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Spatial Analysis: Integrating Multi-Layered Data to Understand Neighbourhood Functionality - A Case Study of Indira Nagar, Bengaluru

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Abstract: *This paper presents a comprehensive spatial analysis of Indira Nagar, Bengaluru, by integrating multiple layers of urban data to understand neighbourhood functionality. Utilizing site analysis, land use maps, building use maps, figure ground maps, height maps, network and connectivity maps, and traffic analysis maps, this study explores the intricate interplay between different urban elements. By overlaying these diverse datasets, we aim to uncover patterns and relationships that influence the area's spatial dynamics. The analysis reveals critical insights into land use distribution, building utilization, connectivity, traffic flow, and overall urban morphology. Our findings highlight the importance of a multi-layered approach in urban planning and design, providing valuable implications for sustainable urban development. This study contributes to a deeper understanding of urban functionality and offers a model for analysing complex urban environments.*

Key Words: *Spatial Analysis, Urban Functionality, Land Use, Building Use, Connectivity, Traffic Analysis, Urban Morphology.*

1. INTRODUCTION:

Urban areas are complex and dynamic environments where various spatial, social, and ecological elements interact. Understanding these interactions is crucial for effective urban planning and design, which aim to enhance liveability, functionality, and sustainability. Indira Nagar, a prominent neighbourhood in Bengaluru, India, exemplifies this complexity with its diverse land uses, building types, network connectivity, and traffic patterns. To gain a comprehensive understanding of such an urban area, it is essential to adopt a multi-layered analytical approach. This paper focuses on Indira Nagar, employing an integrative spatial analysis to decode its neighbourhood functionality. By combining data from site analysis, land use maps, building use maps, figure ground maps, height maps, network and connectivity maps, and traffic analysis maps, we aim to provide a holistic view of the area's urban dynamics. Each layer of data offers unique insights into different aspects of the neighbourhood, and their integration helps to identify patterns and relationships that are not immediately apparent when examined in isolation. Indira Nagar, known for its vibrant commercial zones, residential areas, and significant traffic flow, serves as an ideal case study for this research. The neighborhood has undergone rapid urbanization and development, leading to a complex urban fabric that presents both opportunities and challenges for urban planners and designers. By analysing the spatial characteristics and their interdependencies, this study seeks to contribute to a more nuanced understanding of Indira Nagar's functionality and provide recommendations for its future development. The findings highlight key spatial patterns and their implications for urban functionality. By employing a multi-layered spatial analysis, this research aims to bridge the gap between data-driven urban analysis and practical urban design strategies, ultimately contributing to more informed and sustainable urban development in Indira Nagar and similar neighbourhoods.

2. METHODOLOGY:

The methodology for this study involved a thorough data collection process and an integrated analysis framework to understand the urban design and functionality of Indira Nagar, Bangalore. Site analysis was conducted to study the neighbourhood's urban vistas, nodes, junctions, and design elements. Various mapping techniques, including land use mapping, building use mapping, figure-ground mapping, height mapping, network, and connectivity mapping, were employed to analyse the characteristics of the area. Traffic analysis was also conducted to assess the impact on urban design and functionality. This comprehensive approach ensured a holistic understanding of Indira Nagar's urban fabric, enabling a detailed examination of its design elements and functionality.

3. STUDY AREA :

Indira Nagar is a prominent and vibrant neighbourhood in the eastern part of Bangalore, Karnataka, India. Located approximately 4 kilometres east of the city centre, it is bounded by Old Madras Road to the north, 100 Feet Road through the middle, and the Inner Ring Road to the south. Originally developed as a residential area in the 1970s, Indira Nagar has transformed into a bustling urban locality, driven by Bangalore's IT boom and significant commercial growth. The neighbourhood features a diverse urban fabric, including residential zones with independent houses, apartments, and gated communities, alongside commercial hubs such as 100 Feet Road and CMH Road, lined with retail stores, restaurants, cafes, and offices. Public spaces like Indira Nagar Park and Defence Colony Park add to the area's charm. Connectivity is a major strength, with arterial roads and the Indiranagar metro station providing easy access to other parts of Bangalore. The neighbourhood's proximity to key commercial districts, tech parks, and educational institutions further enhances its appeal. This multifaceted neighbourhood offers rich insights into the complexities of urban living and development, making it an ideal subject for spatial analysis to understand urban functionality in rapidly growing cities.

Fig.1: Study area street map and images of Indira nagar, Bengaluru

4. THEMATIC ANALYSIS:

4.1Land Use Map

The land use maps of Indira Nagar, Bangalore, presented in the image showcase the evolution and current state of the neighbourhood's urban fabric. The 2013 proposed land use map reveals a predominantly residential area (yellow), with commercial zones (blue) concentrated along the main thoroughfares, notably 100 Feet Road and Old Madras Road. Green spaces (green) and public spaces (red) are sparse, indicating limited recreational and communal areas. By 2031, the proposed land use map shows a significant increase in mixed-use areas (purple) and commercial zones, reflecting a shift towards greater commercial development and higher density usage. This change suggests an adaptation to the growing demand for commercial and mixed-use spaces, likely driven by economic growth and urbanization. The latest survey-based land use map highlights the current reality, with a balanced distribution of residential, commercial, and

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mixed-use areas. There is a notable increase in green spaces and public spaces compared to the earlier maps, indicating efforts to enhance the neighbourhood's liveability. However, the commercial expansion along major roads remains a dominant feature, underscoring the area's commercial vibrancy. Overall, the analysis indicates a trend towards densification and commercialization, accompanied by a conscious effort to incorporate more green and public spaces, aiming to balance development with quality of life improvements in Indira Nagar.

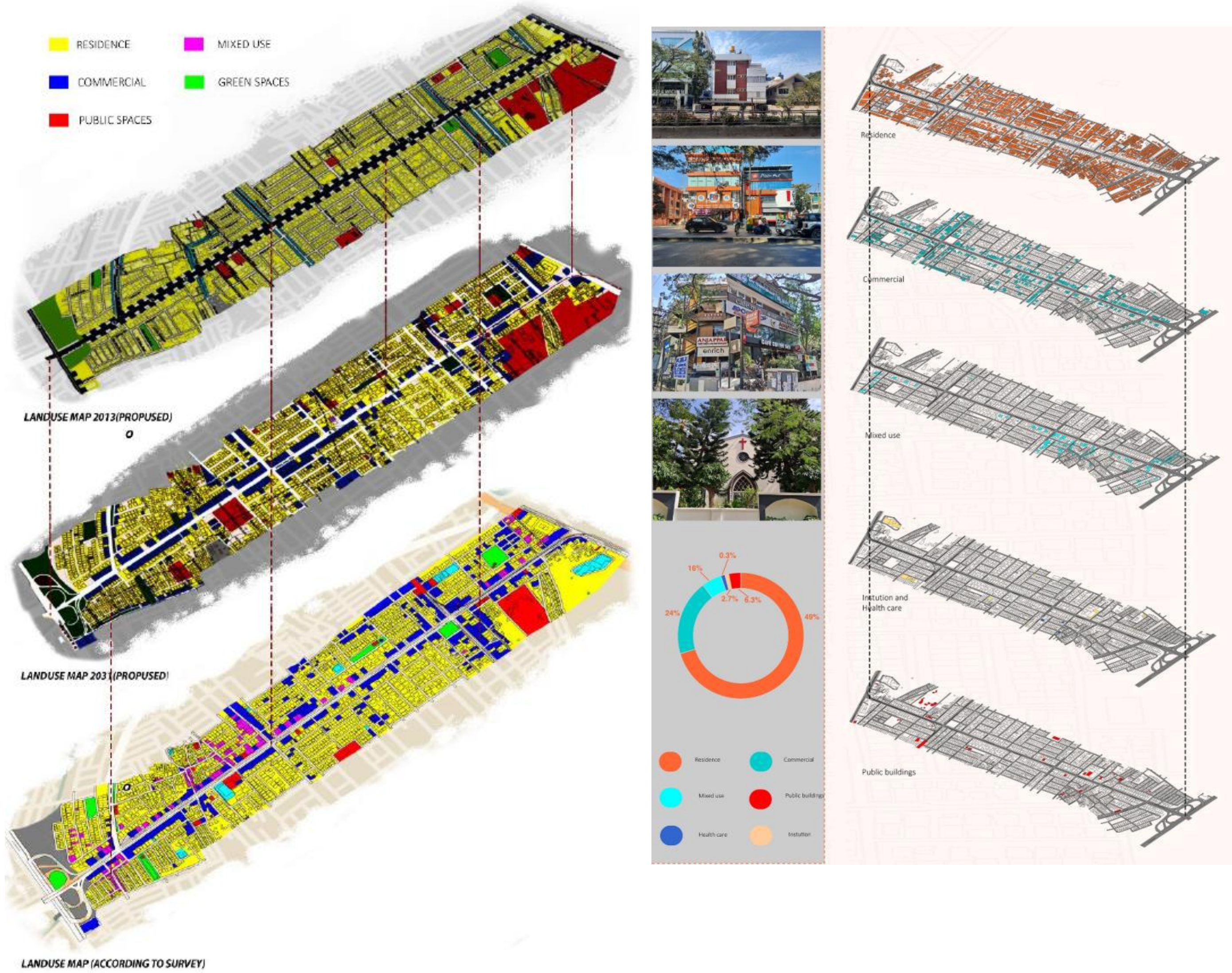

Fig.2: Land use and Building use map of Indira Nagar, Bengaluru

4.2 Building Use Map

The building use map of Indira Nagar, Bangalore, presented in the image, illustrates the distribution of various types of buildings within the neighbourhood. The majority of the area is dominated by residential buildings (49%), shown in orange, indicating that Indira Nagar remains a primarily residential locality. Commercial buildings (24%), marked in blue, are concentrated along major roads such as 100 Feet Road and Old Madras Road, reflecting the area's commercial vibrancy and economic activity. Mixed-use buildings (16%), highlighted in turquoise, are strategically located along key commercial corridors, suggesting an integration of residential, retail, and office spaces to support urban density and walkability. Institutions and healthcare facilities (6.3% each), shown in yellow and teal respectively, are dispersed throughout the area, ensuring accessibility for residents. Public buildings (2.7%), marked in red, are scattered, providing essential services and community functions. The visual data reveal a well-balanced urban structure that supports a mix of living, working, and recreational activities. This blend of building uses contributes to the neighbourhood's dynamic character, catering to the diverse needs of its residents. However, the high percentage of residential buildings highlights a potential need for more public and green spaces to enhance the overall quality of life. The strategic placement of mixed-use buildings suggests an urban planning approach aimed at fostering sustainable and walkable communities, aligning with contemporary urban development trends.

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4.3 Figure Ground Analysis

The figure ground map of Indira Nagar, Bangalore, provides a detailed analysis of the built and open spaces within different urban fabrics of the neighbourhood. The map categorizes areas into slum, dense fabric, and sparse fabric, highlighting distinct urban patterns. The slum area, located near Old Madras Road, consists of 45% built space and 55% open space. This high proportion of open space is indicative of irregular and low-density construction, often associated with informal settlements. The open areas may be used for communal activities but may also reflect a lack of formal infrastructure. The dense fabric area, cantered around 9th Main Road, shows 85% built space and only 15% open space. This indicates a high-density urban environment with closely packed buildings and minimal open areas. Such dense urban fabrics typically have limited green spaces and public areas, leading to potential challenges in terms of liveability and environmental quality. The sparse fabric area, near New Horizon Public School Street, has 70% built space and 30% open space. This represents a more balanced urban pattern, with a significant amount of open space compared to build space. Such areas tend to have better environmental quality and more opportunities for recreational activities, contributing to a higher quality of urban life. Overall, the figure ground map highlights the varying degrees of urban density in Indira Nagar, reflecting different levels of development and infrastructure. The slum areas need improved infrastructure and formalization, the dense fabric areas require more green and open spaces, and the sparse fabric areas provide a more balanced urban environment.

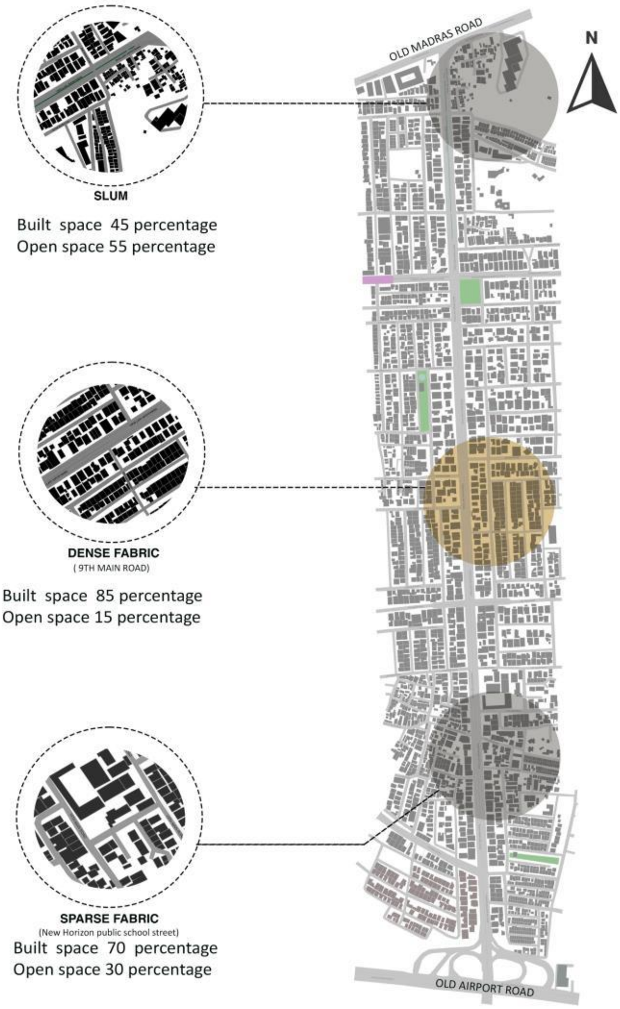

Fig.3: Figure ground map of Indira Nagar, Bengaluru

4.4 Height and Density Distribution

The image provides a detailed analysis of building heights and their distribution along a specific area between Old Madras Road and Old Airport Road. The map on the left shows the ground-level footprint of buildings, with the densest clusters highlighted in red. On the right, the series of perspective diagrams illustrate the vertical distribution of buildings classified by height: ground floor only (G), ground plus one (G+1), ground plus two (G+2), and up to ground plus five (G+5) levels. The density of buildings decreases as the height increases. Ground floor (G) and G+1 buildings are the most prevalent, especially concentrated in the northern and central parts of the area. The southern region near Old Airport Road shows a similar trend but with fewer G+1 buildings. As building height increases to G+2 and G+3, there is a noticeable reduction in density, indicating that mid-rise structures are less common. The tallest buildings (G+4 and G+5) are sparsely distributed across the area, suggesting limited high-rise development.Overall, the map indicates a predominantly low-rise urban fabric, with a gradual tapering in building density and height towards taller structures. This pattern reflects a typical urban scenario where higher buildings are fewer and concentrated in specific zones, possibly due to zoning regulations or land use patterns.

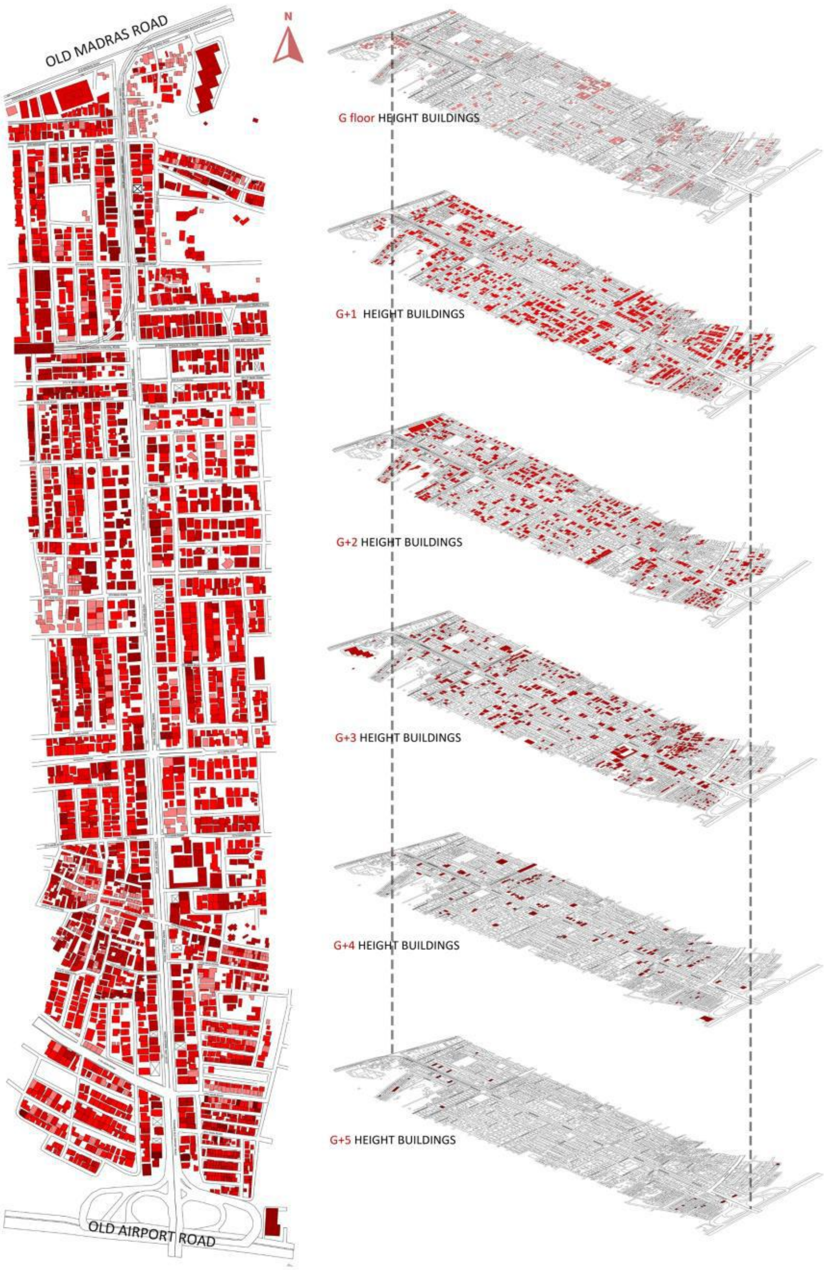

Fig.4: height map of Indira nagar, Bengaluru

4.5 Network and Connectivity

The map on the left categorizes roads into a hierarchy: arterial, sub-arterial, collector, and local roads. Arterial roads, including Old Madras Road and Old Airport Road, are the primary thoroughfares with widths ranging from 30-40 meters, facilitating constant and significant traffic flow. These roads ensure excellent connectivity across various urban areas. Sub-arterial roads, such as the 100 Feet Road and those near Chinmaya Mission Hospital, measure 30 meters in width and also handle substantial pedestrian and vehicular traffic. These roads act as critical connectors, linking major arterial roads to the finer grid of the network. Collector roads are highlighted as primary conduits within the neighbourhood, with widths between 9-12 meters. These roads balance moderate vehicle traffic and pedestrian activity, providing crucial links between local roads and the broader arterial and sub-arterial networks. Collector roads ensure residents can easily access major roads and are frequently used throughout the day, especially during peak hours. Local roads, making up the majority of the network, are narrower at 9-6 meters wide. These roads primarily serve residential areas, exhibiting low vehicular activity but significant pedestrian movement. They are essential for local connectivity, allowing residents to move within their neighbourhood comfortably without encountering heavy traffic.

The road typology map on the right further delineates the distribution of different road types. Arterial roads constitute 9.7% of the network, sub-arterial roads 29.1%, collector roads 29.9%, and local roads 31.3%. This distribution indicates a well-balanced network designed to manage traffic flow efficiently while catering to both long-distance travel and local accessibility. The elements of the roads, such as sidewalks and medians, enhance pedestrian safety and traffic management. Sidewalks are prominent along major roads, ensuring safe pedestrian movement, while medians on CMH Road and 100 Feet Road help in lane separation and traffic regulation. Overall, the road network displays a thoughtful design prioritizing connectivity and accessibility at various scales, from arterial roads facilitating cross-city travel to local roads ensuring neighbourhood mobility. This hierarchical structure ensures efficient traffic management, safety, and accessibility for both vehicles and pedestrians.

Fig.5: Road map of Indira nagar, Bengaluru

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4.6 Traffic and Mobility

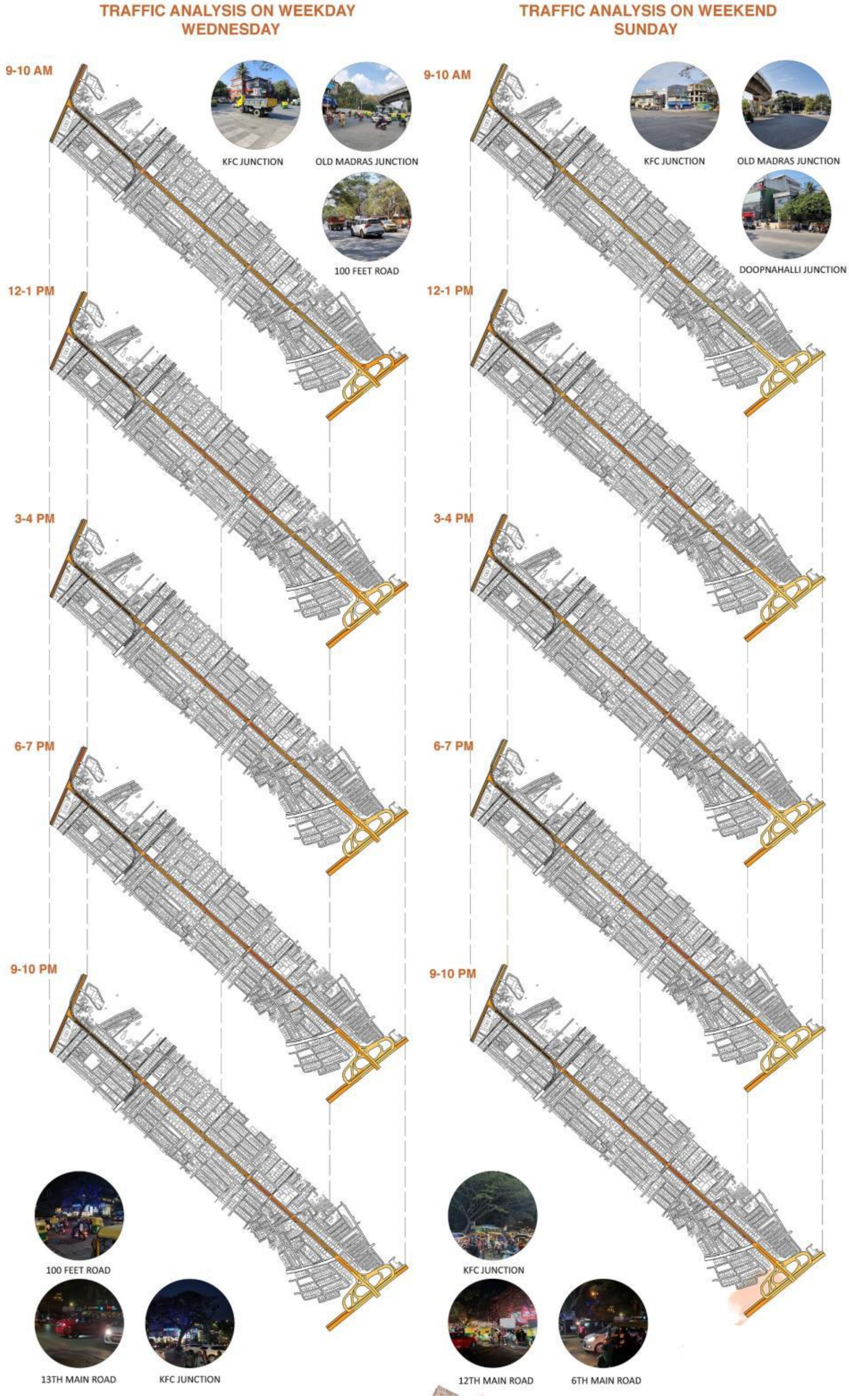

Fig.6: Road map of Indira Nagar, Bengaluru

The image shows a detailed traffic analysis for both weekdays (Wednesday) and weekends (Sunday) at various times of the day in a specified urban area. This analysis highlights key junctions and roads that experience different traffic conditions, depicted through a series of maps for different time slots. On weekdays, traffic is notably heavy at key junctions such as KFC Junction, Old Madras Junction, and 100 Feet Road, particularly during peak hours (9-10 AM and 6-7 PM). The maps indicate that arterial and sub-arterial roads bear the brunt of this congestion. Traffic remains steady but less intense during midday (12-1 PM) and late evening (9-10 PM), though certain areas like 13th Main Road and

100 Feet Road still show significant activity, suggesting continuous high usage of these routes throughout the day. During weekends, traffic patterns exhibit a different dynamic. While morning traffic (9-10 AM) is lighter compared to weekdays, there is still noticeable congestion at major junctions such as Doopanahalli Junction and 100 Feet Road. The afternoon period (12-1 PM) sees an increase in traffic, particularly around shopping and dining areas, indicating higher pedestrian and vehicle activity related to leisure activities. By late afternoon (3-4 PM) and early evening (6-7 PM), traffic density increases, reflecting the typical weekend outings and errands. Late evening (9-10 PM) on weekends shows significant traffic on entertainment and dining hubs like KFC Junction and 12th Main Road, highlighting the area's vibrant nightlife. This contrasts with the weekday late evening, where traffic is more dispersed but still significant in commercial areas. Overall, the analysis reveals distinct traffic patterns between weekdays and weekends. Weekdays show typical peak hour congestion influenced by work and school commutes, while weekends display more spread-out traffic throughout the day, driven by recreational activities. Key roads and junctions consistently face high traffic volumes, necessitating efficient traffic management strategies to mitigate congestion and enhance mobility. This information is important for urban planners and local authorities to design better traffic flow solutions and improve the overall commuting experience for residents and visitors.

5. DISCUSSION :

This study provides comprehensive insights into its urban functionality, reflecting the complexity and dynamism of this prominent neighbourhood. The integration of land use, building use, figure-ground, height, network connectivity, and traffic analysis maps reveals distinct patterns and interactions that inform urban planning and design strategies. The land use analysis shows a transition from predominantly residential to a more balanced mix of residential, commercial, and mixed-use areas. The shift towards commercial expansion along major roads, as indicated in the 2031 proposed map, reflects economic growth and urbanization pressures. This commercial vibrancy is matched by a notable increase in green and public spaces, enhancing livability. The figure-ground analysis distinguishes between slum areas, dense fabrics, and sparse fabrics, each presenting unique urban challenges and opportunities. The high-density areas, with minimal open spaces, emphasize the need for more green and public spaces to improve liveability. Conversely, the sparse fabric areas offer a more balanced urban environment, conducive to recreational activities and environmental quality. Building height distribution further illustrates a predominantly low-rise urban fabric with limited high-rise development, suggesting zoning regulations that maintain neighbourhood character while accommodating growth. The road hierarchy and typology maps reveal a well-structured network designed to manage traffic flow efficiently. Arterial and sub-arterial roads facilitate cross-city travel, while collector and local roads ensure neighbourhood mobility. This hierarchical structure prioritizes both vehicular and pedestrian accessibility, with elements like sidewalks and medians enhancing safety and traffic management. Traffic analysis underscores the differences in weekday and weekend patterns, with peak hour congestion on weekdays influenced by work and school commutes, and more spread-out traffic on weekends driven by leisure activities. Key junctions and arterial roads consistently face high traffic volumes, highlighting the need for effective traffic management strategies. The analysis suggests that improving traffic flow at these critical points can significantly enhance overall mobility.

6. CONCLUSION:

The spatial analysis of Indira Nagar, Bengaluru, highlights its complex urban functionality by integrating various data layers. The shift from a predominantly residential to a balanced mix of residential, commercial, and mixed-use areas reflects urban growth and economic development. Key findings include increasing commercial zones along major roads, balanced by enhanced green and public spaces, indicating a trend toward densification and commercialization while maintaining liveability. Urban density analysis reveals that dense areas require more green spaces, whereas sparse fabrics offer better liveability and recreational opportunities. Building height distribution shows a predominantly low-rise urban fabric, maintaining the neighbourhood’s character with limited high-rise development. The road network is well-structured, with a hierarchy that facilitates efficient traffic flow and connectivity, balancing vehicular and pedestrian accessibility. Traffic pattern analysis distinguishes between weekday peak hour congestion influenced by work and school commutes and more spread-out traffic on weekends driven by leisure activities, highlighting the need for targeted traffic management at key congestion points. Overall, this study underscores the importance of integrated planning to balance growth with liveability, ensuring sustainable and accessible urban environments. Urban planners and designers can leverage these insights to create more sustainable and resilient urban environments. The study of Indira Nagar serves as a model for similar neighbourhoods undergoing rapid urbanization, demonstrating the value of holistic, data-driven approaches in urban planning and development.

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