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Transportation Planning Strategies for Thiruvananthapuram IT-Corridor:The Space Syntax Approach

Sreenath Prakash C[1], Deepa L[2]
[1] M. Plan student, Department of Architecture, TKM college of Engineering, Kollam, Kerala
[2] Assistant Professor, Department of Architecture, TKM college of Engineering, Kollam, Kerala

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ABSTRACT: A well-designed transportation network is a fundamental functional component of any city. In fact, effective planning and management of transportation ensures an efficient, accessible, and sustainable system. This study introduces the Space Syntax method, a framework that employs spatial analysis techniques including accessibility and connectivity measures, to model and quantify the spatial relationships and interactions between the physical urban environment, land use, and transportation infrastructure. Accessibility refers to the ease of reaching destinations or activity opportunities, while connectivity signifies the degree of interconnectedness between different locations. By evaluating accessibility and connectivity, the space syntax method provides valuable insights into the dynamic interplay between a region's land use, activities and its transportation system. Leveraging this information facilitates the identification of areas with limited accessibility or connectivity, allowing for the prioritization of planning strategies that can enhance them thereby improving the liveability of urban environments.

KEYWORDS:
Transportationplanning,Spacesyntax, Street connectivity, Accessibility.

I. INTRODUCTION

Efficient transportation systems are vital for the development and growth of urban areas. The demand for transportation in cities is driven by individuals' decisions regarding their residential locations in relation to key activity locations such as workplaces, shopping centres, recreational facilities, educational institutions, and other significant activities [1]. Space syntax methodology involves a range of techniques that analyze spatial usage, building layouts, and public spaces. It examines the locations, movements, adaptations, development, and communication of people within a given space [3].

As traffic volume continues to surge and open spaces become scarcer, transportation engineers are actively searching for methods to measure and assess the effectiveness of alternative planning approaches. One promising avenue involves the development of measures focused on accessibility and connectivity. These measures provide valuable insights into the degree of interaction between a region's land use pattern and its transportation modes. Accessible transportation is crucial for economic development, as it connects people to job opportunities, markets, and services. It also facilitates the movement of goods and services, promoting trade and commerce [1]. By quantifying accessibility and connectivity, areas with varying levels of accessibility and connectivity can be identified, enabling the prioritization of strategies aimed at enhancing spatial mobility of population. This study aims to contribute in this direction by exploring the benefits and implications of employing spatial syntax measures in planning for transportation in the IT-Corridor of Thiruvananthapuram, Kerala.

II. NEED OF THE STUDY

This study aims to address the following research questions:

- What is the effectiveness of using space syntax as a spatial analysis technique for identifying and evaluating street connectivity and accessibility in theIT-Corridor of Thiruvananthapuram?
- What planning strategies can be recommended to promote sustainable transportation modes, improve accessibility and connectivity, and enhance the overall liveability of the study corridor?

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Furthermore, the study acknowledges the importance of improved accessibility, and enhanced connectivity in creating liveable urban environments. Planning strategies that prioritize these aspects can lead to more efficient and people-centric transportation systems.

III. STUDY OBJECTIVES

Following are the specific objectives of the study.

1. To conduct a comprehensive review and analysis of the existing literature pertaining to space syntax measures and their application in transportation planning.
2. To assess the existing transportation infrastructure and land use patterns in the Thiruvananthapuram IT-Corridor.
3. To apply the space syntax method to the Thiruvananthapuram IT-Corridor to identify and evaluate its street connectivity and accessibility.
4. To formulate planning strategies based on the space syntax analysis, with a focus on enhancing accessibility, connectivity, and the overall liveability of the Thiruvananthapuram IT-Corridor.
5. To provide recommendations for the integration of space syntax measures as a transportation planning tool for other urban contexts.

IV. METHODOLOGY

Following are the various steps outlined in the methodological framework of the proposed study:

1. Literature Review: Conducta comprehensive literature review of previous studies on space syntax measures, and their applications in transportation planning. This will provide a foundation for research and help identify existing research gaps to position the current study.
2. Research Objective: Define the research objectives and research questions. The research objectives should clearly state the aim of the study, while the research questions shall help guide the research process.
3. Case Study Selection: Define the boundaries of the study area - the Thiruvananthapuram IT-Corridor and its 2-km walk catchment buffer.
4. Data Collection: Collect both primary and secondary data sources relevant to the study, including transportation infrastructure data, land use patterns, travel behaviour data, and other pertinent factors. This may involve utilizing surveys, conducting interviews, acquiring maps, accessing census data, and employing other suitable data collection methods.
5. Space Syntax Analysis: Perform a space syntax analysis of the Thiruvananthapuram IT-Corridor to assess street connectivity and accessibility. Develop appropriate measures to quantify connectivity and accessibility and analyse the spatial patterns of the transportation network and land use within the study area.
6. Planning Strategies Development: Based on the findings of the space syntax analysis, formulateplanning strategies to enhance accessibility and connectivity within the Thiruvananthapuram IT-Corridor. These strategies may involve improvements in public transport connectivity, pedestrian accessibility, use of active modes, and people-centric land use planning.
7. Limitations and Future Research: Identify any limitations of the study, such as data constraints or other potential challenges. Additionally, suggest areas for future research, including exploring the application of space syntax measures in similar urban contexts or investigating the long-term effects of implemented planning strategies.

V.THE STUDY AREA

The Thiruvananthapuram IT-Corridor is the designated study area for this research project. It is a prominent region located in Thiruvananthapuram, the capital city of Kerala, India. The Thiruvananthapuram IT-Corridor includes a significant stretch of land that includes office spaces, technology parks, research and development centres, and other IT-related establishments. It serves as a hub for numerous national and international IT companies, attracting skilled workforce and contributing to the economic growth of the region.As of 2015, Thiruvananthapuram IT centre in India contributes 55% of Kerala's software exports [5].

The Kerala state budget for 2022 has prioritized the development of road infrastructure, IT facilities, and the tourism industry in the capital city. As part of decentralizing the state's IT sector, four new IT corridors have been proposed parallel to the existing NH 66. Therefore, the development of the Thiruvananthapuram IT-Corridor aligns with the government’s vision to stimulate economic growth, improve transportation connectivity, and promote the IT and tourism sectors in the region.

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FIG 1: MAP SHOWING THIRUVANANTHAPURAM CORPORATION

The proposed Thiruvananthapuram IT Corridor is located along the NH-66 Bypass, stretching from Kazhakkoottam to Kovalam. The study area focuses on the section between Kazhakoottam and Kovalam Junction (see Fig. 2). There is a buffer zone of 2 KM on both sides of the NH-66 Bypass. This corridor spans a length of 24.5 KM, and the average travel time by car is approximately 28 minutes.

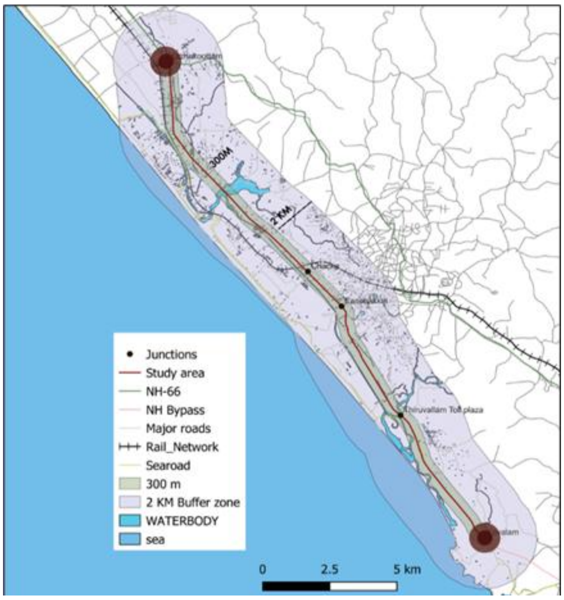

FIG 2: THIRUVANANTHAPURAM IT-CORRIDOR

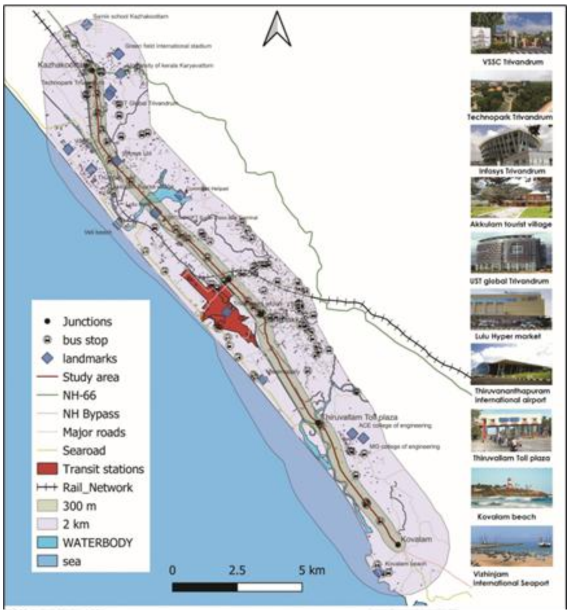

FIG 3: INFRASTRUCTURE IN THE STUDY CORRIDOR

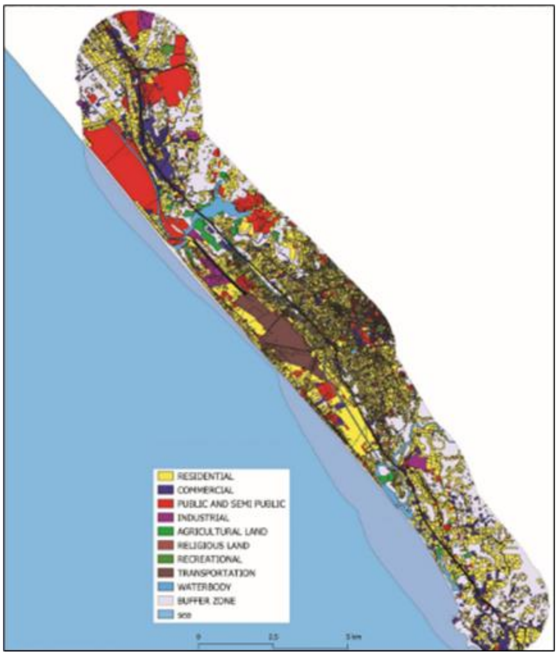

FIG 4: LAND USE IN THE STUDY CORRIDOR

The following section discusses the feasibility of the Thiruvananthapuram IT-Corridor as a prospective case study for examining its accessibilityand connectivity using the space syntax approach.

- Location: The Thiruvananthapuram IT-Corridor holds strategic advantages due to its proximity to various key locations. It is located near the upcoming ICTT (International Container Transhipment Terminal) in Vizhinjam, the VSSC (Vikram Sarabhai Space Centre) aerospace center, Trivandrum International Airport, Technopark IT hub, as well as major tourist destinations such as Kovalam, Varkala, Poovar, and Ponmudi within the capital region.
- Road Infrastructure: The NH-66 bypass is a major arterial road in Thiruvananthapuram, connecting the city centre with other towns and cities in Kerala. It is well-established with multiple lanes, designed to handle high volumes of traffic. The existing road infrastructure can adequately support the transportation requirements of the IT industry.
- Public Transportation: The feasibility of the IT Corridor is also dependent on the availability and efficiency of public transportation options. Thiruvananthapuram has a well-developed public transportation system, including buses, taxis, and auto-rickshaws. The proposed IT Corridor's location along the NH-66 Bypass ensures its accessibility through these existing modes ofpublic transportation, facilitating easy commuting for the employees working in the IT sector.
- Connectivity to Airports and Railway Stations: An essential aspect of accessibility for an IT Corridor is connectivity to airports and railway stations. Thiruvananthapuram is served by an International Airport, which is approximately 12 km from the proposed IT Corridor. Further, the presence of the NH-66 Bypass ensures a direct and convenient road connection between the airport and the corridor. Additionally, Thiruvananthapuram Central Railway Station, a major railway hub, is approximately 17 km away, providing connectivity to the IT Corridor.
- Future Expansion and Upgradation: While accommodating the potential expansion of the IT industry, the NH-66 Bypass has adequate space for potential widening, to handle increased traffic volumes. Additionally, the availability of land along the corridor provides opportunities for the development of additional transportation infrastructure, such as dedicated bus lanes or alternative modes of transport like metro rail. The establishment of the IT Corridor is expected to have a positive impact on the local economy by attracting investments and creating job opportunities in a wide range of establishments including software development firms, business process outsourcing (BPO) companies, technology startups, research and development centres, and related service providers thereby boosting the overall growth of the region.

VI. THE SPACE SYNTAX APPROACH

The study utilizes space syntax measures to a) evaluate the accessibility of the IT-corridor to the population and activities within its catchment, and b) evaluate the connectivity of the IT-corridor to the city centre and other major destinations. To do so, it is important to note the distinction between the accessibility of a transit system, and the connectivity provided by the transit system discussed as follows.

i) Accessibility Provided by The Transit System:

The more population and activity centres a transit system is accessible to, the more would be its ridership [6]. The followingvariablesmay be used to characterize accessibility of the transit system:

• Population density around transit stops or routes withinan acceptable walking distance, and

• Economic activities around stops or routes in the form of commercial, industrial and public service / institutional land uses.

ii) Connectivity of the Transit to Activity Locations:

The more activity locations or destinations that a transit system provides access to, the more would be its ridership [6].
The level of ridership on transit stops or routes is influenced by the connectivity they offer to a larger number of destinations. This connectivity is measured by examining the extent to which a transit stops or route connects to various destinations in the network.

Particularly, the former refers to the measure of accessibility of a given stop to the surrounding population and activities. On the other hand, the latter refers to the measure of how many other destinations can be accessed from a specific stop.

Here are some key measures that can be used for the above analyses:

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- Integration: Integration measures the level of connectivity within a street network [2]. In the context of evaluating the connectivity of the IT-Corridor to the rest of the network, integration can provide insights into how well connected the corridor is to its surroundings. Higher integration values indicate better connectivity, as there are more direct and efficient routes between different parts of the network.
- Depth: Depth measures the distance from a location within the network to all other locations. It helps identify central and peripheral areas within the network. In the context of evaluating the connectivity of the IT-Corridor, depth analysis can identify the areas within the network that are relatively closer or farther away from the corridor.
- Betweenness: Betweenness measures the extent to which a particular street segment lies on the shortest paths between other street segments in the network. It identifies key routes that serve as critical connectors within the network. In the context of evaluating the connectivity of the IT-Corridor to the city centre and other major destinations, betweenness analysis can identify the street segments that play a crucial role in linking the corridor to these destinations. Higher betweenness values suggest that these segments are important for overall network connectivity.

VII. ANALYSIS AND POLICY IMPLICATIONS

To create a connectivity map using space syntax measures, the initial step involves importing a shapefile of the road network for the entire city of Thiruvananthapuram into the QGIS platform. As discussed before, space syntax measures, such as integration, and depth capture various aspects of spatial connectivity. The integration measures the centrality of a location, while depth measures the level of integration required to reach a particular location. To automatically calculate these measures, a space syntax toolkit available in QGIS utilizes topological distances. Once the connectivity measures are calculated, a connectivity map is generated to visually represent the space syntax measures. The QGIS software offers tools for symbolizing and labelling the map, enabling the use of appropriate colours and schemes to communicate the connectivity patterns effectively. This map highlights areas of high connectivity, indicating central locations within the city, while also identifying areas with low connectivity, suggesting peripheral or disconnected spaces. The resulting connectivity map for Thiruvananthapuram city following the above steps is presented in Fig. 5. This map provides a valuable visual representation for further analysis and interpretation of the city's spatial connectivity.

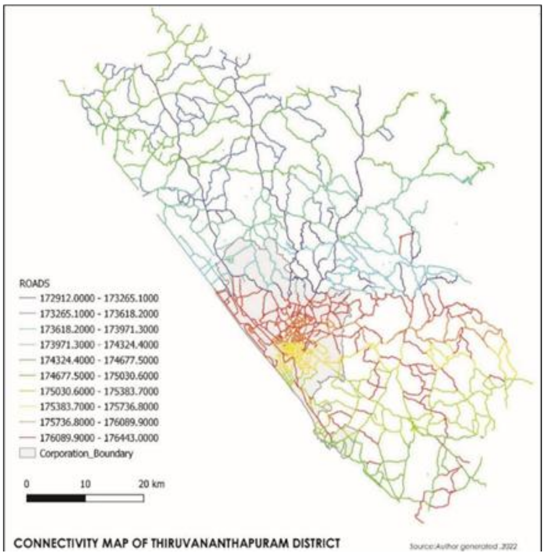

FIG 5: CONNECTIVITY MAP OF THIRUVANANTHAPURAM DISTRICT

To conduct an accessibility analysis, the general approach involves dividing the study area into spatial grids, overlaying land use and connectivity data, calculating grid intensities, and aggregating these intensities to classify bus stops based on accessibility. While the specific techniques and tools employed may vary depending on the software and data availability [4], the following sequence was implemented in this study. First, we divided the study area, which includes the Thiruvananthapuram IT-Corridor and its 2 km walk catchment into 500m x 500m spatial grids within the QGIS software. Next, vector files containing the land use map and the connectivity map (generated in the previous step) were overlaid onto the grid network. This overlay allowed for the integration of land use characteristics and connectivity information within each grid. The resulting grid intensities, as illustrated in Fig. 6, formed the basis for further analysis.

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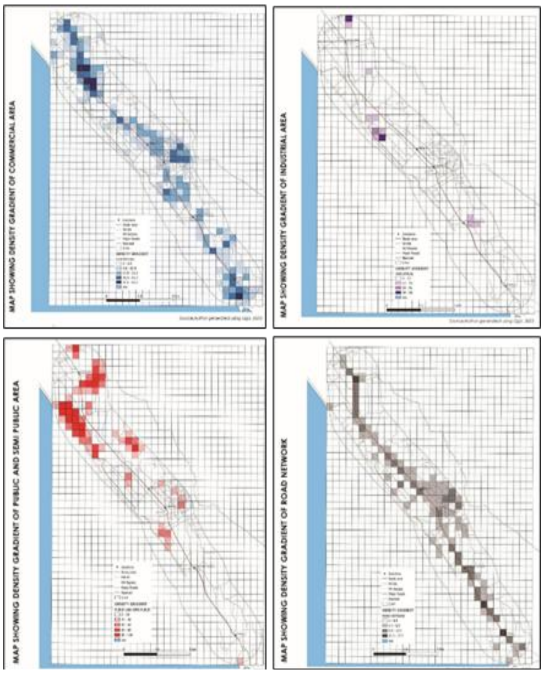

FIG 5: CONNECTIVITY MAP OFTHIRUVANANTHAPURAMDISTRICT

For instance, grids containing roads with high connectivity indicate areas with enhanced transport accessibility, while grids with a higher concentration of commercial, industrial, or public service land use signify increased employment opportunities or activity centres. Analytical operators in GIS are used to aggregate the connectivity and land use intensities of grids situated within the 2 km walk catchment of each bus stop along the IT-Corridor. This aggregation process enabled the calculation of an overall accessibility index for each bus stop.

To develop effective transportation planning strategies for varying levels of accessibility, it is crucial to understand the expected demand from the stop catchment areas. Hence, we performed a similar grid analysis where grids with a higherpopulation density are hypothesized to have a greater anticipated demand. This is illustrated in Fig. 7, to provide a visual representation of the varying population (residential) densities in the study area.

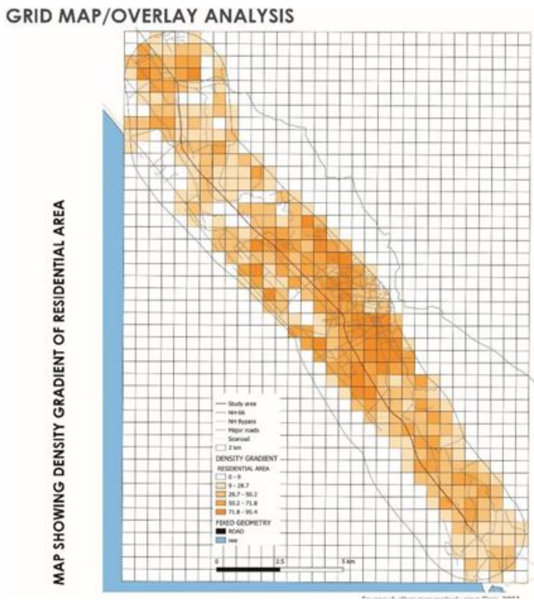

FIG 7: GRID DENSITY ANALYSIS SHOWING POPULATION

Finally, based on the overall accessibility index calculated in the previous step, the bus stops were categorized into three groups: low accessibility stops, medium accessibility stops, and high accessibility stops. The results of the accessibility analysis, showcasing the categorized bus stops according to their overall accessibility index, are illustrated in Fig. 8.

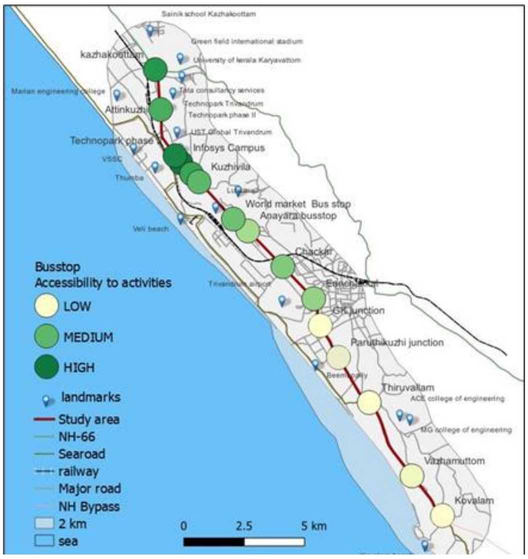

FIG 8: BUS STOP CLASSIFICATIONBASED ON OVERALL ACCESSIBILITY INDEX

These classifications were determined by calculating the combined indices of connectivity

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and land use factors for the grids falling within the catchment area of each stop. This visual representation provides a clear understanding of the distribution and classification of bus stops based on their accessibility levels, allowing transportation planners to identify areas that require specific attention and develop targeted strategies accordingly.

Following a similar approach, the bus stops were also classified into three categories based on the population index within their catchment areas, allowing for an understanding of the varying demand levels. The population index is calculated by considering the population density of the grids falling within each stop's catchment area. The three categories are as follows: low accessibility to population, medium accessibility to population, and high accessibility to population as illustrated in Fig. 9. This classification allows for a clear differentiation of the stops based on their level of accessibility in relation to the surrounding population, enabling transportation planners to develop targeted strategies to cater to the specific needs of each category.

For example, transportation planning strategies for stops categorized as low accessibility with a high anticipated demand would focus on improving accessibility by enhancing the connectivity and infrastructure in these areas. This may involve the development of new transportation routes or extensions to existing ones, implementation of infrastructure improvements like sidewalks, bike lanes, or pedestrian crossings, integrating bus stops.

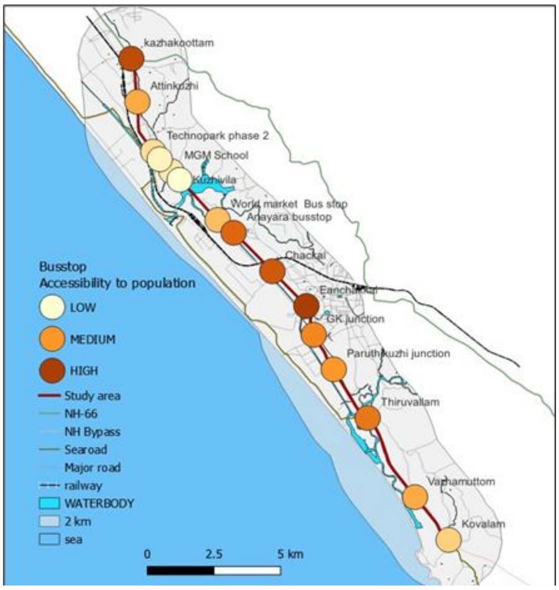

FIG 9: BUS STOP CLASSIFICATIONBASED ON POPULATION DENSITIES

with park-and-ride facilities, enhancing connectivity to major transportation hubs, and implementing last-mile solutions to bridge the accessibility gap.

Alternatively, for high accessibility stops with a lower anticipated demand, strategies may involve optimizing existing resources and services to match the lower demand, strategies to attract more users such as improving pedestrian infrastructure, implementing feeder services, ensuring seamless transfers, and improving amenities and facilities at stops. It may also be necessary to consider land use planning strategies that stimulate the activities and opportunities in these areas, thus increasing demand and maximizing the benefits of high accessibility offered.

When dealing with stops that are classified as having low accessibility and low anticipated demand, transportation planning strategies often require a multifaceted approach.One potential approach is to explore alternative modes of transportation that can better cater to the specific needs of these low-demand stops. This may involve implementing on-demand services, where transportation is provided based on individual requests rather than following fixed schedules.Another approach is to consider flexible routing options. This involves optimizing transportation routes in real-time based on demand patterns and passenger preferences.It allows for more efficient allocation of resources and reduces unnecessary trips, ultimately improving overall transportation efficiency.In addition to these operational strategies, it is also important to consider land use planning and development strategies that aim to stimulate growth and activity in areas surrounding these low-demand stops.Specifically, mixed-use development, that combines residential, commercial, and retail spaces in the same area, can help create a more self-sufficient community. This increased demand then justifies the allocation of resources to improve accessibility at these stops, making it more viable to invest in transportation infrastructure.

VIII. CONCLUSIONS

In conclusion, this journal paper focused on the application of transportation planning strategies using the Space Syntax approach for the Thiruvananthapuram IT-Corridor. By employing spatial analysis techniques, such as accessibility and connectivity measures, the Space Syntax method allowed for the modeling and quantification of spatial relationships and interactions between the physical urban environment, land use, and transportation infrastructure. By identifying areas with limited accessibility or connectivity, urban planners and policymakers can prioritize planning strategies to enhance these areas, thereby improving the liveability of the Thiruvananthapuram IT-Corridor. The targeted approach ensures that resources and efforts are directed towards areas where improvements will have the most significant impact, optimizing the effectiveness of planning intervention. However, it is important to note that the Space Syntax method is not a standalone solution but rather a valuable tool that complements existing transportation planning approaches. By incorporating this method into the decision-making process, urban planners and policymakers can make more informed choices about infrastructure development, land use zoning, and transportation investments. As cities continue to face challenges related to urbanization and transportation, adopting innovative and evidence-based approaches like Space Syntax will be crucial for creating vibrant, liveable, and well-connected urban areas that effectively serve the needs of their inhabitants.

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