TRANSPORTATION PLANNING STRATEGIES FOR THIRUVANANTHAPURAM IT CORRIDOR USING SPACE SYNTAX AS A TOOL

THESIS REPORT

Submitted by

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in

Urban Planning

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DECLARATION

I hereby declare that the Project entitled **“TRANSPORTATION PLANNING STRATEGIES FOR THIRUVANANTHAPURAM IT CORRIDOR USING SPACE SYNTAX AS A TOOL”** is a bonafide record of mine carried out under the supervision of **Prof. Deepa L,** Assistant Professor, Department of Architecture. I declare that the work reported herein does not form any part of any other project report based on which a degree or award was conferred on an earlier occasion to any other candidate. This study is done as a part of the fourth semester M. Plan (Urban Planning), Post Graduate Degree Course in the Department of Architecture, Thangal Kunju Musaliar College of Engineering, Kollam.

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CERTIFICATE

This is to certify that the Thesis Report **"TRANSPORTATION PLANNING STRATEGIES FOR THIRUVANANTHAPURAM IT CORRIDOR USING SPACE SYNTAX AS A TOOL"** submitted by **Sreenath Prakash C** (TKM21MUP015) of MUP (2021-2023) Batch, in fulfilment of the requirements for the fourth-semester final examination in PL6401–Planning Thesis, under the **APJ Abdul Kalam Technological University** is a bonafide work carried out under our guidance and supervision.

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ACKNOWLEDGEMENT

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Sreenath Prakash C

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 livability of urban environments.

Keywords: Transportation planning, IT corridor, Space syntax, Street connectivity, Accessibility

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ABBREVIATIONS

CAD - Computer-aided design

CBD- Central Business District

DUTH-Democritus University of Thrace

GIS-Geographic Information System

GPS-Global Positioning System

IT-Information technology

NH-National Highway

PWD-Public Works Department

RTPO-Regional Town Planning Office

SH-State Highway

SS- Space Syntax

UCL-University College London

CHAPTER 1 INTRODUCTION

Transportation planning is a crucial aspect of urban and regional planning that involves the assessment and development of transportation infrastructure, policies, and strategies. The transportation network is a fundamental component of a city's functioning, and proper planning and management are essential for maintaining an efficient, accessible, and sustainable system.

In this chapter, we present a concise overview of the general concept of using Space Syntax measures for street analysis. The Space Syntax method is a framework that uses spatial analysis techniques to model and quantify the spatial relationships and interactions between the physical urban environment, land use, and transportation infrastructure. Specifically, by measuring accessibility and connectivity, the Space Syntax method can provide insights into the degree of interplay between an area's land development pattern and its available transportation modes. Accessibility refers to the ease of reaching destinations, while connectivity is the degree to which places are linked to each other. This information can be used to identify areas with low accessibility and prioritize alternative projects to enhance the transportation network's efficiency and accessibility. For example, the Space Syntax method can help identify areas with high potential for public transport, walking, and cycling. The following sections delve into the objectives, methodology, scope, and limitations of this approach.

1.1 Background study

Efficient transportation systems are vital for the development and growth of urban areas. It enables the mobility of civic areas efficiently by furnishing access and connectivity to the people. Passenger transport has an overriding influence on the functioning of the megacity. Transportation planning and development of structure for the system are pivotal factors for civic areas, particularly when rapid urbanization is taking place. The need for transportation in urban areas is influenced by people's residential location decisions in relation to their places of employment, shopping destinations, leisure activities, educational institutions, and other significant pursuits. Cities that are expanding support more residents and more dispersed patterns of settlement.

Consequently, increasing demand for transportation is an unavoidable consequence of urban growth. (Kevin B. Modi, 2011).

The transport system of a country plays an integral part in its growth for a multitude of reasons. Due to the quick and easy movement of raw materials, ministry, finished goods, etc. it benefits diligence. The second-largest global road network is found in India, with a total length of about 3.34 million kilometers. Road transport contributes more than 3.6 percent of GDP, or around two-thirds of all transport-related GDP contributions. Over 85% of India's passenger traffic and about 65% of its freight are transported on roads. When it comes to road categories, Major and other District Roads and Rural Roads make up the majority of the total, with National Highways and State Highways accounting for only roughly 2% and 4% of the total, respectively. (IBEF, 2022).

Transport planning is largely essential in shaping metropolises, enabling profitable conditioning, promoting community commerce, and enhancing quality of life. It is also essential for sustainable development and icing safe availability at colorful situations for all individualities. The demand for innovative approaches to breaking down the complicated and developing difficulties in transportation and mobility planning is constantly increasing. Spatial and centrality analysis are becoming more useful in practice as they enable new perspectives on transportation and mobility networks. It can be understood smoothly by guests with little or no prior understanding of the subject. (Rawad choubassi, 2018).

A region's road network is one of the keys to its regional development. Road segment links between them are evaluated using connectivity metrics. The directness of a route between two points is referred to as connectivity. A well-connected network offers continuous, direct paths to destinations by way of its many short linkages, numerous crossroads, and few dead ends. (Sreelekha.M.G, 2015).

Space syntax is a collection of techniques for analysing how people use space and how buildings and public spaces are set out. Additionally, it is a collection of ideas that connects society and space. The use of space syntax method takes into account the locations of people, their movements, their adaptations, their development, and their communication of it. (space syntax, 2022).

The core principle of the Space Syntax method is that the entire network of spaces created by the natural shape of the civic infrastructure in any settlement or megacity may be seen as a single, continuous spatial network system. This system can be broken down into components, examined as networks of options, and represented visually as charts and graphs that show how different areas are connected to one another. The integration analysis, which determines the best shortest path between two sites in each road system, is the most frequently used Space Syntax analysis. (Giannopoulou, 2012)

An IT corridor is a longitudinally aligned, planned collection of information technology businesses, and supporting facilities which usually coincide with a major transportation axis.

Access to economic opportunities and its relation to social inclusion and economic upliftment is an area of work that has been explored extensively in the field of urban planning and transportation. (ghosh, 2019).

The traffic volume is increasing tremendously, open spaces are vanishing and the transportation engineers are searching ways to measure and evaluate the effectiveness of alternate transportation projects. By developing a measure of accessibility and connectivity, it will reflect the extent of interaction between an area's land development pattern and transportation supply modes These can be used to identify areas which have low, medium, or high accessibility allowing for the prioritization of planning strategies that can enhance them thereby improving the liveability of urban environments.

1.2 Need of the study

Today's large urban systems are dealing with escalating transportation issues. Due to this, several research, including those using the street connectivity analysis, which links the layout of cities and other built environments to spatial movement patterns, are attempting to solve the problem of population spatial mobility. This research aims to contribute in this area by investigating the advantages and disadvantages of using space syntax to analyze transport network and provide scenarios with higher levels of transportation efficiency. (Pereira, 2012).

The primary aim of the research is whether present transit planning methods are suitable for producing sustainable cities, and how urban morphology research contribute to conventional transportation planning in order to achieve the legitimate goal. This study is about the spatial potential analysis technique that employs the concept of Space syntax to identify and evaluate the street connectivity and accessibility. (Yonatan Lebendiger, 2019).

Land acquisition and tendering process for new IT park is happening at brisk pace in Kerala. New bypass works have already been kick-started connecting these IT parks. Owing to higher density of population and high land value, national highway will be 45-meter width, 6 lanes, in Kerala. As a part of that major boost to road and IT infrastructure development and tourism industry along the NH 66 is needed. The study helps to understand street connectivity and accessibility of the Thiruvananthapuram NH 66 Bypass. The evaluation of the IT Corridor project would typically involve measuring its impact on the local economy and employment and quality of life in the area.

The advantages of the integration of urban land use and transportation systems, which is widely acknowledged as being necessary to ensure sustainable development, are provided through accessibility-based analysis. Urban environments must have accessibility and mobility because they are essential components of the connections between land use and transportation. Accessibility and mobility are becoming crucial factors in examining the consequences of transport networks, forecasting travel demand and evaluating planning policies in the urban transportation planning process as it is becoming increasingly recognized as a crucial component of overall urban land-use planning. The effects of land use and the transportation system can be combined using accessibility measurements to assess the possible consequences of transportation projects, monitor accessibility changes through time, and track accessibility changes.

Improving future projects: The lessons learned from the evaluation of the IT Corridor project can be used to inform the design and implementation of future projects and improve their outcomes in the study area.

1.3 Research question

1. What is the effectiveness of using Space Syntax as a spatial analysis technique for identifying and evaluating street connectivity and accessibility in a given study corridor?
2. What planning strategies can be recommended to promote sustainable transportation modes, improve accessibility and connectivity, and enhance the overall livability of the study corridor?

1.4 Aim

To explore the potential of the Space Syntax method as a transportation planning tool and its application in developing effective planning strategies for the Thiruvananthapuram IT corridor.

1.5 Objectives

1. To review and analyze the literature related to the concept of space syntax measures and its 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 identify the current transportation infrastructure and challenges faced by the Thiruvananthapuram IT corridor.
5. To evaluate the effectiveness of the developed planning strategies based on the findings of the space syntax analysis in terms of the accessibility, connectivity, and overall livability of the Thiruvananthapuram IT corridor.
6. To provide recommendations for the integration of space syntax measures as a transportation planning tool for other urban contexts.

1.6 Scope

- The study will examine the current state of transportation infrastructure in the Thiruvananthapuram IT corridor, including road networks, public transportation systems, and pedestrian and cycling infrastructure.
- The study will analyse the land use patterns within the corridor, including commercial and residential developments, to understand the demand for transportation and the potential impact on accessibility and connectivity.
- The study will review existing literature on transportation planning, space syntax measures, and case studies of similar transportation planning projects to inform the analysis and planning strategies.

- The study will use spatial data analysis tools and techniques to conduct the space syntax analysis, including Geographic Information Systems (GIS).
- The study will aim to contribute to the development of transportation planning practices that can be applied in other urban contexts, particularly in developing countries, where space syntax measures are currently underutilized.

1.7 Limitation

The study will have certain limitations that need to be acknowledged. First, the absence of previous transportation planning studies for the study method and area chosen may limit the ability to compare and contextualize the findings. Additionally, the lack of availability of spatial land use data related to the study area may result in an incomplete understanding of the impact of land use on the transportation system in the study area. Second, the scope of the study is limited to the Thiruvananthapuram IT corridor and specifically from Kazhakkoottam to Kovalam junction, which may not fully represent the transportation system of the entire city. Third, the study will be limited by the scope of the space syntax measures used, and there may be other factors influencing accessibility and connectivity that are not captured by the above measures. Finally, conducting a comprehensive accessibility study using space syntax measures can be time-consuming and expensive, particularly if it involves collecting new data. The study will be limited by the available resources and data sources, which may impact the depth and accuracy of the analysis.

1.8 Methodology

Step 1: Literature Review: Conducting a comprehensive literature review of previous studies on transportation planning, space syntax measures, and their applications in urban planning. This will provide a foundation for the research and help identify the existing research gaps.

Step 2: Research Objective: Define the research objective and research questions. The research objective should clearly state the aim of the study, while the research questions should help guide the research process.

Step 3: Case Study Selection: Select the Thiruvananthapuram IT Corridor as the case study area and define the study area boundaries.

Step 4: Data Collection: Collecting both primary and secondary data sources related to transportation infrastructure, land use patterns, travel behavior, and other relevant factors. This may involve surveys, interviews, maps, census data, and other data collection methods.

Step 5: Space Syntax Analysis: Conducting a space syntax analysis of the Thiruvananthapuram IT corridor to identify areas with low accessibility and connectivity and prioritize alternative transportation projects. This analysis will involve developing measures of connectivity and accessibility and analyzing the spatial patterns of the transportation network and land use.

Step 6: Planning Strategies Development: Based on the findings of the space syntax analysis, develop planning strategies for the Thiruvananthapuram IT corridor to improve accessibility and connectivity. This could include strategies to improve public transport connectivity, pedestrian access, and land use improvements in the study corridor.

Step 7: Limitations and Future Research: Identify any limitations of the study and suggest areas for future research, such as the application of space syntax measures in similar urban contexts.

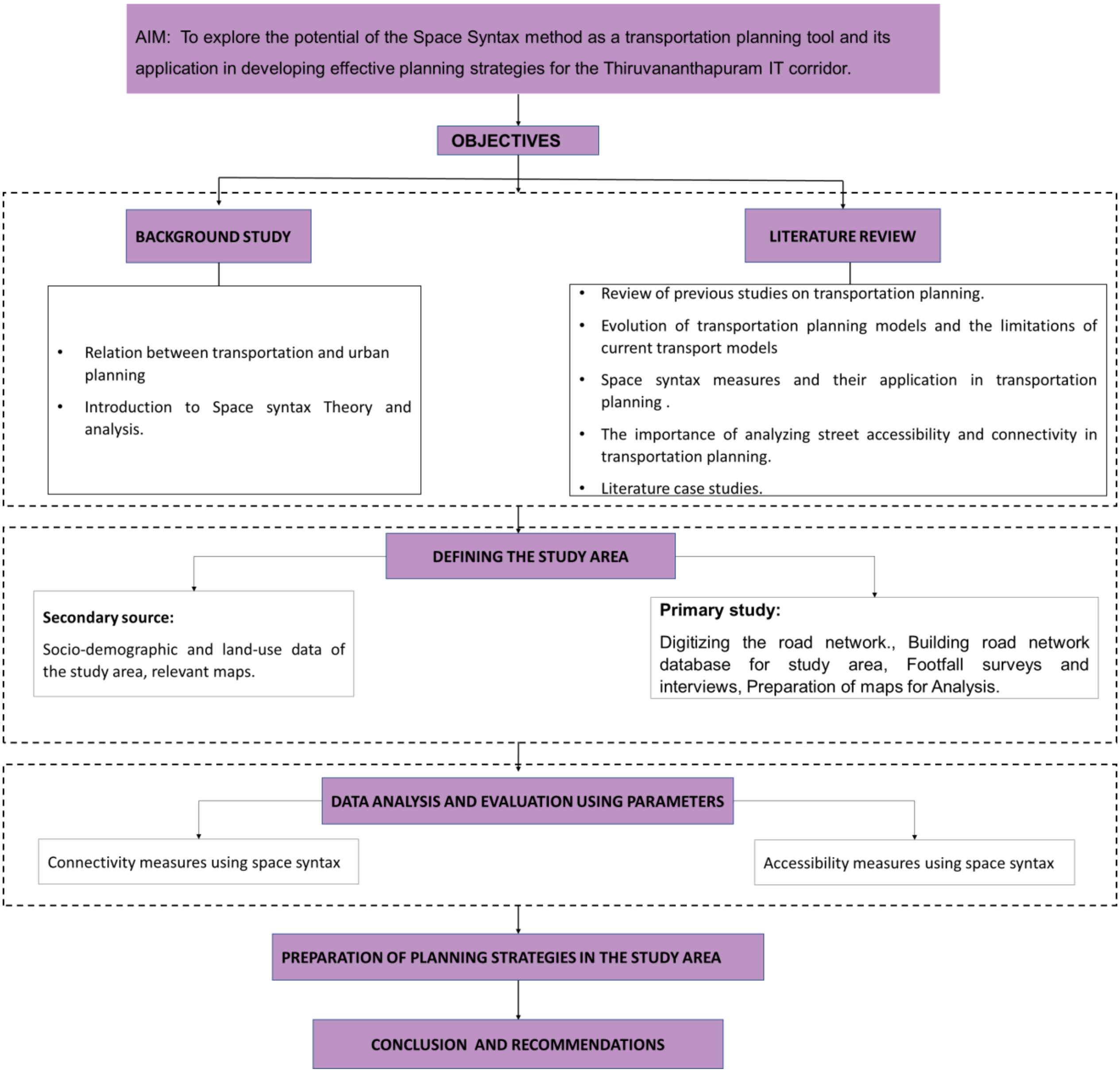

Figure 1. 1 Study methodology

Source: Author generated,2023

CHAPTER 2 LITERATURE REVIEW

This literature review chapter provides an overview of the evolution of transportation planning models and the limitations of current transport models. The chapter then introduces the space syntax method and explores its fundamental elements, as well as its applicability to transportation planning strategies. The second part of the chapter delves into several spatial methods for analyzing the urban street and road network, with a particular focus on connectivity and accessibility. Finally, the chapter summarizes the key findings and discusses the implications of the reviewed literature for the proposed case study, including potential research gaps in current knowledge that this thesis aims to address.

2.1 Transport planning models

The transportation industry has undergone significant changes in recent years, and transportation planners are faced with numerous challenges, including urbanization, population growth, and increased demand for transportation services. To address these challenges, transportation planning models have evolved over time, and researchers have proposed various analytical techniques to improve transportation system design, operation, and management.

2.2 Evolution of transport planning models

By considering the policy advancements and socioeconomic settings that have caused modifications to the transport model, the evolution of road transportation models is briefly examined. This makes it feasible to recognize the four stages of model development. (Behrens, 2002).

- 1950s – 1960s: changes brought about by increased roadway construction and computer advancements.
- 1970s – 1980s: changes made in response to issues about aggregate methods.
- 1980s – 1990s: modifications made in response to concerns about static, trip-based analysis.

- 1990s: changes brought by environmental contamination and policy alterations aimed at managing travel demand.

The utilization of transportation networks was evaluated in the 1950s using data from traffic counts in trip analysis. While these methods worked well when it came to current problems, any projections they made were rough because they were based on past tendencies. Highway development surged significantly during the 1950s, particularly in the United States, and with it the need for increasingly complex forecast tools emerged. Pavements may be created and the economic effects of such plans might be more precisely evaluated and prioritized using such prediction methods. the vast amounts of data needed to simulate entire metropolitan systems were processed thanks to the development of computers during this time. (Behrens, 2002).

By the mid-1960s, opposition to the transport developments of the previous decade had started to emerge.

In 1973, Lee published a harsh assessment of the large-scale urban models that were widely utilized at the time, pointing out seven critical problems.

There were three new analytical approaches: disaggregate methods, that created travel-choice models for people as opposed to households or zones; and micro-simulation techniques, which improved the technique for aggregate assignment by accounting for driver behaviour at the vehicle or "platoon" level. The effects of changes in transportation on the land-use system through time and vice versa were modelled by land-use transportation interaction models.

In response to the critics, new modelling advancements occurred in the 1980s and 1990s: both dynamic and activity-based approaches. (Behrens, 2002).

2.3 Travel demand model

Models of travel demand, also known as traffic models, are used to predict the volume of vehicular traffic as well as its effects, such as congestion and pollution emissions, by measuring the amount of travel that people would choose to make under specific conditions of cost, availability of transportation options, and land use regulations. They typically follow four steps and are known as four-step models. (Stewart, 2019).

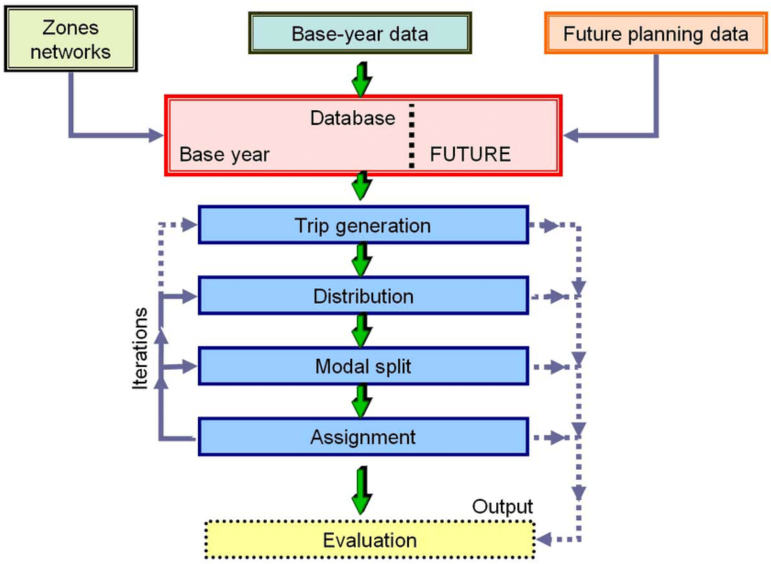

Figure 2. 1 Four-stage transport planning model

Source: The traditional four-stage transport planning model, n.d.

2.3.1 Trip generation

Based on the land use patterns, population, employment, demography, length of roads, quality of transport services, and other features of the transportation system in each zone, as well as the distance between the zones, determine the total number of trips that start and conclude in a certain area. Trip generation determines the frequency of trip origins or destinations in each zone for each trip purpose based on land use, household demographics, and socioeconomic indicators. (Stewart, 2019)

2.3.2 Trip distribution

When linking origins and destinations, trip distribution frequently uses gravity model, when linking origins and destinations, trip distribution frequently uses a gravity model, a calculation that considers the relative activity at the origin and destination as well as the travel impedance between the zones.

2.3.3 Modal split

The further breakdown of movements by modes occurs between origin and destination. Each mode's availability, cost, and social preferences all play a role in this function.

2.3.4 Trip assignment

The transportation network is then "loaded" with all the estimated journeys by origin, destination, and mode, primarily taking into account the fact that users wish to cut down on travel time or must use existing transit networks. Congestion develops when traffic volume exceeds the capacity of a particular transport segment, which is frequently the case. This may then have an impact on trip development and distribution through a feedback process. (Rodrigue, 2020).

2.4 Transport Demand Forecast

- Transport demand forecasting is to predict future transport demand when establishing transport plans within a given budget.
- The forecast is based on current travel patterns of transport systems and under the assumption that general conditions will not greatly change. Therefore, drastic, or detailed changes can result in prediction errors.

  Transport demand forecasting is used as important basic data to evaluate the efficiency of transport facility supply and transport policy, such as road construction, public transport introduction, and transport demand management implementation.

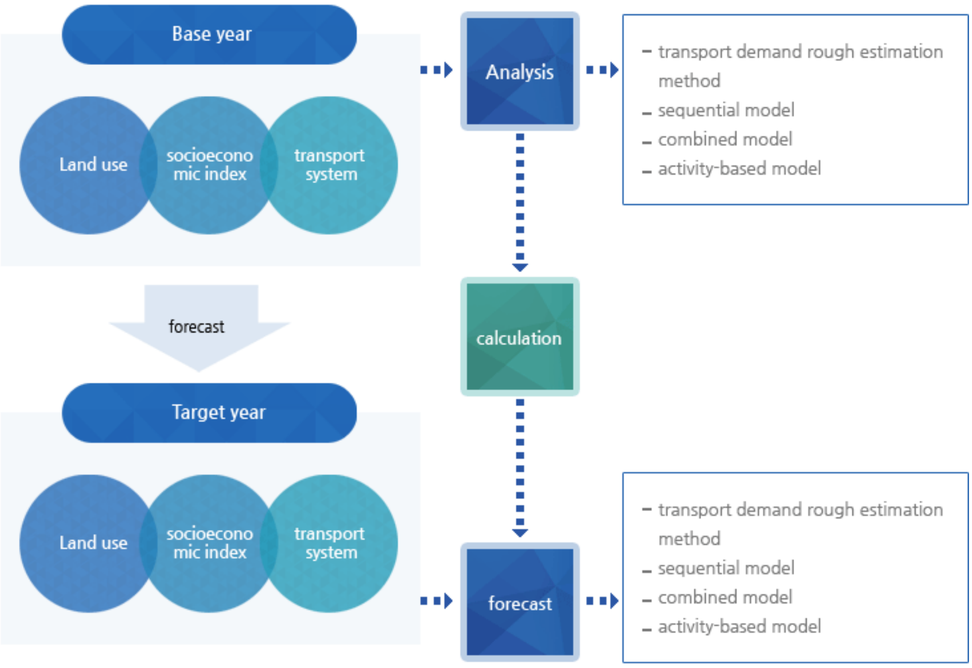

Figure 2. 2 Transport Demand Forecast

Source: The traditional four-stage transport planning model, n.d

2.5 Problems with current transportation planning models

Table 2. 1 Showing Problems with Current Transportation Models

Source: Transport Model Improvements-Improving Methods for Evaluating the Effects and Value of Transportation System Changes, 2019

Factor	Problems With Current Models
Accessibility	Most transportation models primarily evaluate mobility (movement), and fail to reflect accessibility (people's ability to obtain desired goods and activities).
Modes considered	Most current models only consider automobile and public transit.
Travel data	Travel surveys often undercount short trips, non-motorized travel, off-peak travel, etc.
Travel time	Most models apply the same travel time value to all travel, regardless of conditions.
Generated traffic and induced travel	Traffic models fail to account for the tendency of roadway expansion to generate additional peak-period traffic, and the additional costs from induced travel.
Qualitative impacts	Focus on quantitative factors such as speed and user fees, and undervalues qualitative factors such as convenience and comfort. Level-of-service ratings are provided for roadway conditions but not other modes.
Impacts Considered	Current models only measure a few impacts (travel time and vehicle operating costs).
Transit elasticities	Transit elasticity values are largely based on short- and medium-run studies, and so understate long-term impacts.
Self-fulfilling prophesies	Modelled traffic projections are often reported as if they are unavoidable. This creates self-fulfilling prophecies of increased roadway capacity, generated traffic, increased traffic problems and sprawl.
Construction impacts	Economic models often fail to account for construction activity external costs such as congestion and pollution.
Transportation diversity	Models often underestimate the benefits of improved travel options, particularly those used by for disadvantaged people.
Impacts on land use	Models often fail to identify how transport decisions will affect land use patterns, how this affect accessibility and strategic planning objectives.

2.6 Space syntax – general theory

One of the analytical techniques that have gained popularity in recent years is the space syntax method, which uses spatial analysis to understand the accessibility and connectivity of the transportation network. This method can help identify the most critical nodes, streets, and intersections within the transportation system and facilitate the development of effective transportation planning strategies.

The idea of space syntax was created in the 1970s by a team at the University College London (England) under the direction of Bill Hillier and Julienne Hanson, along with scholars from many nations, including Brazil. Based on how built space configuration impacts how a city functions, Space syntax has a certain personality. (Hillier, 1996)

space syntax can be used to examine how people move through space and how they use cities and other built environments. It also refers to a body of beliefs that link society and space. Space syntax focuses on where people are, how they move, adapt, grow, and how they communicate about it. (space syntax, 2022).

Two key ideas serve as the foundation of space syntax.:

1. Space is integral to human activity rather than acting as its background.
2. Space is mostly configured. In other words, the interactions between a place and the network of spaces to which it is connected have a fundamental impact on what happens in any given location, be it a room, hallway, street, or public space.

- When a built environment has multiple public spaces, the relationship between each one and the others is measured by space syntax. The to-movement potential, of each street network in connection to all other network is measured by space syntax. (Hillier B. a., 1984).
- Space Syntax mostly uses **connectivity and integration-focused analysis**. Connectivity is a static local measurement that counts the number of lines (from nearby areas) that cross an axial line in a direct manner (or isovist field). However, integration measures how well the original segment is incorporated into the global system; a higher level of integration indicates that the population is more accessible to the network.
- When calculating connectivity and integration, Space Syntax typically uses topological distance (the fewest amount of direction changes from each street network to all, commonly referred to as depth) or geometric distance (the least

number of angular variations from each street network to others). (Carl Johnsson, 2022).

The basic components of space syntax depend on the size of an area being studied and include axial lines, axial maps, convex maps, and isovist field. Axial lines are equivalent to street segments at the urban scale, and Space Syntax is interested in the topological (relational) component of the street network, or how axial lines are connected to each another. Convex maps and isovist fields can be used for the same things on a smaller scale, as inside buildings or in the common areas between clusters of buildings in a neighbourhood or small hamlet. (Carl Johnsson, 2022)

Graphs serve as the foundation for a schematic approach to space syntax analysis. For this analysis, the following could serve as the definition of the graph: A graph is a collection of finitely many vertices (or nodes) linked together by edges. In the axial map, the streets act as the graph's vertices while their connections serve as the graph's edges. The topological parameters used in the integration measures are well-known. (Giannopoulou, 2012)

Though it was noted that they are derived from various representation systems, Space Syntax can be referred to transport models. Space Syntax is based on a graphic illustration of the environment that highlights the morphologic pattern of a civic area (axial map) as a starting place to describe spatial structure. (Giannopoulou, 2012)

Measurements of various street network characteristics that represent the relative accessibility of various locations within a city or region form the basis of space syntax analysis. Either an axial map or a segment map can be used for this investigation. This axial map is created using a network of straight lines to represent the street system since they are the smallest set of axial lines that can completely cover a street network's open spaces. (Turner et al., 2005).

By considering each section between intersections, a segment map provides a finer resolution and makes it possible to compute the least angular distance (cumulative turn angles) in addition to the topological distance, for which every turn has the same weight. (Turner, 2007) .

Utilizing two centrality variables, integration and choice borrowed from graph theory, space syntax enables you to examine the relative importance of each street segment. As it relates to centrality, which is created by accessibility or movement potentials, integration assesses each node's relative proximity to all other nodes Choice measures a space's capacity for through-movement, or the possibility that a street will be used as a link between every pair of origin-destination nodes in the network. The shortest routes exist from all origins to all destinations in spaces with high choice values. In order to determine a segment's choice and integration values for its local centrality, the analysis can also be limited by a radius. (Turner, 2007)

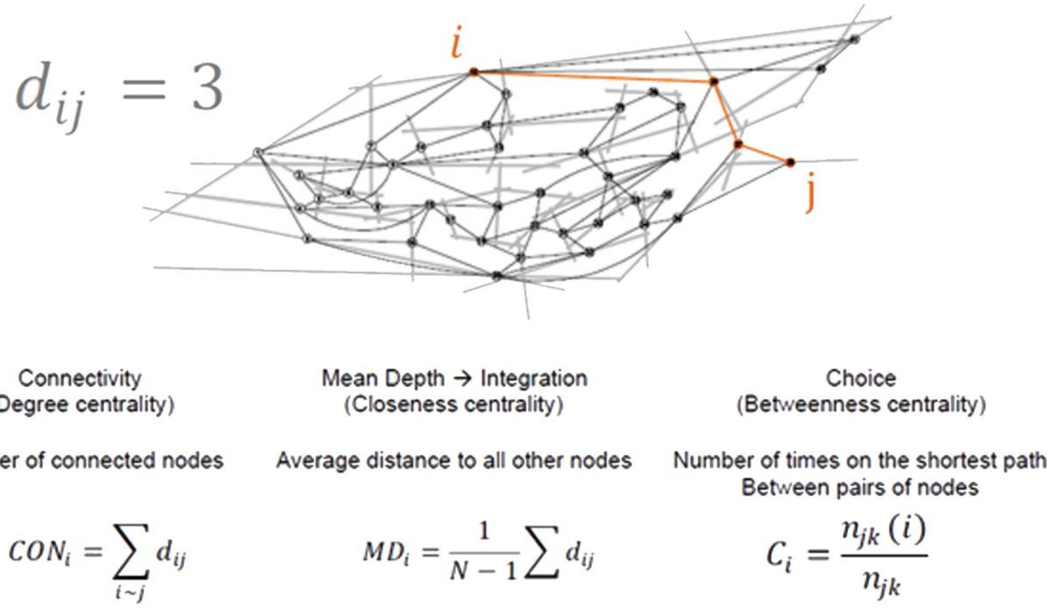

Figure 2. 3 SS Measure of connectivity, integration, and choice

space syntax, 2022

2.7 Four components of space syntax

1. Space Representations:

Geometric representations of spatial components and how individuals experience them serve as examples of these components. They are geometrically derivable (for instance, as a point, axial line, segment, convex space, and isovist) or defined based on function. (space syntax, 2022)

2. Spatial Relationship Analysis:

The configuration of spatial elements creates relationships between them. Several metrics, such as integration and choice, can be used to objectively examine these interactions. These two measurements reflect the two basic components of human mobility, namely the choice of a goal and the choice of a route. One evaluates the pass-through flow, while the other evaluates the accessibility. (space syntax, 2022).

3. Analytical models:

Different types of spatial and socio-economic phenomena are analyzed, described, explained, and forecasted using spatial models. Practically, models are developed to explore general processes like spatial intelligibility as well as specific phenomena like urban movement, urban crime, and centrality as a process. (space syntax, 2022)

4. Theories:

It is possible to investigate whether and how space is internalized into the socio-economic processes that shape the built environment by establishing theories of the relationships between spatial and social patterns. There are two ways this has been done. First off, theories can be employed to search for patterns in the distribution of models across functions and cultures. The hypothesis of the generic city is one such. Second, theories can study the effects of diverse deployment and shaping strategies for objects in space on spatial patterns using tools for space syntax. (space syntax, 2022)

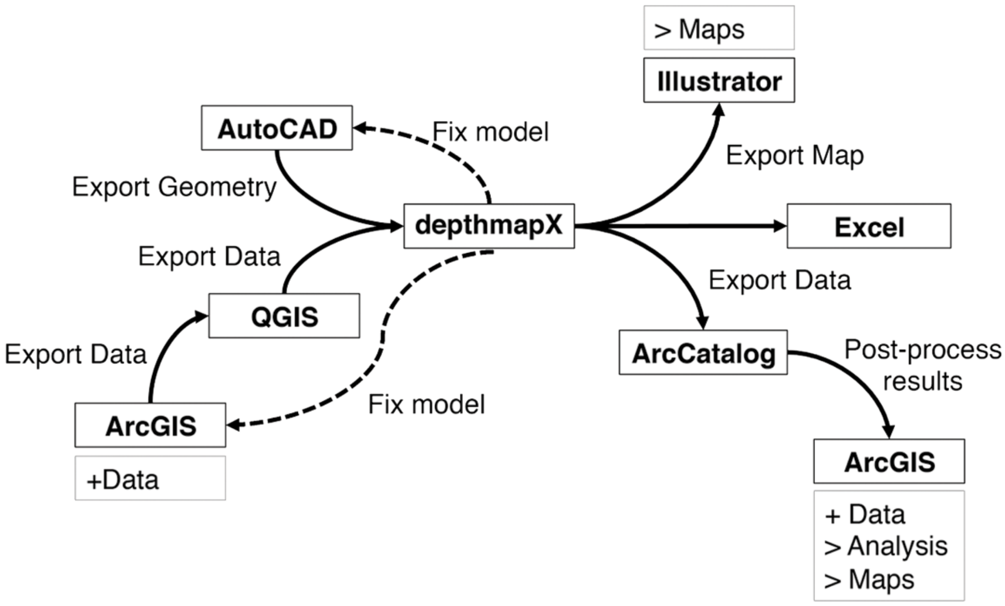

Figure 2. 4 workflow of space syntax analysis using the DepthmapX

space syntax, 2022

2.8 Mobility

Mobility is the capacity to move from one location to another with ease along a network. Mobility is the capacity to move from one location to another with ease along a network. There are two parts to this. The first of them is dependent on how well the transportation system operates, which is influenced by the person's location, the time of day, and the direction they want to go in. The second factor is determined by the qualities of the person, such as whether she has a car or bicycle at her disposal, can pay the costs of a cab, bus, or train, can walk or take public transportation, or is aware of the possibilities. In other words, the first factor is concerned with how well the transportation system connects geographically apart sites, while the second element is concerned with how well a specific person or group of people can utilize the transportation system. Consider two individuals who are a part of a connected network to gain clarity. A person who has a car is more mobile than someone without one (Gupta, 2008).

2.9 Accessibility

The word "accessibility" has been in use for almost 50 years (Cerda, 2009). Different researchers have given it different definitions. The phrases "access" and "ability," which together signify the capacity to gain access to something, are the roots of the word accessibility. Accessibility is described as "the ease and comfort of access to spatially distributed possibilities with a choice of travel" (U.S. Dept. of Environment, 1996) in one definition. The ability of a specific person or group of people to engage in a specific activity or series of activities at a specific location is what accessibility is all about. Therefore, accessibility is more concerned with opportunities or possibilities offered by the transportation and land-use system than it is with behaviour.

2.10 Accessibility in Urban Transport Planning

- It clearly gives an idea about the existing state of transportation system.
- It tracks and monitors changes in accessibility caused by shifts in the distribution of land uses.
- It can be used in travel demand modelling to determine the changes in the trip generation pattern due to changes in level of service of any travel mode or changes in land use pattern.
- Accessibility indices provide the decision makers to target investments more effectively for specific purposes such as improving accessibility to major employment centers.
- Accessibility measure can be used by individual households and businesses as a quality-of-life index when making relocation decisions. It may function as a land use/transportation version of a cost-of-living index.

2.11 Connectivity

It considers all the direct links that each street has to other streets in its surrounding area. Connectivity is a static local assessment. A street's connectivity value is determined by how many connections it has to its side streets; Low connectivity values are found on street network with minimal connections. A colour spectrum is used to represent these values. For example, Fig. 2.1's map illustrates the level of connectivity for each road network in the Mannheim of Germany. The streets with the most links to neighbouring streets are those with axial lines in red and yellow. All of the streets that are dark blue have just one or two connections nearby. High values for connectivity can be found on city centre streets. Kurpfalzstrasse, a major thoroughfare for retail in Mannheim, has one of the best connectivity scores. This street, which is north-south oriented, goes through the heart of Mannheim. Kurpfalzstrasse side streets are similarly highly valued. Local residential street is the one with the highest connection (in the city's north). There is very little connectivity on its side streets. (Akkelies van Nes, 2021).Thus, connectivity analysis is relatively simple. The links between each street and its neighbouring streets are counted. The following section illustrate more advanced connectivity analysis.

Figure 2. 5 Mannheim’s connectivity graph

Source: (Akkelies van Nes, 2021)

2.12 Global axial integration analysis

A street's relationship to every other street in a predetermined spatial system is referred to as global integration. This could be a town, a city, a region, a township, a quarter, a district, a hamlet, etc. In the context of globalisation, the terminology "global" and "integration" are occasionally used to refer to the integration of global economies via trade, foreign direct investment, and flows of capital as well as to societal problems such as migration, the transfer of technology, and the multinational exchange of ideas, languages, and civilizations. It is important to distinguish this from the definition of the term "global integration" in space syntax. In the space syntax language, the word "global" denotes the application of a system-wide radius for spatial analysis. (Akkelies van Nes, 2021).

Figure 2.6 shows the axial integration study results for town X together with morphological footprint (a), raw axial map (b), and results (c). It is important to keep in mind that axial map contains the shortest sightlines that indicate routes. An urban public area that is connected to other urban public spaces is represented by each axial line. As a result, the relationship between each axial line and the others in the given system can be determined. In other words, a calculation is made to determine each axial line's topological length in relation to all the other axial lines. Each change in direction is marked by a syntactic move. The values for the axial integration analysis are color-coded (c), with the red axial lines represents the axes that are most integrated and the dark blue axial lines represents the street that are most segregated. The nodes of the justified graph likewise use the same colour scheme (d). According to the theory that an axial map is the map with the least connections for the graph, the lines are illustrated as nodes and the junction of lines is represented as connections between nodes. The justified graph demonstrates the abstract relationships between the various parts of a system. (Akkelies van Nes, 2021).

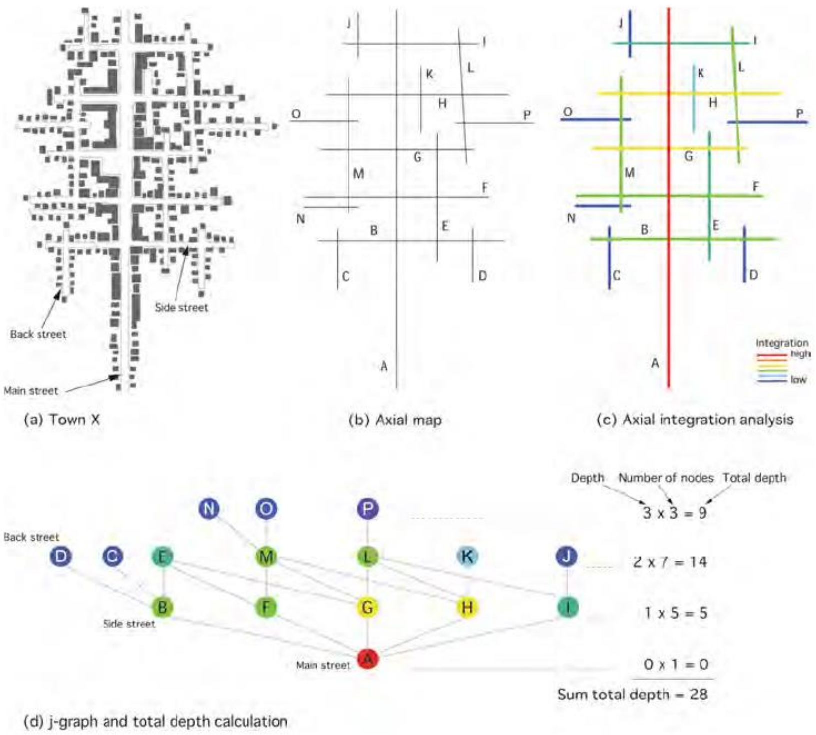

Figure 2. 6 Showing calculation of total depth for town X in space syntax

Source: (Akkelies van Nes, 2021)

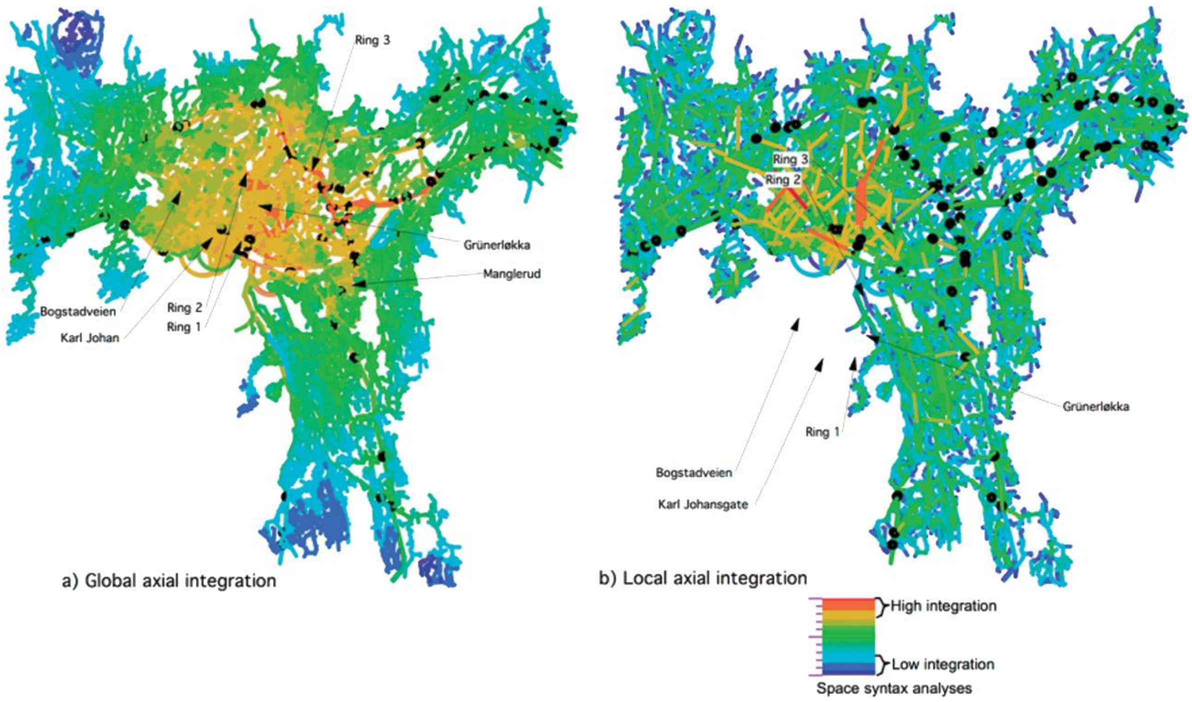

Figure 2. 7 Global (a) and local (b) axial integration of Oslo

Source: van Nes, A. Spatial Configurations and Walkability Potentials. Measuring Urban Compactness with Space Syntax. Sustainability 2021.

- It shows a global and local spatial integration analyses of Oslo's Street and road network.
- The red and orange lines show the streets with the fewest total number of direction changes to all others; thus, they are the spatially highest integrated streets.

The most integrated roads are located on the outer ring road. In the case of Oslo, the pedestrian-based shopping areas are situated along the locally most integrated streets, while the car-based shopping centres are situated along the junctions of the globally most integrated streets.

2.13 Measuring Street connectivity using space syntax

Space syntax is often thought of to use topological approaches to describe or measure the spatial structure of enclosed regions within structures or roadways inside urban space. Its foundations are found in urban planning and architecture. In contrast to intersection density, space syntax measures focus on the topological distance within a network, or the number of turns necessary to move from one place to the next. We won't go into great depth here about how space syntax measurements are calculated because it has already been covered elsewhere. Road integration, a fundamental spatial syntactic parameter, demonstrates how "accessible" a street network to all other street network in a given area topologically. Less turns are necessary to travel from other streets in the network to a street segment with a higher integration value. Figure 1-a shows a street network, while Figure 1-b shows the levels of integration (darker lines are higher in integration). Similar to intersection density, space syntax measurements can be calculated with just street centreline data and specialised, but free, software. (Mohammad Javad Koohsari, 2019)

Figure 2. 8 Base map

Figure 2. 9 SS integration analysis for each street segment

Figure 2. 10 Area-based aggregate integration analysis

Source: (Mohammad Javad Koohsari, 2019)

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.

SPACE SYNTAX MEASURE 1: ACCESSIBILITY PROVIDED BY THE TRANSIT SYSTEM

The more population and activity center a transit system is accessible to, the more would be its ridership. The following variables may be used to characterize accessibility of the transit system:

- population density around transit stops or routes within an acceptable walking distance, and
- economic activities around stops or routes in the form of commercial, industrial and public service / institutional land uses.

SPACE SYNTAX MEASURE 2: CONNECTIVITY OF THE TRANSIT TO OTHER ACTIVITY LOCATIONS

- The more activity locations or destinations that a transit system provides access to, the more would be its ridership. (Ipsita Banerjee, 2021)
- 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.

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.

CHAPTER 3 STUDY AREA

3.1 Introduction

Figure 3. 1 Thiruvananthapuram district map

Source: Thiruvananthapuram district map, Retrieved November 25, 2022

Thiruvananthapuram is located at 8.5°N 76.9°E on the west coast, close to the southernmost point of mainland India, and is a city constructed on seven hills by the sea. The Laccadive Sea to the west and the Western Ghats to the east encircle the city, which is located on India's west coast. (board, 2013)

The capital of Kerala is Thiruvananthapuram, often called Trivandrum. The city has 957,730 residents, and the surrounding metropolitan area has 1.68 million people. As of 2015, Thiruvananthapuram, a significant IT centre in India, contributed 55% of Kerala's software exports.

3.2 Road network

Thiruvananthapuram City has a good network of roads. Erstwhile National Highway No. 47 (now NH 66) between Salem and Kanyakumari runs through the city's centre and passes through key traffic-producing areas like Pappanamcode, Karamana, Killippalam, Thampanoor, Palayam, Pattom, Kesavadasapuram, Ulloor, Sreekaryam and Kazhakkoottam. With the commissioning of the Thiruvananthapuram-Neyyattinkara bypass between Kazhakkoottam and Kovalam which has become NH 66, the section of the road between Killippalam and Kazhakkoottam has come under PWD.

Figure 3. 2 Road network of Thiruvananthapuram corporation

Source: Author generated using Qgis,2022

Figure 3. 3 Classification of road network based on width

Source: Author generated with respect to RTPO masterplan Thiruvananthapuram,2012

The most populus ward in city is ward 65 Thiruvallom with population 25185 and least populus ward is Muttathara with population 1143 persons.

As per Census 2011, the population density of Kerala is 860 persons per sqkm and that of Thiruvananthapuram district is 1509 persons/sqkm, which is the highest among districts in the state. Among wards within Corporation, Population density is more in Ward 72 (Manacaud – 15908 persons/ Sqkm) and is least in Ward 32 (Thuruthumoola ward- 723 persons/Sqkm.) The city has an average density of 4444 persons/Sqkm. The density has however decreased significantly from 5382 persons / km² in 1991 to 4511 persons/ km² in 2011 due to inclusion of adjoining lower density panchayats.

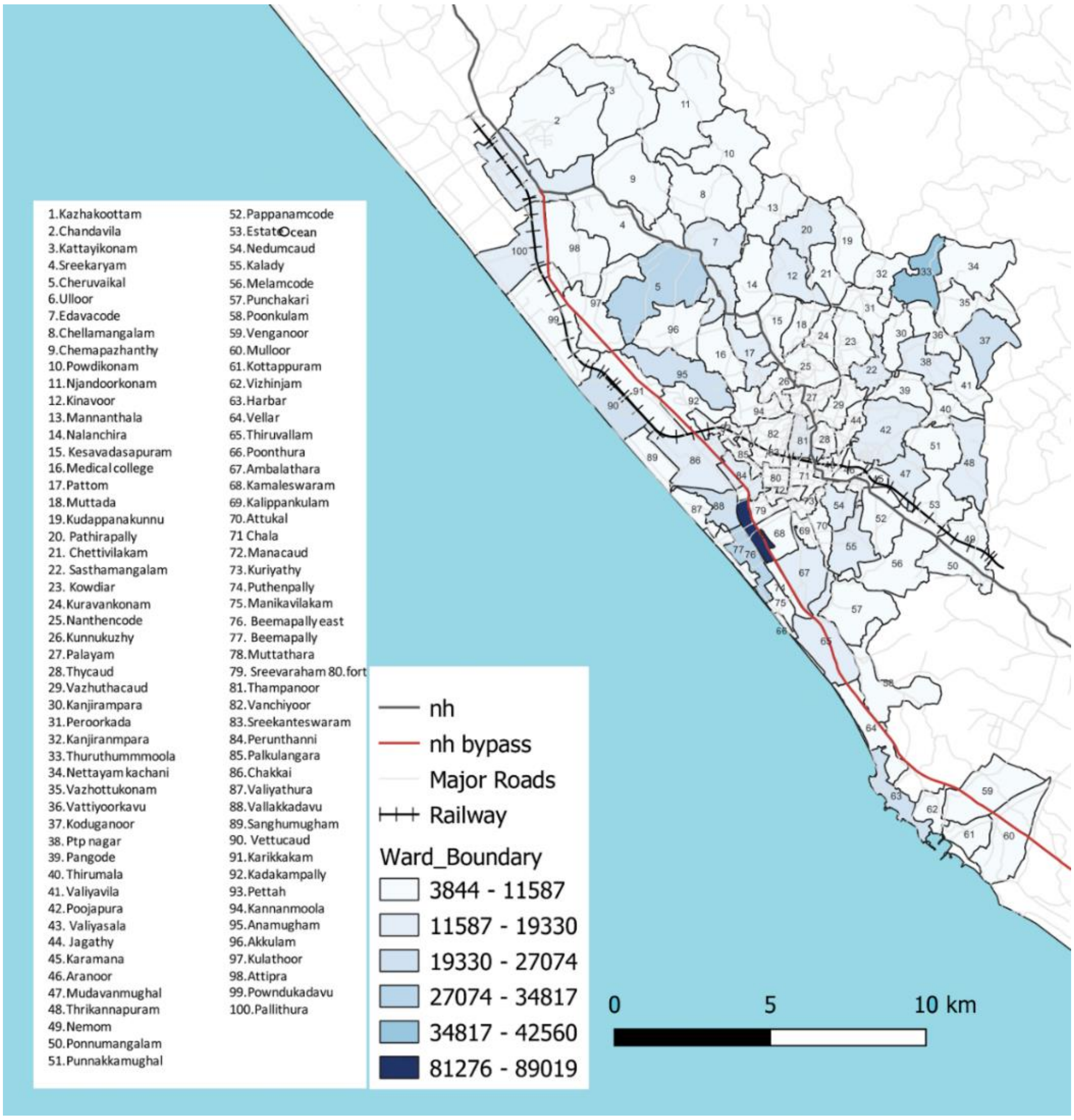

Figure 3. 4 Map showing population density of Thiruvananthapuram corporation

Source: Author generated with respect to RTPO masterplan Thiruvananthapuram,2012

3.3 IT Corridor in Kerala

Along with the existing NH 66, four IT corridors will be made parallel to it as part of decentralizing the states IT sector. There will be four lanes in the corridors which will be Koratty-Ernakulam, Thiruvananthapuram Technopark phase-III-Kollam, Kozhikode-Kannur, and Ernakulam-Cherthala. For the extension of the IT corridor, an IT facility will be set up in Kollam which will cover an area of 5,00,000 square feet.

- The concept for Thiruvananthapuram IT Corridor will be located along the NH-47 Bypass running from Kazhakkoottam to Kovalam.
- It will be outside the city area, in the western suburbs but closely connected to all areas of the urban area.
- Trivandrum International Airport, railway stations and bus terminals lie on or near (< 3 km) the axis.
- The IT Corridor will terminate at the world-renowned tourist destination of Kovalam-Poovar, close to the Vizhinjam International Transshipment Container Terminal.
- Apart from proximity to upcoming ICTT, Vizhinjam, the project location can derive benefit from its proximity to the aero-space centre of VSSC, Trivandrum International Airport, IT Hub of Technopark, and many major tourist locations including Kovalam, Varkala, Poovar and Ponmudi in the Capital region.

3.3.1 Funding

Rs 1000 crore has been sanctioned from the land acquisition pool of the Kerala Infrastructure Investment Fund Board (KIIFB) for acquiring land to set up IT parks in Kannur, Kollam, and other areas. Technopark, Techno city, Info Park, and many more IT centers will be expanded as part of the development of essential infrastructural facilities for the IT sector.

3.4 Advantages of location

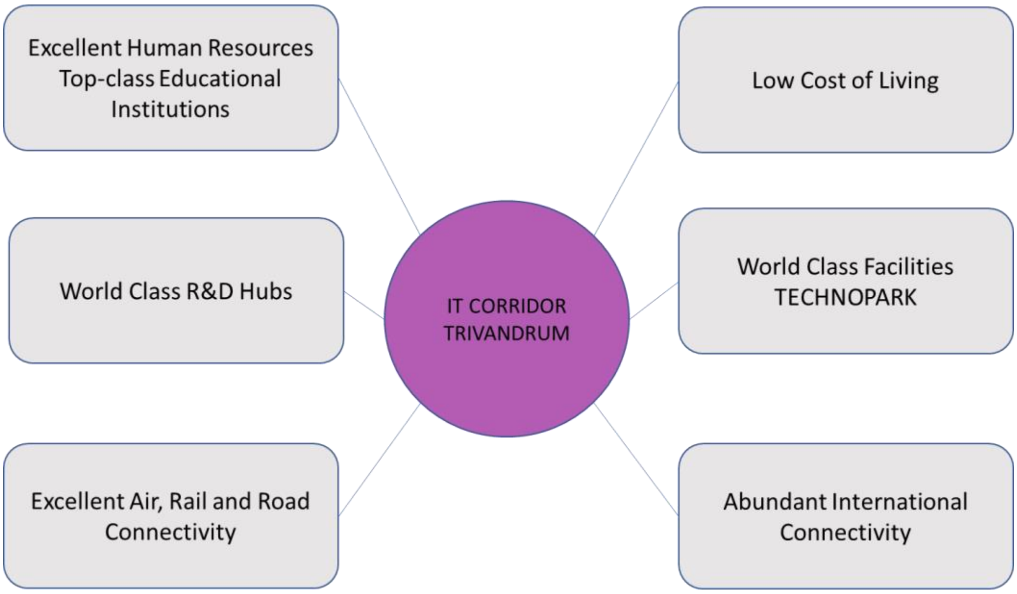

Figure 3. 5 Location advantage of Thiruvananthapuram IT corridor

Source: Author generated ,2023

- **Trivandrum International Airport:**

Connectivity to all major Indian cities as well - International destinations in the Middle East South East Asia, the US and Europe.

- **R&D and Educational Institutions:**

There is a world class cluster of R&D and Educational Institutions on or near the proposed IT Corridor, including:

VSSC, CESS, College of Engineering Trivandrum, Asian School of Business, Indian Institute of Information Technology and Management - Kerala (IITM-K) Kochuveli Satellite Rail Terminal:

Allows access to long distance, commuter and possibly soon, suburban trains just 1.0 Km from the proposed Corridor.

3.5 Study area delineation

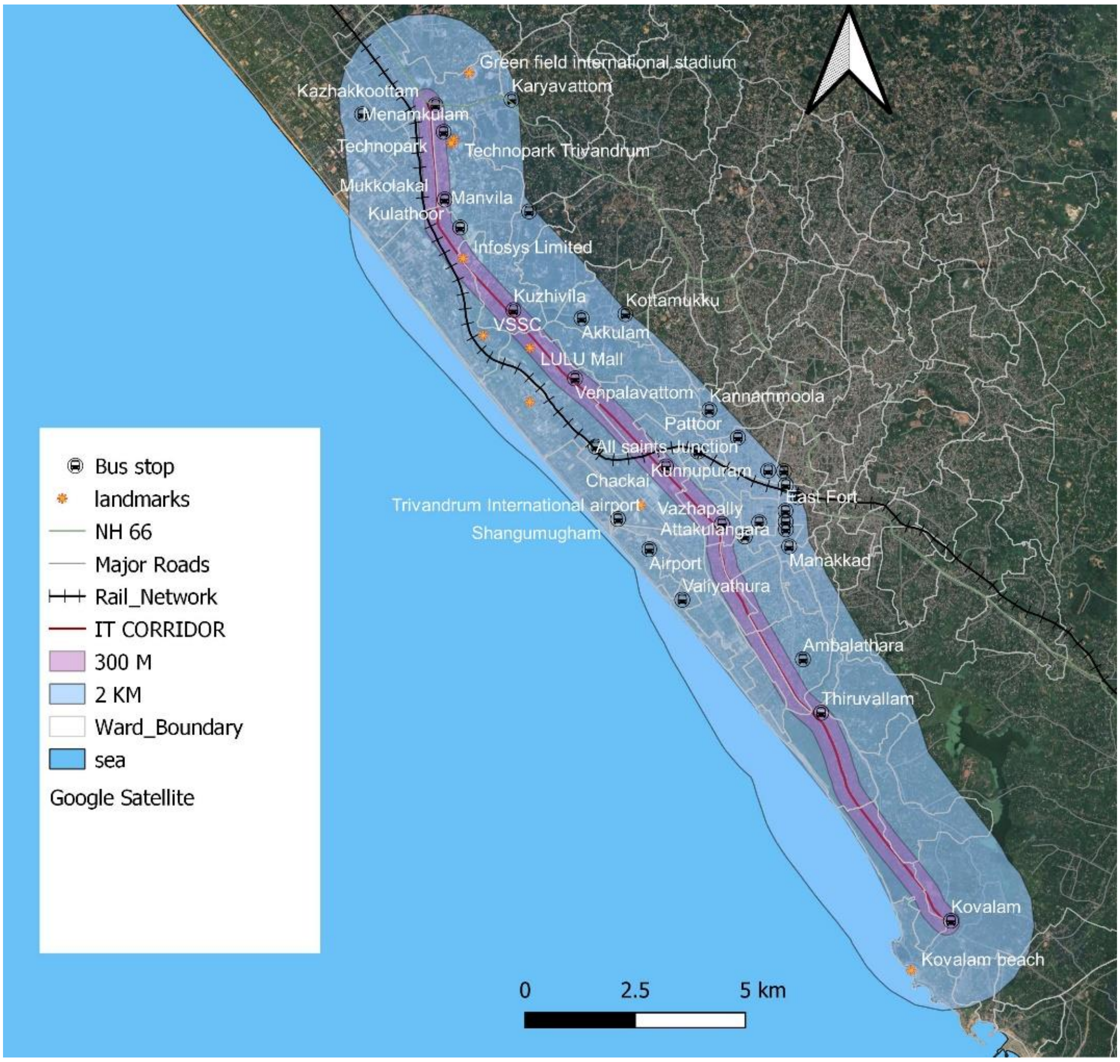

Figure 3. 5 Study area delineation

Source: Author generated using Qgis ,2023

The study area is limited to Kazhakoottam to Kovalam Junction having a buffer zone of 2 KM on both sides Along the NH 66 Bypass. The main road that passes through the study area is the NH-66 bypass. Nh 66 Bypass Road is 24.5 KM long in the study area. The typical trip time by car is 28 minutes.

Kazhakoottam is a major suburb in the capital city of Thiruvananthapuram, Kerala state, India. The largest IT Park of the country in terms of developed area Technopark along with Techno city an upcoming integrated IT township is situated here. Hence it is known as the Information Technology capital of Kerala.

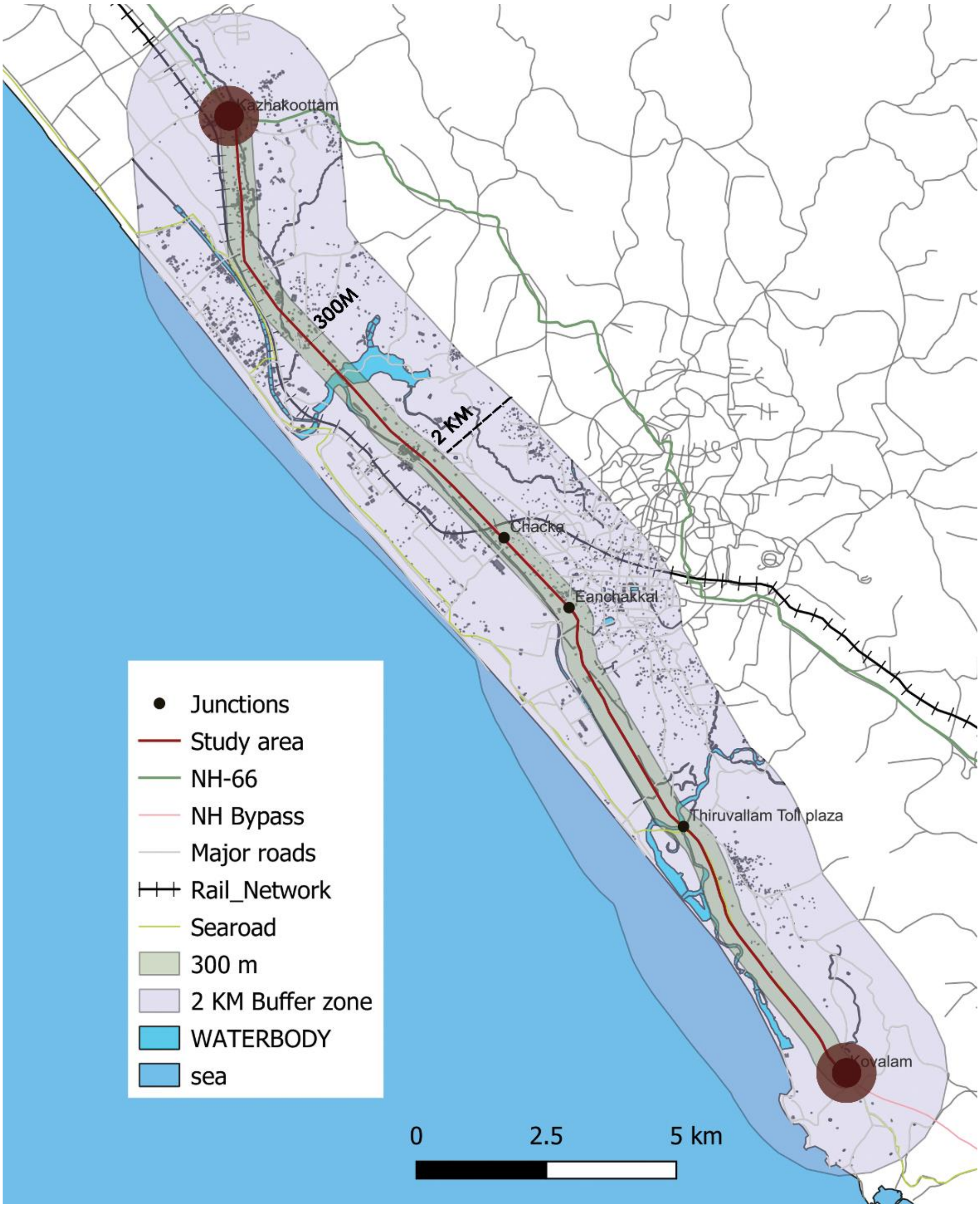

Figure 3. 6 Study area delineation

Source: Author generated using Qgis ,2023

Figure 3. 7 VSSC Trivandrum

Figure 3. 8 Infosys Trivandrum

Figure 3. 9 TCS Trivandrum

Figure 3. 10 Lulu mall

Figure 3. 11 Karyavattom campus

Figure 3. 12 Veli Tourist Village

Figure 3. 13 Thiruvananthapuram international airport

Figure 3. 14 UST global Trivandrum

Figure 3. 15 Kovalam beach

Figure 3. 16 Vizhinjam International Seaport

Figure 3. 17 Akkulam tourist village

Figure 3. 18 Technopark Trivandrum

Source: Google images ,2023

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.

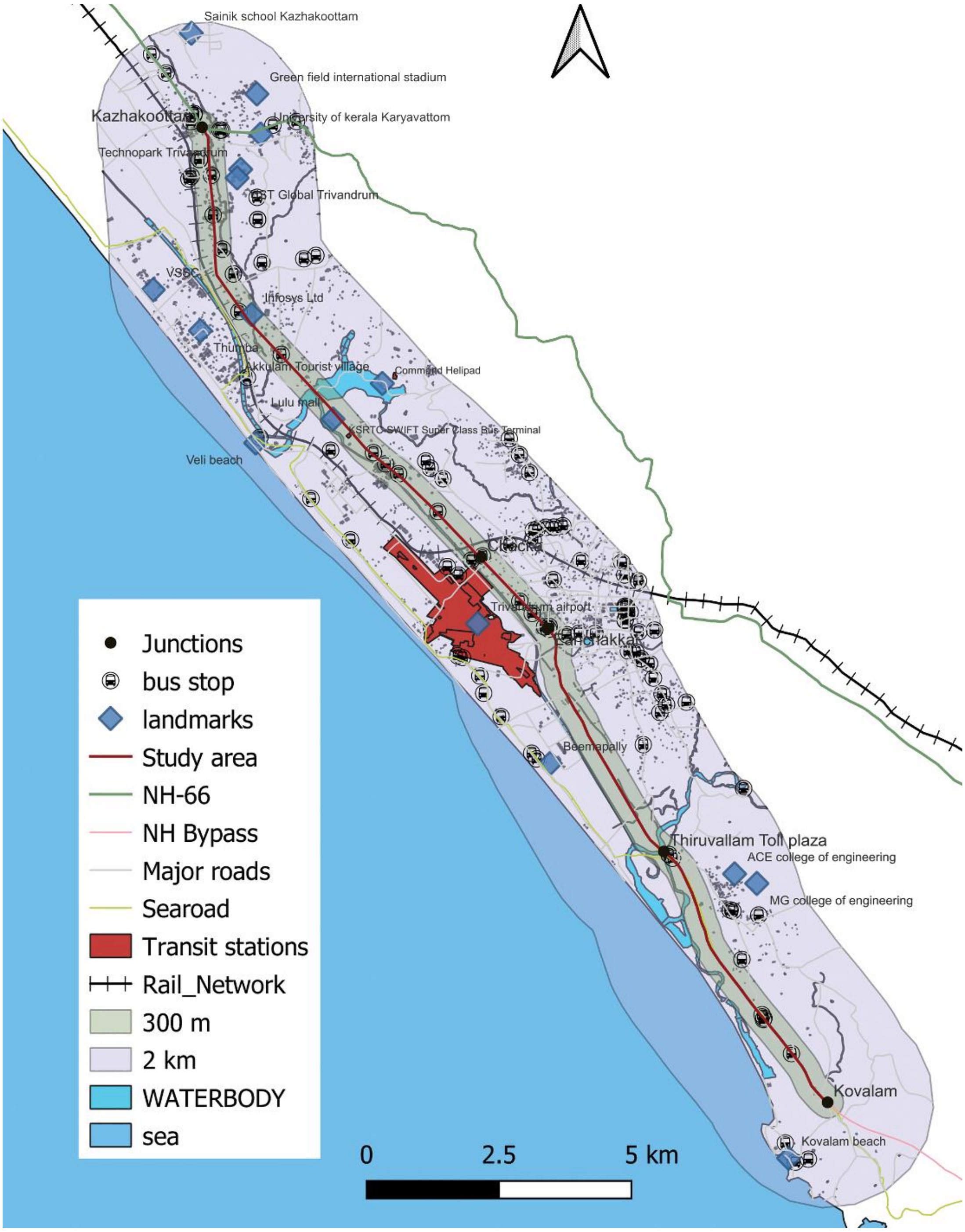

Figure 3.11 Map showing bus stops in the study area

Source: Author generated using Qgis ,2023

CHAPTER 4 STUDY AREA ANALYSIS

The study utilizes space syntax measures to evaluate the accessibility of the IT-corridor to the population and activities within its catchment, and 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.

4.1 Land use map

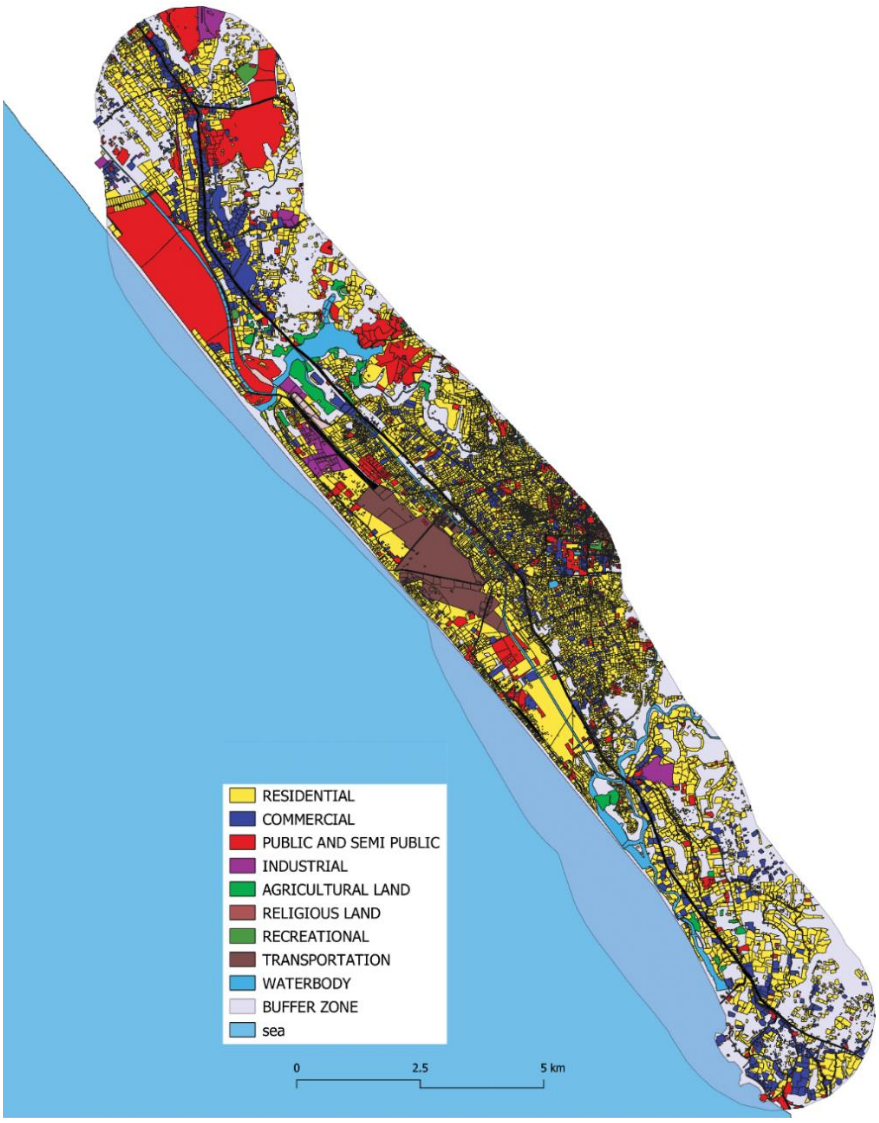

Figure 4. 1 Land use map

Source: Author generated using Qgis ,2023

4.1.1 Land use map analysis

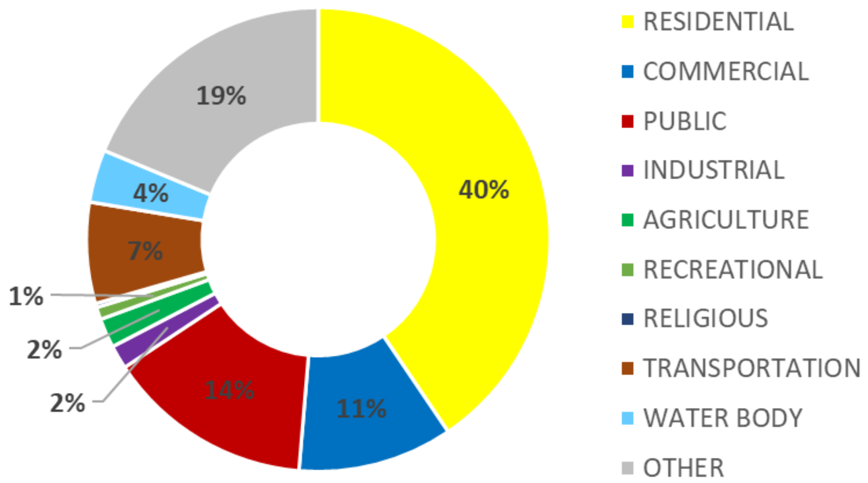

Figure 4. 2 Land use break up

Source: Author generated,2023

- The study area has a total area of 70.78 sq.km.
- The analysis of land use reveals that 40% of the study area is used for residential purposes, 11% is used for commercial purposes, 14% is used for public and semi-public purposes, 2% is used for industrial purposes, 2% is used for dry agriculture, 1% is used for recreational and religious purposes, and 7% is used for transportation.
- The commercial areas are increasing along the transport corridor and new commercial centers are been developed near Kazhakootam, Vizhinjam and Chacka areas. The Public/Semi Public area in the study area limit has considerably increased.
- The Public/Semi Public area in the study area limit has considerably increased.

Table 4. 1 Land use break up

Source: Author generated,2022

CATEGORY	AREA IN SQ.KM
RESIDENTIAL	35.31
COMMERCIAL	9.40
PUBLIC	12.53
INDUSTRIAL	1.44
AGRICULTURE	1.78
RECREATIONAL	0.75
RELIGIOUS	0.24
TRANSPORTATION	6.14
WATER BODY	3.20
OTHER	16.31
TOTAL AREA	87.09

4.1.2 Inference

Along the transportation corridor, particularly around the NH bypass, business sectors are expanding. New commercial centers have also been built, forming a commercial belt close to the Kazhakootam, Chacka and Vizhinjam areas.

The concentration of residential areas has decreased. The residential neighbourhood next to the transit corridor is being converted as mixed land use.

There is open area available along the road network which have a potential for developing the area as part of any future projects.

Public transport facility is covering almost every place in the study area. Every area is well connected with good road network.

People in Kerala preferring to live in single house surrounded by open space/ coconut garden is slowly changing due to various reasons. Homestead biodiversity is declining, so is the case with inter settlement space. Land use change is taking place both at the homestead level and at the level of use category.

4.2 Connectivity analysis of road network

- 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 here. This map provides a valuable visual representation for further analysis and interpretation of the city's spatial connectivity.

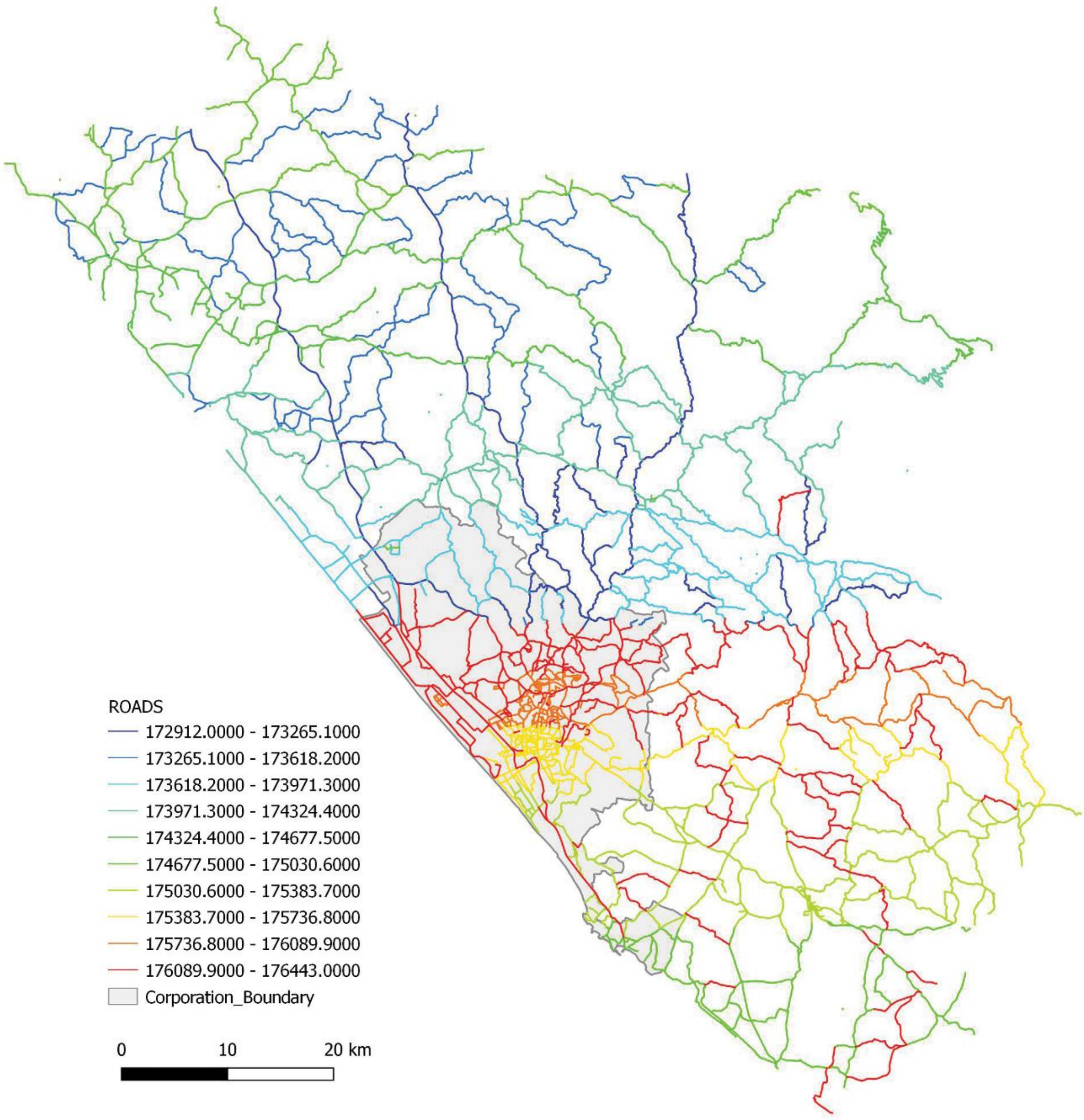

Figure 4. 3 Road Connectivity map of Thiruvananthapuram district city

Source: Author generated using Qgis,2023

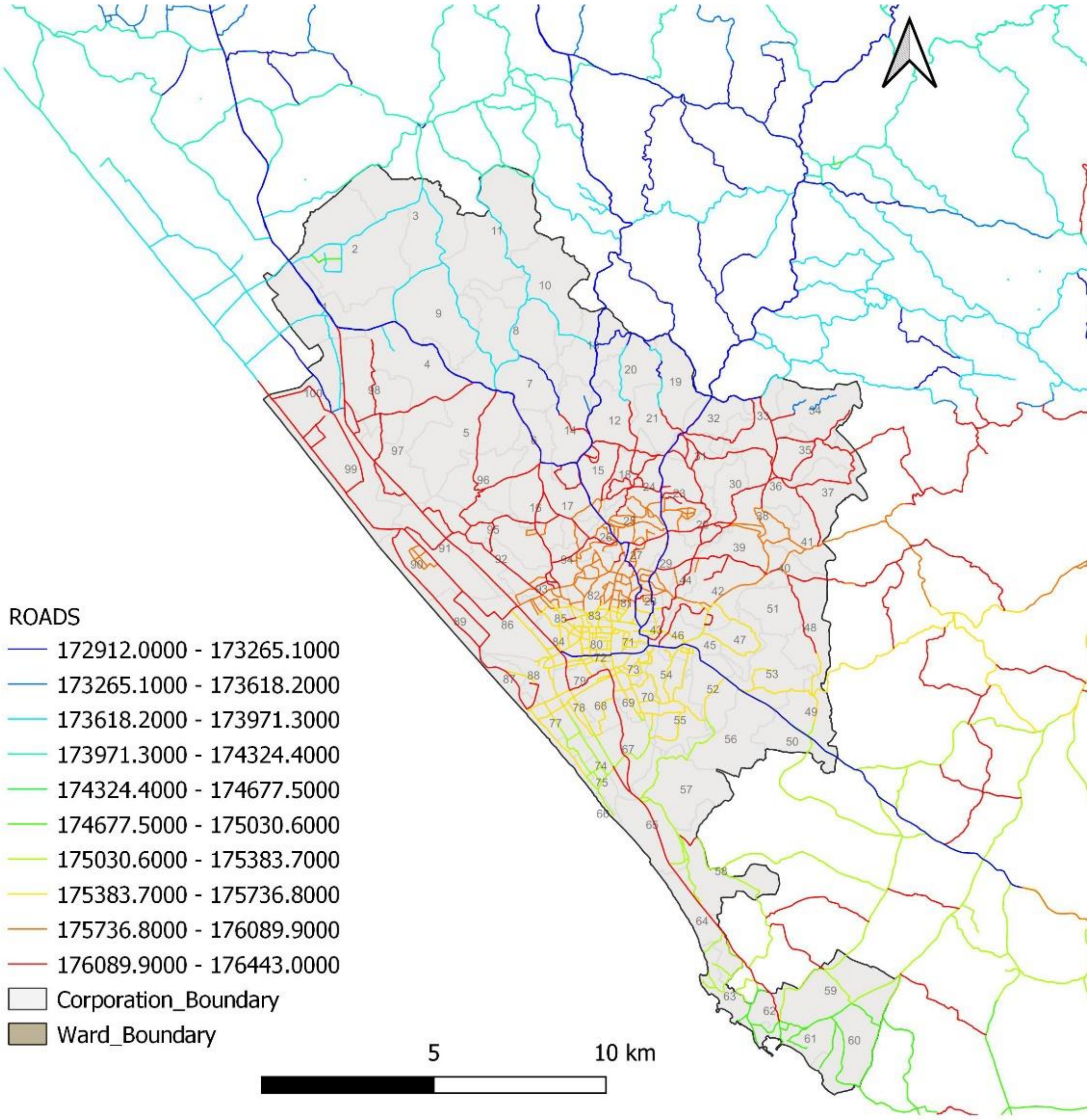

Figure 4. 4 Road Connectivity map of Thiruvananthapuram corporation

Source: Author generated using Qgis,*2023*

- The city centre, Thampanoor area of Thiruvananthapuram city has highest connectivity to its side streets and the road's connecting city has highest connectivity value. It is then followed by NH 66 and NH Bypass.
- Kazhakootam and Eanchakkal street segment shows highest connectivity value towards within and out of the city.
- Road connectivity value is less towards ward 59,60,61of Thiruvananthapuram corporation. ie, Veganoor Mulloor and Kottapuram wards.

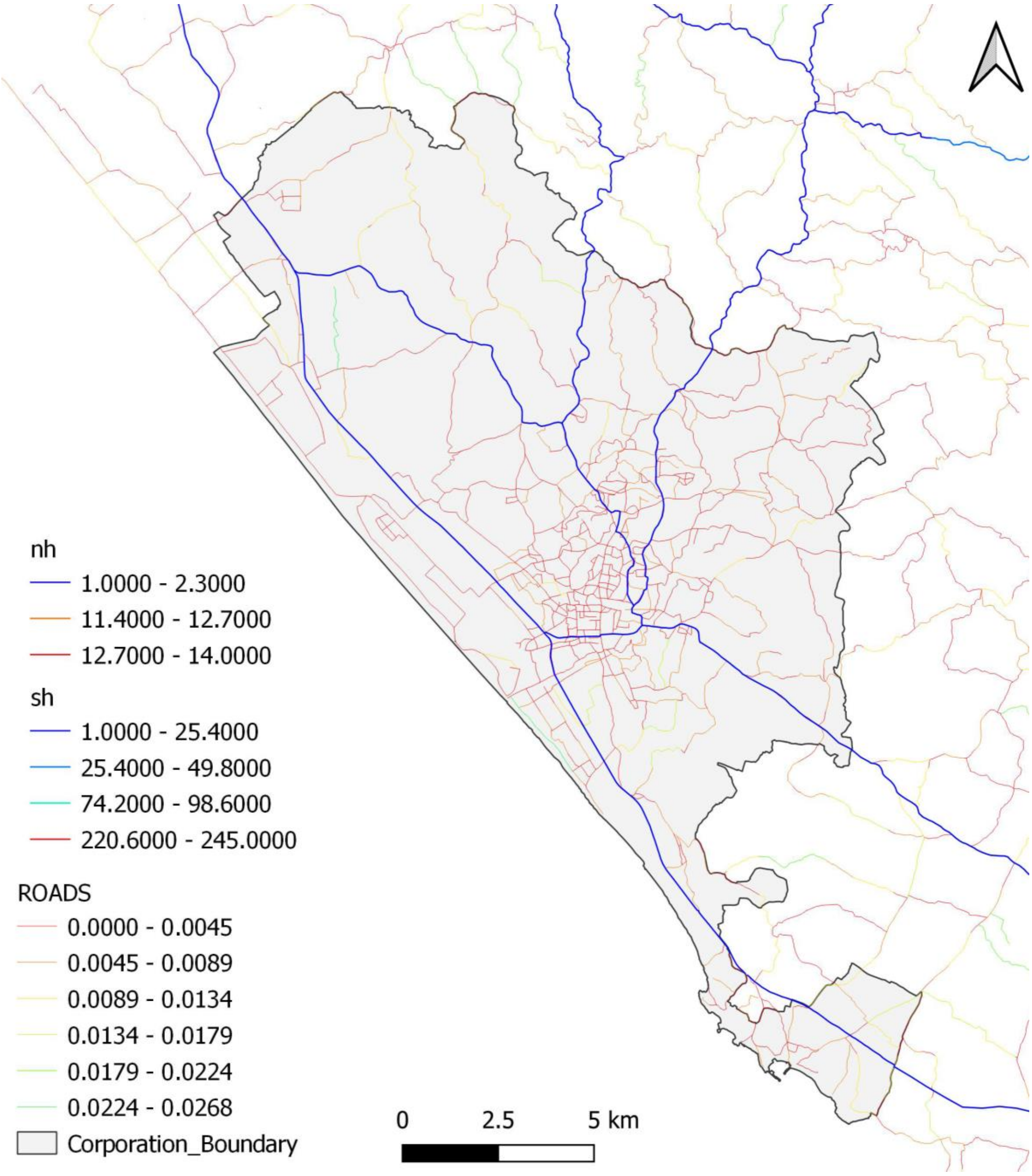

Figure 4. 5 Travel choice map of Thiruvananthapuram city

Source: Author generated using Qgis,*2023*

By the Integration analysis for the selected road network, it identifies that the preferred shortest routes are NH, NH bypass. These roads show highest accessibility values.

Table 4. 2 Attributes of road network

Source: Author generated,2023

SL.NO	ROAD TYPE	MEAN DEPTH	STANDARD DEVIATION	RANGE
1.	NH	4.375	5.048205126	0.115098112
2.	NH BYPASS	2.0133	1.233558537	3.72
3.	SH	42.83333	67.546074809	0.813135872
4.	MAJOR ROAD	0.00843964	0.010036913	0.199654492
5.	OTHER ROADS	0.004227272	0.004178345	0.044723

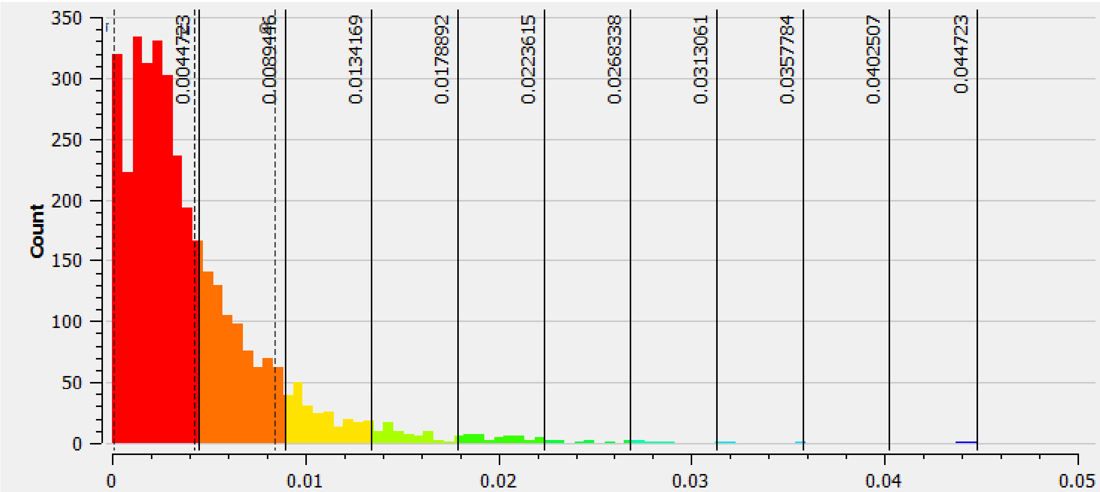

Figure 4. 6 Histogram (road network

Source: Author generated,2023

4.3 Connectivity classification of Bus stop

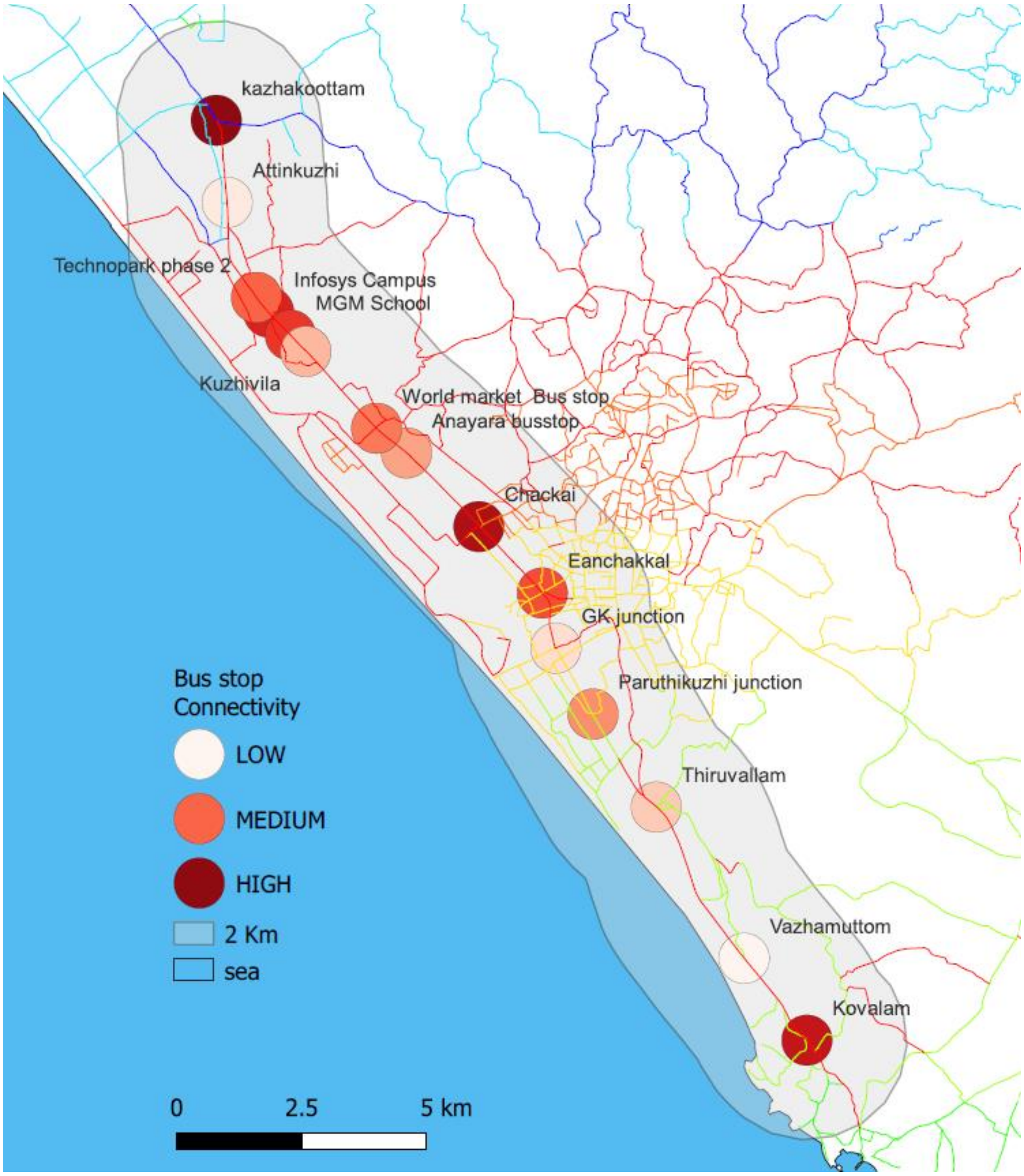

Figure 4. 7 Map showing station wise Connectivity

Source: Author generated using Qgis ,2023

4.4 Accessibility analysis

- 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, 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 following Figures, formed the basis for further analysis.
- 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.

4.4.1 Grid map/overlay analysis

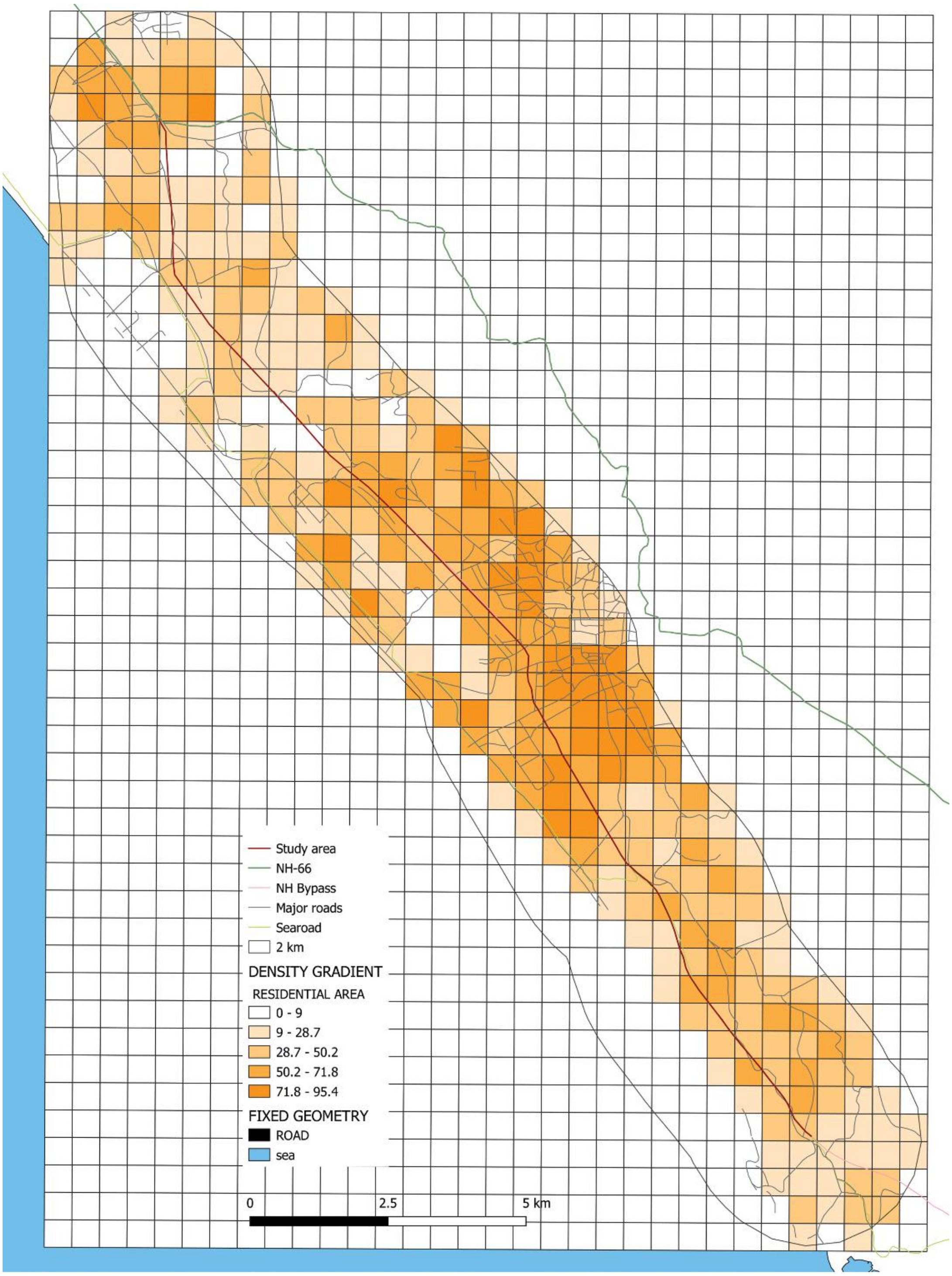

Figure 4. 8 Map showing density gradient of residential area

Source: Author generated using Qgis ,2023

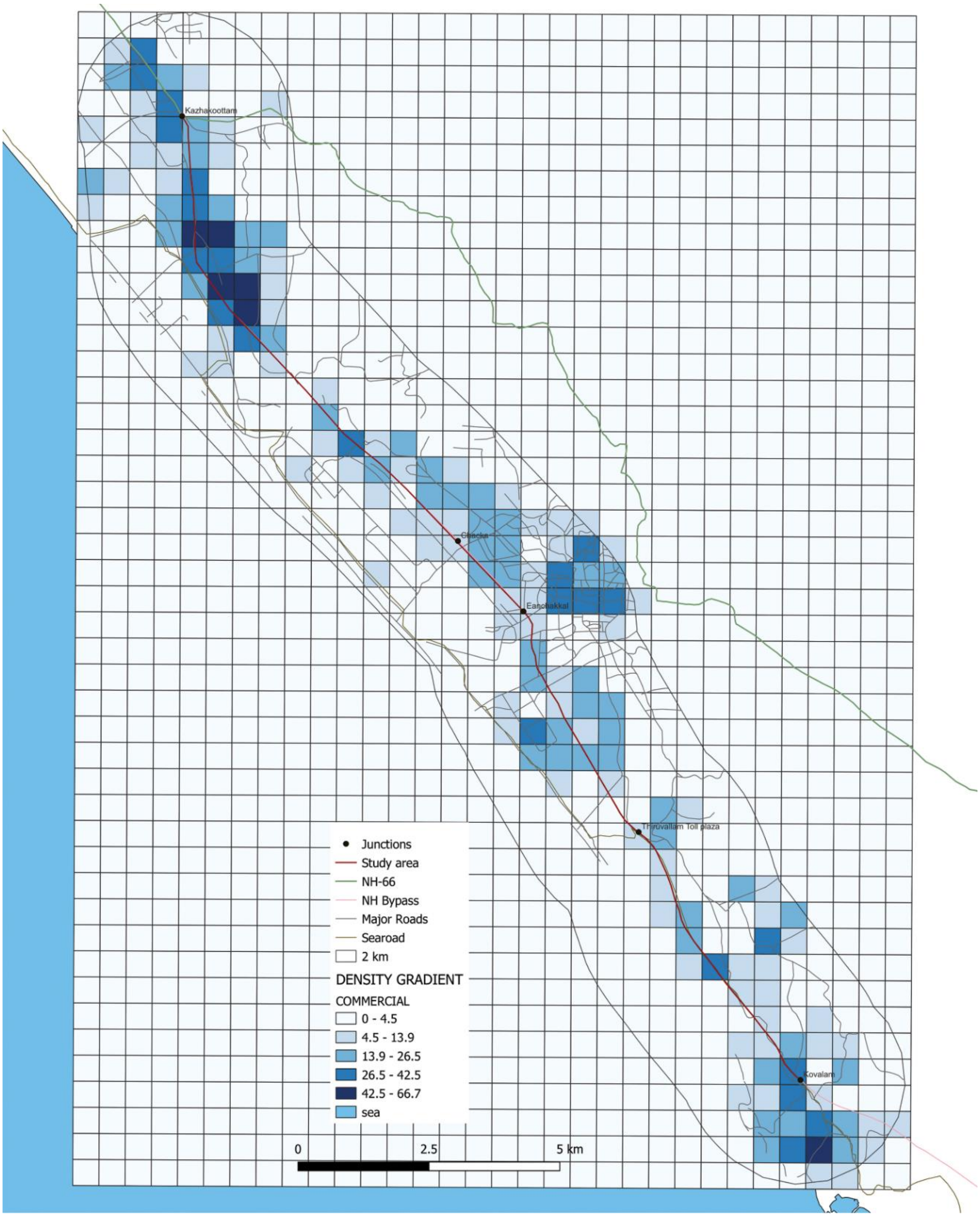

Figure 4. 9 Map showing density gradient of commercial area

Source: Author generated using Qgis ,2023

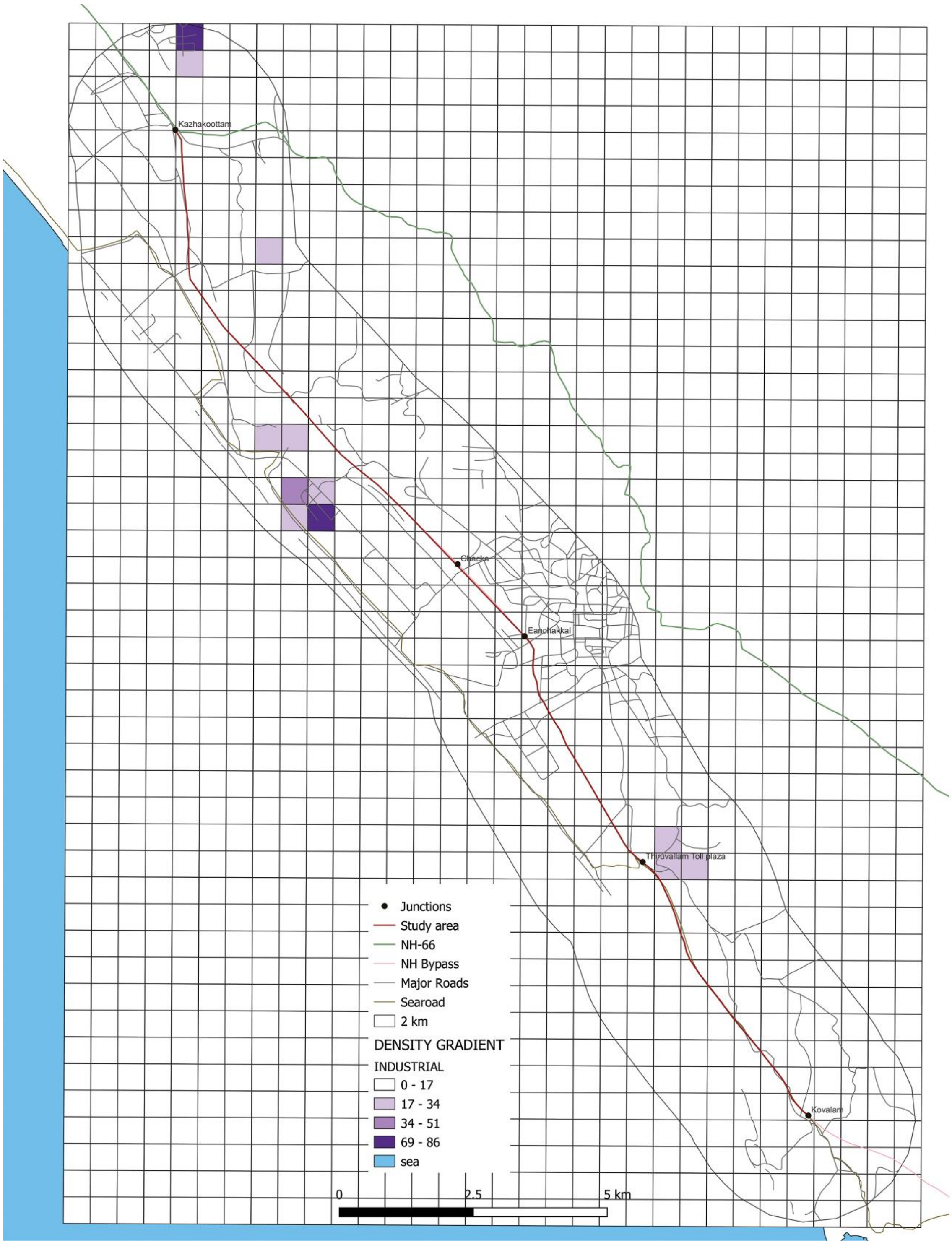

Figure 4. 10 Map showing density gradient of industrial area

Source: Author generated using Qgis ,2023

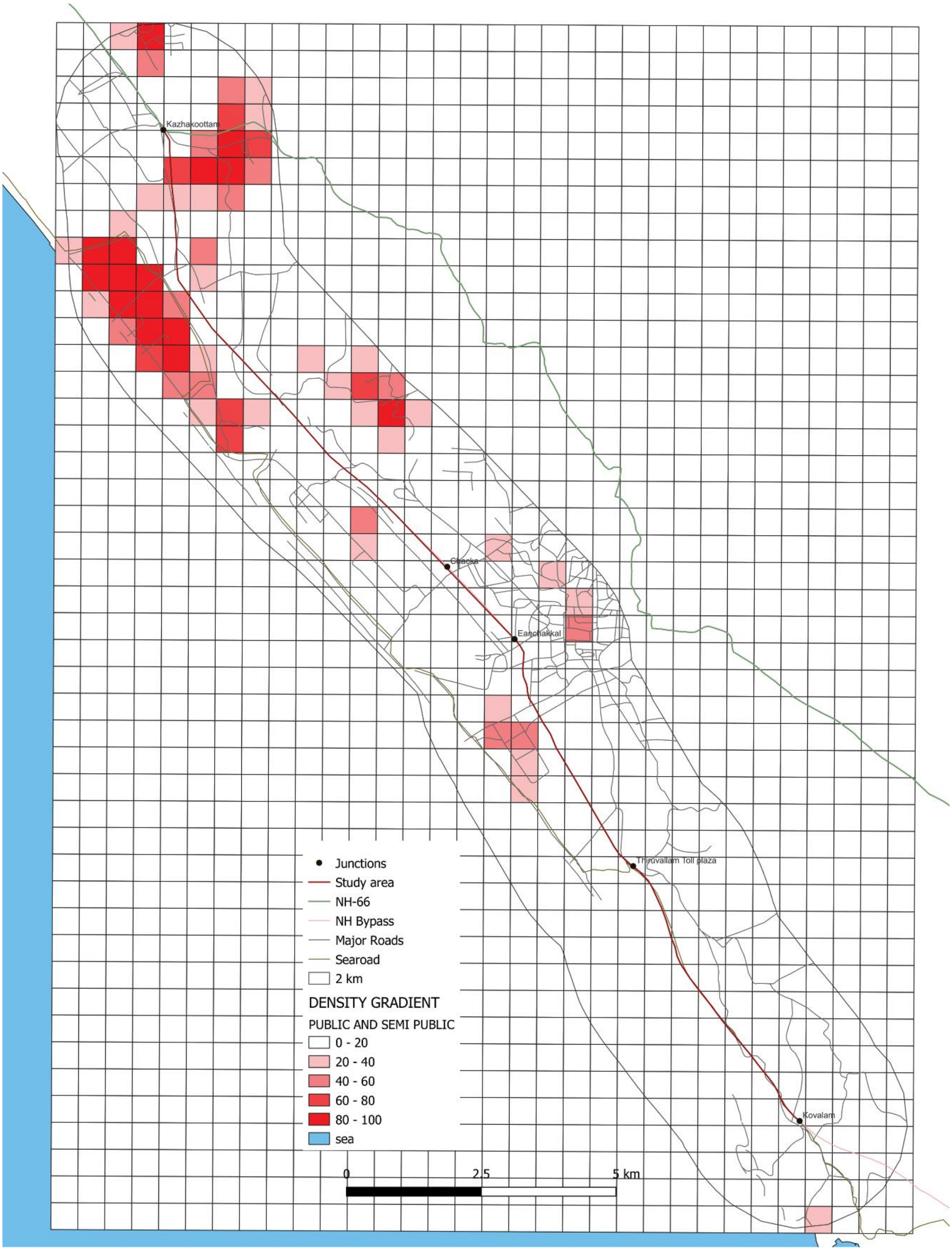

Figure 4. 11 Map showing density gradient of public and semipublic area

Source: Author generated using Qgis ,2023

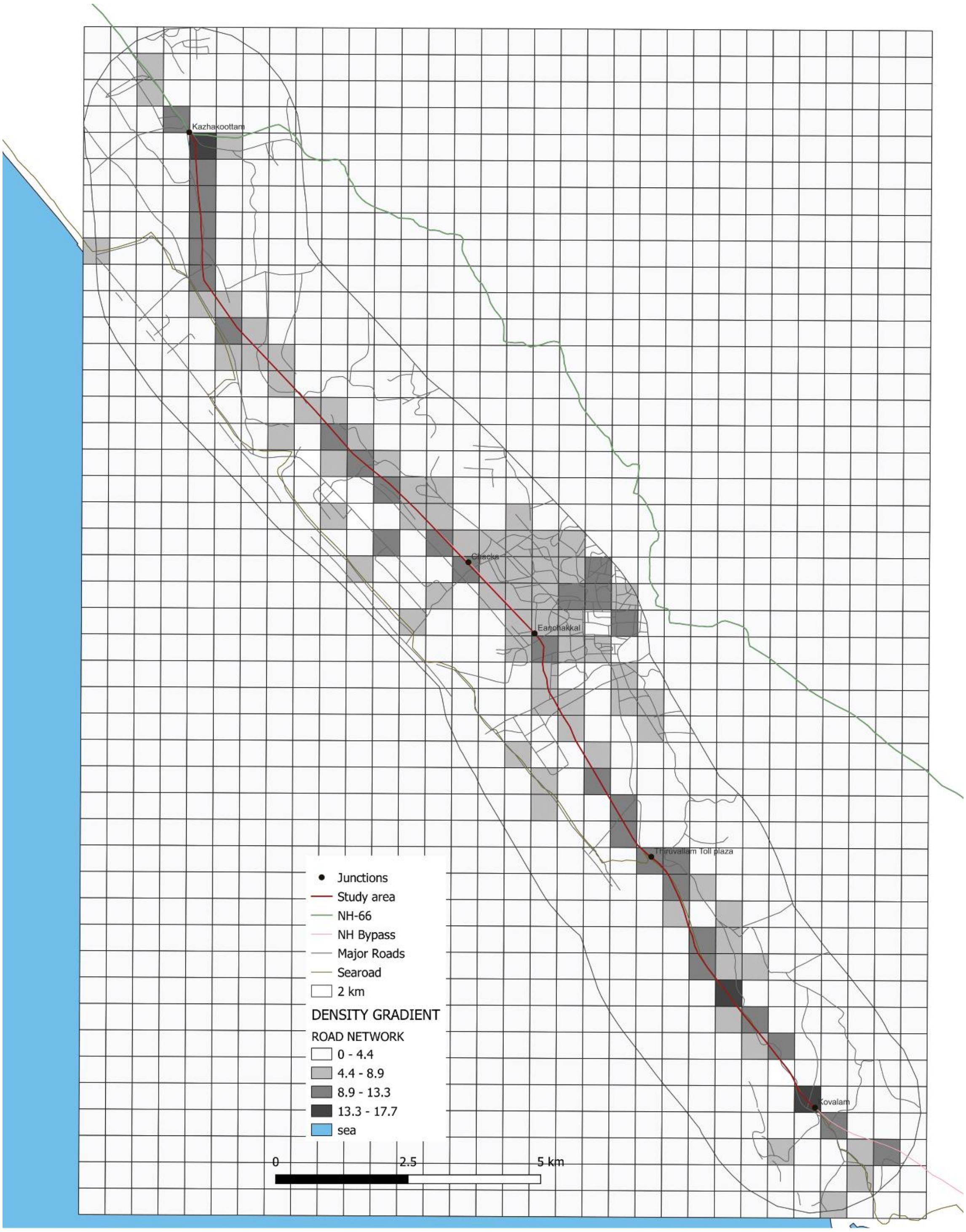

Figure 4. 12 Map showing density gradient of road network

Source: Author generated using Qgis ,2023

4.4.2 Observations

- Density gradient of residential area:
  Residential concentration is high in Kamaleswaram - Ayyankali nagar area, Beemapally and Kazhakoottam area.
- Density gradient of Commercial area:
  Commercial concentration is high in areas like Kazhakoottam, Venpalavattom, Chala market region and Kovalam.
- Density gradient of Industrial area:
  Industrial concentration is high near Kochuveli railway station.
- Density gradient of Public and semipublic services:
  Public and semipublic concentration is high Karyavattom due to the presence of Karyavattom university campus and Thumba due to the proximity of VSSC.

4.4.3 Inference

The density of residential location is high near where road network is available. The retail and commercial areas are in more integrated areas. There is a high job potential along these commercial stretches. People who live near retail and commercial concentration areas likely prefer walking to their work places.

4.5 Bus stop classification

- 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.
- The bus stops were 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

- Following a similar approach, the bus stops were also classified into three categories based on by calculating the combined indices of connectivity and land use factors for the grids falling within the catchment area of each stop.

4.5.1 Accessibility to population

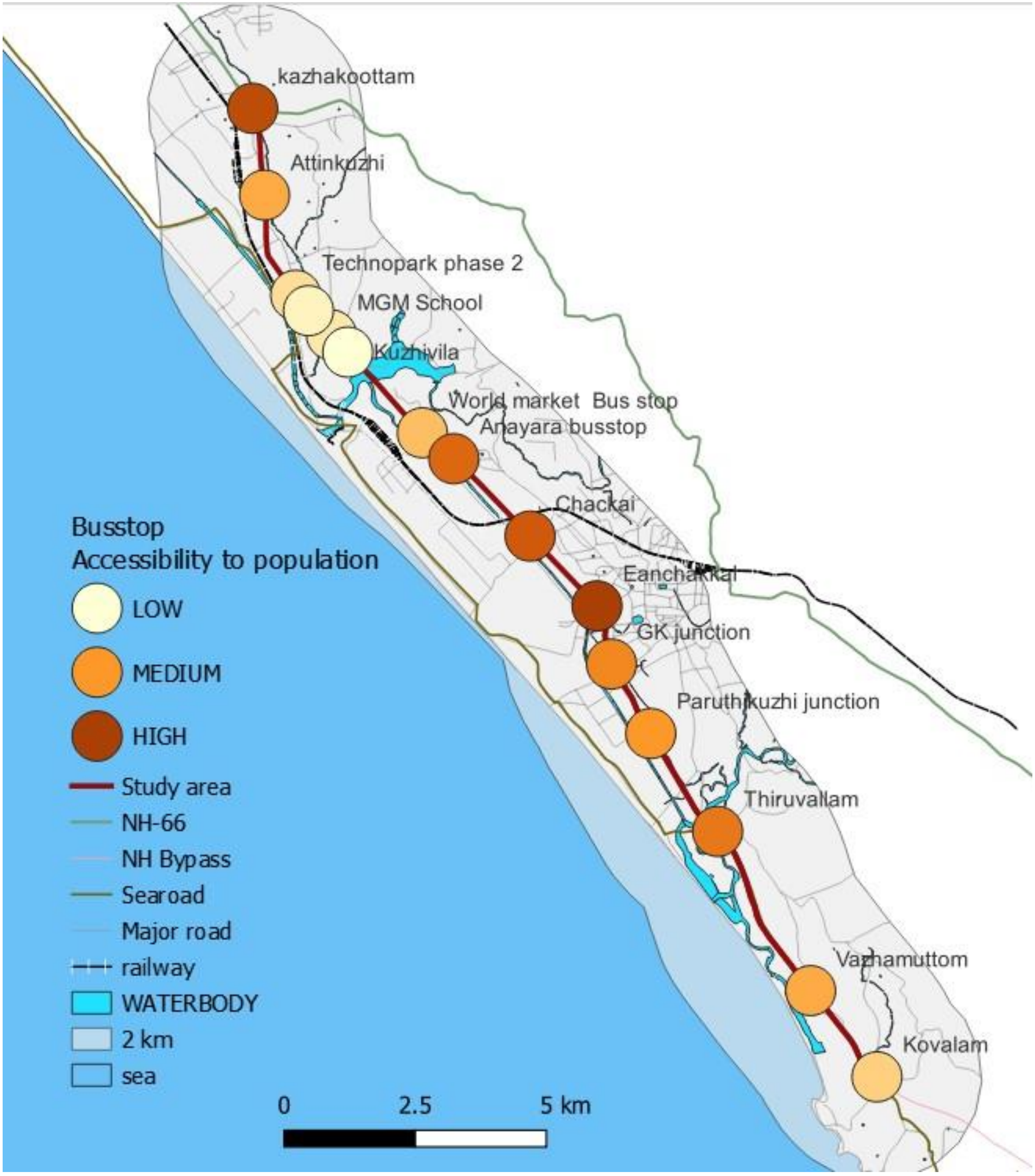

Figure 4. 13 Map showing station wise accessibility to population

Source: Author generated using Qgis ,2023

4.5.2 Accessibility to Activities

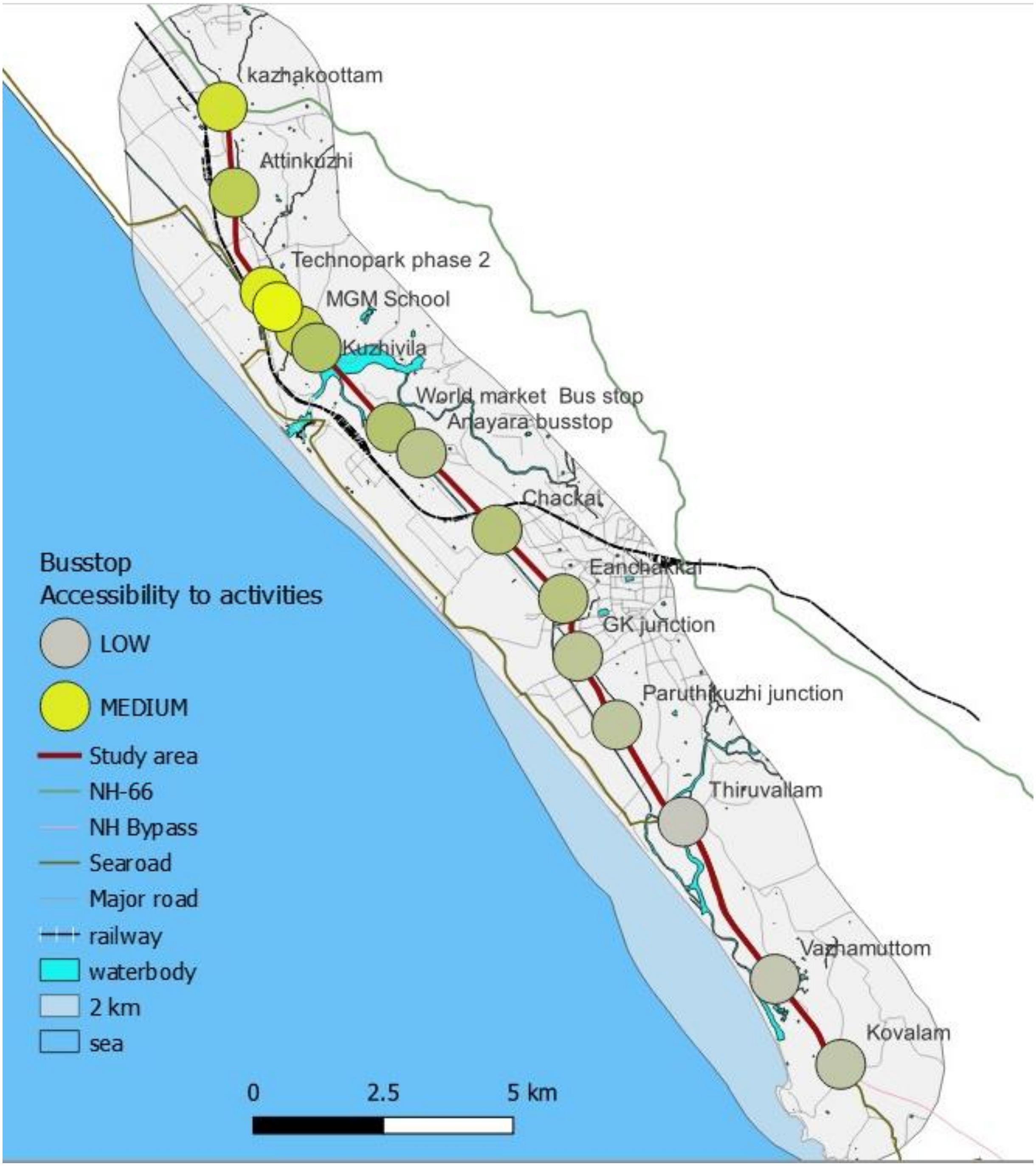

Figure 4. 14 Map showing station wise accessibility to activities

Source: Author generated using Qgis ,2023

Table 4. 3 Station wise accessibility index

Source: Author generated,2023

BUSSTOP	ACCESS TO POPULATION	ACCESS TO ACTIVITIES (com+pub+ind)
KAZHAKOOTTAM	0.60	0.38
ATTINKUZHI	0.32	0.33
TECHNO PARK PHASE II	0.28	0.39
INFOSYS CAMPUS	0.23	0.49
MGM SCHOOL	0.26	0.34
KUZHIVILA	0.23	0.31
WORLD MARKET	0.34	0.28
ANAYARA BUSSTOP	0.54	0.24
CHACKAI	0.56	0.26
EANCHAKKAL	0.68	0.25
GK JUNCTION	0.43	0.22
PARUTHIKUZHI	0.41	0.21
THIRUVALLAM	0.44	0.11
VAZHAMUTTOM	0.33	0.14
KOVALAM	0.29	0.18

4.5.3 Inference

- High accessibility to the population may be seen in Kazhakoottam and Eanchakkal bus stations, which means there are a lot of people living close to them.
- The Infosys campus area serves as a primary hub for activity. The bus station is close to excellent public and commercial facilities.
- The Kovalam area lacks residential concentrations and activity centers.
- High connectivity to neighbouring regions is provided by Kazhakoottam and Enchakkal.However, when compared to other bus stops in the study area, Anayara bus station has poor connectivity to other areas.

4.6 Analysis

Table 4. 4 Categorization of Bus stops

Source: Author generated,2023

BUSSTOP	ACCESS TO POPULATION	ACCESS TO ACTIVITIES
KAZHAKOOTTAM	HIGH ACCESSIBLE	MED ACCESSIBLE
ATTINKUZHI	LOW ACCESSIBLE	MED ACCESSIBLE
TECHNO PARK PHASE II	LOW ACCESSIBLE	MED ACCESSIBLE
INFOSYS CAMPUS	LOW ACCESSIBLE	MED ACCESSIBLE
MGM SCHOOL	LOW ACCESSIBLE	MED ACCESSIBLE
KUZHIVILA	LOW ACCESSIBLE	LOW ACCESSIBLE
WORLD MARKET	MED ACCESSIBLE	LOW ACCESSIBLE
ANAYARA BUSSTOP	MED ACCESSIBLE	LOW ACCESSIBLE
CHACKAI	MED ACCESSIBLE	LOW ACCESSIBLE
EANCHAKKAL	HIGH ACCESSIBLE	LOW ACCESSIBLE
GK JUNCTION	MED ACCESSIBLE	LOW ACCESSIBLE
PARUTHIKUZHI	MED ACCESSIBLE	LOW ACCESSIBLE
THIRUVALLAM	MED ACCESSIBLE	LOW ACCESSIBLE
VAZHAMUTTOM	MED ACCESSIBLE	LOW ACCESSIBLE
KOVALAM	LOW ACCESSIBLE	LOW ACCESSIBLE

- Accessibility to population refers to the ease with which members of a community or population can access a particular service, such as a transit station or system. When evaluating the accessibility of a transit station or system, several factors need to be considered, including the station's location, the transportation modes available to reach the station, and the characteristics of the surrounding population.

- 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.
- 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.

CHAPTER 5 LITERATURE CASE STUDIES

In this chapter, the various case studies selected for the study is explained in detail. Four case studies were analyzed in detail for the study.

5.1 LAND USE AND TRANSPORT MODE CHOICES: SPACE SYNTAX ANALYSIS OF AMERICAN CITIES

5.1 .1 Background

Urban areas land use and transportation patterns are closely linked to one another since each has an impact on the other. When determining the method of transportation to use to get from point A to point B, travelers are required to compare trip times, expenses, and other factors. (Haq, 2017). This study acknowledges the underlying debate over whether choosing a mode of transportation is impacted on the basis of one's dwelling related to their place of employment or the other way around. Depending on the characteristics of the individual or household, Different people will respond to the location-transportation relationship query. For example, housing considerations like neighbourhood top class, safe, and social class may be more significant for higher-income families than factors like proximity to employment or the CBD. An essential criterion that was taken into consideration in this study was the distance between the employment centers and the residential areas. (Haq, 2017)

5.1.2 Methodology adopted

- Configurational Accessibility

Axial lines are utilized in space syntax in order to comprehend the links between the spaces that form an urban morphology.

- Configurational Centrality

The idea that a more central site is one that is closer to all other locations is the basis for the most typical and fundamental understanding of centrality. While configurational centrality is the location of fundamental integration values, urban centrality is described as a concentration of activities. It is anticipated that more movements will be drawn to these areas of higher integration values.

- Selection of case Study

Boston, Pittsburgh, Lubbock, and Salt Lake City were the four cities in America that are selected for a case study analysis to investigate if street configuration affects the choice of transportation option. The goals of this study were to explore the differences and similarities between gridded and non-gridded cities, and this informed the choice of cities. Finding two sets of US cities with roadway networks that exemplify each kind was the task at hand. The distinction between gridded and nongridded qualities, however, is not a duality. Instead, it represents a continuous property, with any settlement being able to fall anywhere along a sliding scale that ranges from a perfect grid to a perfect organic urban shape. Pittsburgh and Boston were chosen to demonstrate nongridded cities after a thorough review of maps of numerous cities; Lubbock and Salt Lake City were chosen to represent the two categorized groupings of cities through axial line linkages, clearly demonstrating that both gridded cities.

cities with fewer and longer axial lines fall on the left side of the sliding scale, whilst cities without axial lines fall on the right. A fully gridded street network results in long axial lines, which causes this pattern (i.e., once unbroken, they reach their full length.). In contrast, axial lines in a natural street layout scheme are split into several lines as the roadways get shorter and curved. (Haq, 2017)

5.1.3 Data sources

The two main sources of data for the study were United States Census survey 2010 and the websites of the relevant cities' open GIS databases. All data relevant to the socioeconomic and demographic characteristics of the census jurisdiction were compiled using the official list of the census data website. All-important data, including transportation stops, transport routes, and uses, was extracted using the unrestricted access websites of the various city GIS sources of data. (Haq, 2017)

5.1.4 Variables used in Space Syntax

Using the two simplest path distance ideas, two types of accessibility analysis, that is integration and choice using Space Syntax were calculated. Topological distance is the initial distance notion, and based on the typical number of turns a point must take to go to every other point in the city, it calculates integration and choice values. The second distance notion, called angular distance, is used to calculate integration and choice values by calculating the mean angular degrees of turn necessary to travel from one location to all other points in a city. Thus, using two accessibility measures computed using two various distance conceptions, four space syntax variables were generated.

Table 5. 1 variables used in space syntax

Source: (Haq, 2017)

	Methods	
Measures of Accessibility	**Topological**	**Angular**
Integration	Topological Integration	Angular Integration
Choice	Topological Choice	Angular Choice

5.1.5 GIS spatial analysis

The study started out with the assumption that integrated neighbourhoods draw in retail and commercial activity, which in turn attracts a sizable number of individuals to work there. These, in turn, affect where people decide to live. It is assumed the people in this study commute to work by foot or bicycle will want to live within range of their place of employment in order to shorten their travel times. As a result, although not necessarily on integrated streets, this study anticipates finding more people who walk and cycle in integrated communities. From this vantage point, the inquiry needs to be concentrated on specific city neighbourhoods rather than on roadways or axial lines. Through the overlaying and aggregating processes of spatial analysis in ArcGIS, linear features of space syntax values were transformed to block group. The relationship between the location of the axial line and the census block group is determined via GIS map overlay analysis. Block-group polygons have axial lines with integration values superimposed on them, as seen in Figure 3.1(b). This indicates on the census block group map which axial line segment corresponds to which block. Next, the average integration values of the axial line for each block group are determined and shows in Figure 3.1(b) (Haq, 2017).

(a)

(b)

Figure 5. 1 (a) Overlapping integration on block groupings, (b) Block groups' average integration

Source: (Haq, 2017)

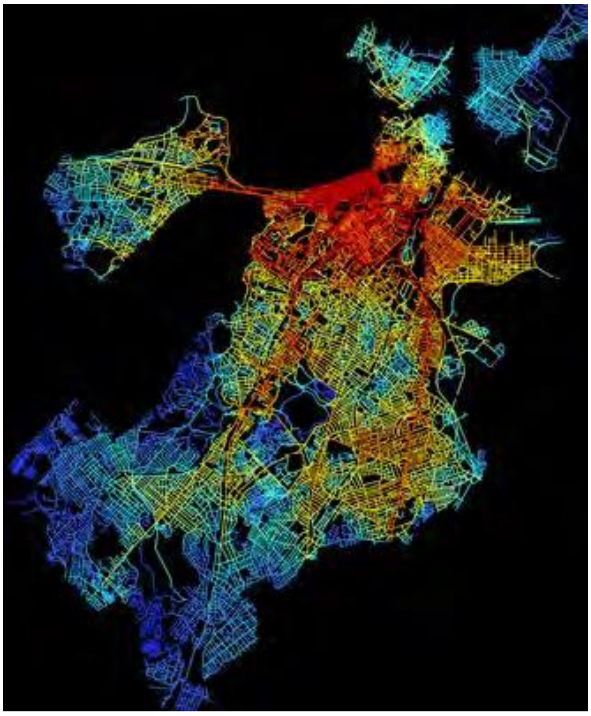

Figure 5. 2 Topological integration of Boston

Figure 5. 3 Topological Choice of Boston

Source: (Haq, 2017)

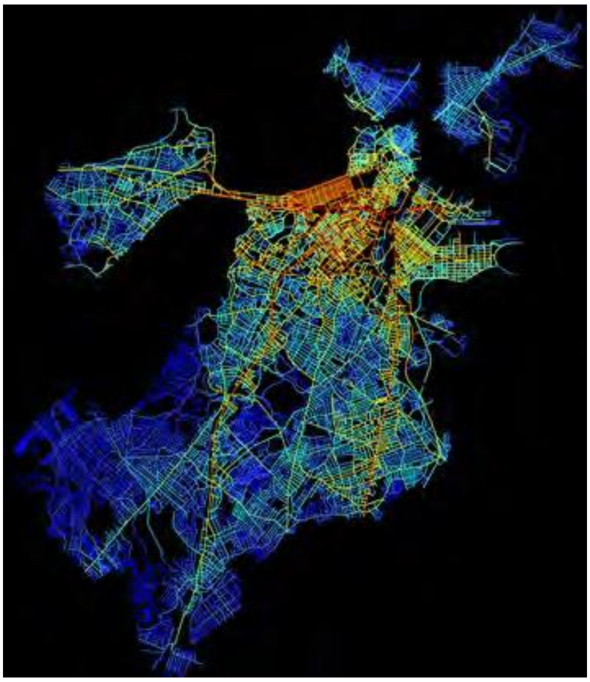

Figure 5. 4 Angular Integration

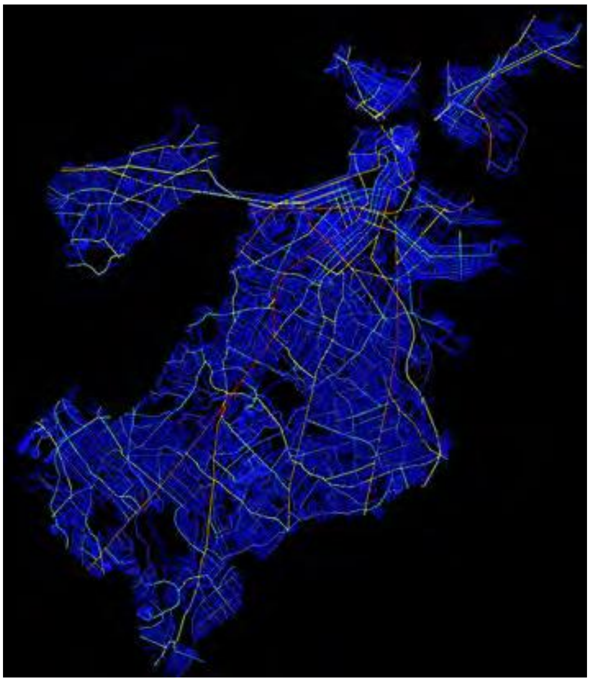

Figure 5. 5 Angular Choice of Boston

Source: (Haq, 2017)

5.1.6 Variables used

In this experimental research, which makes use of enormous lists of variables, the dynamic strength of space syntactic parameters in driving mode choice is investigated. Four dependent factors and 25 independent variables are used in the development of multiple linear regression models for transportation mode choice.

5.1.7 Statistical Analysis

Four mobility methods—driving, walking, taking public transportation, and bicycling were used in the statistical research, according to the US Census Data. Seven of the twenty-five independent variables are connected to land use, eleven are related to socioeconomic and demographic aspects, and three are transportation-related.

Table 5. 2 Showing variables used for analysis

Source: (Haq, 2017)

Dependent variables	Independent Variables	
	Land Use Variables	Transportation Variables
Driving	Population Density	Distance to PTS
Walking	Street Density	Travel Time
Bicycling	Commercial Density	Car Ownership
Public transport	Building Density	
	Age of Buildings	

5.2 THE CITY OF XANTHI, GREEK: HISTORIC EVALUATION AND URBAN CONFIGURATION

5.2.1 About Study area

The elevation of the city of Xanthi ranges from 60 to 145 meters. The relationship of the city's urban configuration process to its geophysical landscape is an intriguing aspect to consider. The historic core's form and growth were limited by the steep gradients, and its modern outlying areas were characterized by the low-lying, flat areas.

Since the Byzantine era, Xanthi has been a planned fortified settlement. It saw major development in the middle of the 16th century. The city began to grow outside of its original residential centre when it had 3,000 residents at the beginning of the 19th century. (Giannopoulou, 2012)

5.2.1 Methodology adopted

Integration is the most used space syntax methodology.

5.2.2 Data analysis and axial map production

Alasdair Turner of UCL developed the computer program DepthMap in 1998. He then donated it to the Lab of Transportation Engineering at Democritus University of Thrace (DUTH) for use in teaching and conducting research. DepthMap was used to create the axial maps of Xanthi city and conduct the space syntax method of analysis. An application for performing examination of the visibility of urban and architectural systems is called DepthMap. It may create a map of the system's "visually integrated" places from the system's plan as input. (Giannopoulou, 2012).

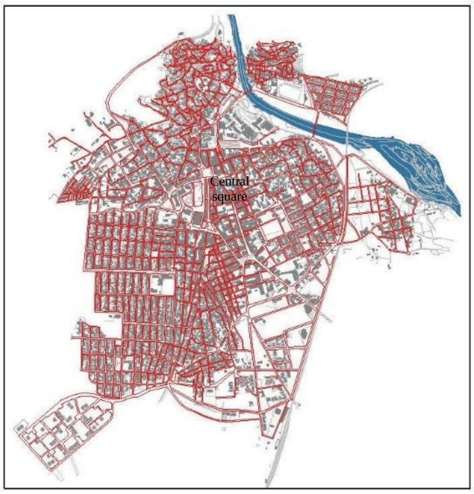

Figure 5. 6 Map of Xanthi city

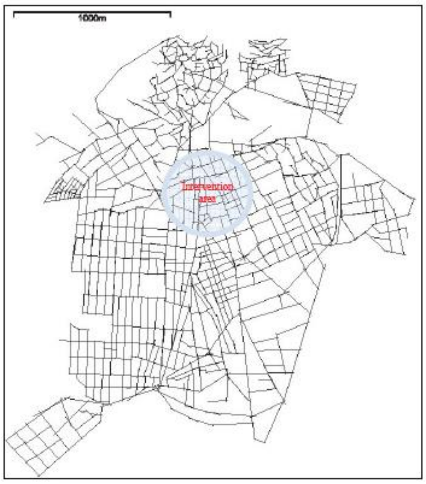

Figure 5. 7 Axial map of Xanthi city

Source: (Giannopoulou, 2012)

Based on maps of Xanthi from 1984, cartographic data was employed for the analysis. The vector data and digitalization were collected from diploma theses that were turned in to the DUTH Lab. Using CAD software, the background was altered, changed, and recreated. The creation of axial maps by DepthMap necessitates control and minimal involvement, especially for the representation of dead ends and entrances through the open space staircases in the Old Town. (Giannopoulou, 2012).

5.2.3 Global integration and integration core

The distribution of commercial land use and the streets that gather land use for recreation and amusement are the two axes on the global integration map that are most clearly shown to be interconnected. The majority of the city's busiest and principal streets may be accurately identified using this method. The findings of several prior transport studies have strengthened this and show a significant positive association between a street's integration and its ability to draw important functions. One of the exceptions is the city's main exit route, which may have been segmented into five axes as a result of the grid's changing gradient because it has low integration values.

Given that the streets around it have the highest integration values, the central square is the city's syntactic, vehicular, and functional core. Around the square, there are clusters of special uses that can be identified by contrasts, like the square of administrative offices and open spaces in the west, the crowded part of the business center in the south, the location of the flea market with specialty shops in the west, and the recreation uses and services in the north. Four compact residential districts with distinct and entirely distinct syntactic and urban qualities are indicated by the 40% of spaces with less integration (blue colour).

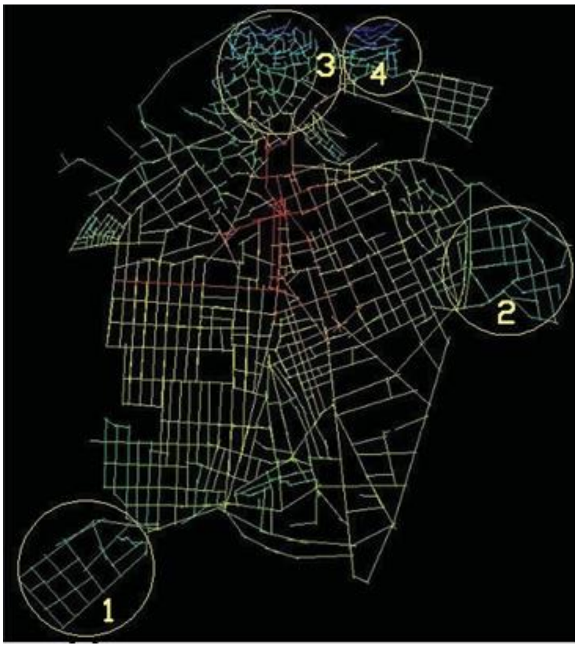

Figure 5. 6 Global integration map

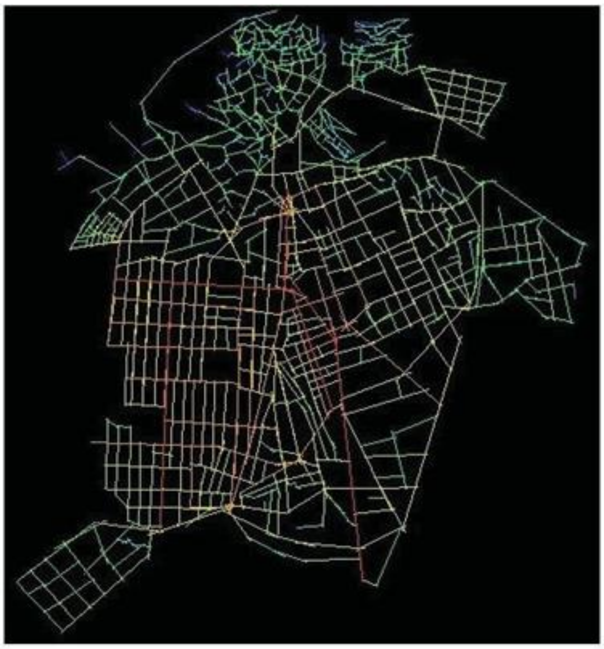

Figure 5. 7 Local integration map (radius 3)

Source: (Giannopoulou, 2012)

The city's overall axial map showing local integration (radius 3) indicates that the most integrated axes as determined by the global integration study do not necessarily coincide with the locally most integrated axes. The city's centre no longer has the highest level of integration. The major differences in the urban tissue between regions, together with the existence of axes with high connectivity and weak integration, all play a significant part in this. High local integration axis draws neighborhood-level commercial use.

5.3 SPACE SYNTAX AS A FOUNDATION FOR A TRANSPORT DEVELOPMENT STRATEGY; TORRANCE, CALIFORNIA, USA

5.3.1 About Study area

Three components are used for the mobility and transport analysis in Torrance, California, USA. Torrance is a component of an urban continuity that, at first look, seems to have low to medium populations, comparable grid systems, a dependence on cars, etc. All of this is true (to a certain level), but when census attributes are examined in greater detail, a new level of complexity emerges, exposing minute variations that characterize the multipolar urban reality of Los Angeles. (Rawad choubassi, 2018).

5.3.2 Methodology adopted

- A thorough network analysis of the city and the towns nearby was done. Through statistical correlation exercises, it makes use of current vehicular counts to comprehend the extent to which the roadway network is utilized. These were given by specialist businesses that gather extensive information about customers' demographics and travel objectives through GPS and mobile devices.
- Created a system for locating "micro-centers" and used it as a tactic to sway the proposals. At certain scales, the areas with the highest betweenness values are designated as the micro-centers.

5.3.3 Mean Depth Analysis: Reinforcing network clusters

This experiment revealed the smallest radius at which network clusters begin to form. It was conducted on a large scale and covered an area of around 500 sq km, extending from the eastern side of Long Beach to the southern edges of Los Angeles International

Airport. Old Town Torrance created a network on its own at 1.6 kilometers, resembling networks in El Segundo, Manhattan Beach, Lennox, and other places. We were able to determine the point at which the network in Old Town Torrance began to become "weaker" in comparison to other much more extended and consolidated network clusters, such as Manhattan Beach, East Compton, and a few others, by performing the same test while gradually increasing the radius. (Rawad choubassi, 2018).

5.3.4 Choice Analysis: Shifting transit modes

In order to determine which streets are a part of the shortest route between all origins and all destinations, the network choice (betweenness) was utilized. High choice scores were used to identify the streets that are naturally essential components of many journeys because they suggest a high potential for "through" movements. Because of the two cities' vastly different forms and personalities, Torrance and Milan were chosen as the comparison point in our comparative study. Because of the two cities' vastly different forms and personalities, Torrance and Milan were chosen as the comparison point in our comparative study.

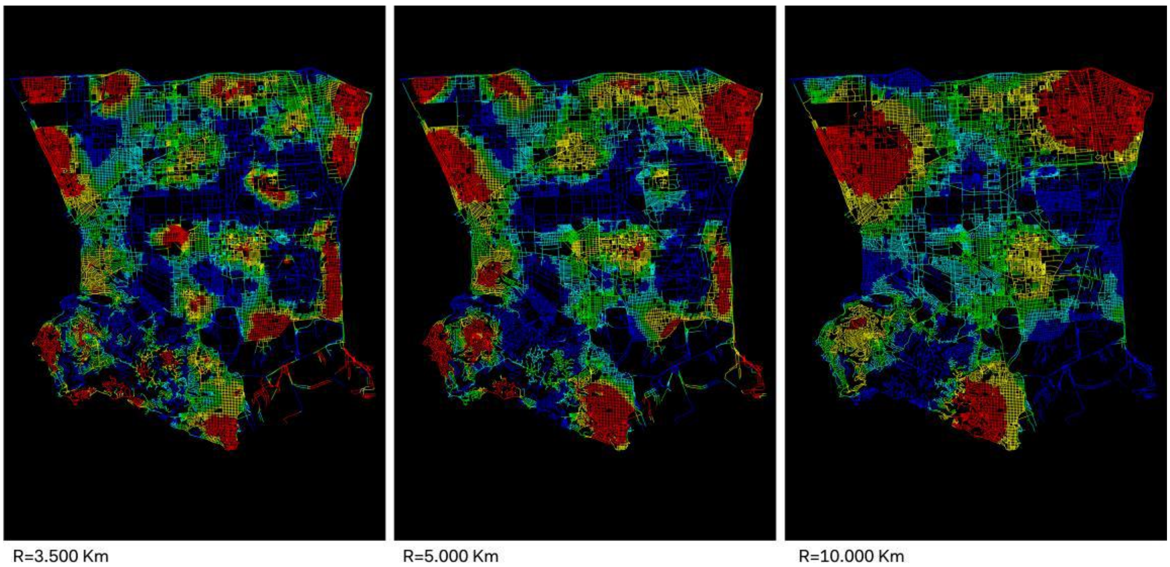

Figure 5. 8 Mean Depth Analysis at different radius

Source: (Rawad choubassi, 2018).

Figure 5. 9 Angular Global Integration

Source: (Rawad choubassi, 2018)

Applying axial analysis for two reasons while considering the morphological and spatial organization of Torrance.

1.Many streets go on in a seemingly endless straight line.

2.The study that can be used to inform decisions on a range of transportation options at various radii, from short-range pedestrian interactions to medium-range bicycle movements to long-range vehicle movements. (Rawad choubassi, 2018)

5.4 PLANNING FOR ACCESSIBLE JOBS: THE CASE OF BANGALORE METROPOLITAN AREA, INDIA

5.4.1 Aim

To explore spatial work accessibility in the Bangalore Metropolitan Area using an accessibility measuring technique.

5.4.2 Objective

In order to develop a perfect spatial organization of occupations and employment in the study location, one must first comprehend the job accessibility in an integrated GIS system.

- To evaluate the occupations' accessibility in relation to the new public transport infrastructure, including the bus, metro, and sub-urban railway.
- The following subject of conversation will be how to best distribute the city's employment zones spatially.

5.4.3 Methodology

The primary data sources are Bangalore's statutory master plan, the city's public transport system, specifically the bus, tube, and suburban rail systems. On an integrated GIS platform, spatial data in vector form has been evaluated.

Using information on population density, land use, and transit stations, a secondary study has been conducted to determine suitable job locations in the city that would be highly accessible (ghosh, 2019).

The findings are displayed as choropleth map outputs that highlight the locations with high and low potential.

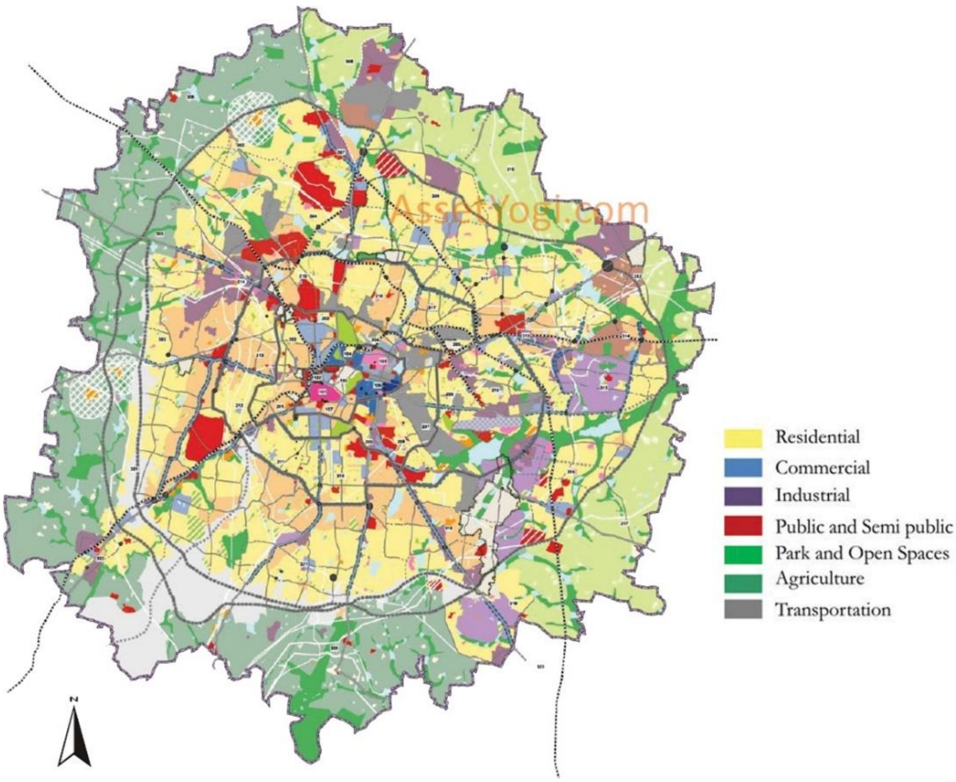

Figure 5. 10 Proposed land-use map of the BMA

Source: CDP Bangalore masterplan ,2015

5.4.4 Public transport network:

- The Bangalore Metropolitan Transport Corporation (BMTC), Bangalore Metro Rail Corporation Ltd. (BMRCL), and Indian Railways are responsible for operating the bus system, the metro rail, and the suburban railway, respectively, in the BMA.
- The regional rail network of Bangalore, which has been envisaged as a contemporary high-speed rail network connecting Bangalore city to the broader Bangalore region through at ground and elevated sections, includes the suburban railway system.

Figure 5. 11 Bus stop and metro network map of Bangalore.

Source: Gargi Ghosh ,2019

5.4.5 Existing scenario of job accessibility

- An integrated GIS environment has been used to analyze the job accessibility utilizing analytical operators on vector data sets for land use and transportation.
- Bangalore's current job density is calculated as a result of the proportion of commercial and industrial land use per grid. A job density gradient map has been used to display the analysis' results.

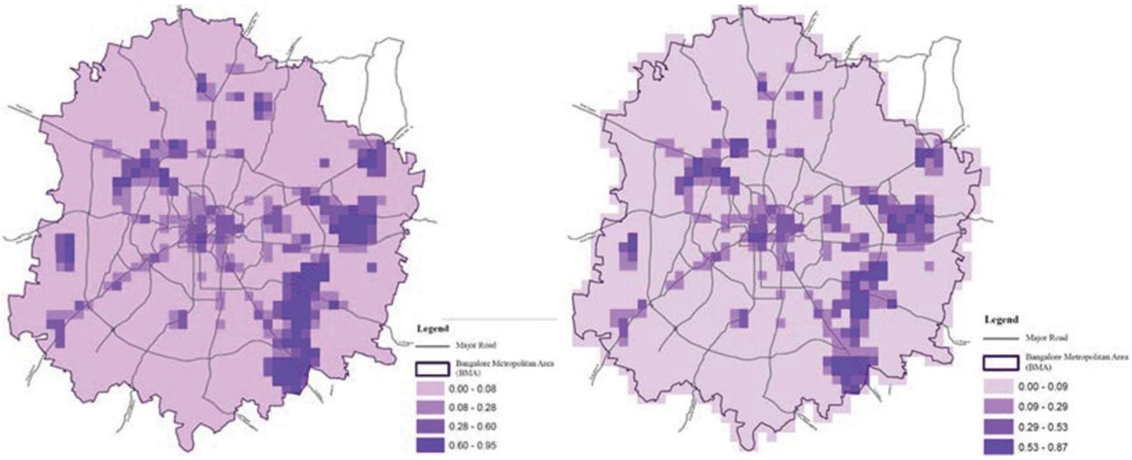

Figure 5. 12 Density gradient of job distribution in BMA

Source: Gargi Ghosh ,2019

5.4.6 Observations

- The positions are most easily accessible by bus, then by metro train, and finally by suburban railway.
- It appears that a sizable portion of occupations are not reachable by public transport. Jobs along the southern arc seem to be the hardest to get to via public transport. Both the south western road corridor and the city center's employment opportunities appear to be less accessible.

5.4.7 Potential areas of job distribution for public transport Accessibility

- To identify high potential places for future work location, a spatial analysis using datasets on job density, station location, and population density was conducted in a GIS environment. Transit station-containing grids have been regarded as having good transport accessibility.
- Low population density grids are seen to have a larger potential for work densification. High transit accessibility grids and low population density grids have been superimposed on the current low job density grids to create grids with high potential.

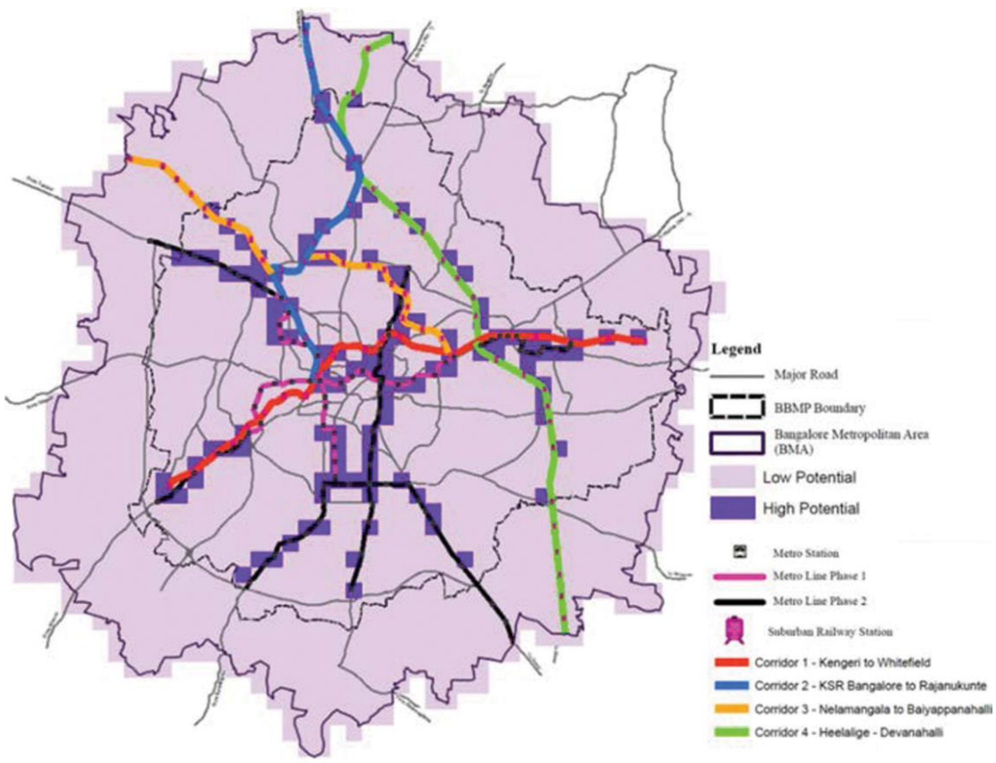

Figure 5. 13 Potential locations for future job location.

Source: Gargi Ghosh ,2019

- According to the analysis, a widening of the North West arc, a new northeast arc, and a corridor expansion in the south-west Kanakapura road are the best places to live and work in order to have easy access to jobs.

5.5 Inference

- A constructed environment's space syntax quantifies the relationships between each public space and each street segment. On the one hand, space syntax quantifies how close or capable of mobility each street segment is to the others. On the other hand, space syntax quantifies the betweenness, or capacity for through-movement, of every roadway segment in relation to every other.

- Space syntax models have been used in transportation planning to examine pedestrian, bicycle, and vehicle movement networks simultaneously. Each street's direct links to other streets in its surrounding area are taken into consideration by connectivity, a static local assessment.
- Using integration analysis, each street network's recommended shortest path between two points is determined. The space syntax can be applied as a quantitative technique to determine accessibility and connectedness between two points or locations.
- Understanding accessibility provides a clear picture of the state of the transport system today. Accessibility indices enable decision-makers to target investments more efficiently for certain goals, such enhancing accessibility to important employment centers. Individual homes and enterprises might utilize accessibility measures as a quality-of-life metric when deciding where to relocate. It may serve as a cost-of-living index for land usage and transportation.

CHAPTER 6 PLANNING STRATEGIES AND PROPOSALS

In this chapter, recommending planning interventions to the selected bus stations in the study area based on the analysis and characteristic of each station.

ACCESS TO POPULATION	ACCESS TO ACTIVITIES	PLANNING STRATEGIES	NAME OF BUS STOPS
HIGH ACCESSIBILITY	**MEDIUM/ LOW ACCESSIBILITY**	1. Areas with high population but medium or low accessibility can benefit from improved public transportation services. Increase the frequency of public transportation services and expand coverage to areas that currently lack service. 2. Encouraging mixed-use development, where residential, commercial, and other uses are integrated into a single area, can help reduce trip lengths and increase accessibility to activity locations. 3. Encourage transit-oriented development around transit stations and hubs. This will create compact, walkable communities where residents can easily access public transportation and other amenities. 4. Carpooling and ride-sharing initiatives can be implemented to encourage residents to share rides to their destinations. This approach can help to reduce traffic congestion while also providing residents with a cost-effective transportation option. 5. Housing and transportation planning should also take into account future growth in the area. This can involve zoning changes, infrastructure improvements, and other measures to accommodate new residents and businesses. 6. Provide zones for street vendors in areas with high population but low accessibility, providing them with a safe, regulated, and economically viable environment to conduct their businesses.	**Kazhakoottam, Eanchakkal**
MEDIUM ACCESSIBILITY	**MEDIUM/ LOW ACCESSIBILITY**	1. Develop mixed-use buildings that combine residential, commercial, and office spaces. This approach will enable residents to live and work in the same area, reducing their trip lengths. 2. Develop a public transportation system that links the area with other parts of the city providing residents with access to jobs, schools, and other activities.	**Anayara,World market, Chackai,GK junction,Paruthikuzhi,Thiruvallam,Vazhamuttom**
LOW ACCESSIBILITY	**MEDIUM/ LOW ACCESSIBILITY**	1. Encourage compact development as well as active transportation modes such as walking and cycling. This could be achieved by constructing sidewalks, crosswalks, bike lanes, and bike racks. 2. Demand-Responsive Transit (DRT) services can be an effective transportation solution for low population areas with scattered demand. DRT services are flexible and can be customized according to the demand patterns, which can help improve accessibility to essential services and activities. 3. Low-population areas often lack affordable housing options, which can prevent residents from living close to the activities they need. By developing affordable housing, such areas can attract new residents and create a more diverse, inclusive community.	**Infosys bus stop ,Attinkuzhi,Technopark bus stop,MGM School,**
LOW ACCESSIBILITY	**LOW ACCESSIBILITY**	1. Encourage the development of affordable housing options to attract new residents and increase the population in the area. 2. Provide incentives for developers to build mixed-use developments that combine residential and commercial spaces to increase accessibility to goods and services. Mixed-use development, which combines residential, commercial, and retail spaces in the same area, can help create a more self-sufficient community. This can reduce the need for long-distance travel, as residents can access essential services within their neighborhood. 3. Establish public transportation options such as bus routes and mini-bus services to increase accessibility to areas with limited transportation options. 4. Establish a local shuttle service to connect the area with nearby cities or towns.	**Kovalam,Kuzhivila**

6.1 AIM

To prepare transportation planning policies and strategies for the bus stations in the study corridor based on the measure of accessibility and connectivity.

6.2 GOAL

- To Improve public transportation services and expand coverage.
- To Encourage transit-oriented development around transit stations and hubs.
- Encouraging mixed-use development to reduce trip lengths and increase accessibility to activity locations.

6.3 CATEGORY 1: STATION WITH HIGH POPULATION ACCESSIBILITY AND MEDIUM/LOW ACCESSIBILITY TO ACTIVITIES

6.3.1 Proposal 1

- Encourage transit-oriented development around transit stations and hubs. This will create compact, walkable communities where residents can easily access public transportation and other amenities.
- Kazhakoottam, Eanchakkal and Technopark phase 3 acts as a main metro rail station from the proposed Metro rail network map of Thiruvananthapuram. (Proposed Masterplan 2030, DTPO Thiruvananthapuram,2023)
- Areas with high population but medium or low accessibility to activities can benefit from improved public transportation services. Increase the frequency of public transportation services and expand coverage to areas that currently lack service.

Figure 6. 1 Map showing Thiruvananthapuram metro rail network

Source: DTPO Thiruvananthapuram ,2023

6.3.2 Proposal 2

- Improve bus or public transport services through Kazhakoottam - Menamkulam road, Kazhakoottam -Kumizhikara road.

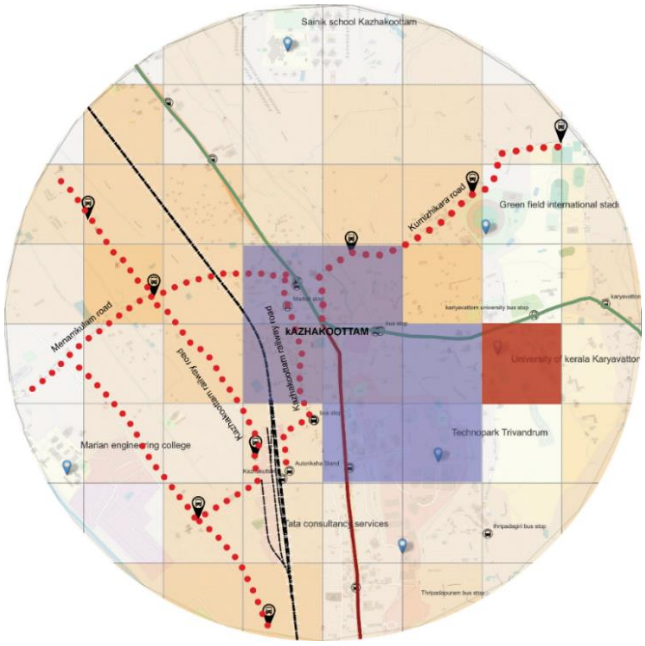

Figure 6. 2 Map showing Proposed bus routes

Source: Author generated ,2023

6.3.3 Proposal 3

- Carpooling and ride-sharing initiatives can be implemented to encourage residents to share rides to their destinations. This approach can help to reduce traffic congestion while also providing residents with a cost-effective transportation option.
- It can be effectively utilized along the IT corridor, particularly from the transit nodes in Kazhakoottam, the railway stations, and Eanchakkal junctions where there is a higher volume of passenger alighting.
- Potential participants are working in the IT sector in Technopark, UST global, TCS Trivandrum, Lulu mall etc.
- Establish communication channels, where participants can connect and coordinate. This could be a dedicated group chat, an email distribution list, or a carpooling app or website that facilitates ride matching and scheduling.

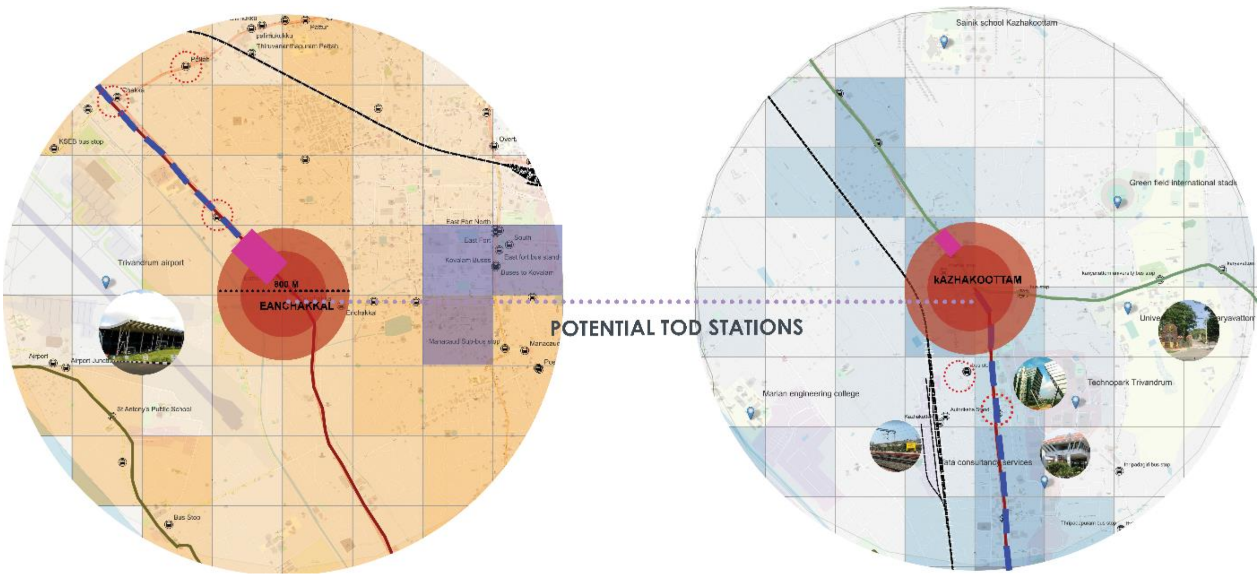

Figure 6. 3 Map showing Potential TOD bus routes

Source: Author generated,2023

6.3.4 Proposal 4

- Encouraging mixed-use development, where residential, commercial, and other uses are integrated into a single area, can help reduce trip lengths and increase accessibility to activity locations.
- Mixed-use developments often prioritize walkability by creating pedestrian-friendly environments. This includes designing wide sidewalks, crosswalks, and pedestrian plazas, as well as ensuring appropriate lighting, landscaping, and amenities.

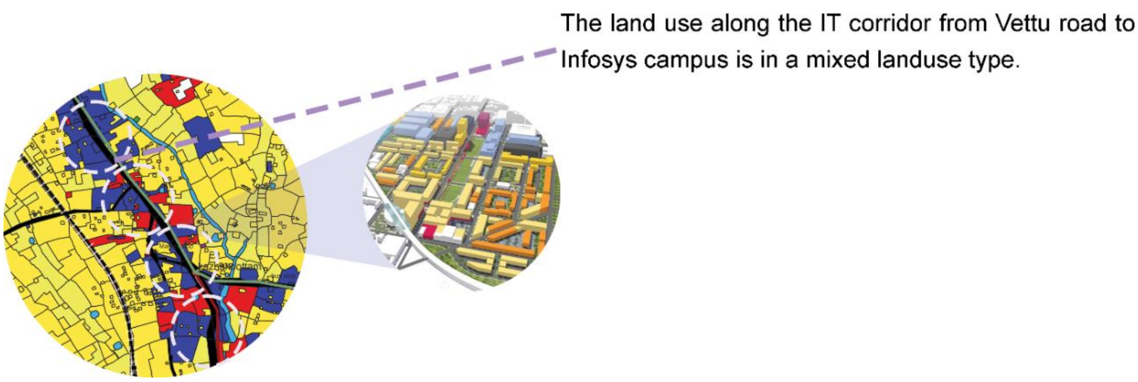

Figure 6. 4 Map showing Mixed use development zone

Source: Author generated ,2023

6.3.5 Proposal 5

- Housing and transportation planning should also consider future growth in the area. This can involve zoning changes, infrastructure improvements, and other measures to accommodate new residents and businesses.
- Zoning helps ensure that land is developed in an orderly and planned manner. It establishes guidelines and regulations for different land uses, which allows for organized growth and development within the area.

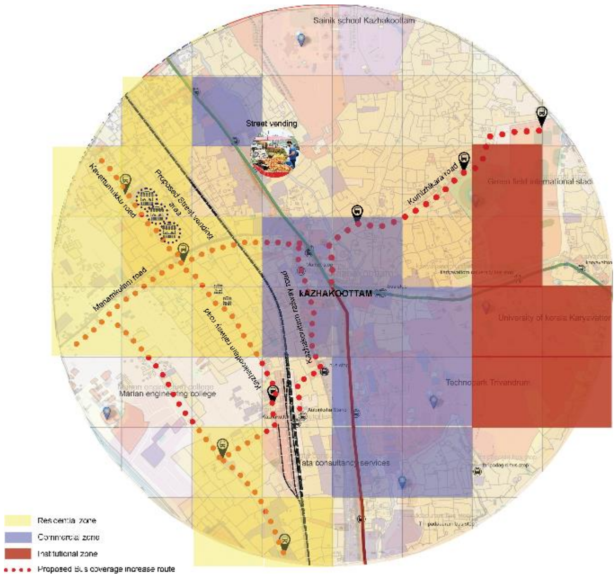

Figure 6. 5 Map showing Land use zoning

Source: Author generated using ,2023

6.3.6 Proposal 6

- Provide zones for street vendors in areas with high population but low accessibility, providing them with a safe, regulated, and economically viable environment to conduct their businesses.
- Proposing street vending area along the Kavattumukk junction road from the Menamkulam road.
- The vending zone is 300 m aligned along the Kavattumukk junction road which is a high residential zone.
- Street vending zones create employment opportunities for local entrepreneurs and vendors. It allows individuals to start their small businesses and generate income, thereby contributing to the local economy.
- This can be particularly beneficial for marginalized groups or individuals with limited access to traditional employment opportunities.

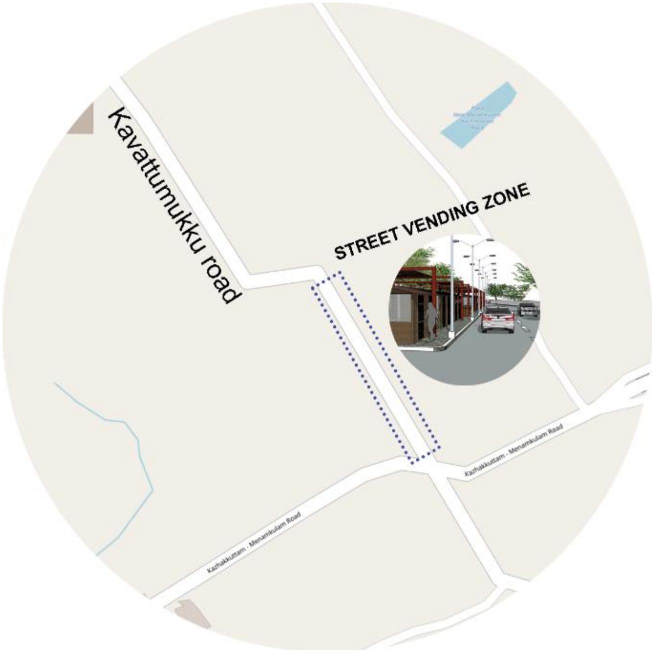

Figure 6. 6 Map showing Proposed Street vending zone

Source: Author generated ,2023

6.4 CATEGORY 2: STATION WITH LOW POPULATION ACCESSIBILITY AND MEDIUM/LOW ACCESSIBILITY TO ACTIVITIES

6.4.1 Proposal 1

- Encouraging active transportation modes such as walking and cycling. This could be achieved by constructing sidewalks, crosswalks, bike lanes, and bike racks.
- Proposing segregated bicycle track and footpath along the Kazhakoottam and MGM school junction.

Figure 6. 7 Map showing proposed bicycle track

Source: Author generated ,2023

- Kazhakoottam to MGM school junction is a high activity centre during peak hours. The proximity of IT based industries, Schools, retail, and commercial centers attracts heavy traffic movements in these areas.
- By promoting cycling, a bicycle lane can help alleviate traffic congestion on the road. As more people opt for bicycles instead of cars for short trips or commuting, it can reduce the number of vehicles on the road, easing traffic flow and improving overall transportation efficiency.
- Provided segregated cycle track and footpath with tree act as a natural separator between the tracks and provided both on same level to reduce the usage of concrete. Also provided plant buffers to reduce the encroachment and considering environmentally sound NMT.

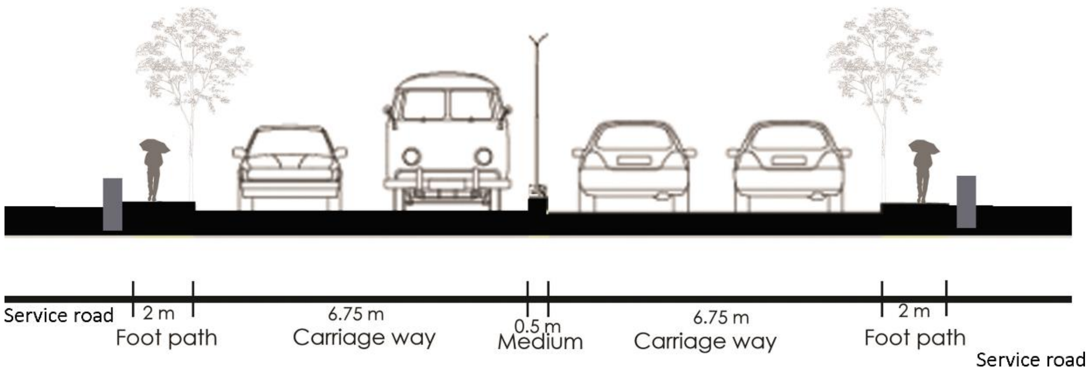

Figure 6. 8 Existing 45 m wide road section

Source: Author generated ,2023

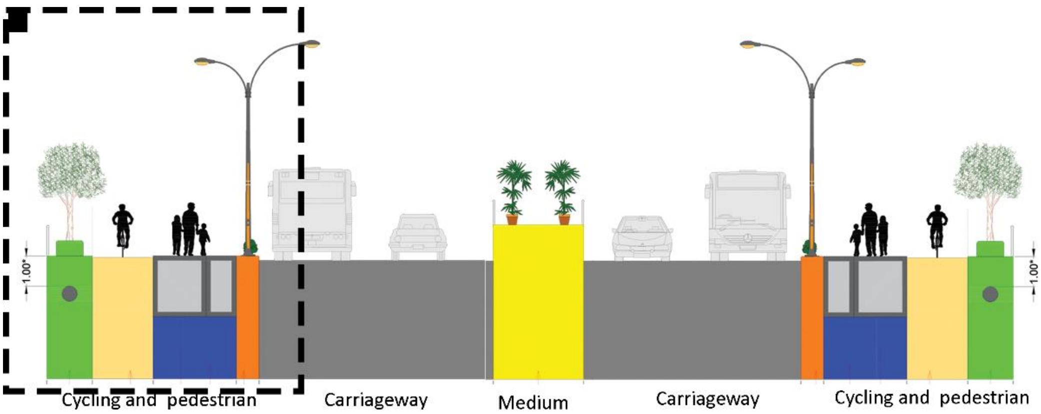

Figure 6. 9 Proposed 45 m wide road section

Source: Author generated ,2023

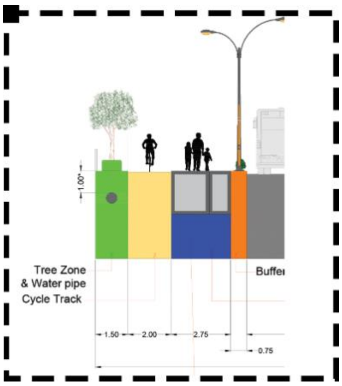

Figure 6. 10 Detailing of NMT facility

Source: Author generated,2023

Figure 6. 11 Cycle Lane and footpath

Source: Google images,2023

6.4.2 Proposal 2

- Implementing Demand-responsive transit (DRT) services connecting high residential area near Kazhakoottam railway station and the high activity centers along the study corridor like,
- Demand-Responsive Transit (DRT) services can be an effective transportation solution for low population areas with scattered demand. DRT services are flexible and can be customized according to the demand patterns, which can help improve accessibility to essential services and activities.
  Infosys, Techno Park, UST global, Lulu mall etc.
- Dhanya nagar, Menamkulam are residential area which have limited access to public transportation services.

- Demand-responsive transit (DRT) refers to a transportation system that adapts its routes and schedules based on passenger demand. It aims to provide more efficient, flexible, and personalized transportation options to meet the diverse needs of individuals and communities.

Figure 6. 12 Map showing DRT proposal

Source: Author generated,2023

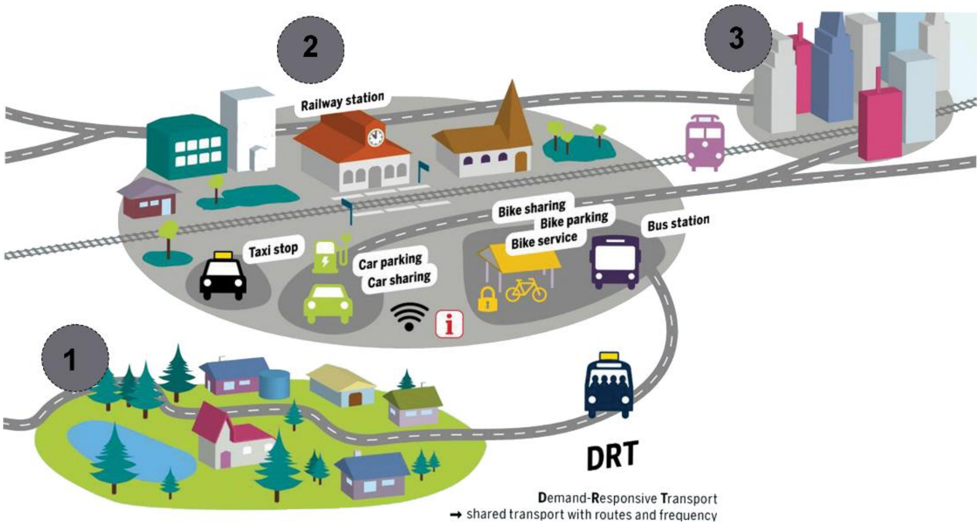

Figure 6. 13 DRT

Source: (Public and Intermodal Transport: Unite Rural and Urban Areas - European Union, n.d.)

DRT can play a vital role in providing last-mile connections to complement existing transit networks. It can fill the gap between major transit stations or hubs and final destinations, such as employment centres, residential areas, educational institutions, or healthcare facilities.

6.5 CATEGORY 3: STATION WITH LOW POPULATION ACCESSIBILITY AND LOW ACCESSIBILITY TO ACTIVITIES

6.5.1 Proposal 1

- Providing Affordable housing integrating Punargeham rehabilitation project.
- Encourage the development of affordable housing options to attract new residents and increase the population in the area.
- Provide incentives for developers to build mixed-use developments that combine residential and commercial spaces to increase accessibility to goods and services.

- Mixed-use development, which combines residential, commercial, and retail spaces in the same area, can help create a more self-sufficient community. This can reduce the need for long-distance travel, as residents can access essential services within their neighbourhood.
- Establish public transportation options such as bus routes and mini-bus services to increase accessibility to areas with limited transportation options.
- Establish a local shuttle service to connect the area with nearby cities or towns.
- The project is to rehabilitate all the families living within 50 meters from the high tide line in a safe area by preparing a house and rehabilitating them in a safe area.

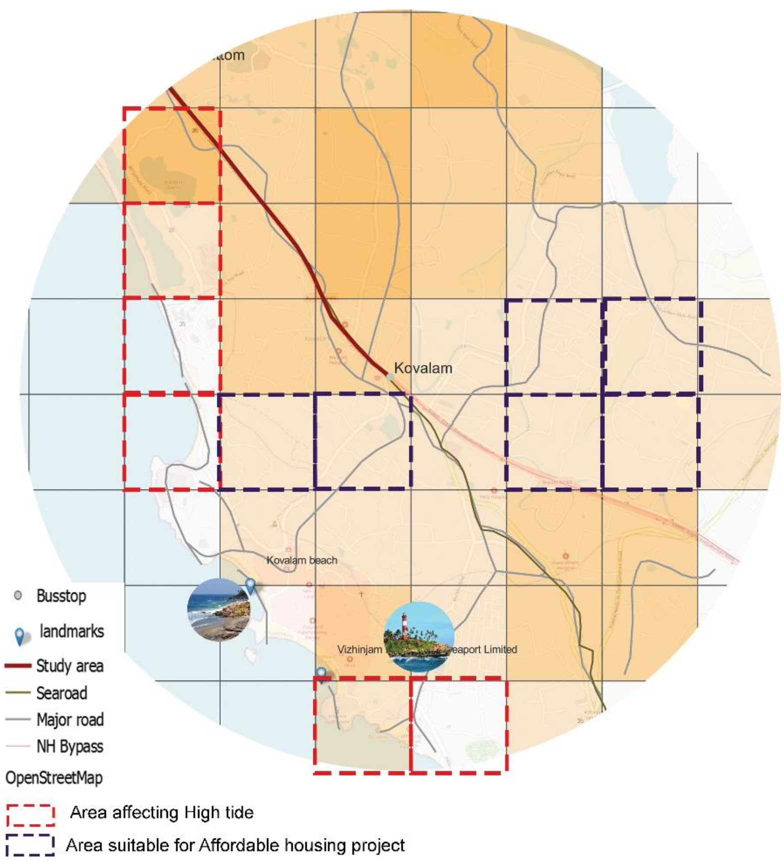

Figure 6. 14 Map showing Site analysis for affordable housing

Source: Author generated,2023

Punargeham rehabilitation project

- The Fisheries Department is going forward with the Punargeham rehabilitation project to fulfil the dream of 423 families living in the coastal areas.

- The project aims to rehabilitate fishermen families living within 50 m of the tidal area by providing them with houses.
- The construction of 134 rehabilitated houses is progressing rapidly, 15 families have already been provided their own houses and the construction of 274 units will begin soon in the Thiruvananthapuram district.

Figure 6. 15 Punargeham project, Thiruvananthapuram

- Create communal areas such as parks, playgrounds, or open green spaces where residents can gather, relax, and engage in recreational activities.
- Ensure that the housing project has good connectivity to public transportation. This facilitates commuting and access to other parts of the city or region.
- Location: 2.5 KM away from the Kovalam Junction
- Road: Kovalam beach road
- Housing for fishermen ensures access to safe and decent living conditions. It provides them with a dedicated place to reside, offering protection from adverse weather conditions, natural disasters, and other risks associated with living in temporary or informal dwellings.
- Providing housing improves the overall quality of life for fishermen and their families. It offers stability, privacy, and a sense of belonging, contributing to their well-being and mental health. Having a comfortable and secure home environment can positively impact their productivity and satisfaction in their work.

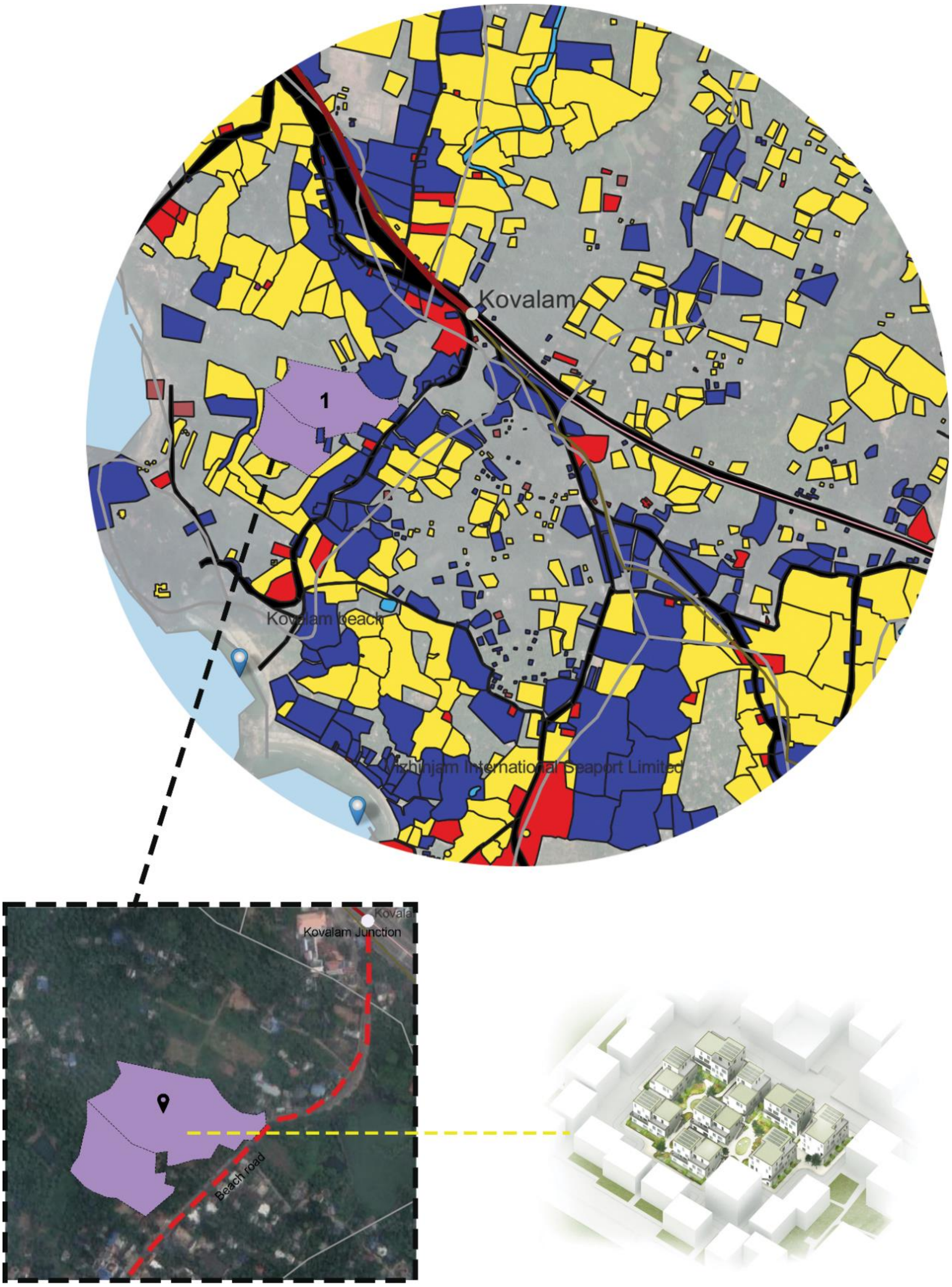

Figure 6. 16 Land use map of the site area

Source: Author generated,2023

- 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.

6.6 CATEGORY 4: STATION WITH MEDIUM POPULATION ACCESSIBILITY AND MEDIUM ACCESSIBILITY TO ACTIVITIES

6.6.1 Proposal 1

- To provide housing for Employees and migrant workers.
- Reform industrial housing polices like to provide the "The residential dwellings in Industrial zone for industrial workers having maximum built up area up to 50 sq.mts per dwelling unit up to a maximum of 20% of the total utilized FSI of the plot area or subject to the relevant regulations. Making this policy mandatory helps the industrial workers to get accommodation near their work places.

- To enable Industrial Rental Housing, Hostels or dormitories and cottages for working class focusing on low earning employees.
- To promote need based Rental Housing for specific target groups such as migrant labourers, who have the capacity to pay only up to a certain amount of monthly rent.
- To encourage employers to Rent-to-Own facilities to their employees.

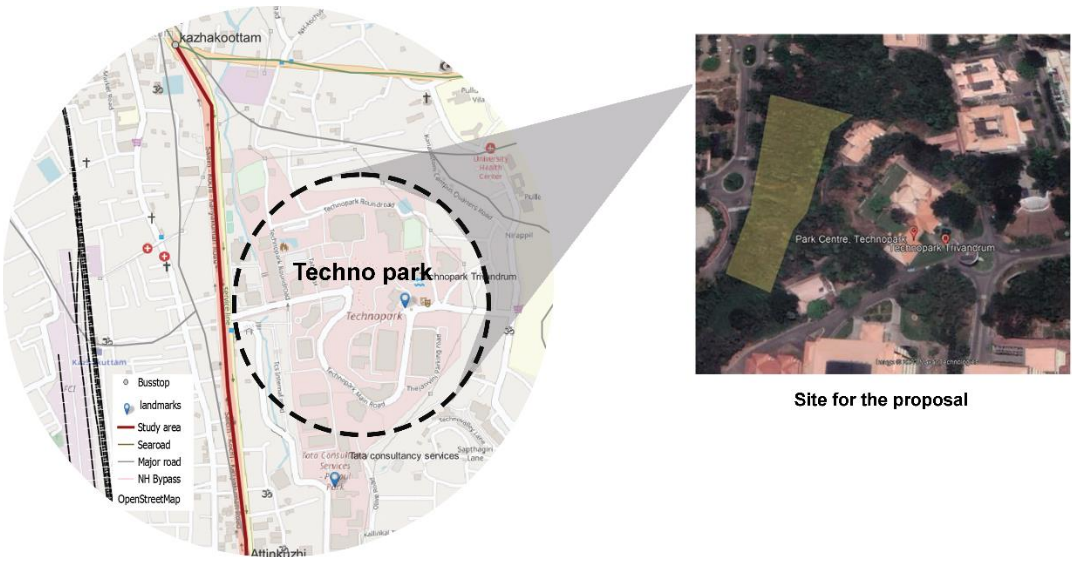

Figure 6. 17 Map showing site location

Source: Author generated,2023

- Parking Facilities:

  Determine the type and capacity of parking facilities needed to accommodate the residents' vehicles. This may include surface parking lots, structured parking, or a combination of both.
- Land selected for affordable housing is 2 ha within Technopark campus.
- By providing accommodation facilities near Technopark helps the employees from different places to have a safe shelter.

CHAPTER 7 CONCLUSION

The project 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 livability 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, livable, and well-connected urban areas that effectively serve the needs of their inhabitants.

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