot corridors, and transitional corridors, each representing a specific form of spatial transformation resulting from different combinations of intensity and occupation levels [19].

Synthesis of the Activity Space Transformation Model

The final stage synthesizes a conceptual model explaining the relationship between informal economic activities and the transformation of urban street space. This synthesis draws on cross-corridor comparisons, considering variations in IIAEI values, SOR levels, and observed spatial conditions. The results indicate that street space transformation is shaped not only by the number of activities but by the interaction between activity intensity and spatial distribution. Notably, the distribution of activities exerts a more significant influence than their quantity in determining spatial pressure and corridor characteristics [20]. This finding underscores the value of a distribution-based analytical approach for understanding urban street dynamics.

The resulting model conceptualizes informal economic activities as active agents in the production of space, operating through spatial pressure generated by the interaction between intensity and occupation. This model provides an operational framework for interpreting urban street transformation and serves as a foundation for more adaptive, context-sensitive corridor planning [21].

RESULTS AND DISCUSSION

Result

Informal Economic Activities and Their Role in Shaping the Spatial and Functional Transformation of Urban Street Space in Medan City

The findings indicate that informal economic activities along urban street corridors in Medan City act as primary drivers of spatial and functional transformation. These changes are systematically produced through the interaction between the spatial distribution and intensity of activities. In this context, urban streets no longer function as neutral corridors for movement, but as spaces actively shaped by ongoing informal practices that generate relatively stable spatial patterns [20], [21]. This demonstrates that street space is produced through everyday socio-economic activities rather than solely through formal planning mechanisms. A central finding of this study is that the character of street space is shaped more by the spatial distribution of activities than by their quantity. Linear distributions generate continuous spatial dominance, clustered (spot) patterns create localized pressure, and mixed patterns indicate more advanced stages of spatial transformation

This confirms that the transformation of urban street space operates through spatial mechanisms in which distribution plays a more decisive role than quantity. Such patterns reflect broader characteristics of informal urbanism in rapidly developing cities, where spatial organization emerges from adaptive practices rather than formal design [21]. The spatial configuration of the study areas shows that all corridors are located within highly accessible zones and are directly connected to key urban functions, including education, trade, and services. Jalan Dr. Mansyur, as an arterial corridor characterized by greater spatial extent and higher connectivity, supports the accumulation of more than 90 informal activity units. In contrast, Jalan Halat and Jalan Gedung Arca, functioning as collector corridors with shorter segments, exhibit lower activity counts but stronger localized concentrations

These differences indicate that accessibility and corridor hierarchy play a fundamental role in structuring informal activity patterns. The map illustrates the spatial positioning of the three corridors within Medan's urban network, emphasizing their connectivity and functional context. Variations in corridor scale and accessibility explain the differences in activity intensity and spatial structure observed across the study areas.

The distribution mapping reveals three primary spatial patterns: linear, spot, and mixed, each representing different levels of spatial dominance. Along the southern segment of Jalan Halat, approximately 36 activity units form a strong linear pattern over a 200-meter stretch, creating a continuous economic strip along the sidewalk. In contrast, the northern segment, with approximately 17 scattered units, exhibits a spot pattern, resulting in weaker and more fragmented spatial dominance. Gedung Arca Street displays a combined linear and spot distribution, with 13 to 16 activity units occupying both sidewalks and road shoulders. This configuration reflects a transitional spatial condition in which economic activities begin

to challenge mobility functions but have not yet fully restructured the corridor. Informal activities are both continuous and nodal.

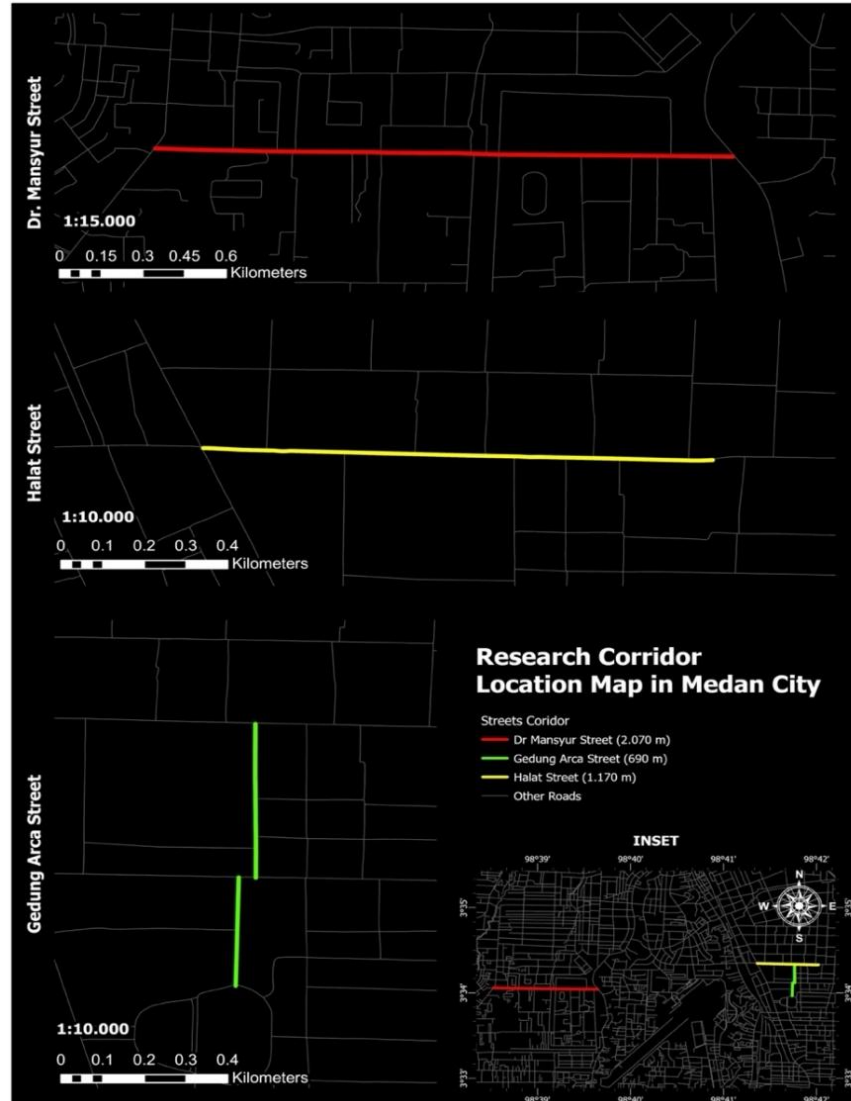


Figure 1. Research Corridor Location Map

Meanwhile, Jalan Dr. Mansyur demonstrates the most intensive and extensive transformation, with more than 90 activity units distributed along a corridor approximately 620 meters in length. The coexistence of linear dominance on one side and clustered concentrations on the other indicates a mature and complex spatial system. The map demonstrates that activity distribution follows a structured spatial logic influenced by accessibility, visibility, and movement intensity. Linear patterns indicate continuous economic occupation along street edges, spot patterns represent localized clusters, and mixed

patterns reflect the integration of both forms within a single corridor. Analysis of spatial occupation reveals significant differences in how informal activities reshape street space. In several segments, particularly along the southern section of Jalan Halat and Jalan Dr. Mansyur, occupation levels reach up to 100 percent, indicating a complete conversion of pedestrian space into economic space. In contrast, Jalan Gedung Arca and parts of Jalan Halat exhibit occupation levels ranging from 23 to 76 percent, representing transitional conditions where pedestrian movement and economic activities coexist.



Figure 2. Spatial Patterns of Informal Economic Activities: Linear, Spot, and Mixed

A key finding is that spatial occupation does not always correspond directly to the number of activity units. In some segments, fewer activities result in higher occupation levels, indicating over-occupation where limited actors utilize space intensively. Conversely,

segments with a greater number of activities may exhibit lower occupation levels due to more distributed spatial arrangements. This confirms that spatial pressure emerges from the interaction between activity intensity and spatial distribution, rather than from quantity alone.

The map illustrates the extent to which informal activities occupy street space, highlighting areas of full occupation and transitional use. High occupation levels indicate the displacement of mobility functions, whereas moderate levels suggest coexistence between economic and circulation functions [22]. The emergence of these spatial patterns is closely associated with the adaptive behavior of informal actors, who tend to occupy locations with the highest economic potential and maintain their presence through repeated use. Over time, these practices evolve from temporary occupation into semi-permanent spatial claims, reinforcing the transformation of street space. This process demonstrates that spatial production results from collective and repeated practices at the micro-corridor scale [23]. Furthermore, the persistence of these patterns is reinforced by interactions with other urban users, including pedestrians, consumers, and vehicular flows, which collectively form a microeconomic ecosystem. Temporal dynamics further intensify this transformation, as activity levels increase significantly during the afternoon and evening, amplifying spatial pressure and reinforcing the role of street space as a flexible yet dense economic environment.

However, the degree of transformation varies depending on local spatial capacity, corridor width, and regulatory conditions, indicating that not all urban corridors experience the same level of spatial pressure. This variation highlights the importance of context-sensitive analysis in understanding informal urban dynamics. Overall, the study demonstrates that informal economic activities not only occupy space but also actively shape the structure and function of urban streets. Their patterns of distribution, intensity, and occupation create spaces that are adaptive yet increasingly contested, as economic functions challenge mobility under conditions of high spatial pressure.

From a planning perspective, these findings indicate that conventional enforcement-based approaches are no longer adequate. Corridors experiencing high spatial pressure, such as Jalan Dr. Mansyur and the southern segment of Jalan Halat, require integrative strategies, including micro-scale zoning, regulated sidewalk use, and adaptive spatial design. Transitional corridors such as Jalan Gedung Arca offer opportunities for spatial control through targeted design interventions that reinforce pedestrian use and manage activity distribution. These results underscore the need for adaptive planning approaches that integrate informal economic activities into the urban spatial system in a structured and sustainable manner.

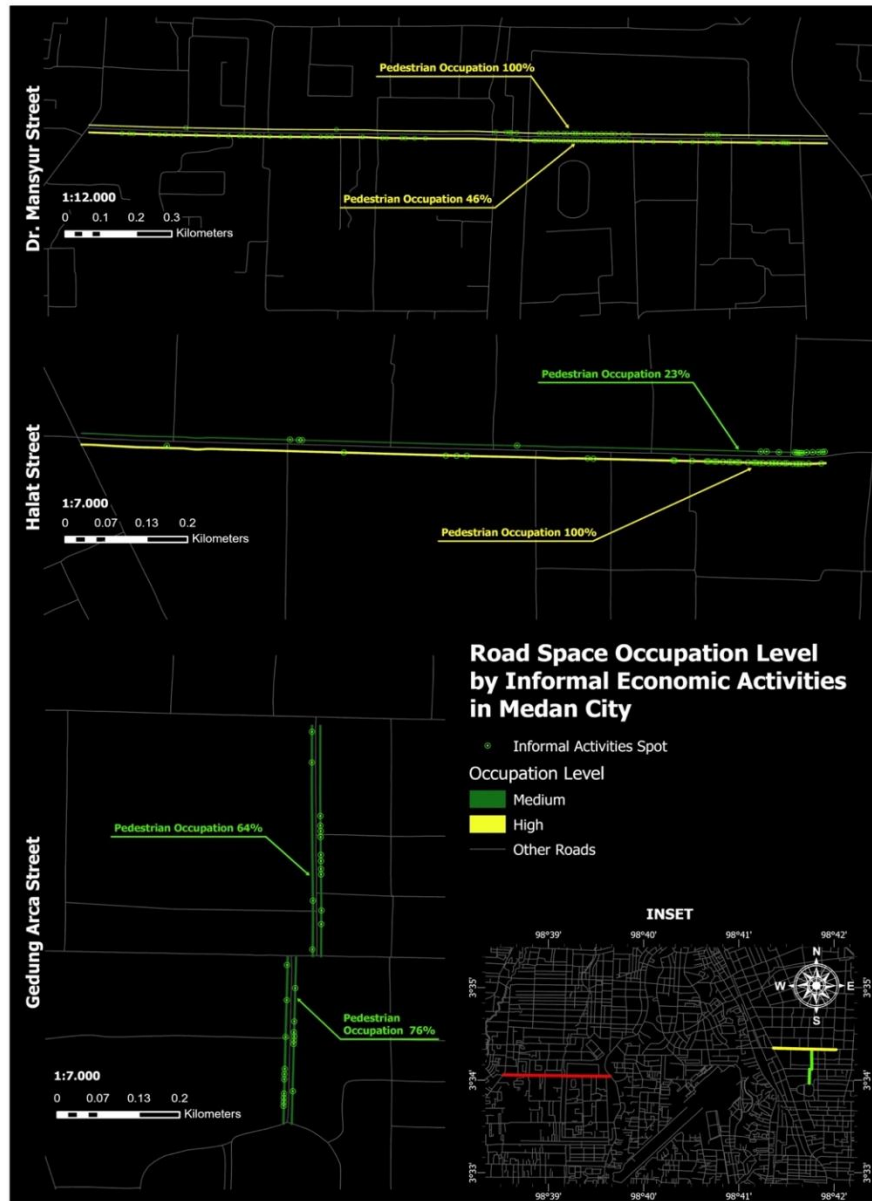


Figure 3. Road Space Occupation Levels by Informal Economic Activities

Spatial Patterns and Corridor Characteristics Based on Activity Intensity and Spatial Pressure

This analysis examines how the intensity of informal economic activities and the extent of spatial occupation interact to generate spatial pressure along street corridors. In contrast to the previous qualitative assessment, this stage employs two quantitative indicators: the Informal Economic Activity Intensity Index (IIAEI) and the Spatial Occupation Ratio (SOR). The IIAEI measures activity density per unit corridor length, while the SOR quantifies the proportion of street space occupied by these activities. By integrating both indicators, the

analysis moves beyond simple activity counts and reveals how informal activity structures street space and generates varying levels of spatial pressure across corridor segments.

This finding underscores that spatial pressure is not determined solely by the quantity of activities, but by the interaction between activity intensity and spatial distribution.

Table 2. Informal Economic Activity Intensity Index (IIAEI) and Spatial Occupation Ratio (SOR)

Corridor	Segment	Activity Units (Ai)	Length (m)	IIAEI	Intensity Category	SOR (%)	Spatial Pressure Category
Jl. Halat	South	36	200	0.18	High	100%	High
	North	17	40	0.43	Very High	100%	High
Jl. Gedung Arca	West	13	137	0.095	Medium	65%	Medium
	East	16	137	0.117	High	76%	Medium
Jl. Dr. Mansyur	North	31	620	0.05	Medium	100%	High
	South	67	620	0.108	High	46%	Medium

The relationship between activity intensity (IIAEI) and spatial occupation (SOR) exhibits a non-linear pattern across the observed corridor segments. This relationship is further illustrated through a scatter plot (Figure 4), which provides a visual representation of the interaction between IIAEI and SOR. A correlation analysis shows a moderate relationship between IIAEI and SOR ($R^2 \approx 0.28$), indicating that activity intensity alone does not fully explain spatial occupation.

Furthermore, a non-linear regression (polynomial) demonstrates that increases in activity intensity do not correspond proportionally to increases in spatial occupation. In several cases, segments with relatively low intensity exhibit high spatial occupation, indicating the influence of spatial distribution patterns.

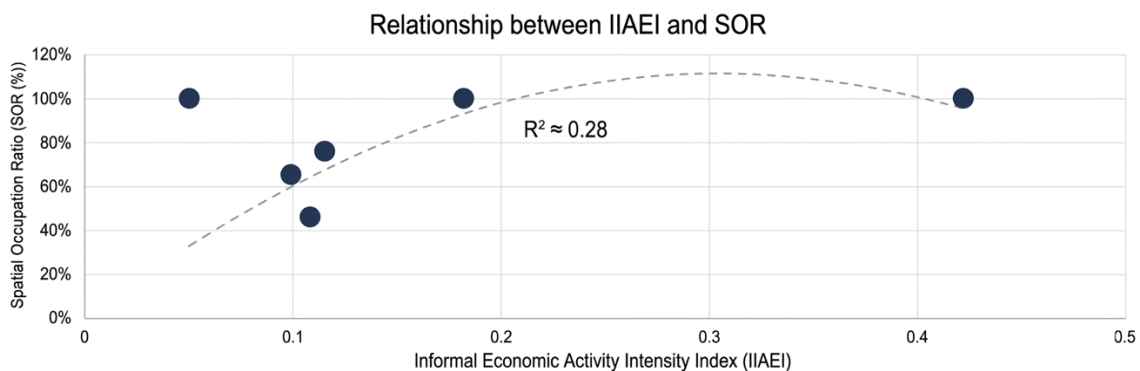


Figure 4. Relationship Between IIAEI and SOR

On Jalan Halat, both the southern and northern segments reach maximum spatial occupation (SOR = 100 percent), yet their intensity profiles differ significantly. The northern

segment records a very high IIAEI (0.43), substantially higher than the southern segment (0.18). This indicates that activities are concentrated within a shorter segment (approximately 40 meters), generating highly localized and extreme spatial pressure in the form of a hotspot. In contrast, the southern segment distributes approximately 36 activity units over a longer stretch (around 200 meters), resulting in a continuous linear occupation of the sidewalk. Although both segments reach full occupation, the southern segment exhibits a more stable and continuous pressure regime, whereas the northern segment concentrates pressure into a compact, high-intensity node.

On Jalan Gedung Arca, IIAEI values fall within the medium-to-high range (0.095-0.117), while SOR ranges from 65% to 76%. This condition reflects a transitional spatial state in which informal economic activities exert noticeable pressure on street space but have not fully displaced mobility functions. The coexistence of linear and spot patterns indicates an intermediate stage of spatial restructuring, where economic use is expanding but has not yet achieved full dominance over the corridor. Jalan Dr. Mansyur presents the most critical contrast, characterized by a clear imbalance between activity intensity and spatial occupation. In the northern segment, the IIAEI is relatively low (0.05), yet the SOR reaches 100 percent, indicating a condition of over-occupation, where a limited number of activities occupy a disproportionately large share of space. Conversely, the southern segment records a higher IIAEI (0.108) but a significantly lower SOR (46 percent), suggesting that activities are more spatially distributed and therefore generate lower spatial pressure despite their greater number. This contrast clearly demonstrates that spatial distribution plays a decisive role in determining spatial pressure outcomes.

Collectively, these findings confirm that the relationship between activity intensity and spatial occupation is non-linear. Activities concentrated within a limited space tend to generate higher spatial pressure than more numerous activities distributed across a wider area. In this context, spatial distribution exerts a more significant influence than activity quantity in shaping corridor characteristics. This pattern is consistently observed across all study corridors and provides an operational explanation of how informal economic activities restructure urban street space. The integration of IIAEI and SOR further enables the identification of three corridor conditions. First, high and stable pressure corridors, exemplified by the southern segment of Jalan Halat, where linear distribution and full spatial occupation result in continuous economic dominance along the street edge. Second, concentration-driven extreme pressure corridors, represented by the northern segment of Jalan Halat, where activities cluster within a short segment, forming hotspots with a high potential for spatial conflict. Third, transitional corridors, such as Jalan Gedung Arca and parts of Jalan Dr. Mansyur, where moderate spatial pressure reflects a relatively balanced interaction between mobility and economic functions.

These distinctions demonstrate that spatial conflict is not solely triggered by the number of activities, but by how activities are distributed and how intensively they occupy space.

Consequently, planning responses must be context-specific. High-pressure corridors require adaptive strategies such as micro-zoning and regulated sidewalk allocation, while hotspot corridors necessitate control over activity concentration to prevent excessive clustering. Transitional corridors, on the other hand, benefit from preventive interventions, including the reinforcement of pedestrian functions and the regulated integration of informal activities [24]. Methodologically, these findings demonstrate that transformations of urban street space are not random but are driven by measurable spatial mechanisms resulting from the interaction between activity intensity and spatial occupation [25]. The combined use of IIAEI and SOR establishes an operational and comparable framework for interpreting urban street dynamics, providing a robust basis for developing context-sensitive, adaptive, and data-driven planning strategies.

Discussion

This study demonstrates that informal economic activities function as primary mechanisms for shaping and regulating street space, rather than serving as residual phenomena in urban environments [25]. Drawing on two complementary strands of evidence, spatial pattern analysis (linear, spot, and mixed) and the integration of quantitative indicators, specifically the Informal Economic Activity Intensity Index (IIAEI) and the Spatial Occupation Ratio (SOR), the findings indicate that street-space transformation occurs systematically through the interaction between activity intensity and spatial distribution. This directly addresses the research problem by elucidating how informal activities restructure the functions and configurations of urban street corridors in a measurable and reproducible manner [26].

The results reveal a non-linear relationship between activity intensity and spatial occupation. Spatial pressure is not determined solely by the number of activities; rather, it is fundamentally shaped by their distribution across space. Linear arrangements create continuous dominance along the street edge, spot patterns generate localized pressure as hotspots, and mixed configurations reflect more advanced stages of spatial restructuring [27]. When combined with IIAEI and SOR, these patterns demonstrate that segments with relatively low intensity can exhibit high spatial pressure when activities are concentrated within a limited area, whereas segments with higher intensity may generate lower pressure when activities are more evenly distributed. Thus, the spatial distribution of activities exerts a stronger influence on corridor characteristics than their quantity [28].

These findings extend the concept of the production of space by emphasizing that space is generated through everyday social practices rather than exclusively through formal design [28]. In Medan, street space emerges from ongoing negotiations between mobility and informal economic uses, continually reproduced through collective practices. This interpretation aligns with the perspective, which positions informality as an essential component of urban dynamics. Informal activities not only occupy space but also actively

organize and stabilize spatial structures through patterned distribution and intensity of use [28]. From a local planning perspective, the findings reveal a significant limitation in prevailing approaches in Medan, which remain predominantly control-oriented and enforcement-driven. Policies that characterize informality as a disturbance often result in reactive measures such as eviction or relocation, without recognizing the structured spatial logic that already exists. The evidence presented indicates that informal activities follow identifiable and predictable spatial patterns, suggesting they can be incorporated into corridor design rather than excluded.

Design implications differ across the three corridors. Jalan Halat, characterized by full occupation and high spatial pressure, represents a stabilized economic corridor that requires integrative strategies such as micro-zoning, regulated use of the street edge, and partial formalization of informal practices. Jalan Gedung Arca exhibits a transitional condition in which mobility and economic functions coexist; in this context, preventive design measures, such as strengthening pedestrian infrastructure and managing activity distribution, can help maintain balance. Jalan Dr Mansyur demonstrates a pronounced imbalance between intensity and occupation, particularly in segments with over-occupation; this situation necessitates spatial reorganization and redistribution of activities to improve efficiency and reduce localized pressure. More broadly, the study confirms that the informal sector is inseparable from the urban spatial system and must be addressed as an integral component of street design. This requires adaptive and flexible approaches that accommodate both mobility and economic functions within clearly defined spatial frameworks. Such an approach aligns with the concept of hybrid space, which highlights the capacity of informal practices to adapt to and reshape urban environments through direct interaction with physical and social structures [29]. The primary scholarly contribution of this research is the development of a quantitative framework for analyzing the relationship between informal economic activities and street-space transformation.

By integrating IIAEI and SOR with spatial pattern analysis, the study offers an operational and comparable method for identifying spatial pressure and corridor typologies. This integrated approach advances the existing literature, which has predominantly relied on descriptive or qualitative accounts, by providing a systematic means to link spatial configuration with measurable indicators [29]. In practical terms, the findings advocate a shift from control-based to integrative, data-informed planning approaches. Informal economic activities should be managed as spatial practices through context-sensitive design and policy, rather than treated as anomalies to be removed. This perspective supports redefining urban streets as inclusive and productive public spaces in which mobility and economic functions coexist within a structured, sustainable spatial system [30].

CONCLUSION

The findings demonstrate that informal economic activities are central to the spatial and functional transformation of urban street space at the corridor scale. By integrating spatial pattern analysis (linear, spot, and mixed) with quantitative indicators such as the Informal Economic Activity Intensity Index (IIAEI) and the Spatial Occupation Ratio (SOR), the study reveals that street transformation occurs systematically through the interaction between activity intensity and spatial distribution. The results indicate a non-linear relationship between activity intensity and spatial occupation. Spatial pressure is determined more by the distribution of activities than by their quantity. Concentrated activities within limited areas generate high spatial pressure, while more dispersed activities produce lower pressure even when their total number is greater. This underscores the dominant influence of spatial distribution in shaping the structure and character of urban street space. The integration of IIAEI and SOR enables the identification of three corridor typologies: high-pressure corridors, concentration-based hotspot corridors, and transitional corridors. Each typology represents distinct spatial conditions and necessitates context-specific planning strategies. The principal contribution of this study is the development of a quantitative framework to operationalise the relationship between informal economic activities and street space transformation. Conceptually, the research affirms that urban street space is a dynamic product of socio-economic interactions rather than solely the outcome of formal planning. Practically, the findings support a shift toward integrative planning approaches that accommodate informal activities, thereby promoting more adaptive, inclusive, and sustainable urban street environments. Future research should extend this framework by incorporating temporal analysis to capture dynamic changes in informal economic activities over time. Further studies may also integrate additional variables, such as pedestrian flow and traffic conditions, to enhance the robustness of spatial pressure analysis.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

- [1] E. Bandauda and G. Arku, "They want to get rid of us by all means: A critical analysis of policy and governance responses and their implications for street traders' access to urban space in Harare, Zimbabwe," *Urban Studies*, 2024. <https://doi.org/10.1177/23996544241298414>
- [2] E. Bandauda and G. Arku, "Negotiating access to contested urban spaces: Street traders' resistance against exclusionary practices in Harare, Zimbabwe," *Urban Studies*, 2025. <https://doi.org/10.1177/02637758251322343>
- [3] F. Chen, L. Li, K. Yin, and K. Yu, "Quantifying vitality and structure: A multi-source spatiotemporal data analysis of Beiyuanmen Lane, Xi'an, as a historic cultural district," *Sustainability*, vol. 18, no. 6, p. 2755, 2026. <https://doi.org/10.3390/su18062755>

- [4] L. R. Ciriolo, “Fractured fiscal authority and fragmented infrastructures: Financing sustainable urban development in Sub-Saharan Africa,” *Habitat International*, vol. 104, p. 102233, 2020. <https://doi.org/10.1016/j.habitatint.2020.102233>
- [5] T. K. Connor and F. Charway, “Ambiguities of xenophobia in a border town: Inner city informal traders and Ekasi shopkeepers in East London, South Africa,” *Journal of Contemporary African Studies*, vol. 38, no. 2, pp. 257–273, 2020. <https://doi.org/10.1080/02589001.2020.1779917>
- [6] K. Dovey and R. B. Ricio, “Inventraset assemblages: The spatial logic of informal street vending, transport, and settlement,” *Urban Studies*, vol. 61, no. 12, 2024. <https://doi.org/10.1177/00420980231223060>
- [7] K. Gu, J. Liu, D. Wang, Y. Dai, and X. Li, “Analyzing the supply and demand dynamics of urban green spaces across diverse transportation modes: A case study of Hefei City,” *Land*, vol. 13, no. 11, p. 1937, 2024. <https://doi.org/10.3390/land13111937>
- [8] X. Jia, Y. Ren, X. Li, J. Huang, and G. Zhong, “Street store spatial configurations as indicators of socio-economic embeddedness: A dual-network analysis in Chinese cities,” *Urban Science*, vol. 10, no. 2, p. 78, 2026. <https://doi.org/10.3390/urbansci10020078>
- [9] Y. Jin, R. He, J. Hong, D. Luo, and G. Xiong, “Assessing the accessibility and equity of urban green spaces: A case study of a mountainous city in China,” *Land*, vol. 12, no. 9, p. 1793, 2023. <https://doi.org/10.3390/land12091793>
- [10] I. Lindell, C. Ampaire, and A. Byerley, “Governing urban informality: Re-working spaces and subjects in Kampala, Uganda,” *International Development Planning Review*, vol. 41, no. 1, 2019. <https://doi.org/10.3828/idpr.2019.4>
- [11] X. Liu, L. Ge, and J. Huang, “Measuring vitality and spatial efficiency of public spaces in commercial complexes: A multi-source data-driven analysis in Guangzhou,” *Land*, vol. 15, no. 3, p. 501, 2026. <https://doi.org/10.3390/land15030501>
- [12] P. L. Malasan, “The untold flavour of street food: Social infrastructure as everyday politics for street vendors in Bandung, Indonesia,” *Asia Pacific Viewpoint*, vol. 60, no. 1, pp. 51–64, 2019. <https://doi.org/10.1111/apv.12217>
- [13] L. Martínez and J. R. Short, “The informal city: Exploring the variety of the street vending economy,” *Sustainability*, vol. 14, no. 12, p. 7213, 2022. <https://doi.org/10.3390/su14127213>
- [14] R. Meneses-Reyes and J. A. Caballero-Juárez, “The right to work on the street: Public space and constitutional rights,” *Planning Theory*, vol. 13, no. 4, 2013. <https://doi.org/10.1177/1473095213503967>
- [15] M. Musara and C. Nieuwenhuizen, “Informal sector entrepreneurship and leadership emergence,” *Africa Journal of Management*, vol. 6, no. 3, pp. 194–213, 2020. <https://doi.org/10.1080/23322373.2020.1777817>
- [16] K. T. Ngo, N. Peimani, and H. Kamalipour, “Forms and spatiality of street vending in informal settlements: The case of in-between spaces in Hanoi,” *Cities*, vol. 161, p. <https://doi.org/10.1016/j.cities.2025.105870>
- [17] N. Peimani and H. Kamalipour, “Informal street vending: A systematic review,” *Land*, vol. 11, no. 6, p. 829, 2022. <https://doi.org/10.3390/land11060829>

- [18] N. Peimani and H. Kamalipour, "Mapping the spatiality of informal street vending," *Journal of Urbanism*, vol. 18, no. 3, pp. 329–348, 2022. <https://doi.org/10.1080/17549175.2022.2150267>
- [19] N. Peimani and H. Kamalipour, "Informal public space: Exploring street vending in Tehran," *Journal of Urbanism*, 2024. <https://doi.org/10.1080/17549175.2024.2348792>
- [20] Y. Qi *et al.*, "Perception of local characteristics in cultural street vending spaces," *Buildings*, vol. 14, no. 1, p. 192, 2024. <https://doi.org/10.3390/buildings14010192>
- [21] M. J. Rahayu, I. Buchori, and R. Widjajanti, "The need for improvement of street vendors management in public spaces at Surakarta City," *Planning Malaysia*, vol. 17, no. 10, 2019. <https://doi.org/10.21837/pm.v17i10.636>
- [22] N. W. I. Rahayu, M. Sawir, F. Melawati, and A. Mu'lis, "The public space paradox: Balancing governance and street vending in urban Indonesia," *Social Sciences & Humanities Open*, vol. 11, p. 101559, 2025. <https://doi.org/10.1016/j.ssaho.2025.101559>
- [23] S. Resch, "Informal street vending: A comparative literature review," *International Journal of Sociology and Social Policy*, vol. 41, no. 7–8, pp. 805–825, 2021. <https://doi.org/10.1108/IJSSP-07-2020-0285>
- [24] S. Sutrisno, "Elevating informality: Street vending and the remaking of public space in Bandung," *Urban Planning*, vol. 11, no. 1, 2026. <https://doi.org/10.17645/up.v11i1.1073>
- [25] S. Tsarwe and A. Mare, "Mobile phones and informal markets in Zimbabwe," *Area Development and Policy*, vol. 6, no. 3, pp. 347–362, 2020. <https://doi.org/10.1080/23792949.2020.1790021>
- [26] R. Widjajanti *et al.*, "Street vendors' adaptation to limited infrastructure," *International Journal of Innovative Research in Social Sciences*, vol. 8, no. 4, 2025. <https://doi.org/10.53894/ijirss.v8i4.8258>
- [27] Y. Zhang, M. Wang, X. Yang, and R. Zhang, "Urban commercial space vitality evaluation based on social media data," *Land*, vol. 14, no. 4, p. 697, 2025. <https://doi.org/10.3390/land14040697>
- [28] Y. Zhao, J. Liu, and Y. Zheng, "Visual evaluation of urban historical street landscapes," *Sustainability*, vol. 14, no. 14, p. 8775, 2022. <https://doi.org/10.3390/su14148775>
- [29] H. Zhou *et al.*, "Zoning management of urban informal vendor spaces using machine learning," *Sustainable Cities and Society*, vol. 133, p. 106858, 2025. <https://doi.org/10.1016/j.scs.2025.106858>
- [30] C. Li, Y. Huang, Y. Shen, and L. Xu, "Spatiotemporal patterns and mechanisms of street vending from the social sensing perspective: A comparison between law-enforcement reported, and residents' complaint events," *Cities*, vol. 124, p. 103597, 2022. <https://doi.org/10.1016/j.cities.2022.103597>