PLANNING FOR TRANSIT ORIENTED DEVELOPMENT AROUND TRANSIT NODES IN THIRUVANANTHAPURAM CITY

THESIS REPORT

Submitted by

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M. Plan (2021-2023) BATCH

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in

Urban Planning

DEPARTMENT OF ARCHITECTURE

THANGAL KUNJU MUSALIAR COLLEGE OF ENGINEERING

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June 2023

DECLARATION

I hereby declare that the Project entitled **" PLANNING FOR TRANSIT OREINTED DEVELOPMENT AROUND TRANIST NODES IN THIRUVANANTHAPURAM CITY"** is a bonafide record of mine carried out under the supervision of **Prof. Josin baby Mathew,** Assistant Professor, Department of Architecture. I declare that the work reported herein does not form any part of any other thesis project or dissertation work on the basis of 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 **"PLANNING FOR TRANSIT OREINTED DEVELOPMENT AROUND TRANIST NODES IN THIRUVANANTHAPURAM CITY"** submitted by **Josy Job** (TKM21MUP011) 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.

THESIS GUIDE	**HEAD OF THE DEPARTMENT**
Prof. Josin Baby Mathew	**Dr. Annie John**

INTERNAL EXAMINER	**EXTERNAL EXAMINER**

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ABSTRACT

The car centric development has become the heart of urban planning, yet although a city is being designed for humans, the road network seldom provide individuals without automobiles any decent space. Numerous transportation problems have been caused by rapid urbanisation and rising economic growth. Private car usage and growth have increased at a never-before-seen rate, causing significant traffic congestion, high accident rates, air pollution, and greenhouse gas emissions.

Initiatives like MRTS and BRTS in growing cities show that traffic problems in the city aren't always fixable. To combat the rising demand for traffic, the government has started transit-oriented development. A stronger vision of a future Transit rich cities has to be taken into consideration since car centric development cannot alleviate the strain on infrastructure.

The idea that TOD is constructed around already-existing transit stations has gained widespread acceptance via several studies. To attain more transportation options within easy walking distance. Consequently, we may create communities that are sustainable and raise living standards.

Mobility is hampered by the transit corridor's unchecked urbanisation, which makes Thiruvanathapuram city overcrowded and its centre districts congested with traffic. Additionally, it limits the scope for scientifically improving roads. In order to handle numerous urban challenges including traffic congestion and environmental difficulties, a TOD plan is now urgently needed.

The research looks at the problems with urban settlement patterns, methods for designing transportation systems effectively, and the viability of transit-oriented development in Trivandrum. The research focuses on ways to create a Transit oriented development within the context of Thiruvanathapuram city and offers a strategic framework using characteristics derived from related topics.

Keywords: Transit nodes, Mobility, Transit Oriented Development

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ABBREVATIONS

Ahmedabad Municipal Transport Service (AMTS)

Bus rapid transit system (BRTS)

Mass rapid transit system (MRTS)

Ministry of Urban Development (MoUD)

Non-Motorised Vehicles (NMV)

Non –Motorised transport(NMT)

The National Urban Transportation Policy (NUTP)

Transit oriented development (TOD)

Transit oriented zone (TOZ)

Urban and Regional Development Plans Formulation and Implementation Guidelines (URDPFI)

World Health Organization advises (WHO)

CHAPTER 1 INTRODUCTION

The background and need for the study are explained in this chapter. This chapter also covers the study's aim and objectives. It also includes the methodology used for the study, its scope, and its limitations.

1.1 Background study

In 2022, the two most populous regions were both in Asia: Eastern and South-Eastern Asia with 2.3 billion people (29 percent of the global population) and Central and Southern Asia with 2.1 billion (26 percent). These two Asian regions were the most populous in the world (26 percent). With 1.4 billion inhabitants both, China and India made up the majority of the population in these two areas. In 2023, India is anticipated to overtake China as the world's most populated nation (World Population Prospects , 2022).

Urbanization is the key to India's future. Our cities occupy just 3% of the nation's land, but their contribution to the GDP is a whopping 60%. India is swiftly moving forward to becoming half urban in a couple of decades. Cities are like living organisms for them to flourish, their economic and social infrastructure must be in a sound state. We must rethink, reimagine and re-establish the very purpose and approach towards the planning of cities and towns in India (NITI Aayog - Reforms in urban planning capacity in India, 2021).

Transit-oriented development means integrated urban places designed to bring people, activities, buildings, and public space together, with easy walking and cycling connection between them and near-excellent transit service to the rest of the city. It means inclusive access for all to local and citywide opportunities and resources by the most efficient and healthful combination of mobility modes, at the lowest financial and environmental cost, and with the highest resilience to disruptive events. Inclusive TOD is a necessary foundation for long-term sustainability, equity, shared prosperity, and civil peace in cities (ITDP, 2022). National TOD policy, encourage TOD in cities, especially those with upcoming mass transit systems (Ministry of Housing and Urban Affairs, 2022). For cities

to be sustainable, equitable, and to have shared prosperity and civic peace, inclusive transit-rich centres are a must. It is vital that urban sprawl throughout the world.

With regard to quickly expanding and crowded towns, **transit-rich centres** have attracted attention. Urbanization has led to horizontal growth of the cities thus creating problems of urban sprawl. This has resulted in increase of trip lengths and higher usage of private vehicles, problems of pollution and increased demand of infrastructure. To address these issues, many cities have strengthened their public transport by developing mass rapid transit systems (MRTS) such as metro rails and Bus Rapid Transit Systems (BRTS). It is however, important to efficiently use these systems by integrating the land use with the transport infrastructure to make the cities liveable, healthy and smart (National Transit Oriented Development, 2022). Transit oriented development has been implemented in many cities and in most contexts it implementation and success rate is limited by the over dependency in private mode of transportation. Thus car free mobility planning is vital for an inclusive transit oriented development.

By fostering the creation of dense, walk able communities that significantly reduce the need for transportation and energy consumption, transit-oriented development is also a significant answer to the urgent and expanding issues of climate change and global energy security.

This study is particularly focussing on the Transit oriented development of Thiruvanathapuram.

1.2 Need for study

1. Transit systems like metro rail, BRTS, and others are being proposed to meet the rising demand for transport, as Trivandrum city is expand quickly and aiming at a decentralized planning. Hence, having TOD implement along with mass transportation networks has become a must.
2. Improve road safety by expanding public transportation and ensuring that everyone has access to safe, affordable, accessible, and sustainable transportation systems. Pay particular attention to Trivandrum smart city initiative.

3. The majority of people do not use public transportation due to the lack of accessibility and availability. So expanding public transportation, accessibility planning is urgently needed to meet the needs of increasing daily commuters traffic, it is possible to achieve both increased density and enhanced connections with TOD development.

1.3 Research question

What are the main indicators to measure the TOD around the transit nodes which can be accommodated in GIS model for guiding Transit oriented development?

1.4 Aim

To develop **transit oriented development around transit nodes in Thiruvananthapuram city**

1.5 Objectives

1. To identify **indicators for measuring the TOD around the transit nodes**
2. To identify **optimal nodes for transit oriented development**
3. To develop **GIS based model for quantifying the TOD indicators**
4. To identify **aspects which need to be improved around the transit nodes** for **Transit oriented development**

1.6 Methodology

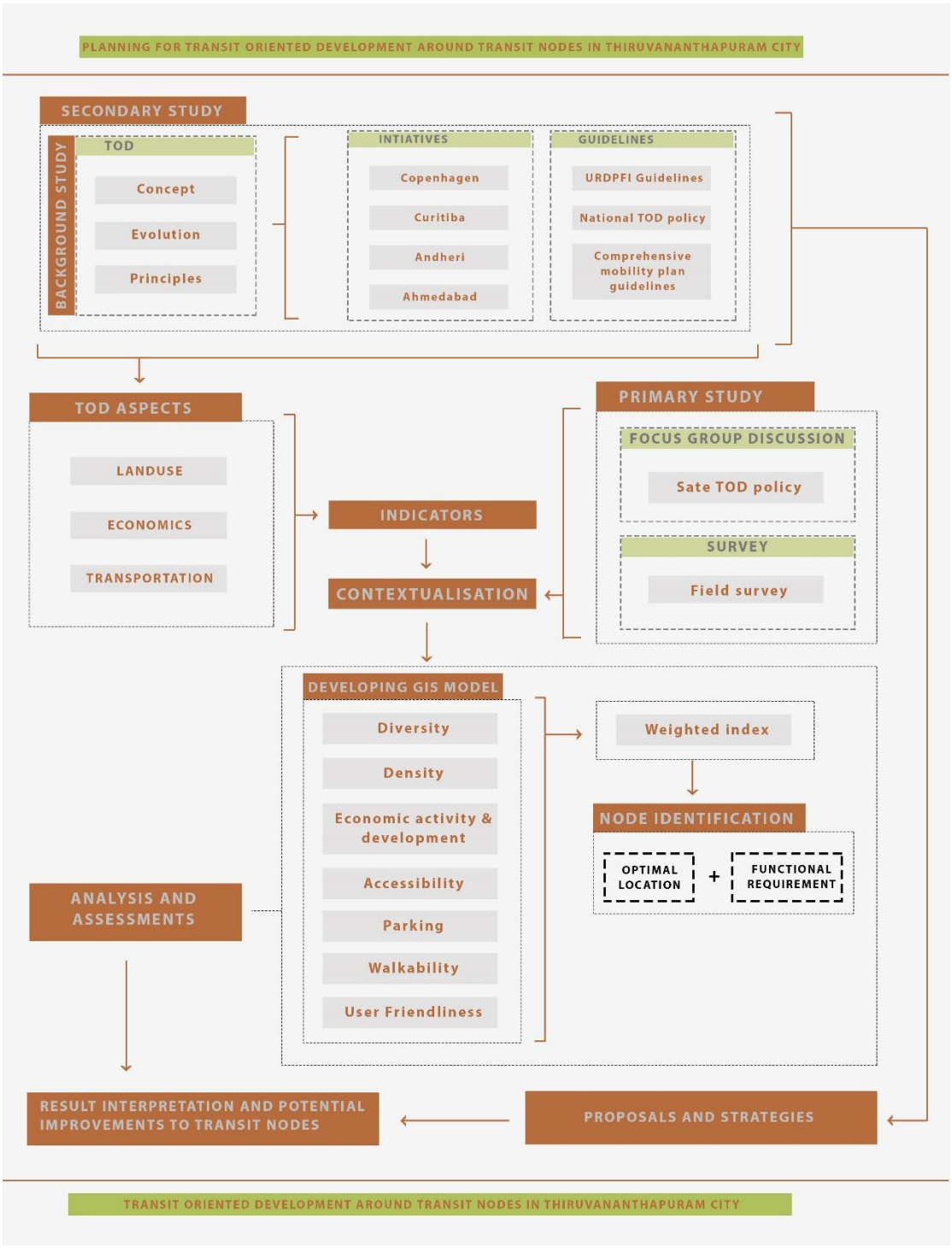


Figure 1.1 Methodology

Source : Author Generated, 2022

1.6 Scope

1. The study provides decision-makers with the core resources they require to launch a state TOD policy in Trivandrum city.

2. Planning infrastructure that is user-friendly for pedestrians and non-motorized transportation (NMT), car free mobility planning increases the accessibility of transit stations. This boosts usage at the facility and enhances the system's economic and financial sustainability of Trivandrum ABD area.

3. Transit oriented development increases accessibility and liveability, which will benefit both their present residents and visitors of Trivandrum.

1.8 Limitations

The study and identification of parameters and development plan will be context specific for Thiruvanathapuram.

CHAPTER 2 LITERATURE REVIEW

The concept of transit-oriented development are explained in this chapter. The various concepts and definitions related to it and various tools adopted to identify and depict relationships between and among concepts

2.1 Transit oriented development

"Transit oriented development is defined as a walkable, mixed-use form of development within walking and cycling radius of a mass transit station" - Peter Calthorpe (TOD for indian cities , 2016) .

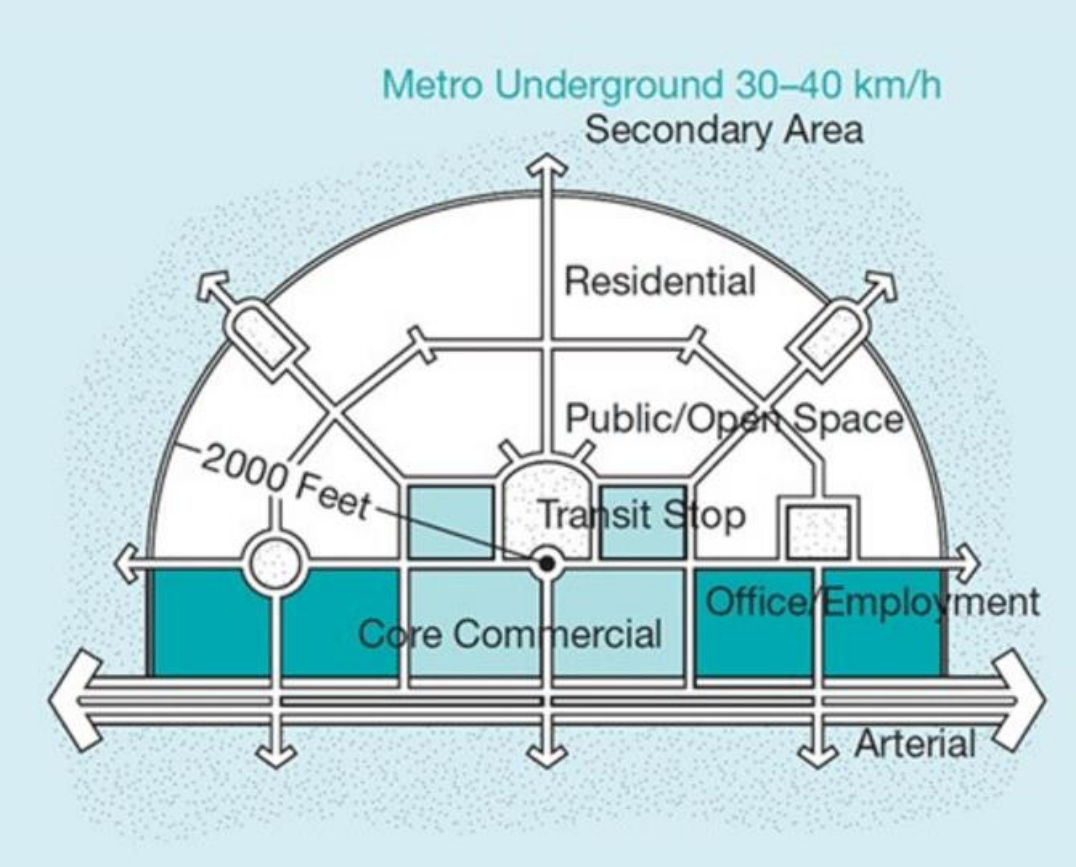


Figure 2.1 Illustration of TOD based on Calthorpe (1993)

Source: (Pal, 2017)

According to Peter Calthorpe, a "mixed-use community that pushes people to live near transit services and decreases their dependency on driving" is what a transit oriented development is. Since then, the idea has revolutionised the process of human settlement and civilisation in numerous parts of the world.

What's fascinating about TODs is they're really nothing new. We did this very successfully 100 years ago. Most of our cities grew rapidly along early streetcar lines and inner urban systems. In the pre-automobile age, that's how cities developed. They were compact and had a mix of land-uses that were physically oriented to transit because there was no other way to get around. So TODs are, in many ways, just a new name for traditional urbanism - Robert Cervero (TOD for indian cities , 2016).

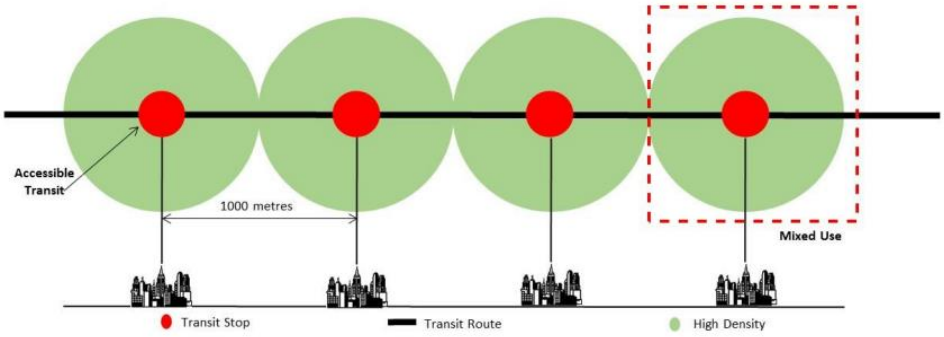


Figure 2.2 Transit oriented development

Source: (National conference on urban reforms , 2022)

TOD is today advocated as the sustainable alternative to sprawl and automobile dependency because it promotes the optimum utilisation of existing infrastructure, optimising the use of transit networks and creating mobility options for transit users and the local residents. Besides its role in creating compact, walkable communities, TOD is increasingly being looked at as a major solution to the serious and growing problems of climate change and global energy security by creating dense, walkable communities that greatly reduce the need for driving and energy consumption.

2.1.1 TOD Principles

TOD has been rediscovered as one "smart growth" alternative. TOD provides one such tool to organize integrated community planning principles. It relates to spatial planning for development around transit stations. This tool is expected to integrate the land use and transport systems, thereby creating sustainable development, pedestrian and non-motorized friendly areas and neighbourhood (Pal, 2017).

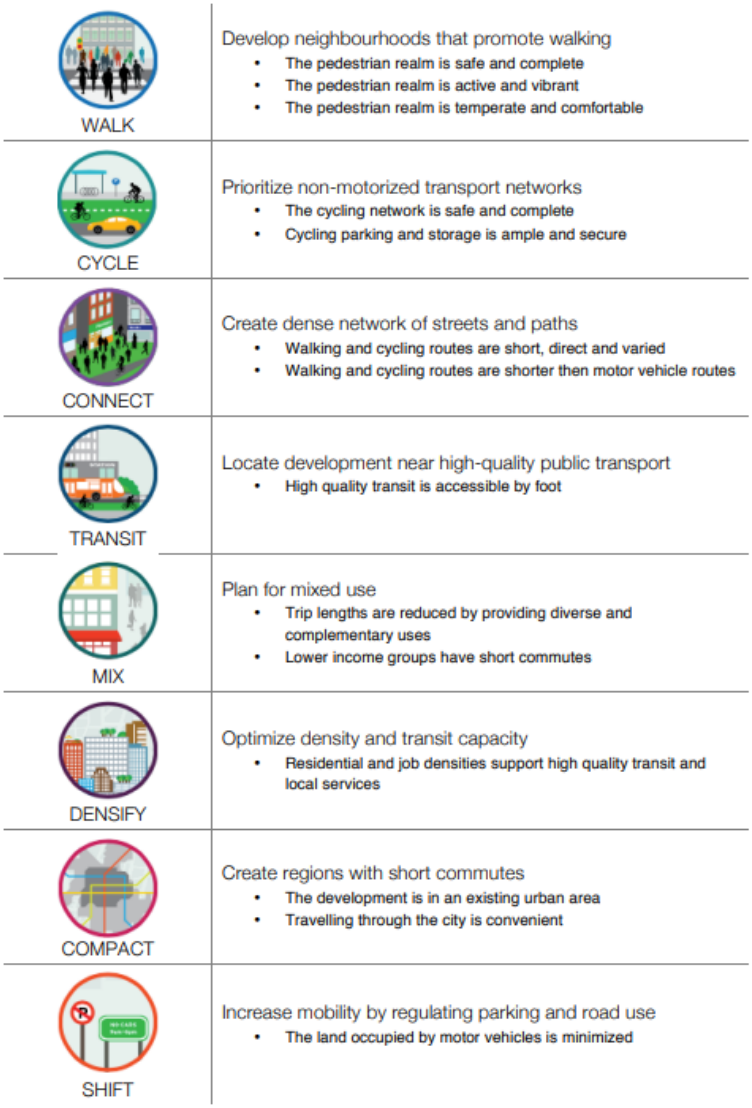


Figure 2.3 TOD principles

Source: (National conference on urban reforms , 2022)

Transit systems like metro rail, BRTS, etc. are being developed to meet the rising demand for transport as cities experience fast expansion. Thus, TOD has become a must for all such communities that already have or want to build mass transportation networks.

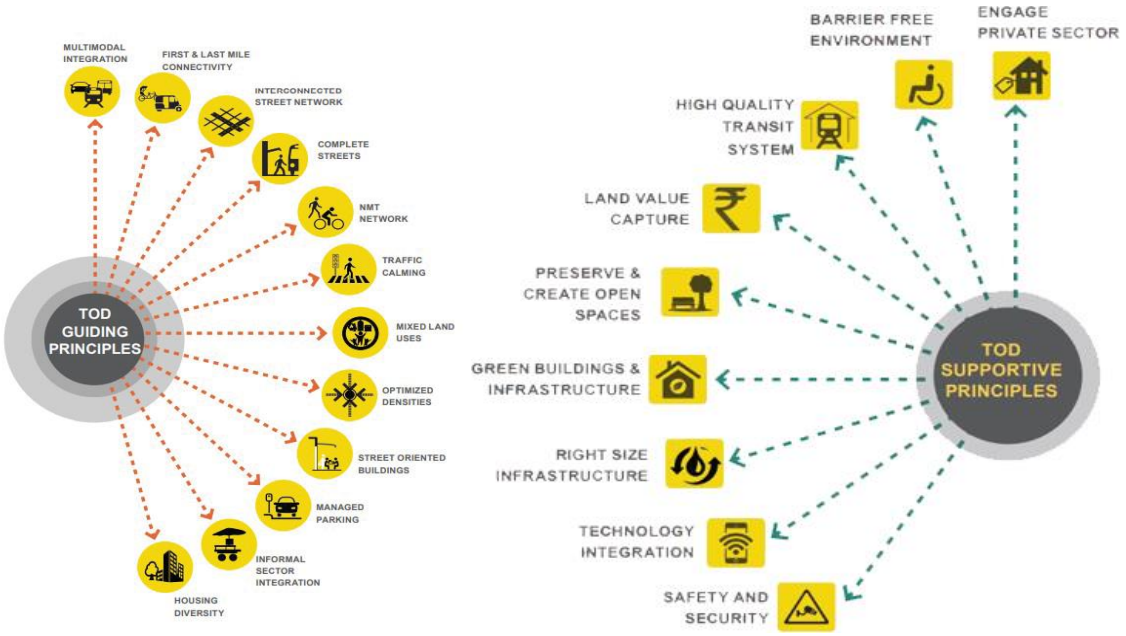


Figure 2.4 TOD principles

Source: (National conference on urban reforms , 2022)

expand along rail lines and gave rise to the concept of the "transit city." Finally, the "automobile city" as well as the accompanying lower-density suburbanization and longer commute times between homes and offices emerged about 1930 (coorporation, 2005).

The modern concept of car development its development is attributable to studies conducted in the 1960s and 1970s that showed the significant social and environmental consequences of unchecked automobile use (coorporation, 2005).

2.2 TOD –Definitions

Table 2.1 : Definitions of TOD

Source: Author generated

SL No	Definition	Source
1	Transit oriented development is defined as a walk able, mixed-use form of development within walking and cycling radius of a mass transit station.- Peter Calthorpe	*TOD for indian cities* . (2016). Retrieved from https://niua.org/tod/todfisc/book.php?book=1&section=3#:~:text=The%20term%20transit%20oriented%20development,of%20a%20mass%20transit%20station
2	Transit-oriented development (TOD) is defined as "walk able, compact, mixed-use, higher-density development within walking distance of a transit facility." TOD generally provides a mix of residential and commercial uses and is designed to make public transit successful, enhance the convenience and safety of walking and bicycling, and provide for a vibrant, liveable community.	*COMPLETE COMMUNITIES* . (2022). Retrieved from https://www.completecommunitiesde.org/planning/complete-streets/tod/
3	In urban planning, transit-oriented development is a type of urban development that maximizes the amount of residential, business and leisure space within walking distance of public transport. It promotes a symbiotic relationship between dense, compact urban form and public transport use.	*wikipedia*. (2022). Retrieved from https://en.wikipedia.org/wiki/Transit-oriented_development

4	TOD integrates land use and transport planning and aims to develop planned sustainable urban growth centres, having walk able and liveable communes with high density mixed land-use. Citizens have access to open green and public spaces and at the same time transit facilities are efficiently utilized.	*National Transit Oriented Development.* (2022). Retrieved from https://mohua.gov.in/upload/whatsnew/59a4070e85256Transit_Oriented_Development_Policy.pdf

In short - **TOD concentrates on a transit rich development guided by MRTS or BRTS system to promote compact development.**

2.3 TOD –URDPFI Guidelines

Transit Oriented Development is a compact & integrated transportation development, which should be incorporated in Compact Cities. It is defined as, "any development, macro or micro that is focused around a transit node, and facilitates and complete ease of access to the transit facility, thereby inducing people to prefer to walk and use public transportation over personal modes of transport (URDPFI Guidelines, 2014).

TOD	Ideal Land use mix and mixed land use development (with Density)	Transit mode function
Core Area	▪ Residential: High Intensity ▪ Commercial/ Office: Medium Intensity ▪ Mixed Use ▪ Supporting retails & services	▪ Bicycle Lanes ▪ Pedestrian Networks ▪ Intermediate transportation supported by non-motorised vehicles ▪ Limited Parking Lots
Commercial Zones	▪ Employment (commercial, office, industrial, institutional): High Intensity ▪ Supporting retail & services: Medium Density ▪ Residential: Minimal	▪ Parking Lots, if required ▪ Pedestrian Networks ▪ Bicycle Lanes ▪ BRT and Bus Stops ▪ Intermediate transportation supported by motorised vehicles
Neighbourhood	▪ Residential: Medium Intensity ▪ Employment (commercial, office, industrial, institutional): Medium Intensity ▪ Supporting retails & services	▪ Pedestrian Networks ▪ Bicycle Lanes ▪ Considerable Multi-level Parking Areas ▪ Intermediate transportation support by non-motorised vehicles
Peri-urban Area	▪ Commercial: High Intensity along TOD ▪ Residential: Medium Intensity in inner region ▪ Mixed Use including compatible institutional use	▪ Transition to higher density and greater mix of uses close to the transit source ▪ BRT and Bus Stops ▪ Green Interconnected Pedestrian Network ▪ Considerable Multi-level Parking Areas

Figure 2.5 Transit Oriented Development Matrix

Source : (URDPFI Guidelines, 2014)

2.3.1 TOD Development control

The TOD mainly has 6 components.These components are as following:

1.Pedestrian & Cycle/ Cycle-Rickshaw Friendly Environment

2.Connectivity: Create dense networks of streets and paths for all modes.

3.Multimodal Interchange: Mass transportation modes servicing the area should be well integrated to afford rapid and comfortable modal transfers.

4.Modal Shift Measures: Shift to Sustainable Modes by using Design, Technology, Road Use Regulation, Mixed-Use, Parking Policy and Fiscal Measures

5.Placemaking and Safety: Urban places should be designed for enjoyment, relaxati on and equity.

6.High Density, Mixed Income Development: Compact Neighbourhoods for Shorter Commutes and equity for all sections of society.

2.3.2Non-Motorised Vehicles

National Urban Transport Policy encourages use of NMVs by offering Central financial assistance for this purpose. As per MoUD guidelines, NMVs can be promoted through the following initiatives (National conference on urban reforms , 2022):

1. Providing better facilities to accommodate existing NMV use and encourage more NMVs through visible infrastructure.

2. Developing a strategic NMV plan including a network of routes available to NMVs throughout the city.

3. Segregating NMVs/MVs to improve safety and smooth passage of NMVs.

4. Promoting freight NMVs for the transport and delivery of small goods to markets and shopping areas.

5. Identifying sub-projects which make positive, pro-active provision for NMVs as part of a balanced approach to traffic planning.

6. Giving NMVs priority over MVs on selected routes and in selected areas.

7. Strengthening Road User Education (RUE) programmes for NMV users to improve behaviour and road safety.

8. Rationalising and improving NMV registration, licensing for use as a Public Transport or freight vehicle, regulation and enforcement.

9. Encourage NMV by improving women's access.

2.3.3 Influence Zone Plan

A Detailed Influence Zone Plan is a document that provides a framework and vision for future TOD development for MRTS. The Plan shall be prepared or be approved by the competent Planning Authority for each influence zone area in a phased manner, customized to site characteristics and context. The plan shall include the following components (National conference on urban reforms , 2022):

A. Urban Design Framework

1. Street Network Plan indicating street hierarchy and character
2. Landscape and Open Space Structure indicating type of open spaces and distribution of play areas. To include planting strategy for all street trees.
3. Vertical mix of uses for each TOD parcel indicating location of civic amenities within mixed –use blocks
4. Location and numbers of short and long term parking spaces

B. Transport Impact Assessment& Mitigation Strategies

1. Achieving the desired modal shift, in particular mode shift for short trips
2. Street network improvement through assessment of existing capacity and augmentation of network as required through new linkages, alternate routes, junction designs etc. for all modes with priority for intermediate public transport, pedestrians, cyclists / NMT.
3. Integrated strategy for Public transport, Pedestrian and Cycle access.
4. Determining the optimum mix of uses to mitigate negative impact on surrounding land uses and transport networks.
5. Parking Strategy as a Demand Management Tool.
6. Mitigation strategies for traffic noise and vibration.

2.4 State TOD policy

As the cities are experiencing rapid growth, transit systems light metro rail, BRTS, etc. are being implemented to cater to the growing travel demand. It has thus become inevitable to have TOD for all such cities which have an existing mass transit systems or planning to do so. It is the responsibility of the state government to manage the urban spaces, however a National TOD policy would serve as guidelines and play a catalytic role in formulating state/ city level policies for promotion of transit oriented development and mobility corridors (National conference on urban reforms , 2022).

The National Urban Transportation Policy (NUTP), launched in 2006, aims at providing better mobility and sustainability by focussing on people mobility and not vehicle mobility. The policy envisages an urban mobility framework that is contextual, and is suited to the geographical, social and economic needs of our cities and citizens (National conference on urban reforms , 2022).

However, the progress in implementation of the NUTP in our cities is far from satisfactory. Change need to happen before Indian cities double in population by 2050 (World Economic Forum, 2016). The present focus is on building roads and flyovers to cater to the ever-increasing vehicular traffic of India. What is missing is adequate infrastructure for moving people through means, such as bicycle tracks and dedicated pedestrian pathways. Even

where such infrastructure is available, it is not being used to its full extent. For example, pedestrian pathways are being encroached upon for other uses or are not walk able because of being broken or lined with garbage, etc. making it neither obstruction free nor safe. Similar is the case with our cycle tracks. The pattern of urban growth in terms of urban sprawl has resulted in an even higher demand for motorized travel (National conference on urban reforms , 2022).

The need of the hour is to focus on public transportation (PT) in India, especially, low carbon non-motorised transport (NMT). As income levels increase, people too aspire to shift to private transport, due to infrequency and unreliability of public transport. As a result, the use of such desirable modes of transportation (such as NMT or PT) is declining and the use of undesirable modes (i.e. car and 2-wheelers) is growing. To keep India walking, the government needs to oversee an incremental and mixed mode approach for a transition into a low carbon pathway. Cities and states needs to be pro-active and may consider following interventions for sustainable urban mobility solutions (National conference on urban reforms , 2022):

- A Comprehensive and Integrated Transport Plan for Each City

City transport is administered by various modal agencies such as the city bus corporation like DTC, the municipality, the rail and metro-rail corporation, the city development authority like DDA, etc. What is really required is an integrated process of transport planning for co-ordinated inter-city and intra-city transport. Sustainable urban transportation system, however requires**,** *integration of Land Use and Transport Planning.* The *Transit Oriented Development (TOD)* policy will build a roadmap in integrating public transport systems with the built environment.

- Doing Away with 'One Size Fits All' Approach

More cities are going for MRT, LRT and monorail, despite the fact that these are capital intensive and require massive capital and operating subsidies. Tier-II and Tier-II cities require a different approach, given their population densities, urban form and socio-

economic conditions of the city. Intermediate public transport (IPT) modes like e-rickshaws, shared autos and cycle rickshaws and NMT assume importance as they can meet the travel demands in small and medium size cities. Even within large cities, 20 to 30 per cent of the family income of nearly 50 percent those living in unauthorized settlements is spent on public transport (Tiwari 2007). Therefore, a mixed modal strategy is best pursued in different cities, to cater to different segments of the population.

-System-based Approach is Critical

Transport networks cannot exist in silos. Sustainable urban mobility calls for *Intermodal Integration,* i.e., integration of various modes of transport to provide seamless connectivity for the commuters. Last mile connectivity is an important factor for determining the success of public transport system in a city.

-Empowering Municipal Governments and Citizens

Municipalities needs to be empowered by providing autonomy in functions, finances and functionaries for better citizen engagement in city planning. The Smart Cities Mission focuses on developing sustainable and shared mobility systems, in addition to laying smart roads, street redesign and smart parking systems. Huge resources are being spent on improving urban transport projects such as real time bus tracking system, smart bus shelters and junction improvements (MoHUA 2018). There is need to create demand from the bottom-up level to increasing citizen participation and urban practitioners' awareness.

-Making Public Transportation Accountable

For Indian cities to be liveable, urban mobility, especially, public transport such as bus and bus rapid transit (BRT) systems must become a vital part of urban growth. We need to think of innovative ways of financing our PT ventures and operate to dis-incentivize private vehicles. There is need to improve operations of PT by adopting Intelligent Transport System (ITS) and GPS tracking of buses for better route planning. This would induce a long term behavioural change where people are encouraged to go for public transport.

-Providing Barrier-free Integrated Transport Solutions for Vulnerable Groups

To make cities more inclusive and to address the requirements of the vulnerable sections of the population, planners need to take into account the concerns of different segments of the population during transport planning. Women represent the largest share of public transport users around the world, yet they face many barriers that limit their mobility and entry into the formal work-force. Therefore, all experiences of public transport, such as those of women, children, the poor and the disabled needs to be taken into consideration, budgeted and planned for. The buses and train corridors, stops and junctions need to be well lit, easily accessible and located in crime-free areas.

2.5.1 Urban reforms in Kerala context

Town planners from Trivandrum, Kozhikode, and Ernakulam participated in the first presentation of the state's draft TOD policy held on August 29, 2021 for the formulation of state TOD policy. The Town and Country Planning Department has consistently emphasised the need to update specific town planning plans and include transit-oriented development into state master plans for cities. In the sectoral suggestions for transportation in the proposed Trivandrum-2040 master plan, initiatives to combine land use with urban transportation have been recommended, including TOD (National conference on urban reforms , 2022).

2.5.2 Policies

1. Transit corridor to be densified

Transit-Oriented Development, Nodes linked by mass transit Source: infra Trans Consultancy

Width of TOD Zone shall be desirably around 500 meters on either side of transit corridor. The width may vary based on walkability and other associated factors.

Minimum FSI & Plot Size may be specified (Excluding Residential Buildings with up to 4 Dwelling Units)

Relaxed and shared open space requirements may be specified for main transit corridor (Excluding Residential Buildings with up to 4 Dwelling Units).

Additional fee on higher FSI outside TOD zone (eg. > 2.0). Provision for extra premium FSI in the TOD zone (eg 4.0)

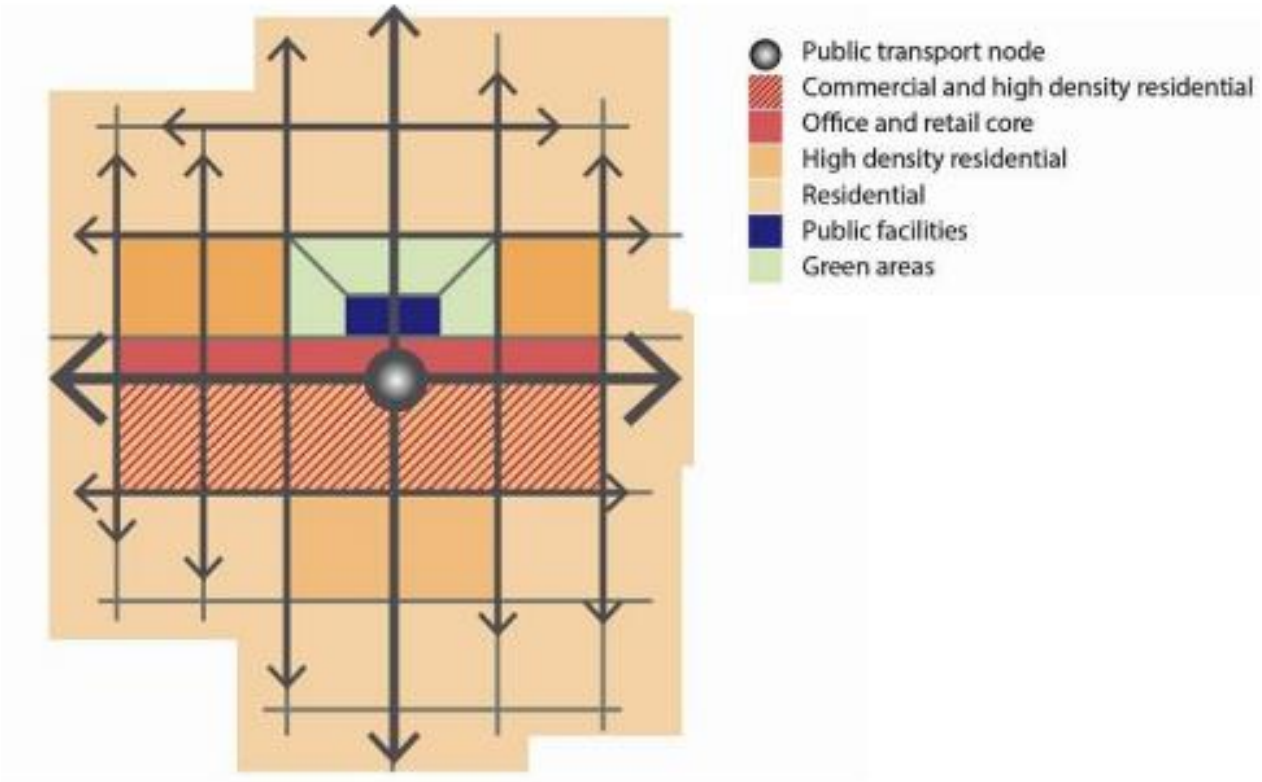


Figure 2.6 Densification of nodes

Source : Kerala State TOD policy

2. Mixed use buildings & zones to be promoted in the TOD Zone

- Taxation allowances/rebates to Mixed Use Buildings
- Allowances on Building Rules for mixed use buildings utilizing high FSI.

- Category of buildings & threshold FSI to be specified through master plans. (e.g> 3 occupancies & FSI > 3.5)

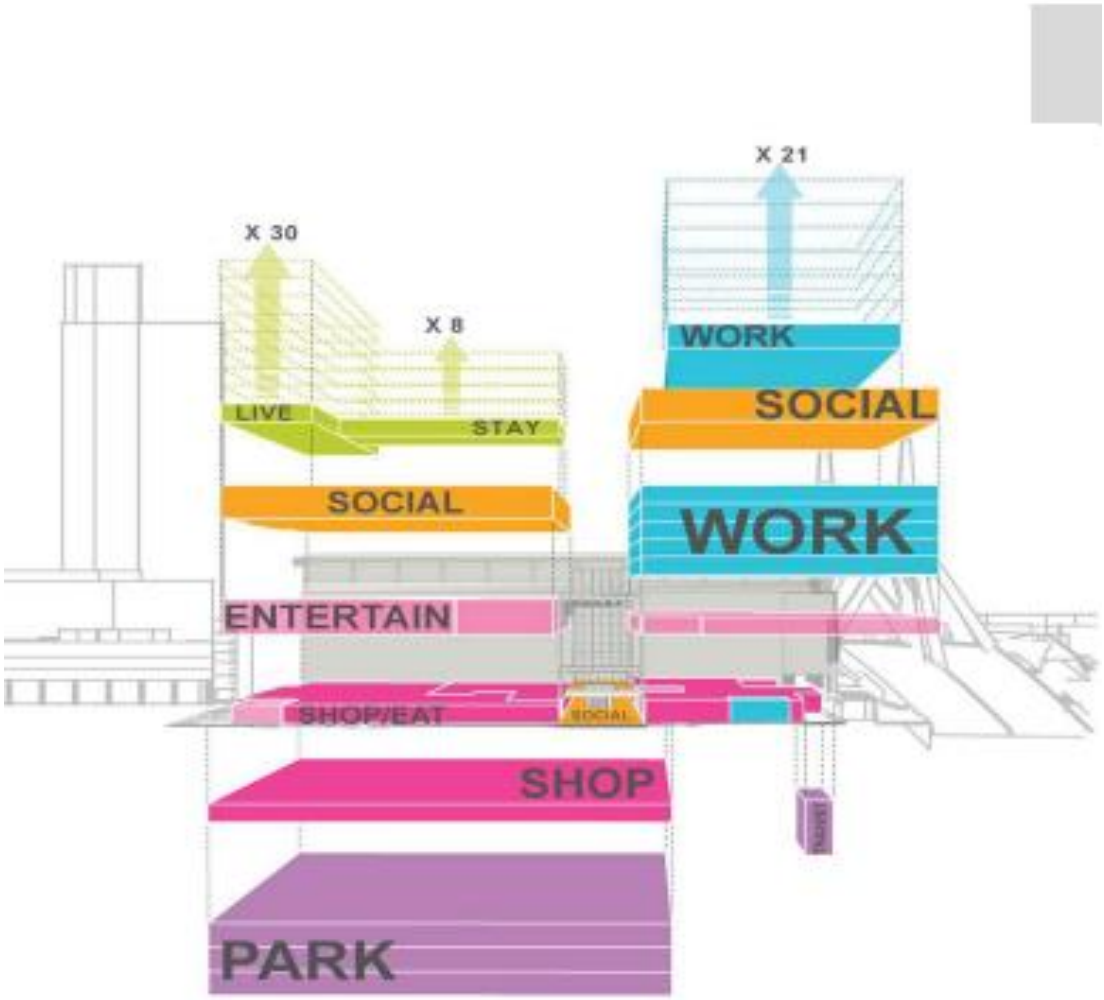


Figure 2.7 Mixed use development

Source : Kerala state TOD policy

3.Promote multi-use transit stations (MRTS/LRTS / Bus / Mobility Hubs) along the transit corridor

- Promote leasable space at all transit stations (promote vertical multi-uses) with relaxation in building rule regulations/provisions, as feasible. Mandatory public amenities to be provided at all transit stations (accessible also to non-commuters).

- Designated spaces for NMT / Pedestrian facilities.

Figure 2.8 Kiosks in Metro stations

Source : Kerala state TOD policy

4. Include wide spectrum of inclusive housing

- Promote affordable housing units within the TOD area for all large scale housing and apartment projects (Scale to be specified through Master Plan).

5. Incorporate Multi modal integration of transit modes

- All transit stations should be equipped with informed integrated public transport network.
- Compact design of transit stations.

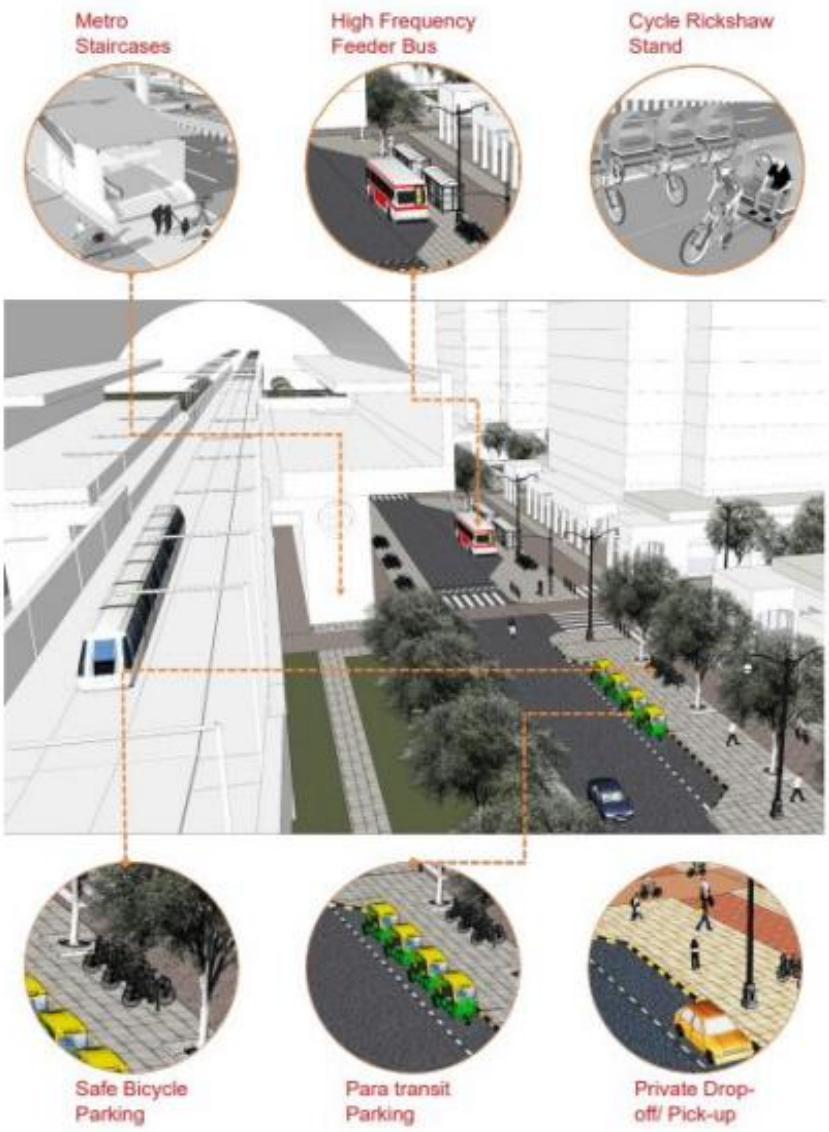


Figure 2.9 Multi modal integration

Source : Kerala state TOD policy

6. Ensuring safety of pedestrians, cyclists and NMT users

- Fixed building line
- At least 2 meter front open space to be shared as footpath
- Remaining mandatory front open space to be landscape & made accessible.
- Separate cycle tracks to be designated along roads

- Incorporating barrier free guidelines for all public facilities.

Figure 2.10 Pedestrianization

Source : Kerala state TOD policy

7. Street oriented buildings & public spaces

- No compound wall on front setbacks
- Landscaping pattern may be specified
- No parking allowed on front open space
- Front open space and footpath may be uniformly lighted
- Urban Design guidelines with regard to elements such as street furniture,
- Size/height of signage, hoardings etc. may be specified Promote extended late working hours for identified commercial buildings/facilities.
- Designated advertisement zones may be provided Designated vending zones may be provided

Figure 2.11 Street vending zones, Hyderabad

Source : Kerala state TOD policy

8. Managed public parking facilities/zones.

- On street parking to be priced and regulated
- Open spaces of public buildings to be opened up for parking on off-days

Figure 2.12 Public parking facilities

Source : Kerala state TOD policy

9. Green & Recreational open spaces.

- A percentage of the total area of TOD zone may be maintained as green recreational space.
- Recreational space to be formed through land pooling/land acquisition processes. Feasible public lands, river buffers and conservation zones may be opened up as recreational spaces.
- Formation and upkeep of such recreational spaces may be vested with the Transit Authority.

Figure 2.13 Recreational space

Source : Kerala state TOD policy

2.6 Related planning Concepts

Table 2.2 : Related concepts

Source: Author Generated, 2022

CONCEPTS	PRINCIPLES/GOALS	SOURCE
GREEN CITIES- City designed with consideration for social, economic, environmental impact, and resilient habitat for existing populations, without compromising the ability of future generations to experience the same	1. **Economy** Quality infrastructure increases house and office values (either rental or freehold). It provides a more attractive environment for inward investment and draws additional visitors to a city. 2. **Health** Residents and workers are happier and healthier when they live and work in . Improved health results in lower costs for the health-care sector, benefits the economy, and leads to enhanced human well-being. 3. **Social** Interaction environments encourage people to spend more time in outdoor spaces which in turn increase the rates of social interaction and mixing. 4. **Climate and pollution** moderating the impacts of the urban heat island effect which is recognised as a significant cause of premature death in cities.	AIPH. (2020). Retrieved 2022, from The Green City Guidelines are founded on the principles of the Green City philosophy: https://aiph.org/green-city/guidelines-2020/principles/

	The shade and air-cleaning benefits 5. **Sustainable transportation** Refers to low- and zero-emission, energy-efficient, affordable modes of transport, including electric and alternative-fuel vehicles, as well as domestic fuels	
15-MINUTE CITIES- A 15-minute city is a residential urban concept in which most daily necessities can be accomplished by either walking or cycling from residents' homes.	1. **Improve walking and cycling infrastructure**, including by reallocating street space to pedestrians and cyclists. 2. **Create complete neighbourhoods** by decentralising core services and developing a social and functional mix. 3. **Update the city's plans and zoning** to ensure that they require critical public services, infrastructure and green space to be accessible to all residents at neighbourhood level. 4. **Promote affordable housing** in each neighbourhood. 5. **Flexible use of space and decentralisation** to support the reopening of night-time venues. 6. **Well-connected public transport, jobs and services** within the region.	c40 knowledge . (2015). Retrieved 2022, from How to build back better with a 15-minute city: https://www.c40knowledgehub.org/s/article/How-to-build-back-better-with-a-15-minute-city?language=en_US#:~:text=In%20a%20'15%2Dminute%20city,decentralising%20city%20life%20and%20services.

	7. **Local shopping and employment opportunities**. 8. **Safe streets and spaces**	
LIVEABLE CITY - A liveable city provides equitable access to the necessities of life, including housing, mobility, food, services, education, and meaningful work. It gives all residents an opportunity participate in the civic, economic, and cultural life of the city.	1. **Reclaim the Streets** The city should make walking a joy—safe, comfortable, interesting. The quality of sidewalks, parks, and plazas—life "between" buildings—is one of the ultimate signs of a healthy city 2. **Fast and Frequent Local Transit** The best way to attract people to public transit is to make it the fastest way to get around. That means getting transit out of traffic. Imagine an express network of rapid transit buses and trains that took only 20 minutes to get all the way across town. 3. **Connected Regional Transit** A liveable, sustainable, and vital Bay Area depends on a robust, effective, and connected regional transit system. 4. **Safe and Comfortable Bicycling** In a compact city where most trips are under five miles, bicycling could be a much more useful and popular mode of transportation.	liveable city . (2021). Retrieved 2022, from https://www.livablecity.org/missiongoals/#:~:text=There%20are%20five%20fundamental%20aspects,vibrant%20public%20spaces%2C%20and%20affordability.&text=The%20city%20should%20make%20walking,%E2%80%94safe%2C%20comfortable%2C%20interesting.

	5. **Living Gracefully with the Car** All over the world, cities have found ways to provide everyone with access to a car when they need one, without letting cars ruin neighbourhoods. We must accommodate the car, but let's do it gracefully. 6. **Planning for a Better Future** In many ways, the city is gripped by pessimism, only able to imagine things getting worse. Official city plans predict that congestion will increase and mobility will decrease.	
SUPER BLOCK - A very large commercial or residential block barred to through traffic, crossed by pedestrian walks and sometimes access roads, and often spotted with grassed malls.	1. **Land use and urban morphology:** distances should be considered in spatial planning to intensify social cohesion. 2. **Urban functionality:** Public space should be safe and contribute to mobility and quality of life. 3. **Urban complexity:** A diversity of institutions, individuals and activities increases the available knowledge. The ideal ratio of local manufacturing to residential and commercial space is 1:4 to 1:3 in buildings. 4. **Urban green and biodiversity:** there is no way of detaching sustainability and	toposmagazine . (2022,October). Retrieved from https://toposmagazine.com/superblocks-in-urban-planning/

	biodiversity of ecosystems from the city. 5. **Metabolic efficiency:** urban material and energy cycles should be as efficient as possible without compromising the ecosystem. 6. **Social cohesion:** coexisting social groups need access to housing and necessary public facilities, which should always be within a maximum of 10 minutes walking distance.	
PEDESTRIAN ORIENTED DEVELOPMENT	1. Narrower streets, scaled down for pedestrians and less conducive to high motor vehicle speeds. 2. Traffic-calming treatments to help ensure that motor vehicles are operated at or below compatible speeds. 3. Wide and continuous sidewalks that are fully accessible, that maintain fair levels, and that are well maintained. 4. Well-designed intersections to ensure easy, safe crossings by pedestrians of all ages and abilities. 5. Well-designed and marked crosswalks, both at intersections and, where needed, at mid	*mcmdev*. (2017). Retrieved from https://www.mcmdev.com/stories/pedestriandesign

	block locations 6. Appropriate use of signs and signals for both pedestrians and motorists, with equitable treatment for pedestrians 7. Median islands on wider streets to provide a refuge area for crossing pedestrians. 8. Street lighting designed to pedestrian scale (e.g, shorter light poles and/or lower light fixtures that are designed to be effective in illuminating the pedestrian travel way). 9. Planting buffers, with landscaping and street trees that provide shelter and shade without obstructing sight distances. 10. Street furnishings and public art intended to enhance the pedestrian experience, such as benches, trash receptacles, drinking fountains, and newspaper stands, placed so as not to interfere with pedestrian travel.	
NEW URBANISM	1. Walkability-A principle of new urbanism; most things within a 10 minute walk of home and work. 2. Connectivity-A principle of new urbanism; interconnected street grid network disperses	*Quizlet*. (2022). Retrieved from https://quizlet.com/549984603/10-principles-of-new-urbanism-flash-cards/

	traffic and eases walking. 3. Mixed-Use and diversity-A principle of new urbanism; a diversity of people and shops, offices, apartments, and homes on sale exists. 4. Mixed Housing-A principle of new urbanism; a range of types, sizes, and prices in close proximity 5. Quality Architecture & Urban Design-A principle of new urbanism; emphasis on beauty, aesthetics, human comfort, and creating a sense of place. 6. Traditional Neighborhood Structure-A principle of new urbanism; Discernable center and edge, public space at center, importance of quality public realm; public open space designed as civic art, transect planning: Highest densities at town center; progressively less dense towards edge. 7. Increased density-A principle of new urbanism; more building, residences, shops, and services close together. 8. Green transportation-A principle of new urbanism; a network of high quality transit	

	connecting cities and towns together. 9. Sustainability-A principle of new urbanism; minimal environmental impact of development and its operations. 10. Quality of Life- A principle of new urbanism; the result of all principles together	

CHAPTER 3 LITERATURE CASE STUDY

In this chapter, the various practices selected for the study are explained in detail. International case studies as well as initiatives and policies at the national level have been highlighted.

3.1 Curitiba, Brazil

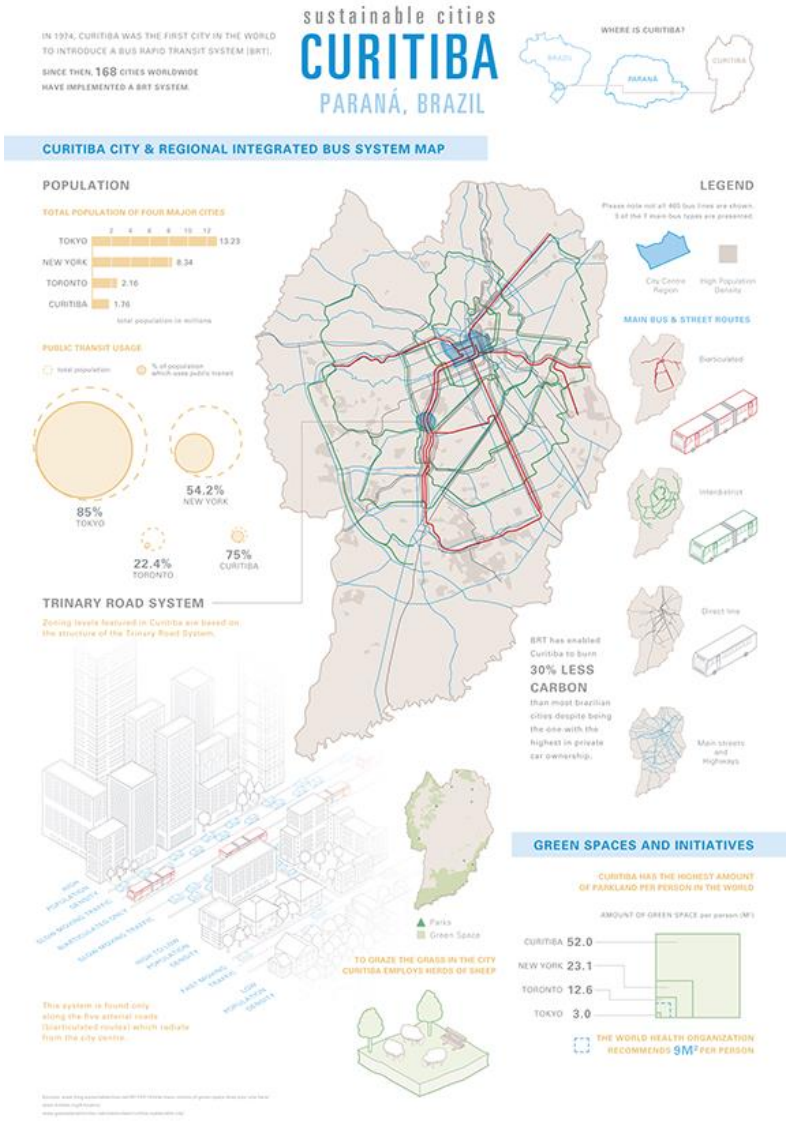


Figure 3.1 Map of Curitiba showing BRTS planning

Source: *(Behance , 2022)*

Location

Curitiba is the capital of the southern Brazilian state of Paraná. Curitiba is the capital of the southern Brazilian state of Paraná.

Why TOD ?

When Curitiba's contemporary metropolis began to grow quickly in the 20th century, it took a radically different approach than other developing metropolitan regions. It created pedestrian spaces rather than constructing vast, open roadways in its centre. Local authorities instead started a competition to re-imagine Curitiba's growth route in response to the city's increasing pains, which were manifested by crowding and congestion.

Objectives

One of the main objectives of the change to more environmentally friendly modes of transportation was accomplished by the practical, integrated, and accessible bus network: a modal shift from vehicle usage to bus mass transit, which is more effective, safer, and less polluting.

Initiatives

In its mobility plan, Curitiba formalised :

a. Transit-Oriented Development (TOD) ,
b. Mandating mixed-use urban projects along BRT lanes
c. Fortifying the centre city with car-free zones
d. Installation of dedicated bus lanes
e. Eliminate vehicles from the equation
f. Double-articulated buses with a capacity of up to 270
g. Structural Avenues were designed to direct linear growth by attracting residential and commercial density along a mass transportation lane.

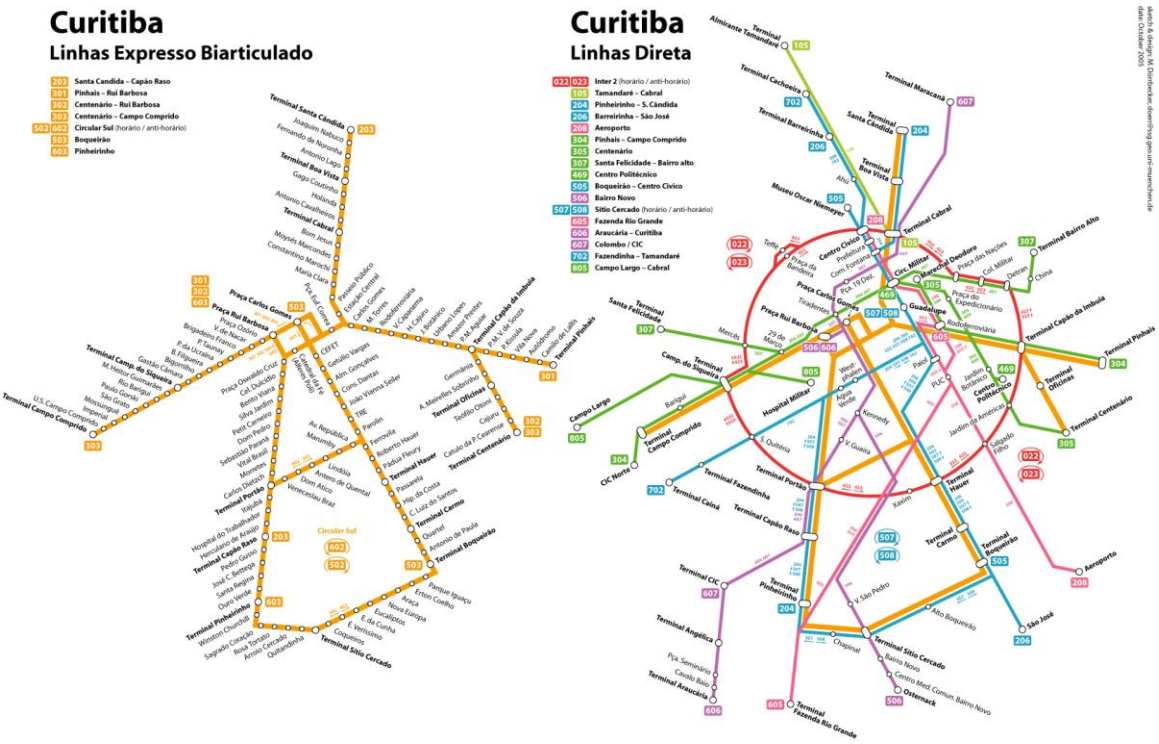


Figure 3.2 Curitiba BRTS network

Source: (Behance , 2022)

Result

- By 1991, it is estimated that 27 million automobile trips had been avoided, and 28% of car users had shifted to bus transportation (car free mega cities , 2022).
- The Bus Rapid Transport System (BRT) was moving 1.5 million people each day by 1993. (car free mega cities , 2022).
- Curitiba is now regarded as one of the world's top cities for urban planning.
- The BRT is used by over 85% of the population of Curitiba

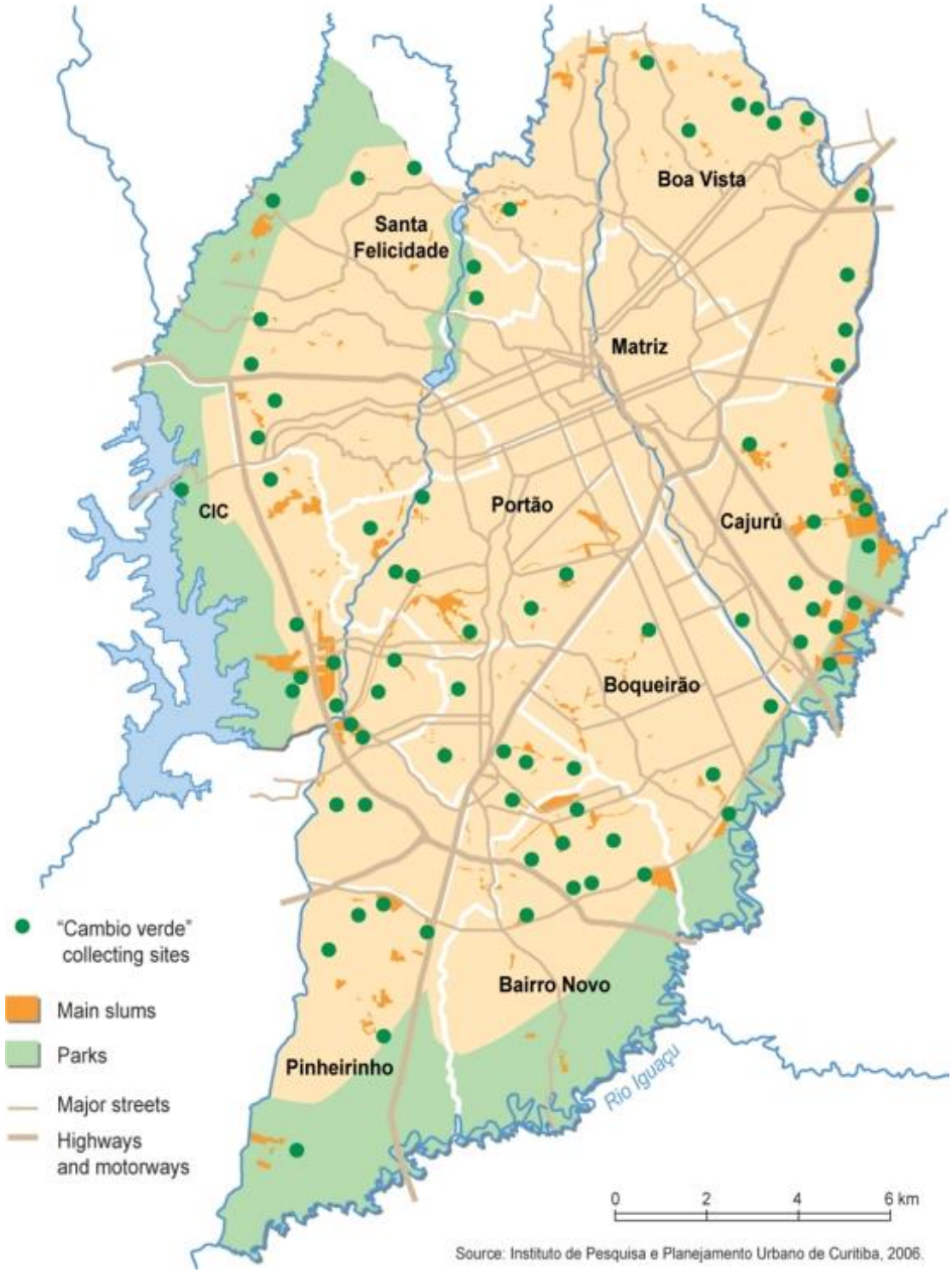


Figure 3.3 Map of Curitiba showing introduction of parks and slum concentration

Source: (Behance , 2022)

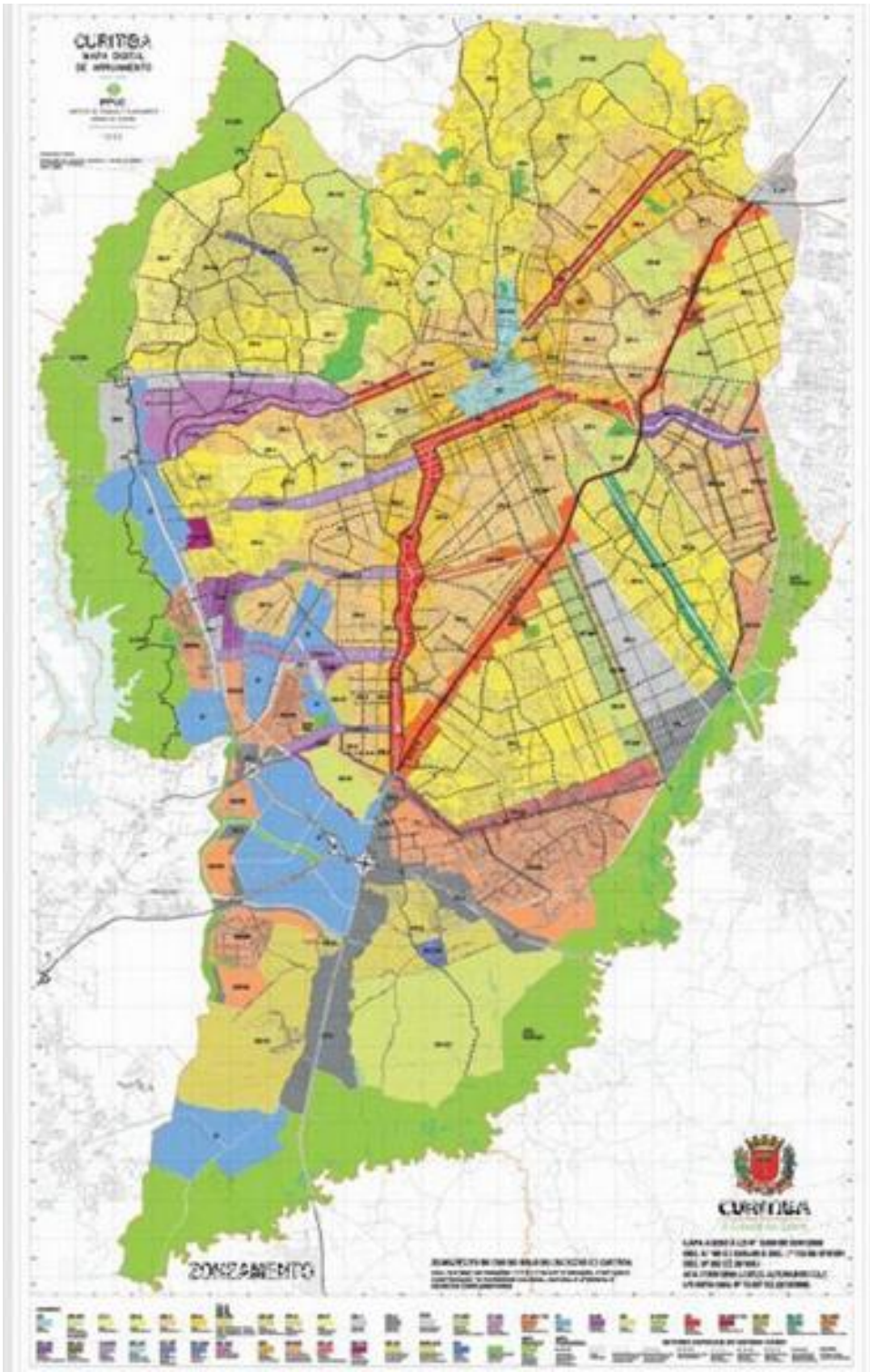


Figure 3.4 Landuse map of Curitiba

Source: (Feldman Architecture , 2020)

Figure 3.5 Map showing connectivity

Source: (Feldman Architecture , 2020)

Aspects of success

• The visionary leadership of a mayor

• Central Government financial assistance for the first capital outlay

•Government and business sector roles are clearly separated

•The local government oversees and controls the operation to maintain a specific standard:

3.1.1 Inference

Bus transit should be planned, developed, bought, and operated in a coordinated manner, much like an LRT system. The mobility plan, which is founded on the idea of strengthening BRTS," prioritises people walking, mixed use linear development, compact city and repurposing city scape with landscape facilities to promote liveability.

Through employing a TOD strategy, the City of Curitiba offers valuable lessons as a city having responded to a surge in growth with a long-term, cost-effective and innovative plan. Curitiba may have pioneered TOD, yet countless other cities – such as Guangzhou, China; Hamburg, Germany; Bogota, Colombia; and Vancouver, Canada – and many more have followed in Curitiba's footsteps. In employing a TOD approach, Curitiba set the stage, providing other cities with a blueprint for how to create a low-carbon, integrated, innovate and socially conscious city

3.2 Ahmedabad, India

Location

Gujarat is one of the most developed states of India and it has experienced a rapid rate of urbanization in last four decades. Ahmedabad is the seventh largest metropolitan area and third fastest growing cities of India. Ahmedabad is strategically located in the center of Gujarat, in the basin of the Sabarmati River. It is spread on both banks of Sabarmati River which cuts through the city.

Why TOD in Ahmedabad?

Looking at its growth rate and rapid expansion, there is a pressing need to reconsider and redirect the development and growth patterns in the next decade
The residents of the city are facing the issues:

-high cost of housing and real estate.
-increased travel distances and travel times between home and work places.
-traffic congestion
-increased demand for social-physical infrastructure facilities i.e. gardens, open spaces and much more.

Figure 3.6 Satellite view of Ahmedabad

Source: Google map

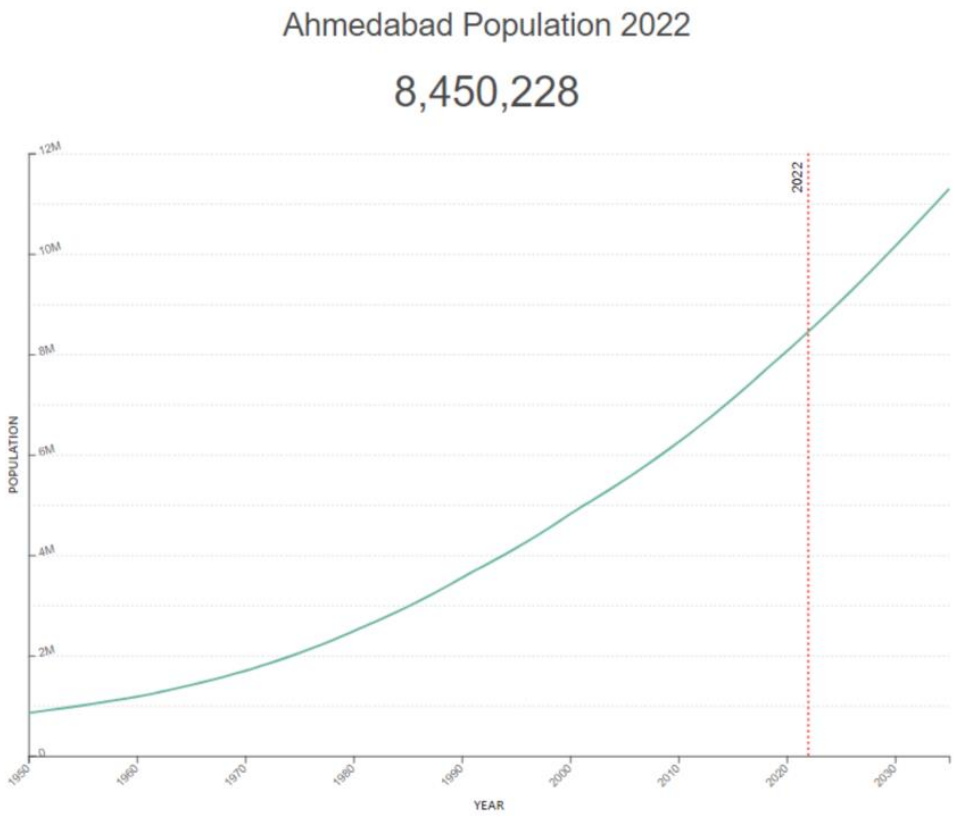


Figure 3.7 Population of Ahmedabad

Source : Census India 2011

Initiatives

Currently Ahmedabad has three systems of public transport namely:

AMTS: Ahmedabad Municipal Transport Service is working with in the city limit. AMTS is a major public transit mode with 1680 km network and carrying highest number of commuters.

BRTS JANMARG: With the intension of providing frequent, comfortable and affordable mode of transit within the city Janmarg BRTS has been started in 2008.

BRTS plan includes 5 phases. Serving the rapid growth of the city currently BRTS is successfully running on 92 km of stretch implemented under phase 1, 2.

Metro (Proposed): Metro rail is a fast, comfortable and high-volume carrying mode of travel across the city.

Characteristics of TOZ

- Walkable development Within 5min. Legal Procedure of Local Area Plan(400m) - 10min. (800m) walking distance.
- Boundary shall publish in Official Gazette us 76 A (2) of the GTPUD Act, 1976
- High density development.
- Mixed Uses (Horizontal & Vertical Mix).
- Improved Street Network Connectivity and Walkable Block Size.
- Pedestrian friendly street environment.
- Efficient use of ground.
- Intermodal connectivity.
- Efficient infrastructure.
- Seamless integration of public and private
- Parking Management (On-street and Off-street).

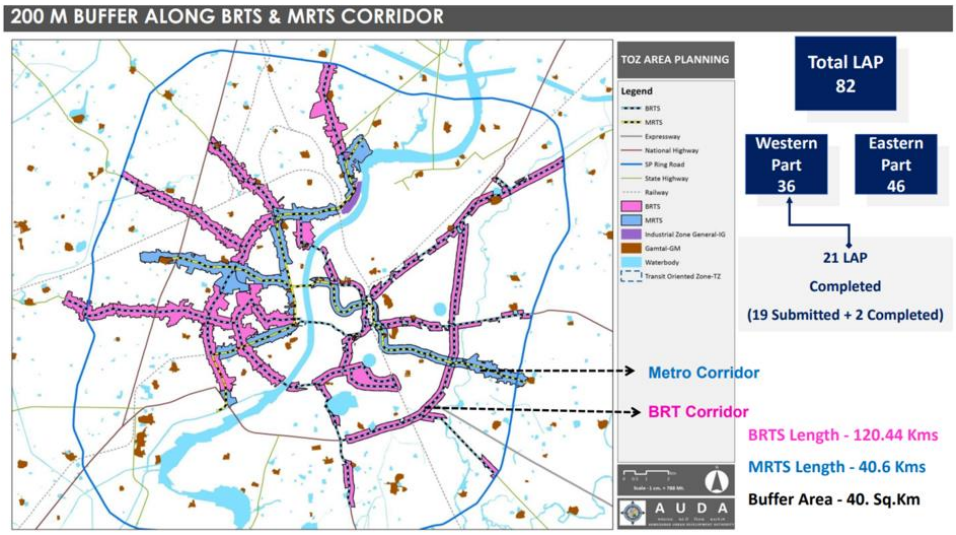


Figure 3.8 Buffer zones along BRTS & MRTS corridor

Source: National workshop on urban reforms

The currently the development around the transit corridors of Ahmedabad are not "Transit Oriented". They are typically low density, not very walkable, not pedestrian friendly, encroached by haphazard parking and lacks sufficient infrastructure.

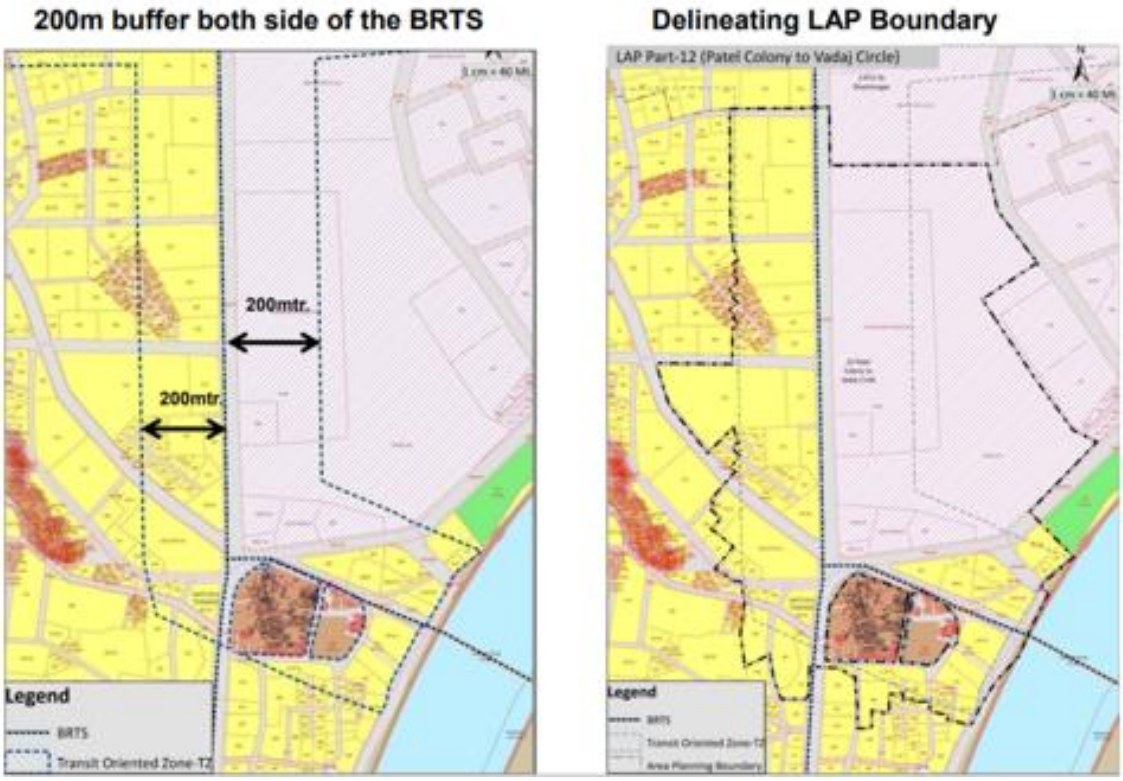


Figure 3.9 Buffer zones boundaries is shown in the map

Source : National workshop on urban reforms

General control and regulations -recommendations

Maximum permissible height

The maximum permissible building height shall be as per provision of Planning Regulation 9.45 and according to the width of the road on which it abuts as prescribed below.

Table 3.1 Maximum permissible height

Source : National workshop on urban reforms

No.	Road Width (in meters)	Maximum Permissible Building Height (in meters)
1	Less than 9.0 mts	10.0
2	9.0 mts and less than 12.0 mts	21.0
3	12.0 mts. and less than18.0 mts	25.0
4	18.0 mts and less than 36.0 mt	45.0
5	36.0 mts and above	70

Provided that building height up to 210 m and up to 4 shall be permitted on 9.0 road. Other regulations for 5.0 m wide road shall be applicable as per GDCK Provided that, if the height of the building is more than 45 meters, the pro vision of regulation No 4.8 shall also be applicable as per GDCR-202

Table 3.2 Margins required

Source : (National workshop on urban reforms, 2022)

Sr.no	Categorization	Road Typology	Margin Required
1	Future ROW-(Right Of Way)	New proposed road in LAP	(1) 1.5m from new plot boundary for building height up to 25 m. 2) 2.0 m from new plot boundary for building height above 25 m and up to 45 m (3) 3.0m from new plot boundary for building height more than 45 m
2	Flexible Road	Flexible road identified in LAP	To be converted in Future ROW with planning liberty and margins shall be as required as for ROW
3	Pedestrian Road	Existing road to be utilized for public movement	Can be realigned at the time of redevelopment, as stated by the Authority
4	Existing ROW		

Relaxation in Parking

For Building units within the Transit Oriented Zone with Commercial (Business and Mercantile 1) Use, the parking requirement shall be as under:

Table 3.3 Maximum permissible height

Source : (National conference on urban reforms , 2022)

Type of Use	Minimum Parking Required	Visitor's Parking and Remarks
Business, Mercantile-1	35% of Total Utilised FSI	20% of the required parking shall be provided as visitors parking

Limitations

Availability of Land and Land Acquisition

Land aggregation is a major concern for the TOD policy as undertaking necessary pedestrian-friendly development would require acquisition of land along the right of way of the public transportation system.

Increased flexibility in existing contracts and contractual commitments

In case the existing contractual framework does not permit 'expansion' or 'change in the original scope of work of the transit-oriented development, it may lead to delay in implementation of the TOD project.

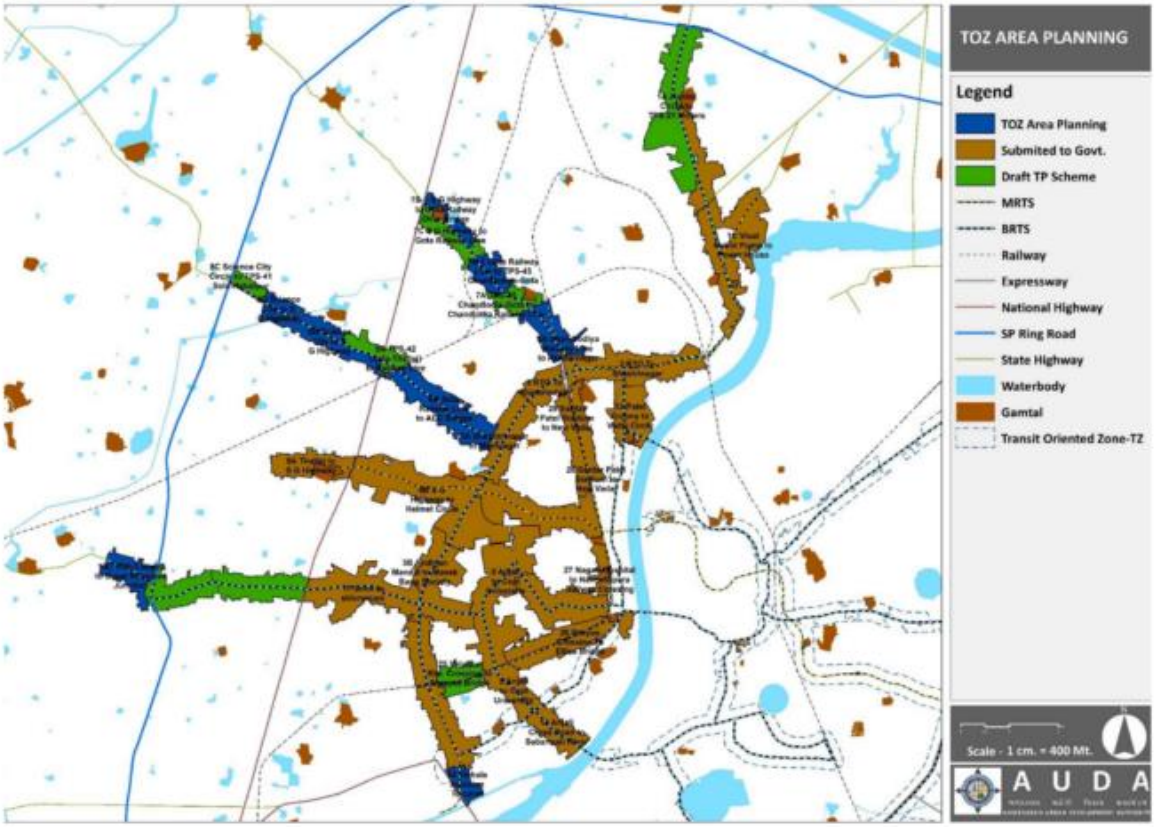


Figure 3.10 Local area draft plan

Source : (National conference on urban reforms , 2022)

Gentrification

Average prices for homes near TOD areas may be costlier than in areas far from such developments. In this context, those with poor purchasing power may get replaced by the richer households through the process of Gentrification.

3.2.1 Inference

Ahmedabad exemplifies an incremental approach to the implementation of TOD. The goal of this city is to prevent sprawl by encouraging a compact city layout with greater densities in areas with convenient access to public transportation. The central business centre of the city will be developed using a market-driven approach to land use, mixed-use construction, high densities, public transit, and a grid-based pedestrian circulation network.

3.3 Indore, India

Indore is known as the traditional city of TOD. Two major arteries M.G. Road and Jawahar Marg are developed over a period of nearly 100-125 years in organic growth pattern earlier up to 1920 and later as a part of plan development as per Master Plan prepared by Sir Patrick Geddes in year 1918. Indore, located on the Western region of Madhya Pradesh is one of the most important commercial centers of the state. The rich chronological history of Indore is worth considering (Government of Madhya Pradesh, 2023).

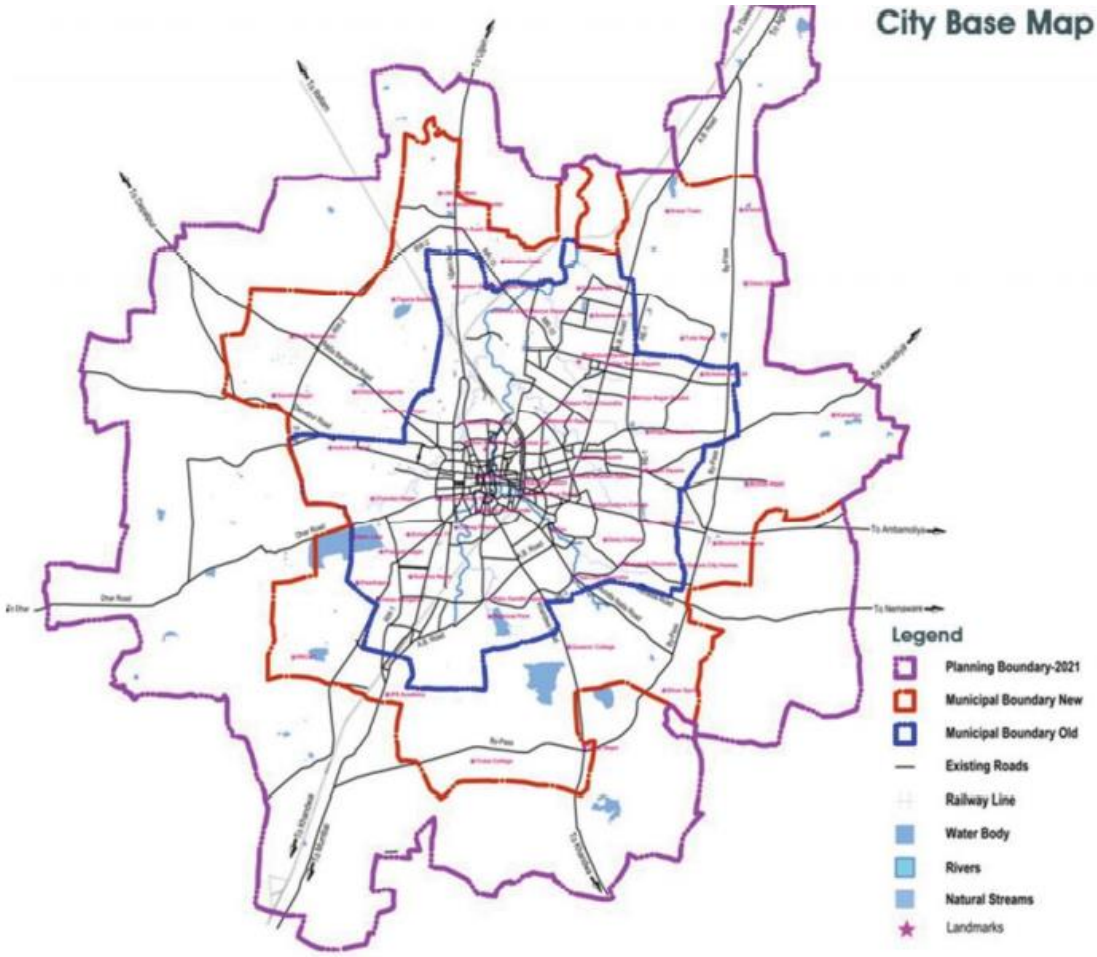


Figure 3.11 Indore base map

Source : Indore smart city master plan ,2022

Why TOD ?

Cities in Madhya Pradesh are witnessing rapid growth not only in terms of population but also in their spread leading to low density urban sprawls. The urban sprawl is leading to stress on limited urban infrastructure and urban local bodies are often trying to catch up with providing extended urban services to the ever-expanding urban sprawl. This has also drained their financial capacity in providing access to urban services to the highly populated, sparsely distributed and largely spread cities. Further with increase in urban spread the travel lengths and time are also increasing which is leading to use of un-sustainable means of transport. This together with the increased number of trips have made sustainable modes of transport such as public transport unviable and often falling short to meet the huge travel demands.

TOD implementation

Transit oriented development is defined as moderate to high, pedestrian, friendly, mixed-use development containing major transit stops within walking distance. Placing of commercial, housing, offices, parks, and civic uses within walking distance of transit Stations and Corridors. TOD can be new construction or redevelopment of an area which encourage transit use. Major goals of TOD are:

• Organize Growth and Development on a regional level to be compact and transit-supportive.

• Enhance Ridership along all transit corridors

• Reduced incentive to sprawl, increased incentive for compact development on and along transit Stations and Corridors

• Create pedestrian- friendly street networks which directly connect local destinations.

• Raise additional resources for economic development on the corridor due to generation of “activity centres” around the station/ stop area.

• TOD should provide a wide range of supporting benefits for local communities, including increased uses and services, a variety of housing, increased transportation options, and a more walkable environment and community amenities through consultation with them.

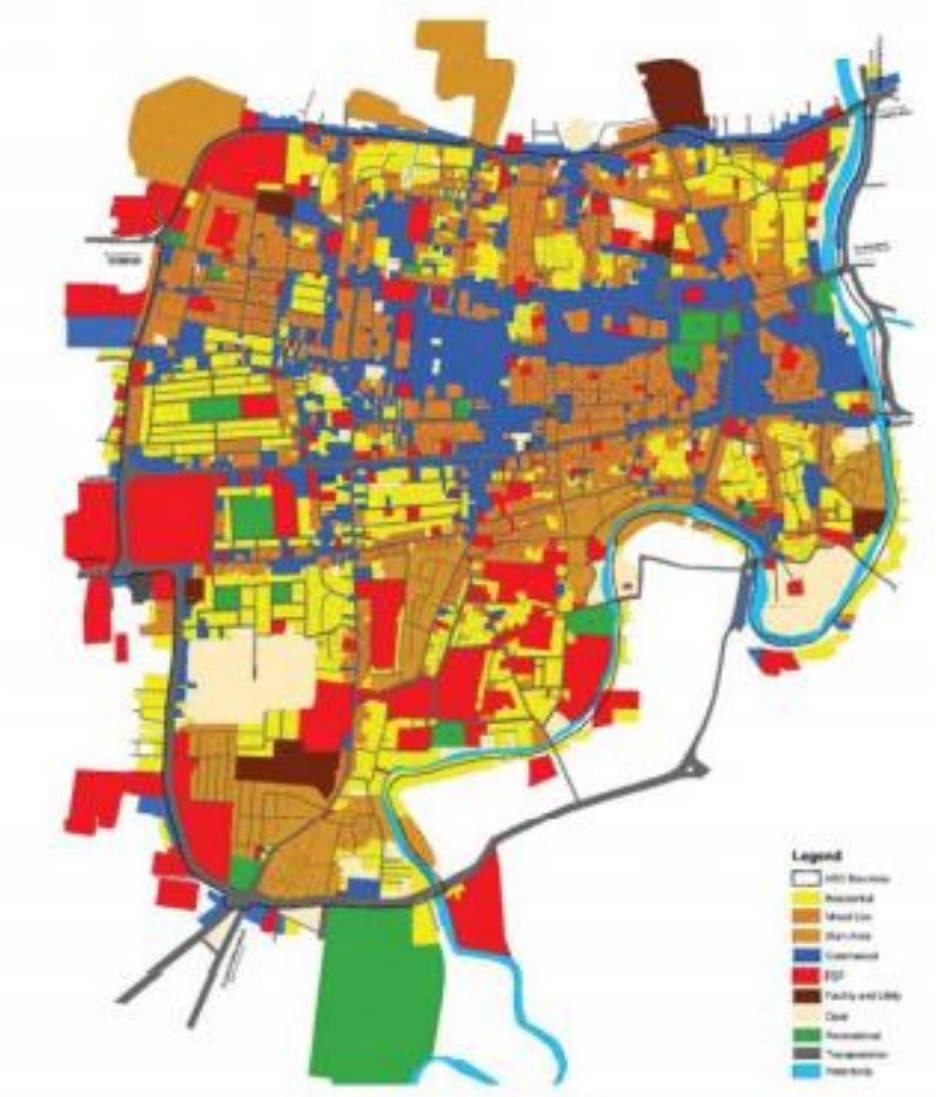


Figure 3.12 Indore landuse map

Source : Indore smart city master plan ,2022

Smart mobility

To ease movement in the heritage precinct and to integrate it with smart city features, a smart vehicle route (e-rickshaw) is proposed. It begins from Bakshi gali (adjacent to the proposed parking) and covers the entire Heritage Precinct Area with designated drop-off points. The proposed length of e-rickshaw route is 2.15 km. 20.1.12

Parking

focusing on the heritage precinct, which is proposed to generate and attract maximum vehicular traffic. highlighting pedestrian only streets, access road is to be proposed to connect proposed parking sites. These sites are: bazazkhana (existing), khajuri bazar, veer sawarkar market, bakshi gali and cloth market.

Attractive and vibrant streetscape

To create a safe high quality public realm, utilizing facades that enliven the street, thus making walking more interesting. Sensitive design of the building forms and scale is important to complement and reinforce the greenery, civic and heritage characters of the area. Barrier free and visually appealing streetscape should be provided in the core of ABD. To develop a common language for street scaping, enhance connections to the open space network and generally provide safe, comfortable connections between uses. To extend the street network through a series of improved streets, sidewalks, walkways, and driveways to service and address new development, and provide safe, comfortable connections between uses, minimizing the traffic impacts on surrounding residential areas.

3.3.1 Inference

Create dense networks of streets and paths for all modes of transport. Disperse high traffic volumes over multiple parallel streets rather than concentrating traffic on fewer major arterial roads. Create fine networks of streets that provide choice of routes, for all modes of transport, while reducing distances between places. The development proposals/Layout Plan/TD Scheme etc. in the TOD Area shall provide shortest direct route for pedestrians and NMV modes up to Transit Stations/Corridors as well as between individual

buildings/complexes. The development proposals in the TOD Area shall create “eyes on the street” by removing boundary walls or compounds and building to the edge of the street ROW and by having uniform building line. This would discourage misbehaviour, shady corners, urinating in public places, etc. Mixed use without boundary walls, built-to-edge buildings with minimum/no roadside marginal open space (MOS) and non-opaque fences along with other informal on-street activities like hawker’s zone in the TOD Area, shall help provide natural surveillance of public spaces.

3.4 Analysis of case studies

Table 3.4 Case study analysis – Ahmedabad

Source: Author Generated, 2022

SLNO	CATEGORY	AHMEDABAD
1	Theme	An incremental and progressive approach based on BRTS
2	Context	• Urban agglomeration population of 6.3 million • Located on strategic Delhi-Mumbai industrial corridor, that creates a large potential for investment and development. • 52% decline in ridership of public transport
3	Scale	Regional level
4	Mode of transit	BRTS
5	Strategies	• Increased density along the corridor • Max FSI : 5.4 in CBD, 4 in transit corridor and 1.8 in other part • No segregated land use under influence zone • Pedestrian only zone along parts of CBD • Bike sharing programme MYBYK (cycle for rent app) • Increased parking rates at CBD • Reduced slums by providing resettlement plan

SLNO	CATEGORY	CURITIBA
1	Theme	Managing existing transportation system with BRTS
2	Context	• Urban population of 1750 million in 435sqkm • Uncontrolled urbanization • Traffic congestion a major issue • Low NMT network
3	Scale	Regional level
4	Mode of transit	BRTS
5	Strategies	• Restricting land use typology – mixed use development along transit corridor • Mixed use development along 2.5km radius along transit • Limited duration of off street parking and expensive • Private vehicles has partial restriction to CBD area • TOD zone has a density of 294 persons/Ha
SLNO	**CATEGORY**	**COPENHAGEN**
1	Theme	Five figure plan concept and stroget
2	Context	• Contiguous streets running from town hall to kings new square

3	Scale	• Regional level
4	Mode of transit	• BRTS
5	Strategies	• Radial public transportation system serving the city with five fingers • Concentric urban housing development along the medieval city centre • Housing and employment placed close to the main lines for daily commutation • Pedestrianizing central city area and restricting private vehicle entry • Outer zone for recreational facility
SLNO	**CATEGORY**	**INDORE**
1	Theme	**Smart mobility** To ease movement in the heritage precinct and to integrate it with smart city features
2	Context	• . Indore, located on the Western region of Madhya Pradesh • Indore is known as the traditional city of TOD • organic growth pattern of city • estimate population of Indore city in 2023 is **2,707,000**
3	Scale	• CBD area (smart city project)

4	Mode of transit	• NMT , e-riksha, MRTS
5	Strategies	• TOD Area shall provide shortest direct route for pedestrians • Removing boundary walls or compounds and building to the edge of the street ROW and by having uniform building line. • Disperse high traffic volumes over multiple parallel streets rather than concentrating traffic on fewer major arterial roads. • Disperse high traffic volumes over multiple parallel streets rather than concentrating traffic on fewer major arterial roads.

CHAPTER 4 SITE ANALYSIS

In this chapter, the introduction to study area, location, demography, landuse and transportation network. A brief overview of urban travel trends and patterns, as well as community and land use connected to transportation study methodologies such surveying, network analysis, assignment, and distribution procedures.

4.1 Location

The district is located at latitudes 8° 17' and 8° 51'N and longitudes 76° 41' and 77° 17'E. On the west coast, close to the southernmost point of the continent, the city is situated at 8°30 N and 76°54 E. The Lakshadweep Sea to the west and the Western Ghats to the east encircle the city, which is located on India's west coast. Thiruvananthapuram City, the State's capital and the district's administrative centre, is shown on the map. The city has a 212.84 sq km area.

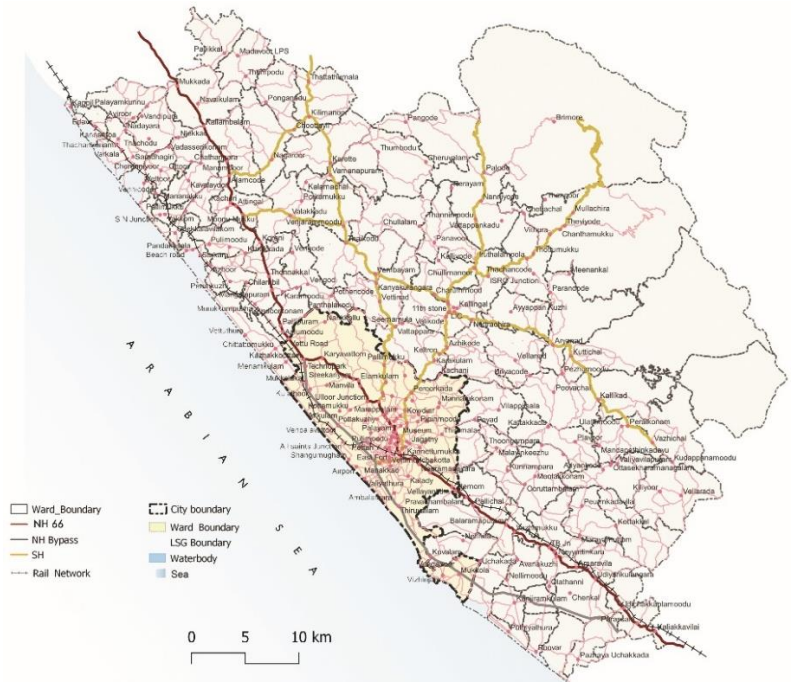


Figure 4.1 District map of Trivandrum

Source : Author generated ,2023

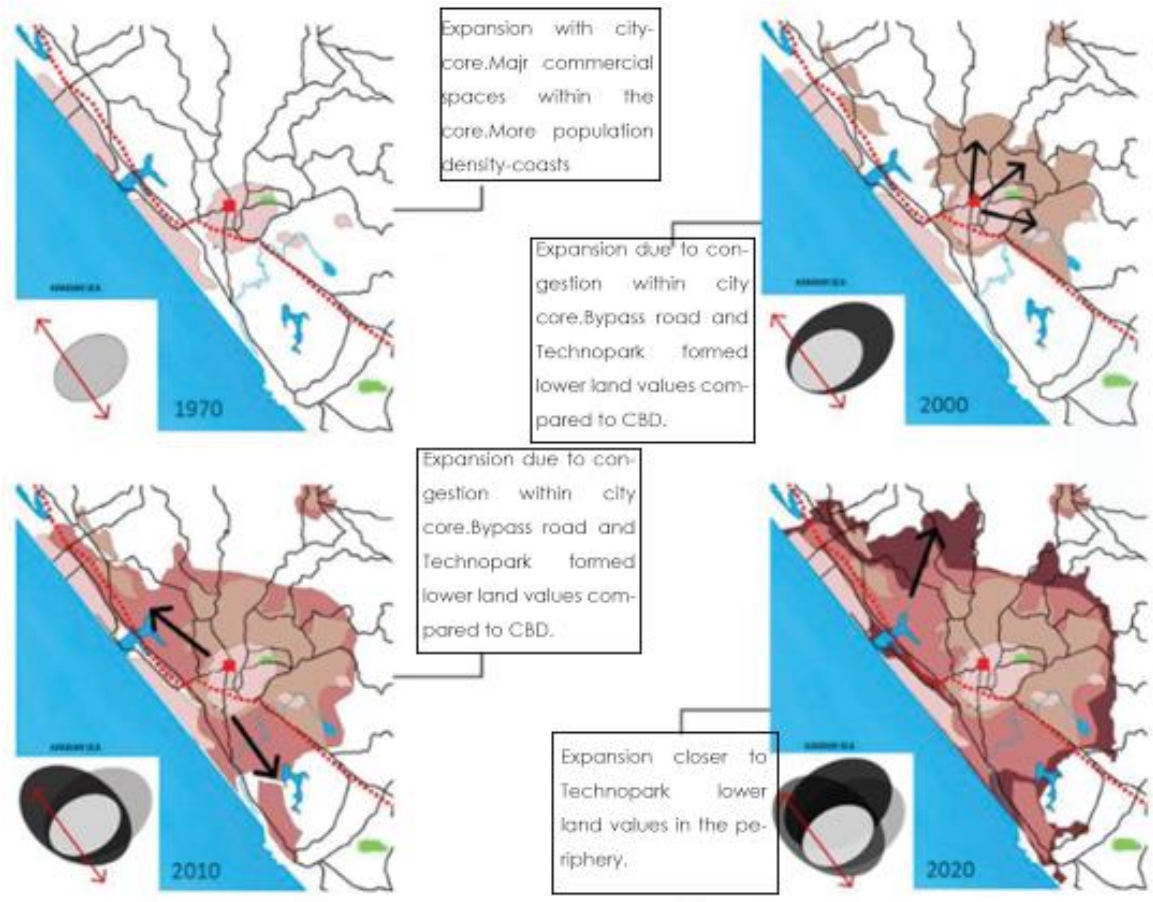


Figure 4.2 Growth of the city

Source : Retrieved from CEPT 2021 thesis report

4.2 Administrative divisions

The district headquarters of Thiruvananthapuram district is at Vanchiyoor. The Thiruvananthapuram district has a single revenue division which is Thiruvananthapuram. Thiruvananthapuram is divided into 4 taluks and 120 villages. The 4 administrative taluks in Thiruvananthapuram are Thiruvananthapuram, Chirayinkeezhu, Neyyattinkara and Nedumangadu. In Thiruvananthapuram there are 12 Blocks and 78 Grama Panchayats, Thiruvananthapuram is a Municipal Corporations and there are 4 Municipalities namely Attingal, Neyyattinkara, Nedumangad and Varkala. There are 2 Parliamentary Constituencies namely Chirayinkeezhu and Thiruvananthapuram and there are 14 Assembly constituencies.

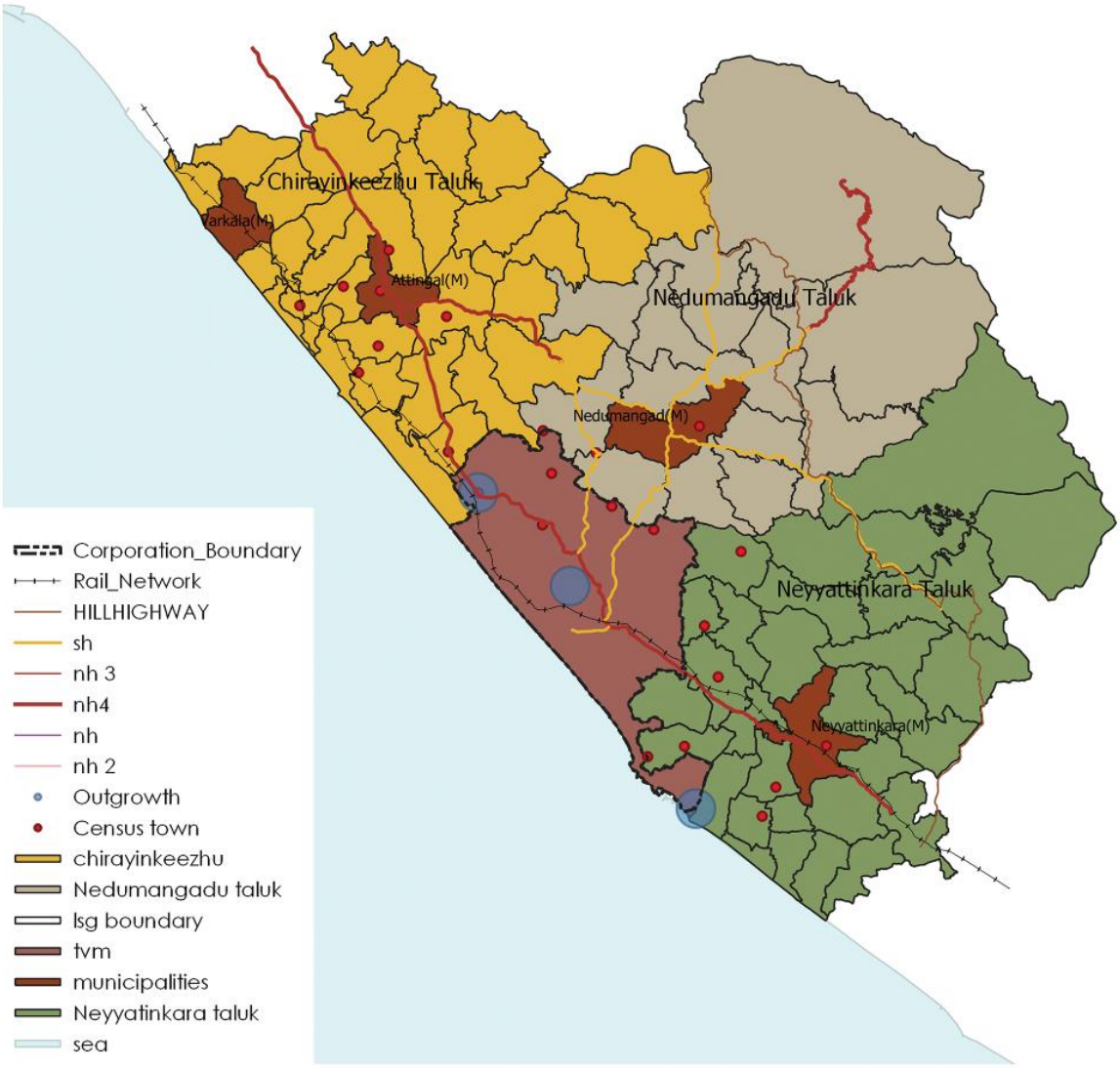


Figure 4.3 District map of Trivandrum

Source : Author generated ,2023

4.3 Planning interventions

The Department of Town Planning started functioning in 1957 with head quarters at Thiruvananthapuram and regional offices at Ernakulam and Kozhikode, mainly to ensure planned development of urban settlements in the State. In 1999, this Department was renamed as the 'Department of Town and Country Planning' in the context of 73rd and

74th Constitutional Amendments.

Functions :-Preparation of various plans , statutory approvals, drafting legislations and government policies ,spatial planning , Art and heritage,Nodal agency of the centrally sponsored

DTP SCHEMES

The first Master Plan for Thiruvananthapuram was prepared during 1966, and was sanctioned by Government in 1971. -Later, two Area Development Plans and 13 Detailed Town Planning Schemes were prepared and sanctioned by the State Government in accordance with the Town Planning Act, 1108 as detailed below.

Area Development Plan for Trivandrum Medical College area was prepared and sanctioned in 1976 and Area Development Plan for Kovalam, Vizhinjam was sanctioned by Government in 1978.

4.4 Population

As per 2011, census the total population of Thiruvananthapuram Corporation is 986578 which was 955494 during 2001. To have a comprehensive notion about the demographic dynamics, it is necessary to view the population size and other aspects from a vast scenario. Census 2011 place Kerala's population at 33387677 persons which includes 15,84,200 males and 17,23,084 females. Although Kerala accounts for only about one per cent of the total area of India; it contains about 2.76% of the country's population. The population of Thiruvananthapuram district as per Census 2011 is 33,07,284. Though Thiruvananthapuram accounts for only 5.64% of State's area (2,192 Sq.km against 38,863 Sq.) it comprises 9.9% of the State population. There is a linear increase in the population of the district, and it has grown from 21,98,606 to 3307284 in a period of 1971 to 2011.

Table 4.1 : Population data

Source: Author generated from census 2011

Year	Kerala	Thiruvananthapuram district	Thiruvananthapuram corporation
1981	25453680	2596112	781592
1991	29098518	2946650	885483
2001	31841374	323435	955494
2011	33406061	3307284	986578

It is seen that the population size is more in coastal wards towards south of airport, and the size is less in wards located towards city core. The peripheral areas of city which are added to corporation limits by merging GPs are showing below average population size. Among Wards within Corporation, total population is more in Ward 65 (Thiruvallom 25185 persons) and is least in - Ward 78 (Muttathara - 1143 persons).

Figure 4.4 Graph showing population growth

Source: Author generated

4.4.1 Population density

The average population density of the State is 859 persons per square kilometres, 2.25 times the national average. The average population density of and 1991-2001 Thiruvananthapuram district is 1509 which is 1.75 times g 2001-2011 as higher than the State average.

Within the district, coastal LSGs are having greater population density which lowers on going towards mid land to high land. the population density is higher in city core area and towards coastal wards.

The areas recently merged with the City Corporation are less dense. It can be inferred that land is available for new development in the expanded peripheral areas than in core city area or coastal belt. Towards northern side in the coastal belt large chunks of land are occupied by airport, Vikram Sarabhai Space Centre (VSSC), and other industries. Among wards within Corporation, Population am density is more in Ward 72 (Manacaud- 15908 persons/ Sq.Km) and is least in Ward 32 (Thuruthumoola ward-723 persons/Sq.Km.) The city has an average density of 4444 the persons/Sq.km.

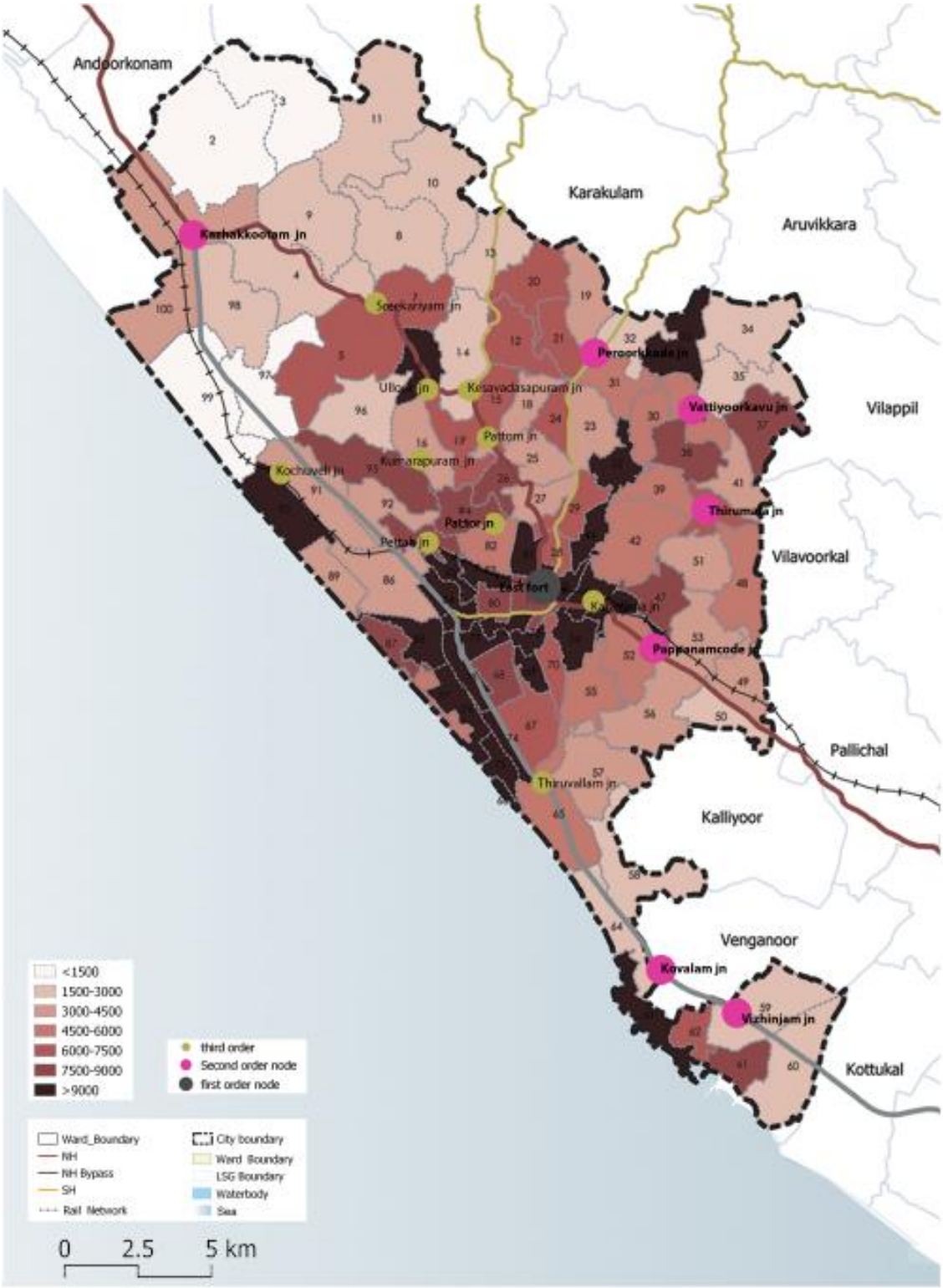


Figure 4.5 Map showing population density

Source: Author generated

4.4.2 Sex ratio

0 to 9 yrs. the number of girls is less than In the City corporation area for considering the inter ward distribution of sex-ratio, the same reconfigured combination of wards was used and found that some planning units in the city core and old Corporation area of are having higher sex ratio than areas on northern side recently merged with Corporation. This shows that these areas are probably having a higher migration of male not members in search of employment. boys. In age group between 25 to 49 yrs. the female population is higher than males.

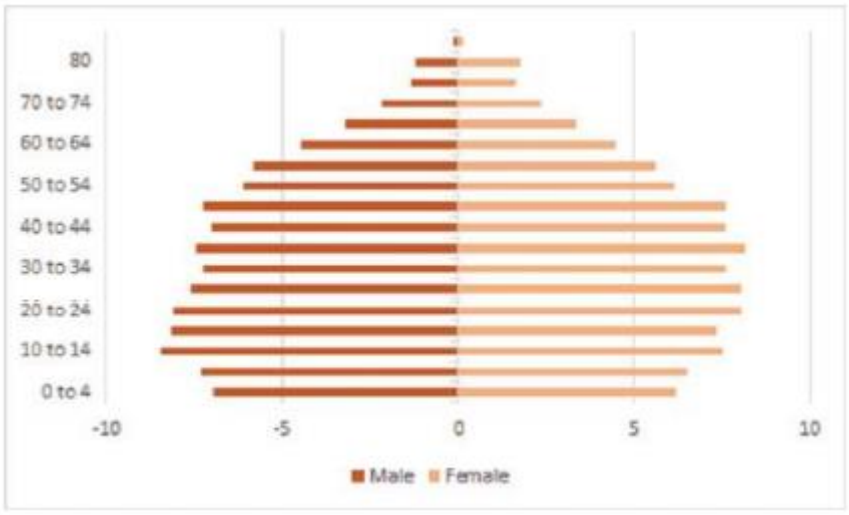


Figure 4.6 Graph showing sex ratio

Source: Author generated

4.4.3 Literacy rate

The average literacy of Thiruvananthapuram City in 2011 was 95.10% (96.51% among males and 93.78% among females). This is higher than the average literacy of the district which was 93.02% (95.02% among males and 91.17% among females). Comparing the literacy rate of the city with that of other cities, within Kerala State, it is seen that Thiruvananthapuram city's literacy rate is comparatively less

4.5 Land Use

The major single and use (65%) in 1966 was residential followed by agriculture (11%). There was discussed considerable Public and Semi-Public land use (6%) am City in naturally being the Capital city. A major area of the corporation limit was kept as vacant land (6%). Area under transportation was 5% and 2% area was restricted area and waterbodies. The land use breaks up of Thiruvananthapuram city 1990 is shown in Chart 7.2. Thiruvananthapuram Corporation during 1990 had a total area of around 141.74 Sq. kms. In 1990 the major single land use was residential (59%) followed by paddy (10%). There was considerable Public and Semi-Public land use (9%) and 8% parks and open spaces. Roads and street covered an area of 7% in the Corporation limit. The core of the area was having more concentration of commercial activities and the city had general function of vibrant core with the periphery acting as raw material centre

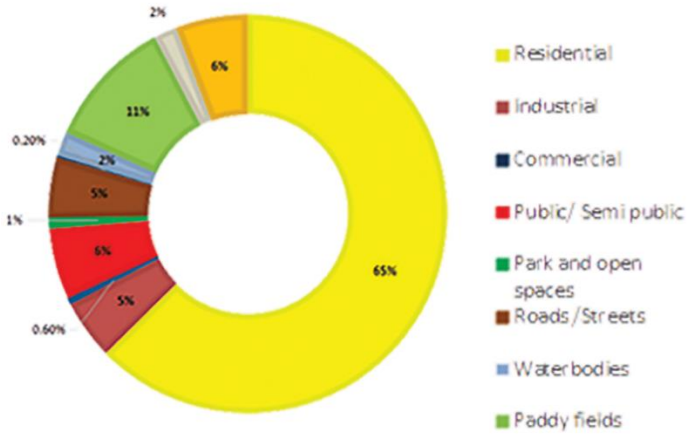


Figure 4.7 Landuse breakup 1966

Source: Author generated with respect to 1966 landuse map

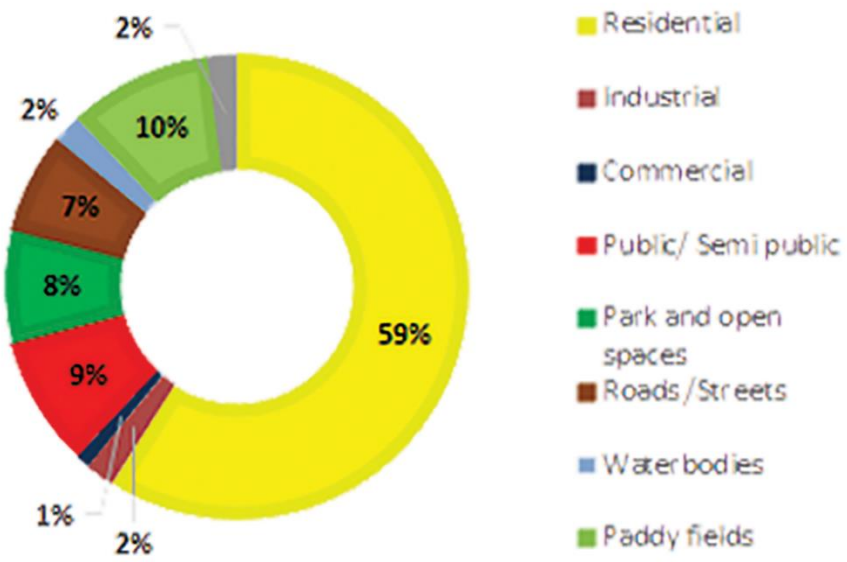


Figure 4.8 Landuse breakup 1990

Source: Author generated with respect to 1990 landuse map

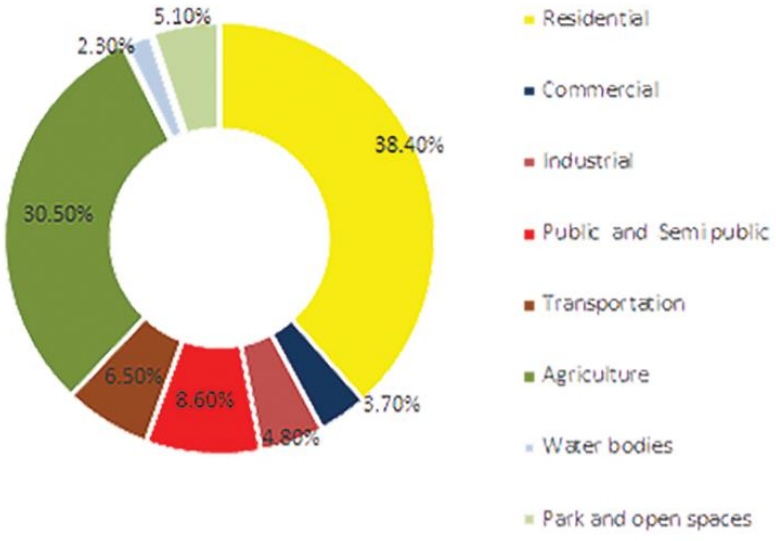


Figure 4.9 Landuse breakup 2001

Source: Author generated with respect to 2001 landuse map

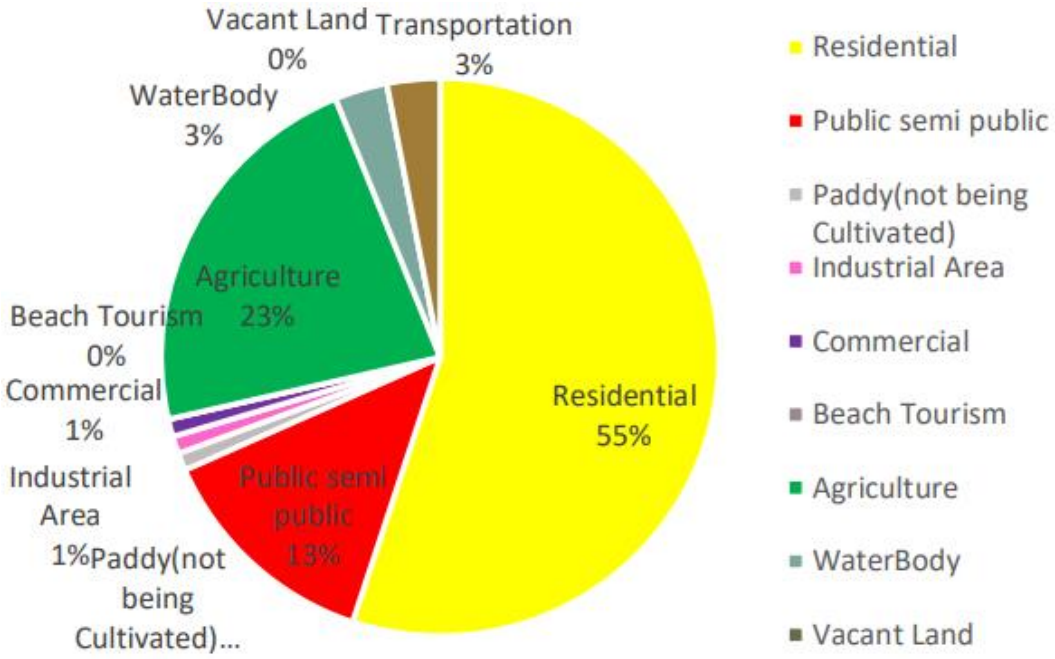


Figure 4.10 Landuse breakup of the city of 2012

Source : Author generated with respect to 2012 landuse map

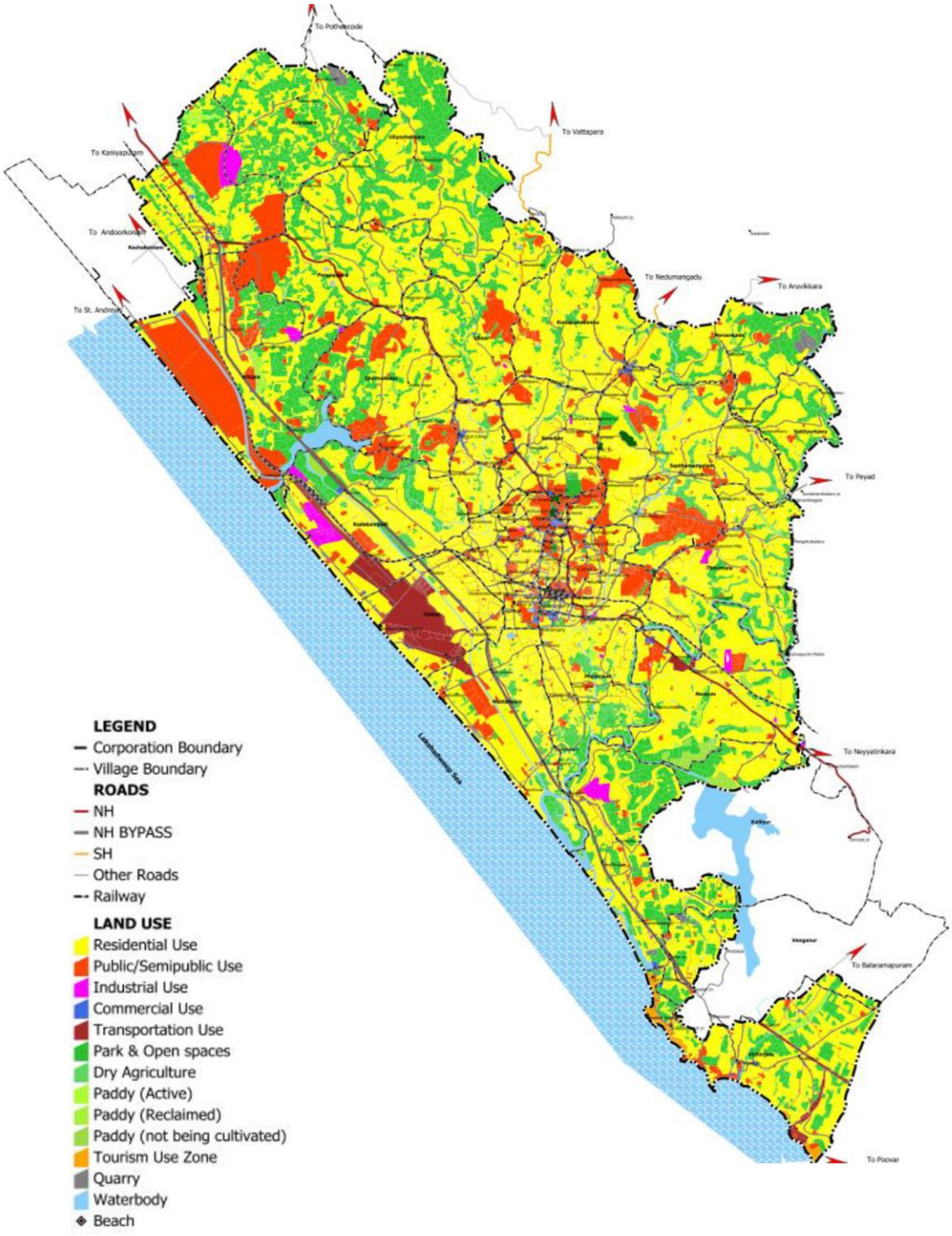


Figure 4.11 Landuse of Thiruvanthapuram 2012

Source: Trivandrum master plan 2012

4.5.1 Proposed Land use map 2031

The existing land use pattern is so changed to facilitate the future developments according to the development vision, to arrive at the proposed land use plan. Thiruvananthapuram city is envisioned as a green city of various functional aspects with an economically lively compact urban form possessing global standards in basic the third priority, in facilities and services.

The city has to be developed to function simultaneously as a Tourism city, Art city, Techno city, Knowledge city and Health Care City and as the State's City, is suggested Capital with a spirited economy while conserving its Blue there is scope for blue - Green Network and achieving a level of compact urban This is taken as a form endowed with high standard infrastructure and service facilities to the people.

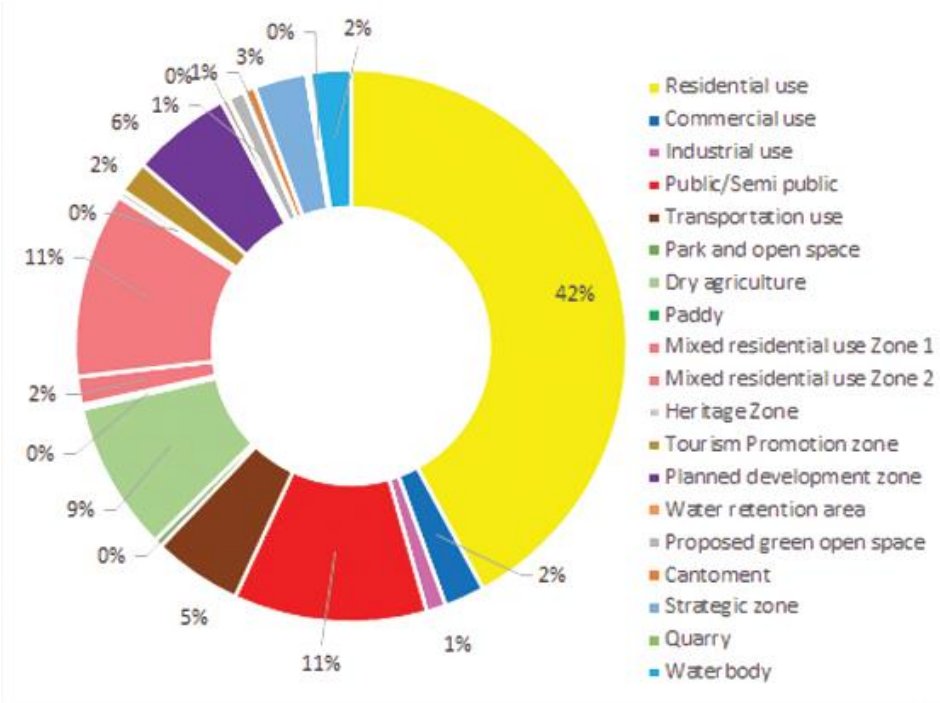


Figure 4.12 Proposed land use breakup of 2031

Source: Thiruvananthapuram master plan 2012

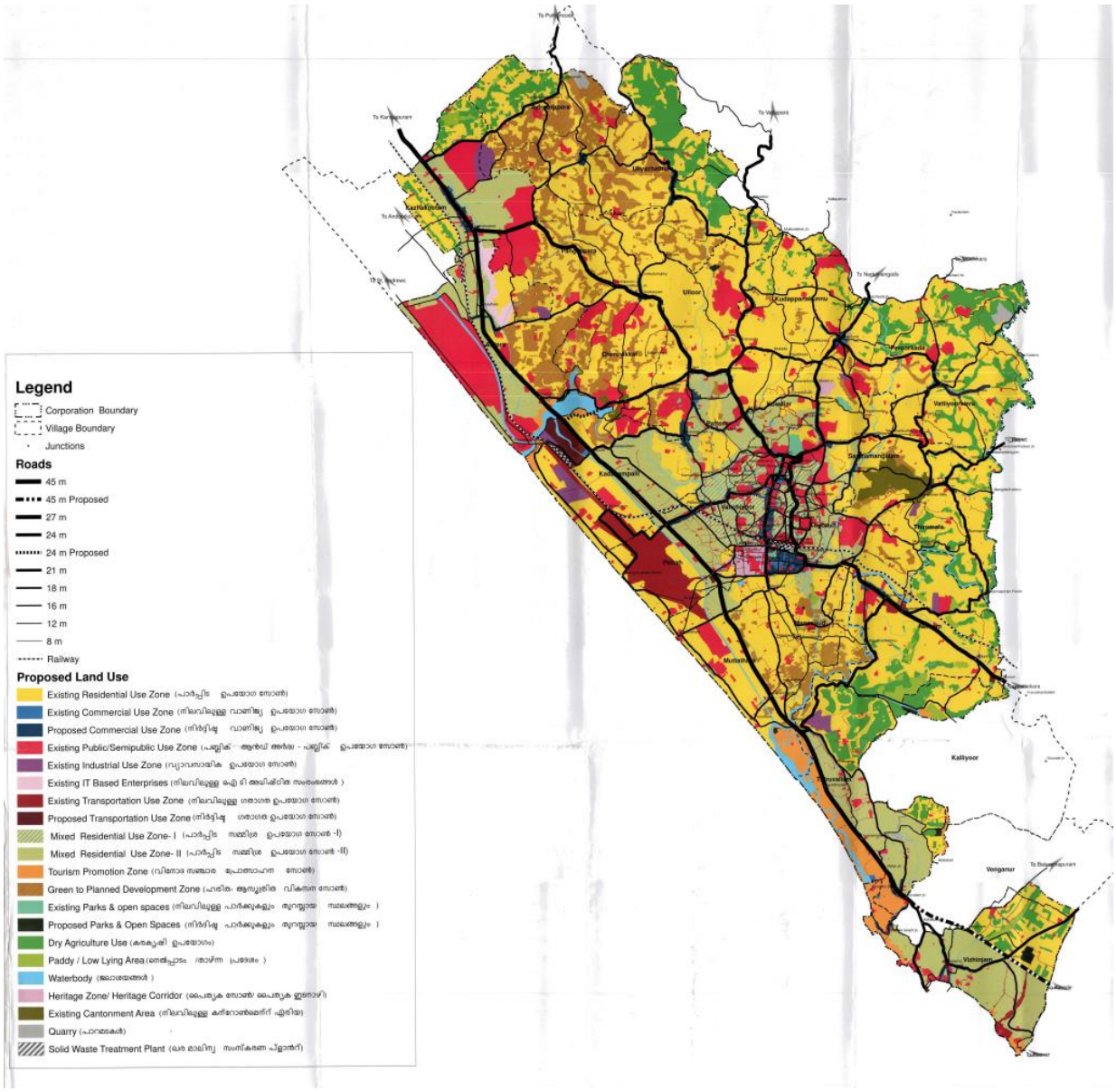


Figure 4.13 Proposed land use map of 2031

Source: Thiruvananthapuram master plan 2012

4.6 Transportation

Thiruvananthapuram City has a good network of roads. Erstwhile National Highway No. 47 (now NH 66) between Salem and Kanyakumari passes through the heart of the City and covers important traffic generating points 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.

The second major road is the Main Central Road (M.C Road, part of State Highway 01) leading to Kottarakkara/Kottayam from Kesavadasapuram which covers Nalanchira and Mannanthala enroute. Thiruvananthapuram-Chenkottai inter-State highway (SH 02) is another major road leading from the city centre and passes through Vazhuthakadu, Vellayambalam, Peroorkada and Vazhayila within City limits.

Rail network

The central railway station is located at Thampanoor in the heart of the city, 8 km from the airport. It is a very important terminus which handles over 50 trains daily. The daily commuter traffic coming from the north and south of the city mainly depend upon the rail transport system.Thiruvananthapuram is well connected to every part of the country by train. Thiruvananthapuram and Kochi cities, the two most important cities in Kerala are also well connected by commuter trains.

Figure 4.14 Map showing connectivity of Trivandrum study area and major nodes

Source : Author generated using QGIS with reference to Base map TPO, Thiruvananthapuram

The second satellite station at Kochu Veli was opened in 2005 near the Thiruvananthapuram International Airport.Apart from Thiruvananthapuram Central and Kochu Veli Railway stations, the following stations are located in the Thiruvananthapuram City.

-Thiruvananthapuram-Eranakulam section
-Thiruvananthapuram Pettah
-Veli
-Kazhakkoottam
-Thiruvananthapuram-Kanyakumari section
-Nemom

By Air : Trivandrum Airport is located 4 km (2.3 miles) of Thiruvananthapuram city centre. Trivandrum Airport is having 628 acres Thiruvananthapuram international airport is located within the corporation limit. It was upgraded to international airport in the year 1991.

By Road: Long distance buses depart from the Central Bus Station (KSRTC Bus Terminal) at Thampanoor, opposite the Central Railway Station.

By Sea: The district has one minor port at Vizhinjam.The total Number of vessels handled was 40 atVizhinjam during 1999-2001(11 steamers and 20 sailing

Inland water : transport is in planning stage with proposals for development of Parvathy Puthanar canal into a major water network and connecting it to the National Water way No. 3 from Kollam to Kottappuram.

4.6.1 Hierarchy of nodes

First order node : The major junction Thampanoor(Thiruvananthapuram Corporation) is taken as the firstorder node in the district. The service area of the node is the entire district.

Second order node : The second order nodes have to fulfill the functions of a city centre mentioned in guidelines for commercial facilities in the Town and Country Planning Organization (TCPO), Govt. of India . As per TCPO guidelines, city centre has to cater a

population of 3 lakhs. But due to dispersed settlement in the district, the service population of the II order nodes is taken as 4.5 lakhs.

Figure 4.15 Trivandrum city map showing road characteristics

Source: Author generated using QGIS with reference to Base map TPO, Thiruvananthapuram

4.6.2 Traffic Characteristics

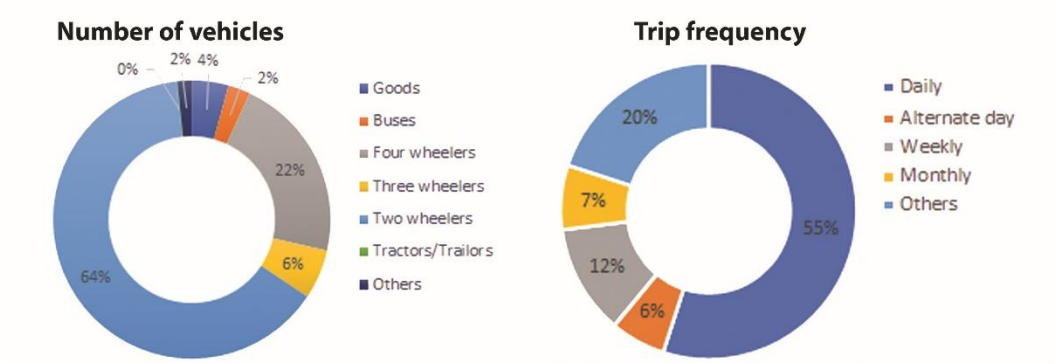
(i) Speed and delay: Average journey speed in the city on the major travel corridors is found to be 25 kmph.

(ii) Traffic flows at screen line locations: Uppidamoodu and Overbridge ROB had the highest traffic volume of 63,000 each during the 16 hour period between 6.00 AM and 10.00 PM, followed by 47,000 PCU at Karamana Bridge, 40,000 PCU at Thampanoor ROB and 37,000 PCU at Petta ROB.

(iii) Occupancy: Average peak hour occupancy of bus was found out to be 41, that of car 2.03, auto 1.60 and two wheeler 1.22.

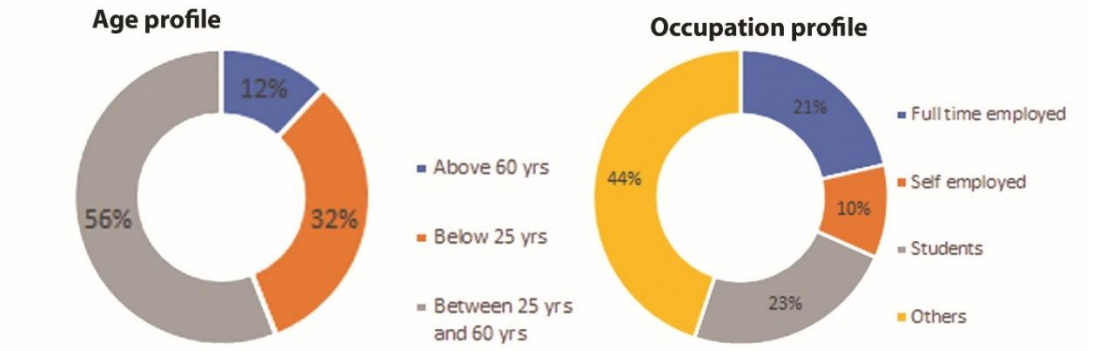
(iv) Traffic flows at Outer cordon locations: Out of 1.78 lakh vehicles traffic through the 19 outer cordon locations, two locations on NH 66 and two locations on SHs together accounted for more than 44% of the total vehicular traffic.

(v) Traffic flow at intersections: Out of the 56 major intersections in the study area, the highest volume of peak hour movements was observed at Pattom Jn (>8,000 PCU). Kesavadasapuram had traffic volume between 7,000 and 8,000 PCU. 11 intersections had traffic volume between 6,000-7,000 and nine between 5,000 and 6,000 PCU.



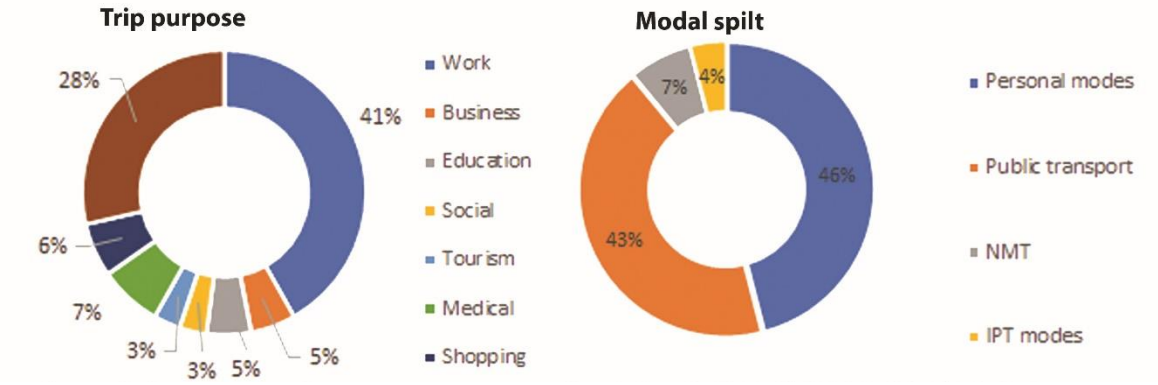
Two-wheelers and four-wheelers are the main modes of transportation. Public transportation makes up a relatively small percentage.

Daily excursions have a high frequency of travel, whereas alternative day trips have a low frequency.



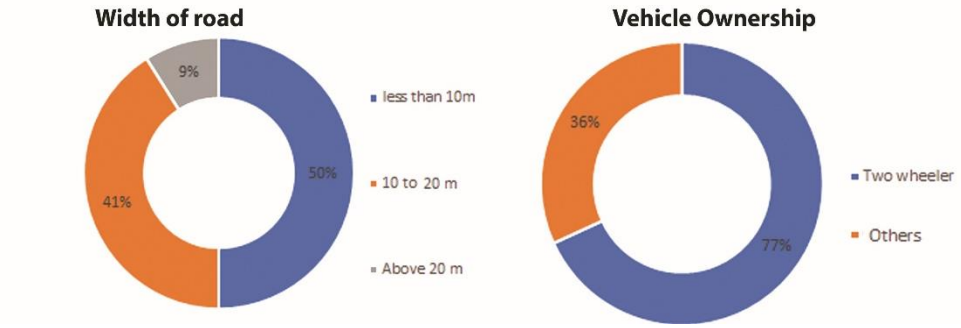
The majority of commuters are between the ages of 25 and 50.

Among the community members' occupations are full-time, independent students and other workers.



The majority of commuters travel for work-related reasons.

The concentration of the modal divide is on personal and public transportation.



Most roads are between 10 and 20 metres wide.

The two-wheeler category has a higher proportion of vehicles owned.

Figure 4.16 Thiruvanathapuram city main junction PCU count

Source: *Author **g**enerated using QGIS with reference to Base map TPO, Thiruvananthapuram*

Table 4.2 : PCU at important intersection in Thiruvananthapuram city

Source: Author generated with respect to NATPAC study 2018

Node	Volume (PCU/ day)	Volume capacity ratio	Road width(m)	Adjoining landuse	Parking time(hr)	Peak Hours	Peak hour PCU
1ST ORDER NODE							
East Fort	1,28,603	2.99	19.2	-	10-16	16.30-18.15	4,751
2nd ORDER NODE							
Kazhakkoottam	61,302	2.92	25	commercial	-	17.30-18.30	3,647
Peroorkada	65,211	1.94	16.5	mixed	-	9.45-10.45	3,775
Vattiyoorkavu	26,132	2.07	10	mixed	-	16.45-17.45	1,986
Thirumala	25,043	1.99	14	mixed	-	9.15-10.15	3,859
Pappanamcode	14,838	1.18	14	mixed	11	8.45-9.45	5,557
Kovalam	10,913	0.87	10	mixed	-	9.15-10.15	1,877
Vizhinjam	7,941	0.63	10	mixed	-	10.00-11.00	1,339
3rd ORDER NODE							
Sreekaryam	50,747	2.42	9	commercial	10	9.30-10.30	2,814
Ulloor	63,251	3.01	11	residential	18	16.45-17.45	5,415
Pattom	123,933	2.46	19	mixed	10	9.00-10.00	7,517
Petta	72,860	3.47	15	mixed	10-12	11.00-12.00	3,191
Kumarapuram	33,696	2.01	13	mixed	-	16.15-17.15	2,222
Medical college	33,390	1.99	12	mixed	18	9.45-10.45	4,676
Thiruvallam	21,218	1.01	12	mixed	-	9.00-10.00	2,488
Karamana	28,250	2.24	10	mixed	17	8.45-9.45	5,545
Veli	12,746	1.01	12	mixed	-	8.45-9.45	4,156

Table 4.3 : PCU at important intersection in Thiruvananthapuram city

Source: Author generated with respect to NATPAC study 2018

Node	Bus	Mini bus	car	Auto rikshaw	Two wheeler	Truck	Mini truck	Goods auro rikshaw	Bi-cycle
1ST ORDER NODE									
East Fort	10610	437	14114	17125	17930	82	259	330	260
2nd ORDER NODE									
Kazhakkoottam	1947	1221	14112	2362	12957	2869	1171	636	324
Peroorkada	1258	288	12735	10905	17392	329	450	509	137
Vattiyoorkavu	175	325	2732	2673	4655	104	89	227	333
Thirumala	304	154	1342	1775	6334	0	349	226	466
Pappanamcode	268	66	2251	1512	5245	360	686	378	240
Kovalam	1032	460	6586	4983	8992	1049	954	911	197
Vizhinjam	531	440	6050	4122	8209	869	792	849	148
3rd ORDER NODE									
Sreekaryam	2045	95	12004	4346	11017	898	372	279	64
Ulloor	2124	673	13724	7265	17050	29	591	515	113
Pattom	2369	939	24990	16147	22998	324	437	447	322
Petta	906	347	11944	9996	16400	594	322	738	187
Kumarapuram	918	327	7207	5730	7474	0	343	392	124
Medical college	1883	620	13005	9257	16483	121	396	478	237
Thiruvallam	601	20	6256	7079	8396	863	942	863	0
Karamana	337	228	6715	3589	8315	239	213	384	72
Veli	18	55	696	526	2293	73	677	41	180

Table 4.4 : Parking duration of vehicles at corridors in Thiruvananthapuram city

Source: Author generated with respect to NATPAC study 2018

Sl. No.	Vehicle type	Duration (Minutes)								Total
		0	<30	30-60	60-90	90-120	120-150	150-180	>210	
1	Bus/ Mini-bus/ tempo	78.57	-	14.29	-	7.14	-	-	-	100
2	Car	79.17	8.96	5.15	3.28	2.21	0.95	0.28	0.38	100
3	Pass auto	82.37	8.90	4.54	2.44	0.87	0.87	-	-	100
4	Two wheelers	77.10	10.42	6.20	2.80	2.00	1.13	0.35	0.14	100
5	Goods vehicles	93.94	3.03	-	3.03	-	-	-	-	100
	Total	**78.33**	**9.72**	**5.67**	**2.95**	**1.99**	**1.04**	**0.30**	**0.22**	100

4.6.3 LTR network

The Comprehensive Mobility Plan Study strongly recommends that a TOD Study be initiated once the higher order mass transit corridors suggested in CMP are approved by the concerned authorities and the Stakeholders.

Eight major corridors that have been identified for the introduction of Mass Transit in Thiruvananthapuram are the corridors along which TOD can be initiated. These corridors include:

Corridor 1: NH – 66
Corridor 2: NH -66 Bypass
Corridor 3: MC Road
Corridor 4: Nedumangad road
Corridor 5: Vattiyoorkavu road
Corridor 6: Peyad road
Corridor 7: Vizhinjam Road
Corridor 8: Airport road

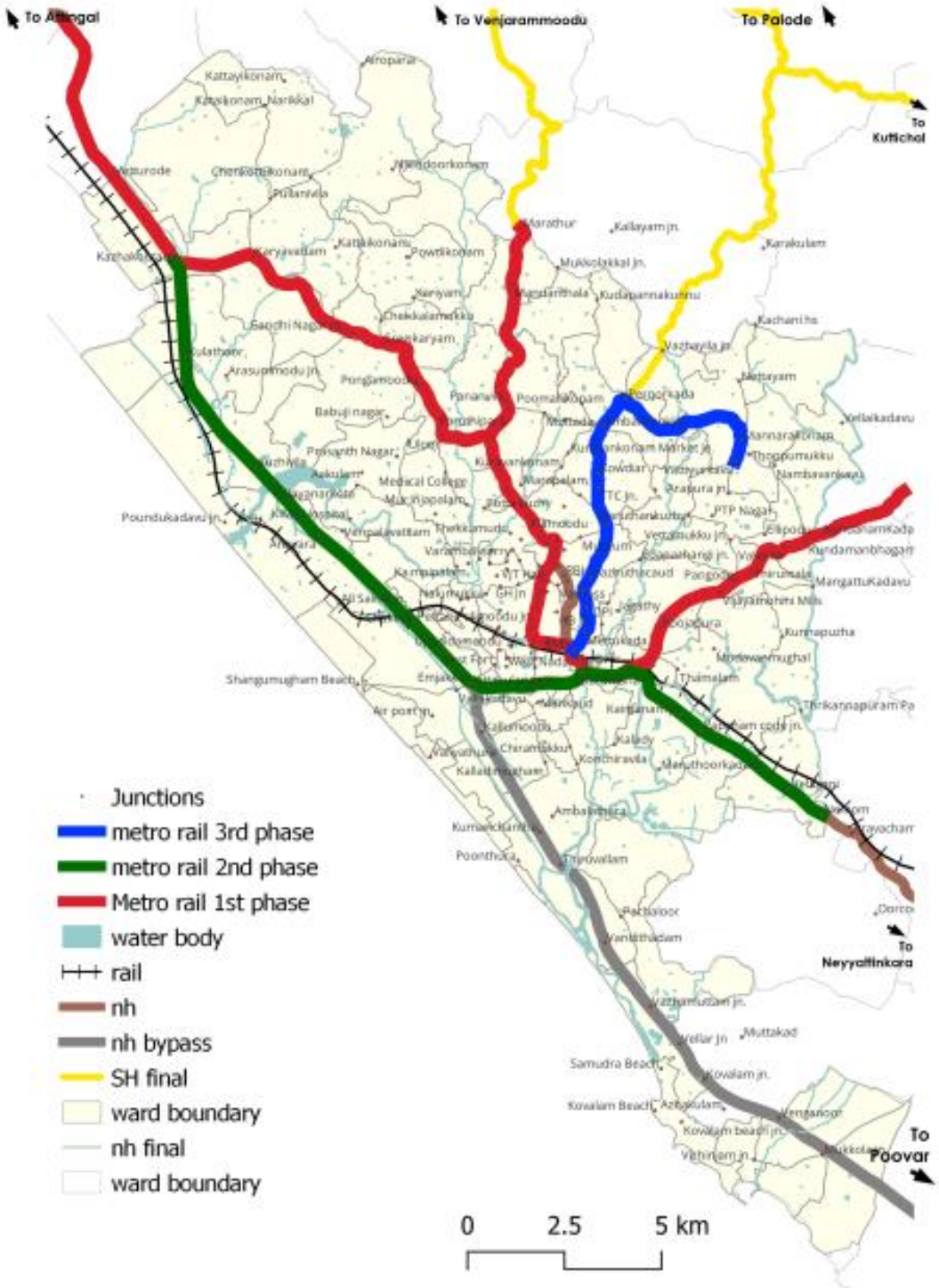


Figure 4.17 Thiruvanathapuram proposed metro rail network

*Source : Author **g**enerated using QGIS with reference to Base map TPO, Thiruvananthapuram*

Table 4.5 : LRT corridors

Source: NATPAC study 2015

Sl.No.	Corridors	From	To	Length (Km)
1	NH-66	Mangalapuram	Neyyattinkara	40
2	NH-66 Bypass	Kazhakkoottam	Vizhinjam	25
3	MC Road	Kesavadasapuram	Mannanthala	5
4	Nedumangad Road	Thampanoor	Peroorkada	8
5	Vattiyoorkavu Road	LMS	Vattiyoorkavu	5
6	Peyad Road	Karamana	Peyad	8
7	Kovalam Road	Over Bridge	NH Bypass	5
8	Airport Road	Palayam	Airport	8
Total				**104**

The output of transport model has highlighted major corridors which need to be well thought-out for selecting higher order public transport system in Thiruvananthapuram. The corridors comprise NH-66, NH-66 Bypass, MC Road, Nedumangad road Vattiyoorkavu Road, Peyadroad, Vizhinjam Road, Airport Road.

Table 4.6 : List of Stations for the Thiruvananthapuram Light Rail Transit system

Source : DMRC Study, 2015

SI No:	Station name		Chainage (m)
1	Dead end		-428
2	Technocity		0
3	Pallipuram		687.8
4	Kaniyapuram		1672.7
5	Kazhakoottam		3062.7
6	Kazhakoottam junction		4181.9
7	Karyavattom		5864.9
8	Gurumandiram		6903.2
9	Pangapara		8274.0
10	Sreekaryam		10002.6
11	Pongumoodu		11488.5
12	Ulloor		12709.5
13	Kesavadasapuram		14296.4
14	Pattom		15114.7
15	Plamoodu		15833.1
16	Palayam		16993.0
17	Secretariat		18284.5
18	Thampanoor		19443.9
19	Killipalam		20527.1
20	Karamana		21821.3
	End of track		22109.3

4.6.4 Proposed ring road

The Outer Ring Road is a green-field project on the outer area of Thiruvananthapuram city. The proposed peripheral road is designed to interconnect all these arterial roads and connect with the aforesaid two major economicgrowth centers on North and South side of the city. This concept plan for the Thiruvananthapuram metro rail network will consist of three lines, which we name Red, Green and Blue, totalling to about 73 km . The network is designed based on the city layout, commuting patterns, traffic flows, destination hotspots and population distribution of the city and surroundings, and its future potential growth.

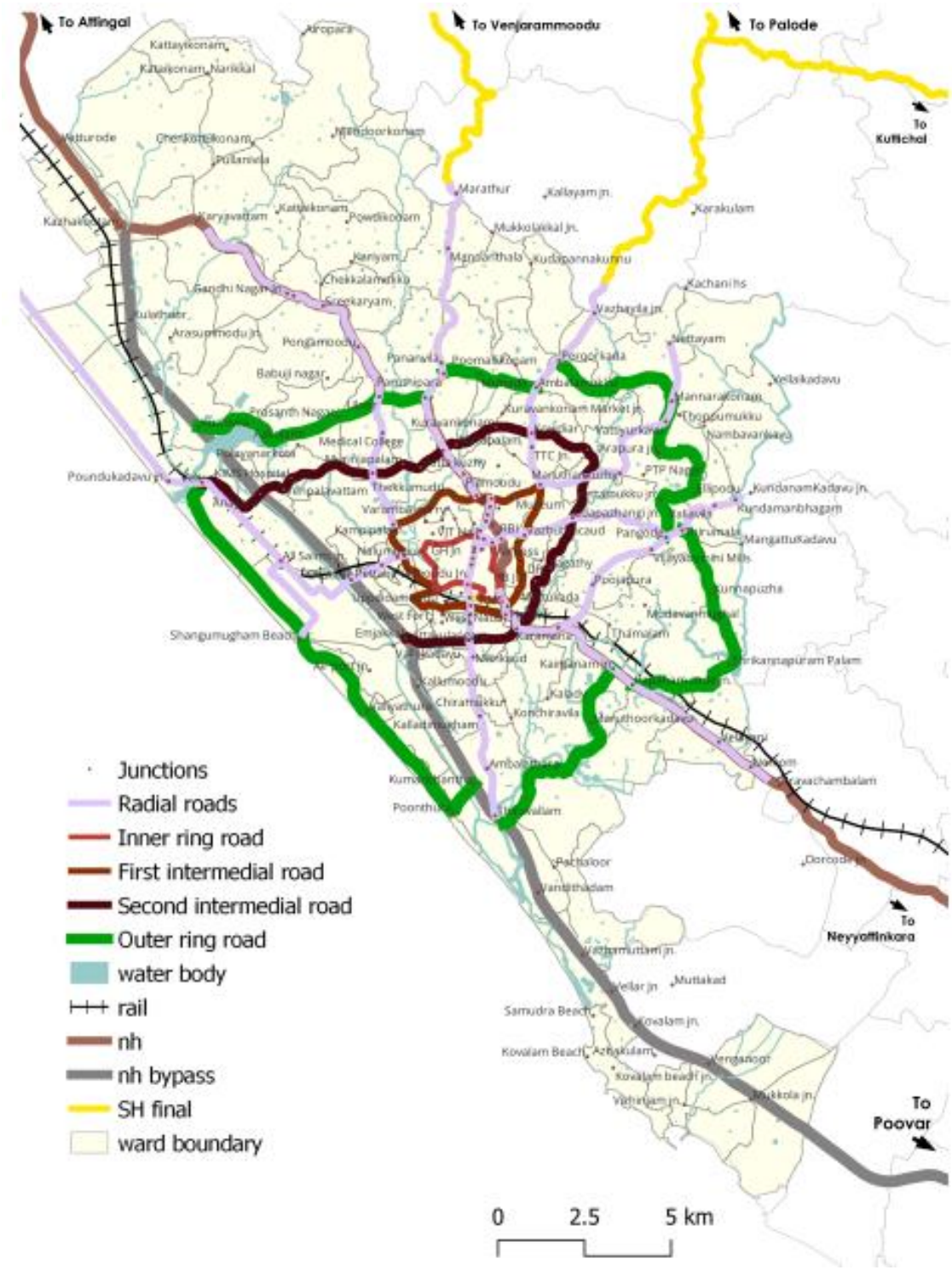


Figure 4.18 Thiruvanathapuram proposed ring road

*Source : Author **g**enerated using QGIS with reference to Base map TPO, Thiruvananthapuram*

4.7 Industry

Thiruvananthapuram is one of the major industrial hubs in Kerala state, The district is also establishing in IT base industries. Many medium and large-scale industries operate in and around the city, giving the city's economy a much-needed boost and offering many employment opportunities.

The Kerala State Industrial Development Corporation is at the forefront of encouraging industry to set up bases in and around the city. These include such majors as Kerala Automobiles Ltd., Travancore Titanium Products Ltd., Indian Clays Ltd., Hindustan Latex Ltd., and Brahmos Aerospace Pvt. Ltd etc The industrial sector includes Primary Secondary, Tertiary, and Quaternary industries.

The primary sector includes agriculture, forestry, fishing, mining, quarrying, and the extraction of minerals. The secondary sector, also called the manufacturing industry, (1) takes the raw materials supplied by primary industries and processes them into consumer goods, or (2) further processes goods that other secondary industries have transformed into products, or (3) builds capital goods used to manufacture consumer and no consumer goods. The tertiary sector also called the service industry includes industries that, while producing no tangible goods, provide services or intangible gains or generate wealth.

An extension of the tertiary industry that is often recognized as its own sector, the quaternary industry, is concerned with information-based or knowledge-oriented products and services. Like the tertiary sector, it comprises a mixture of private and government endeavours. Industries and activities in this sector include information systems and information technology (IT,2018).

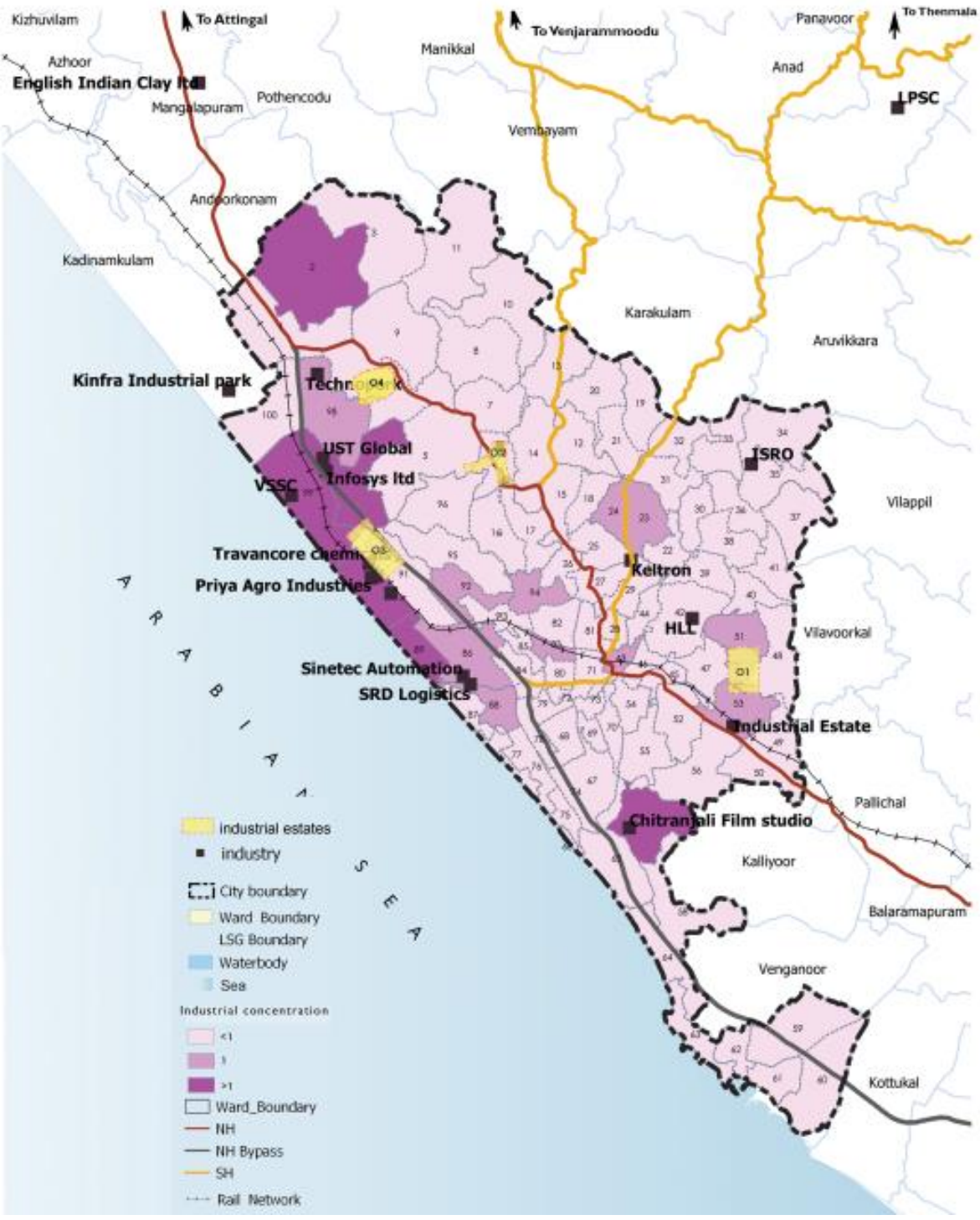


Figure 4.19 Thiruvanathapuram industrial concentration map

*Source : Author **g**enerated using QGIS with reference to Base map TPO, Thiruvananthapuram*

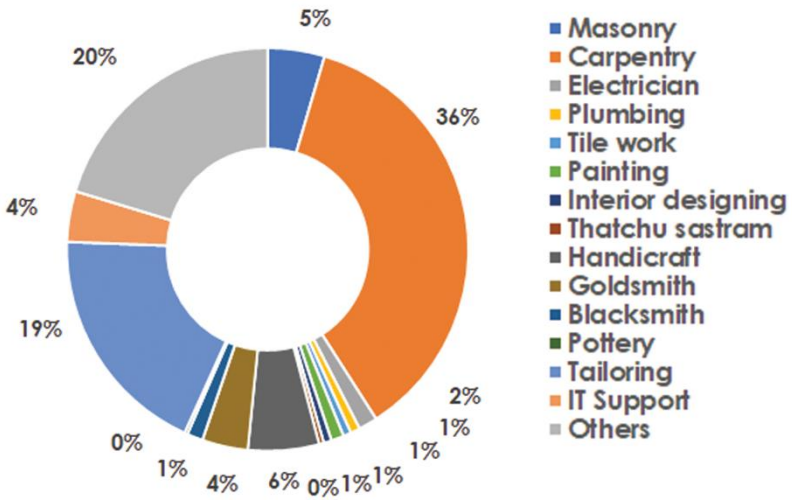


Figure 4.20 Category of registered labours

Source : District handbook

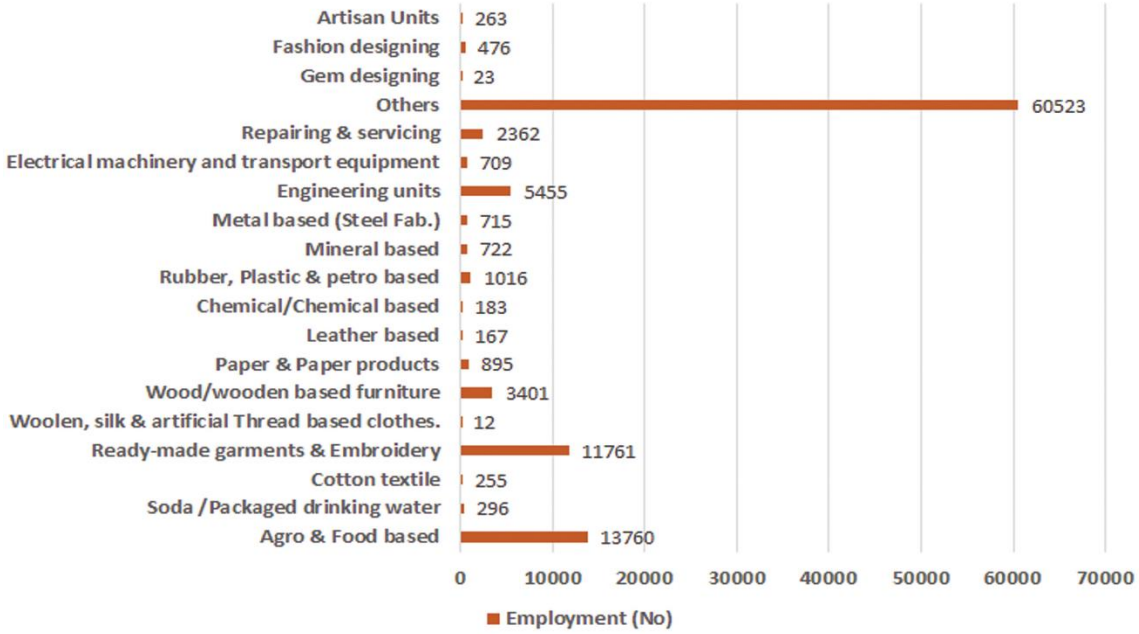


Figure 4.21 Employment pattern

Source : District handbook

4.7.1 Industrical parks

Technopark is an autonomous organization fully owned by the Government of Kerala, a CMMI Level 4 certified Technology Park. it is one of the world's greenest Technopolis as well. Technopark came into existence in 1990.470 companies,70,000 employ IT professionals. Spread across 766.86 acres of land with 106 lakhs sq. ft of IT built-up space and home to 470 IT/ITeS. The exalted list of companies in Technopark currently includes big names such as Infosys, UST Global, Tata Consultancy Services (TCS), Ernst & Young, Allianz, IBS Software, Oracle, Nissan, Guidehouse, SunTec, Tata Elxsi, Envestnet, Quest Global, etc. The growing IT infrastructure facility of Technopark is supported by co-developers such as Embassy-Taurus, Brigade Enterprises, Carnival Info Park, Seaview, Amstor House, and M-Squared.

Name of the developer	Location	Type of SEZ	Area
Electronic techonlogy park-SEZ-I&SEZ II	Near Technopark campus	IT/ITES	34.47+12.55
KINFRA Filim&video park	Kazhakoottam	Animation&Gaming	10.121

Figure 4.22 Thiruvanathapuram industrial parks

Source : Thiruvananthapuram master plan 2012

Industrial estate under SIDCO	Land area (In acres)	No.of sheds with inftastructure support
Industrial estate Pappanmcode	18.5	43
Mini industrial area Ulloor	1	12
Industrial estate under DICTrivandrum	**Land area**	**No.of units of working units**
Indutrial area veli	81.11	168(148)
Industrial plots Manvila	21.99	56 (Plots) 45 units

Figure 4.23 Thiruvanathapuram industrial Estates

Source : Thiruvananthapuram master plan 2012

4.8 Market place in city

There are 74 market places in Thiruvananthapuram city.This comprises all open markets and road-side vendors.All manner of essentials like vegetables and meat are available in these markets together with handcrafted and manufactured goods.

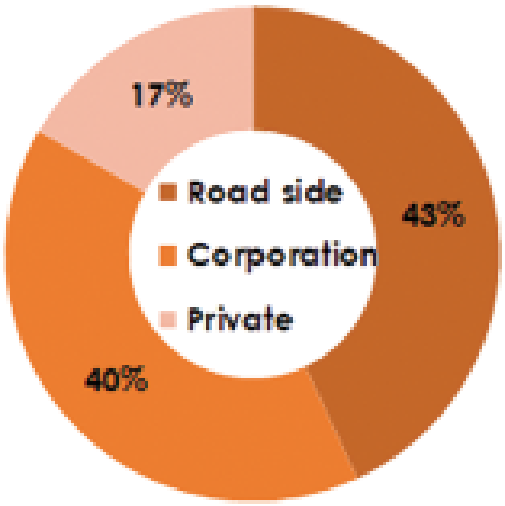


Figure 4.24 Types of market

Source : DIC, Thiruvananthapuram

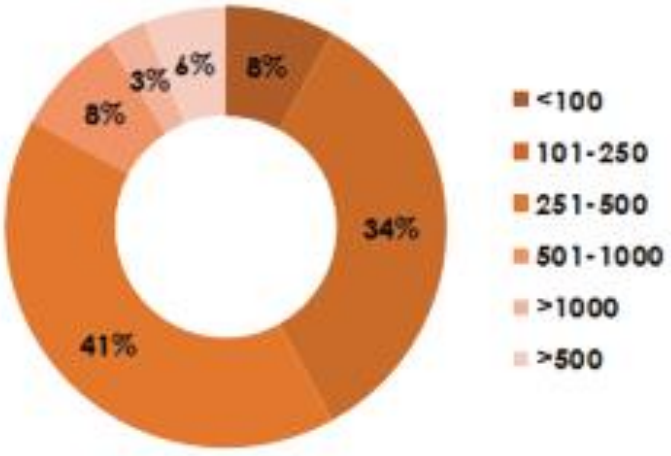


Figure 4.25 Income pattern

Source : DIC, Thiruvananthapuram

Figure 4.26 Major market in Thiruvanthapuram

*Source : Author **g**enerated using QGIS with reference to Base map TPO, Thiruvananthapuram*

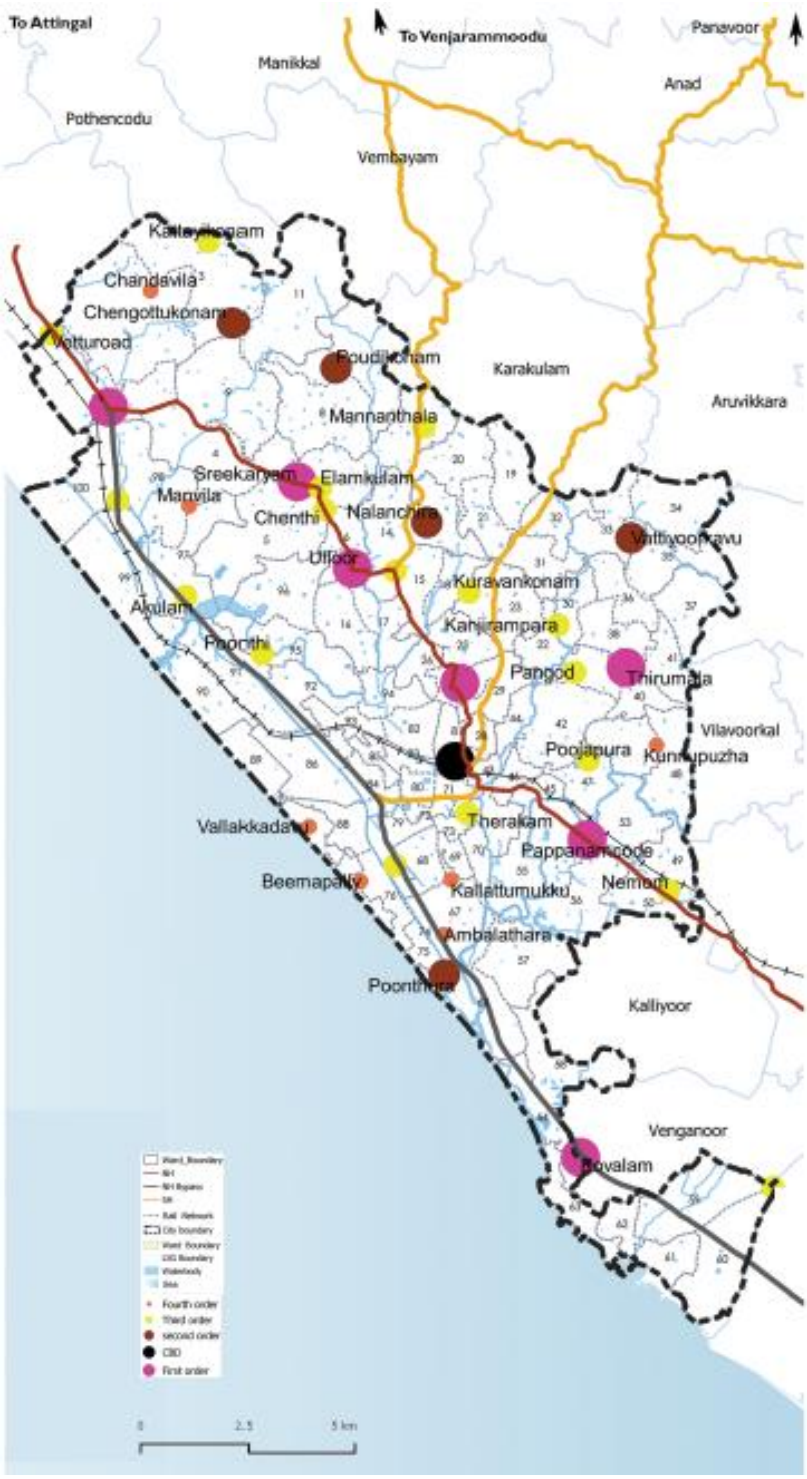


Figure 4.27 Major commercial nodes in Thiruvanthapuram

*Source : Author **g**enerated using QGIS with reference to Base map TPO, Thiruvananthapuram*

4.8.1 New initiatives

Construction of multi-level Parking Plaza,rehabilitation block for traders, internal roads, Auditorium and commercial complexes (5.5 acres of land in Chalai area by TRIDA)
'M' Block at Palayam is also a commercial complex proposed by the government and Joint venture of TRIDA and Smart city misssion.
Kazhakootam Bus bay/terminal, Commercial Complex

4.8.2 Major issues

The reason for low scores for most markets was their lack of waste disposal facilities.
The major problems identified are that only 51% wards have their own markets while some of the wards are having more than one market. 73% have shed, 79% have enough space and only 33% have enough parking spaces. Only 3 markets (Sreekaryam, Kazhakoottam and Kanjirampara market) have waste management facility. Unhygienic and congested

4.9 Inference

The city exhibits the same pattern of declining population as seen across the State as a whole. The population distribution reveals the extent of potential geographical development. Both the seaside wards and the core region wards have higher population densities .In general, the density of the city diminishes from the centre outward. However, not every area of the city exhibits this pattern. In comparison to other local bodies, the city is also viewed as having excellent qualities for literacy rates and gender ratios. The population forecast is generated by taking a uniform growth rate for the upcoming years into account, even if the growth rate is seen to be declining and is showing zero growth rate in the near future it has potential to grow exponentially.

Along the transportation route, business districts are expanding, and new commercial centres are being built close to the Kazhakootam and Vizhinjam regions.The greatest concentration of commercial activity is in the CBD area.The Corporation limit's Public/Semi Public area has grown significantly.The distribution of land use demonstrates

that agriculture is located mainly on the outskirts of the city.The number of genuine paddy fields has significantly decreased since they are being put to different uses. Residential area proportionally decreased. Low lying paddy fields disappeared far more quickly between 1966 and 1991 when only the core region is taken into account. In a period of 25 years, open space was reduced by about 35%. The area that was being settled with mixed tree crops remained the same during this time. The core area, which up until 1966 included the municipal corporation area, was heavily populated and continued to become so, losing all of its green space. The rural-urban mixed landscape that was formerly present within the city has been pushed out to its edges. The city is currently expanding both horizontally and vertically. Growth that is more horizontally oriented. There aren't any adaptable open places.

Thiruvananthapuram is one city which has continuous and defined footpaths in major nodes .Pedestrianization initiatives are limited to the central ABD area. Medical College Kumarapuram has a high pedestrian population and has been noted as a possible hotspot for conflict that requires immediate response.

Inadequate design of intersections result in traffic conflicts points in major junctions. Good traffic uses the bypass for moving goods to major commercial node -CBD area. Majority of the traffic pass through CBD area due to lack of alternative ring road. The issues of urban development and transportation related issues are overlapping problems. Strategic policies and actions with a futuristic view are often needed to overcome this issue. Short term solutions are often seen backfiring.

At the city level, there are a many manufacturing enterprises. industrial parks/ IT parks/ mini industrial parks, information technology parks, industrial estates and traditional industries. Technopark Thiruvananthapuram, is India's first information technology park and hence the importance of Kazhakoottam and business corridor .A With the rise in population and land value, the prospects of large scale industries in the urban area have diminished to an extent even within the industrial estates.

The commercial concentration is high in central area of the city. Shopping has to be in a comfortable and clean place which is acceptable to people. This demands well developed infrastructure facilities for markets. Even though the City has enriched trade and commerce activities, it is not enough to create a backwash effect to develop the City as a major secondary commercial hub. This has to be achieved through selective concentration of economic activities within the City by developing a well distributed hierarchy of commercial nodes and locating the market facilities accordingly.

CHAPTER 5 NODE STUDY

This chapter focuses on the delineation of nodes using a regional analysis and a thorough examination of nodes at the micro level.

5.1 Parameter and indicators

Sector	Parameters	Indicators
Landuse	Diversity	1. Diverse function 2. Vertical / Horizontal mix
	Density	1. Compact Neighbourhood 2. Population density 3. Commercial density 4. Busness concentration
Economics	Economic activity & Development	1. Development opportunities 2. Value capture 3. Landuse pattern 4. Location 5. Employment level 6. Investments 7. Revenue generation
Transportation	Accessibility	1. Frquency of transportation 2. Interchange in mode 3. Location
	Parking	1. Parking supply & demand 2. Park and ride 3. Parking for special commuters
	Walkable Environment	1. Catchment area 2. Level of mix use 3. Pedestrian friendly 4. Core commercial area 5. Transit stop 6. Quality of access 7. NMT availability
	User Friendliness	1. Spatial availability 2. Access to information 3. Capacity 4. Travel time 5. Convenience 6. Comfort 7. Safety and security 8. Amenities for passangers

Figure 5.1 Parameters and indicators

Source : Author generated

5.2 Node Delineation

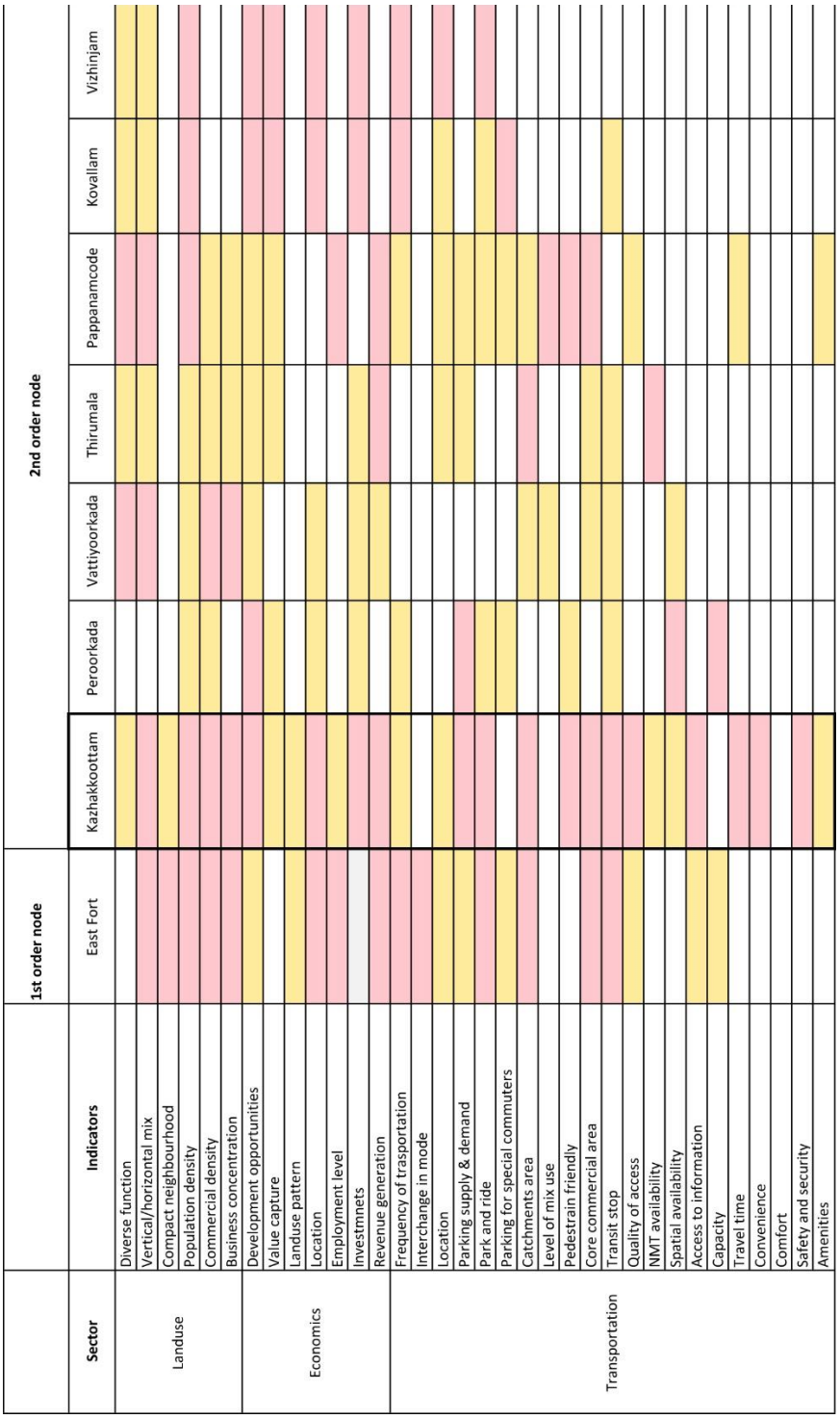


Figure 5.2 Node delineation

Source : Author generated

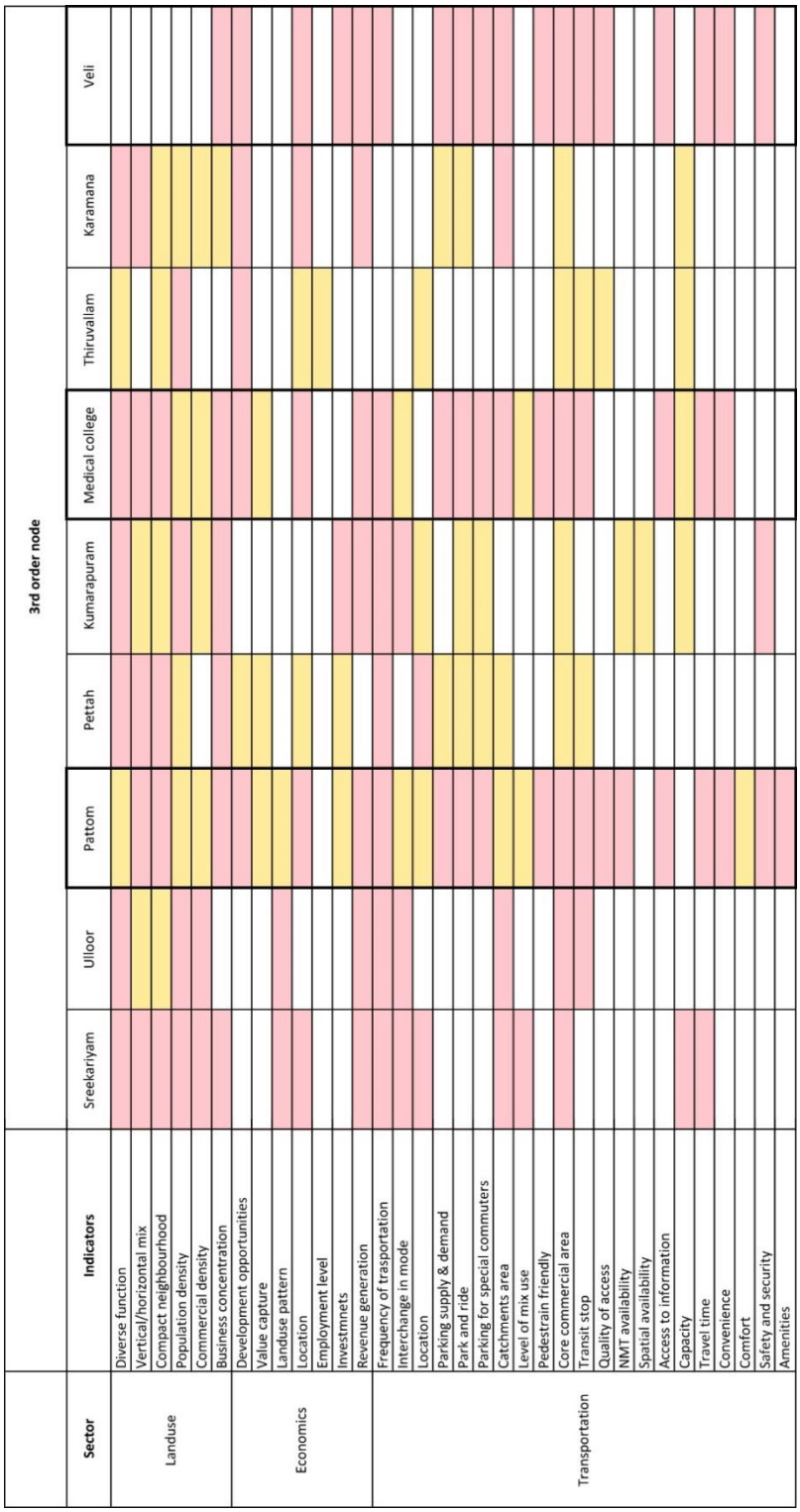


Figure 5.3 Node delineation

Source : Author generated

5.3 Delineation of nodes

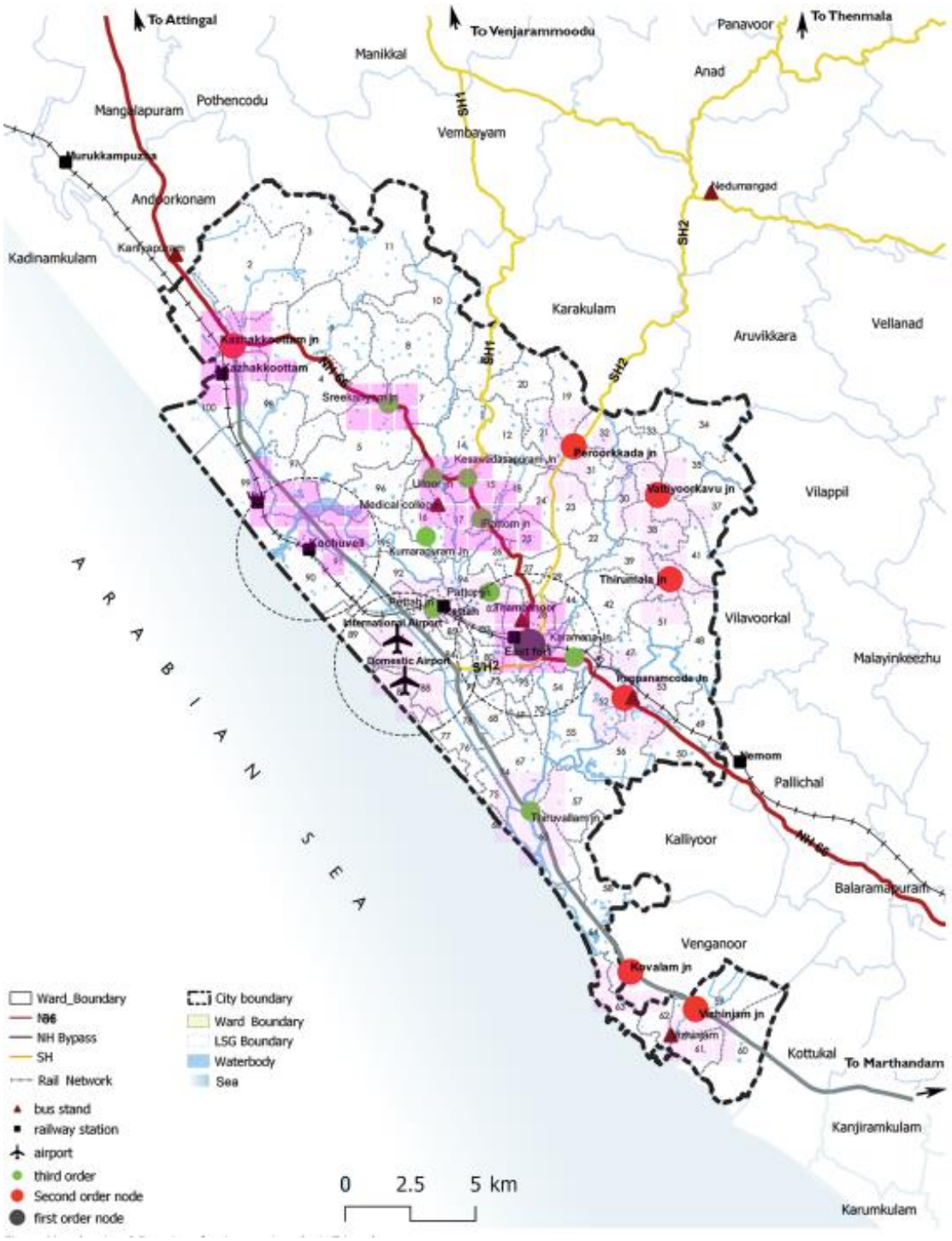


Figure 5.4 Delineation of nodes

Source : Author generated using QGIS with reference to Base map TPO, Thiruvananthapuram

5.4 Nodal study – Kazhakootam

Location

Located in the northern edge of Trivandrum city, Kerala, Kazhakkoottam lies at a latitude of 8.5686° N, 76.8731° E . Kazhakkoottam, popularly known as New Trivandrum. The largest IT Park of the country in terms of developed area Technopark along with Technocity an upcoming integrated IT township is situated here. Hence it is known as the Information Technology capital of Kerala.

Figure 5.5 Base map of Kazhakootam

Source : Retrieved from open street map

Landuse

The area is filled with alternate usage of mixed built up and paddy lands. Residential, agricultural, public and semi public uses are seen to be maximum in the area.

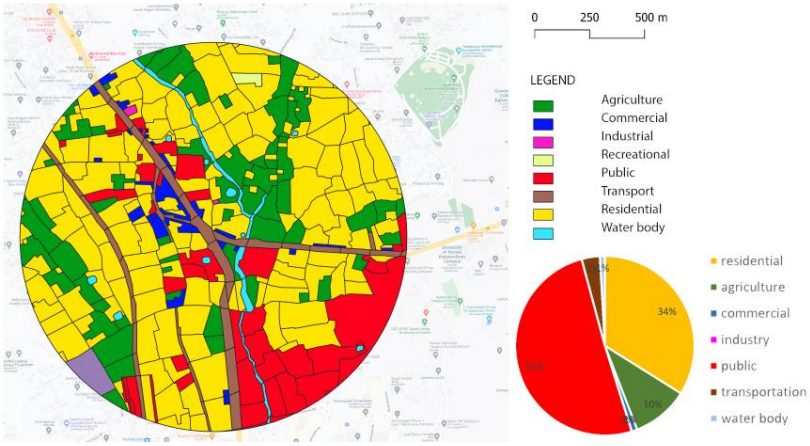


Figure 5.6 Map showing existing Land use pattern of Kazhakootam tranist node

Source : Author generated from qgis

Transportation

Inventory details of major roads in Thiruvananthapuram study area

Homogeneous section		Length (m)	Width (m) CW	Width (m) ROW	Median (m)	Footpath (m) L	Footpath (m) R	Shoulder (m) L	Shoulder (m) R	Bus stops	Adjoining land use L	Adjoining land use R	Road type	Capa-city	Width (m) CW	Width (m) ROW
MAJOR ROADS																
Kazhakkoottam	Stationkadavu	2.90	4.50	8.00				1.75	1.75	1	mixed	Mixed	Collector	900	4.50	8.00

Link volume on major homogeneous sections of Thiruvananthapuram study area

Homogeneous section		Type of vehicle: Bus	Mini-bus/ tempo	Car/Van/jeep	Pass. Auto-rikshaw	Two wheeler	Truck	Mini-truck/ tempo	Goods autori-kshaw	Bi-cycle	Hand cart	Others (Specify)	Total: No. of vehicles	PCU
Karyavattam Jn	Kazhakkoottam	1715	325	11180	2231	11206	586	592	577	225	0	3	28636	28674
Kazhakkoottam	Vettu Road (Andoorkonam Pt)	1947	1221	14112	2362	12957	2869	1171	636	324	0	0	37599	37634
Kazhakkoottam	Station Kadavu	135	116	1200	1243	2490	0	68	58	160	0	0	5469	5504

Road Link		Capacity (PCU/ day)	2010 Volume (PCU/ day)	2010 Volume capacity ratio	2015 Volume (PCU/ day)	2015 Volume capacity ratio	2020 Volume (PCU/ day)	2020 Volume capacity ratio	2030 Volume (PCU/ day)	2030 Volume-capacity ratio
Kazhakkoottam to Station kadavu										
Kazhakkoottam	Stationkadavu	12,600	5,504	0.44	6,381	0.51	7,397	0.59	8,167	0.65
Vettu road to Thykkad										
Vettu road	Kattaikonam	12,600	18,013	1.43	20,882	1.66	24,208	1.92	26,728	2.12

Figure 5.7 Transportation data

Source : Retrieved from Natpac study 2020

Movement count at intersection

About 7822 (7623 PCU's) and 7342 (8852 PCU) vehicles pass at this junction during the morning and evening peak hour respectively.

Morning peak hour

-Goods vehicles account for 9.6% and passenger vehicles account for 90.1% of the total traffic. Non-motorized traffic constitutes about 0.3% of total vehicles.

-Among the passenger vehicles, two wheelers and cars are the dominant ones constituting about 41.3% and 36.1%. Whereas buses are at 4.1%.

-Goods traffic consisted of LCV's (5.2%), HCV's (2.1%) and Goods auto (2,3%).

Evening peak hour

-Goods vehicles account for 13% and passenger vehicles account for 86.4% of the total traffic. Non-motorized traffic constitutes about 0.6% of total vehicles.

-Among the passenger vehicles, two wheelers and cars are the dominant ones constituting about 35.7% and 33% Whereas buses are at 9.6%.

-Goods traffic consisted of LCV's (4.7%), HCV's (4.5%) and Goods auto (3.8%)

In this location, majority of the traffic is two-wheeler and four wheelers. Majority of this traffic is local and is generated because of Techno Park situated near the junction.

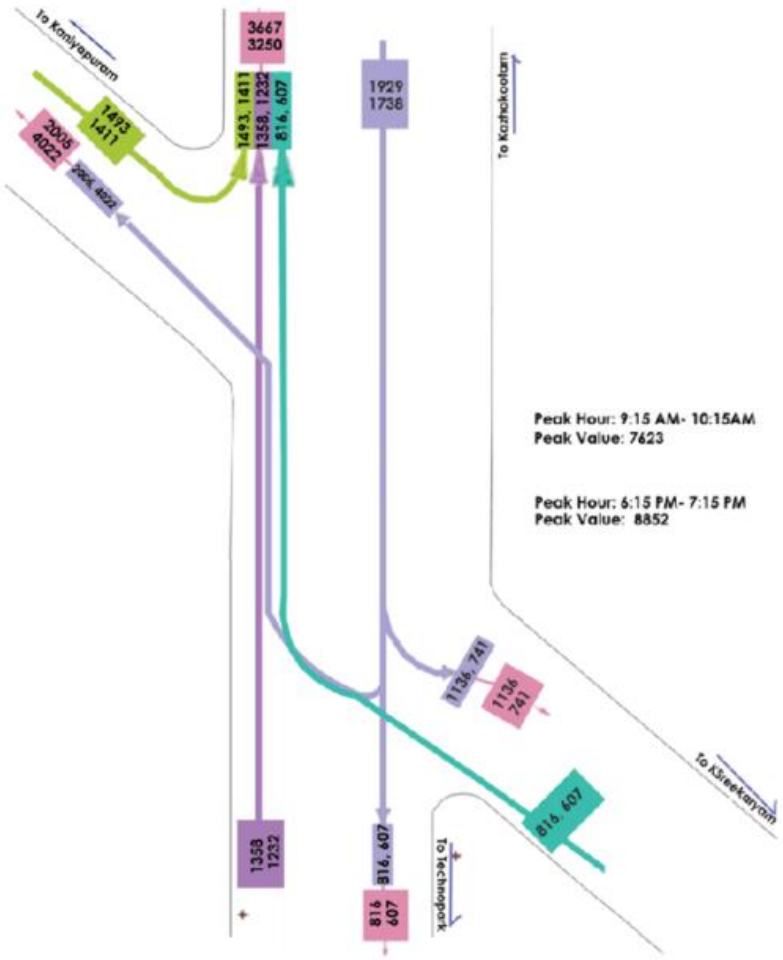


Figure 5.8 Transportation data

Source : Retrieved from Natpac study 2020

Inference

The overall study area needs development in terms of land management and transportation . The new population at Kazhakkoottam are short of open spaces parks and other recreational facilities. Lack of bus stops is also a major
concern faced by the people of the area.

Land use of the area is continuously changing into built up urban uses, which puts a greater pressure on economic development and planning. This is due to lack of zoning in land uses

in the study area. The increased land values in the area has also paused the opportunities of further industrial development in the study area, which will affect the economy of Trivandrum city. Ensure zoning of land uses by managing residential growth in agricultural areas. Plan for adequate public infrastructural facilities and services.

5.5 Nodal study – Medical college and Pattom

Medical college -pattom road is the lifeline of Thiruvananthapuram city, passing through its central area. It is one of the busiest activity centers in the city and is easily accessible from NH 66. The Medical College campus houses several hospitals and institutions, other than the Medical College Hospital (MCH), including the College of Nursing College of Pharmaceutical sciences, Regional Cancer Centre, Thiruvananthapuram Dental College, Sree Chitra Thirunal Institute of Medical Sciences and Technology, Priyadarshini Institute of Paramedical Sciences and Sree Avittom Thirunal Hospital for Women and Children (SAT Hospital). Also, major traffic generators like educational institutions and several banks. commercial centers, shopping complexes, etc. are located along medical college road.

Figure 5.9 Base map of medical college and pattom node

Source : Retrieved from open street map

Landuse

The area is filled with alternate usage of Residential, , public and semi public uses are seen to be maximum in the area with hospitals and education institutions.

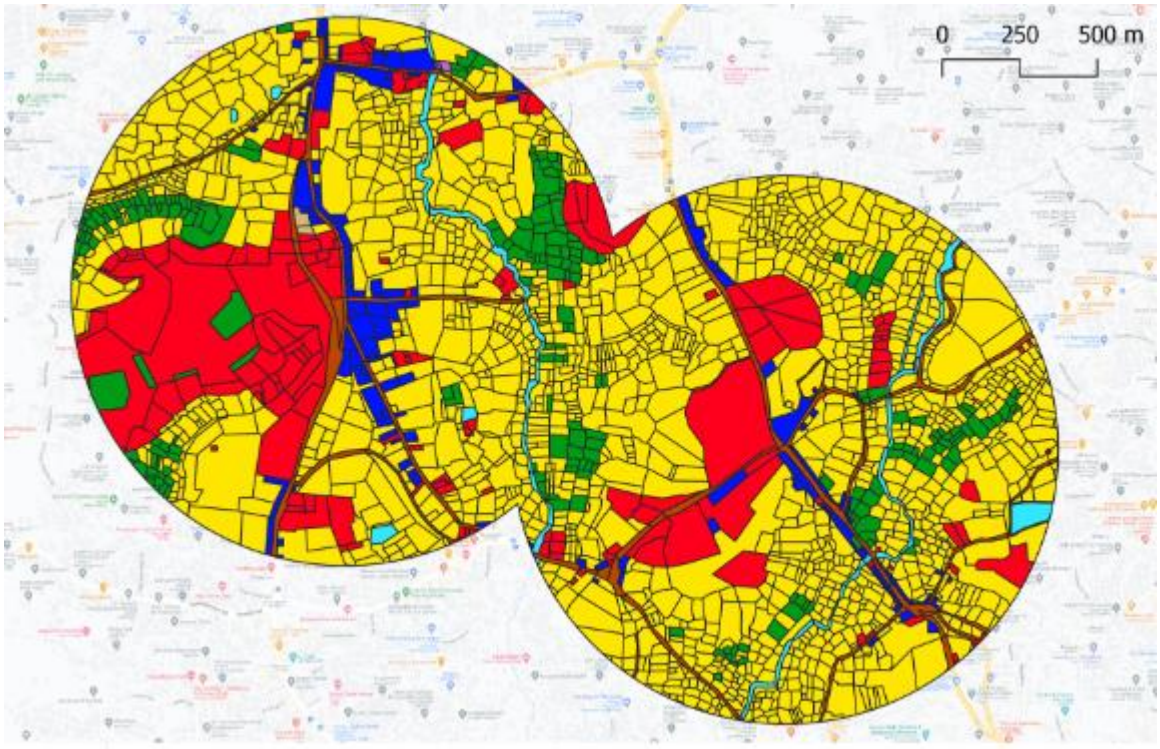


Figure 5.10 Map showing existing Land use pattern of medical college and pattom

Source : Author generated from QGIS

Transportation

Inventory details of major roads in Thiruvananthapuram study area

Homogeneous section			Length (m)	Width (m) CW	Width (m) ROW	Median (m)	Footpath (m) L	Footpath (m) R	Shoulder (m) L	Shoulder (m) R	Bus stops	Adjoining land use L	Adjoining land use R	Road type	Capacity	Width (m) CW	Width (m) ROW
Plamoodu	-	Pattom	1.00	14.00	19.00	1.00	2.00	2.00			1	mixed	mixed	Arterial	3600	14.00	19.00
Pattom	-	Kesavadasapuram	1.50	14.00	18.50	1.00	2.00	2.00			2	mixed	mixed	Arterial	3600	14.00	18.50
Kesavadasa-puram	-	Ulloor	1.10	7.00	11.00		2.00	2.00				Resi-dence	Resi-dence	Arterial	1500	7.00	11.00
Ulloor	-	Sreekaryam	2.80	7.00	9.00				1.00	1.00	2	Com mercial	Com-mercial	Arterial	1500	7.00	9.00
Pallimukku		Kumarapuram	2.20	7.00	13.00				2.00	2.00	3	Mixed	Mixed	Sub Arterial	1200	7.00	13.00
Kumarapuram		Medical college	1.10	8.00	12.00				2.00	2.00		mixed	Mixed	Sub Arterial	1200	8.00	12.00
Medical college		Ulloor	0.90	10.00	14.00		2.00	2.00						Sub Arterial	1200	10.00	14.00

Link volume on major homogeneous sections of Thiruvananthapuram study area

Homogeneous section			Type of vehicle: Bus	Mini-bus/ tempo	Car/Van/Jeep	Pass. Auto-rikshaw	Two wheeler	Truck	Mini-truck/ tempo	Goods autori-kshaw	Bi-cycle	Hand cart	Others (Specify)	Total: No. of vehicles	Total: PCU
MAJOR ROADS															
Plamoodu	-	Pattom	3465	754	24997	14064	31950	26	455	573	154	3	7	76042	76084
Pattom	-	Kesavadasapuram	2309	939	24990	16147	22998	324	437	447	322	17	9	68990	69033
Kesavadasa-puram	-	Ulloor	1509	538	12881	6409	16265	127	514	373	164	13	5	38791	38831
Ulloor	-	Sreekaryam	2124	673	13724	7265	17050	29	591	515	113	0	0	42084	42119
Pallimukku		Kumarapuram	697	1036	7023	5799	7086	6	399	348	134	0	10	22720	22764
Kumarapuram		Medical college	918	327	7207	5730	7474	0	343	392	124	0	10	22513	22557
Medical college		Ulloor	1683	620	13005	9257	16483	121	398	478	237	13	5	42493	42533
Pattom Jn		Pottakuzhy Jn	1757	372	7897	6245	8404	60	156	218	44	0	0	24953	24988
Pottakuzhy Jn		Murinjapalam	1719	237	8898	6351	8078	180	298	279	5	0	0	26045	26080
Murinjapalam		Medical Hospital	1690	268	9888	5014	8178	158	170	103	53	0	0	21313	21348

Volume-capacity ratio on major road links within Thiruvananthapuram study area

Road Link			Capacity (PCU/ day)	2010 Volume (PCU/ day)	2010 Volume capacity ratio	2015 Volume (PCU/ day)	2015 Volume capacity ratio	2020 Volume (PCU/ day)	2020 Volume capacity ratio	2030 Volume (PCU/ day)	2030 Volume-capacity ratio
Plamoodu	-	Pattom	50,400	76,084	1.51	97,104	1.93	123,933	2.46	150,783	2.99
Pattom	-	Kesavadasapuram	50,400	69,033	1.37	88,106	1.75	112,448	2.23	136,810	2.71
Kesavadasapuram	-	Ulloor	21,000	38,831	1.85	49,559	2.36	63,251	3.01	76,955	3.66
Ulloor	-	Sreekaryam	21,000	42,119	2.01	53,755	2.56	68,607	3.27	83,470	3.97
Pallimukku		Kumarapuram	16,800	22,764	1.36	27,696	1.65	33,696	2.01	39,063	2.33
Kumarapuram		Medical college	16,800	22,557	1.34	27,444	1.63	33,390	1.99	38,708	2.30
Medical college		Ulloor	16,800	42,533	2.53	51,748	3.08	62,959	3.75	72,987	4.34
Pattom Jn		Pottakuzhy Jn	16,800	24,988	1.49	30,402	1.81	36,989	2.20	42,880	2.55
Pottakuzhy Jn		Murinjapalam	16,800	26,080	1.55	31,731	1.89	38,605	2.30	44,754	2.66
Murinjapalam		Medical Hospital	16,800	21,348	1.27	25,973	1.55	31,600	1.88	36,633	2.18

Figure 5.11 Transportation data

Source : Retrieved from Natpac study 2020

The peak hour traffic is observed during 8.45 to 9.45 with a peak value of 10443 PCU. The major traffic is contributed by Pattom arm followed by medical college arm. Two wheelers

are the major proportion of traffic (36.10%) observed at the medical college junction followed by Passenger auto rickshaws with 33.51% and cars/jeep/van with 27.76%.35 % of the vehicles are moving towards medical college arm.31 % of the vehicle movement are happening along Ulloor arm.

Inference

The floating population are short of open spaces parks and other recreational facilities. Lack proper bus stand planning concern faced by the people of the area. The lack of land in the area has also paused the opportunities of further transit development in the study area, which will affect the accessibility of the area. Safer transportation and better access to commuters for adequate public infrastructural facilities and services need to be planned .Service along with high density and mixed-use development to encourage transit based development to be planned.

5.6 Nodal study – Kochuveli

Located hardly 10 km from the capital city, it is easily accessible by bus, auto or private vehicles. The tourist destination features a calm pool, children's park, horse rides, pedal boating and floating café. The garden is a hotspot of activities.The Kochuveli railway station is located towards the north of the city, approximately at a distance of 8 kilometers from Thiruvananthapuram city. The Kochuveli railway station is located near to NH bypass Thiruvananthapuram City bypass.

Figure 5.12 Base map of Kochuveli node

Source : Retrieved from open street map

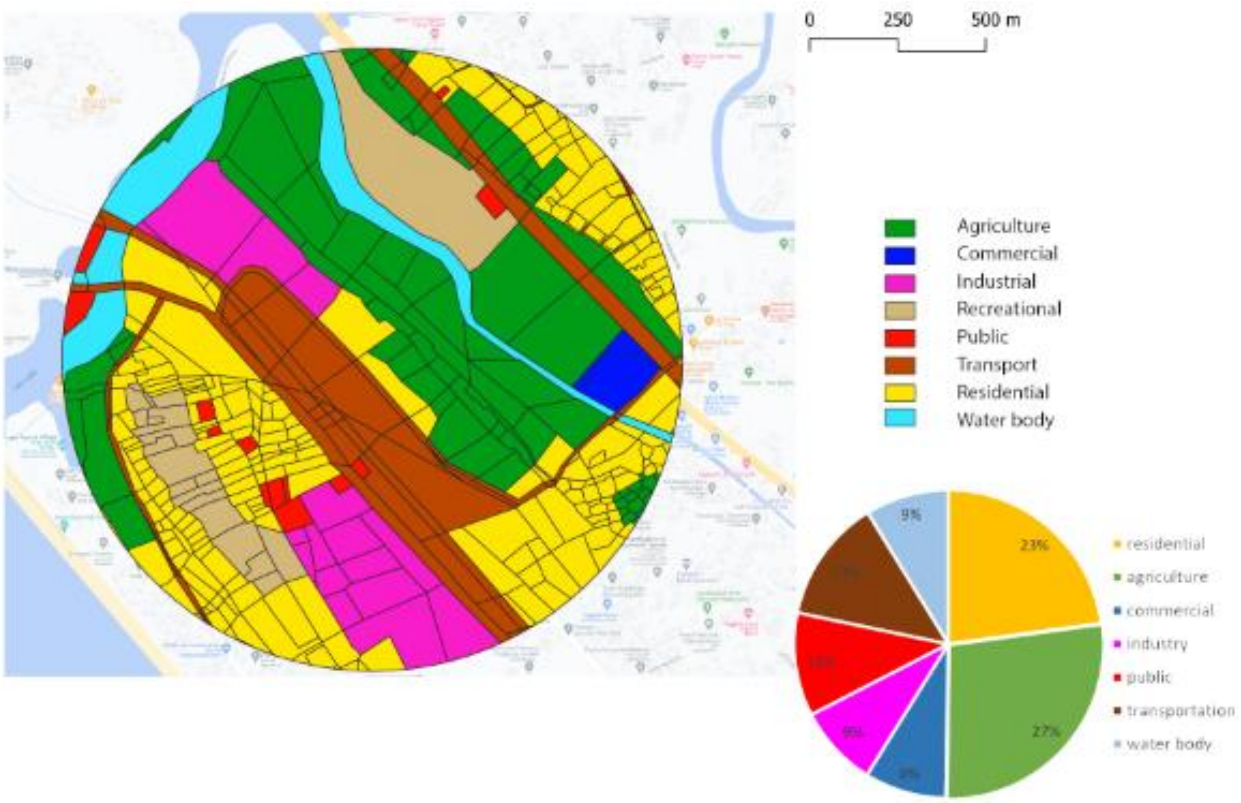


Figure 5.13 Map showing existing Land use pattern of Kochuveli

Source : Author generated from QGIS

With the presence of commercial centres, the kochuveli railway station, recreational space with the Veli tourist village, and the Veli industrial sector, the area has a vibrant mix of landuses that supports the economy

Transportation

Inventory details of major roads in Thiruvananthapuram study area

Homogeneous section		Length (m)	Width (m)		Median (m)	Footpath (m)		Shoulder (m)		Bus stops	Adjoining land use		Road type	Capacity	Width (m)	
			CW	ROW		L	R	L	R		L	R			CW	ROW
MAJOR ROADS																
Shangumugam Jn	Veli Jn	4.10	8.00	10.00				1.00	1.00		Mixed	Mixed	Collector	900	8.00	10.00
All Saints College	Veli	2.60	7	11				2.00	2.00		Resi-dence	Rail	Collector	900	8	12
Veli	Station kadavu Jn	5.00	5.50	18.00				2.00	2.00		Resi-dence	Resi-dence	Collector	900	5.50	18.00
Anayara Jn	Veli	1.80	6.00	10.00				2.00	2.00		Mixed	Mixed	Collector	900	6.00	10.00

Link volume on major homogeneous sections of Thiruvananthapuram study area

Homogeneous section			Type of vehicle											Total	
			Bus	Mini-bus/ tempo	Car/Van/J eep	Pass. Auto-rikshaw	Two wheeler	Truck	Mini-truck/ tempo	Goods autori-kshaw	Bi-cycle	Hand cart	Others (Specify)	No. of vehicles	PCU
Chakkai	-	Kazhakkoottam	837	487	1210	7027	13694	1913	541	575	89	0	0	37274	37309
All Saints College	-	Veli	396	176	2614	1480	4230	36	332	112	74	0	0	9449	9484
Veli	-	Station kadavu Jn	269	182	1672	716	2380	34	444	221	389	0	0	6286	6321

Volume-capacity ratio on major road links within Thiruvananthapuram study area

Road Link			Capacity (PCU/ day)	2010		2015		2020		2030	
				Volume (PCU/ day)	Volume capacity ratio	Volume (PCU/ day)	Volume capacity ratio	Volume (PCU/ day)	Volume capacity ratio	Volume (PCU/ day)	Volume-capacity ratio
MAJOR ROADS											
Chakkai	-	Kazhakkoottam	21,000	37,309	1.78	47,617	2.27	60,773	2.89	73,940	3.52
All Saints College	-	Veli	12,600	9,484	0.75	10,995	0.87	12,746	1.01	14,073	1.12
Veli	-	Station kadavu Jn	12,600	6,321	0.50	7,328	0.58	8,495	0.67	9,380	0.74

Figure 5.14 Transportation data

Source : Retrieved from Natpac study 2020

Morning peak hour

-Goods vehicles account for 26% and passenger vehicles account for 74% of the total traffic. Non-motorized traffic constitutes about 0.5% of total vehicles.

-Among the passenger vehicles, two wheelers and cars are the dominant ones constituting about 63% and 32%. Whereas buses are at 5%.

-Goods traffic consisted of LCV's (6.2%), HCV's (2.1%) and Goods auto (2,3%).

Evening peak hour

-Goods vehicles account for 13% and passenger vehicles account for 86.4% of the total traffic. Non-motorized traffic constitutes about 0.6% of total vehicles.

-Among the passenger vehicles, two wheelers and cars are the dominant ones constituting about 22.2% and 52% Whereas buses are at 2.6%.

-Goods traffic consisted of LCV's (5.2%), HCV's (4.5%) and Goods auto (3.8%)

In this location, majority of the traffic is two-wheeler and four wheelers. Majority of this traffic is local and is generated because of Techno Park, lulu mall , Railway station and airport.

Proposal - Inland water ways

Parvathy Puthanar (national waterways 3) was once the main water transport network of the city of Trivandrum, but now its current state is terrible and suffocating from all kinds of garbage.

This project will help preserve the canal due to the daily use of the water utility and the need to preserve it, and, in turn, will help reduce congestion in the city by moving goods from the road to the waterways. The government proposal to connect the tourist site of Kovalam to the waterways will also attract more users to the center.

Proposal – Krail

Thiruvananthapuram – Kasaragod high speed rail project, also known as Kerala Silver Line, corridor is a 530.6 km long approved semi high-speed rail line connecting Trivandrum and Kasargod in Kerala through 11 stations with an estimated cost of Rs. 63,941 crore.

The project’s new alignment will connect 11 districts and aims to ease transportation along the entire north – south length of Kerala and reduce the total travel time to less than 4 hours, compared with the present 12 – 14 hrs it takes via the Indian Railways.

The project will be executed by Kerala Rail Development Corporation Limited (KRDCL or K-Rail), a joint venture of the Government of Kerala and Ministry of **Railways of the** Government of India set up to augment railway infrastructure within Kerala. 5 new townships are planned to be built at Thiruvanathapuram, Kollam, Kottayam, Ernakulam and Thrissur.

Inference

- The kochuveli region's varied and vibrant landuse has the potential to grow into an alternative mobility hub, easing the commuter overcrowding in the east fort area.

-Veli Tourist Village lies at the mouth of Veli Lake with the Arabian Sea, and is a popular picnic spot in the Thiruvananthapuram district. Separated by a sandbar from the sea, Veli lagoon is the centre of this tourist village.

- The Veli Akkulam Lake has great potential as a bus terminal and a water metro stop to expand the mobility corridor.

CHAPTER 6 SWOT

This chapter discuss, strategic planning and management techniques that help organisations assess their strengths, weaknesses, opportunities, and threats in relation to planning.

6.1 Kazhakootam

Strength

-Largest IT Hub with in the district ,a workforce of more than 70,000 people is housed in Technopark, which is comprehensively spread out on a sizable 766.86 acres.

- Close proximity to multiple transit points.

- The conversion of vacant sites into high density residential and commercial uses, as well as the construction of mixed-use commercial and accommodation facilities.

Weakness

-Due to the lack of a mobility centre, the majority of them rely on taxi services or personal vehicles.

-Lack of interconnectivity between landuse

- Planning for pedestrian traffic is not prioritised, and pedestrian amenities are not well maintained.

- Lack of sufficient parking facilities to accommodate the node's developing commercial nature .

- Lack of public space in Kazhakootam, which is under pressure to develop due to the techno centric expansion

-The absence of public transport in wards other than Kazhakkoottam, which is a result of the unequal growth of companies that eat up vast amounts of land.

Opportunity

-The fast development of techno centric developments and industrial parks such as Kinfra, forming the two special economic zones has led to the migration of new population of students and migrant workers.

-TOD can act as a green corridor for sustainable development

- Congested narrow streets can promote NMT

Threat

- The increased land values in the area has also paused the opportunities of further industrial development in the study area, which will affect the economy of Trivandrum city.

6.2 Medical college

Strength

-Medical college Trivandrum is the best medical college in Kerala as per the NIRF(national institute ranking framework) ranking.

-High concentration of health care facilities and Educational facilities

Weakness

-Congestion on street due to lack of street planning and zoning

-Lack of facilities to cater the high number of floating population.

-Narrow corridors and dead end which negatively impact commercial streets.

-Lack of character and spirit of place as its suppose to be place of healing

Opportunity

-Make use of vacant land and redevelopment of negative spaces .

-Attractive node which will replace the current chaotic node design through TOD

-Floating population backed by reliable transit system

- Differently friendly planning which will cater health care facilities

Threat

- Heavy traffic and congestion that result from a lack of segregation between vehicular and non-vehicular areas make it challenging for NMT users.

- Unauthorised parking on the street, which even blocks pedestrian walkways, causes traffic congestion.

6.3 Pattom

Strength

- Transit node catering the highest number of vehicular population.

- Defined commercial characteristics which attract customers and investment.

Weakness

-Congestion due to lack of parking space and violation of byelaws in commercial space design

-High flow of traffic during school timings which lead to traffic congestion

- Lack of recreational area that would complement the node's educational resources .

Opportunity

- With the youthful commuter population in the area, NMT has a lot of promise.

- Undeveloped water body that might be developed to support pedestrian planning.

Threat

- High usage of private vehicles due to insufficient dependable public transit

6.4 Kochuveli

Strength

- Thiruvananthapuram North railway station is a satellite passenger railway terminus of Thiruvananthapuram city

- Veli Tourist Village lies at the mouth of Veli Lake with the Arabian Sea, and is a popular picnic spot in the Thiruvananthapuram district.

- The Parvathy Puthanar links the city of Travancore with Kadinamkulam, the Vamanapuram River, and ultimately Kochi.

Weakness

- The railway is unable to expand Kochuveli into a Thiruvananthapuram Central satellite terminal due to a lack of funding.

- Despite the cleansing process being in progress, waste is still being recklessly disposed of at Parvathy Puthanar.

Opportunity

- To become a significant mobility hub, the Kochuveli Railway Station should undergo significant infrastructure improvements.

-Creating a waterway along the Parvathy Puthanar canal, decongesting the National Highway-bypass, and utilising tourism potential.

Threat

- Around Parvathy Puthanar, encroachments continue to be a concern.

CHAPTER 7 PROPOSAL

7.1 Vision

To provide a transport system within the development area that will allow for the safe and convenient movement of pedestrians and NMT between different uses and transit stations.

7.2 Regional level strategies

7.2.1 Short term goals

1. TOD Influential zone shall be 200m on either side of transit corridor and 800m radius in case of nodal development(0-400m core influential zone and 400-800m secondary influential zone).

2.Additional fee on higher FSI outside TOD zone (eg. > 2.0). Provision for extra premium FSI within in the TOD influential zone (eg. 4).

3.Relaxed and shared open space requirements may be specified for main transit corridor(front yard parking to be restricted for new permits and promote parking at rear side).

4.Taxation allowances/rebates to Mixed Use Buildings. Allowances on Building Rules for mixed use buildings utilizing high FSI.

5. High taxation for under developed or vacant plot/buildings within the influential zone.

6. Enable a balanced mix of jobs and housing along MRTS corridors coupled, higher housing affordability.

7.2.1 Long term goals

1. Promote multi-use transit stations (MRTS/LRTS / Bus / Mobility Hubs) along the transit corridor.

2.In all integrated schemes, a minimum of 30% of overall FAR shall be mandatory for Residential use, a minimum 5% of FAR for commercial use and minimum 10% of FAR for community facilities. At least 50% of the total FAR shall be as per Zonal based development use.

3. EWS housing shall be provided a reserved FAR of 5% over (mass housing)and above the permissible FAR will be applicable.

4. Land Aggregation of under developed and undeveloped land and properties within the core area.

5. In order to provide first and last mile connectivity to the population outside the influence zone, intermediate public transportation (IPT), non-motorized transportation (NMT), and feeder buses all play a vital role.

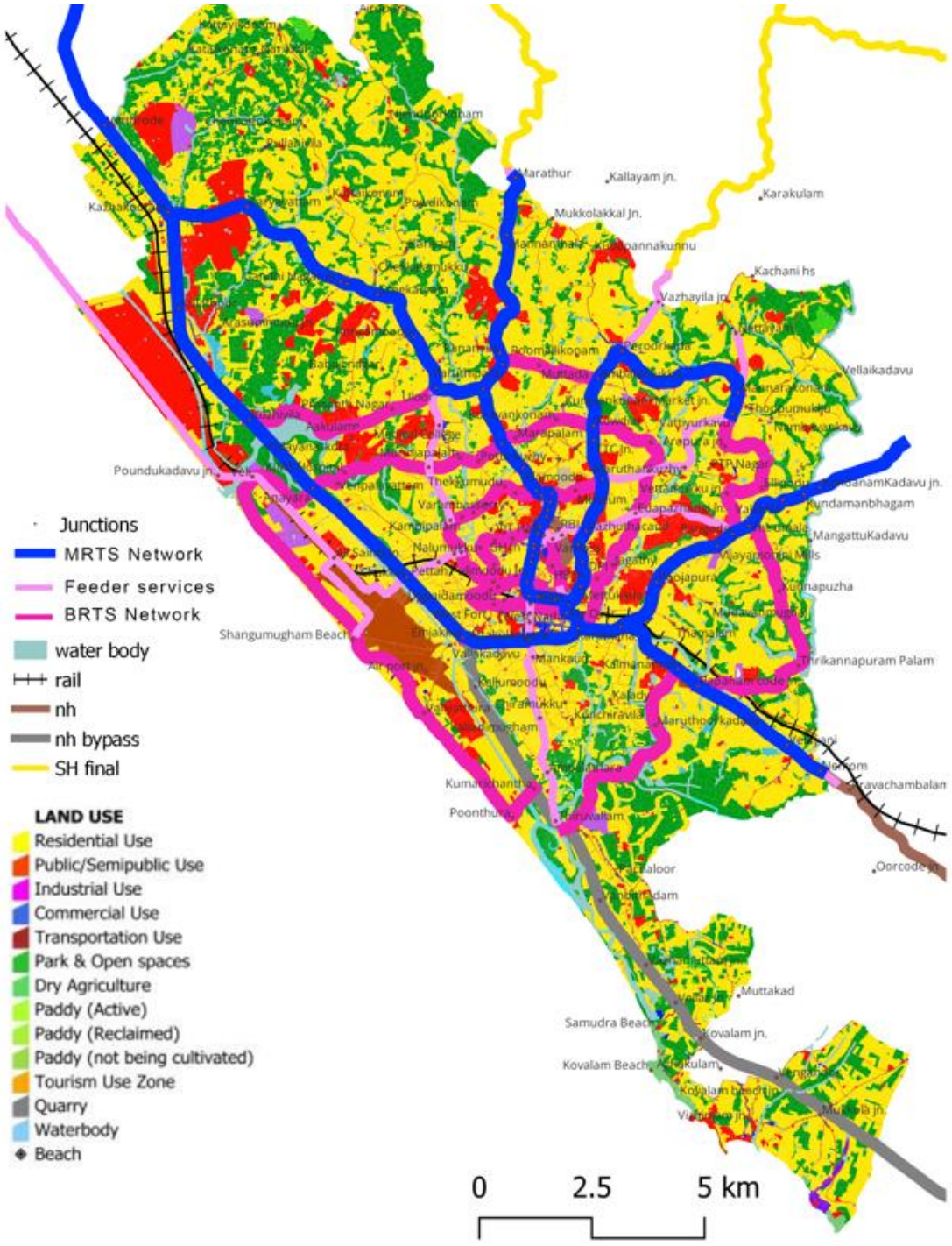


Figure 7.1 Map showing proposed tod corridor

Source : Author generated using QGIS with reference to Base map TPO, Thiruvananthapuram

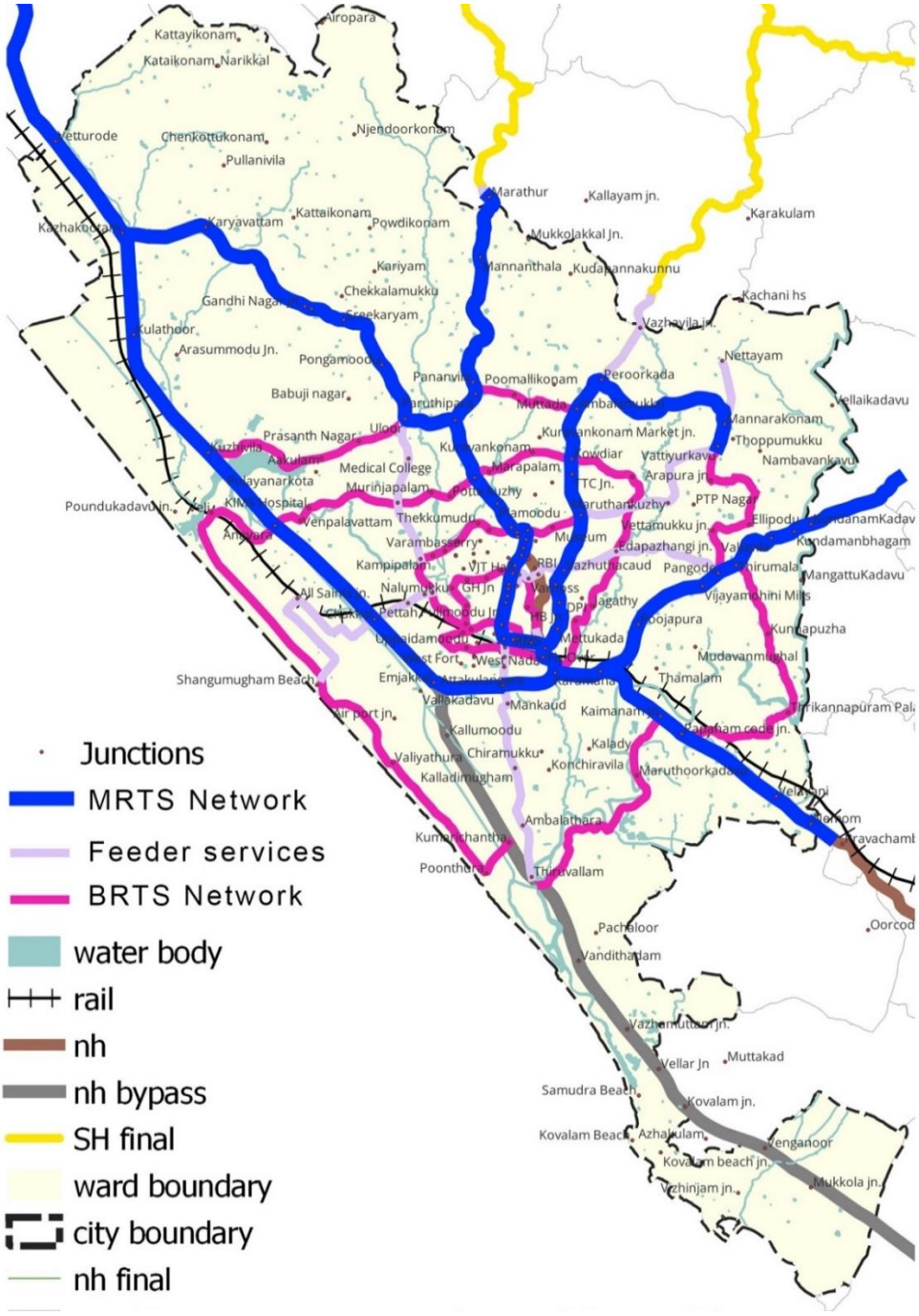


Figure 7.2 Map showing proposed tod corridor for densification

Source : Author generated using QGIS with reference to Base map TPO, Thiruvananthapuram

7.3 Nodal level strategies

Table 7.1 : Strategies for nodal based TOD development

Source : Author generated

Node classification	Sector	Strategies
1st order node	Landuse	Removal of boundary walls and reduce setbacks and promote non opaque fences that help in natural surveillance of public areas.
		Identifying and redeveloping land-locked, unoccupied, or undeveloped parcels for public facilities.
		Prioritize the design of streets and parking facilities for pedestrians and cyclists, minimizing conflicts with vehicles.
		Conflicting mix uses to be removed - Determining the optimum mix of uses to mitigate negative impact on surrounding land uses and tr ansport networks
	Transportation	Street network improvement through assessment of e xisting capacity and augmentation of network as req uired through new linkages, alternate routes, junction

		designs etc. for all modes with priority for intermedi ate public transport, pedestrians, cyclists / NMT.
		Modal Shift Measures: Shift to Sustainable Mode s by using Design, Technology, Road Use Regula tion, Mixed-Use, Parking Policy and Fiscal Measures
		Place making and Safety: Urban places should be desig ned for enjoyment, relaxation and equity.
		Segregating NMVs/MVs to improve safety and smoo th passage of NMVs
		Strengthening Road User Education (RUE) program mes for NMV users to improve behaviour and road s afety.
2nd & 3rd order nodes	Landuse	Promote a mix of land uses, including residential, commercial, retail, and civic spaces, to create a vibrant and diverse community
		Ensure that buildings have active ground floors with entrances facing the street, fostering a sense of safety and vibrancy.
		Create a safe, vibrant, comfortable urban “place”, by providing round the-clock active streets and incidental spaces to relax. Introduce mixed land use and other informal street activities like vendors, etc. to promote

		round-the-clock activity and also promote informal surveillance.
		Minimize boundary walls and setbacks of compounds, and build to the edge of the street RoW. Street walls with transparency, built-to-edge buildings, minimum setbacks and non-opaque fences help provide natural surveillance of public spaces
		Offer premium fsi to support High Density, Mixed-Income Development: Compact Neighbourhoods for Shorter Commutes and equity for all sections of so ciety.
		Ensure that local street networks, physical and soci al infrastructure and shared parking facilities have be en planned for the area, before densification commen ces.
		Penalties such as vacant land tax, etc. on underutiliz ed land and/or underutilized FAR could be levied , in order to ensure time bound densification alon g with MRTS corridor. Such penalties should apply t o all developers as well as Govt. bodies, to even inef ficient use of valuable land.
		- Provide open spaces, parks, and green infrastructure to improve the quality of the urban environment and support community well-being.

	Transportation	Pedestrian & Cycle/ Cycle-Rickshaw Friendly Environment
		Connectivity: Create dense networks of streets and paths for all modes.
		Multimodal Interchange: Mass transportation modes servicing the area should be well integrated to afford rapid and comfortable modal transfers.
		Modal Shift Measures: Shift to Sustainable Modes by using Design, Technology, Road Use Regulation,MixedUse, Parking Policy and Fiscal Measures
		Promoting freight NMVs for the transport and delivery of small goods to markets and shopping areas;
		Providing better facilities to accommodate existing NMV use and encourage more NMVs through visible infrastructure
		Giving NMVs priority over MVs on selected routes and in selected areas.

7.4 Kazhakootam Nodal Based TOD development guidelines

Figure 7.3 Base map of Kazhakootam

Source : Author generated from QGIS

1. Pedestrian and Non-motorised Transport (NMT) Friendly Environment

-The policy Design for pedestrian safety, comfort and convenience

-Create street-level activity and vibrant urban spaces.

-Provide amenities and infrastructure for pedestrians, cyclists, NMT and public transport users.

- All streets and public spaces shall be universally accessible.

- Provide street furniture and intermediate break points.

2. Prioritize multimodal connectivity

-Emphasize multimodal connectivity by integrating various transportation modes within the transit hub.

-Designate dedicated areas for buses, taxis, bicycles, and pedestrians.

3. Development of Kazhakootam railway station

- Accessibility: Stations should be easily accessible to passengers, including people with disabilities, through appropriate provisions for ramps, elevators, and clear signage.

-Passenger Facilities: Guidelines should outline the provision of passenger amenities, such as waiting areas, seating, restrooms, drinking water facilities, ticketing counters, information kiosks, and baggage handling facilities. Consideration should also be given to facilities for children, the elderly, and people with special needs.

Capacity and Expansion:

- Adequate provisions for expansion and future growth should be incorporated into the design to accommodate increasing passenger volumes.

Integration with the Surrounding Area: Guidelines should emphasize the integration of the station with the surrounding urban context.

4. Green and Sustainable Design:

- Incorporate green building practices, energy-efficient design, and renewable energy sources in new developments.

- Provide open spaces, parks, and green infrastructure to improve the quality of the urban environment and support community well-being.

5. up gradation of street vending

-Provide designated vending zones or areas equipped with basic amenities such as proper lighting, waste disposal bins, and seating arrangements.

-Install public toilets, drinking water facilities, and hand washing stations near vending areas to ensure hygiene and sanitation.

7.5 Medical college- Pattom Nodal Based TOD development guidelines

Figure 7.4 Base map of Medical college- Pattom node

Source : Author generated from QGIS

1. Pedestrian and Non-motorised Transport (NMT) Friendly Environment

-The policy Design for pedestrian safety, comfort and convenience

-Create street-level activity and vibrant urban spaces.

-Provide amenities and infrastructure for pedestrians, cyclists, NMT and public transport users.

- To ensure universal accessibility and amenities for all street users

2. Water front development

- Protect and enhance water quality, including measures to prevent pollution and manage storm water runoff.

- Preserve and restore natural habitats, wetlands, and vegetation along the waterfront.

- Promote sustainable practices, such as using green infrastructure, renewable energy, and eco-friendly construction materials.

Public Access and Recreation:

- Ensure public access to the waterfront through walkways, promenades, or trails.

- Designate public parks, plazas, or open spaces along the water's edge for recreational activities.

3. Prioritize multimodal connectivity

-Emphasize multimodal connectivity by integrating various transportation modes within the transit hub.

- Improvement of existing transit station and development of mobility hub to facililate the requirement of commuter.

-Barrier free crossing points under passes for pedestrian and cyclist.

7.6 Kochuveli Nodal Based TOD development guidelines

Figure 7.5 Base map of Kochuveli node

Source : Author generated from QGIS

1. Pedestrian and Non-motorised Transport (NMT) Friendly Environment

- Design streets and sidewalks to prioritize pedestrians, with wide sidewalks, street trees, and pedestrian crossings.

-Create a network of pedestrian-friendly paths and greenways that connect the transit node

to surrounding areas.

-Ensure that buildings have active ground floors with entrances facing the street, fostering a sense of safety and vibrancy.

2. Water front development

- Protect and enhance water quality, including measures to prevent pollution and manage storm water runoff.

- Preserve and restore natural habitats, wetlands, and vegetation along the waterfront.

3. Public Access and Recreation:

- Ensure public access to the waterfront through rejuvenation od existing walkways, promenades, or trails.

-Promote high-quality architecture, landscaping, and public art to enhance the waterfront's visual character.

-Consider view corridors and protect scenic vistas for public enjoyment.

4. Proposed mobility hub

-The project aims to reduce congestion on the city's roads, as well as to preserve and maintain the Parvathy Puthanar Canal, as well as to create space for people to relax so that they can enjoy the beautiful greenery in the city.

5. Water metro

-Reduced traffic congestion: By utilizing waterways, water metros can help alleviate traffic

congestion on roads and highways, especially in cities with extensive water networks.

- Environmental sustainability: Water metros have the potential to be more environmentally friendly compared to traditional land-based transportation systems.

CHAPTER 8 CONCLUSION

In this study, concept of TOD is studied through various literatures and identified the indicators for measuring the TOD. Generally low rise high density development is predominantly seen in Trivandrum which increase the rise in demand for housing and land. Urban compaction can solve issues in underutilization of land and urban sprawl on Trivandrum and TOD can help in achieving urban compaction which promises of a more sustainable urban future. From the analysis using selected metrics, it's seen as there are much more to do in the study area to achieve a TOD. The gaps felt here are generally due to failure of proper land use planning and lack of transportation facilities.

From a planning standpoint, successful urban planning may significantly contribute to promoting sustainable travel habits and enhancing implementation effectiveness in the context. A five-minute walk from a public transit station, well-lit and well-organized street networks connecting various activity hubs, and a secure, attractive environment with a variety of uses and activities nearby may all help promote walkability which is major let down in Tivandrum city even with the smart city initiatives in place.

The term "Transit oriented development" doesn't have a single, accepted definition. Different definitions have been used in literature, ranging from cities without private automobiles to cities with no motorised traffic except from emergency services. Because each form of Transit oriented development has its own distinct traits, it is challenging to characterise the attributes. However, there are some traits that apply to everyone.

Similar steps might be used in Trivandrum City as interim measures, traffic-calming streets, or car-free city centres were commonly employed in earlier periods.. Later, this can be expanded to reducing the dependency on private vehicles and further development of low-car zones in urban areas. A combination of hard and soft measures, such as MRTS, BRTS, and taxation etc to promote TOD .

TOD helps in achieving urban compaction which promises of a more sustainable urban future. From the analysis using selected metrics, it's seen as there are much more to do in the study area to achieve a TOD. The gaps felt here are generally due to failure of proper land use planning. Even though it is planned, general trend seen in Trivandrum or in Kerala is a ribbon development which makes city spread more without utilizing existing land and creating burden to existing infrastructure and natural resources. A finer use of FAR, guidelines and policies has to be implemented in order to successfully bring about the benefits of Transit Oriented Development in Thiruvananthapuram.

An endeavour of transit-oriented development (TOD) initiative seeks to build thriving, sustainable, and easily accessible neighbourhoods centred around major public transportation hubs. During the planning and execution phases, interaction with neighbourhood residents, businesses, and community organisations helps guarantee that the project meets their needs and goals.

To sum up, the concept of TOD was not fully embraced, and its viability was questioned. However, by establishing suitable rules and adhering to them, certain communities in various areas of the world have attempted and others are still working to transition to a label "car free" and "low-car" are inclusive and all-encompassing, and the same is true of the intended outcomes and objectives. There are many other potential outcomes; traditionally, they frequently aimed to reduce traffic, while now they frequently have to do with making cities more liveable. There is a wide range of potential legislative initiatives that may help achieve the objectives of TOD.

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Annexure

SURVEY FORM

Ward number:

Ward name :

Migrant population : no ☐ If yes - Year of migration: ☐
From where:
Reason for migration:
Willingness to relocate: yes ☐ no ☐

Economic status : LIG ☐ HIG ☐ EWS ☐

Belongs to :- a) BPL b) APL

Belongs to which group ? a) OBC b) EWS c) OEC d) General e)SC /ST

Religion :-

Disabled or Differently-abled :-

If receiving any benefits :-

Age	Gender	Occupation	Annual income	Location	Mode of transport to work (parking)	Parking (parking lots, road side ,private)	No of vehicles and type

Ownership of vehicle : ☐ owned ☐ rented ☐ Other _____

Access road width :

Traffic node (specify name & time):-

1	2	3	4	5
Very poor	poor	Acceptable	good	Very good

Did you have room to walk? Some common problems: Sidewalks or paths started and stopped Sidewalks were broken or cracked Sidewalks were blocked with poles, signs, dumpsters, etc. No sidewalks, paths, or shoulder	rating
Was it easy to cross streets? Some common problems: Road was too wide Traffic signals too long or did not give enough time to cross Needed crosswalks or traffic signals Parked cars blocked our view of traffic Needed kerb ramps or ramps needed repair Dead-end streets with no connections to destination	rating
Was the walk pleasant? Some common problems: Needed more grass, flowers or trees Not well lit Dirty, lots of litter, run-down houses or vacant lots Dirty air due to automobile exhaust Fear of crime or attacks Loose dogs or other threat	rating

Did you have a place to bicycle safely?

a) On the road, sharing the road with motor vehicles?

Yes, some problems: …No space for cyclists to ride …Bicycle lane or paved shoulder disappeared …Heavy and/or fast-moving traffic …Too many trucks or buses …No space for bicyclists on bridges or in tunnels … Poorly lit roadways
Other problems: _____

b) On an off-road path or trail, where motor vehicles were not allowed?

Yes, some problems: …
Path ended abruptly … Path did not go where I wanted to go … Path intersected with roads that were difficult to cross …Path was crowded …Path was unsafe because of sharp turns or dangerous downhills … Path was uncomfortable because of too many hills Path was poorly lit
Other problems: _____

Overall rating as a safe place to ride: (circle one) : _____

c) How was the surface on which you rode?
Good, some problems.
The road or path had: … Potholes … Cracked or uneven pavement … Debris (such as broken glass, litter, gravel, etc.) …Dangerous drain grates or utility covers
Other problems: _____

d) How were the intersections through which you rode?
Good, some problems: …
Had to wait too long to cross □ Couldn't see crossing traffic □ Signal did not give me enough time to cross …Unsure where or how to ride through intersection
Other problems: _____

e)Was it easy for you to use your bicycle?

Yes, some problems:
…No maps, signs, or road markings for cyclists …No secure place to leave my bicycle …No way to take my bicycle with me on the bus or train …Scary dogs …Hard to find a direct route I liked …Route was too hilly Other problems: _____

Active transport to and from school …
Does the school support and encourage walking and cycling to and from school in collaboraion with parents, the police and local agencies, such as safe routes to school programmes or walking school bus programmes?
..yes no

Does the school have safe, secure parking facilities for bicycles? yes ☐ no ☐

Which mode do you prefer for commuting with the city ?
Bike
Car
Cycle
Auto
Other _____

Please specify the location/ routes in which you prefer NMT ?

_____

Please specify the junction in which you face traffic issue ?

_____

Do you refer MRTS system over regular mode of transportation ?

_____