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Analysis of Walkability on Mixed-Use Urban Streets Utilizing Space Syntax Methodologies: A Case Study of Field Marshal Cariappa Road, Tumakuru

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Abstract: Walkability, a critical element in urban design and planning, is defined by multiple factors that contribute to a safe and enjoyable pedestrian experience. This paper investigates the application of Space Syntax tools to assess walkability on a mixed-use street within an Indian urban context, a domain where such sophisticated spatial analysis has been underutilized despite its potential for informing urban planning (Zhu et al., 2019). The research employs a quantitative methodology to evaluate pedestrian environments, utilizing Space Syntax metrics such as connectivity and integration, which are critical for understanding how urban layouts influence accessibility and human mobility (Morales et al., 2017) (Nag et al., 2022). This approach aims to develop a quantitative measure to assess pedestrian environments, thereby aiding the prioritization of investments in infrastructure that supports active transportation (Anapakula & Eranki, 2021). A spatial examination of walkability along Field Marshal Cariappa Road in Tumkur city of Karnataka, was conducted utilizing Space Syntax methodologies. This research contributes by illuminating the current pedestrian conditions along Field Marshal Cariappa Road, pinpointing areas that necessitate improvement, and thereby informing the development of more pedestrian-centric urban environments within Tumkur.

Keywords: *Walkability, Space Syntax, Urban Planning, Pedestrian Environment*

1. Introduction

The interconnectedness of human behavior and the urban environment has historically been a neglected area for architects, urban designers, and planners. The act of walking possesses both social and morphological dimensions. Socially, it is linked to health outcomes, encompassing mental and physical well-being, and also carries economic implications(Job, 2020). Morphologically, walking serves community needs, requiring affordability in terms of walking space, accessibility, and time/distance costs(Litman, 2003). Furthermore, safety and spatial coherence are crucial, ensuring navigable and varied spaces between destinations. Considering these considerations, this study has developed a comprehensive framework that integrates visual, graphical, and syntax analyses, alongside urban design and planning theories, with a specific focus on enhancing walkability. The theoretical underpinnings and methodologies were explored and validated through a case study of Field Marshal Cariappa Road in Tumkur, Karnataka. This research endeavors to ascertain the prevailing pedestrian conditions and movement dynamics along Field Marshal Cariappa Road, pinpointing existing impediments such as safety vulnerabilities, accessibility constraints, and infrastructural shortcomings. It will leverage Space Syntax methodologies to map the road's spatial configuration and connectivity. Fundamentally, this investigation seeks to elevate the pedestrian experience on Field Marshal Cariappa Road in Tumkur through a Space Syntax-driven evaluation and subsequent proposal of design enhancements. The research offers a granular examination of pedestrian activity, road structure, and spatial context using Space Syntax principles, considering physical, environmental, and functional elements that influence walkability. The insights derived are intended to assist urban planners and architects in

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cultivating more pedestrian-centric urban settings within the broader metropolitan framework.

2.Literature Review

The concept of walkability pertains to the creation of environments that are safe, accessible, and conducive to pedestrian movement(Foti, 2014). Space Syntax, as a methodology, analyzes the configuration and function of spatial arrangements, particularly in relation to human movement patterns. Introduced by Hillier and Hanson, this approach quantizes the connectivity and integration within the urban fabric, positing that high connectivity facilitates pedestrian activity and social interaction, while low integration impedes movement(Nag et al., 2022). Empirical studies indicate that urban street systems with a grid-like structure, mixed land uses, and enhanced safety features exhibit improved walkability. Computational tools such as axial and segment analysis, within the Space Syntax framework, enable the measurement and visualization of pedestrian flow dynamics. Case studies, including those in London, have demonstrated the utility of Space Syntax in identifying urban bottlenecks and informing design optimizations(Nag et al., 2022). Tumkur City, experiencing rapid urbanization, provides a relevant context for examining the importance of sustainable and walkable streets, exemplified by Field Marshal Cariappa Road. Employing Space Syntax analysis on this road can reveal spatial inefficiencies, thereby guiding design improvements. Enhancements to walkability are significantly influenced by infrastructural quality, functional usability, and safety considerations(Patil et al., 2021). This analytical approach offers practical insights for urban planners aiming to foster walkable and accessible urban environments.

2.1 Site Study:

The street sample chosen is Field Marshal Cariappa Road, a prominent mixed-use street located in the heart of Tumkur city, Karnataka, India (Mehta, 2008). This particular road was selected due to its representative character as a vibrant urban corridor, featuring a diverse array of commercial, residential, and institutional establishments that contribute to complex pedestrian movement patterns (Marangão et al., 2022). The thorough integration of various land uses along this arterial road presents an ideal scenario for analyzing how spatial configuration impacts pedestrian accessibility and vibrant street life, particularly within an Indian urban context (Zhu & Wang, 2005). Moreover, the selected street facilitates an investigation into how spatial intelligibility and visual perception influence user experience and appropriation of outdoor spaces in a residential environment, which is critical for understanding habitability (Fenghour et al., 2022). The analysis of Field Marshal Cariappa Road will therefore provide valuable insights into the interrelationship between spatial legibility, land use diversity, and pedestrian activity, offering a foundation for developing urban design strategies that promote greater walkability and liveliness in similar mixed-use urban settings (Askarizad & He, 2022). Figure 1 presents the scenario of the street sample chosen.

Figure 1: Existing street condition of Field Marshal Cariappa Road, Tumkur. (Image source: Author)

Primary data collection was carried out through on-site observations, pedestrian volume counts, and user perception surveys to gather empirical evidence regarding existing conditions and user experiences along Field Marshal Cariappa Road (Kaur et al., 2021). This multi-faceted data collection approach, combining quantitative metrics with qualitative perceptions, allows for a holistic understanding of walkability, moving beyond purely physical attributes to incorporate the human experience of the built environment (Zhang et al., 2019). It addresses how attributes like sidewalk quality, street enclosure, and building facade transparency affect pedestrian satisfaction and safety, while also considering how physical accessibility influences the conviviality of public spaces (Chen et al., 2025) (Apritasari, 2020) (Patil et al., 2021) (Thombre & Kapshe, 2020). Figure 2 presents the street sections drawn during the documentation process.

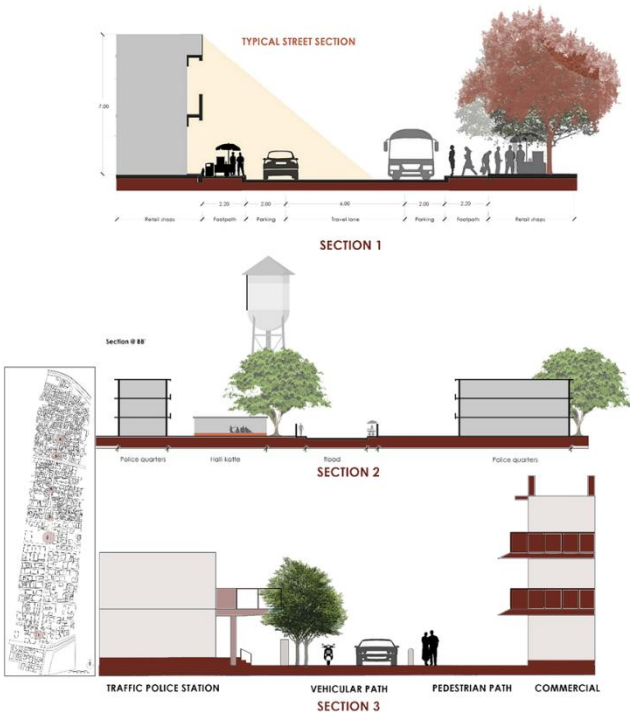

Figure 2: Street Sections

3. Methodology

The methodology for assessing street networks using Space Syntax begins with a thorough review of existing literature to establish a robust theoretical and methodological foundation. This involves synthesizing previous research on urban morphology, mobility systems, and the application of Space Syntax, identifying critical variables such as accessibility, integration, safety, and inclusivity, and drawing upon insights from prior case studies to ensure the subsequent analysis is well-informed.

Following this, a relevant study area is defined, considering its accessibility and the presence of urban challenges like congestion, inadequate pedestrian infrastructure, or safety issues. This area is then systematically examined through field surveys covering the mobility network, street environment, and visual documentation. Mobility analysis encompasses the road network hierarchy, traffic volumes, parking, and transport modes. The street environment assessment focuses on pedestrian infrastructure, usage patterns across different demographics, and safety conditions, supported by photographic records and mapping for visual and spatial evidence.

To provide context, drawings of existing conditions are prepared, including base maps, building footprints, and detailed street cross-sections that illustrate the spatial arrangement of roadways, pavements, parking, and adjacent structures, identifying spatial conflicts and dysfunctional patterns. These preparatory steps lay the groundwork for computational analysis.

The methodology then progresses to Space Syntax analysis utilizing DepthmapX software, which models the street network into axial or segment maps. The software computes three key syntactic measures: the Connectivity Index, assessing direct spatial linkages; the Local Integration Index, measuring accessibility to immediate neighbors; and the Global Integration Index, evaluating position within the broader urban system. Results are visualized through color-coded maps, with warmer colors indicating higher integration and cooler shades denoting spatial segregation, facilitating both quantitative assessment and visual interpretation of street hierarchy and accessibility.

The final phase integrates field observations with computational findings to generate conclusions and recommendations. This integrated approach identifies primary connecting streets, spatially segregated areas, and sites requiring intervention. Recommendations may include redesigning pavements, enhancing lighting and surveillance, mitigating vehicular-pedestrian conflicts, or generally improving walkability. Figure 3 provides the workflow of the analysis.

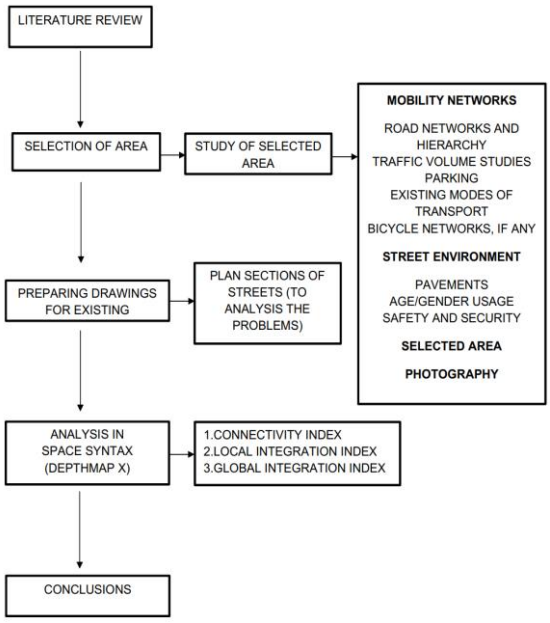

Figure 3: Workflow of the study

In summary, this methodology offers a rigorous framework that combines empirical surveys with Space Syntax analysis to evaluate urban street system performance. Its strength lies in balancing qualitative observations with quantitative spatial metrics, rendering it a valuable tool for heritage precinct planning, urban renewal, and sustainable mobility strategies.

4. Results

The research methodology involved analyzing three key spatial syntax measures: Connectivity Index, which quantifies direct path accessibility; Local Integration Index, which assesses ease of access to immediate surroundings; and Global Integration Index, which measures overall accessibility within the entire urban system. The syntactic properties of Field Marshal Cariappa Street were computed, with the results, including connectivity, presented in visual maps. The maps indicated varying degrees of network interconnection and the presence or absence of sidewalks. Specifically, DepthmapX analysis revealed specific minimum and maximum values for Connectivity, Local Integration, and Global Integration indices. The Global Integration index was found to be the most influential, despite a declining trend, demonstrating a strong correlation with pedestrian choice and the availability of street-side sidewalk infrastructure. This analysis statistically confirms the impact of sidewalks on street connectivity, integration, and pedestrian behavior along Field Marshal Cariappa Street. Figure 4 presents the global integration index maps and scores.

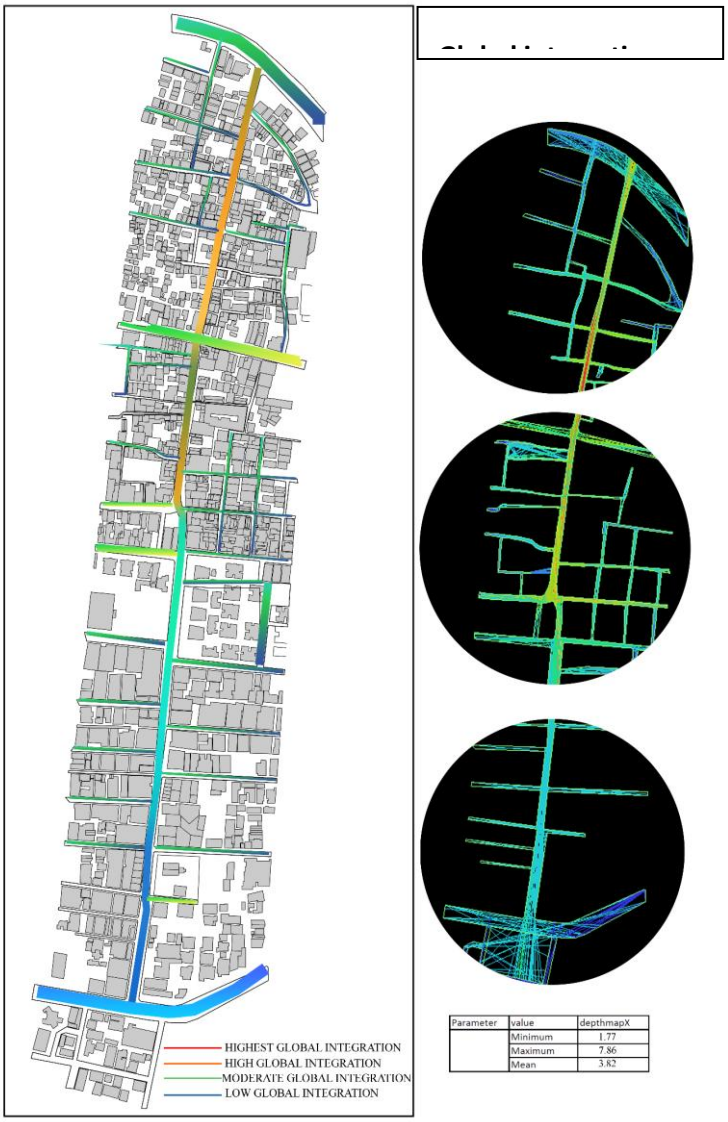

Figure 4: Global integration index

The study identified that the absence of designated footpaths on Field Marshal Cariappa Street significantly impedes pedestrian movement and walkability due to insufficient spatial connectivity and hazardous pedestrian crossings. This discontinuity is further exacerbated by encroachments from businesses and service stations, creating significant barriers to continuous and safe pedestrian movement (Quijada-Alarcón et al., 2025). The lack of dedicated pedestrian infrastructure forces pedestrians to share roadway space with vehicular traffic, increasing accident risks and deterring walking as a viable mode of transport (Asadi-Shekari et al., 2014).

5. Discussion

Academic analysis of Field Marshal Cariappa Street using space syntax methodologies indicates that the absence of well-designed walkways and sidewalks is a primary contributor to significant walkability and connectivity challenges. Deficiencies in pedestrian infrastructure discourage public movement and create substantial barriers to walkability. The study's findings are underpinned by an examination of three key spatial indices:

5.1 Connectivity Index - This analysis highlights considerable variations in path accessibility, with connectivity indices ranging from 4.00 to 509, reflecting both well-connected and poorly connected segments within the network. Such asymmetry is attributable to differing network morphologies,

resulting in certain segments exhibiting limited connectivity.

5.2 Local Integration Index - Measuring accessibility within immediate vicinities, local integration values span from 2.48 to 8.36, averaging 5.80. These findings suggest that while some segments offer good local accessibility, the broader network remains less accessible at comparable length scales, hindering short-range pedestrian movement.

5.3 Global Integration Index - With global integration values fluctuating between 1.77 and 7.86, and an overall average of 3.82, the street network exhibits relatively low overall connectivity. This indicates a less integrated network structure, less conducive to long-distance pedestrian movement.

5.4 Interpretation - The Global Integration Index emerges as the most critical metric for network assessment, reflecting underlying connectivity and accessibility issues. The lack of sidewalk continuity profoundly impacts both local and global integration; the absence of a cohesive sidewalk system significantly degrades spatial integration. Visual representations of colour transitions across maps correlate directly with the fragmented connectivity and integration patterns within the street network, underscoring the imperative for more optimized pedestrian route design. This comprehensive understanding underscores the necessity of targeted interventions to enhance pedestrian infrastructure, thereby improving the overall walkability and functional integration of urban spaces (Froehlich et al., 2022).

6. Conclusion

This research elucidates the critical role of robust pedestrian infrastructure in fostering urban walkability and connectivity, particularly within the challenging context of a mixed-use Indian street. The findings consistently demonstrate that the absence of continuous and well-maintained sidewalks significantly compromises both local and global integration, leading to reduced pedestrian activity and increased safety concerns (Baek & Lim, 2023) (Rukmana et al., 2023). The study specifically highlights how fragmented pedestrian networks, often characterized by discontinuous sidewalks and encroachments, directly impede pedestrian flow and diminish the overall accessibility of urban spaces (Quijada-Alarcón et al., 2025). These insights advocate for an integrated approach to urban planning that prioritizes pedestrian networks as a foundational element for sustainable urban development, echoing calls for frameworks that incorporate comprehensive pedestrian network concepts (Jabbari et al., 2023).

Enhancing sidewalk accessibility and upkeep significantly benefits both local and global integration within the urban fabric. The most effective strategy for improving pathways and incorporating pedestrian-friendly elements involves ensuring walkability and connectivity, thereby encouraging more individuals to walk to their intended destinations. Preserving continuous connectivity throughout the network is crucial for dismantling existing barriers and improving user accessibility across the region. Future studies should consider integrating socio-spatial information with street-level imagery and advanced analytical techniques, such as multimodal deep learning, to further unveil nuanced pedestrian injury risk factors within diverse urban contexts (Baek & Lim, 2023).

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