PLANNING GUIDELINES FOR COMPACT TRANSPORT-ORIENTED DEVELOPMENT IN INDIA: CASE STUDY DELHI

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF URBAN AND RURAL PLANNING

By

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CERTIFICATE

Certified that this report entitled **"Planning Guidelines for Compact Transport-Oriented Development in India: Case Study Delhi"**, which has been submitted by **Mr. Gaurav Singh**, in partial fulfillment of the requirements for the award of the Degree of **Master of Urban and Rural Planning**, submitted in the Department of Architecture and Planning, **Indian Institute of Technology- Roorkee, Roorkee**, is the student's own work carried out by him under my supervision and guidance. The matter presented in this dissertation has not been submitted by him for the award of any other degree of this or any other institute.

Date: 30/6/2010

Place: **Roorkee**

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the Dissertation entitled **"Planning Guidelines for Compact Transport-Oriented Development in India: Case Study Delhi"**, in partial fulfillment of the requirements for the award of the Degree of **Master of Urban and Rural Planning**, submitted in the Department of Architecture and Planning, **Indian Institute of Technology- Roorkee**, Roorkee, is an authentic record of my own work carried out for a period of about one year from June 2009 to June 2010, under the supervision of R.Shankar, Professor and Former Head, Department of Architecture and Planning, **Indian Institute of Technology- Roorkee**, Roorkee, India.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree of this or any other institute.

Date: 29 June 2009

Place: Roorkee

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This is to certify that the above statement by the candidate is correct to the best of my knowledge.

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ABSTRACT

Delhi is one of the largest metropolises in country not only in terms of area but also in terms of the population that it accommodates. As it is an administrative city and major work center, about 3 million people traveled to city daily, leading pressure on the transportation system. Three major trends characterize the urbanization process of Delhi in the 21st century. The first trend is of in-migration. Urban centers are seen as attractive, lively places to live and work, and as centers of intellectual and creative capacity.

The second equally powerful trend is the continuing growth and emerging maturity of Delhi's suburbs, many of which are as a part of the National Capitol Territory struggling to become cities in their own right. Suburban areas are increasingly diverse in race, ethnicity and income, and increasingly experiencing the travails of rapid growth. These growth issues include the need to diversify land uses to build more solid revenue bases, the need to create urban centers, and the growing problem of traffic congestion along overburdened suburban arterials

The third trend is an increased interest in transit use and transit investment. Virtually every metropolitan city in India is planning some form of urban rail or rapid bus system. Introduction of MRTS brought changes in distribution of people, in activity patterns or in land uses in form of informal sector, congestion, parking problem, increased land value followed by the transformation of land use. It may lead to unplanned development, so to have planned development there should be proper integration of landuse with transportation leading to Transit supportive development.

At the convergence of these three trends is the realization that a substantial market exists for a new form of walkable, mixed-use urban development around these new rail or rapid bus stations and transit stops.

The present work is an effort to evolve planning guidelines for the compact transport-oriented development in Delhi.

During the study, the data was collected in form of maps from the previous studies and primary data collection done by mapping the existing land use of the area and carrying out surveys. For conducting the primary survey, stratified random sampling was done and the strata's that were formed were based upon the area under pure residential use and area under mix of residential and commercial use. The survey findings revealed lots of facts and figures and the improvement that the people in the area wanted and the changes that they desired should have been taken care of.

In order to have compact transit oriented development, recommendations and guidelines are laid to integrate the landuse planning with transportation.

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CHAPTER - 1

INTRODUCTION

1.1 INTRODUCTION

There has been a rapid growth in the phenomenon of urbanization in India between 1991to 2001. This extensive urbanization has put many Indian metropolitan cities under tremendous pressure especially in terms of land, resources and environment.

The unplanned urbanization has led to the haphazard pattern of spatial development of Indian cities. The pattern of urbanization in India is characterized by continuous concentration of population and activities in large cities which simultaneously keep increasing in their geographical area.

The process of rapid and extensive urbanization in India has put many of the Indian cities under great pressure. The pressure is not only on the resources and environment but also on the people living in the city and the government which provides the infrastructure and other amenities. The pattern of spatial development of the Indian cities is haphazard and Indian cities lack infrastructure facilities. The major problem faced by Indian cities is the urban sprawl. Urban sprawl puts the burden on the government to come up with a solution to accommodate the desires of a rural lifestyle and urban services while protecting health, safety and environment. The Indian cities became the magnet for foreign direct investment due to the economic liberalization of 1991. This led to the major restructuring in the pattern of cities growth.

1.2 BACKGROUND

The level of urbanization in India was 28% in 2001. The total urban population has increased 11 folds during twentieth century. Enlargement of urban center and emergence of new towns has played a significant role in the growth of urban population and urbanization in the country. More than 60% of urban population in India lives in Class I towns. Out of 423 cities, 35 cities/ urban agglomeration are metropolitan cities. Six of them are mega cities with population over five million each. More than one fifth (21.0%) of urban population lives in these mega cities.

The lack of infrastructure facilities affects the quality of life. The people living in the cities have to face miserable situation due to the lack of public transport, housing,

traffic jams, frequent power cuts, inadequate water supply, no good quality of air to breath, no open spaces and green parks to socialize. The per capita availability of arable land decreased from 0.5 ha in 1950-51 to 0.15 ha in 1999-2000 owing to population escalation and it is further expected to come down to 0.09 ha by 2031.

In this context there is an urgent need to understand in detail the concepts of Compact city and Transit-Oriented Development and adopt it for application in Indian situation and modify suitably the existing urban form and structure.

1.3 NEED FOR STUDY

In the context of the variety of growing problems and increasing trends of unsustainable urban growth there's a need to find out ways of directing urban development towards sustainability. There have not been any city specific studies done to fulfill this need. The present MURP dissertation study is an attempt to fill the gap.

1.4 IDENTIFICATION OF THE PROBLEM

The present trends of urban growth witnessed particularly by metropolitan cities cause the following problems:

- Increasing use of productive land for urbanization, reducing the base of food self-sufficiency.
- Urban Sprawl causing loss of cultivable land, growth of slums, and increased congestion, pollution and decrease in open spaces.
- Use of land thereby disturbing ecosystem, loss of tree cover, increasing run off, increasing heat island effect and pollution.
- Increasing private ownership of automobiles and its increasing use thereby increasing dependence on depleting fossil fuels.
- Extensive infrastructure network for serving all land uses.
- Inadequate use of Mass Transit Systems due to poor integration of land use development with transit system.

1.5 AIM

To evolve planning guidelines for compact transport-oriented urban development in Indian cities.

1.6 OBJECTIVES

1. To understand the origin, principles and strategies of compact city concept and Transit-Oriented Development (TOD).
2. To infer lessons and useful planning guidelines from relevant case studies of compact city and Transit-Oriented Developments.
3. To study the growth pattern, land use structure and transit network of Delhi.
4. To analyze the potential for Compact Transit Oriented Development of Delhi.
5. To formulate planning guidelines and recommend a plan for Compact Transit Oriented Development for Delhi.

1.7 SCOPE

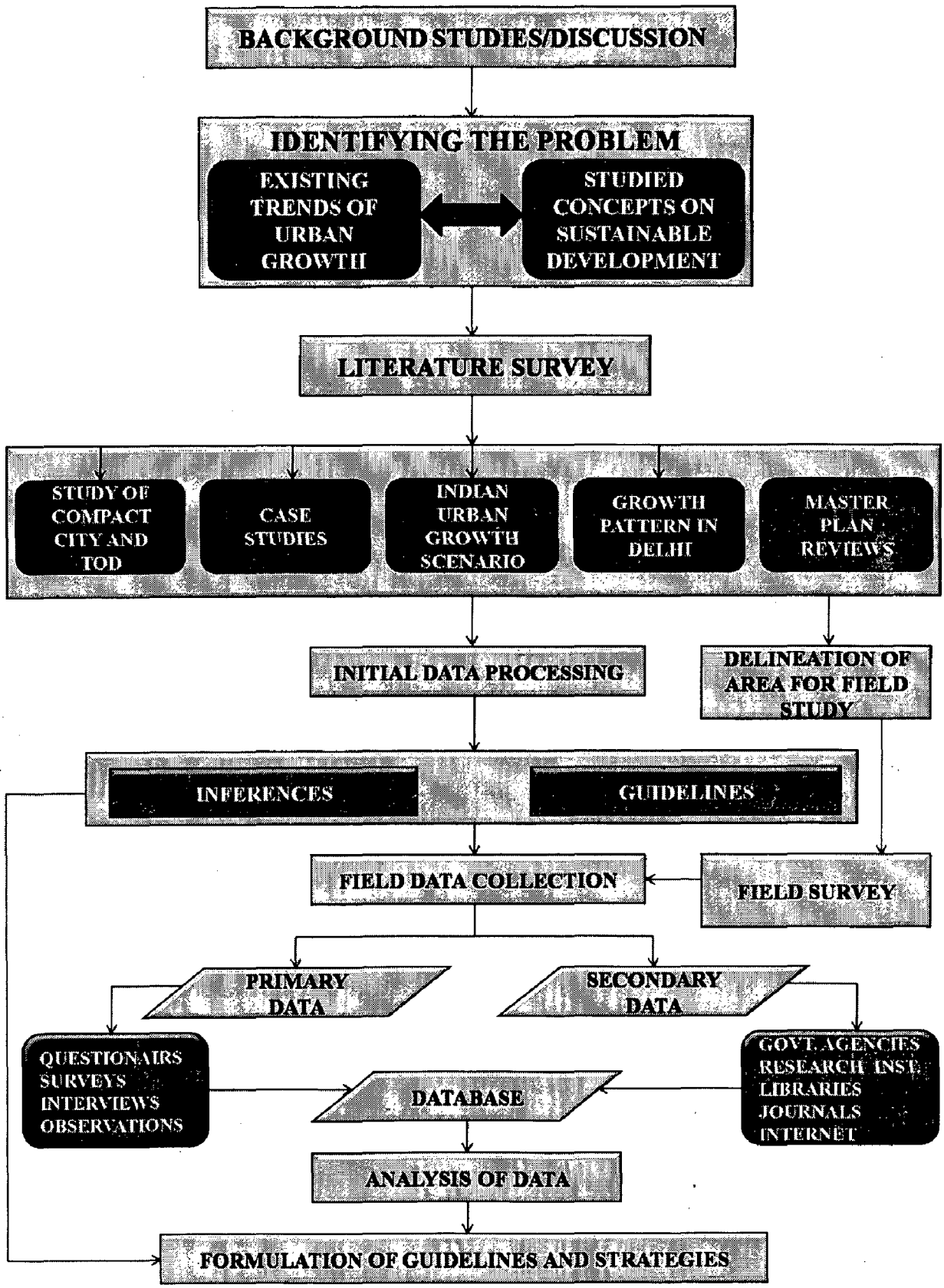
- The application of compact transport-oriented development finds relevance in present and future scenario of unsustainable urban growth of Indian metropolitan cities.
- With the growing need for high quality transportation system in Indian metropolises there is also a need for general guidelines for development of high density mixed use settlements along them.
- The planning guidelines for transport-oriented compact development will be based on the available data from secondary sources.

1.8 LIMITATIONS

- The scope of the project will be limited by the availability of data and its accuracy.
- Due to time constraint only selected area of Delhi will be taken for application.

1.9 RESEARCH METHODOLOGY

Figure 1.1: Research Methodology



Source: Author

CHAPTER - 2

LITERATURE REVIEW

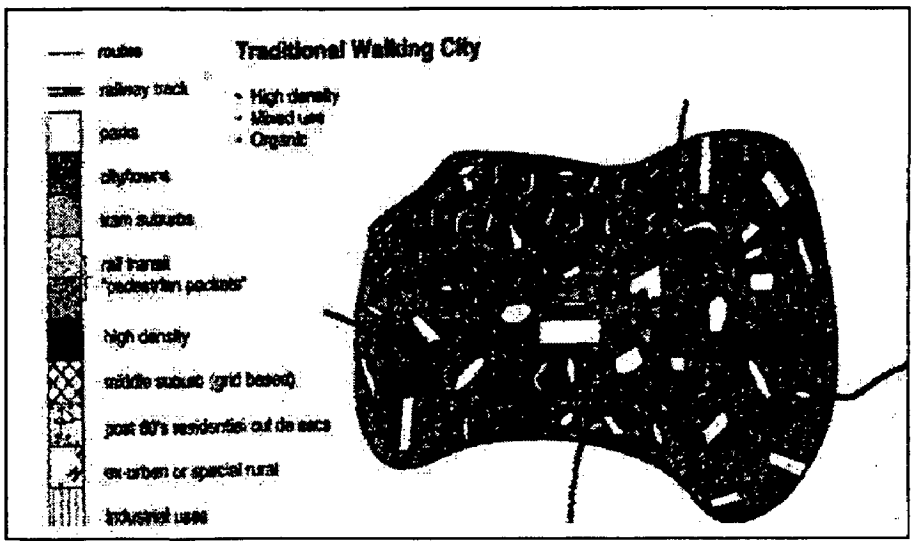
2.1 INTRODUCTION

This literature review explores the two dominant concepts of sustainable development and growth. Relationship between Urban Planning and Transit is highly considerate by many researchers. This chapter first defines the concepts of Compact City and Transit-Oriented Development and explains its principles and benefits. Thereafter a review of two published research papers based on these concepts has been done to understand the implantation of these concepts in the developed countries.

2.1.1 Walking city

Before the advent of automobile in last century, most people use the travel mode of walk, the form of cities everywhere was based on walking. The traditional walking city always characterized by high density, mixed land use, and narrow streets in an organic form. All the destinations can be reached on foot in half an hour on average, and thus these cities are constrained to be within 5 kilometers across. Traditional walking cities are usually with high density and mixed use, they are almost organic growing. [1]

Figure 2.1: Traditional Walking City



Source: TOD moving from rhetoric to reality

2.2 COMPACT CITY

In late 1990's the concept of compact cities was created by the idea of sustainable urban planning in the European countries.

According to Burton (2000), a compact city is relatively a high-density, mixed-use city, based on an efficient public transport system which reduces automobile dependency and environment that encourage walking and cycling.

There is a widespread consensus that progress towards sustainable development is essential. Human activity cannot continue to use resources at the present rate without jeopardizing opportunities for future generations. Cities are the main arena of human activity, but they are also the greatest consumers of natural resources. However, urban sustainability is not just about environmental concerns; it is also about economic viability, livability and social equity. Recently, much attention has focused on the relationship between urban form and sustainability, the suggestion being that the shape and density of cities can have implications for their future. From this debate, strong arguments are emerging that the compact city is the most sustainable urban form.

2.2.1 Characteristics of Compact City

1. Community-Based Society

Sustainable Compact Cities could reinstate the city as the ideal habitat for a community-based society. It is an established type of urban structure that can be interpreted in all manner of ways in response to all manner of cultures. Cities should be about the people they shelter, about face-to-face contact, about condensing the ferment of human activity, about generating and expressing local culture. Whether in a temperate or an extreme climate, in a rich or poor society, the long-term aim of sustainable development is to create a flexible structure for a vigorous community within a healthy and non-polluting environment.

2. Proximity

Proximity, the provision of good public space, the presence of natural landscape and the exploitation of new urban technologies can radically improve the quality of air and of life in the dense city. Another benefit of compactness is that the countryside itself

is protected from the encroachment of urban development. The concentration of diverse activities, rather than the grouping of similar activities, can make for more efficient use of energy.

3. Mixed functions

The whole premise of the Compact City is that interventions trigger further opportunities for efficiency. A Compact City composed of overlapping activities, for instance, is more convivial and can reduce the need for car journeys, which in turn dramatically reduces the energy used for transportation - usually a quarter of a city's overall energy consumption. Fewer cars mean less congestion and better air quality, which in turn encourages cycling and walking rather than driving. Better air quality makes opening windows to fresh air more attractive than turning on filtered air-conditioners.

4. Rich Urban Landscaping

There are other important environmental advantages to a compact form of city that has fewer roads but more landscaped public spaces. Parks, gardens, trees and other landscaping provide vegetation that shades and cools streets, courtyards and buildings in summer. Cities are generally 1-2^{0}C warmer than their hinterland. The overall effect of rich urban landscaping is to reduce the heat 'bloom' of cities, measurably reducing the need for air-conditioning. Plants dampen noise levels and filter pollution, absorb carbon dioxide and produce oxygen - further factors that reduce the need for air-conditioning to supply cooled fresh air to buildings in what would otherwise be hot and polluted urban areas. Urban landscape absorbs rain, reducing the discharge of urban rainfall and storm water. Landscape plays an important psychological role in the city and can sustain a wide diversity of urban wildlife.

5. Reduced Waste of Energy

A Compact City reduces the waste of energy. Generating electric power produces hot water as a by-product, which in conventional power plants is simply wasted. Local Combined Heat and Power plants (CHPs) can be used both to distribute electricity and, due to their proximity, to pipe hot water directly into buildings. This can more than double the efficiency of conventional urban power distribution. City rubbish, which is usually either dumped as landfill or incinerated, both with polluting effects, can be burned by

local CHPs and supply up to 30 per cent of a community's energy needs. In a city that combines a variety of activities, it is easier to transfer waste heat from one activity to another.

6. Recycled Human Waste

Human waste that is rich in nutrients is currently discharged in such high concentrations that it poisons the environment. It can instead be recycled to produce methane fuel pellets and fertilizers. Grey water can be filtered through natural systems on site and be re-used for irrigation of urban landscape or to restock local aquifers. Experimental sewerage treatment schemes that discharge their waste below industrial forestry have been shown both to increase the growth rate of the forests, woods and parks and to restock local aquifers with purified water. Clean water is recognized as the critical resource of the coming millennium, and we must develop systems that maximize the efficiency of its use.

2.2.2 Benefits of Compact City

In recent years city planners, developers and policymakers have increasingly looked towards designing a more compact city in order to achieve a more sustainable urban form. Policies of urban compaction involve the promotion of urban regeneration, the revitalisation of town centers, restraint on development in rural areas, higher densities, mixed-use development and promotion of public transport and the concentration of urban development at public transport nodes. There are many perceived benefits of the compact city over urban sprawl, which include:

1. less car dependency thus lower emissions,
2. reduced energy consumption,
3. better public transport services,
4. increased overall accessibility,
5. the re-use of infrastructure and previously developed land,
6. a regeneration of existing urban areas and urban vitality,
7. a higher quality of life,
8. the preservation of green space,
9. And the creation of a milieu for enhanced business and trading activities. [6]

2.2.3 Issues Addressed by Compact City.

The following are some of the issues that should be addressed for the compact city to show improvements across all three spheres.

The creation of the modern Compact City demands the rejection of single-function development and the dominance of the car.

The issues to be addressed are:

- How to design cities in which communities thrive and mobility is increased.
- How to design for personal mobility without allowing the car to undermine communal life.
- How to design for and accelerate the use of clean transport systems and re-balance the use of our streets in favor of the pedestrian and the community.

The Compact City addresses these issues because it grows around centers of social and commercial activity located at public transport nodes. These provide the focal points around which neighborhoods develop. The Compact City is a network of these neighborhoods, each with its own parks and public spaces and accommodating a diversity of overlapping private and public activities. London's historic structure of towns, villages, squares and parks is typical of a polycentric pattern of development. Most importantly, these neighborhoods bring work and facilities within convenient reach of the community, and this proximity means less driving for everyday needs.

In large cities, Mass transit systems can provide high-speed cross-town travel by linking one neighborhood centre with another, leaving local distribution to local systems. This reduces the volume and impact of through traffic, which can be calmed and controlled, particularly around the public heart of neighborhoods. Local trains, light railway systems and electric buses become more effective, and cycling and walking more pleasant. Congestion and pollution in the streets are drastically reduced and the sense of security and conviviality of public space is increased. [4]

2.2.4 Compact City Issues

The following are some of the issues that need to be addressed by planners and policy makers for a successful Compact City:

- What next when a compact city achieves its highest possible density?
- Compact City implications for individual lifestyles
- The link between city compactness and social equity: Sustainable development involves more than just environmental conversation; it embraces the need for equity.
- Equity and community issues: The urban periphery, doughnuts of deprivation, social inclusion / exclusion, crime and security issues
- Urban management and safety
- Industry structure and the redistribution of population
- Family size, lifestyle, culture etc. effect on dwelling / building size, type and design, housing needs, relocation and transaction costs, health, education infrastructure, facilities and services etc.
- Compact City implications for politicians / planners: health issues, education, communication, information systems, industrial, etc.
- The effect of intensification/decentralization on the increase/decrease in urban vibrancy:
- Town centers offering more cultural and entertainment facilities, because of the concentration of retail and employment activities.
- More neighbors, as well as neighbors of increasingly diverse socio-economic backgrounds effects on local identity or a sense of community.
- Safety due to security cameras, increased policing and the concentration of entertainment facilities in the town center.
- Profitability of business and trading activities, such as entertainment facilities.
- The effect of compactness on the need to travel and feasibility of public transport, thus reducing emissions and contributing to environmental sustainability.
- The effect of compactness on the efficiency of services, such as public transport, sewers and rubbish collection etc.
- The impact of intensification policies on the urban landscape.

Compact, livable urban neighborhoods attract more people and business. Creating such neighborhoods is a critical element of reducing urban sprawl and protecting the climate. Such a tactic includes adopting redevelopment strategies and zoning policies that channel housing and job growth into urban centers and neighborhood business districts, to create compact, walkable, and bike- and transit-friendly hubs. [6]

2.3 TRANSIT-ORIENTED DEVELOPMENT (TOD)

2.3.1 History

Peter Calthorpe codified the concept of Transit-Oriented Development (TOD) in the late 1980's and, while others had promoted similar concepts and contributed to the design, TOD became a fixture of modern planning when Calthorpe published "The New American Metropolis" in 1993. TOD has been defined generally as "a mixed-use community that encourages people to live near transit services and to decrease their dependence on driving." Calthorpe saw it as a neo-traditional guide to sustainable community design. Beyond its definition of built form, it was also a community design theory that promised to address a myriad of social issues.

Calthorpe, a student of the environmental sustainability movement, developed TOD to address the ecology of communities. He also saw TOD as an easily comprehensible solution for regional growth. It also met the need of transit agencies for alternative revenue sources. And it was a natural evolutionary next-step from many familiar community design precedents. In its most bold promise, TOD was to help "redefine the American Dream." As later TOD analysts explained, "These Transit-oriented developments have the potential to provide residents with improved quality of life and reduced household transportation expense while providing the region with stable mixed-income neighborhoods that reduce environmental impacts and provide real alternatives to traffic congestion." [13]

2.3.2 Chronology

The first transit-oriented development projects in the United States were the railroad and streetcar suburbs of the late 19th and early 20th centuries. The earliest commuter rail lines were powered by steam engines that could achieve high sustained speeds efficiently but were slow to accelerate and decelerate, and thus promoted the development of stations that were several miles apart.4 In New York City, for example, three commuter railroads – the Hudson River Railroad, Harlem River Valley Railroad, and Long Island.

Sound Railroad – helped channel population expansion from the five boroughs to outlying suburban townships.5 although more common in large east coast cities, a steam-powered commuter rail service did exist in the San Francisco Bay Area in the late 19th century.

Electric street railways were developed in the late 1880s. Electric streetcars picked up their power from an overhead electrical line (using a "trolley" pole), and used the running rail as a ground. By the early 1900s, electric streetcar systems had emerged in cities throughout the United States, replacing horse-drawn or cable pulled systems.
Typical features of these early transit neighborhoods included a transit depot and public space in the center of the neighborhood, small cottage-type houses, and a street pattern and scale that allowed convenient walking distances to transit.

However, studies from the 1970s began to point out that joint development conferred other benefits by demonstrating that transit ridership was related to the intensity of development near transit stations. Transit authorities began to see that they could play a part in increasing ridership by guiding the type and scale of development on land near stations.

The 1980's saw transit agencies look beyond joint development to become true promoters and instigators of development. This period coincided with the anti-suburb, anti-sprawl movement of the 1980's. The advocacy of both the transit agencies and the anti-sprawl groups for high-density, pedestrian-oriented development was synergistic.

2.3.3 What is Transit-Oriented Development (TOD)

Transit oriented development is a concept which involves the functional integration of land use and transit through the creation of compact, walkable, mixed-use communities within ¼ to ½ mile of a transit stop or station. A TOD brings together people, jobs, and services and is designed to maximize access to public transport, and often incorporates features to encourage transit ridership.

A TOD neighborhood typically has a center with a train station, metro station, tram stop, or bus stop, surrounded by relatively high-density development with progressively lower-density development spreading outwards from the center. TODs generally are located within a radius of one-quarter to one-half mile (400 to 800 m) from a transit stop, as this is considered to be an appropriate scale for pedestrians.

For example, the neighborhood center may have a transit station and a few multi-story commercial and residential buildings surrounded by several blocks of townhouses and small-lot single-family residential and larger-lot single-family housing farther away. TOD neighborhoods typically have a diameter of one-quarter to one-half mile (stations spaced one-half to 1 mile apart), which represents pedestrian scale distances.

It includes these design features:

- The neighborhood is designed for cycling and walking, with adequate facilities and attractive street conditions.
- Streets have good connectivity and traffic calming features to control vehicle traffic speeds.
- High density mixed-use development that includes shops, schools and other public services, and a variety of housing types and prices, within each neighborhood.

Parking management to reduce the amount of land devoted to parking compared with conventional development, and to take advantage of the parking cost savings associated with reduced automobile use. [12]

2.3.4 WHY PLAN FOR LAND USE AROUND TRANSIT STATIONS?

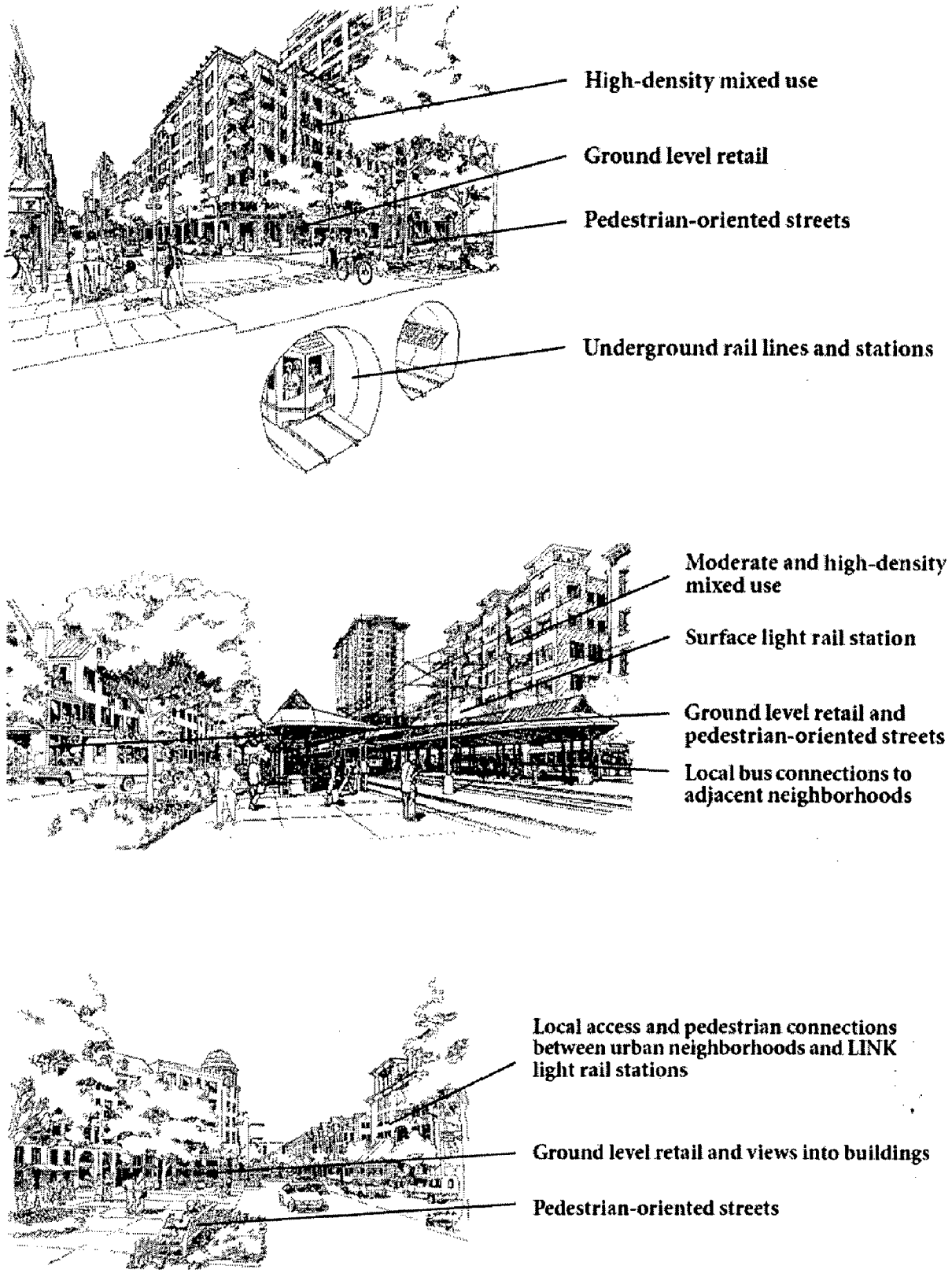
Strategically planned density mixed land use areas help promote the economic, social, and environmental well-being of a city by:

- Highlights transportation alternatives and increases transit ridership
- Decreasing auto dependency and exhaust emissions
- Using serviced land efficiently to help create a more compact urban form
- Making better connections between jobs and housing
- Revitalizing commercial corridors and older communities
- Providing increased neighborhood and travel options for those not owning cars
- Making identifiable and walkable neighborhoods
- Creating more street activity and a safer people oriented urban environment

2.3.5 Factors Driving the Trend Toward TOD

- Rapidly growing, mind-numbing traffic congestion nation-wide
- Growing distaste for suburbia and fry-pit strip development
- Growing desire for quality urban lifestyle
- Growing desire for more walkable lifestyles away from traffic
- Changes in family structures: more singles, empty-nesters, etc
- Growing national support for Smart Growth

Figure 2.2: Transit-Oriented Development (TOD) concepts



Source: Seattle Light rail station area planning report

2.3.6 Benefits of TOD

- Higher quality of life
- Better places to live, work, and play
- Greater mobility with ease of moving around
- Increased transit ridership
- Reduced traffic congestion and driving
- Reduced car accidents and injuries
- Reduced household spending on transportation, resulting in more affordable housing
- Healthier lifestyle with more walking, and less stress
- Higher, more stable property values
- Increased foot traffic and customers for area businesses
- Greatly reduced dependence on foreign oil
- Greatly reduced pollution and environmental destruction
- Reduced incentive to sprawl, increased incentive for compact development
- Less expensive than building roads and sprawl
- Enhanced ability to maintain economic competitiveness
- Transit investment has double the economic benefit to a city than does highway investment.
- Transit can enable a city to use market forces to increase densities near stations, where most services are located, thus creating more efficient subcenters and minimizing sprawl.
- Transit enables a city to be more corridor-oriented, making it easier to provide infrastructure.
- Transit enhances the overall economic efficiency of a city; denser cities with less car use and more transit use spend a lower proportion of their gross regional product or wealth on passenger transportation.

Source: Sustainability and Cities, by Newman & Kenworthy

2.3.7 TOD implementation

The implementation of TOD has not occurred as rapidly as the adoption of other New Urbanist concepts. Calthorpe originally believed that TOD fit within the needs, preferences, and purchasing power of the public but his perceived level of demand has not led to a substantial supply of TOD. As Calthorpe notes in his forward to "New Transit Town", "[TOD] is in its adolescent phase. The concept is developing but the body of work lags a bit behind."

Only a small percentage of the anticipated TOD projects have been developed and what has been produced does not fully incorporate the philosophies Calthorpe outlined. [12]

2.3.8 Example of Transit-Oriented Development (TOD) - Curitiba

Curitiba has a master planned transportation system, which includes lanes on major streets devoted to a bus rapid transit system. The buses are long, split into three sections (bi-articulated), and stop at designated elevated tubes, complete with disabled access. There is only one price no matter how far you travel and you pay at the bus stop.

The system, used by 85% of Curitiba's population, is the source of inspiration for the TransMilenio in Bogotá, Colombia; Metrovia in Guayaquil, Ecuador; as well as the Orange Line of Los Angeles, U.S. State of California, and for a future transportation system in Panama City, Panama as well as Cebu City, Philippines.

The city has also paid careful attention to preserving and caring for its green areas, boasting 54 square metres (580 sq ft) of green space per inhabitant.

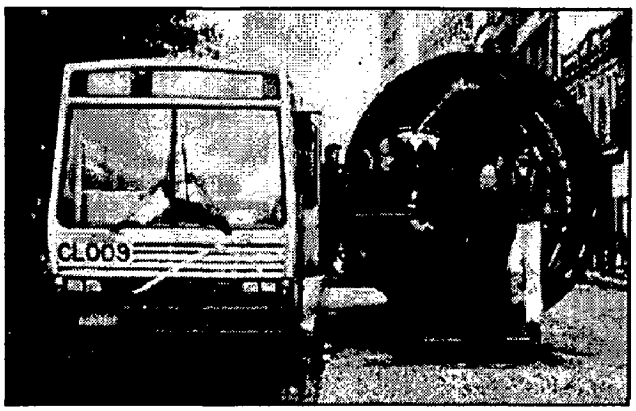
Figure 2.3: Skyline of Curitiba

Source: Cities in Transition

a) TOD Basics

- The system is planned along long linear avenues.
- Road hierarchy system.
- Central avenue : Two restricted express bus lanes
- Paralel roads : adjacent avenues
- 5 structural corridors created for growth to follow.
- Free transfers between zones.

Figure 2.4: Tube Station



Source:curitibaplanning.pdf

Figure 2.5: Articulated Bus

Source:www.curitibaplanning.pdf

b) Transit Facilities and Services

- Bus rapid transit operates on the five main arterials leading into the center of the city like spokes on a wheel hub.
- Tube stations serve the dual purpose of providing shelter from the elements, and facilitate the simultaneous loading and unloading of passengers.

c) TOD Facts

BRT limited central area growth, while encouraging commercial growth along the transport arteries radiating out from the city center. The city center was partly closed to vehicular traffic, and pedestrian streets were created. Linear development along the arteries reduced the traditional importance of the downtown area. [3]

d) Lessons Learned

- Curitiba's BRT successes were due to careful planning, smart decision making, and inspired leadership.
- Curitiba took many innovative measures: the creation of ternary roads, introduction of zoning bonuses, and initiation of direct-line services that tie into boarding tubes.
- Curitiba also kept things simple. Curitiba set off with a small set of realistic long-range goals.

2.4 Relationship of TOD to New Urbanism and Smart Growth

In recent years, both "New Urbanism" and "smart growth" have emerged as buzzwords in the planning profession, and have even gained some recognition in the mainstream media as progressive approaches to solving problems associated with suburban sprawl.Both the New Urbanist and smart growth movements advocate some of the basic elements of transit-oriented development, so it is useful to briefly discuss each here.

New Urbanism, also called "neo-traditional planning," has been championed over the past two decades by urban designers and architects such as Peter Katz, Andres Duany, Elizabeth Plater-Zyberk, Peter Calthorpe, and Daniel Solomon. These individuals and other promoters of New Urbanism have even encorporated themselves into an architectural reform movement called the Congress for the New Urbanism. The New Urbanists generally advocate returning to pre-World War II town planning principles, with an emphasis on designs that provide mixed land uses, narrow streets laid out in tight grid mesh, decreased setbacks, and reduced parking, among others. Many of the types of design features that make TOD projects successful are the types of features that are included in New Urbanist projects. However, transit is not a required feature of New Urbanist development. Many New Urbanist projects are taking place in suburban or exurban areas – and while they may contain higher densities and more pedestrian friendly design features – they are not accessible via public transit. Some New Urbanist projects include transit stations; for example, Peter Calthorpe's "Crossings" project in Mountain View, California, is situated across from a stop on the Cal Train line. [9]

Transit Oriented Development shares many of its principles with the New Urbanism few of them have been listed below:

- **Mix of uses**

It is emphasised that the level of public life that is seen as the lifeblood of any urban environment requires the overlay of multiple urban functions within a scarce spatial arrangement. This brings about the synergy of constant human presence and interaction in public spaces without the purpose of this presence being immediately obvious, and corresponds to the New Urbanist principle of *variety*. [10]

- **Eyes on the street**

A concept first coined and promoted by Jane Jacobs (1961), this element recognises the relations between public and private spheres and the significance of their spatial arrangement to facilitate interaction. This is a fundamental prerequisite for the functioning of the urbanity-related behaviour code mentioned earlier and has been strongly linked to the mitigation of street crime. In New Urbanist terminology, this principle is referred to as *passive surveillance.*

- **Enclosed streetscapes**

What is essential here is that public spaces have clearly visible boundaries with adjacent private uses, which in turn, as discussed, are oriented to the street. It is also paramount that each public space thus enclosed has more than one exit and connects well to other streets and squares - a concept known in New Urbanism as *permeability.*

- **Street windows**

This refers to the core architectural interface between public and private sphere, which are the windows overlooking the street or square and without which the above three principles would be obsolete. Another aspect in this context is the application of building aesthetics to clearly indicate its use and function in the urban context, or *legibility* to New Urbanism.

Smart growth is a somewhat broader and more mainstream movement that draws on many of the principles of New Urbanism.

There is no single definition of smart growth, but the common thread is development that revitalizes central cities and older suburbs, supports and enhances

public transit, and preserves open spaces and agricultural lands. The underlying premise that much of America's post-World War II suburban development – with its strict separation of land uses, low densities, and heavy auto dependency – has contributed to such problems as increased traffic congestion, loss of farmland, and the decline of traditional downtown areas. Smart growth generally calls for higher-density, transit-oriented development, with an emphasis on providing a balanced mix of housing, jobs, and shopping opportunities within a community. The "Ahwahnee Principles," which are often cited as the basic tenets of smart growth, contain many of the elements of successful transit-oriented development.

2.5 REVIEW OF THE PUBLISHED RESEARCH PAPER – 1

This study is being done as a part of the literature review from the published paper- '*Transit Oriented Development: Moving from Rhetoric to Reality*'
Author: Dena Belzer and Gerald Autler
Strategic Economics

The author of this paper attempts to bring clarity to the debate around transit-oriented development by creating a performance oriented definition, and by analyzing the challenges encountered in attempting transit-oriented development around the country.

In order to understand why transit-oriented development is not more prevalent, we must first consider what it means. One of the first things that become apparent with a scan of the literature and interviews is that there is no universally accepted premise about exactly what TOD should accomplish. Many projects that fail to provide the full range of synergies and benefits made possible by TOD are proclaimed successes because there is no standard benchmark for success. For example, some developments are labeled TOD by virtue of their proximity to a transit station, regardless of how well they capitalize on that proximity.

In the future, unless objective measures can be established to examine both the positive and negative outcomes of TOD, the excitement about TOD may be overshadowed by unintended effects. Government policy must continually be reexamined to produce sustainable outcomes; and, without indicators for TOD, we cannot truly measure success.

The following discussion of transit-oriented development presents a framework that can be used for planning and analysis of projects. Specifically, it creates a framework that allows the following:

1. A focus on the desired functional outcomes of TOD, not just physical characteristics.

Although appropriate physical qualities (e.g. density, distance, and urban form) are essential for making TOD work, an exclusive focus on these characteristics can obscure the main goal of transit-oriented development, which is not to create a particular physical form but to create places that function differently from traditional development. TOD projects should capitalize on the synergy that results from a functional integration of land use and transit, such as reduced auto dependency, which in turn leads to other benefits. Physical characteristics are a means of achieving those desired ends, not ends in and of themselves.

2. Acknowledgement of a continuum of success.

The degree to which a TOD project achieves desired functional outcomes can vary depending on the quality of the project and the characteristics of the place. This provides criteria that can be used as performance measures to assess *how well* projects fulfill certain goals. A high-density development within one quarter mile of a transit station may fail to take advantage of the full range of synergies made possible by TOD, even if it is better in some ways (e.g. mode split3) than more conventional development. Focusing on functional outcomes allows such a project to be labeled a partial success rather than wholly labeling it TOD on the basis of physical characteristics.

3. Adaptation to different locations and situations.

Transit systems and locations vary greatly in their characteristics and their suitability for TOD. We should not expect the same results from a project in the core of a metropolitan area and one in the distant suburbs, just as we cannot necessarily hope for the same outcome in Dallas as in Chicago. Focusing on quantifiable functional outcomes accounts for both different degrees of success and the uniqueness of individual places.

Just as a project can be judged as more or less successful TOD, so two projects with the same functional outcomes in very different places can be assessed within the context of those places.

2.5.1 Defining Transit-Oriented Development for the 21st Century

Transit stations offer a unique opportunity for development to be simultaneously locally and regionally oriented. This powerful combination is fundamental to what makes distinguishes transit oriented development from other types of urban infill projects. However, it is not always clear how best to create synergy between these two functions.

Definitions of transit-oriented development often focus on built form. For example, Bernick and Cervero (1996) emphasize the role of the "three Ds" (density, diversity, and design) in the success of TOD. Although proper built form is a necessary element, that alone is not sufficient for achieving all the benefits of TOD. For example, units per acre are a measure of physical form that tells us very little about the way a place functions: a high-density area can easily be less pedestrian friendly than a low-density one. In contrast, the ability of residents to make fewer trips, own fewer cars, breathe cleaner air, and enjoy more parks are all functional outcomes that can be measured.

Because most definitions of TOD focus on built form, many projects that are billed as successful transit-oriented development don't function very well. They may have overcome the main barriers to creating dense mixed-use development next to a transit station, but they fall short when measured by performance rather than physical characteristics. A focus on outcomes allows a better benchmark of success and a better measure of the tradeoffs that most projects must make. It permits a subtler assessment of projects that judges them as more or less successful in different areas rather than simply built or not built.

This section presents a definition in the form of six performance criteria that can be used to evaluate project function and outcomes. The major departure from previous thought on TOD is not so much the novelty of these performance areas, since many have been addressed in one way or another, but rather the emphasis on their use as a planning tool.

1. Location Efficiency

Ample evidence demonstrates that, on average, residents of denser urban neighborhoods own fewer cars, drive less, and walk and ride transit more than residents of suburban areas. This is true even when controlling for income. This suggests that reduced auto dependency will result from an effective blending of convenient and efficient transportation links (node functions) with enhancements of the ability to carry out most everyday tasks close to home (place functions).

Location efficiency requires neighborhoods that provide high-quality transit, a mix of uses, and pedestrian-friendly design. Proximity to transit is just one of several key variables that determine the location efficiency of a neighborhood. Other critical factors include net residential density, transit frequency and quality, access to community amenities, and a good quality pedestrian environment (good sidewalks, safety, reasonable topography). Location efficiency can be enhanced by the introduction of additional mobility choices such as car sharing, which makes it even more feasible for residents not to own a car. [10]

Location-efficient neighborhoods can provide the following types of outcomes:

- Increased mobility choices (walking and bicycling as well as transit).
- Increased transit ridership.
- Good transit connections to the rest of the city and region.
- Reduced auto use and reduced auto ownership.
- Reduced transportation costs to individuals and households.
- Sufficient retail development (quantity, quality, and diversity) to satisfy the basic daily needs of residents and employees working in the area.
- Ability to live, work, and shop within the same neighborhood.

2. Value Recapture

The benefits of location efficiency can translate into direct savings for individuals, households, regions, and nations. It seems intuitive – and it has been demonstrated – that residents of denser, transit-rich neighborhoods spend less on automobile transportation

than people in auto dependent areas.

Overall, residents of denser, more transit-rich metropolitan areas pay less for transportation than their counterparts in auto-dependent metropolitan regions – even when the cost of public investments in transit is included in the calculation. [11]

3. Livability

At its core, transit-oriented development strives to make places work well for people. While to some livability may conjure up the idea of vague and unimportant concepts irrelevant to such "nuts and bolts" issues as prosperity, in fact livability and quality of life are increasingly viewed as closely connected to economic development.

TOD may take different forms in different places. Ultimately, though, the question becomes:

Can, or does, TOD help improve the quality of life?

Measures of livability that relate directly or indirectly to transit-oriented development include the following:

- Improved air quality and gasoline consumption.
- Increased mobility choices (pedestrian friendliness, access to public transportation).
- Decreased congestion/commute burden.
- Improved access to retail, services, recreational, and cultural opportunities (including opportunities for youth to get involved in extra-curricular activities within the neighborhood).
- Improved access to public spaces, including parks and plazas.
- Better health and public safety (pollution-related illnesses, traffic accidents).
- Better economic health (income, employment).

4. Financial Return

Successful TOD projects typically mix of public and private development projects. The public Sector generally builds the transit station and the surrounding streets and public spaces, while private development may include housing, office buildings, and retail. Parking garages may be built by either the public or private sector. In some instances non-profits or other quasi-public entities can also own facilities such as day care

centers, and both public and private landowners can lease space to private and non-profit tenants. All TOD projects should be evaluated in terms of the total return to public as well as private investors so as to assist in making decisions about the trade-offs involved in potential public subsidies for various uses.

Financial outcomes should include:

- For local governments: higher tax revenues from increased retail sales and property values.
- For the transit agency: increased fare box revenues and potential ground lease and other joint development revenues.
- For the developer: higher return on investment.
- For employers: shorter and more predictable commute times, easier employee access.

5. Choice

One of the problems with standard suburban development is the lack of choice. Residents have few options in terms of housing types, places to shop, and modes of transportation. Meanwhile, people in a broad range of different contexts have emphasized the desire to have more transportation options in many of the livability indexes cited above. In other words, many people's idea of a good place includes the notion of choice.

Those who don't understand TOD sometimes describe it as an attempt to "force" people to live in high-density apartments and take transit. TOD is about expanding rather than circumscribing options. Lower-income people with less money to spend on transportation, first-time homebuyers, and others inadequately served by most currently available housing options may particularly value the location efficiency offered by TOD.

Enhanced choice may entail:

- A diversity of housing types that reflects the regional mix of incomes and family structures.
- A greater range of affordable housing options.
- A diversity of retail types. Diversity will necessarily be limited by the market area and the particular desires of the residents; however, this outcome could be

measured in terms of how well the retail mix meets the needs and desires of the residents as they themselves define them.

- A balance of transportation choices.

2.5.2 Efficient Regional Land-use Patterns

Most metropolitan areas in the United States have been urbanizing new land at a faster rate than they have added new residents. Some areas have continued to consume land even as their populations have shrunk.6 The causes of this trend are complex, but the results are quite clear: less open space, more area given over to roads, longer commutes, significantly unequal provision of services such as education across the metropolitan area, more air pollution, and so forth. Not all of these ills can be blamed exclusively on sprawl, but sprawl is a factor in all of them.

Smart growth measures such as the ones that have proliferated in recent years must do more than simply curtail growth if they are to be truly effective. They must channel growth to the places that are best suited for it. As frustration with sprawl and its consequences grows, more and more regions will look to a coordinated set of land-use policies and transportation investments to alleviate some of the problems. Transit-oriented development embodies these goals. Neither transit nor transit-oriented development promise a panacea for the problems associated with accommodating future growth, but both are important components of creating healthier, more livable cities, towns, and regions.

Outcomes of these efficient regional patterns include:

- Less loss of farmland and open space.
- More suitable regional and sub regional balance between jobs and housing.
- Shorter commutes.
- Less traffic and air pollution.
- Station areas as that can serve as destinations as well as origins. [15]

2.5.3 Challenges for Transit-Oriented Development

The factors that keep TOD projects from succeeding, meanwhile, are rarely examined. This is because, as noted earlier, TOD is normally declared successful or unsuccessful without comparing the actual outcomes or functional aspects of a project to a fixed performance standard. If the project is built, it is deemed successful, and if it is not built, that is generally attributed to any one of a variety of problems. In this fashion, the literature focusing on the difficulties of building TOD projects tends to focus on a limited number of barriers to success.

These barriers include: local neighbors' fears new TOD will harm the character of their neighborhood or depress property values; developers' and lenders' perceptions that TOD entails higher risks and costs; the failure of existing land-use patterns to support TOD; a lack of a market for it; difficulties of financing; poor transit design; and an unsupportive regulatory framework.

Thus, the barriers people associate with TOD tend to parallel the barriers associated with building all types of high-density infill projects, regardless of proximity to transit.

This approach ultimately does not explain why many of the projects billed as transit-oriented development fall short of their potential. Even if all of the above barriers were removed, it is highly likely that future TOD projects would still fail to capture the full range of benefits offered by a transit oriented location. A project that achieves high densities does not necessarily achieve the outcomes of TOD described above. To discover why, we must look beyond the barriers to building high density.

However, if these challenges can be dealt with and overcome, it is likely that both the overall number and quality of such projects would be greatly increased.

- No universal working definition of transit-oriented development exists. Often, the actors engaged in TOD projects bring different goals to the table, pursue strategies that work at cross-purposes to each other, and lack unifying policy objectives.
- Transit-oriented development must deal with the tension between node and place. That is, it must achieve a functional integration of transit and the surrounding uses.
- Planners have few guidelines for translating the concept of location efficiency into

concrete prescriptions for TOD in different settings. What makes a place has not been codified.

- TOD requires synergy among many different uses and functions, but this synergy is extremely difficult to achieve. As a result, TOD almost always involves more complexity, greater uncertainty, and higher costs than other forms of infill development.
- Transit-oriented development typically occurs in a very fragmented regulatory and policy environment. There is often no comprehensive plan or vision, and many local governments suffer from a significant leadership gap.
- Transit alone does not drive real estate investment when other conditions – particularly market conditions – are not supportive.

2.5.4 Recommended actions

The challenge is to recognize the full extent of the opportunity offered by such sites and push for real transit-oriented development, rather than settling for sub-optimal projects that will provide considerably fewer benefits over the long run.

Transit-oriented development should be both place-based and market-oriented. It needs to work for communities and for people, for employers and for employees, and for all those who are keeping an eye on the future such as planners, civic and community leaders, and politicians. Like all other place-based assets, no single agency or interest can make it work by itself. In order to fulfill its potential, then, TOD needs to have the benefit of conditions, resources and policies that are highly, dependably, and accountably aligned around the task at hand. There must also be a high degree of flexibility during the planning and development process to embrace different approaches depending on the particular context, whether it is light rail or commuter rail, low-density or high-density areas, strong or weak real estate markets.

TOD offers an opportunity to put the place back into marketplace, but it cannot happen if there's a sense of delusion about what works and what doesn't, or a lack of realistic strategies for building on success. Seizing this opportunity therefore requires that the many actors who influence the shape of transit-oriented development projects change the way they have traditionally done business. All parties must better understand what

TOD projects can and should accomplish how those goals can dovetail with each actor's own interests, and the role of each actor within the larger decision-making and development process.

In addition to the main actors – transit agencies, local government, developers, and lenders there is room for other actors to serve as TOD intermediaries.

The following recommended actions include various ways in which each of these stakeholders can work to reform the current process so as to achieve optimal transit-oriented development.

a) TOD-Related Development Intermediary

Broad-based education, information, and advocacy about the challenges and opportunities of transit-oriented development needs to be undertaken. To be sure, this is beyond the scope of most local governments and transit agencies.

TOD intermediaries can play a critical role in meeting this challenge by conducting research and disseminating the results, helping to build community support, working to shape public policy, educating actors in the TOD process, and developing toolkits for TOD implementation. [15]

The following are the most important actions to be taken.

1. Establish a "TOD Fund" to financially support TOD projects that cannot obtain conventional financing.
2. Provide technical assistance to local governments, transit agencies, and developers implementing TOD projects.
3. Create a typology of TOD projects appropriate for different types of stations in different contexts, as well as performance criteria for each project type.
4. Develop and disseminate materials to showcase examples of the benefits of these TOD goals and the ways in which they can be realized.
5. Help develop and promote appropriate parking standards and educate actors about parking reduction strategies.

b) Transit Agencies

1. Participate in planning for both transit agency property and the wider station area with the aim of fostering long-term rather than short-term value. Use transit agency resources to support this long-term value.
2. Create station-access plans that recognize the critical link between the station and its adjacent land uses, as well as the need for the station to be an integral part of a larger area.
3. Plan for TOD at the system-wide scale, assessing opportunities at each station site and thinking regionally about the interplay between land uses around each station and the way they can affect system-wide ridership.

c) Local Government

1. Establish transit-oriented development area plans around all transit stations.
2. Develop a process for interagency coordination with the transit operator(s) who will be involved in transit-oriented development projects to ensure that such projects will both achieve the goals of transit-oriented development and move forward expeditiously.
3. Create comprehensive parking strategies for TOD projects that include comprehensive management and that "unbundle" parking from other land-uses.
4. Provide financial and land assembly assistance to transit agencies and/or developers as an incentive for creating optimal TOD projects, including identifying new revenues streams to support bond financing.
5. Establish explicit policies for incorporating mixed-income housing in TOD projects.

d) Developers & Lending Institutions

1. Become educated about the financial structure and performance of existing TOD and appropriate mixed-use projects.
2. Use phasing and design flexibility into projects in order to demonstrate market viability, examine assumptions, and allow for the evolution of TOD over time.
3. Revise underwriting practices that require standard parking ratios for TOD projects.

4. Create loan guarantee pools to help transit-oriented retail projects get financing, especially those in revitalizing or inner city areas.

e) Community Organizations

1. Become active in planning activities sponsored by local governments and transit agencies around transit stations.
2. Advocate for mixed-income housing and recognize the benefits of mixed use and location efficiency as part of an affordable housing strategy.

2.5.5 Conclusions

This paper has argued that transit-oriented development can help alleviate a wide range of urban and metropolitan problems, from traffic congestion and air pollution to sprawl, long commutes, and shortages of affordable housing.

The paper also argues that it is important to focus not only on whether or not ostensibly transit-oriented projects are built, but on the quality of those projects as measured by the functional outcomes of projects. The three main goals of TOD projects – location efficiency; mobility, housing and shopping choices; and value-recapture and value-return – can be measured and quantified.

Instead of focusing on the barriers to getting projects built, this paper examines why the projects that get built so often do not live up to the full potential of TOD.

It finds that that:

- No working definition of TOD exists
- Projects fail to resolve the tension between "node" and "place"
- Planners lack guidelines about what makes a place work
- Unleashing synergy is complicated
- The regulatory and policy environment is fragmented
- The market may not be supportive

TOD surely offers only one part of the solution to our urban problems. However, if brought up to scale and integrated with other modern concepts of urban development TOD can play a central role in creating more livable, sustainable, and socially just cities and regions.

2.6 Review of the published Research Paper – 2

This study is being done as a part of the literature review from the-'Best Practices Handbook on Transit Oriented Development (TOD)' for the city of Calgary, Alberta, Canada.

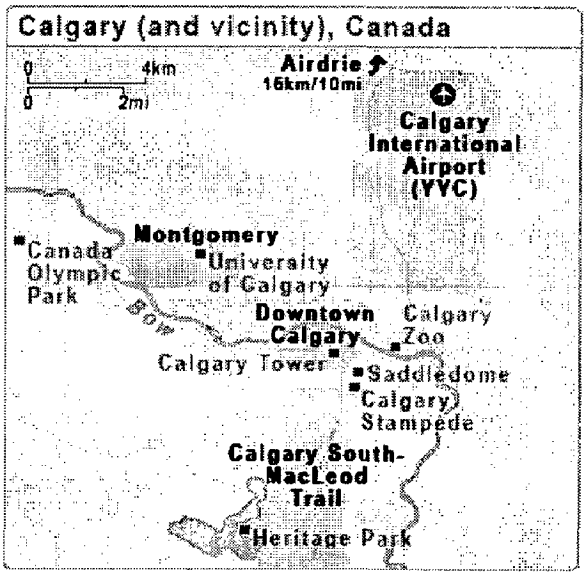
The Best Practices Handbook introduces the key planning principles behind successful TOD. It summarizes some of the current practices for designing and implementing transit oriented development. The Best Practices Handbook is not a policy document. It is intended as an information resource for Council, developers, builders, planners, urban designers, communities and the general public. Its purpose is to explain TOD, its characteristics, its benefits and its challenges.

The Handbook also helps stimulate creative thinking and discussion, and ultimately facilitate the smart development of lands around Calgary's LRT stations. [12]

2.6.1 Why Plan for Land Use Around Transit Stations?

Calgary City Council has endorsed Advancing Smart Growth as a key priority in its 2002-2004 mandates. Smart Growth recommends a balanced approach to municipal development by supporting economic development, a healthy environment and strong communities.

The wise use of land around LRT stations and high volume bus stops is one approach to help Calgary achieve its smart growth objectives.



Map 01: Location map Calgary, Canada

Strategically planned station areas help promote the economic, social, and environmental well-being of a city by:

- Highlighting transportation alternatives and increasing transit ridership
- Taking advantage of non-peak direction transit capacity
- Decreasing auto dependency and exhaust emissions
- Using serviced land efficiently to help create a more compact urban form

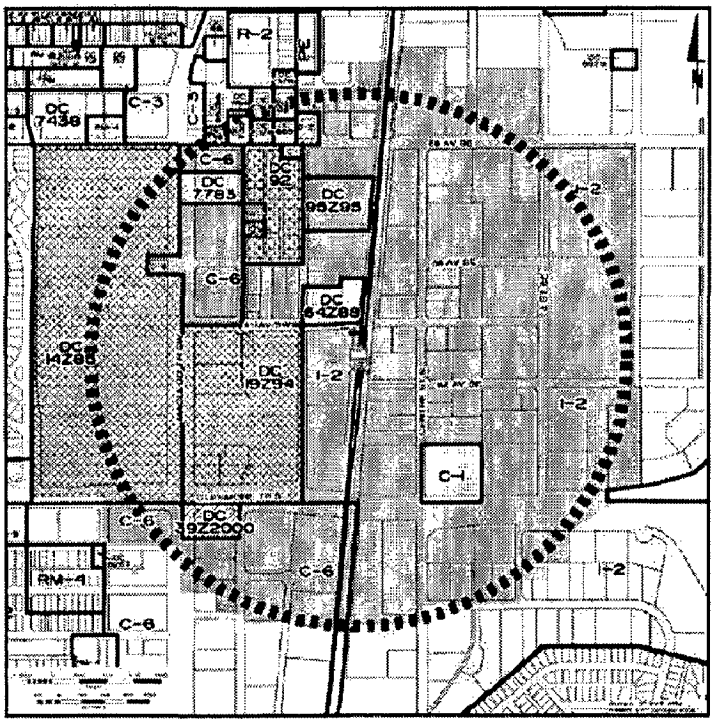
- Making better connections between jobs and housing
- Revitalizing commercial corridors and older communities
- Providing market housing in a variety of forms and price ranges
- Creating opportunities for affordable housing
- Providing increased neighborhood and travel options for those not owning cars
- Making identifiable and walkable neighborhoods
- Creating more street activity and a safer station environment
- Acting as a catalyst for private investment and development
- Increasing assessment values of vacant and underused land

2.6.2 Where does TOD occur?

Transit riders start and end their trips as pedestrians. Whether riders arrive on foot or via bus, private vehicle or even bicycle, every transit trip has a walking component. Creating a pedestrian environment which makes the transit trip easier and more enjoyable is therefore paramount in planning for a successful station area.

Map 02:

Chinook Station, Calgary, showing 600 m radius circles for TOD.



Source: Best Practices Handbook

The distance that a person is willing to walk to take transit defines the primary area within which TOD should occur. This distance is equivalent to roughly a 5 minute walk, or 400 to 600 metres. At these radii around a station, there is potential for 125 to 250 acres of land for transit oriented development.

2.6.3 Why is TOD important in Calgary?

To date, The City of Calgary has invested over $628 million in LRT infrastructure, which includes 32.7 km of operational track on three lines. There are 33 stations including 11 downtown platforms. In 2002, Calgary Transit carried 31 million LRT passengers. It has the highest LRT ridership in North America.

By 2004, a further $148 million will have been invested to add three new stations and 5.6 km of track to the system. With this significant investment in the network and current ridership success, TOD can become an important component of Calgary's future growth and traffic management strategies.

2.6.4 Calgary's Policies for TOD

The Calgary Plan (1998) is the City's municipal plan that establishes a long term vision for the type of city Calgarians want to live in. It forms the cornerstone of the City's transportation and growth management strategies by proposing increased mobility options, reduced reliance on the automobile and increased transit use. Increasing the number of jobs and housing near LRT stations is central to achieving these objectives. Key policies in The Calgary Plan that support TOD include:

- Encourage appropriate new office development to locate in transit supportive areas through the amendment of land use classifications, and the provision of infrastructure, etc.
- Promote greater land use efficiency and convenience by encouraging new housing close to transit facilities and within mixed-use centers to support transit and pedestrian mobility choices.
- Support the utility and vibrancy of LRT stations by actively encouraging both private and public sector development and integration of a full range of compatible land uses.

The LRT South Corridor Land Use Study (1981) was approved in conjunction with the first leg of the LRT. The study established a vision of intensified land uses around Calgary's first seven stations, while protecting the stability of existing communities. It also included a plan for automobile and pedestrian circulation, and improvements to facilitate long term development of the station areas. Density bonusing was provided as an incentive to encourage residential and mixed-use developments and high quality pedestrian connections.

The Employment Centre Strategy (1999) identifies many LRT station areas as "secondary employment centers." These are nodes with potential to accommodate future employment activity near to suburban residential growth corridors and transit facilities. The station areas are also identified as good sites for a range of supporting services such as shopping, recreation and residential uses, to be developed in the context of the site and adjacent communities.

The Transit Friendly Design Guide (1995) provides urban design principles and policies The Guide recommends mixed use development around all transit nodes, higher densities near stations, friendly pedestrian environment and passenger amenities to make transit more convenient.

2.6.5 Key TOD Components

A review of practices from cities across North America indicates that TOD is a unique form of urban development. No two stations are the same. How a station area is planned and developed will depend on the particular attributes of that station and surrounding community.

However, the following key components are commonly found to be critical to the success of any transit oriented development.

- Get the Land Uses Right
- Promote Density
- Create Convenient Pedestrian Connections
- Ensure Good Urban Design
- Create Compact Development Patterns
- Manage Parking
- Make Each Station a "Place"

1) Get the Land Uses Right

a) Ensure transit supportive uses.

Transit supportive uses are high pedestrian generators that directly promote greater transit ridership. They also provide opportunities for multi-purpose trips that can be made as a pedestrian. Medium to high density residential, offices, high schools and colleges are significant transit supportive uses.

Appropriate retail, restaurants, personal service and civic functions will support these major uses and generate activity in both peak and off-peak hours.

b) Discourage non-transit supportive uses

Non-transit supportive uses generate little or no ridership. They consume large areas of land, or create bleak or unsafe environments for pedestrians. They are often dependent upon a vehicle for transporting goods, or require significant land areas for low intensity development and parking. Large format wholesale stores, warehouse storage, car dealerships, auto service centers and regional sports fields are examples of uses that are not transit supportive.

c) Encourage a mix of uses

A mix of residential, office and supporting services in station areas can generate transit trips throughout the day. It provides opportunities for people to live closer to their jobs or to take advantage of reverse flow transit capacities. Workers can run daily errands within walking distance of their jobs; transit riders can access convenient services while at the station. Residents and visitors can continue a variety of activities in off-peak times.

2) Locate the uses as close to the LRT station as possible

Locating a majority of transit-supportive uses within a 400 to 600 m walking distance of the LRT station makes transit the most convenient and attractive travel mode for the site.

3) Promote density

Development densities are "as great as possible" within the context of a particular station and surrounding community. Minimum residential densities around rail stations are high enough to support higher frequency transit service and to foster lively, walkable communities. Housing forms include townhouse, walk-up apartment and high-rise buildings. Minimum employment densities are established in station areas to create a destination which generates transit trips. Below are some examples of minimum densities being used in LRT station areas by other jurisdictions?

a) Density concentration and transition

The highest densities are ideally located closest to the station, to optimize transit rider convenience. This includes high-density housing and offices. Intensity of development can taper off away from the station, to create an appropriate transition and interface with the surrounding community.

b) Plan for density

Plans for areas around LRT stations should address the ability to increase density over time. Vacant lots, surface parking lots and existing low intensity uses present opportunities for future infill development. A phasing plan that demonstrates how the station area can intensify over time offers flexibility to meet changing community needs and provides a vision for this transition.

4) Create Convenient Pedestrian Connections

Pedestrian Route Design Considerations:

- Short
- Continuous
- Direct = convenient

Figure 2.6: Direct and visible link between parking and retail space, Calgary

Source: Best Practices Handbook, TOD

a) Walking distances are short

Pedestrian routes between the station and key destinations are short and direct. Key destinations are located within a 400 to 600 meter radius of the station. Circuitous routes are avoided

b) Pedestrian connections are continuous

Sidewalks and pathways are continuous routes that are easy to find and follow. Major connections to the station for pedestrians and bicycles are constructed at the outset. Routes are universally accessible to wheelchairs, strollers, scooters and other mobility aids.

c) Access is direct

Sidewalks connect directly to the entrances of the station and buildings. Bus stops are located as close as possible to building entrances. Walking distances from the station to the nearest bus stop are generally shorter than the distance to the nearest parking space.

Clearly marked crosswalks identify space for the pedestrian, Calgary

d) People are at street level

Pedestrian routes are at ground level, with minimal stairs and grade changes. Adjacent buildings provide "eyes on the street" and informal security here. Pedestrian routes are located on public streets unless there are good opportunities to tie in to a safe, existing above-grade system.

Clearly marked crosswalks identify space for the pedestrian, West Market, Calgary

e) Separate vehicular and pedestrian functions

Vehicular and pedestrian ways are designed to minimize points of conflict. Sidewalk and pathway routes have as few driveway or parking lot crossings as possible.

5) Ensure Good Urban Design

a) Create high quality streets

A pedestrian-friendly street is visually interesting and makes walking enjoyable. Trees, landscaping, wide, separate sidewalks and on-street parking protect people from vehicle traffic and create a pleasant pedestrian zone. Benches provide places for people to rest and relax.

Architecture and street related uses can make the street interesting. _Orenco Station, Hillsboro, OR.

b) Make the most of architecture

Architectural variety on the lower three to four storey can define an interesting public realm. Articulated building facades incorporate attractive windows and varied architectural elements, and are built to the sidewalk. Upper floors of tall buildings can be set back to allow sunlight to reach the street and help reduce the sense of scale of the building.

c) Relate the ground level to pedestrian uses

Foot travelers tend to relate to the ground storey of buildings. This level accommodates residential units, building entrances and retail shops oriented to the sidewalk. Surface parking lots, parkade accesses and blank exterior walls are limited along major pedestrian streets.

d) All season design

Where possible, pedestrian connections and transit waiting areas provide weather protection in the form of awnings, building projections and colonnades. Ample enclosed shelters make waiting for transit more comfortable.

e) Lighting, landscaping, and signs

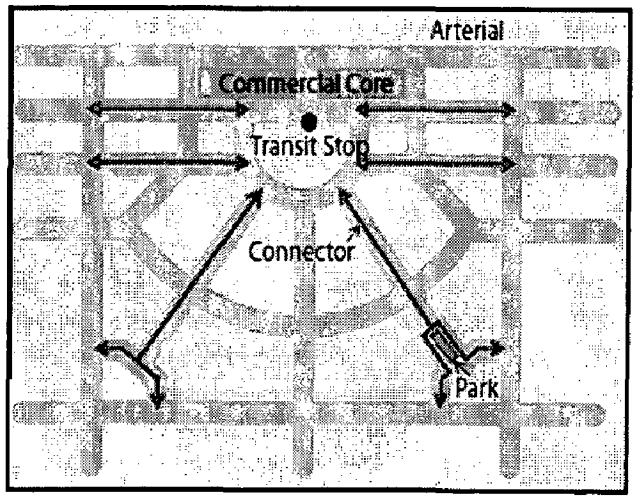
Stations are well-lit and designed to accommodate "around-the-clock" activity. Landscaping features can define special precincts and encourage transit patrons to linger and explore the station area. Convenient and legible signs orient visitors to buildings and activities around the station.

6) Create Compact Development Patterns

a) Compact Street Network

Frequent, interconnected streets increase the efficiency of transit circulation and offer more choices for pedestrians. Blocks of 100 to 150m in length keep walking distances short and provide alternative route options. A grid based street pattern offers multiple accesses to the station and forms the overall development framework for long term transit supportive uses.

Figure 2.7: Compact Development Patterns



Calthorpe, 1994

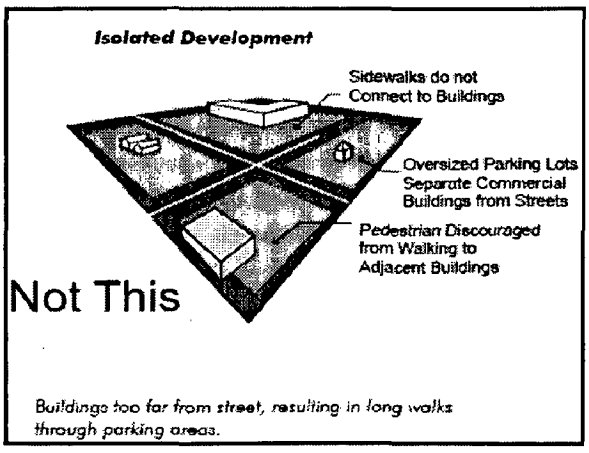
b) Cluster buildings

Buildings that are grouped together, or clustered, offer a "one-stop" opportunity to conveniently access a variety of destinations on foot. Clustered buildings can frame distinct character areas and create an easily navigable walking environment.

c) Leave room to grow

Buildings can be thoughtfully sited on a property to accommodate future intensification. Placing buildings to one side of a parcel, instead of in the centre, leaves sufficient land that can be developed later. This will allow an initially low density area around an LRT station to intensify over time.

Figure 2.8: Placing buildings to one side of a parcel, instead of in the centre



Source: Best Practices Handbook, TOD

7) Manage Parking

a) Accommodate the automobile

By design, TOD lessens the need for automobile use in a station area. However, accommodating vehicles is still critical to the success of a vibrant TOD district. Convenient parking and drop-off zones need to be planned for in all station area plans.

Parking areas can be located behind buildings to keep the street oriented to pedestrians.
Orenco station, Hillsboro, OR

b) Parking - enough, but not too much

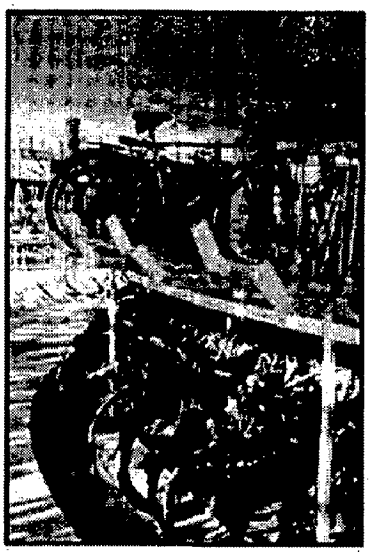
TOD provides an opportunity to reduce the amount of parking in the station area through increased transit ridership's, reduced residential vehicle ownership and shared off-peak parking at public Park & Ride sites. Setting both minimum and maximum parking standards can help ensure the success of a station area as well as optimize transit ridership.

c) Locate parking to the rear and sides of buildings

Parking lots are located at the periphery of the station area and to the rear or sides of buildings. This keeps the station and building entrances oriented to the sidewalk and to pedestrian users.

d) Bicycle parking

Bicycles can extend the local commuting range beyond the typical 600 m. Ample, convenient and secured bicycle storage locations are provided at each station, close to the entrance of the transit station.



Provide spaces for bicycles, Germany

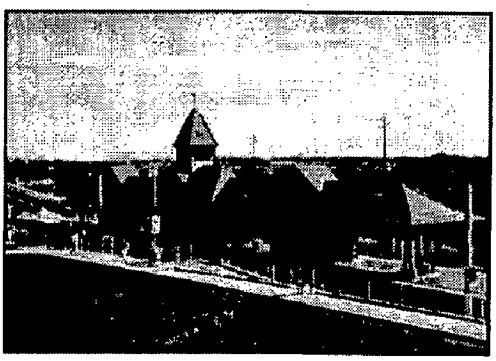
8) Make Each Station a "Place"

a) Create a Destination

A transit station is a destination in its own right, as well as a gateway to the rest of the city. A station area with a collection of unique places will attract visitors, while also serving transit patrons and the local community.

b) Make buildings landmarks

Landmarks create notable places and aid in local way finding. LRT stations and other significant buildings with distinctive design elements can make the area attractive and memorable.



Unique transit stops and buildings act as landmarks for the station area - Fish Creek/Lacombe, Station Calgary

c) Sightlines and views

Sight lines to and from the station help orient pedestrians to their surroundings. Views are critical for pedestrians to find their way. Sight lines can be terminated by important features such as the station, a community building, monument or public art.

d) Orient buildings to the street

Buildings that are adjacent to and overlook public areas create a visually interesting and safer pedestrian environment. Buildings oriented towards the street edge can enclose important vistas and shape the public realm.

e) Public open spaces

Open spaces near an LRT station emphasize the station as a public place. They provide comfortable waiting and drop-off areas for users and act as central activity and gathering points for the local community. The station area can be strategically punctuated with small parks or plazas, which might incorporate fountains or other landmark features.

2.6.6 How are cities implementing TOD?

Many cities, counties and state/federal agencies across Canada and United States are achieving TOD in their jurisdictions, using a variety of implementation tools. A number of implementation "best practices" have emerged, which are outlined below.

1. Provide a vision for TOD

A comprehensive, strategic vision establishes TOD as a key element of a City's overall land use and mobility plan. The vision encompasses broader city-wide land use and development goals, as well as performance expectations for future development around transit stations.

2. Build Community Support

A broad understanding and acceptance of TOD is important. Community wide information and education programs should be promoted. Planning processes that involve neighborhoods, elected officials, land owners and the development industry can create a TOD program that is supported and will be implemented.

3. Identify priority transit station areas

Wherever there is an LRT station there is an opportunity for TOD. However, the market is not limitless. Identify priority stations where there is market interest, sufficient land and a reasonable opportunity for success. Focus attention at these priority stations to ensure early TOD projects are successes.

4. Station Area Plans

Individual stations need specific plans that recognize local market strengths, site opportunities and community interests. These plans will outline clear goals for TOD at the individual station and provide guidelines for land use, density, public systems, urban design and parking management.

5. Ensure TOD plans are market responsive

TOD plans will only be implemented if they can entice the local real estate market to build. Development industry participation in preparing station area plans, land use mixes and marketing strategies is essential. Station area plans need to provide flexibility to allow the market to evolve, adapt to this new form and ultimately flourish.

6. Public and private participation

The participation of both the private sector and local government is important in reducing project risk. Foremost, it is governments and transit authorities that will encourage supportive land use policies that facilitate TOD. Secondly, there are typically large public land holdings around transit stations. These lands can be leveraged to reduce developer risk, speed development timing and ensure other public benefits are achieved through TOD.

7. Financing and Incentive Strategies

TOD and mixed use development provide financing challenges. Creative solutions have often been needed to make it happen. In many U.S. jurisdictions federal grants, tax incremental financing, public-private partnerships, joint ventures and "Location Efficient Mortgages" have been used to encourage development. Local governments also provide density bonusing, key public infrastructure and reduced approval timelines as incentives for TOD. [21]

8. Interim Development

Establish guidelines for "interim" developments that will maintain the long term vision for the station area. Interim development can be used to provide key public infrastructure, identify future development patterns and establish quality pedestrian environments. Interim uses that prematurely fragment land or create negative external impacts that discourage TOD opportunities are avoided.

CHAPTER - 3

CASE STUDIES

3.1 INTRODUCTION

Two case studies have been presented to infer useful lessons and planning guidelines for TOD and compact urban growth. Each case study begins with the description of the location, site, project and context description. This is followed by the TOD principles adopted and its implementation.

Then a critical evaluation of the case study is done describing its success and achievements. Inferences are drawn from each case study and finally usefull guidelines are drawn from the case studies.

3.2 CASE STUDY 1 – AHMEDABAD

3.2.1 Background

Public transit is a practical means to access employment, education and public services, therefore the land use can be enhanced such that its restructuring to an extent brings about changes in the sprawl of population and the mobility needs of the people are served. In the process there is also scope for rationalizing the land use and improving living environment. Community benefits could be optimized in terms of improvement of landscaping, infrastructure and environment.

The city of Ahmedabad, largest among all cities of Gujarat state, accommodating about 5 million people, has a registered vehicular strength of 1.4 Million. The rate of growth of vehicles has been about 9 to 10% per annum. Public transport situation has deteriorated rapidly over the past decade.

The present case study deals with restructuring of land use confined to the immediate boundaries of the BRTS Corridor in Ahmedabad. Hence a distance of 500 m along the roads meeting the corridor has been taken as Immediate Transit Influence Zone.

3.2.2 The City

The city of Ahmedabad was founded in 1411 AD as a walled city on the eastern bank of the river Sabarmati, now the seventh largest metropolis in India and the largest in the state. The urban agglomeration (UA) population has increased from 3.31 Million in 1991 to 4.5 Million in 2001. Ahmedabad is the commercial capital of the state. Known as the textile capital of India, it is also a major industrial and financial city contributing about 14% of the total investments in all stock exchanges in India and 60% of the total productivity of the state.

The area within the Ahmedabad Municipal Corporation limits consists of:

1. The traditional city center within the fort walls with relatively high-density development, large concentration of commercial activities and narrow streets,
2. The eastern sector accommodating large and small industries and low income residential areas, and
3. A well planned western sector with wide roads accommodating major institutions and high-income residential areas.

3.2.3 Location and Climate

Ahmedabad City lies between 22o 55' and 23o 08' North Latitude and 72o30' and 72o 42' East Longitude. The city is devoid of any major physical features except for the river Sabarmati, which is a perennial river cutting the city into two parts: eastern walled city and western Ahmedabad on either side of its banks.

Ahmedabad has a tropical monsoon climate which is hot and dry, except in the rainy season.

3.2.4 Demographic Trends

The Greater Ahmedabad Urban agglomeration covering an area of about 4200 sq. Km is an amalgam of:

- An area of 190 square kilometers under the jurisdiction of Ahmedabad Municipal Corporation (AMC), and
- 150 villages in the periphery of the city under the jurisdiction of Ahmedabad Urban Development Authority (AUDA),

- Municipalities in the periphery of the city under the jurisdiction of (AUDA),
- Gandhinagar and the surrounding villages,
- Chatral, Bhopal and other surrounding villages adjoining AUDA limits

1. Spatial Patterns of Population Growth

Table 3.1: Population Growth – Greater Ahmedabad

Spatial Unit	Population		
	1981	1991	2001
1. Ahmedabad Municipal Corporation (AMC)	**2159127**	**2876710** (2.9)	**3520085** (2.0)
1.a Walled City	476138	398410 -1.8	372633 -0.7
1.b. East AMC	1122073	1902868 5.4	2521013 2.9
1.c West AMC	463922	575433 2.2	675362 1.6
2. A.U.D.A.	**2721925**	**3756246** 3.3	**4709180** 2.3
2.a East AUDA	101144	128999 2.5	202494 4.6
2.b West AUDA	204923	457271 8.4	701424 4.4
2.c AUDA (Rural)	209826	246560 1.6	274391 1.1
3. Kalol	78407	92550 1.7	112013 1.9
4. Mehemdabad	22309	26103 1.6	30768 1.7
5. Dehgam	24868	31378 2.4	38082 2.0
6. Sanand	22465	25674 1.3	32417 2.4
7. Other areas outside AUDA	**264555**	**309871** 1.6	**334531** 0.8
8. Gandhinagar	**199353**	**280234** 3.5	**373663** 2.9
8.a. Gandhinagar (GNA)	62443	123359 7.0	195926 4.7
8.b. Rest of Gandhinagar	136910	156875 1.4	177737 1.3
GREATER AHMEDABAD	**3185833**	**4346351** **3.2**	**5417374** **2.2**

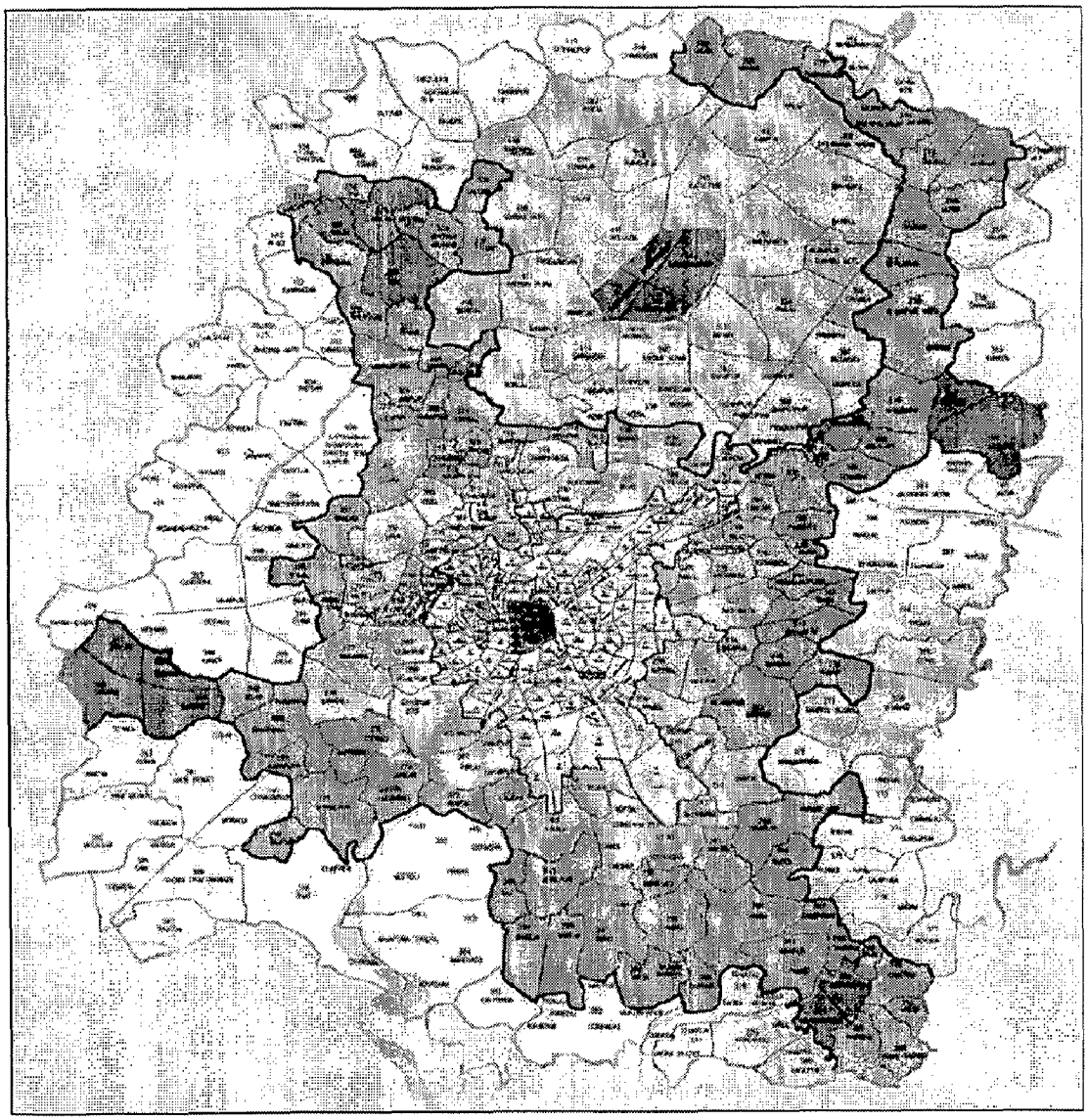
Source: Respective Census Documents

Note: Figures in parenthesis indicate annual compound growth rate

The population in the AMC limits increased to 35.15 lakh in 2001 from 28.77 lakh in 1991. The population in AUDA area in 1991 was 38.75 lakh. The Ahmedabad Urban Agglomeration (AUA) housed 23.25 % of the State's urban population in 1991, which has gone up to about 25% in 2001.

The AMC area is spread over 190.84 sq km, the AUA area is about 350 sq km and AUDA area is 1330.08 sq km. Spatial distribution of this population within the city over the decades shows that up to 1981 most of the new population added to the city was concentrated within the old AMC limits itself, especially in the eastern part. Expansion of the peripheral areas began in the 1980s and has continued.

Map 03: Greater Ahmedabad

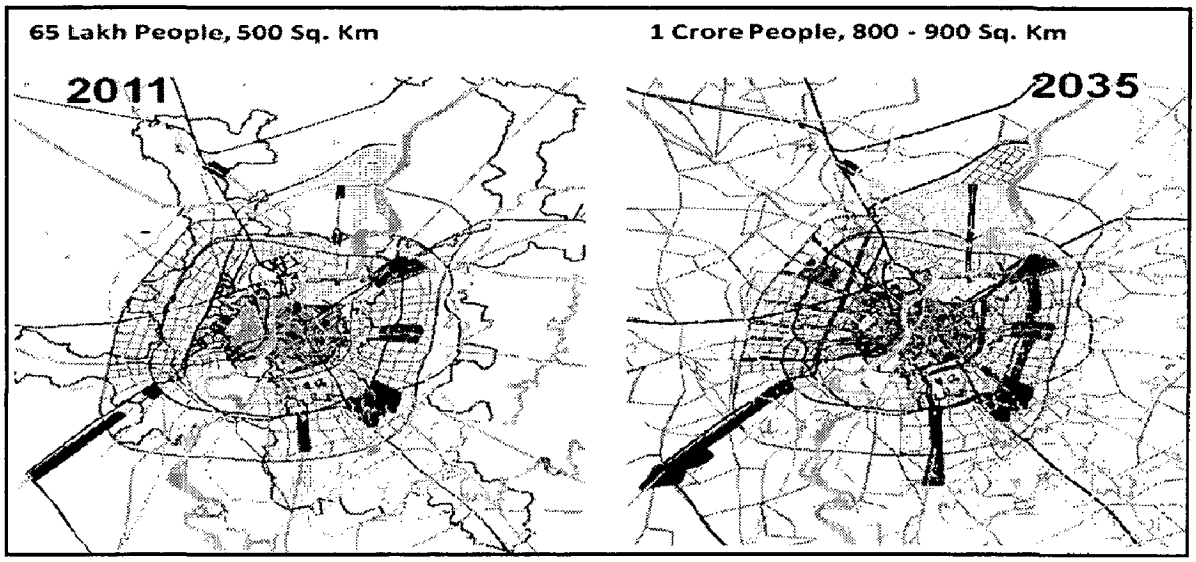


Source: GIDB/LB (2000) , Socio-Economic & Land use Studies

The population in the AMC limits increased to 35.15 lakh in 2001 from 28.77 lakh in 1991. The population in AUDA area in 1991 was 38.75 lakh. The Ahmedabad Urban Agglomeration (AUA) house 25 % of the State's urban population in 2001.

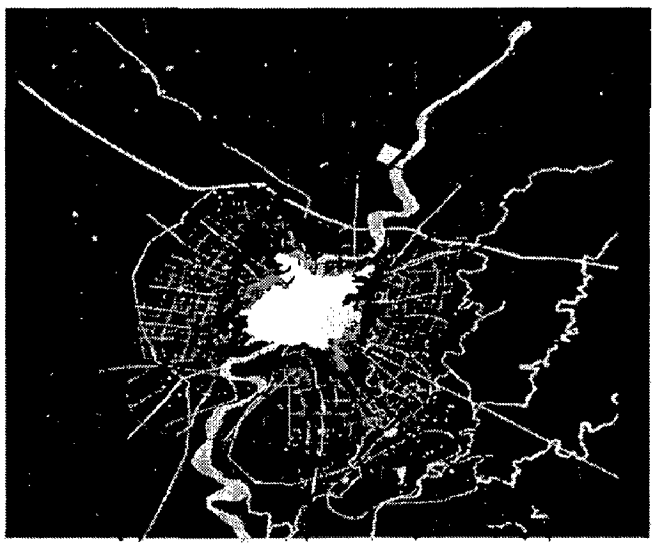
The AMC area is spread over 190.84 sq km, the AUA area is about 350 sq km and AUDA area is 1330.08 sq km. Spatial distribution of this population within the city over the decades shows that up to 1981 most of the new population added to the city was concentrated within the old AMC limits itself, especially in the eastern part. Expansion of the peripheral areas began in the 1980s and has continued.

Map 04: Greater Ahmedabad Development Area: 2011 and 2035



Source: CDP Ahmedabad

Map 05: Ahmedabad City Growth



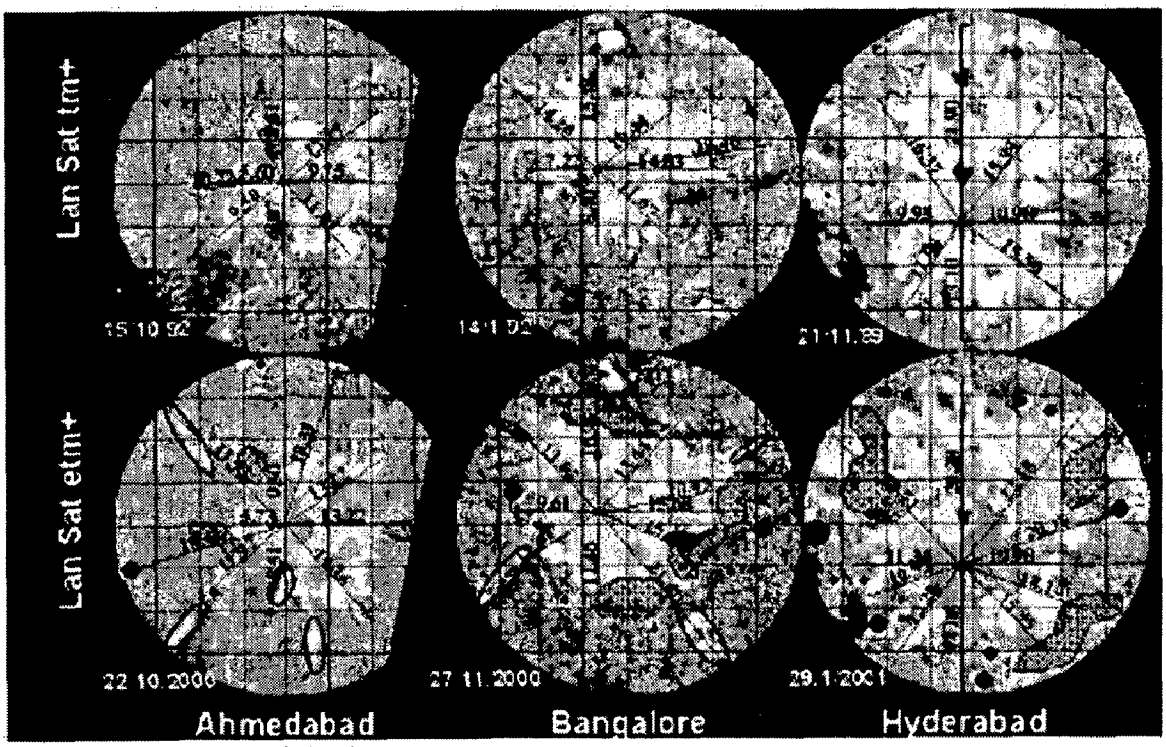
Year	Population (Lakhs)	Area (Sq.kms)
1971	17.78	90
1981	23.35	130
1991	34.37	250
2001	45.34	350
2011 (Forecast)	65.00	500

Source: CDP Ahmedabad

2. Population Density

The density pattern presented below indicates that the spatial expansion is limited to contiguous areas around AMC. The walled city is one of the most densely populated areas in the study area, and it has reached levels of saturation. The new outgrowths have been in the western parts of the city in the AUDA jurisdiction with people preferring to stay in the peripheral areas where they could avail of better infrastructure facilities. The zones along the 132' Ring Road and Naroda - Narol Highway have seen a higher level of physical development in the last few years. It also appears that most of the eastern part and a few parts in the southwest and northwest have higher densities.

Figure 3.1: False Color Composite (FCC) image showing sprawl between 1992-2000



Source: CDP Ahmedabad

A comparative analysis of three cities in terms of spatial expansion over a decade has been carried out based on Lan Sat Images shown above. From the above images it is evident that Hyderbad is the most spread out city followed by Bangalore. The blue patches indicate low-density sprawl type of development. [29]

Table 3.2: Population Density of Ahmedabad

Spatial Unit	Persons/Hectare		
	1981	1991	2001
1. Ahmedabad Municipal Corporation (AMC)	113	151	184
1.a Walled City	716	599	560
1.b. East AMC	79	134	178
1.c West AMC	109	135	159
2. A.U.D.A.	11	61	77
2.a East AUDA	6	7	11
2.b West AUDA	13	28	43
2.c AUDA (Rural)	12	14	16
3. Kalol	27	31	38
4. Mehemdabad	19	22	26
5. Dehgam	11	13	16
6. Sanand	6	7	9
7. Other areas outside AUDA	8	9	10
8. Gandhinagar	5	7	9
8.a. Gandhinagar (GNA)	24	47	75
8.b. Rest of Gandhinagar	4	4	5
GREATER AHMEDABAD	12	16	20

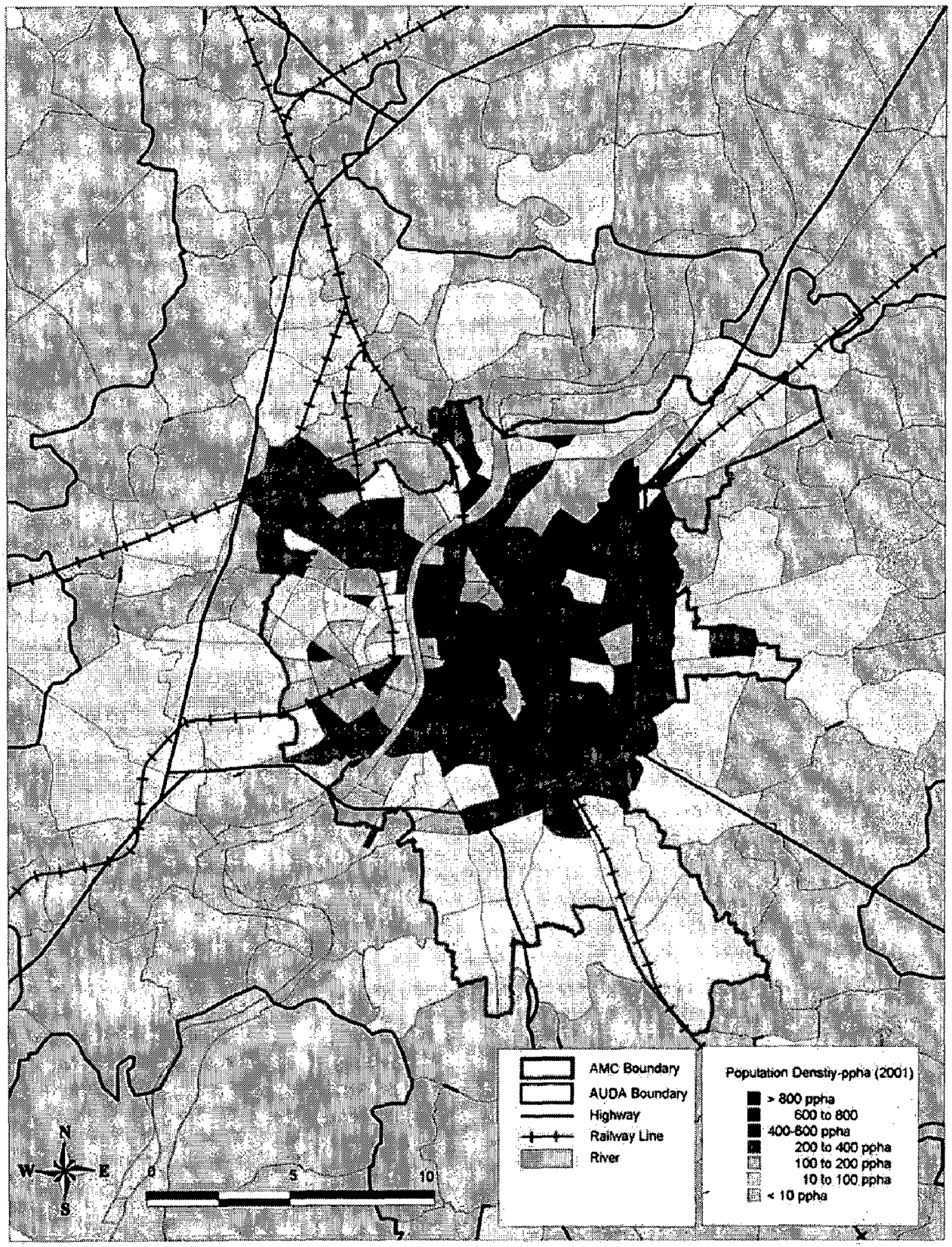
Source: Respective Census Documents

Table 3.3: Population Forecast for Ahmedabad

Sl. No.	Year	Population (Million)	Approx. Area (Ha)
1	1981	2.5	19000
2	1991	3.4	23000
3	2001*	4.6	30000
4	2011	6.0	40000
5	2035	10.9	50000

Source: GIDB/LB (2000) 'Socio-Economic & Land use Studies

Map 06: Population Density of Ahmedabad



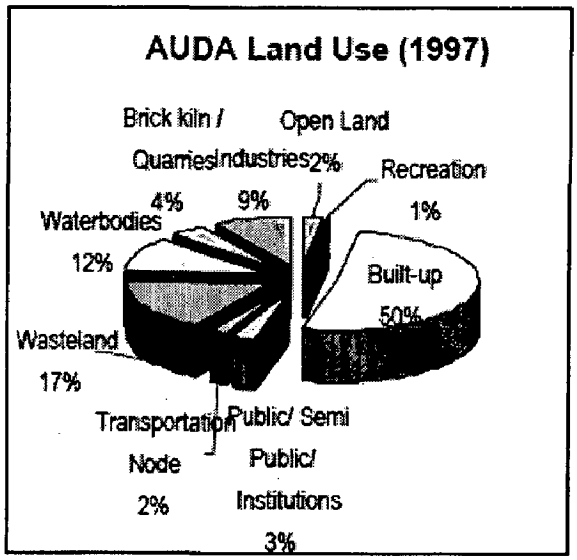
Source: CDP Ahmedabad

3.2.5 Land-use

1. Land-use in AUDA area

Of the total AUDA area of 1294.65 sq. km, nearly 50 percent is built up. Water bodies and wastelands cover 12 percent and 17 percent of area respectively. Industries cover 9 percent of the area. [29]

Figure 3.2: AUDA Land Use (1997)

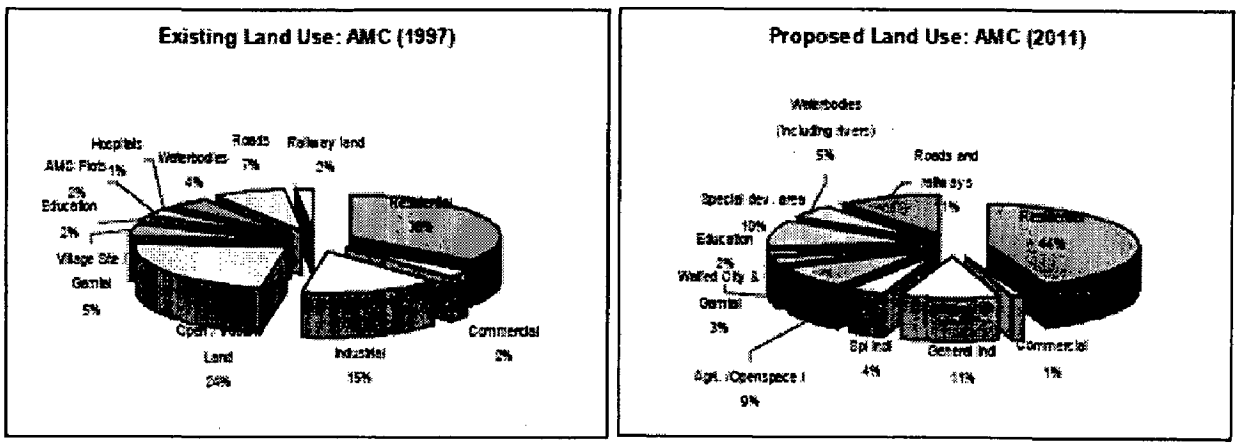


Source: CDP Ahmedabad

2. Land Use in City area

As per existing land use (1997), more than one third of the total area is under residential use, followed by 15 percent of the area under the industries. Large tracts of land (23.44%) are lying vacant, mostly in the newly acquired area of the AMC. Only 9.5 percent of the total area is under transportation network as against the norm of 15-18%.

Figure 3.3: Pie charts for existing and proposed landuse



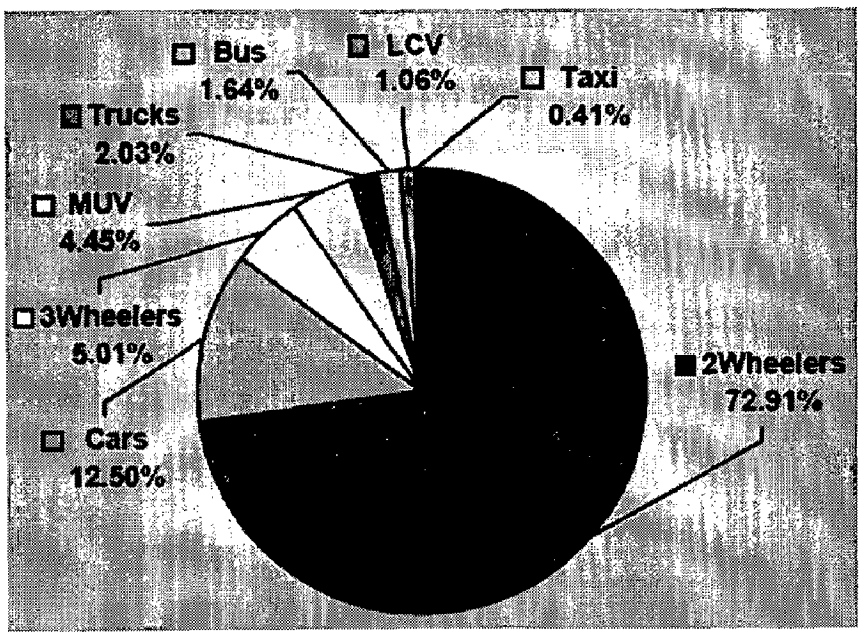
Source: CDP Ahmedabad

3.2.6 Existing transportation system - Vehicles, Facilities & Performance

Ahmedabad city is well connected by an expressway, several national and state highways, the broad-gauge and meter-gauge railways and an international airport. The city transportation system is predominantly dependent on roadway systems. Vehicular growth has been rapid. The network is experiencing heavy congestion. Consequently air pollution has become severe.

The information below provides an overview of the existing transportation system in terms of road network, vehicular growth and composition, performance of the system Ahmedabad district has a total number of 14.9 Lakh motor vehicles registered in the year 2004. Of this 73% were two wheelers. [28]

Figure 3.4: Composition of vehicles in Ahmedabad



Source: Transport Department, Gujarat, Ahmedabad, 2004

Table 3.4: Total motor vehicle growth and growth of two/three wheelers and AMTS buses in Ahmedabad (1961-2001)

Year	All Vehicles		Two Wheelers		Three Wheelers		AMTS Buses	
	Total	Growth	Total	Growth	Total	Growth	Total	Growth
1971	62922	-	21702	-	4685	-	525	-
1981	165620	163%	86550	299%	16741	244%	610	16%
1991	538182	225%	361372	318%	38359	249%	756	24%
2001	1210278	125%	863003	139%	65888	72%*	886	17%
Total Growth (71-2001) 1823%			3877%		1253%		69%	

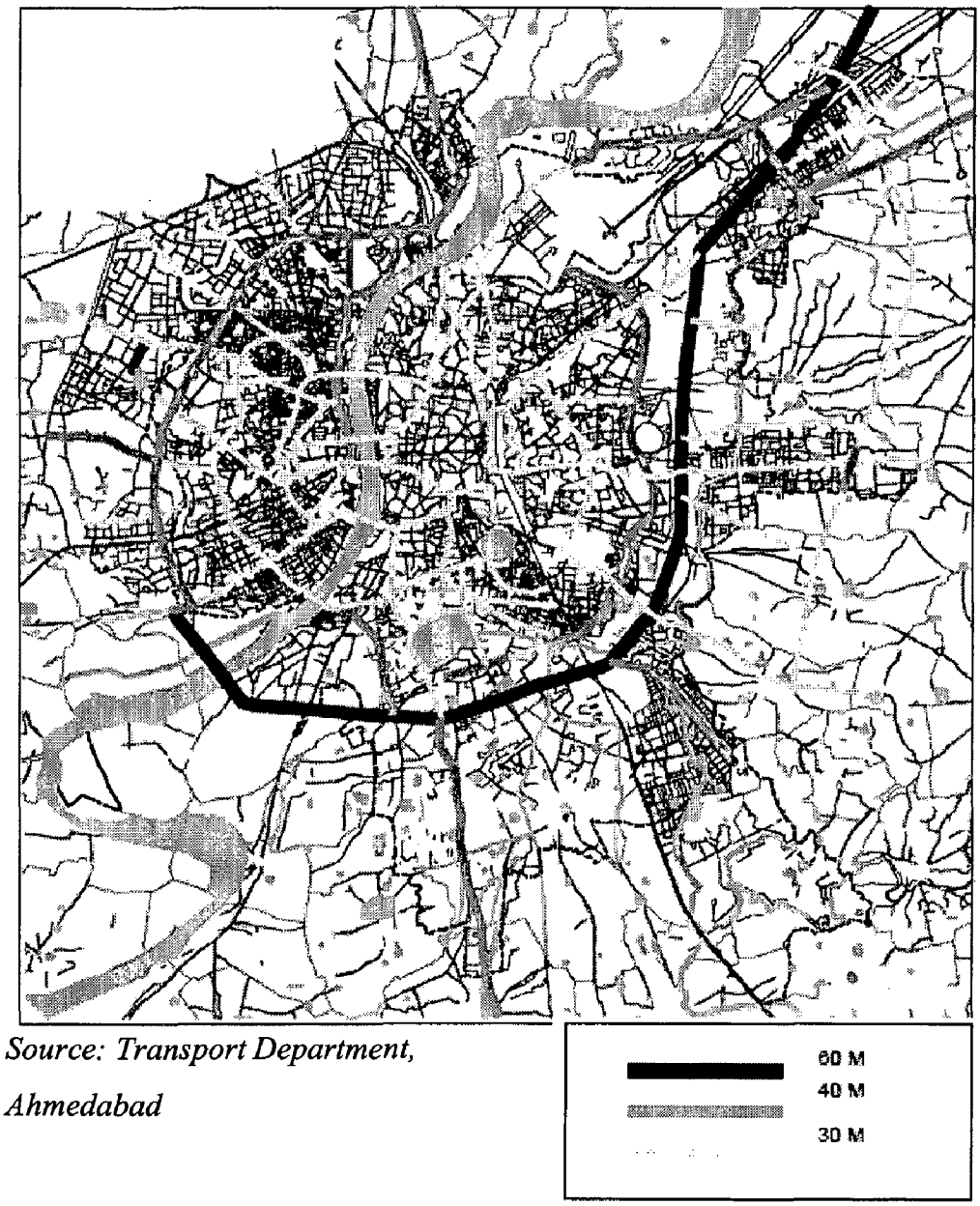
Source: Transport Department, Gujarat, Ahmedabad, 2004

Table 3.5: Road Network of Ahmedabad - Length given in km.

Road widths in Study Area		
No. of Lanes	Length	% of Total Length
1 Lane	2106	61%
1.5 Lane	522	15%
2 Lane	411	12%
2.5 Lane	12	0%
3 Lane	48	1%
4 Lane	299	9%
6 Lane	46	1%
8 Lane	34	1%
Grand Total	3478	100%

Source: Based on LB Study

Map 07: Ahmedabad Map Showing Roads Widths



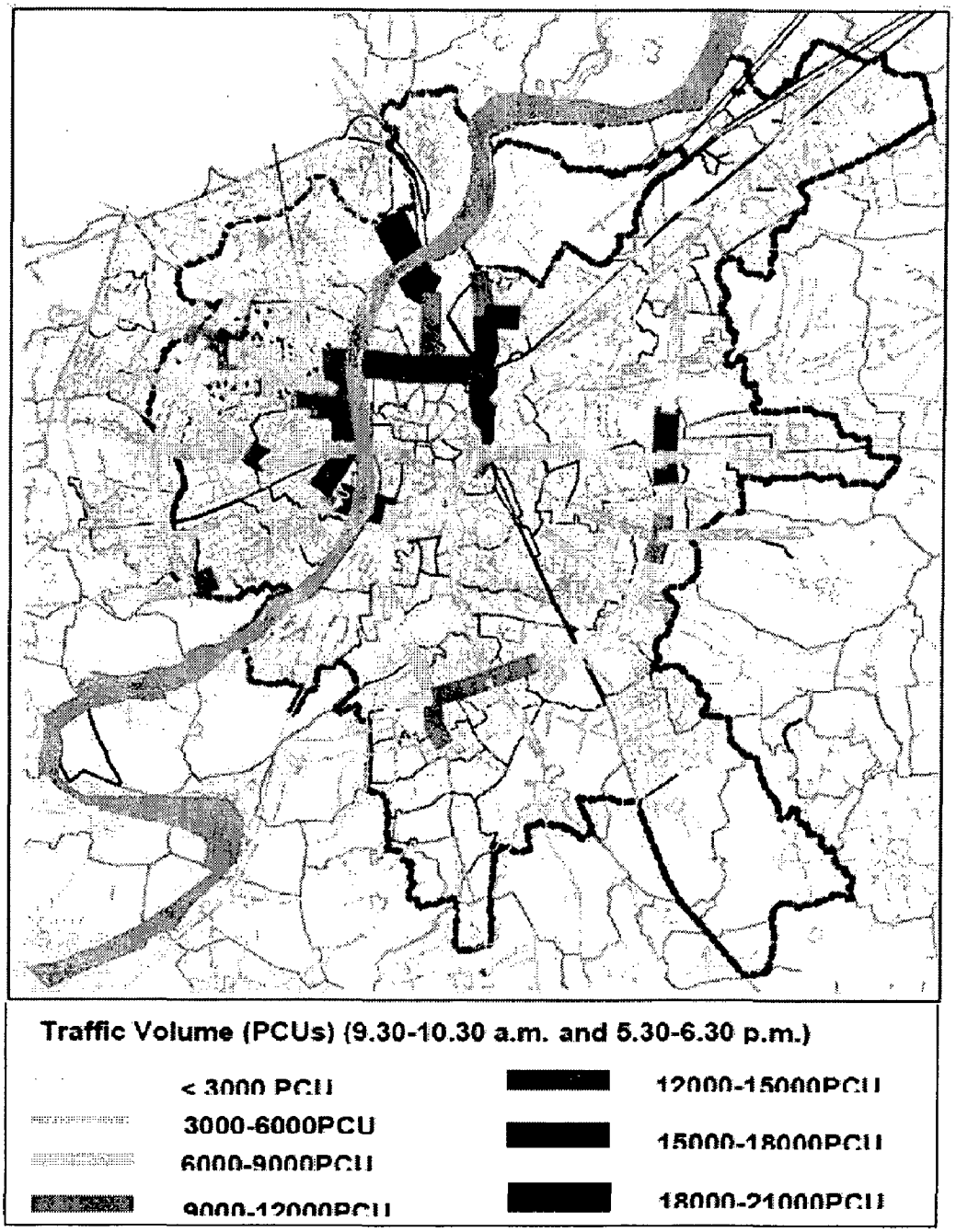
Source: Transport Department, Ahmedabad

Table 3.6: Types of Roads in AMC

Parameters	1997-98	1998-99	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004
Surfaced roads (km)	1118.9	1149.6	1189.01	1187.1	1208.3	1220.0	1256.5
% black topped	90.66	92.25	93.50	93.34	-	-	-
Un-surfaced roads (km)	115.3	96.6	84.6	84.64	90.6	78.9	68.6
Total length of roads (km)	1234.2	1246.2	1271.7	1271.74	1310.6	1318.2	1325.1
Length of roads per sq.km	6.47	6.53	6.66	6.66	6.9	6.9	6.9

Source: AMC Statistical Outline, 2000-2001

Map 08: Traffic Volume at different locations in Ahmedabad



Source: Transport Department, Ahmedabad

1. Public Transport

In the city of Ahmedabad, AMTS has been providing public transport facilities. AMTS, a municipal body, operates the services with about 550 buses of which only about 350 are on road every day. They used to service about 250,000 passengers per day in the

month of March 2004. The service had deteriorated significantly over the years. Now the system has improved with passenger patronage increasing to 6,50,000 per day.

2. Level of Operations and Coverage

AMTS caters to 2.5 lakh trips every day. About 150 routes are in operation with a fleet size of 540 buses. Fleet utilization has been consistently low. The average load factor has decreased and the number of cancelled service kms has increased.

AMTS bus route lengths average about 17 kms and range from about a minimum to 5km to a maximum of 57 kms. About 55 percent of buses operate on routes with lengths of 10 to 20 kms, with a running time of 30 to 90 minutes. The AMTS average bus stop spacing is 410 meters which is convenient for passengers, but results in longer travel time and delays. In the absence of faster bus services, average operating speed of AMTS is between 15-20 kmph. [17]

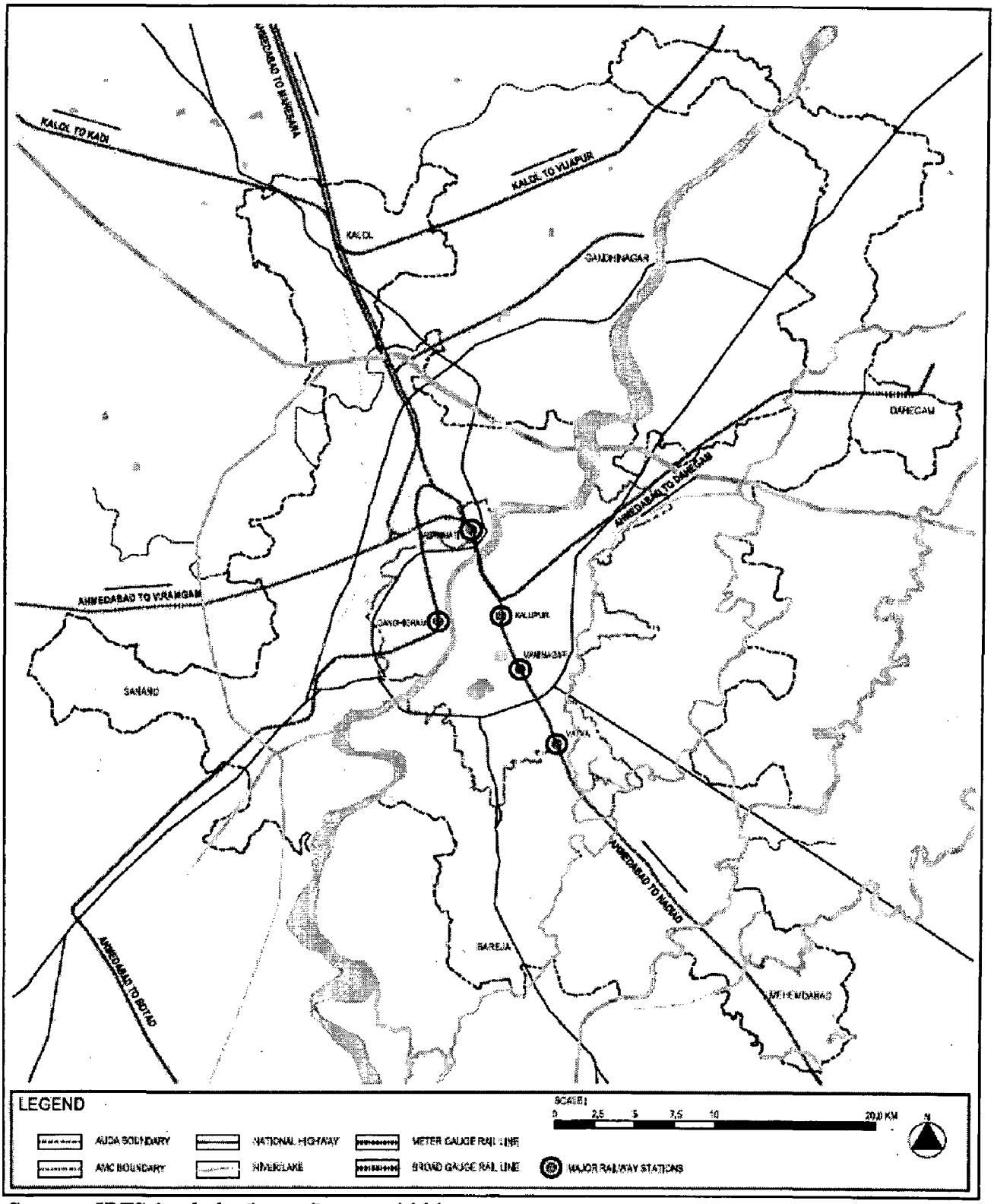
Though the primary duty of AMTS was to provide bus-services only within the municipal area, the AMTS gradually expanded its services to the areas on the outer periphery of municipal limits with the increased dependency of the city and peripheral areas with each other. As a result the operational area of AMTS grew to as high as 375 sq. kms. Compared to the earlier 198 sq. kms. area of the city.

Table 3.7: Level of Operations of AMTS (1948-2005)

Year-ending 31st March	Fleet-size (Buses)	No. of Routes	Service kms per day	Buses per lakh of population	No. of passengers per day
1948	205	38	15000	26	109024
1951	188	57	19755	21	153004
1961	337	100	44038	27	333885
1971	525	164	75757	33	541096
1981	610	205	96685	30	786301
1991	756	248	111452	24	819726
1995	705	180	115123	19	825479
1996	724	170	119583	19	883607
1997	820	164	134192	21	800822
1998	882	166	141726	22	791370
1999	882	132	150134	22	799321
2000	942	144	155675	22	757852
2001	886	140	151245	21	678861
2002	801	136	124375	18	574257
2003	687	115	81802	15	385682
2004	601	110	76028	13	325378
2005	540	117	77411	11	349853

Source: AMTS

Map 09: Railway Network of Ahmedabad City



Source: IPTS Study by Louis Berger, 2000

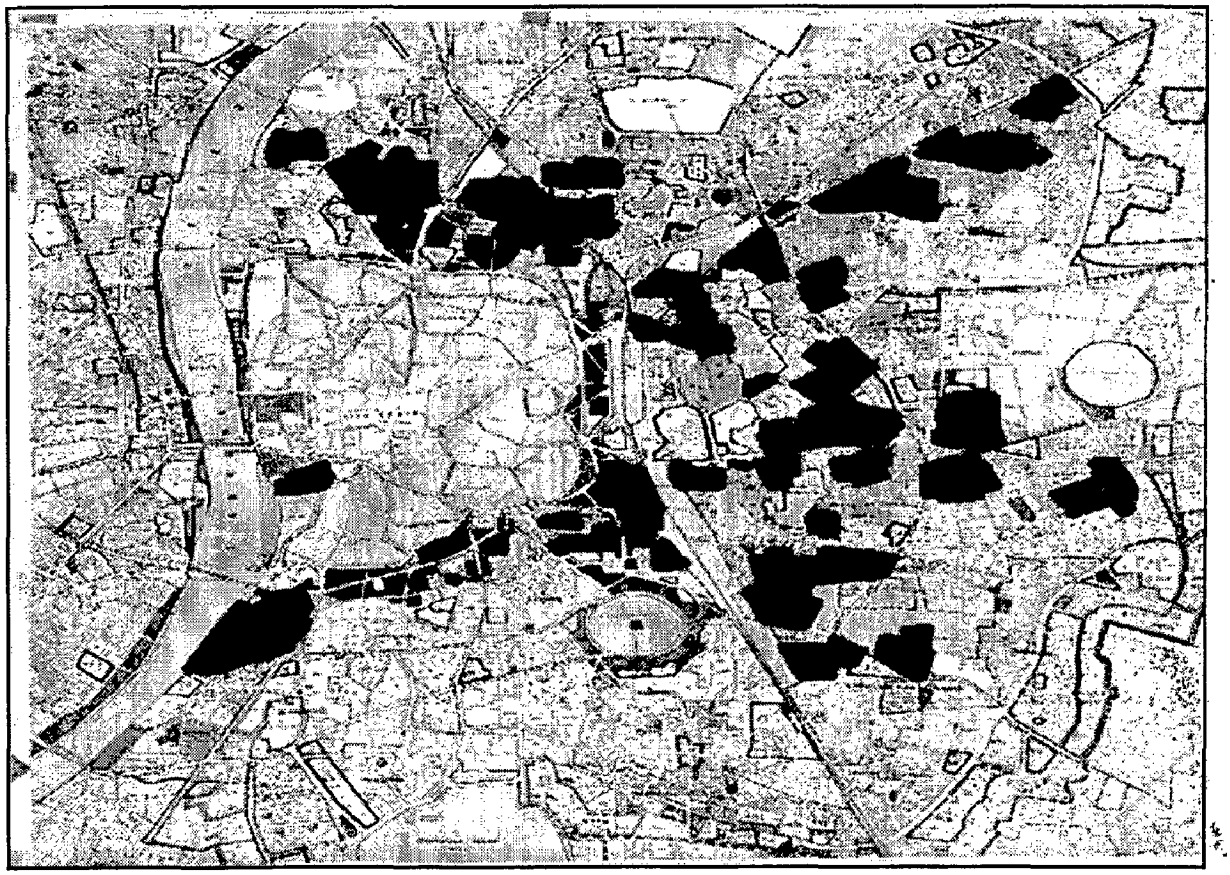
3.2.7 Growth Management- Development Plan

The City is poised for a real estate boom

State has appropriate measures to plan & release serviced land

- Development Plan
- Town Planning Schemes
- Multi-Sector Growth Nucleus
- Closed Mill Land to be developed
- Integrated Land use-Transport Development
  1. Metro
  2. Regional Rail
  3. BRTS

Map 10: Closed Mill Land to be developed in Ahmedabad : Vacant total land area (Since 1985-86) - 3.34 sq. kms.



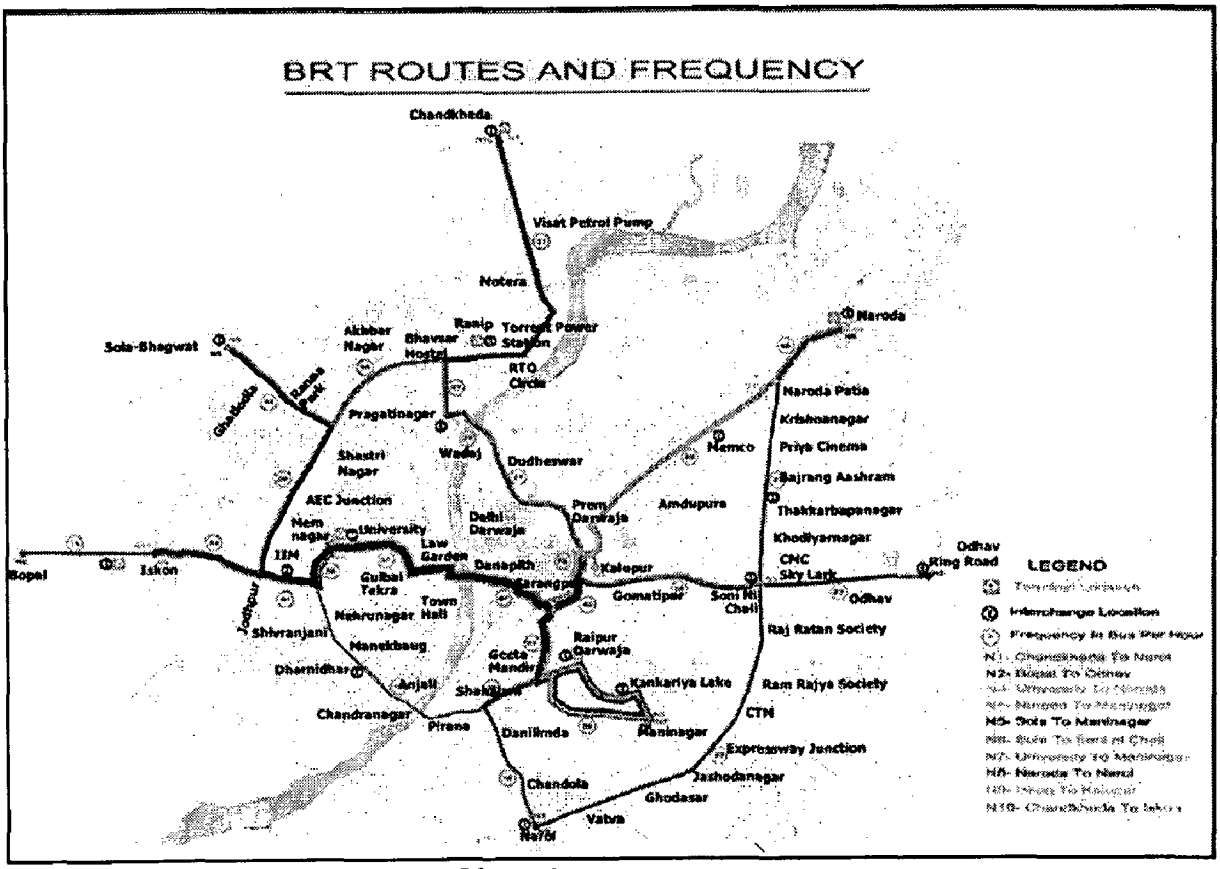
Source: Working paper on landuse restructuring, ART, Ahmedabad.

3.2.8 Ahmedabad bus rapid transit system (ART)

Janmarg

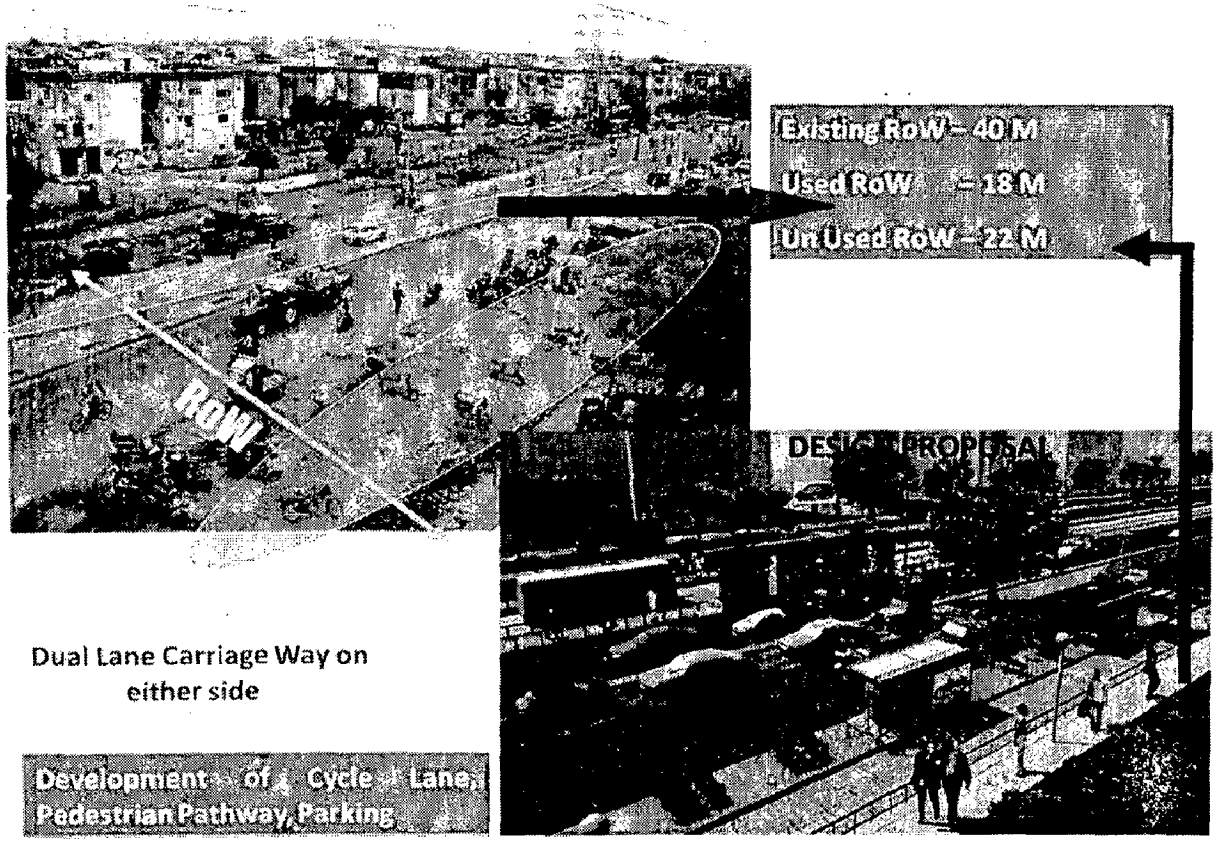
- The concept of Janmarg is influenced by the successful Transmilenio system built in Bogota and the BRT system of Curitiba.
- The system gives top priority to buses, pedestrians and non motorized transport and this is achieved by segregating these modes from fast moving motorized traffic.
- Buses run on dedicated lanes provided in the centre of the road while bicyclists get their own dedicated track and pedestrians get wide footpaths.

Map 11: Ahmedabad BRT Routes and Frequency



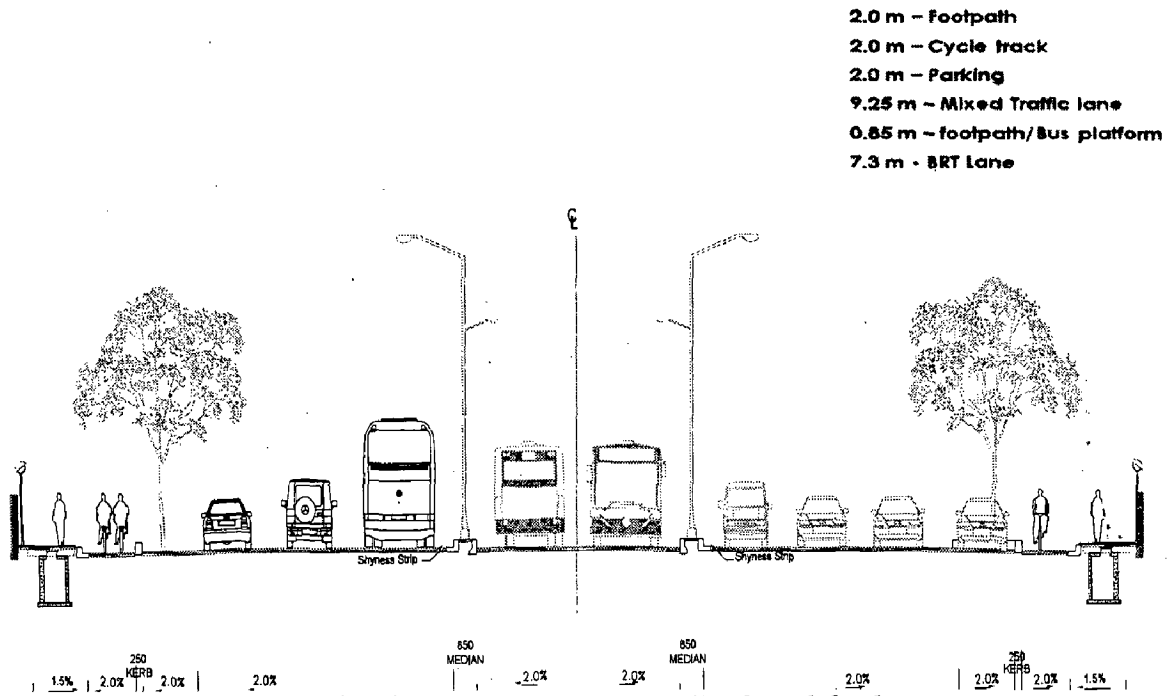
Source: Ahmedabad BRTS DPR Phase 2

Figure 3.5: Road design – existing characteristics



Source: Working paper on landuse restructuring, ART, Ahmedabad.

Figure 3.6: Road cross section – 40 m RoW – Median bus lane

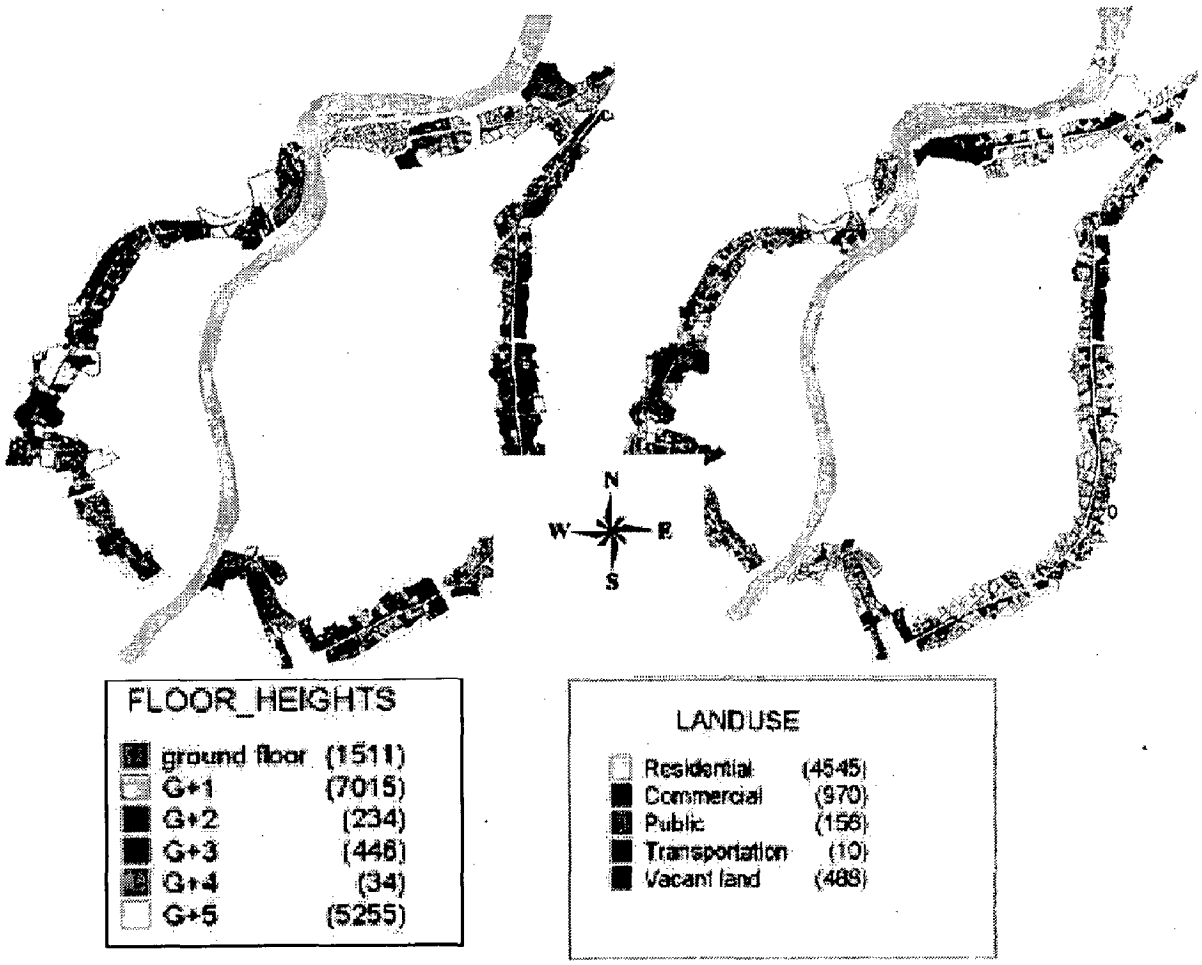


Source: Working paper on landuse restructuring, ART, Ahmedabad.

1. Land use status of immediate transit influence zone

Public transit impact would be significantly higher in the walking distance zone of transit routes. A distance of 500 meters is generally taken as Traffic Influence Zone. Within this zone the areas closer to the road are likely to experience higher level of impact, as the accessibility changes would be more favourable. Hence a zone extending along the Rapid Transit Corridor extending to 250 meters on either side or the nearest road, whichever is farther has been taken as Immediate Transit Influence Zone. Near junctions, the influence is expected to extend longer. Hence a distance of 500 mts along the roads meeting the corridor has been taken as Immediate Transit Influence. The Corridor, its immediate influence zone, land uses and the intensity of use in this area are marked below. [30]

Map 12: Floor Heights and Land use status of immediate transit influence zone



Source: Working paper on landuse restructuring, ART, Ahmedabad.

Table 3.8: Existing Land Use of immediate transit influence zone (Area in sq.kms)

Links	Residential	Commercial	Public	Ind.	Vacant	Total
Chandranagar - Shivranjani	3.96	0.091	0.351	-	0.261	4.663
Shivranjani - Helmet Junction	1.316	0.009	0.727	-	0.899	2.951
Helmet Junction - Akhbarnagar	6.50	0.063	0.156	-	0.461	7.51
Akhbarnagar - Sabarmati (New Bridge Alignment)	10.137	0.484	2.589	0.504	2.373	16.087
New Bridge – Naroda-Himmatnagar Highway Intersection	4.56	0.027	0.148	0.057	1.563	6.355
Naroda-Himmatnagar Highway Intersection-Soni ni Chali	8.801	1.006	0.792	0.292	0.715	11.606
Soni Ni Chali-C.T.M Crossroads	2.78	0.107	0.001	0.027	0.002	2.917
C.T.M. Crossroads-Dani Limda Bridge	5.30	0.572	0.0958	0.416	0.658	7.0418
Total	**43.354**	**2.359**	**4.859**	**1.296**	**6.932**	**58.8**

Source: Working paper on landuse restructuring, ART, Ahmedabad

Table 3.9: Land Use of inner link (Dani Limda-Maninagar Station, Dani Limda-Kalupur Station and Sarangpur Bridge-Soni ni Chali)

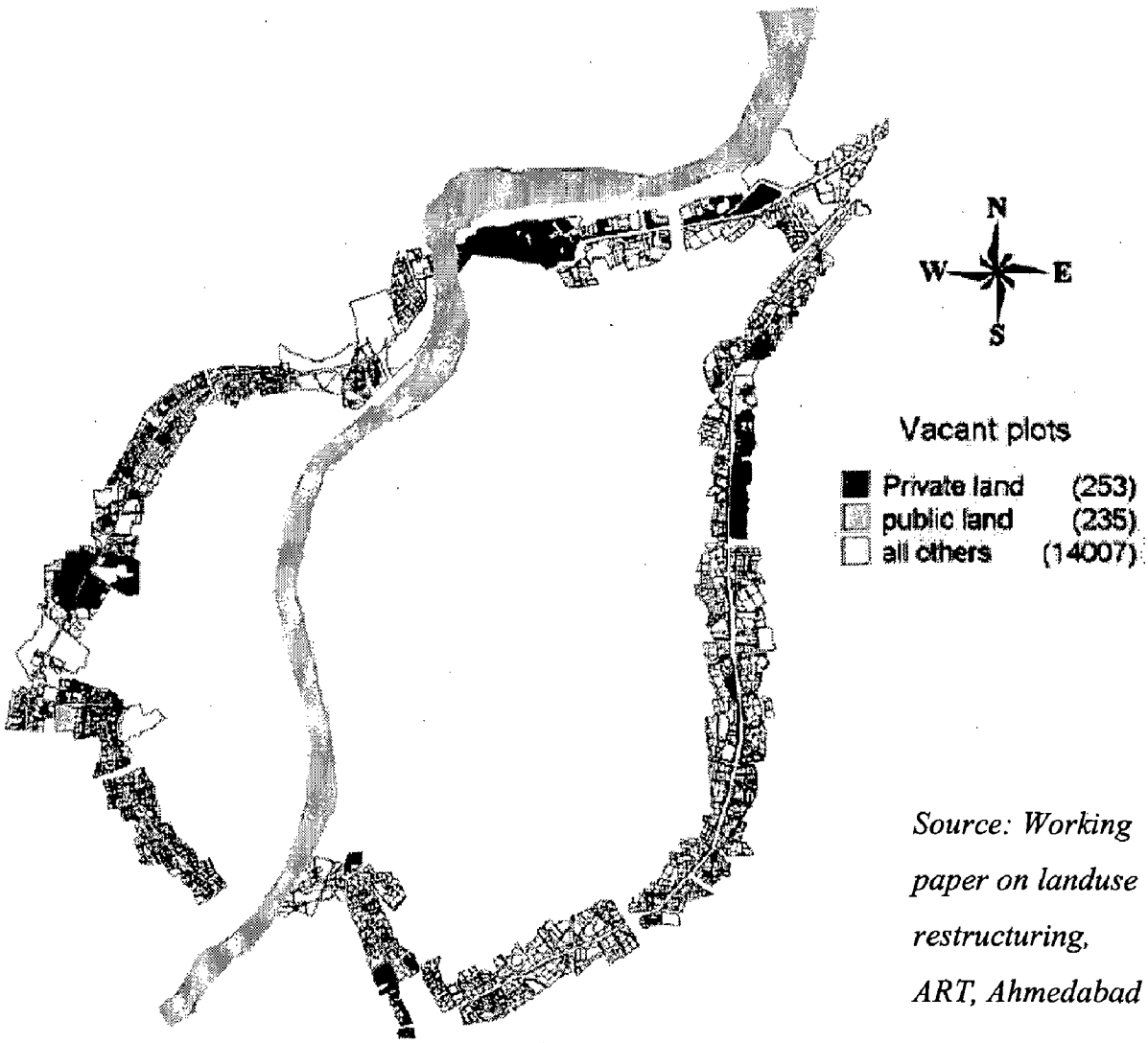
Sr.No.	Type of Landuse	Area (sq.kms)
1	Residential	1.23
2	Commercial	0.81
3	Mixed	0.56
4	Industrial	0.44
5	Vacant	0.07
6	Others	2.76
	Total	**5.88**

Source: Working paper on landuse restructuring, ART, Ahmedabad

2. Land amenable for development and redevelopment

The vacant land and the area under slums, which are in the immediate corridor influence zone, are likely to be influenced by road and transit development. They are likely undergoing development pressure in the immediate future. Giving extra FSI for new construction undertaken can intensify the land use in the catchments area of the corridor. The land occupied by slums under private ownership is 1.34 sq. km whereas under government ownership is 0.54 sq km. The vacant land owned by government is 5.92 sq. km whereas 0.77 sq. km land is privately owned. The total land, which is amenable for development and redevelopment, is 13.47 sq.km. Areas of GHB have been developed as housing colonies and hence may not be readily amenable for redevelopment. [30]

Map 13: Vacant Lands in the Immediate Influence Zone



Source: Working paper on landuse restructuring, ART, Ahmedabad

Table 3.10: Vacant Land and Slums in the Immediate Influence Zone

Links	Slums (sq.kms)	Vacant Govemment owned (sq.kms)	Vacant (Privately Owned) (sq.kms)
Chandranagar – Shivranjani	0.063	0.162	0.099
Shivranjani - Helmet Junction	0.006	0.820	0.078
Helmet Junction – Akhbarnagar	0.492	0.263	0.197
Akhbarnagar - Sabarmati (New Bridge Alignment)	2.694	2.265	0.107
New Bridge – Naroda-Himmatnagar Highway Intersection	0.183	1.449	0.114
Naroda-Himmatnagar Highway Intersection-Soni Ni Chali	2.472	0.706	0.008
Soni Ni Chali-C.T.M Crossroads	0.179	0.001	-
C.T.M. Crossroads-Dani Limda Bridge	0.801	0.253	0.163
Total	**6.89**	**5.919**	**0.766**

Source: Working paper on landuse restructuring, ART, Ahmedabad

3. Potential for development and redevelopment in terms of size and type of buildings

Considering the fact that the FSI utilization in Bungalows and Tenements is quite low and they have more potential for redevelopment compared to Apartments and High rise Buildings. In addition, with the removal of slums, the potential land available for redevelopment is approximately 36 sq. km.

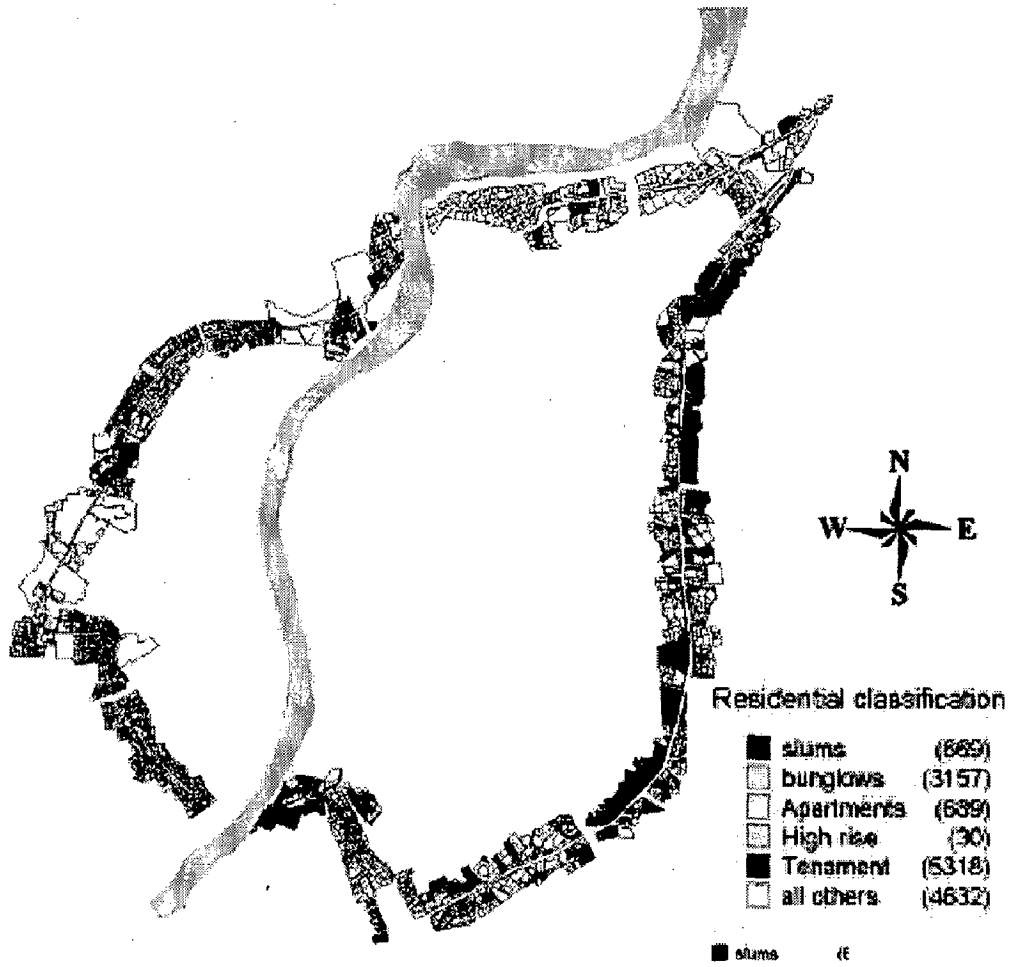
The type of residential land use in the immediate corridor influence zone is shown in the figure below. As shown in figure 3, a majority of the land is occupied by bungalows and tenements, which in most cases do not have multiple ownerships. Such property can be redeveloped. [30]

Table 3.11: Type of Residential Land Use in the Immediate Influence Zone

Link No.	Detail of Link	Type of Building									
		Bungalows		Tenements		Slums		Apartments		High-rise Buildings	
		Area(km²)	No. of Plots	Area(km²)	No. of Plots	Area(km²)	No. of Pockets	Area(km²)	No. of Plots	Area(km²)	No. of Plots
1	Chandranagar - Shivranjani	1.95	456	1.18	550	0.063	11	0.73	269	0.05	19
2	Shivranjani - Helmet Junction	0.91	151	0.23	460	0.006	1	0.168	15	-	-
3	Helmet Junction - Akhbarnagar	2.01	187	1.18	552	0.492	21	2.78	169	0.035	6
4	Akhbarnagar - Sabarmati (New Bridge Alignment)	3.15	199	1.89	566	2.694	21	2.11	109	0.15	1
5	New Bridge – Naroda-Himmathagar Highway Intersection	2.12	232	1.18	547	0.183	14	0.185	23	-	-
6	Naroda-Himmathagar Highway Intersection- Soni Ni Chali	3.81	1331	2.21	1345	2.472	475	0.13	26	0.004	4
7	Soni Ni Chali-C.T.M Crossroads	1.37	259	1.23	565	0.179	37	-	-	-	-
8	C.T.M. Crossroads- Dani Limda Bridge	2.06	342	2.10	727	0.801	89	0.22	78	-	-
	Total	17.38	3157	11.2	5312	6.89	669	6.323	689	0.239	30

Source: Working paper on landuse restructuring, ART, Ahmedabad

Map 14: Type of Residential Land-use in Immediate Influence Zone

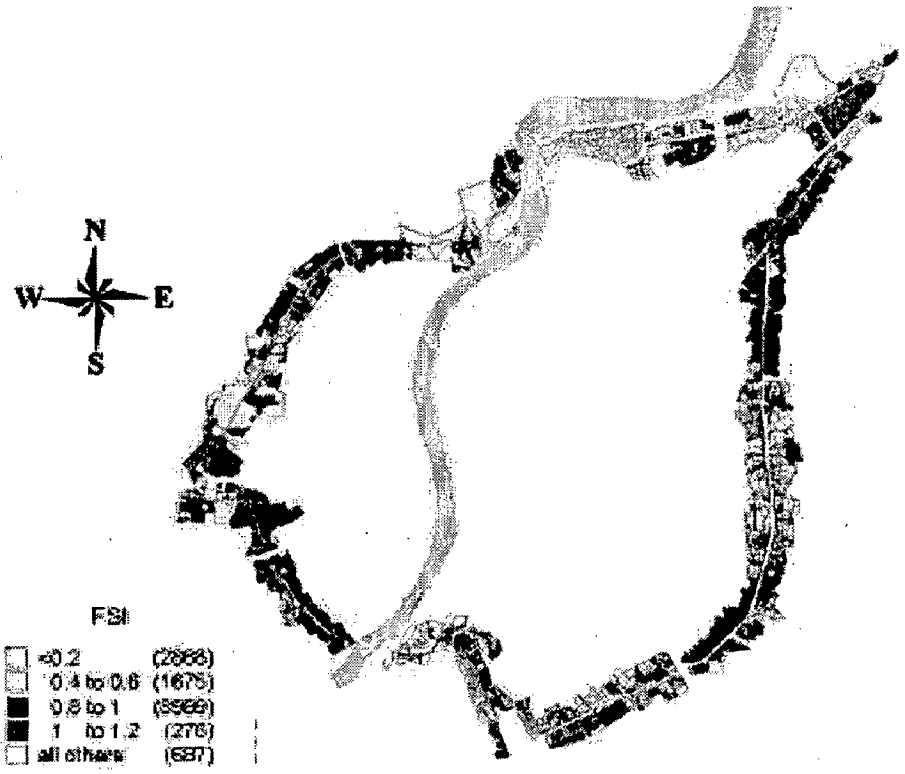


Source: Working paper on landuse restructuring, ART, Ahmedabad

4. Varying usage of FSI in different areas

The permissible FSI is 1.8, whereas the utilized FSI in majority of the stretches is quite low which indicates that the land is underutilized and its full potential can be exploited. The average FSI utilized is 0.645.

Map 15: Varying usage of FSI in different areas of Influence Zone



Source: Working paper on landuse restructuring, ART, Ahmedabad

Table 3.12: Utilization of FSI in the Immediate Influence Zone

Link No.	Detail of the Link	Existing Utilized FSI
1	Chandranagar - Shivranjani	0.80
2	Shivranjani - Helmet Junction	0.70
3	Helmet Junction - Akhbarnagar	0.66
4	Akhbarnagar - Sabarmati (New Bridge Alignment)	0.62
5	New Bridge – Naroda-Himmatnagar Highway Intersection	0.50
6	Naroda-Himmatnagar Highway Intersection-Soni ni Chali	0.68
7	Soni Ni Chali-C.T.M Crossroads	0.57
8	C.T.M. Crossroads-Dani Limda Bridge	0.63

Source: Working paper on landuse restructuring, ART, Ahmedabad

Table 3.13: Areas having High-rise Development along the Corridor

Sr.No.	Link	No. of Plots with high rise development	Area (sq.kms)
1	Chandranagar - Shivranjani	19	0.050
2	Helmet Junction-Akhbarnagar	6	0.035
3	Akhbarnagar-Sabarmati	1	0.146
4	Naroda Himmatnagar Jn.-Soni ni Chali	4	0.004

Source: Working paper on landuse restructuring, ART, Ahmedabad

5. New buildings and utilized FSI

The recent development in the AMC and AUDA limits indicate that all the commercial and corporate houses have fully utilized the FSI. The residential units like flats and apartments have also utilized the available FSI. In areas consisting of low rise buildings due to height restrictions of 16 m, the builders have utilized an extra FSI of 0.45 by making impact fee and built using FSI of 2.25. The bungalows have utilized FSI ranging from 1-1.2.

6. Assessment of the uses and users for additional area generated

A survey of real estate developers indicates that for an increased FSI upto 0.45 there shall be willing buyers provided relaxations are given in height regulations. The potential for the commercial development is more along roads wider than 60ft. Pedestrian accessibility, which is about 500m or a 10 minutes walking distance should be the prime consideration in deciding the distance for intensification on either sides of the corridor.

The feasibility of commercial development (retail and wholesale) is higher on the ground and first floor of a building considering the past trends of development of shopping areas in the city. The property rates for office and residential development on second floor and above are Rs. 1000-1100 per sq. m. Another alternative could be issuing FSI tickets for the entire T. P. Schemes through which the corridor passes.

Rules and regulations can be formulated according to the use of these tickets. The development due to the increased FSI shall be vertical. Considering the fact that the commercial space on higher floors shall be utilized only as office premises and such properties do not have a good sale price, the impact fees for increased FSI shall be fixed at 50-60% of the impact fees charged by Ahmedabad Municipal Corporation. Presently,

the impact fee levied by Ahmedabad Municipal Corporation is Rs. 1500 per sq. m and that by Ahmedabad Urban Development Authority is Rs. 1000 per sq. m. It is observed that the land use has been transformed in the east recently. Restaurants, banks and commercial complexes are a few of the recent developments along this stretch in past 2 years. In due course of time land prices along the corridor would escalate.

7. Land prices

The land prices vary significantly between the areas situated along the 132' ring road and the Old N.H.8 on the other side. The residential and commercial land value along Shivranjani crossroads is significantly high due to substantial commercial development of late. The land value on the Old N.H.8 is lower due to existence of low income group housing for the workers working in the nearby industrial estates of Odhav, Vatva and Narol and the diamond polishing units located in Bapunagar and Thakkarnagar. [30]

8. Land development options and assumptions

a) Total area available for Development and Redevelopment: 13.47 sq. km
b) 50% of this land will be available for development.
c) The development will be staggered beyond 20 year time period and by 20th year 50% plot owners will use additional FSI
d) FSI to be increased to 2.7 on either side of the road for 250 meters and 500 meters along the intersecting road
e) For the rate chargeable for additional FSI three scenarios have been developed
   - Rs. 500 per sq mt
   - Rs. 750 per sq mt
   - Rs. 1000 per sq mt

Table 3.14: Revenue Yield from Sale of FSI in Influence Zone

Year	End of 3rd year	End of 5th year	End of 10th year	End of 15th year	End of 20th year	Total
Pace of Restructuring (%)	5	15	25	30	50	
Land Development	0.6735	1.347	1.347	0.6735	2.694	6.735
Amount Rs. Lakh @ 500/sq mt	1515	3031	3031	1515	6062	15154
Amount Rs. Lakh @ 750/sq mt	2273	4546	4546	2273	9092	22730
Amount Rs. Lakh @ 1000/sq mt	3031	6062	6062	3031	12123	30308

Source: Working paper on landuse restructuring, ART, Ahmedabad

3.2.9 LAND USE RESTRUCTURING

1. Residential land use

An analysis was carried out for estimating residential land use intensification along the corridor. The population for the year 2001 was taken as the base year population and population for 2011, 2021 and 2035 was projected considering the decadal growth rates for various zones in the city. Two scenarios were considered to analyse the impact on the gross densities due to intensification:

Scenario 1:

Year 2021-Natural Population Growth-Existing FSI utilization and Existing area under land use

Scenario 2:

Year 2021-FSI of 2.25 and area under residential reduced to 50%

Scenario 1:

Table 3.15: Natural Population Growth-Existing FSI utilization and Existing area under land use for 2021

Link	Total Area	Existing area under residential	Existing FSI	Built-up-residential	Population (No Intervention Scenario)	Existing Gross Density
Chandranagar -Shivranjini	4.663	3.96	0.80	3.17	71504	181
Shivranjini-Helmet Junction	2.951	1.316	0.70	0.92	22546	171
Helmet Junction-Akhbarnagar	7.51	6.5	0.66	4.29	109772	169
Akhbarnagar - Sabarmati	16.087	10.137	0.62	6.28	321744	317
New Bridge-Naroda-Himmatnagar Highway Intersection	6.355	4.56	0.50	2.28	65754	144
Naroda - Soni ni chali	11.606	8.801	0.68	5.98	416071	473
Soni ni chali - CTM Crossroads	2.917	2.78	0.57	1.58	87879	316
CTM Crossroads - Danilimda Bridge	7.0418	5.3	0.63	3.34	95387	180
Total	59.131	43.354		27.85	1190657	

Source: Working paper on landuse restructuring, ART, Ahmedabad

Scenario 2:

Table 3.16: Year 2021-FSI of 2.25 and area under residential reduced to 50%

Link	Total area (sq.kms)	Area under residential land use @50% (sq.kms)	Proposed FSI	Built-up-residential (sq.km)	Population	Proposed Gross Density-ppha (2021)
Chandranagar -Shivranjini	4.663	2.33	2.25	5.25	262294	662
Shivranjini-Helmet Junction	2.951	1.48	2.25	3.32	165994	1261
Helmet Junction-Akhbarnagar	7.51	3.76	2.25	8.45	422438	650
Akhbarnagar -Sabarmati	16.087	8.04	2.25	18.10	904894	893
New Bridge-Naroda-Himmatnagar Highway Intersection	6.355	3.18	2.25	7.15	357469	784
Naroda - Soni ni chali	11.606	5.80	2.25	13.06	652838	742
Soni ni chali - CTM Crossroads	2.917	1.46	2.25	3.28	164081	590
CTM Crossroads -Danilimda Bridge	7.0418	3.52	2.25	7.92	396101	747
Total	59.1308	29.57		66.52	3326108	Average-791

Source: Working paper on landuse restructuring, ART, Ahmedabad

The existing gross residential densities were also calculated for various links along the corridor to prioritize links for land use intensification. The analysis of the residential densities indicates that the Naroda-Soni ni chali and Soni-ni-chali-CTM Crossroads has high residential densities primarily consisting of low income groups households working in industrial areas in vicinity.

2. Commercial development/employment generation

The commercial development was analysed in the context of the employment that existed along the various links along the corridor. There is a clear demarcation between employment densities along the western and eastern part of the corridor.

The employment densities along the eastern corridor from Naroda to CTM crossroads are high due to presence of a number of industries along the stretch. The employment densities on the western sides are lower primarily to residential development, although there is high level of commercial activity around Shivranjani junction towards Satellite.

Table 3.17 Employment Generation

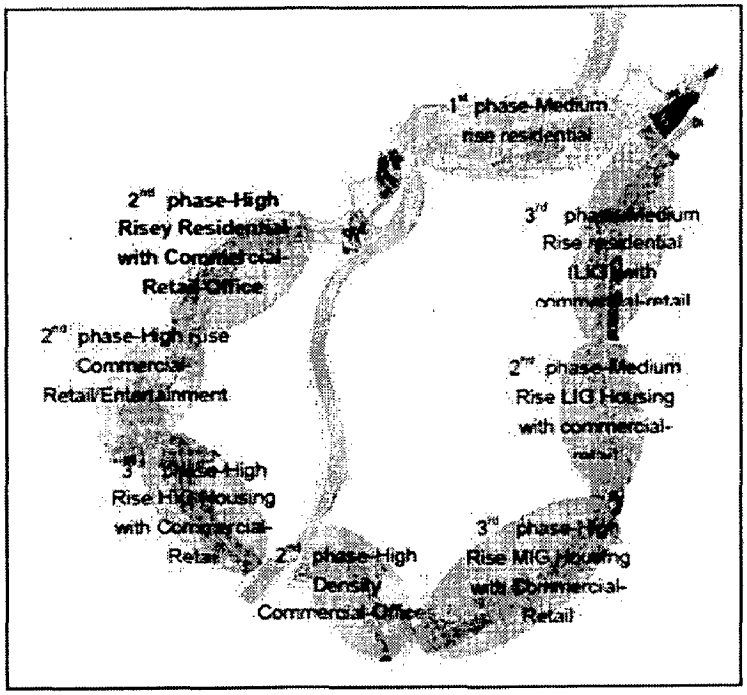
Link	Employment Density	Employment
Chandranagar to Shivranjni	5220	24340
Shivranjni-Helmet Junction	1406	4149
Helmet Junction-Akhbarnagar	4066	30539
Akhbarnagar - Sabarmati	3349	53882
New Bridge-Naroda- Himmatnagar Highway Intersection	2230	14174
Naroda - Soni ni chali	9409	109206
Soni ni chali - CTM Crossroads	4672	13629
CTM Crossroads - Danilimda Bridge	2046	14411
Total		264330

Source: Working paper on landuse restructuring, ART, Ahmedabad

3. Proposed land use restructuring

The land use restructuring for the corridor was arrived after analysing the development trends along the corridor and contextual development in proximity of various links along the corridor. The following table illustrates the proposed phase wise land use restructuring along the links. [30]

Figure 3.7: Phasing of Land Use Restructuring along the Corridor



Source: Working paper on landuse restructuring, ART, Ahmedabad

Table 3.18 Phase-wise Development for various links of Ahmedabad BRTS

Sr.No.	Link	Phase	Type of Development	Justification
1	Chandranagar - Shivranjni	Third	High Rise Residential with Commercial-Retail	Proximity to HIG/MIG households
2	Shivranjni-Helmet Junction	First	High Rise Entertainment-Student Activity Centres	Number of Educational institutes in vicinity
3	Helmet Junction-Akhbarnagar	Second	High Rise Residential with Commercial-Retail	Recent development of Apartments with retail shopping on ground and first floors
4	Akhbarnagar - Sabarmati	Second	High Rise Residential with Commercial-Retail	Proximity to a high density residential areas in vicinity
5	New Bridge-Naroda-Himmatnagar Highway Intersection	First	Medium Rise Residential	Proximity to airport
6	Naroda - Soni ni chali	Third	Medium Rise Residential (LIG) with commercial-retail	Presence of LIG households consisting of workers
7	Soni ni chali - CTM Crossroads	Third	Medium Rise Residential (LIG) with commercial-retail	Presence of LIG households consisting of workers
8	CTM Crossroads - Danilimda Bridge	Second	High Rise Commercial-Retail and Office	Many transport operators are located here so favourable for

Source: Working paper on landuse restructuring, ART, Ahmedabad

The land use restructuring for residential land use would be phased over a period of 30 years. The first phase (2011) would consist of conversion of vacant plots, slums and tenements into high-rise development, which would be followed by bungalows in the second phase (2021). The third phase (2035) would consist of conversion of apartments into high-rise development. The corridor has been divided into links based on similar residential land use typology and income group households.

3.2.10 IMPACTS OF LAND USE RESTRUCTURING

1. Traffic

The impacts of land use restructuring were calculated for the intensification in residential and commercial development. The increase in traffic volume was predicted for the year 2021 for FSI utilization of 2.25 and assuming that 50% of the land would be developed as residential land.

Table 3.19: Impact of land use restructuring along Ahmedabad BRTS on traffic.

Link	2021-FSI-2.25 & Residential Land Use 50%						
	Total area	Area under residential land use @50%	Proposed FSI	Built-up-residential (sq.km)	Population	Proposed Gross Density-ppha (2021)	No Intervention Gross Density (2021)
Chandranagar to Shivranjini	4.663	2.33	2.25	5.25	262294	662	153
Shivranjini-Helmet Junction	2.951	1.48	2.25	3.32	165994	1261	76
Helmet Junction-Akhbarnagar	7.51	3.76	2.25	8.45	422438	650	146
Akhbarnagar - Sabarmati	16.087	8.04	2.25	18.10	904894	893	200
New Bridge-Naroda-Himmatnagar Highway Intersection	6.355	3.18	2.25	7.15	357469	784	103
Naroda - Soni ni chali	11.606	5.80	2.25	13.06	652838	742	358
Soni ni chali - CTM Crossroads	2.917	1.46	2.25	3.28	164081	590	301
CTM Crossroads - Danilimda Bridge	7.0418	3.52	2.25	7.92	396101	747	135
Total	59.1308	29.57		66.52	3326108	791	

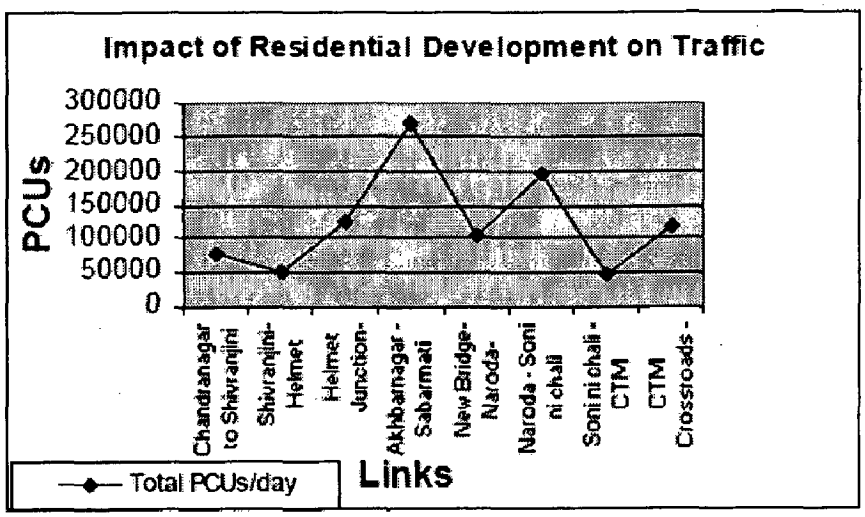
(Area in sq.km.)

Source: Working paper on landuse restructuring, ART, Ahmedabad

2. Impact on Residential densities due to Land Use Restructuring

The increased commercial activity along the corridor would result in increase in traffic volume along the corridor. This impact on increase in traffic generation was analyzed for residential and commercial development. These scenarios were built for various levels of FSI utilization and percentage allocation to residential and commercial land use.

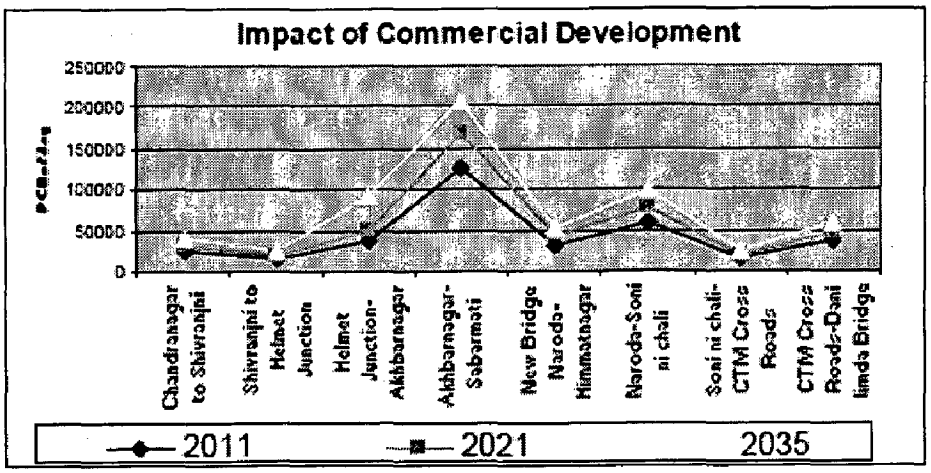
Figure 3.8: Impact of residential development on traffic



Source: Working paper on landuse restructuring, ART, Ahmedabad

The figure below indicates the impact of intensified commercial development along the corridor. The traffic generation along the corridor would be due to the additional employment generation and visitors to the offices

Figure 3.9: Impact of commercial development



Source: Working paper on landuse restructuring, ART, Ahmedabad

3. Impacts on supporting infrastructure

The intensification of land use would have impacts on the supporting infrastructure along the corridor. This impact has been quantified for the year 2021 for the following scenario:

(a) FSI utilization of 2.25 and area under residential land use is projected to be 50%.

Table 3.20 Impact on infrastructure due to Land Use Restructuring along Ahmedabad BRTS

Link	Population (No Intervention)	Population (FSI-2.25)	Additional Load on Infrastructure	Water Supply @ 135 lpcd (MLD)	Solid Waste @ 450gm/capita/ day (kg/day)	Sewerage @ 500 gm/capita/ day (kg/day)
Chandranagar to Shivranjini	71504	262294	190790	25.76	85855	95395
Shivranjini-Helmet Junction	22546	165994	143448	19.37	64552	71724
Helmet Junction-Akhbarnagar	109772	422438	312665	42.21	140699	156333
Akhbarnagar - Sabarmati	321744	904894	583150	78.73	262417	291575
New Bridge-Naroda-Himmatnagar Highway Intersection	65754	357469	291715	39.38	131272	145857
Naroda - Soni ni chali	416071	652838	236766	31.96	106545	118383
Soni ni chali - CTM Crossroads	87879	164081	76202	10.29	34291	38101
CTM Crossroads - Danilimda Bridge	95387	396101	300715	40.60	135322	150357
Total	1190657	3326108	2135451	288.29	960953	1067725

3.2.11 Inferences

a) Land use

- Land use planning needs to be integrated with existing and proposed transit corridors and is the key to success of any transportation system.
- Residential and Commercial land uses are the most critical in land use restructuring along a transit corridor.
- Land use should not be seen as merely the 'use to which land is put to. The quantum of movement of people and the trips they carry out depend largely on the density of use.

- By restructuring of the land use the area under residential was reduced to 50% and achieving a gross residential density of 791 pph.
- The provision of mixed-use employment attached to dwellings within residential areas.
- Balanced development along network and BRTS is also seen as a measure to finance the cost of infrastructure developments.

b) Major improvements in efficiency of operations, service quality and ridership.

- Integration of trunk and feeder services with other modes of transportation helped in increase of passengers per day from 355,000 (March '05) to 9 30,000 (July '08).
- BRT can simultaneously create green transport, environment of walk, bike, and public transport.
- Bus routes are so designed as to simplify the junction signal phasing. Most junctions have a two- to three-phase signal cycle.
- Public transit routing has been rationalized so that AMTS complements BRTS. This increases overall efficiency of public transit
- The Janmarg BRTS stations are along the median and only BRTS buses are allowed access to these. Passengers can change buses without exiting the stations.
- There is a comprehensive ITS package, which includes automatic vehicle tracking, area traffic control and electronic fare collection systems. A fare policy based on business model has been prepared. Real-time passenger information system is part of the package.
- Cycles are observed to be around 10 to 20% all along the corridor. Going by number, cycles are observed to be 350-500 per hour per direction which justifies the need of dedicated cycle track along this corridor.

3.2 CASE STUDY 2 – SINGAPORE

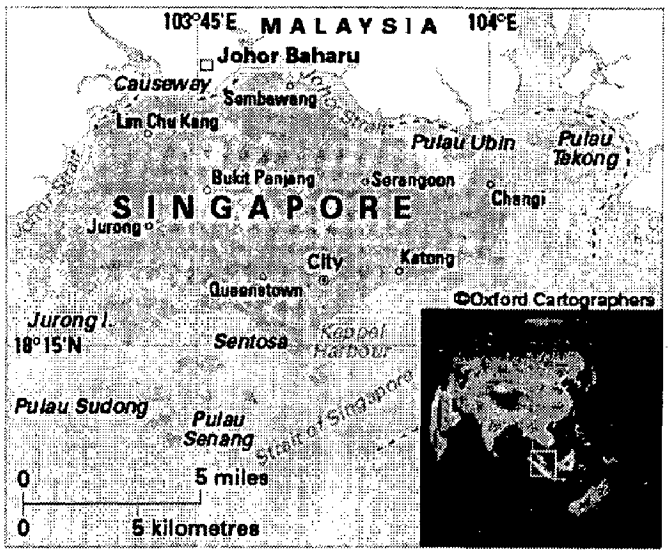
3.2.1 Background

In 1819 Sir Stamford Raffles arrived in the small port of Singapore to establish trade for the East India Trade Company, and within a few decades Singapore had grown from a small enrapt town to a strategic trading port in the Far East, helped by its deep waters and naturally sheltered harbors favored by the British colonists and their steam powered vessels. Its influence continued to grow over the next century until World War II.

In the subsequent years, under the leadership of Lee Kuan Yew, the government set upon to implement a set of strategies to counter the worsening effects of the faltering trade. Some of these strategies focused on the physical development of the city. Described as "massive re-ordering of living, industrial and commercial spaces as well as the transport systems laid down to connect urban activities at the everyday level."

- Area : 648 km^2
- Population: 4.1 mil
- Rail lines (MRT/LRT): 109 km,
- Expressways: 150 km
- Major arterial roads: 575 km
- Signalised junctions: 1500

Map 16: Location Map Singapore



3.2.2 Location

Singapore with a land area of 690 sq km (about 42 km. from east to west and 23 km. from north to south) is located just 1° north of the equator in the sub-region of South-east Asia. It has a present population of 4.5 million with projection to 6.5 million under its long-term development plan.

Singapore is at the same time a city as well as a country with the city centre occupying an area of about 110 sq km in the southern part of the main island

3.2.3 Climate

Warm and fairly humid summer temperatures throughout the year (approximately 30°C/86°F during the day and 23°C/74°F in the evening). There is no distinct wet/dry season. Most rain falls during the northeast monsoon (November to January) and showers are usually sudden and heavy.

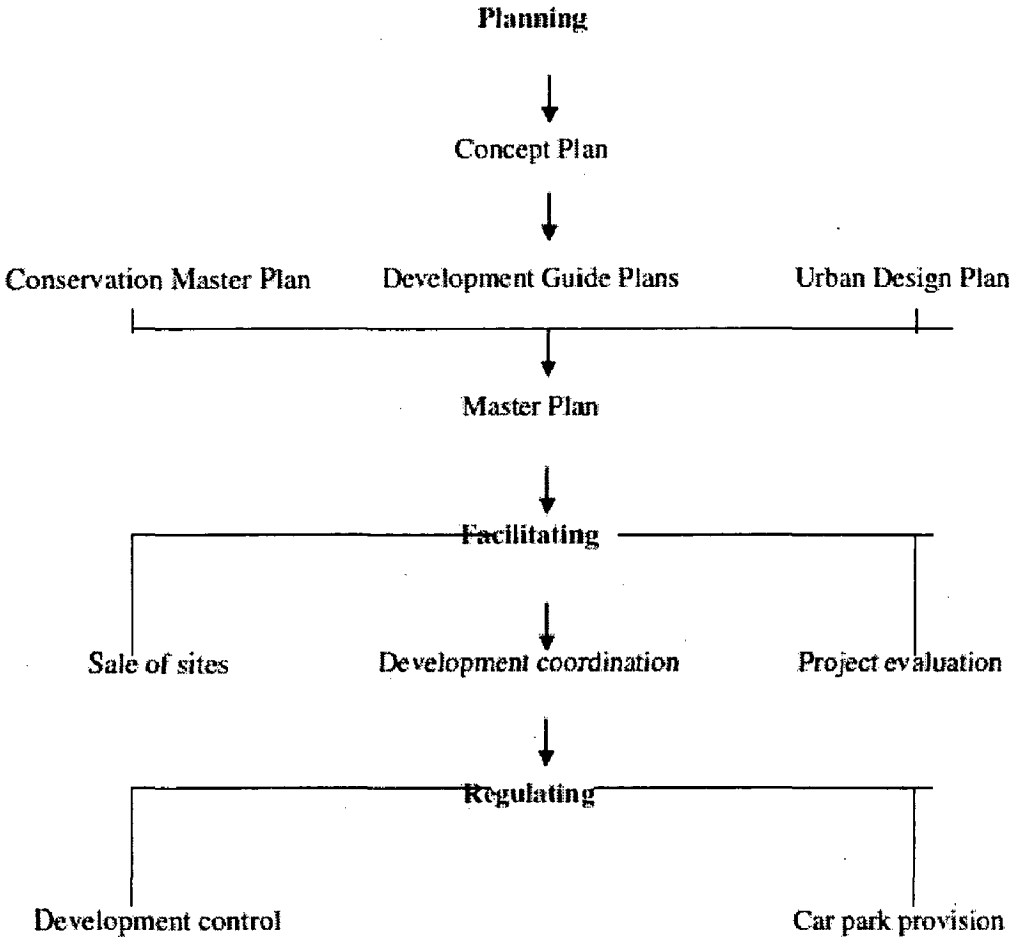
3.2.4 Planning Authority

The highest level of central decision-making in Singapore is the Cabinet developed from the British parliamentary model (Lim, 2000). Planning and development control are administered through a central planning agency, the Urban Redevelopment Authority (URA), a statutory board which comes under the portfolio of the Minister for National Development3. The Minister for National Development is currently the minister in charge of physical planning in Singapore. The Minister is the final authority in planning and development control matters. The day-to-day administration of physical planning and improvement of Singapore rests with the Urban Redevelopment Authority.

The functions of URA, as illustrated, include to:

- prepare and revise development plans;
- control land use and development;
- provide good urban form;
- implement conservation; and
- coordinate public and private sector development proposals.

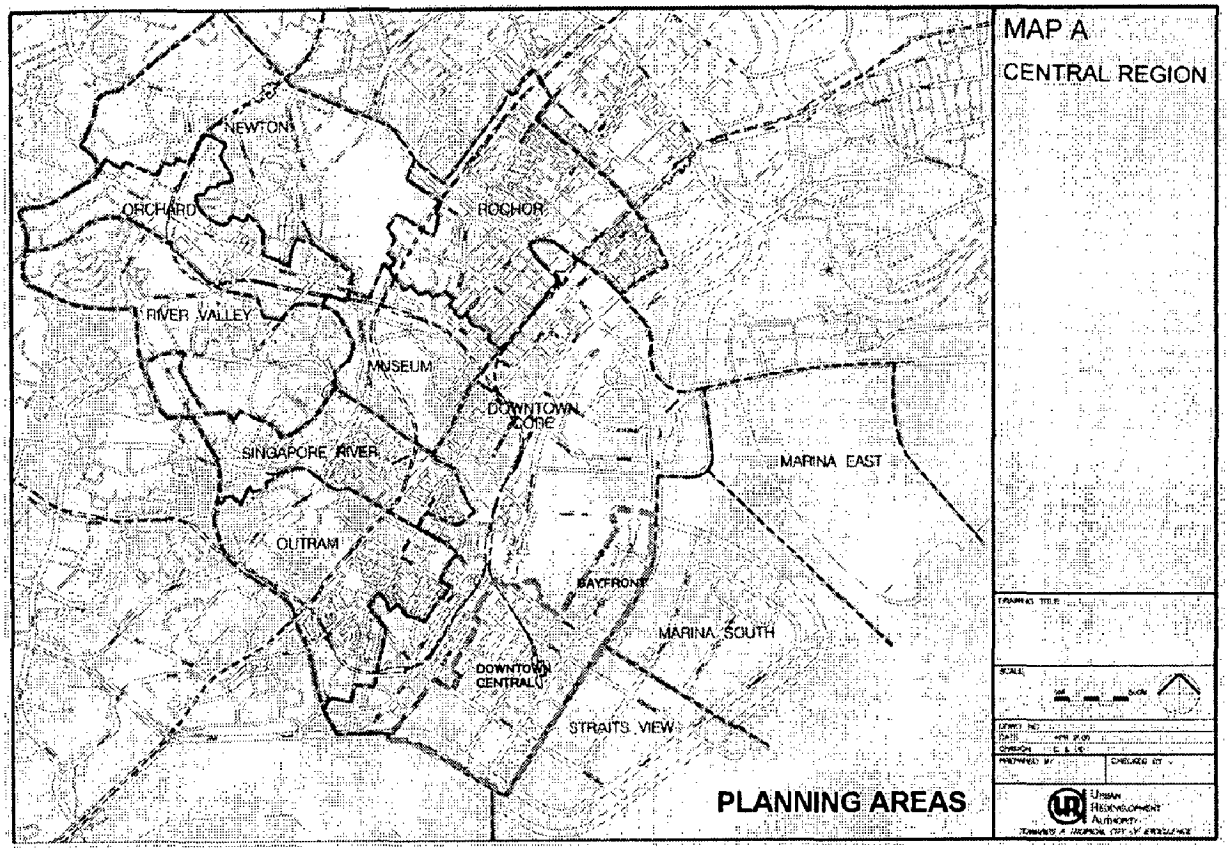
Figure 3.10: Function of Singapore's national planning authority



Source: Urban Redevelopment Authority website, http://www.ura.gov.sg

3.2.5 The Planning Process In the 1960's Singapore's government passed the Land Acquisition Act that allowed the mandatory acquisition of lands from private owners for the benefit of the public. This act allowed for stronger central planning and less hindrance of the government's plans for urbanization. The Housing Development Board (HDB) initiated bringing "the physical form of the city into line with the ambitions of the Singapore government to make the city a modern and efficient metropolis." and "the first developed city in the equatorial belt by the turn of the century". The structure for the delivery of this dream city however was never fully developed and government planning agencies such as the HDB, the Urban Redevelopment Authority (URA) and the Jurong Town Corporation (JTC) approached the task in a piece-meal fashion that lacked coordination. [8]

Map 17: Planning areas of the central region of Singapore



Source: *URA Singapore*

In the 1980s Singapore adapted a planning model that reflected the top-down nature of the planning process in Singapore. Many developments were created without consultation with the community or the private sector. These developments therefore did not reflect the identity of the city nor the "environmental legibility to the people for whom such landscapes had been developed."

This practice of pragmatic development superseded the need for conservation and many landscapes that once defined Singapore were removed.

This had the effect of highlighting the problem of the whole planning process within the government over the decades, and the government implemented the long required reforms. By the late 1980's a holistic approach and improved coordination became the signature characteristic of the state's urban development programme. This may however be starting to be challenged by the increasing diversity of needs and global demands that are driving development decisions more recently: in 1989 the government

allowed the private sector to prepare developmental plans as an injection of new concepts in urban development.

1. Comprehensive planning

The challenge here is to anticipate the needs for Singapore in the long term, and yet, come up with flexible plans that will take into account unanticipated changes. To do this, URA divides planning into three areas: the Concept Plan, the Master Plan and Urban Design and Conservation Plans.

2. Concept Plan

This is the "big picture" plan that charts out Singapore's long term land use concepts and directions for the next 40 to 50 years.

The focus of the plans has evolved since the first one was drawn up in 1971. At the time, the emphasis was on addressing the basic needs and infrastructure of a new nation. Concept Plan 1991 looked at sustaining economic growth and providing a good quality of life.

Many of the ideas proposed in that plan are now part of Singapore's landscape. For example, Singaporeans now have a wider range of housing types to choose from; ranging from waterfront housing in Tanjong Rhu, once an industrial area; to Punggol 21, a new waterfront town that is planned with an LRT system right from the start and boasts new planning ideas such as clustering of community facilities and a common green for each housing estate.

Other ideas that have borne fruit include: creative land reclamation, which saw three small islands amalgamated to form the new petro-chemical hub of Jurong Island; and the development of regional centres in Tampines, Jurong East and Woodlands HDB estates, which integrate services, shopping and transport to form significant business and commercial nodes in the heartlands.

Concept Plan 2001 looks at creating a thriving, world-class city in the 21st century for a projected population of 5.5 million, from the current 3.9 million. It promises: new homes in familiar places, high-rise city living, more recreation choices, greater flexibility for businesses, a global business centre, an extensive rail network, and a sense of identity.

3. Master Plan

This short to medium-term plan is reviewed every five years, and brings the broad directions of the Concept Plan down to more localised and specific strategies. The last Master Plan, presented in 1998, was the first one to offer Development Guide Plans for each of the 55 planning areas covering Singapore.

Each plan captured in detail the land use intentions for a particular area, and allowed homeowners and business people to respond to changes to site boundaries, revision of land uses and other issues that affect their homes and businesses.

Work has already started on the next Master Plan, to be presented next year. The focus will be on identity and quality of life issues, with proposals to retain and enhance Singapore's built and natural heritage.

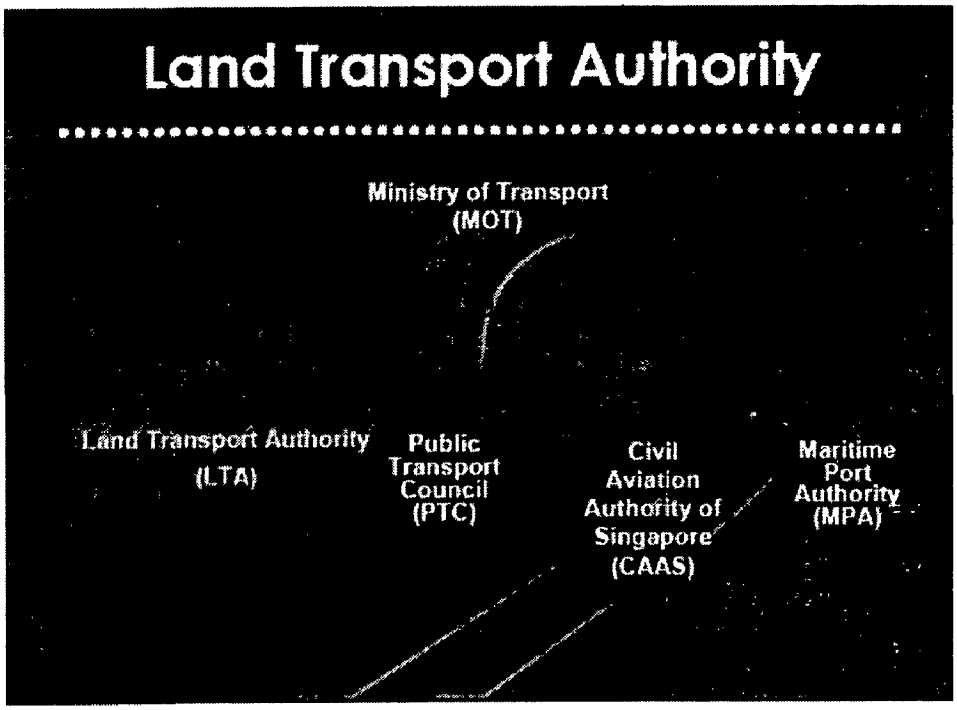
4. Urban Design and Conservation Plans

These narrow the planning focus to specific places, like Chinatown or Orchard Road. In April last year, for example, a plan was unveiled for Singapore's shopping street, one that presented ideas on "Making Orchard Road More Happening".

In drawing up the plans, URA consulted stakeholders, the Singapore Tourism Board and architects here and abroad. Their efforts will see shoppers enjoying a revamped Orchard Road Mall, with new landscaping, paving and street furniture; more public places with activities to fill them; and the new concept of urban verandahs on the second storey of buildings. These will have outdoor refreshment areas and act as covered walkways to bus stops and neighboring buildings. [7]

3.2.6 Overview of Singapore's Land Transport

Figure 3.10: Authorities under ministry of transport in Singapore

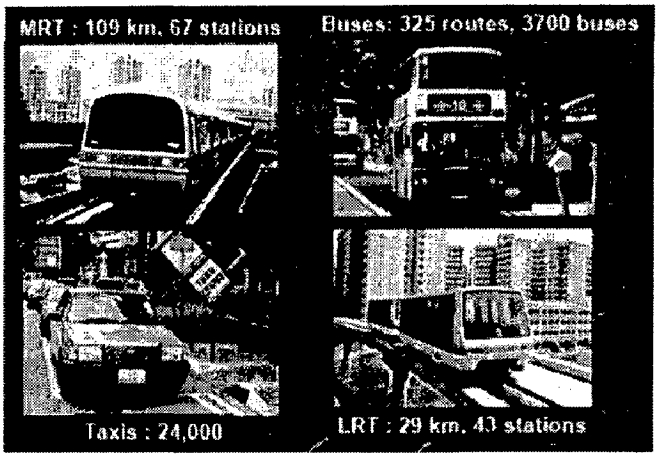


Scource: LTA Report

1. Land Transport Authority's Functions

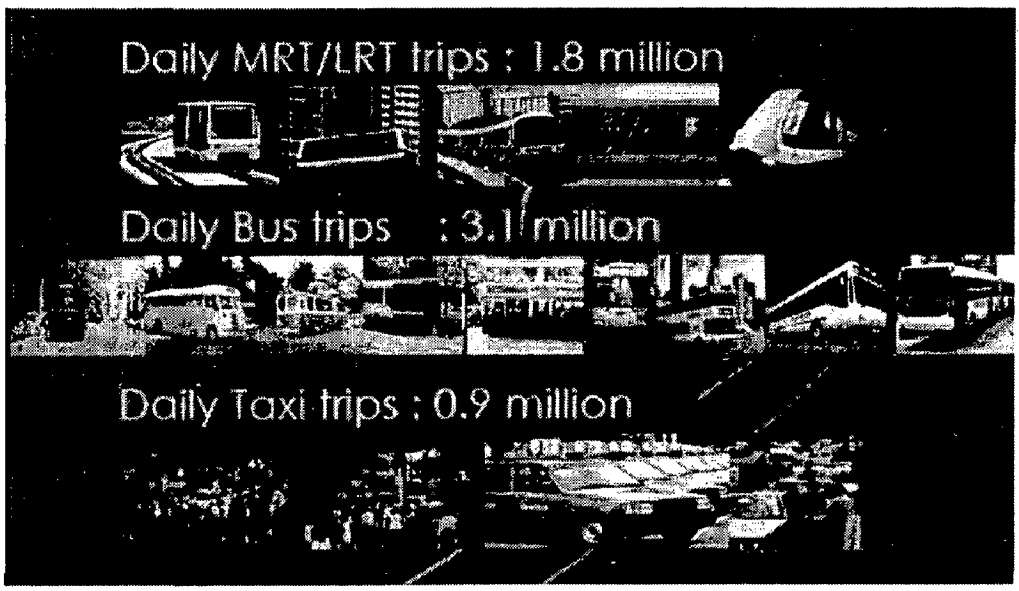
- Formulation of land transport policies
- Integration of transport planning together with land use
- Planning, design and development of Rapid Transit
- System (RTS) and road infrastructure & systems
- Management of road traffic and maintenance of related
- road infrastructure & systems
- Promotion of public transport
- Regulation of public transport services
- Regulation of private transport ownership and usage
- Centralised bus network planning (from 2009)

Figure 3.11: Public Transport



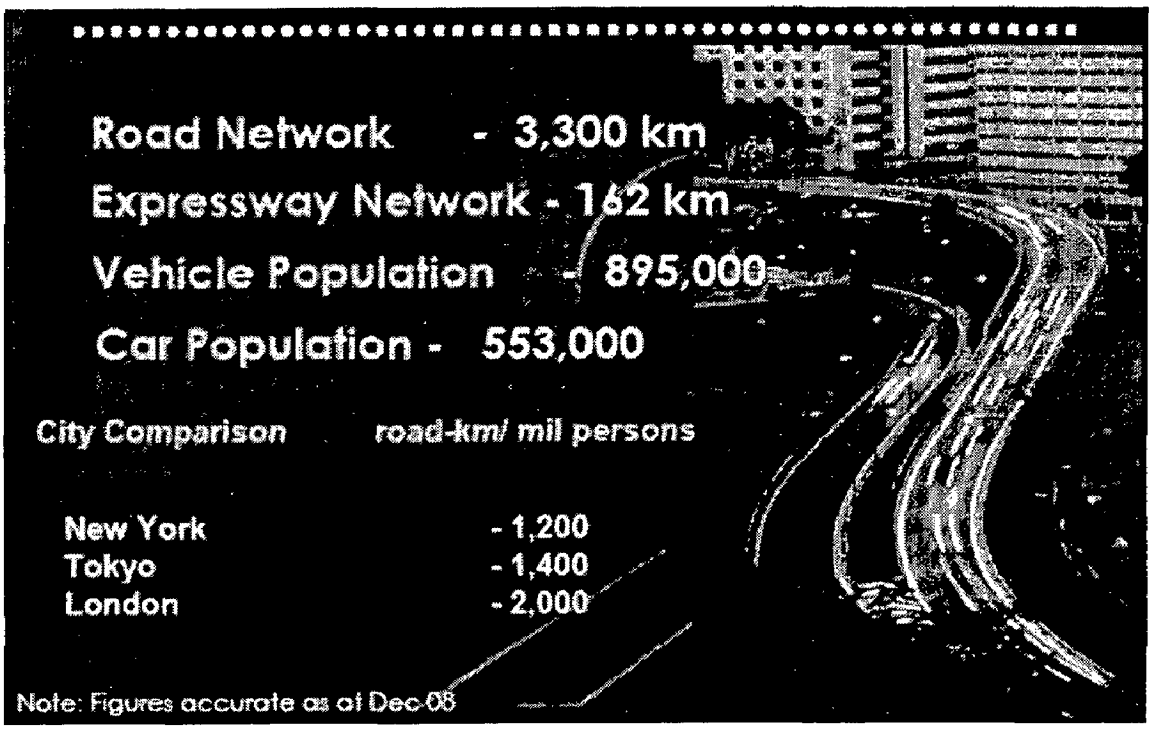
Scource: LTA Report

Figure 3.12: Travel Statistics



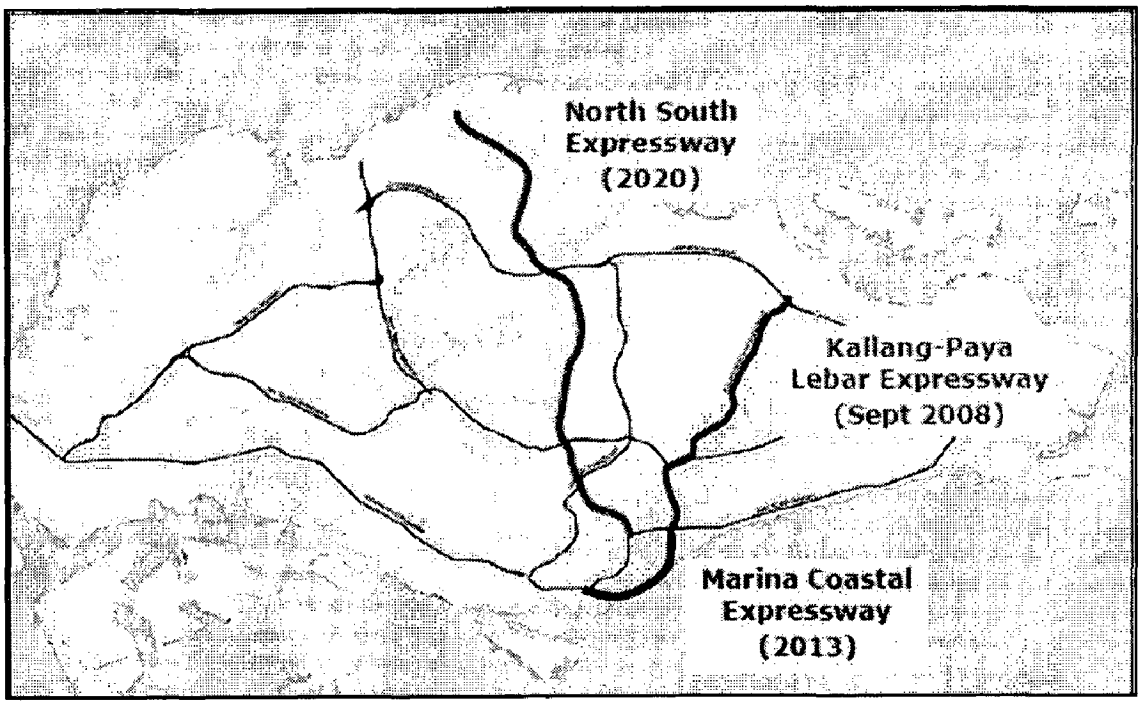
Scource: LTA Report

Figure 3.13: Road Transport



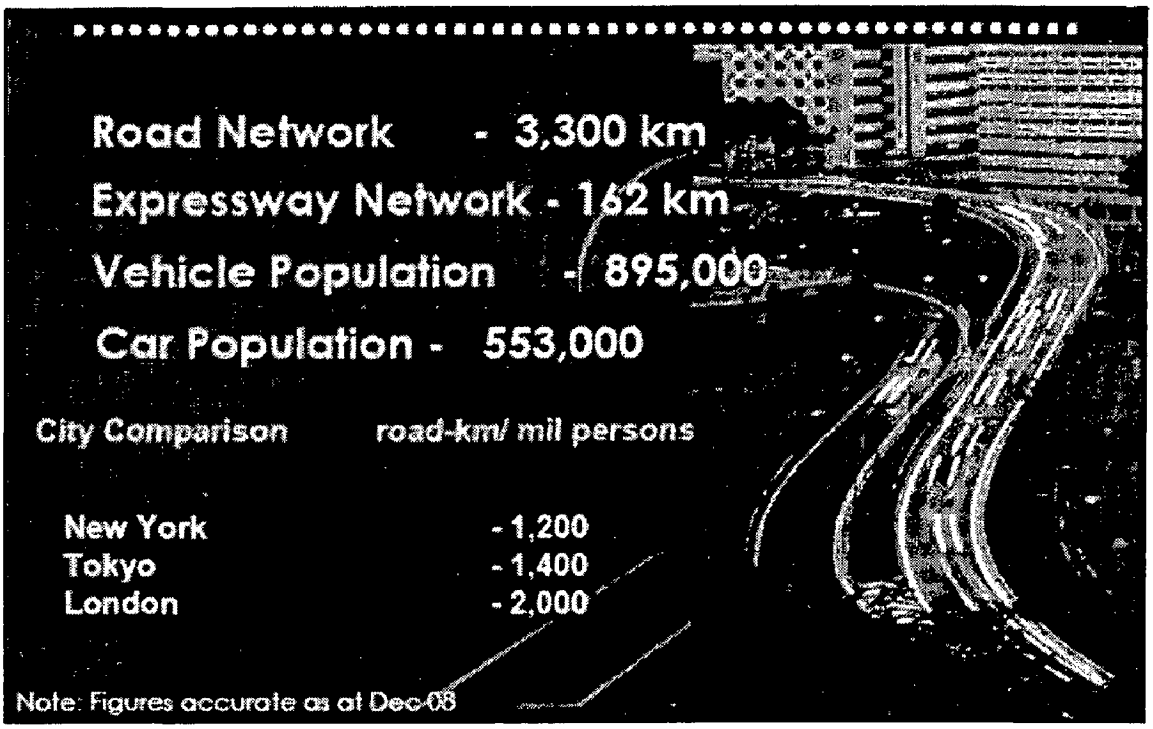
Scource: LTA Report

Map 18: Singapore Expanding road network



Scource: http://www.mip.org.my/forms/paper6.pdf

Figure 3.14: Traffic Charecteristics



Scource: LTA Report

2. Integrated Public Transport System

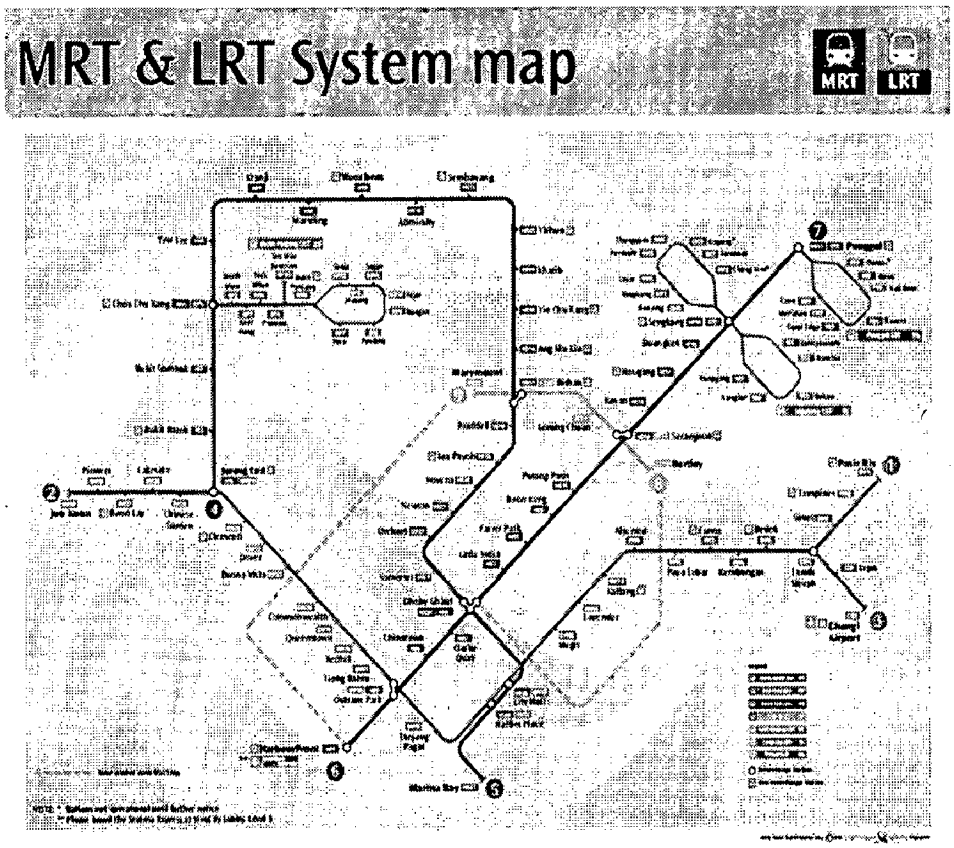
Singapore has adopted an integrated public transport system which incorporates fare information and network integration so that travelling in the city is quick and convenient. Singapore's transport system is based upon Integrated Urban Land Transportation policy with the following key strategies:

a) Integration of land use and transportation planning to minimize the need for travel;
b) Development of a comprehensive road network, including capacity maximization;
c) Management of the car population and the demand of road usage to alleviate traffic congestion; and
d) Provision of quality public transport choices, including the development of mass rapid transit and light rail.

3. Train Network

There are at present two train networks in Singapore – the mass rapid transit (MRT) lines and the light rapid transit (LRT) system. The MRT links the main population centres north-south and east west, while the LRT serves the intra-town and localized transport needs of the residents of satellite townships. Another 57 kilometres of MRT and LRT lines will be added to the existing 91 kilometre network over the next five years A 'traveller information system' is being introduced for the bus service. This will provide commuters with real-time information on bus movements, locations and expected arrival times, to help them plan their journeys better and cut down waiting time. At the same time, more and more taxis in Singapore are being equipped with a satellite global positioning system, allowing them to be directed to the nearest passenger pick-up points.

Map 19: Singapore MRT and LRT Map



Scource:http://www.lta.gov.sg/projects/images/system_map.gif

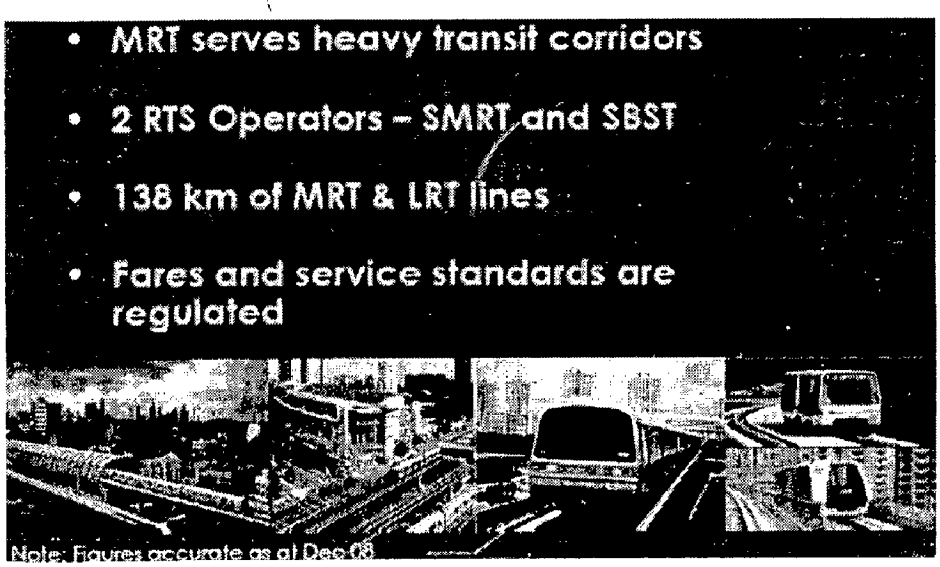
4. Rapid Transit Systems

A fully Integrated Public Transport System is one in which buses, the MRT and the LRT combine their services to provide a single planned network.

Information Integration the Transit Link Guide gives commuters integrated information in just one book. Comprehensive information panels are put up at MRT stations and major bus stops for the ease of commuters making transfers.

Network Integration Transit Link's central planning and coordination of the bus network, designed mindful of the MRT and LRT systems, reduces wasteful duplication of services and improves the use of transport resources.

Figure 3.15: MRTS Overview



Scource: LTA Report

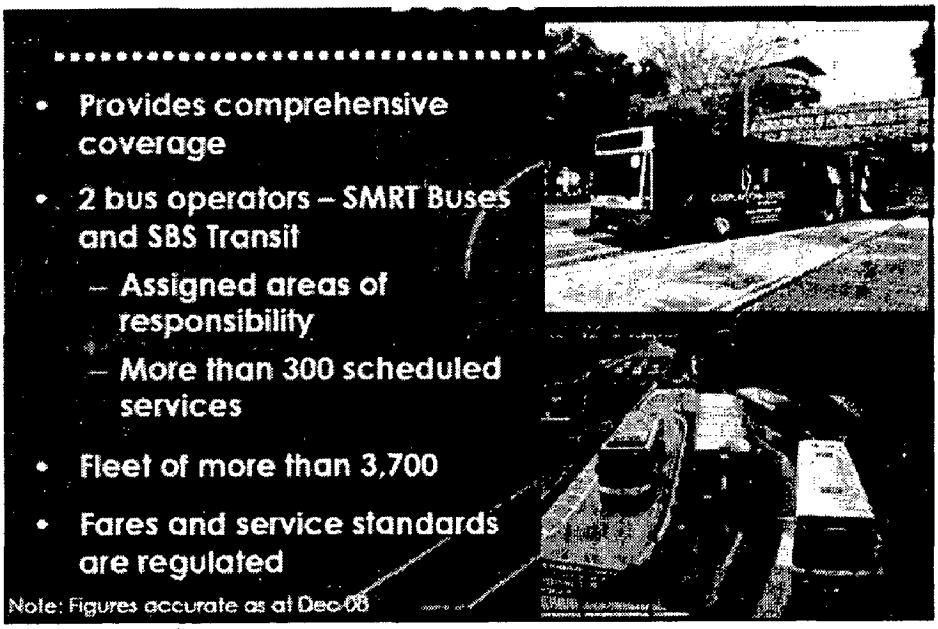
5. Buses

The quality of bus service is emphasized in managing buses. This includes service standard, efficiency and low cost of travel. The Public Transport Council (PTC) sets up standards to guide the two main bus operators: the SBS Transit Ltd and Trans-Island Bus Services Ltd (TIBS). Since 1994 the bus companies are audited every year to check on their performance to these standards.

The LTA has put in place a number of rules and mechanisms in order to improve bus services. These include giving priority to buses at more traffic light junctions by having more traffic lights fitted with a special bus "B" signal, installing intelligent traffic

lights to detect approaching buses and turn green automatically, and introducing more bus lanes (LTA, 1996).

Figure 3.16: Bus Overview



Scource: LTA Report

6. Taxis

The taxi is a significant form of public transport in Singapore. This mode of transport carries about 1 million passengers per day (May, 2004). Taxis play a key role in providing high end, personalized services, and bridging the gap between private and other public transport (i.e., bus, MRT/LRT). The taxi fare in Singapore is very cheap by international standards, as a result of lower vehicle taxes and lower fuel taxes (LTA, 1996).

Figure 3.17:Taxi Overview

Scource: LTA Report

3.2.6 Other Policy Initiatives

1. Vehicle Quotas

Under Singapore's vehicle quota system a certificate of entitlement (COE) must be acquired before a person can register a vehicle for use on the road. The price of a COE is determined by market demand through a public tendering system, and it is valid for ten years. By limiting the number of COEs issued each month, the quota system has served as an effective means to keep the growth of the vehicle population in Singapore at a level of 3% per year. The Vehicle Quota System (VQS) fixes an annual ceiling on the number of vehicles that can be bought. Thus, the government can directly control the vehicle population in Singapore in order to achieve its target vehicle population in line with road capacity and traffic conditions, instead of allowing the free market to dictate the number of vehicles. The target growth rate of the vehicle population is reviewed annually on the advice of the Public Works Department. This rate is the level at which traffic is able to flow smoothly given the current and projected expansion in infrastructure.

2. Road pricing

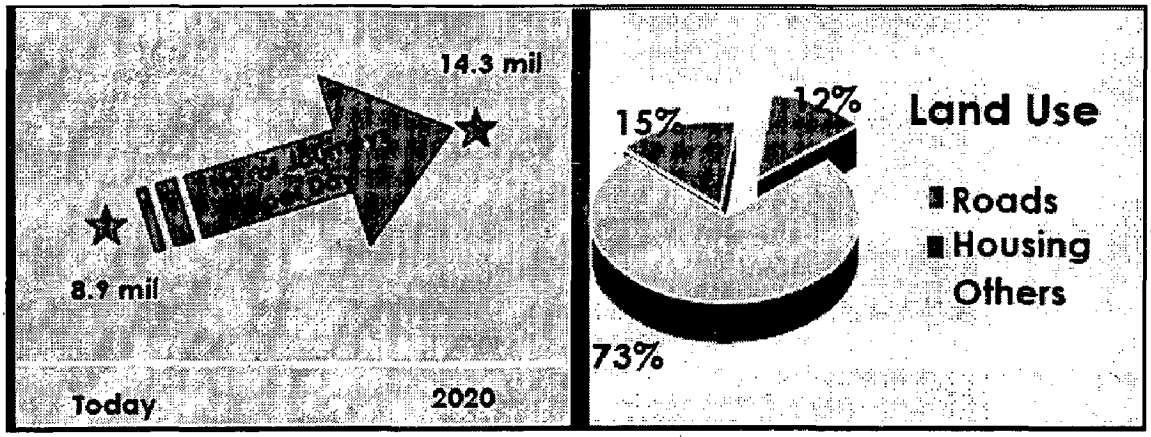
In July 1989, the Singapore government announced that it would implement electronic road pricing. As of 5 May 1997, there were four road pricing scheme locations in Singapore. Motorists have had to display a valid area license (according to the licensing scheme/road pricing scheme) to pass through any of the scheme gantries during the operational hours of 7:30 to 9:30 a.m. from Monday to Friday (excluding Saturdays, Sundays, and public holidays). With the extension of the road pricing scheme, the operational peak hours of the area licensing scheme have been revised accordingly. To facilitate motorists, licenses can be purchased from any post office, specially set up sales booths, designated petrol stations, as well as the Land Transport Authority office.

When fully implemented, the electronic road pricing will essentially be an automated version of the area licensing scheme, with flexibility to vary charges at different times and places according to traffic conditions. Such a system provides for more efficient control of congestion, and allows for the possibility of using electronic road pricing much more extensively as a traffic management tool. [8]

3. Area Licensing Scheme

In June 1975, the Singapore government introduced an area licensing scheme for automobiles entering the city area. It was a usage measure to control traffic congestion in the Central Business District (CBD) during peak hours. The scheme was based on a "cordon" pricing system. The cordoned area, referred to as the "restricted zone," was demarcated by twenty-eight overhead gantry signs. During the restricted hours, private cars and taxis buy and display a special area license on their windscreen to enter the restricted zone.

Figure 3.18: Challenge: Increasing Travel Demand and Limited Land Space



Increase in travel demand must be met largely by public transport

4. Integrated transport and landuse planning

- Integrate transport facilities with building developments
- Work closely with other agencies to integrate transport with land use planning
- Integrated commercial development with underground MRT and elevated LRT
- Air-conditioned bus interchanges integrated with adjoining RTS stations and commercial developments

5. Provision of Travel Information

Bus service information posters

- Key Bus Services Map
- Real-time bus arrival information panels
- Public Transport Journey planner
- Multi-Modal Travel Information System
- Real-time bus arrival information via SMS and mobile platforms

3.2.7 TOD in Singapore

Singapore is a good model of TOD, underscored by the island-state's Constellation Plan and development of compact, mixed-use new towns around many suburban MRT stations.

The city-state of Singapore is internationally renowned for its successful integration of transit and regional development, placing the urbanized island of 2.8 million inhabitants on a sustainable pathway, both economically and environmentally. Singapore has embraced Scandinavian planning principles that call for radial corridors that interconnect the central core with master-planned new towns. Its structure plan, called the Constellation Plan, reflects its namesake – from plan view, it has the appearance of a constellation of satellite "planets", or new towns, that orbit the central core, interspersed by protective greenbelts and interlaced by high-capacity, high-performance rail transit. [7]

Singapore adopted the approach of building new towns that are not independent, self-contained units but rather nodes with specialized functions that interact with and depend upon other new towns. Some satellite centers are primarily industrial estates, some are predominantly dormitory communities, and most are mixed-use enclaves. Aroun quarters of residents of master-planned new towns work outside of their area of residence. Most, however, commute within the radial corridor that connects their new town to Singapore's Central Business District. This means travel is predominantly within, not between, rail-served corridors. Also, the dispersal of mixed land uses along corridors has created two way travel flow.

Singapore is also noted for its progressive "transit first" policies that complement its transit-oriented Constellation Plan. The city has introduced a three-tier fiscal program that comes as close to "getting the prices right" within the urban transport sector city in the world. The first tier of charges is subscription fees for owning a car. Comprised of high registration fees, import duties for automobile purchases, and a licensing surcharge based on a quota system (indexed to congestion levels), these charges principally cover fixed costs associated with providing basic levels of road infrastructure and parking facilities. The second tier of charges are use-related, in the form of fuel taxes and parking fees, that cover incremental costs for scaling road capacity to traffic volume and maintaining roadway infrastructure. The third set of charges – in the form of real-time electronic road pricing (ERP) – force motorists to internalize the externalities the impose in using their cars during peak hours. Fees fluctuate according to congestion levels, meaning motorists bear some of the costs they impose on others such as time delays and air pollution. Within a month of initiating electronic road pricing, traffic along a main thoroughfare fell by 15 percent and average rush-hours speeds rose from 36 to 58 kph. Vehicle quotas, congestion prices, and an assortment of fees and surtaxes add as much as 150 percent to a car's open market value) have reduced Singapore's annual vehicle population growth from 6 percent fifteen years ago to under 3 percent today.

3.2.8 Integrating land use and transportation planning

Strategies aims at integrating urban development with transport planning by closely relating the expansion of urban transport facilities with other measures for promoting desired patterns of land use. This involved, for example, a proposal for a proper mix of development, and concentrating high building densities around mass rapid transit stations so as to ensure maximum accessibility for commuters to key nodes of employment, housing, leisure, and other social activities.

Another effort includes a recent plan to decentralize commercial activities from the central area to four new regional centres in major suburban residential areas. Once completed, this urban hierarchy will help reduce the threat of congestion in the central area. It will also closely integrate urban development with the present, planned transport system, thereby bringing jobs closer to workers' homes. [7]

This will result in a less transport-intensive, less costly, and more efficient and congenial urban environment.

- Singapore has 3.6 million people living in a total area of just 646 square kilometers, making it one of the most densely populated and urbanized countries in the world.
- Rapid industrialization and intensive development have required a corresponding growth in transport infrastructure.
- Roads currently take up about 12% of total land area.
- Given the scarcity of land, the push factor is to develop a comprehensive rapid transit network with dedicated rights of way, transporting large numbers of people to their destination quickly and reliably.

Strategy-1

- Singapore has chosen integrating the goals of transportation planning with land use planning which had been set out since the Concept Plan 1971. As travel is always made with a purpose, the amount and number of travels can be reduced by means of effective land use and transport planning. For example, by proper location of homes, offices and other uses in relation to the transport system.

- Singapore's government used 'land banking', buying land around the metro rail transit system before and during construction, and re-selling some of this land at a profit which in turn financed the construction of high density moderate income housing around the MRT stations.
- Singapore's government also developed a network of bike and pedestrian paths to MRT stations, and provided extensive bicycle parking facilities at the MRT stations.

Strategy-2

In the 1991 Revised Concept Plan, transport considerations resulted two key land use planning strategies:

- Decentralizing commercial and other economic activities through the development of regional, sub-regional, fringe centers of MRT stations. This has resulted in

better utilization of MRT network in both directions during peak hours. Therefore, Singapore aimed for a proper mix of residential, industrial, and even institutional developments, and the highest plot ratios at and around MRT stations (White Paper of Transportation Planning, 1996).Reducing the need for people to travel by locating employment centers like in industrial estates,

- Business Park and commercial centers near residential areas. Specifically, more homes would be built in the western part of island while more employment centers would be created in the eastern part of the island.
- Central to the success of Singapore model is high density urban development that is closely integrated around the transit system. Singapore's basic urban structure plan shows a series of radial and circumferential mass transit and light rail lines with major and minor sub-center nodes developed at high densities around the intersection of all these lines (Kenworthy et al., 1994).
- The success of Singapore in integrating development around their respective rail systems is shown by high percentage of city's total activities lying within walking distance of stations and the ease with which stations are reached either on foot or by transit.

The story of Singapore's successful transit system is not without its battles, nor is it without the support of highly successful policies aimed at restraining car use, such as:

(i) Area Licensing Scheme (ALS) introduced in 1975 to reduce morning peak commuting into CBD;

(ii) Long history of steep vehicle taxes; and

(iii) The more recent Certificate of Entitlement (COE) system, which requires would be car owners to bid for the right to buy a vehicle. The price of COE varies continuously, but in the early 1994 it was as high as US$ 47,000, on top of the car purchase price (*Straits Times, December 17, 2003*).

Table 3.21: Integration of Land Use with Transit in Singapore

Descriptor	*% Population/Passengers*
Percentage of Singapore population living within walking distance of MRT station	30.0%
Percentage of Singapore population living within 1 km of the line	50.0%
Percentage of all businesses and industrial areas located near stations	40.0%
Percentage of passengers who walk to and from MRT stations	65.0%
Percentage of passengers who transfer to or from buses at MRT stations	35.0%
TOTAL	100.0%

Source: Letter from Singapore MRT Ltd, July 5, 1994, quoting Transit Link Figures, and Introduction to "The MRT Story" (Singapore: MRT Corporation, 1988).

3.2.9 Future expectations

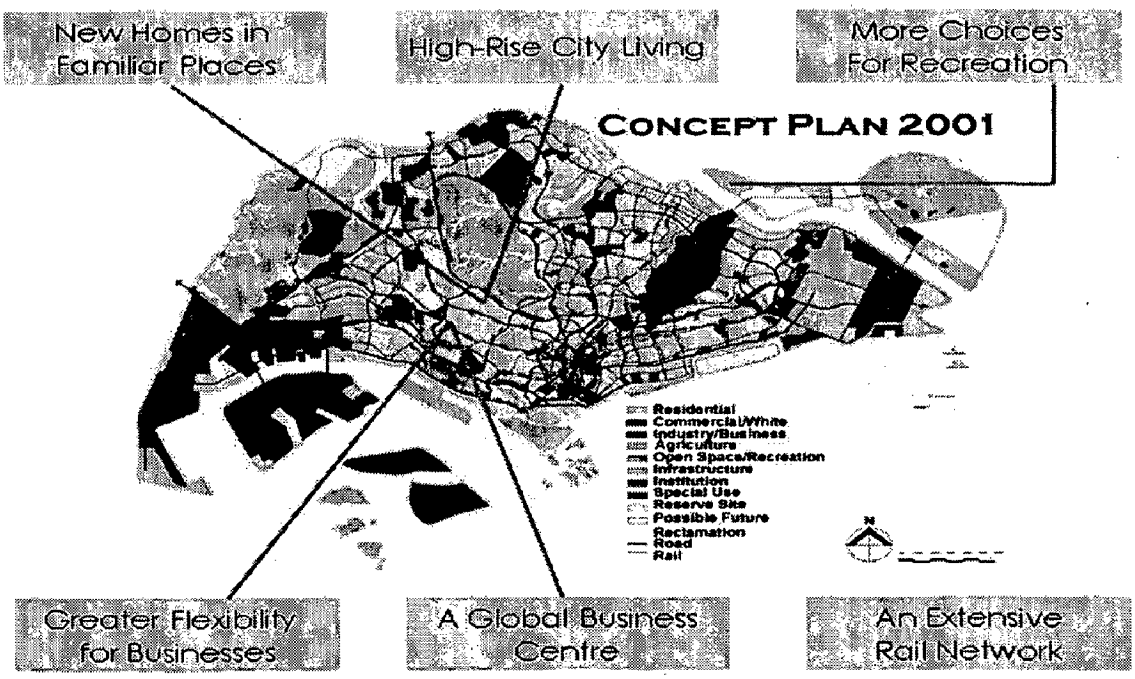
Singapore will continue to ensure high quality of living. The Concept Plan 2001 will provide a variety of housing choices and a comfortable living environment. The concept also includes initiatives to be flexible and responsive to the needs of businesses, to support value-added industries, and to provide for the growth of Singapore into an international business hub.

These future expectations will create:

- *More intensification:* industries and businesses close to MRT stations to optimize the use of land around these important transport nodes. This will allow people to enjoy the convenience of working near an MRT station.
- *More jobs closer to homes:* more jobs will be provided in the North, North East, and East regions. In addition, there will be more housing in the West and in the city so that more can live to their workplace.

- Boundaries between businesses and services are blurring.
- One of the key new ideas in the Concept Plan 2001 is to have a new zoning system in the future: New Business Zone and New White Zone.
  - Under the new zoning system, industrial and business activities will be grouped according to their impact on the surrounding environment. New business zones will be introduced, with B1 for non-pollutive uses and B2 for pollutive uses.
  - This new "impact-based" zoning approach will allow businesses to house different uses under one roof and change activities easily without rezoning.
  - A new white zone will be introduced, allowing all uses except pollutive ones.

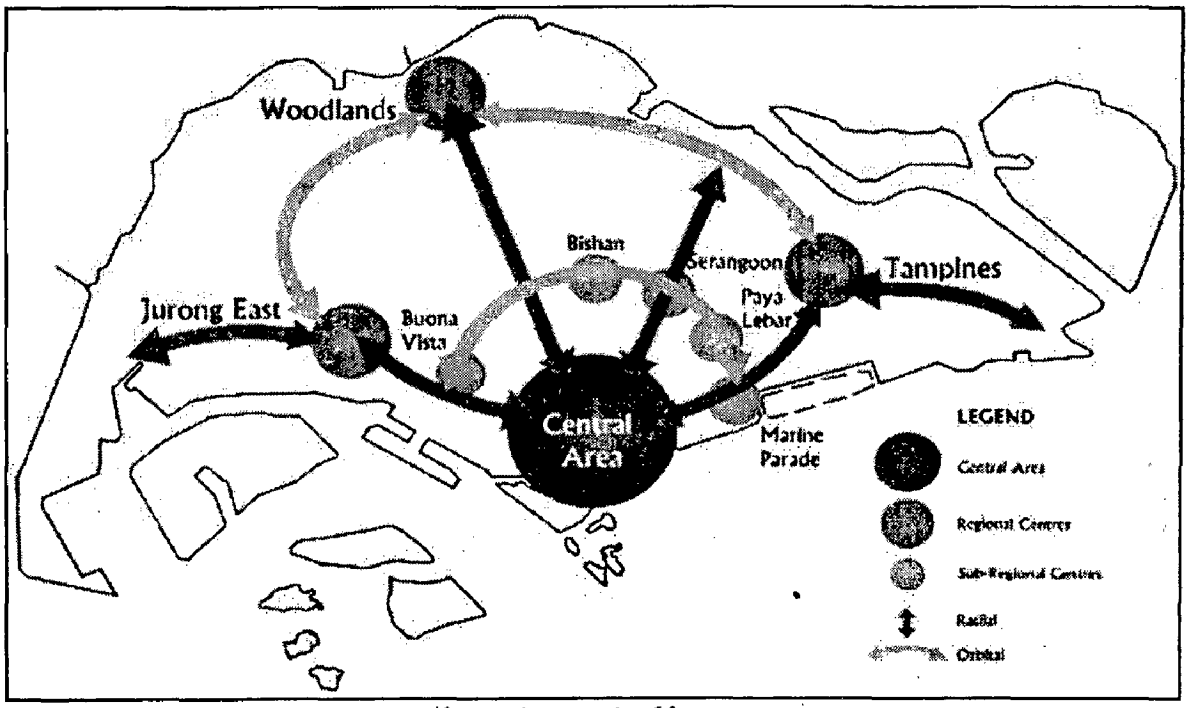
Map 20: Map showing Concept Plan 2001



Source: http://www.mip.org.my/forms/paper6.pdf

The Concept Plan plans for new orbital and radial lines in future. Radial lines will enable the community to travel to the city directly. Orbital lines will enable them to get from one place to another outside the Central Area more quickly. The existing 93 km of rail lines will increase to about 500 km in future.

Map 21: Singapore Concept Plan for new orbital and radial lines



Source: http://www.mip.org.my/forms/paper6.pdf

3.2.10 Inferences from Singapore's Case Study

- Intensifying developments around MRT stations alone is not sufficient to ensure good accessibility. Planners must fully integrate MRT stations with building developments and other transport modes.
- Factors influence the success of creating a transit-based urban form which expected to overcome automobile dependence are:
  - Developing Non-auto-dependent land uses
  - Favoring alternate modes
  - Utilizing economic penalties
  - Creating traffic calming

- To follow the success of Singapore, it is necessary to build:
  - Commitment to building up quality transit, preferably rail;
  - Some preparedness to introduce physical and economic restraint on private transportation that support the investment in transit; and
  - Investment in relatively inexpensive improvements in the environment for pedestrians and cyclists.

- The study demonstrates that high density land use planning has an impact on maintaining low travel demand, higher transit share, and urban quality.

- Planning and developing an alternative urban structure, wherein economic activities become dispersed and physical integration between employment, amenities, and housing is improved.

- Bus interchanges integrated with the MRT station and commercial buildings.

- Covered link ways have been built to link MRT stations to buildings.

- Para-transit services are improved to supplement major public transport modes.

- The Singapore transport system satisfies the need of the current generation with minimal use of the limited land.

CHAPTER-4

STUDY AREA CHARACTERISTICS

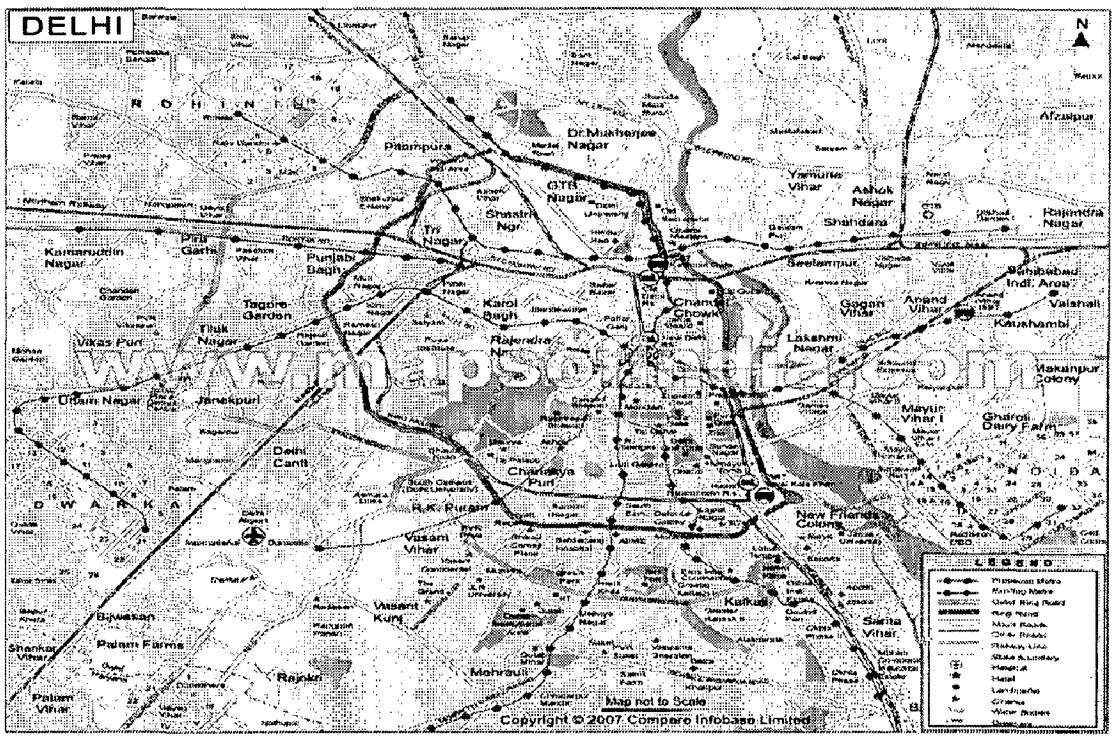
4.1 INTRODUCTION

In this chapter the study on Delhi city has been made on the current trends of development in Delhi and a review of the Master Plan based on Compact and Transport-Oriented development principles has been done. An overview of Delhi city is presented, then the characteristics of the site area has been discussed.

4.2 DELHI: CITY PROFILE AND CHARACTERISTICS

Delhi is the largest metropolis by area and the second-largest metropolis by population in India (Source: http://en.wikipedia.org/wiki/Delhi). The National Capital Territory of Delhi is spread over an area of 1,484 km2, of which 783 km2 is designated rural, and 700 km2 urban. There are three local bodies (statutory bodies) namely, Municipal Corporation of Delhi (area is 1,397.3 km2), New Delhi Municipal Committee (42.7 km2) and Delhi Cantonment Board (43 km2).

Map 22: Map of Delhi



Source: www.mapsofindia.com

The MPD 1961-81 further extended to 2001 was prepared by DDA and approved by Government of India to ensure appropriate balance between the spatial allocation for the distribution of housing, employment, social infrastructure and transport and adequate arrangement to accommodate all other physical infrastructure and public utility systems in Delhi.

The urbanization of Delhi dates back to the beginning of the 20th Century. In 1901, 52.76% of the population of Delhi was urban. The urban area in Delhi territory has increased from 22% in 1961 to 62.5% of the total area in 2001. At present about 702 sq.km is estimated to have been developed as built up areas accommodating about 138 lakh populations.

The rapid urbanization of Delhi has resulted in sharp increase in the density of population. In 1901, the density was 274 persons per square km., this increased to 1176 persons per sq. km. in 1951 and 9294 persons per sq. km. in 2001.

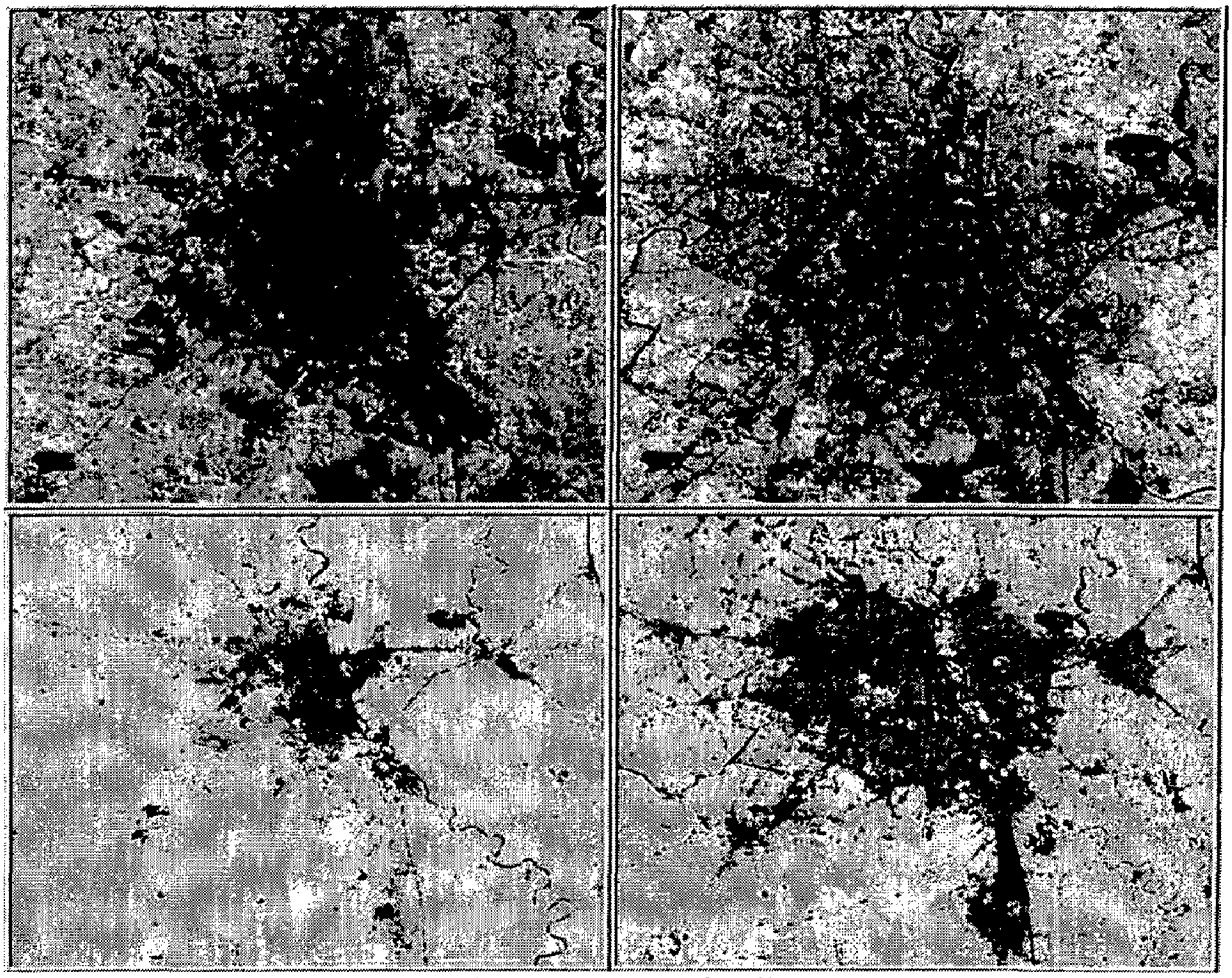
The first MPD (1961-81) was reviewed and amended for its extension for another 20 years by DDA and published in 1990. This amended MPD (second MPD 2001) envisaged acquisition of 20,000 ha of land for urban area extension of Delhi by 2001 making a target for development of 68,770 ha urban area. DDA has subsequently proposed to develop 83,804 ha of land as urban area within the framework of MPD 2001. This includes 3360 ha area for urban development along National Highways, 1996 ha of Dwarka Ph II and 9700 ha of Yamuna River bed.

Table 4.1: Trend of Urbanization in Delhi 1901-2001

Census Year	Population	Urban	% Urban	Annual Exponential Growth Rate	Decennial Growth %
1901	405819	214115	52.76	-	-
1911	413851	237944	57.50	1.1	11.13
1921	488452	304420	62.32	2.5	27.94
1931	636246	447442	70.33	3.9	46.98
1941	917939	695686	75.79	4.4	55.48
1951	1744072	1437134	82.40	7.3	106.58
1961	2658612	2359408	88.75	5.0	64.17
1971	4065698	3647023	89.68	4.4	54.57
1981	6220406	5768200	92.73	4.6	58.16
1991	9420644	8471625	89.93	3.8	46.87
2001	13782976	12819761	93.01	4.1	51.33

Source: Economic Survey of Delhi, 2001-02

Figure 4.1: Delhi: Growth in urban area from 1974 to 1999



Source: Remote Sensing Studies of urban growth of Delhi

The upper images are a 1974 Landsat MSS (80m resolution) on the left and a 1999 Landsat Thematic Mapper (28.5 m resolution) on the right. Growth in urban area from 1974 to 1999 is portrayed in the lower maps as areas colored red.

This image set compares a 1974 Landsat MSS image to a Landsat 7 Thematic Mapper data set collected in 1999. The two lower panels reflect land use in and around the city for the respective dates. The color red is used to depict the presence of urbanized areas. Clearly the city has demonstrated a significant growth in area over the past 25 years. The population of New Delhi increased from approximately 5 million in 1975 to over 13 million in 2001 (projected). Urban expansion around existing population centers results in a number of problems with policy and management issues. Prime agricultural land is often lost, additional transportation and other infrastructure services are required, and natural ecosystems are destroyed or disrupted with resultant pollution problems. [31]

4.2.1 Demographic Profile of Delhi

Delhi is the second most populated city in India. In 1901, Delhi was a small town with a population of only 0.4 million, which had increased to 9.42 million by 1991. The annual growth of population in Delhi was the highest (6.628%) during 1941-51 because of the huge settlement of displaced persons from Pakistan after partition in 1947. The total population of Delhi has been constantly growing at the rate of 51-53% every decade since 1951. Since then, the annual growth has been 4.31% during 1961-71, 4.36% during 1971-1981 and 4.24% during 1981-91. As per the 1991 census, the annual growth of Delhi's population during 1981-91 (4.24%) was almost double the national average (2.16%). The population of Delhi is estimated to have increased at an average of 5 lakh per annum since 1991. Nevertheless, despite the decreasing annual growth rate during the last decade, the net addition in terms of population of Delhi is considerably contributed by the in-migration to Delhi.

As per the first Master Plan of Delhi in 1962 the total redensified population assigned to be accommodated in Urban Areas was 52.60 lakhs by 1981. The actual urban population of Delhi enumerated by the 1981 census was 57.68 lakhs. Similarly, the Master Plan for Delhi-2001 (MPD-2001) forecasts that population of Delhi may range between 125 and 130 lakhs for the year 2001. Thus considering the amount of land, infrastructure, transport etc. this plan has assigned the population of Delhi to be 128 lakhs. The plan estimated the annual growth rate to be 4.0% till 1991 and then drop down to 3.5% in 1996 and in 2001. It has estimate the population in 1991 to be 91.02% lakhs and it is observed that the actual population of 2001 could exceed the assigned-estimated limit as per the prevailing growth trends. [31]

Table 4.2: Population Trends in Delhi

YEAR	POPULATION (LAKHS)
1901	4.06
1911	4.14
1921	4.88
1931	6.36
1941	9.18
1951	17.44
1961	26.59
1971	40.66
1981	62.2
1991	94.17
2001	137.82

Source: MPD 2021

Table 4.3: Comparison of Proposed Population with actual Population of Delhi

CATEGORY	POPULATION 1991	POPULATION 2001
MPD 2001	91.02	137.82
NCR 2001	92.56	132 (P). 112 (A)

A: Assigned

P: Projected

Source: MPD 2021.

1) **Density**

At 6352 persons per sq. km., the population density of Delhi was the highest among the States and Union Territories (1991 Census) but fifth among the major cities, namely Mumbai, Calcutta, Chennai, Bangalore and Hyderabad. By the end of the Ninth Five-Year Plan (2002), the density of Delhi will be 10,062 persons per sq. km compared with the projected national density of 313 persons per sq. km.

2) Migration

The estimates of migration into Delhi are based on birth and death rates and total increase in population. The estimates reveal that migration has been steadily increasing since 1991 and is now more than one-and-a-half times the natural growth in population (1:1.55) in 1997. In absolute terms, the natural increase in population during 1991 was 2.11 lakh compared to migration of 1.78 lakh. However, the natural increase reached 2.18 lakh in 1997 whereas migration was estimated at 3.37 lakh.

3) Rural-urban ratio

The rural population, which was 47.24% of Delhi's population in 1901 continued to decline to 7.27% in 1981, but increased to 10.07% in 1991. This reversal of the long term trend during 1981-1991 was due to mushrooming of unauthorized colonies in rural areas.

4) Age Distribution

The trends indicate that

1. Population in age group 0-14 has declined significantly from 40.50% in 1961 to 34.73% in 1991.
2. Population in age group 15-59 has increased significantly from 55% in 1961 to 60% in 1991.
3. Population in age group 60 & above has increased from 4.10% in 1961 to 5.11% in 1991.

5) Family size

As per 1991 census, the average family size is 5.06 persons. The highest number of families i.e. 50% is in the category of 3-5 persons and the lowest 9% in the category of 9 & more persons. The family size in urban areas is 4.99 persons in comparison with rural family size of 5.90 persons. Average household income is 4471 with 46% having monthly incomes between Rs.2000-Rs.5000. [34]

4.2.2 Landuse Profile of Delhi

The Delhi Development Authority (DDA) is responsible for guiding planned development in Delhi, through successive Master Plans (1962, 1982 and 2001). It is also the sole agency mandated to develop and dispose of land in the city. Forty four percent of the geographical area of Delhi is built-up area.

In 1999, the urban area of Delhi was 701.62 sq. kms (47.3 % of NCTD area). This is proposed to be increased to 977.91 sq. kms, or 66 % of the total area, by 2021.This area as per the 2021 plan has been assigned a population of 230 lakh. In 2001, about 702 sq km of area was estimated to have been built up, accommodating about 138 lakh population.

To accommodate the projected population of 230 lakh by the year 2021, a three-pronged strategy is recommended:

1. To encourage the population to deflect in the NCR towns.
2. To increase the population holding capacity of the area within existing urban limits through redevelopment; and
3. Extension of the present urban limits to the extent necessary.

Existing residential areas may provide a potential to accommodate about 153 lakh populations ultimately i.e. 114 lakh in Zones A to H and 39 lakh in Dwarka, Rohini Phase III, IV & V and Narela. The remaining population for the year 2021 will have to be accommodated in the planned new urban extensions. Out of the remaining 77 lakh (230-153 lakh) population, 29 lakh already exists in villages, census towns, unauthorized colonies and JJ clusters in the present rural areas. Therefore about 48 lakh additional population is to be accommodated in the future urban extensions. [34]

Table 4.4: Landuse Profile of Delhi as Per the Mpd-1961 and MPD-1981

Landuse Profile of Delhi	Area 1961-1981 (HA)	% Area	Area 1981-2001 (HA)	% Area
Residential	17998	40.2	30445	47.0
Commercial	586	1.3	2591	4.0
Pub/Sp	3079	6.9	4534	7.0
Industrial	2234	5.0	4534	7.0
Green/Open Spaces	9715	21.7	12955	20.0
Circulations	5373	12.0	7773	12.0
Total	44777	100	64777	100

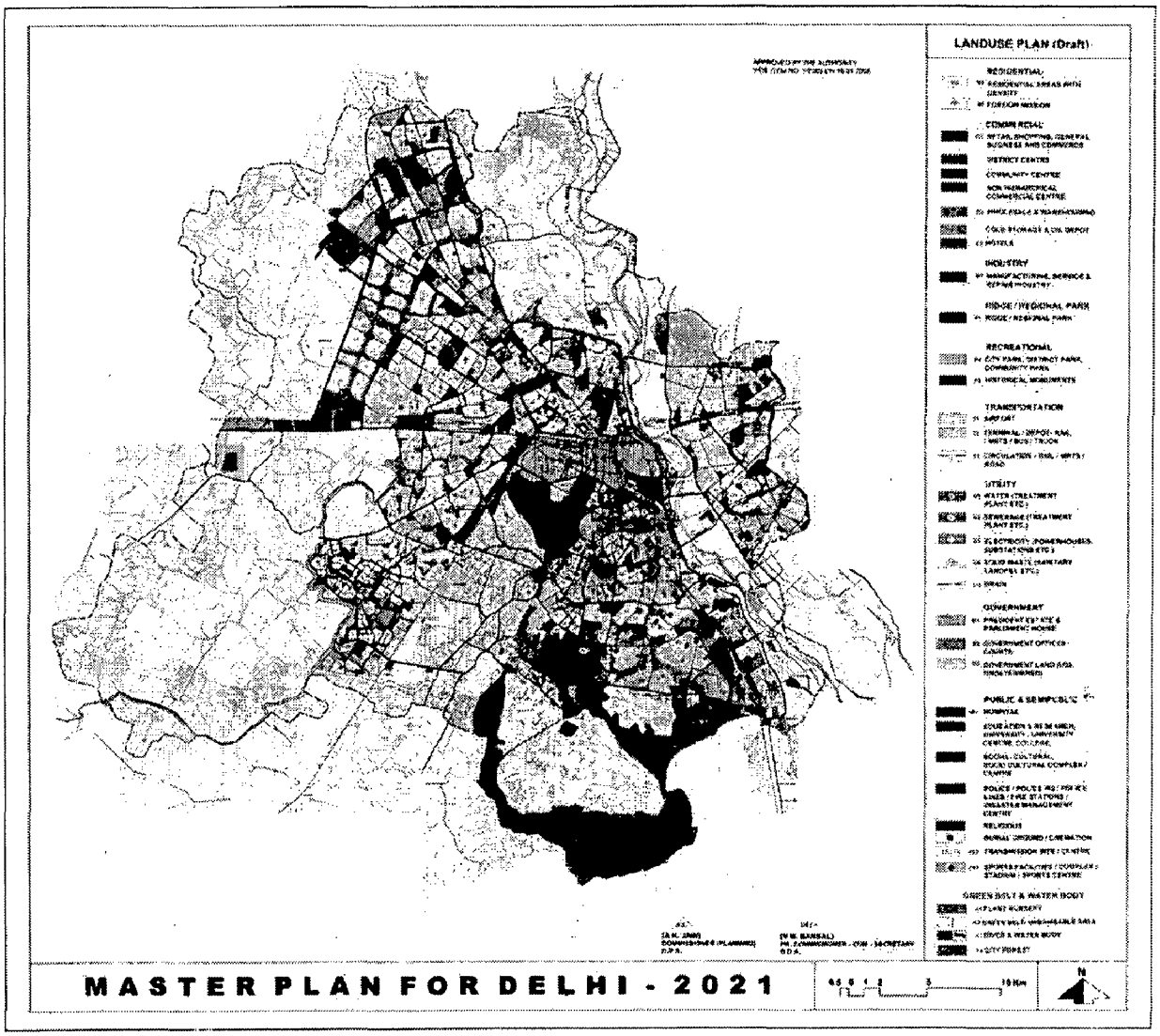
Source: MPD 2021

Table 4.5: Existing Land Cover Pattern of NCT Delhi

Landuse	Percentage
Built up Area	44
Agriculture	41
Vegetative Cover	8
Water Body	4
Waste Land	2
Open Land	1
Total	100

Source: MPD 2021

Map 23: Landuse Plan of Delhi



Source: MPD 2021

Table 4.6: Existing Landuse Break up of NCT Delhi

Landuse	Percentage
Residential	49
Commercial	4
Public/ Semi Public	7
Industrial	7
Green/ Open Space	21
Circulation	12

Source: MPD 2021

4.3 REVIEW OF MASTER PLANS, DELHI

A review of the three master plans of Delhi has been done with respect to the proposals given for increasing the density, mixed use, integration of landuse and transportation and the success in implementing these proposals.

4.3.1 Master Plan Delhi [1962-81]

The principle of decentralization of work centers and its location in functional relationship with housing was kept in mind while making the landuse plan. Self-contained divisions and decentralization of employment centers are necessary if traffic is not to be increased at an alarming rate.

In order to secure balanced development and minimize frictions, decentralization of places of employment and their right relationship with the residential areas is necessary.

With this objective the planning area has been divided into eight planning divisions which are self contained in the matter of employment residential places, recreational areas, shopping and other requirements. The basic scheme of the Urban Delhi Plan, was to organize all new developments, and reform old areas, on the basis of large districts [A to H] relatively self contained for daily purposes and needs: housing, employment, district and neighborhood, centers for recreation, shopping, commercial and cultural activities.

In order to decentralize the commercial activities it was proposed to develop 15 District centers in the outlying planning divisions.

The Delhi Master Plan [1962-81] was prepared with the following objectives: Decentralization of work centers and its location in functional relationship with housing so as to:

1. Make employee housing both accessible to such centers and also protected from any deleterious influences that might derive from their unplanned juxtaposition.

2. Ensure the location of employment centers, are in places that are accessible to needed facilities and services.

3. Obviate the necessity of costly new transport line and to have provision for ring roads and loops.

Higher densities are proposed nearer to the work areas so as to have maximum number of people living around them. The proposal to have an electrified sub-way was to be explored for future.

4.3.2 Master Plan Delhi [1981-2001]

The second Master Plan of Delhi proposed urbanization of further 18000-24000 ha to accommodate the additional population in urban extension areas like Dwarka, Rohini and Narela sub cities. In addition to the holding capacity of MPD 1962 urban area was increased through the process of low rise high density development i.e. the residential development to be compact and with low rise structures. An increase in the residential and overall city level density was proposed. **The residential density was proposed in the range of 350 to 400 ppha and the gross city level density was proposed at 100 ppha.**

To achieve this population density the distribution pattern proposed was to increase the population holding capacity of the areas within urban sable limits declared till [DUA-81] and extension or urban sable limits to accommodate additional population. The work centers were planned to be decentralized by development of development of district centers for each district. Apart from this, two sub central business district centers at sub city level were proposed one in the trans-Yamuna area and other in the Urban Extension. Overall the development envisaged by the previous Plans was poly nodal with hierarchy of Commercial Centers located either on ring or radial roads.

4.3.3 Master Plan Delhi [2001-2021]

The 2021 Master Plan proposed incentivized redevelopment with additional FAR has been envisaged as a major element of planning of Influence Zone along MRTS and Major Transport Corridor; underutilized / low-density areas; Special Area; shopping / commercial centers; Industrial areas / clusters and resettlement colonies.

It proposes the redevelopment of the 500 meter wide belts on either side of Metro tracks as economic corridors. Shopping malls, Cineplex's, food courts, pubs, games centers, services apartments, hotels, hi-tec parks are proposed along the metro corridors.

The proposed MRTS network will bring sizable urban area within walking distance from the proposed stations. This will have an impact on the existing structure of the city and consequently its development. This changed scenario provides opportunities for city restructuring and optimum utilization of the land along the MRTS corridors. In this process, a sizable proportion of the additional population with requisite facilities and employment can be absorbed along these corridors.

Influence Zone along MRTS corridor is envisaged as intensive development zone. The scheme for Redevelopment of Influence Zone shall be prepared on the basis of the following:

1. Maximum upto 500 m. wide belt on both sides of centre line of the MRTS / Major Transport Corridor (to be identified in consultation with GNCTD) will be designated as Influence Zone which will be identified in the respective Zonal Development Plans.
2. Entire approved layout plan of a scheme will be included in the zone if more than 70% of the plan area falls inside the influence zone. In case of large schemes, block / pocket boundary should be considered as one scheme for this purpose.
3. The approval of schemes will be granted only after commencement of execution of the respective phase of MRTS.
4. Development Controls applicable will be as permissible for the respective use zones / use premises.
5. Higher FAR and height can be availed of through the preparation and approval of comprehensive integrated scheme.
6. In the proposed Urban Extension areas the land uses will be integrated with the proposed movement corridors at planning stages only.
7. The following areas shall be excluded from the enhancement of FAR: -
   - Lutyens' Bungalow Zone, Chanakya Puri., DIZ Area and Matasundari Area.
   - Civil Lines Bungalow Area.
   - Monument Regulated Zone (As per ASI guidelines).
   - Property development of DMRC.
   - Comprehensive commercial schemes.

The exact product mix in each stretch of the corridor will be worked out through market surveys at the time of planning and development. Enhanced floor area ratio or built up area will be permitted along the economic corridor.

MRTS network when fully completed will serve 109 lakh passengers per day or about 50 to 60 percent of city's population.

The plan and strategy for transportation will have to be worked out in this background. The broad aim of this would be to ensure safe and economical commuting between place of origin and destination, convenient and quick access to all areas for all sections of the society, reduction of pollution and congestion, energy efficiency and conservation, safety for all sections of the road and transport users and, towards meeting these objectives, providing a significant increase in efficient rapid public transport systems and facilities with a corresponding reduction in individual private transport usage.

This is in addition to pedestrianisation and properly planned use of non-motorized transport systems in specific areas.

The following strategy is proposed in order to meet these objectives: -

1. Preparation and operationalisation of an integrated and mutually complementary multi-modal transportation and traffic plan comprising the Road, Rail and Metro-rail network, so that work centers / residences are within a walkable distance.
2. The multimodal system will be integrated with safe facilities for pedestrians, bicyclists, disabled persons and Intelligent Transport System (ITS) enabled taxis and three-wheeled scooter rickshaws (TSR).
3. Optimal use and utilization of the existing road network and full development of ROW by removing all impediments. All arterial roads will be restructured to allow for smooth and safe flow of buses and nonmotorized transport to minimize pollution and congestion.
4. Expansion and restructuring of the existing network through expressways, arterial roads, elevated distributors and relief roads with a view to creating alternate access ways and reducing congestion on the existing roads to the extent possible. Urban Relief Roads should also be identified as additional or alternative link roads, wherever possible, to reduce congestion.

5. Planning of new road network in such a manner as to prevent possibilities of future congestion by modifying road sections to promote use of public transport, which would reduce use of private transport modes.
6. Planned and targeted expansion of the Metro-rail network.
7. Expansion and strengthening / restructuring of the Ring Rail System and sub-urban rail system.
8. Developing an integrated relationship between the bus, rail and metro-system to provide for seamless multimodal transport, through provision of additional stations, park and ride facilities, introduction of single multi-modal ticketing, etc. The choice of technology for the multimodal public transport system (Bus Rapid Transit System, Metro, Mono-Rail, Light Rail) be based on comparative cost-effectiveness analysis studies to ensure rapid development of public transport and to ensure judicious use of public funds.
9. Development of a comprehensive parking policy in line with the broad aims of the Plan for transportation mentioned earlier, including measures for linking new vehicle registration with owner parking facilities.
10. Establishment of a quick and efficient transport network between the NCR and the NCT of Delhi.
11. Provision of directional Goods and Passenger Terminals with adequate infrastructure.
12. Review of the licensing policy and systems, and effective arrangements for training of drivers / transport operators.

It is expected that about 60% of the urban area will be within 15-minute walking distance from the proposed MRTS stations, after full development of the system. Additional areas could come within easy access and connectivity with the Metro Rail through inter-linkages with other transport modes. About 15% of urban area of Delhi is likely to be directly affected, and may undergo a dramatic impact and change.

Further, due to development of economic activities along the Metro Corridors and optimization of connectivity provided by it, the rider ship on the Metro is expected to grow substantially over time. Correspondingly, it is expected that vehicular trips may also progressively shift from road-based transport to MRTS, particularly, with reference to the longer trip lengths (greater than 10 Kms) within the city.

To achieve the above potential impact of the Metro Rail System a number of measures will be necessary. These will include the following:

1. Preparation of detailed plans to facilitate and encourage direct pedestrian access to the Metro Rail System/ Station.
2. Preparation of detailed multi-modal transport plans with reference to each major Metro Station, with particular reference to bus transport routes, which could provide inter-linkages and feeder arrangements.
3. Parking arrangements at Metro Stations, both for short and medium period viz. for those who would travel for local level requirements such as shopping, etc. and those who would need parking by way of a Park and Ride facility.
4. Provision of Park and Ride facilities at identified points from where feeder bus services would be available, or convenient direct pedestrian access would be feasible.

4.4 PRESENT TRENDS OF URBANIZATION IN DELHI

Population	14,000,000 (2007)
Area	1,483 sq. km.
Density	11,463 /km^2

- Delhi the national capital territory spread over a land of 1,483 sq. km. area with a population of nearly 14 million.
- Delhi has been one of the fastest growing cities in the country, clocking over 47% decadal growth from 1991-2001, more than double the national rate.
- The annual average exponential growth rate of population of Delhi was the highest (6.42%) during 1941-1951 due to large-scale migration from Pakistan to India after partition.

The National Capitol Area consists of 3 municipality areas:

(MCD)		NDMC		DCB
1,397 sq.kms,	+	42.74 sq.kms	+	42.927 sq.kms,
94 % of Delhi area		3% of Delhi area		3% of Delhi area
97% population		2.07 % population		0.93% population

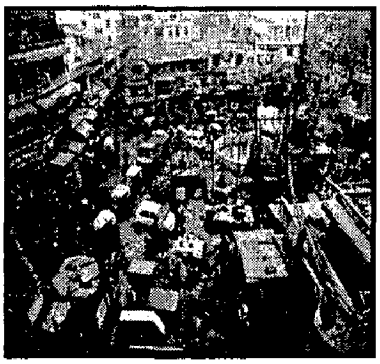
In 1999, the urban area of Delhi was 701.62 sq.kms (47.3% of Delhi area). This is proposed to be increased to 977.91 sq.kms, or 66% of the total area, by 2021.

Table 4.7: Rural and Urban area of Delhi in 1991 and 2001

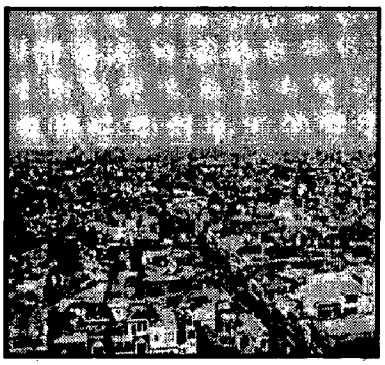
Period	Rural Area	Urban Area	Total
As per 1991 Census	797.66 Sq.Km	685.34 Sq.Km	1483 Sq.Km
As per 2001 Census	591.01 Sq.Km	891.09 Sq.Km	1483 Sq.Km
Proposed by 2021	725 Sq.Km	977.91 Sq.Km	1703 Sq.Km

P – Population; A – Area; D – Density

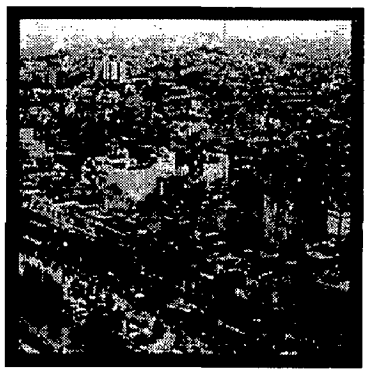
Figure 4.2: Urban Sprawl in Delhi



Traffic congestion



Haphazard development



Old Delhi

The DUA's core consists of three statutory towns: New Delhi Municipal Council (NDMC), Delhi Municipal Corporation (DMC), and Delhi Cantonment (DC). Delhi's periphery— a contiguous urban spread area—in 2001 shelters 56 Census towns of various size groups.

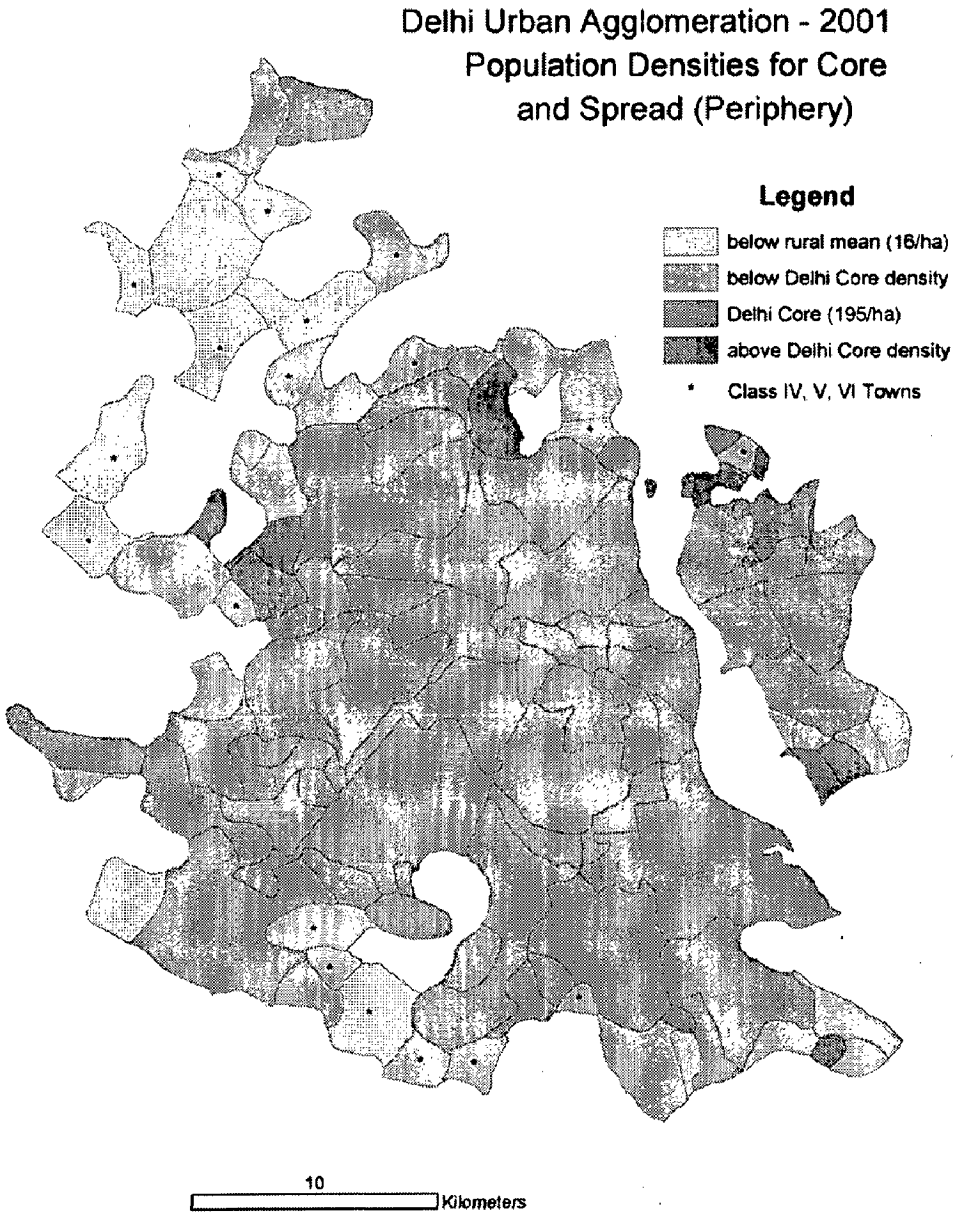
The growth patterns of the core city and the urban spread of the DUA in the 1991-2001 periods (Tables 2A and 2B) reveal a marked difference between the core and the spread during the past decade the population in the spread increased over 212% as compared to 35% in the core.

Table 4.8: Delhi Urban Agglomeration: Population Density By Core and Spread 1991-2001

Agglo-meration	1991			2001			% Change 1991-2001		
	P	A	D	P	A	D	P	A	D
Core	7,602,394	46,831	162.8	10,236,674	52,366	195.5	34.65	11.81	20.4
Spread	816,690	10,586	77.1	2,554,784	23,749	107.6	212.8	124	39.4

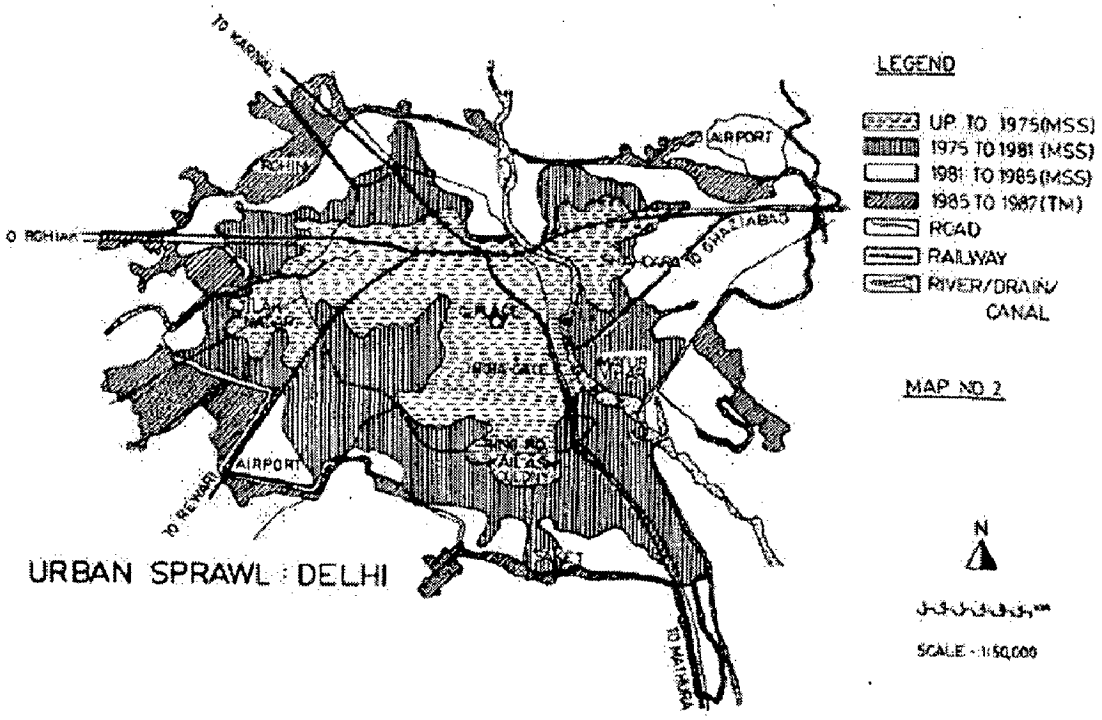
Source: Calculated by authors from census data

Map 24: Delhi Population Densities for Core and Spread 2001



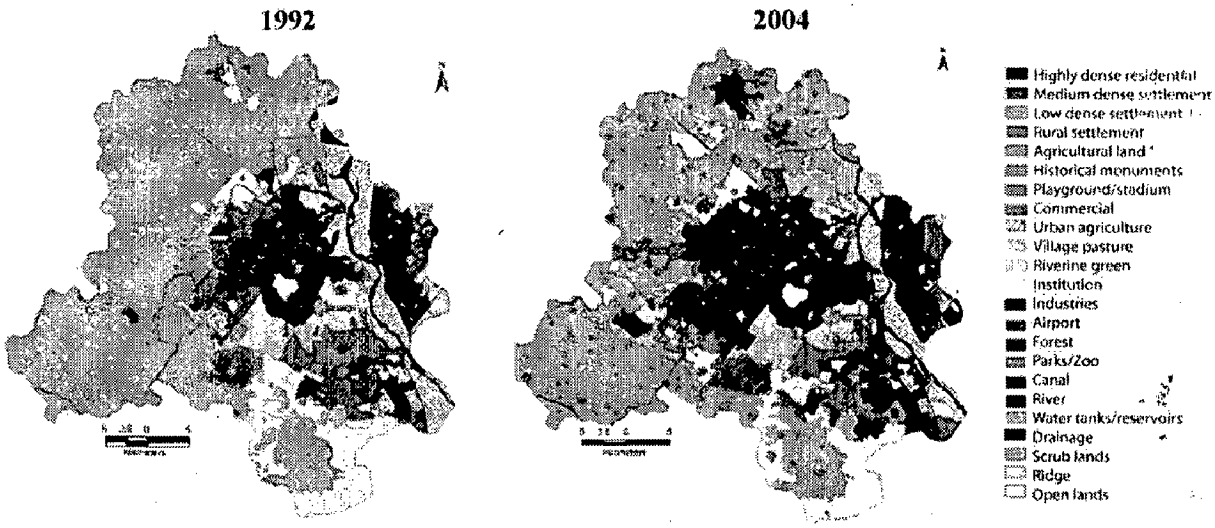
Source: Cities In Transition: Monitoring Growth Trends in Delhi Urban Agglomeration 1991 – 2001

Map 25: Urban Sprawl Map of Delhi from 1975 to 1985



Source:MPD 2001

Map 26: Recent urban sprawl map of Delhi



Indicating how the cultivable land is being occupied for development.

Source: CDP Delhi

Table 4.9: Forecasted Travel Demand in Delhi, 1990-2020

Year	Two-wheelers	Cars & jeeps	Autorickshaws	Taxis	Buses	Rail Transit	Total
1990	8.0 (17%)	8.6 (18%)	3.4 (7%)	0.3 (<1%)	27.2 (57%)	0.0 (-)	47.5 (100%)
2000	14.8 (16%)	29.0 (31%)	3.5 (4%)	0.4 (<1%)	46.8 (49%)	0.0 (-)	94.4 (100%)
2010	33.8 (15%)	61.6 (28%)	7.6 (3%)	0.6 (<1%)	105.0 (48%)	10.4 (5%)	219.1 (100%)
2020	102.6 (20%)	153.3 (30%)	15.8 (3%)	1.3 (<1%)	220.0 (44%)	10.4 (2%)	503.4 (100%)

For motorized travel only (billion passenger-kilometers)

Source: CDP Delhi

4.5 TRANSPORTATION SYSTEM IN DELHI

4.5.1 Synergy between Transport and Landuse

The concept of the Master Plan for Delhi 1962 was based on a poly-nodal, polycentric, distribution of work centers, largely based on road transport nodes. A major fall-out of this has been distortion between infrastructure, transport and land use. To achieve spatial balance, development should take place according to new corridors of mass movement. This has implications in terms of land use planning along major transport corridors and the Mass Rapid Transport/Transit System. This would not only help to solve, to some extent, the enormous problems of mass transportation, but would also generate a dynamic potential for growth and employment. This is particularly true for the Metro Rail System.

In this context the Metro corridors upto a certain depth would require selective re-development and re-densification/intensification of existing land uses based on site conditions. It is proposed that comprehensive redevelopment schemes of the influence area of MRTS stations be prepared.

4.5.2 Integrated Multi-Modal Transport System

Integrated Multi-Modal Transport System suitable for the overall structure of the city and at the same time interlinking the various sub-structures is necessary.

It is envisaged that the future transport system shall consist of a mix of rail and road based systems which may include Metro Rail, ring rail, dedicated rail corridors for daily commuters, (IRBT/ RRTS corridors as identified in NCR Plan 2021), Bus Rapid Transit System (BRTS), other mass transit modes as technologies become available and Intermediate Passenger Transport (IPT) and private modes on selected corridors to be identified as per the needs from time to time. All roads should be made pedestrian, disabled and bicycle friendly as far as possible. [34]

4.5.3 Roads

Delhi is planned on a ring - radial pattern with a hierarchical road network. Broadly, the road network is designed for regional, intra - city and local traffic. The proposed roads are classified taking into account the land use pattern and road system hierarchy with recommended right of ways as follows:

1. National Highways

The recommended minimum right of way (ROW) is 90 meters, wherever possible. However, within the city it shallnot be less than 60meters. All the National Highways within the NCTD shall be access controlled upto the Delhi Border.

2. Arterial Roads

These include primary roads with access control and other primary roads.

i) Primary Roads:

Vehicular routes carrying heavy volumes of traffic will generally have free / stable flow conditions with controlled access. The recommended ROW in existing urban area is 60-80 m. and minimum 80 m. in the proposed urban extension.While designing roads with 30m. ROW and above, provision should also be made for public mass rapid transport system, which may include BRT. Present ring road and outer ring road to be converted to access controlled arterial

roads. Cycle tracks should also be constructed along all arterial roads wherever possible.

ii) Other Primary roads:

Vehicular routes carrying heavy volumes of traffic, BRT route may also be allowed on these roads. The recommended ROW in existing urban area is 45-60 m. and minimum 60 m. in the proposed urban extension. Cycle tracks should also be constructed along all other primary roads wherever possible.

3. Sub Arterial Roads

These include primary and secondary collector streets.

(i) Primary Collector:

These roads will connect major arterial roads and inter residential district collectors. The recommended ROW in existing urban area is 30-40 m. and minimum 45 m. in the proposed urban extension.

In addition to this, a separate cycle track should be provided wherever possible.

(ii) Secondary Collector:

These roads are intended to collect traffic from local streets within one residential district. The recommended R/W in existing urban area is 18-24 m. and minimum 30 m. in the proposed urban extension.

4. Local Streets

These are intended for neighbourhood (or local) use on which through traffic is to be discouraged. The suggested ROW is 12 to 20 m. in the existing and proposed urban area. These roads should be made pedestrian and bicycle friendly by using modern traffic calming designs to keep the speeds within limits as per design. A special cell should be set up within

Transport Department for developing standards and guidelines for traffic calming designs and for their implementation in the whole city in a phased manner. In existing areas like Rohini project, having plot sizes below 90 sq.m. minimum ROW of 9 m. may continue.

As a matter of general policy, it is proposed that for all categories of roads, the full cross section should be developed in future and no encroachments will be permitted on the existing road network. Further, the development of roads should start from the extremes of the designated ROW.

5. Underground roads

Vehicular traffic is a major contributor to the air pollution in Delhi. In order to reduce road congestion and the level of pollution, the possibility of having Underground Roads or Tube roads in critical areas needs to be considered. Such measures, together with provision of Metro Services, will also help to make historically important areas like Connaught Place, Chandni Chowk and Karol Bagh etc. pedestrian friendly. With advancement in technology, and a better climate for private participation and investment in infrastructure development, such proposals could be explored.

6. Grade separators

The Master Plan studies indicate the need for provision of intersections with grade separators. In case of existing grade separators the possibility of providing cloverleaves and direct interchanges, wherever necessary and feasible, may be examined in order to make the junctions signal free. To provide uninterrupted traffic movement various other options such as elevated roads with supporting infrastructure etc. will also need to be explored.

7. Freeways

Freeways are defined as divided arterial highways for vehicular traffic with full access control and provided generally with grade separation at intersections. A freeway network in the NCR should be developed so that the cris-cross movement through Delhi is lessened.

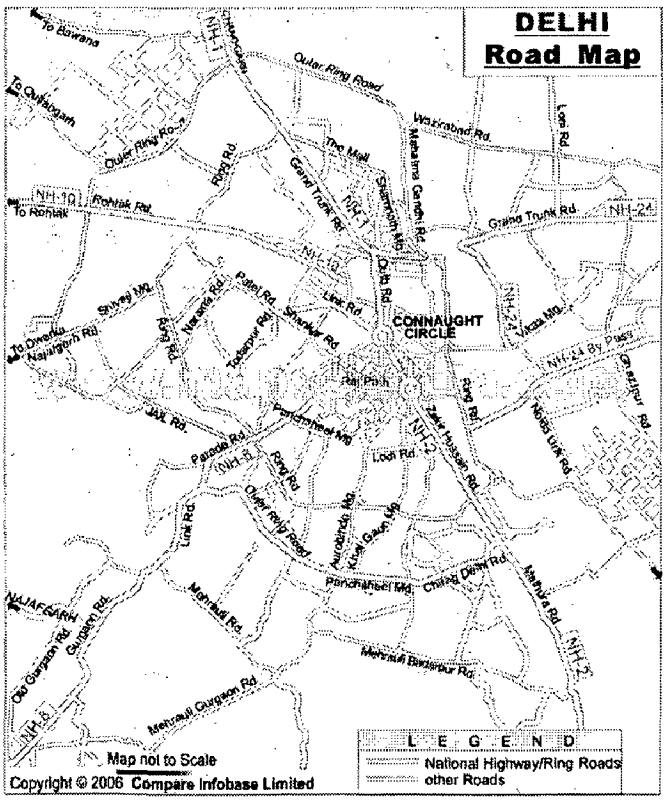
With such a network of Freeways, Highways, MRTS and Electric Multiple Units (EMUs) a 2 to 3 hour movement network can be generated which will cover entire NCR. This will encourage interaction between Delhi and NCR towns.

Table 4.10: Roads and their lengths in Delhi (In Kilometer)

Agency	1990-91	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Local Bodies							
M.C.D	18673	21467	22769	22769	23143	23143	23143
N.D.M.C	1289	1297	1298	1299	1299	1299	1299
Delhi Cantonment Board	143	144	144	144	144	144	144
Public Works Department (Delhi Admn.)							
National Highway	324	337	337	337	337	337	-
Other Roads	1135	1400	1400	1400	1400	1400	-
Total	21564	24643	25948	25949	26323	26323	-

Source: Local Bodies & Public Works Department, Govt. of National Capital Territory of Delhi.

Map 27: Road Map of Delhi



Source: www.mapsofindia.com

4.5.4 Mass rapid transit system (MRTS)

The Metro Rail System the most important, component, of a Mass Rapid Transport System (MRTS) in the City.

The Metro Rail network for the entire city has been identified in various phases, which comprises of a network of underground, elevated and surface corridors aggregating to approximately 250 Kms., and is expected to carry 108 lakh daily passengers with an average trip length of 15 Km. by 2021.

Phase I of the network is already implemented and operational.

Phase-II of the network covering a length of 56.76 km is likely to be completed by 2010 for the following stretches.

1. Vishwavidyalaya - Jahangir Puri.
2. Central Secretariat - Qutab Minar.
3. Indra Prastha - Yamuna Depot - New Ashok Nagar.
4. Yamuna Depot - Anand Vihar ISBT.
5. Shahdra - Seemapuri.
6. Kirti Nagar - Nangloi along Rohtak Road.

Subsequent phases shall be worked out in conjunction with the overall circulation plan for the city.

Rohini and Narela sub-city projects with population of more than 10 lakh each need to be connected to the MRTS.

Following extensions of routes are proposed:

i) From existing Rithala Station upto Barwala (Rohini Ph.IV-V).

ii) From Sanjay Gandhi Transport Terminal to Narela.

Considering the future needs of the city additional links of MRTS may be identified by the DMRC.

It is expected that about 60% of the urban area will be within 15-minute walking distance from the proposed MRTS stations, after full development of the system. Additional areas could come within easy access and connectivity with the Metro Rail through inter-linkages with other transport modes. About 15% of urban area of Delhi is likely to be directly affected, and may undergo a dramatic impact and change. Further, due to development of economic activities along the Metro Corridors and optimization of

connectivity provided by it, the rider ship on the Metro is expected to grow substantially over time. Correspondingly, it is expected that vehicular trips may also progressively shift from road-based transport to MRTS, particularly, with reference to the longer trip lengths (greater than 10 Kms) within the city.

To achieve the above potential impact of the Metro Rail System a number of measures will be necessary. These will include the following:

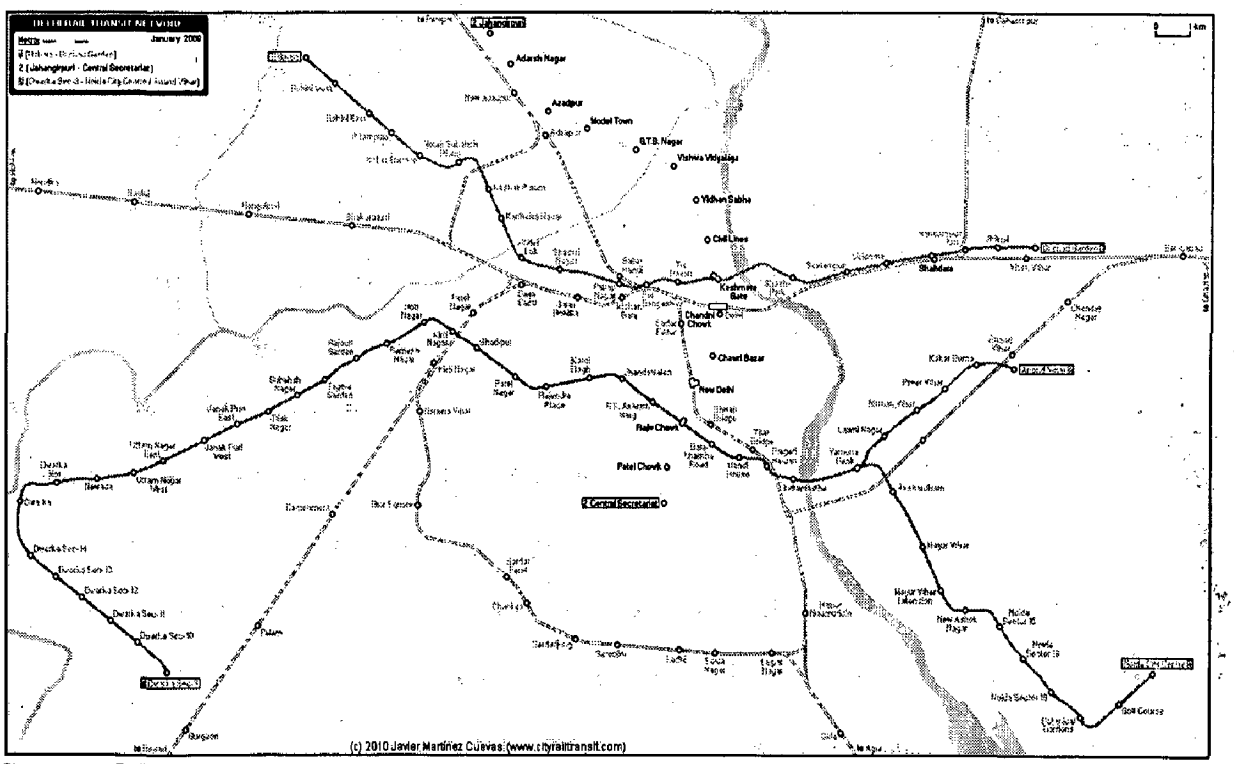
i) Preparation of detailed plans to facilitate and encourage direct pedestrian access to the Metro Rail System/Station.

ii) Preparation of detailed multi-modal transport plans with reference to each major Metro Station, with particular reference to bus transport routes, which could provide inter-linkages and feeder arrangements.

iii) Parking arrangements at Metro Stations, both for short and medium period viz. for those who would travel for local level requirements such as shopping, etc. and those who would need parking by way of a Park and Ride facility.

iv) Provision of Park and Ride facilities at identified points from where feeder bus services would be available, or convenient direct pedestrian access would be feasible.

Map 28: Delhi Metro Map



Source: DMRC

4.5.5 Bus Rapid Transit System (BRTS)

Apart from the Metro Rail System, buses will continue to be other major public transport in the city. The Bus Transport system is presently estimated to carry around 23.40 lakh passengers per day (2002). Even after the introduction/expansion of the Metro, major dependence will continue to be on Bus Transport as a form of comfortable and convenient public movement within the city. However, keeping in view the extension of road network in Delhi on one hand and the existing/likely congestion on the roads on the other, it is necessary to take steps for rationalization of Bus Transport.

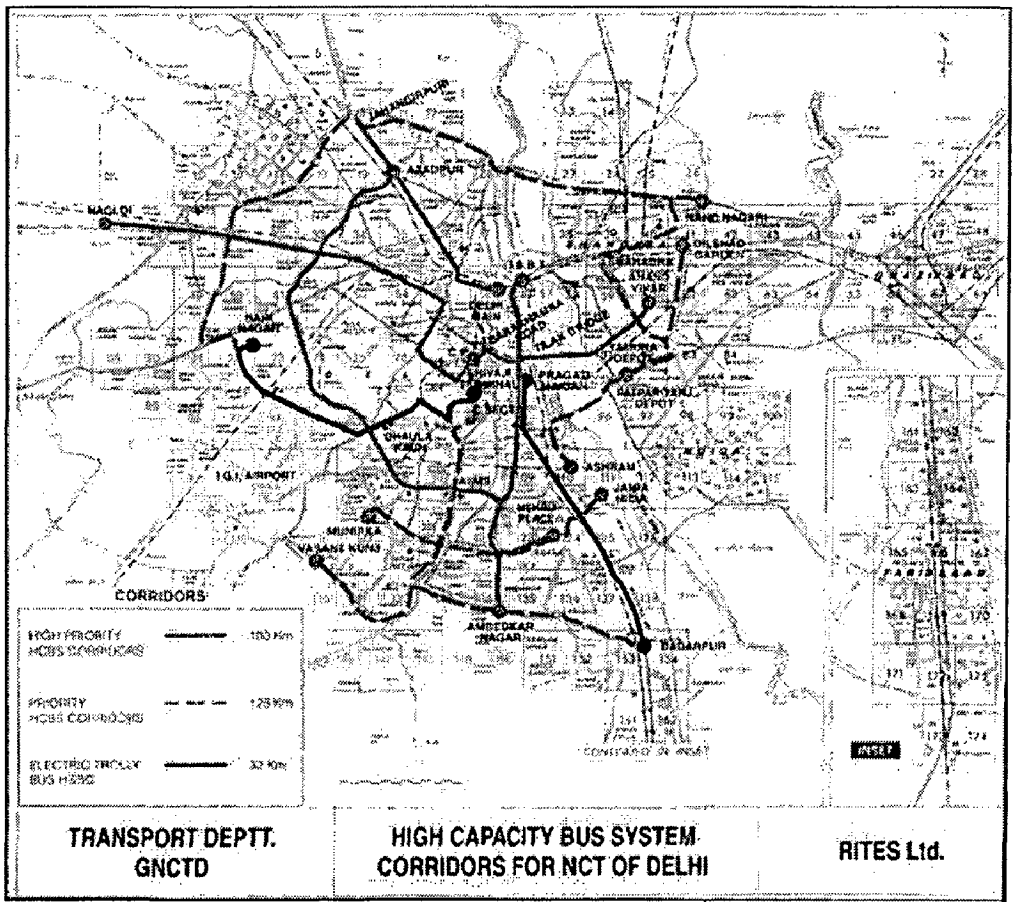
This would entail action on the following fronts: -

i) Bus connectivity would need to be planned to a considerable extent in the form of feeder services to the Metro Rail Stations and the Ring Rail System.
ii) Park and ride facilities will have to be developed at important bus terminals.
iii) The quality and design of buses would have to be significantly upgraded with a view to providing comfort to the riders and thereby make bus travel a part of an efficient mass public transport system which could also help to reduce individualized / private vehicle usage.
iv) On all roads with ROW greater than 30 m exclusive bus lanes will be planned to implement the Bus Rapid Transit System (BRTS) in a phased manner to cover the whole city.
v) New bus terminals need to be planned and developed in strategic locations to make the use of BRTS and Metro Stations convenient for all commuters. [25]

Figure 4.3: Low floor DTC bus

Source:www.nic.in

Map 29: Delhi BRTS Map



Source: Transport Department GNCTD.

4.5.6 Rail

In the National Capital Territory of Delhi both intercity and intra-city passenger movements are being catered to by the existing rail network comprising the Regional and Ring Rail Systems respectively.

In order to improve the rider-ship on Ring Rail, the following is proposed:

a) Intensive land use around the following:

i. Anand Parbat

ii. INA Colony

iii. Pusa Institute

iv. Kirti Nagar

b) Accessibility improvement and augmentation of infrastructure on ring rail stations:

i. Shivaji Bridge
ii. Bhairon Marg
iii. Kasturba Nagar (Sewa Nagar)
iv. Lajpat Nagar
v. Kirti Nagar
vi. Shakur Basti

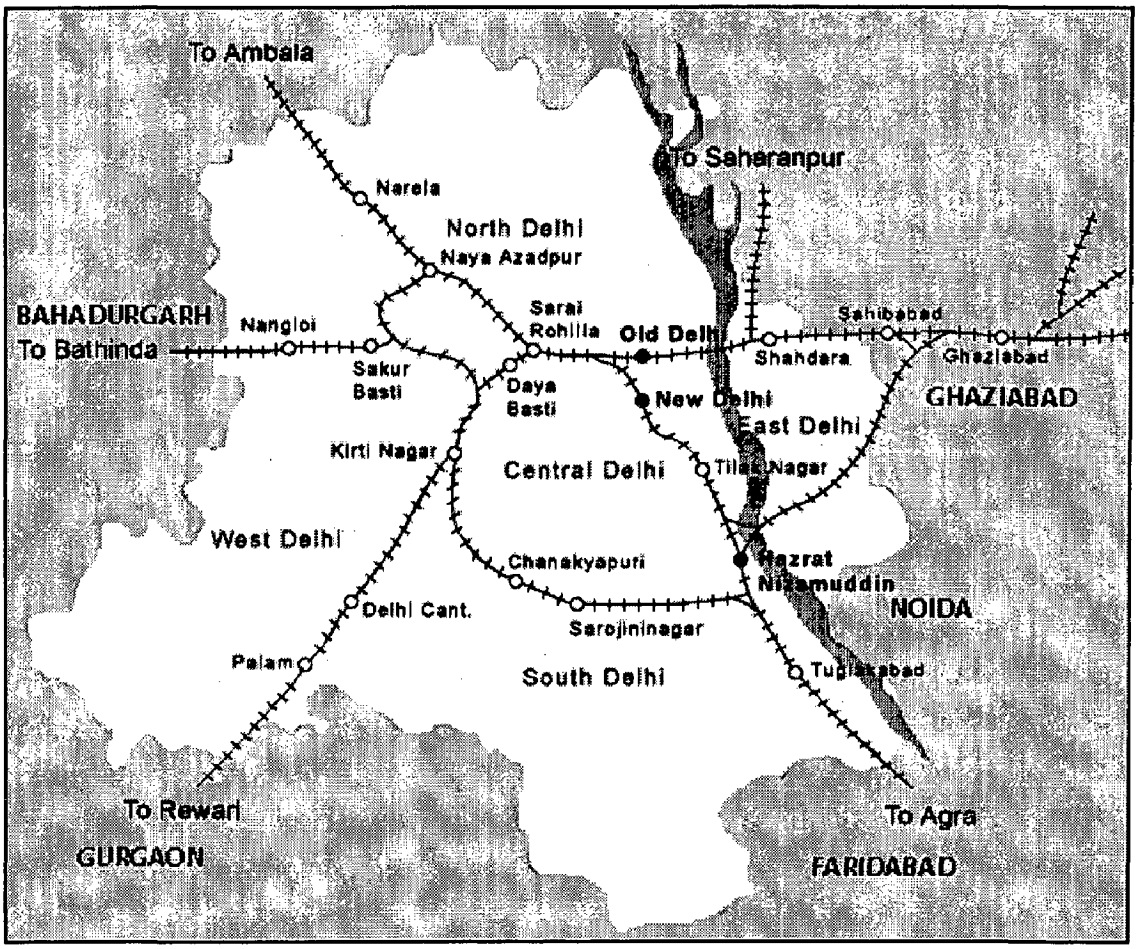
c) Provision of Halt Stations on ring rail at the following locations:

i. Moti Bagh
ii. Bhairon Road
iii. Hans Bhawan (ITO)
iv. Ganesh Nagar
v. Preet Vihar
vi. Shyamlal College.

The interchange points of Regional Road, MRTS, Ring Rail and any other future rail network should be developed as interchange stations/convergence zone. The change over facilities should include approach roads, pedestrian walkways, shuttle services, wherever feasible parking, areas for various modes including feeder buses, and adequate public conveniences, etc.

Figure 4.4: Satellite Image of the New Delhi Railway Station and the surrounding development.

Map 30: Delhi Railway Map



Source: www.delhicapitol.com

At present there are 43 railway stations in Delhi. The total passengers catered to at these stations in 2001 are 12.08 lakh/day including about 9.06 lakh commuters. Out of these stations, major stations catering more than 1.0 lakh passengers per day are:

Delhi Junction 2.72 lakh

New Delhi 3.19 lakh

Nizamuddin 1.28 lakh

Sadar Bazar 1.00 lakh

Five directional Metropolitan Passenger Terminals (MPT) have been proposed to decongest the central area.

These are:

i. Anand Vihar, East Delhi

ii. Bhartal in Dwarka, South-West Delhi

iii. Holumbi Kalan in Narela, North Delhi
iv. Tikri Kalan, West Delhi
v. Hazrat Nizammudin, South West Delhi

It is proposed to integrate the Inter State Bus Terminus with Delhi main railway station and the land should be made available by the shifting the IP University to the new campus.

Since about 75% of the total passengers are commuters, therefore in order to facilitate improvement in their movement between Delhi and surrounding towns either of the following is proposed based on the feasibility by the concerned authorities:

i. Extension of MRTS.
ii. Provision of dedicated railway corridor with supplementary feeder bus services for linking with other modes of transport (IRBT Corridors).

4.5.7 Bus

The total passenger trips per day catered by road-based transport are 15.97 lakh, out of which about 9.54 lakh (60%) are commuters. Majority of such trips are by bus.

Out of four new Interstate Bus Terminals (ISBT) as proposed in MPD-2001, only one at Anand Vihar in East Delhi has been developed as a part of Metropolitan Rail Terminal. The terminal at Dwarka (Bhartal) has also been included in Dwarka Project. The remaining two terminals at Okhla (Madanpur Khadar) and Narela (Holambikalan) have not been developed.

In order to cater to the additional passenger requirements, it is proposed to develop the following ISBTs (10 Ha each) along the Metropolitan Passenger Terminals:

i. At Bhartal, Dwarka.
ii. At Holambi Kalan, Narela Subcity.
iii. At Sarai Kale Khan. the existing Bus terminal should be upgraded and be linked to Hazrat Nizammudin Railway Station.
iv. At Tikri Kalan.

Apart from above ISBT, it is proposed to identify exclusive bus terminal sites at the intersection points of NH and outer ring road/ ring road to cater to the passenger movement. [26]

These could be developed at:

i. Dhaula Kuan.

ii. IFC Madanpur Khadar to relieve Intercity Passenger congestion at Ashram Chowk.

iii. Tikri Kalan to relieve Intercity Passenger congestion at Peeragarhi Chowk.

iv. Narela to relieve Intercity Passenger congestion at Outer Ring Road and G.T. Karnal Road Junction- Jahangirpuri Byepass.

4.5.8 Bicycle/ Cycle-Rickshaw

Bicycle/ Cycle-Rickshaw could be an important mode of travel, particularly with reference to short and medium trip lengths. To the extent that it meets individual or public transport requirements, it is a non-energy consuming and nonpolluting mode of transport. However, there are several issues, which have to be kept in view while planning in respect of these modes.

With a mixed type of fast moving traffic on the roads, travel by bicycle and rickshaws is very unsafe. In so far as rickshaws are concerned, apart from issues pertaining to the aspect of mixed traffic, this mode also provided employment to a very large number of unskilled workers residing in the city.

In view of the above, the following actions should be considered/ taken: -

i. On all arterial roads fully segregated cycle tracks should be provided with provision for safe parking in park and ride lots.

ii. In urban extension, cycle tracks should be provided at the sub-arterial and local level roads and streets.

iii. In specific areas, like the Walled City / Chandni Chowk / Sadar Bazar / Karol Bagh / Lajpat Nagar and Trans Yamuna Area, the use of cycles/rickshaw as a non-motorized mode of transport should be consciously planned along with pedestrianisation.

4.6 AGENCIES INVOLVED IN TRANSPORT SECTOR

The main agencies involved in managing the transport sector are:

P.W.D., M.C.D. --- Construction and maintenance of roads,

D.T.C. – operating public bus transport system,

D.D.A. --- Construction of roads in newly planned areas

N.H.A.I. --- Construction and maintenance of National Highways

D.M.R.C. is responsible for Metro Rail

Table 4.11: Activities of Delhi Transport Corporation (*Source: DTC*)

Description	1990-91	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Total Buses in the Fleet (At the end)	4392	3480	2770	2682	2669	3131	3094
Buses on Road (Daily Average)	3722	2313	1722	1648	2282	2619	2668
Passengers(in Lakhs)	16001	6363	5781	5482	7258	8662	8939
Daily Average Passengers (in Lakhs)	43.84	17.43	15.79	15.02	19.89	23.73	24.42
K meters operated (in lakhs)	2977.82	2121.68	1697.38	1610.32	1943.34	2002.08	2090.99
K M operated Daily Average (in lakhs)	8.16	5.81	4.64	4.41	5.32	5.48	5.71
Break-down(000)	24	9	9	9	7	5	5
Accidents	3065	1287	907	626	651	621	543
Major	283	235	237	197	145	170	161
Minor	2782	1052	670	429	506	451	382
Inter State Bus Route covered by DTC	118	192	178	139	126	124	130
D.T.C Workshop	38	35	35	35	35	35	35
D.T.C Depots	36	33	33	33	33	33	33

4.7 DELHI METRO RAIL

4.7.1 The Need

Delhi, the national capital with the population of about 13 million is, perhaps, the only city of its size in the world, which depends almost entirely on buses on it sole mode of mass transport.bus services are inadequate and heavily over-crowded. This situation had led to proliferation of personalized vehicles, so much so that Delhi has more registered vehicle than the total number of vehicles in Mumbai,Calcutta and Chennai put together. Nearly 70% of these are two wheelers. The result of extreme congestion on the road, ever slowing speeds, increasing accident rate, fuel wastage and environmental pollution. Delhi has now become the fourth most city in the world, with automobiles contributing more than two thirds of the total atmospheric pollution. Pollution related health problems are reaching disconcerting levels.

Immediate steps were, therefore, needed to improve both the quality and availability of mass transport service. This was possible only if a rail-based mass transit system, which is non-polluting, was introduced in the city without further delay.

4.7.2 About Metro Rail in Delhi

Delhi, the capital city of India, is one of the fastest growing cities in the world with a population of 13 million as reported in the Census of India Report for the year 2000. Until recently, it was perhaps the only city of its size in the world depending almost entirely on roads as the sole mode of mass transport. The total length of the road network in Delhi has increased from a mere 652 km in 1981 to 1122 km in 2001 and it is expected to grow to 1340 km in the year 2021. This increase in road length is not at par with the phenomenal growth in the number of vehicles on these roads in Delhi. The cumulative figure of registered private and government buses, the main means of public transport, is 41,872 in 1990 and it is expected to increase to 81,603 by the year 2011. The number of personal motor vehicles has increased from 5.4 lakhs in 1981 to 30 lakhs in 1998 and is projected to go up to 35 lakhs by 2011.

With gradual horizontal expansion of the city, the average trip length of buses has gone up to 13 km and the increased congestion on roads has made the corresponding journey time of about one hour. Delhi has now become the fourth most polluted city in the world, with automobiles contributing more than two thirds of the total atmospheric pollution. In this context, the decision of the Government of India to develop a mass transport system for Delhi providing alternative modes of transport to the passengers was most appropriate

4.7.3 Delhi MRTS Project

With a view to reducing the problems of Delhi's commuter, the launching of an Integrated Multi Mode Mass Rapid Transport System for Delhi had long been under consideration. The first concrete step in this direction was, however, taken when a feasibility study for developing such a multi-modal MRTS system was commissioned by GNCTD (with support from GOI) in 1989 and completed by RITES in 1991. It has recommended a 198.5 km predominantly rail based network, with first phase to cover a length of 55.3 km, report was completed by RITES during 1995.

The Delhi Metro (DM) planned in four phases is part of the MRTS. The work of Phase I and part of Phase II is now complete while that of phase III is in progress. The first phase DM consists of 3 corridors divided in to eight sections with a total route of 65.1 kms, of which 13.17 kms has been planned as an underground corridor, 47.43 kms as elevated corridors and 4.5 kms as a grade rail corridor. The second phase covers 53.02 kms of which the underground portion, grade and elevated section are expected to be 8.93 kms, 1.85 kms and 42.24 kms respectively. The construction of the first phase of DM was spread over 10 years during 1995-96 to 2004-05 while that of the second phase, which started in 2005-2006 is expected to be complete by 2010-11. The total capital cost of DM at 24 prices for Phase I and Phase II are estimated as Rs. 64,060 and Rs. 80,260 million, respectively. Phases III and IV of DM will cover most of the remaining parts of Delhi and even extend its services to some areas such as Noida and Gurgaon belonging to the neighboring states of Delhi. Table I provides overview of the Delhi MRTS.

Table 4.12: Overview of the Delhi MRTS

	Phase I (1995 - 2005)	Phase II (2005 –2011)
Distance	65.10 km	53.02 km
Corridors	1) Shahdara - Barwala (22)	1) Vishwa Vidhyalaya- Jahangirpuri (6.36)
	2) Vishwa Vidhyalaya- Central Secretariat (11)	2) Central Secretariat- Qutab Minar (10.87)
	3) Barakhamba Road - Dwarka (22.8)	3) Shahdra- Dilshad Garden (3.09)
	4) Barakhamba Road – Indraprastha (2.8)	4) Indraprastha- New Ashok Nagar (8.07)
	5) Extension into Dwarka Sub city (6.5)	5) Yamuna Bank- Anand Vihar ISBT (6.16)
		6) Kirti Nagar- Mundka (18.47)
Investment	Rs 6406 crores (2004 prices)	Rs 8026 crores (2004 prices)
	Phase III	Phase IV
Distance	62.2 km	
Corridors	1) Rangpuri to Shahabad Mohammadpur	1) Jahangirpuri to Sagarpur West
	2) Barwala to Bawana	2) Narela to Najafgarh
	3) Jahangirpuri to Okhla Industrial Area Phase I	3) Andheria Mod to Gurgaon
	4) Shahbad Mohammadpur to Najafgarh	

Source: RITES Gurgaon

4.7.4 Economic Benefits

The Delhi MRTS is essentially a "social" sector project, whose benefits will pervade wide sections of economy. The modified first phase will generate substantial benefits to the economy by the way of:

- Time saving for commuters
- Reliable and safe journey
- Reduction in atmospheric pollution
- Reduction in accident
- Reduced fuel consumption
- Reduced vehicle operating costs
- Increase in the average speed of road vehicles
- Improvement in the quality of life
- More attractive city for economic investment and growth

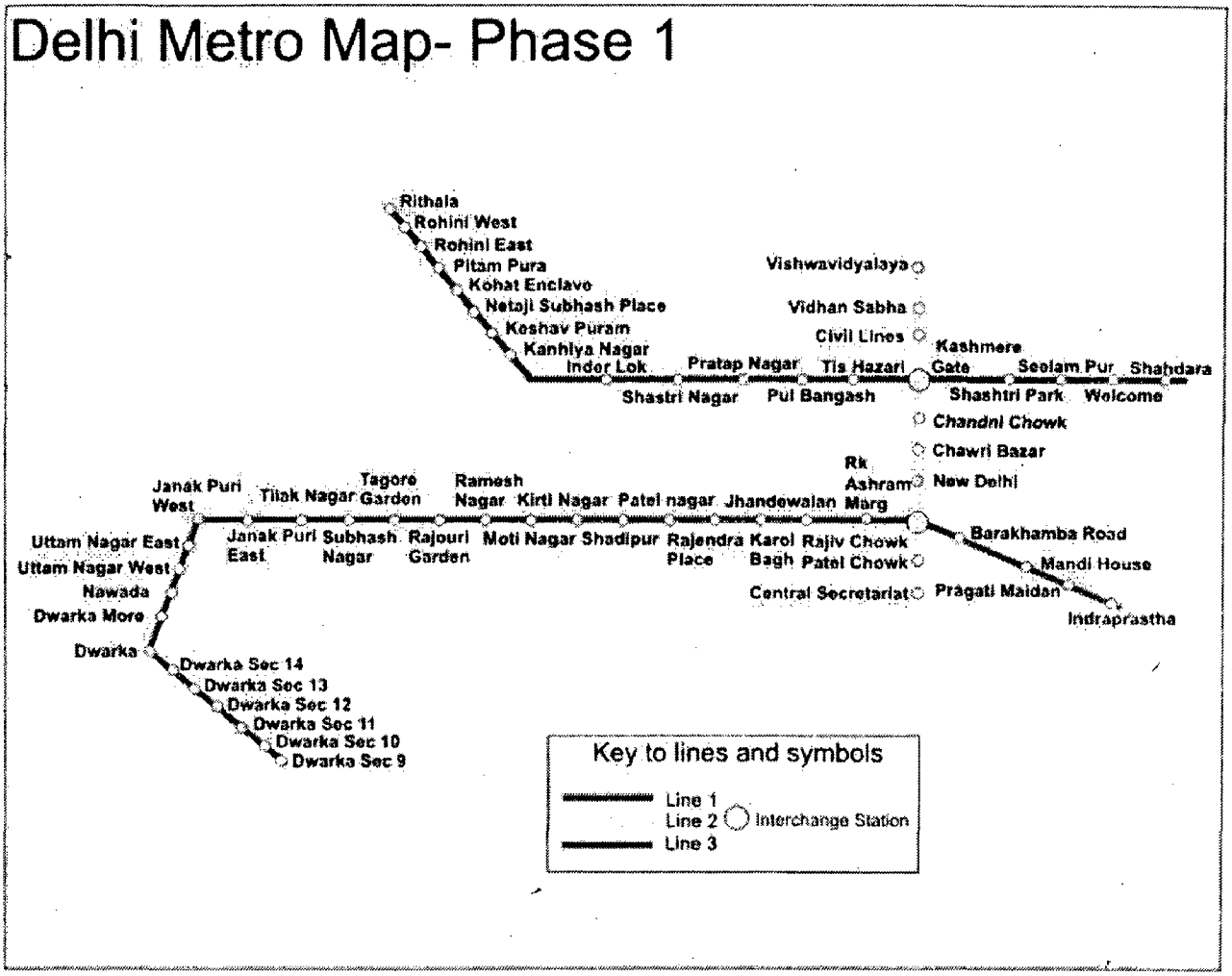
4.7.5 Phase I Network

Phase I of Delhi Metro Rail project consists of the following three lines:

Line	Length (Kms)	No. of Stations
Line No. 1- Shahdara-Tri Nagar-Rithala	22.06	18
Line No. 2- Vishwa Vidyalaya-Central Secretariat	10.84	10
Line No. 3- Indraprastha-Barakhamba Road-Dwarka Sub City	32.10	31

Source: Delhi Metro Corporation (DMRC)

Map 31: Delhi Metro Map Phase-I



Source: Delhi Metro Corporation (DMRC)

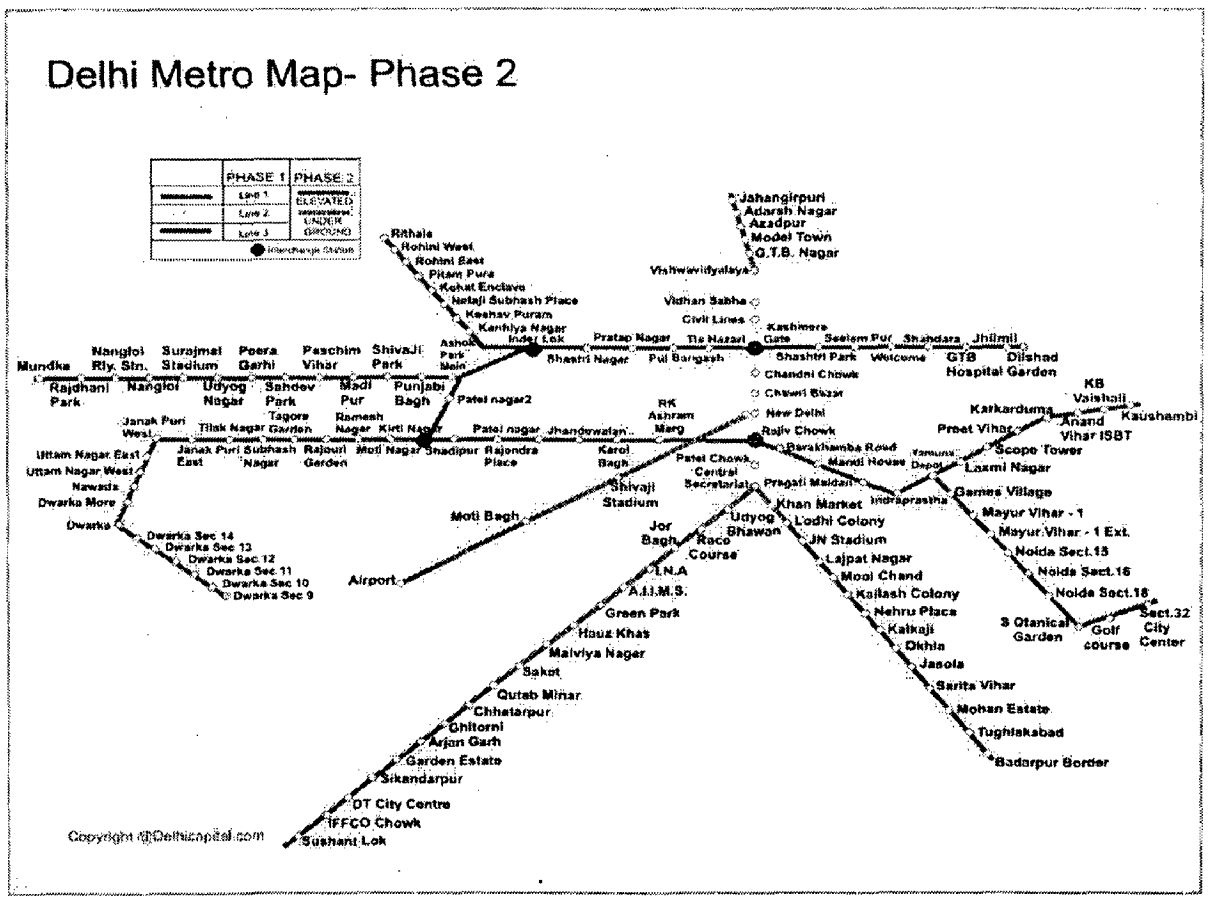
4.7.6 Phase II Network

Phase II of Delhi Metro Project consists of the following lines:

Line	Length (Kms)	No. of Stations
Shahdara-Dilshad Garden	3.09	3
Indraprastha-Noida Sector 32 City Centre	15.07	11
Yamuna Bank-Anand Vihar ISBT	6.17	5
Vishwavidyalaya-Jahangir Puri	6.36	5
Inderlok-Kirti Nagar-Mundka	18.46	15
Central Secretariat-Sushant Lok	27.45	19
Dwarka Sector 9-Dwarka Sector 21	2.76	2
New Delhi-Airport	19.20	4
Anand Vihar-KB Vaishali	2.57	2
Central Secretariat-Badarpur	20.04	15
Total	121.17	81

Source: Delhi Metro Corporation (DMRC)

Map 32: Delhi Metro Map Phase-II



Source: Delhi Metro Corporation (DMRC)

4.7.7 Financing Plan

As urban MRT projects are mean to provide a safe, speedy and affordable mode of travel to the commuters, they have not generally been found to be financially viable in the most cities of the world, despite their large economic benefits. MRT fares cannot be fixed purely on the basis of commercial principles, without drastic decrease in ridership and defeating the very object of setting up such mass transit system. Hence, the city dwellers must necessarily supplement the contributions to be made by the system users to meet the costs of setting up. as well as running the system. Delhi being national capital and international city, the GOI and GNCTD must also contribute to meet part of these costs. It has accordingly been decided that the project will be financed by way of equity contributions from the GOI / GNCTD, soft loan from the OECF (Japan), property development revenue and certain decided levies / taxes on the city dwellers.

The financial plan of the project has been approved by the GNCTD and GIO on 24.7.1996 and 17.9.19996 respectively.

Table 4.13: Sources of Funding of Delhi MRTS

Source of Fund	**Percentage of Total Cost**
1. Euity contribution from GOI& GNCTD	15% each
2. OECF (Japan) Loan	Approx. 56%
3. Revenue from Property Development	Approx. 6%
4. Subordinate Debt towards Cost and Land	Approx. 8%
The above financial plan is based on : • Debt Equity ratio 2:1 • Fare: Base rate rs. 5.00 (at April, 1995 prices) per passenger trip of 7.12 km.	

Source: RITES Gurgaon

The main source of revenue of the MRTS system is the fare box collection, which is a product of the total passenger ridership on the MRTS as reported in Tables 2 and the fare charged. RITES (1995b) considered four rates per trip: Rs 3, 4, 5, 6 at April 1995 prices and the fare sensitivity of ridership. Full ridership is expected to materialize on the metro with a fare comparable to the DTC bus fare of Rs. 3 per passenger trip. However, with higher fares, the ridership is expected to decline given that the willingness of passengers to travel by the metro depends on the value they place on time savings, frequency and safety of service, comfort and ease of travel, capacity to pay, etc.

4.8 DELHI BRTS SYSTEM

BRT means giving right of way to buses and safeguarding cyclists and pedestrians by encouraging lane driving on engineered road spaces along large and wide corridors and link them to metros and other colony roads for easy access. Besides giving priority to buses, the system also provides dedicated lanes for pedestrian and Non-motorized vehicles like cycles and rickshaws etc.

4.8.1 Introduction

The corner stone for the introduction of BRT system in Delhi was put up in 1995, when Central Pollution Control Board commissioned a Study for reducing vehicular pollution in Delhi. The final report, with a recommendation to introduce segregated bicycle lanes and bus lanes, was submitted in 1997. An international workshop was organized by the Delhi Transport Corporation in collaboration with SIAM, IDFC and IIT Delhi on High Capacity Bus System in January 2002. This was the first major step in the conceptualization of the BRT System for Delhi.

In 2004, GNCTD appointed RITES and Indian Institute of Technology Delhi (IIT Delhi) for designing and implementing the first corridor from Dr. Ambedkar Nagar to Delhi Gate. RITES were appointed the Project Management Consultant and TRIPP IIT, Delhi the technical and conceptual advisor. In 2006, GNTCD established Delhi Integrated Multi-Modal Transit System (DIMTS), a Special Purpose Vehicle to oversee the establishment of public transport systems in Delhi. DIMTS is currently entrusted with the operation and maintenance of the existing corridor as the Corridor Manager.

In October 2006, the construction work on the corridor started. The stretch from Dr. Ambedkar Nagar to Moolchand has been under trial run since April 20, 2008.

4.8.2 Technical Details

The first corridor of BRT in Delhi, from Ambedkar Nagar to Delhi Gate, is 14.5 km long with ROW varying from 28 meters to 51.5 meters. Bus Lane is in the middle of Road with a width of 3.3 meters. Motorized vehicle lane is on the side of bus lane with a width of 6.75 meters. Separate tracks are made for non-motorized vehicles and pedestrians.

4.8.3 Traffic Volume

Traffic volume on the BRT corridor is very high. The corridor is situated along some of the prime colonies in South Delhi and is the main connecting road to the large commercial development in Gurgaon. On the stretch from Dr. Ambedkar Nagar to Moolchand, there are 6 key intersections, of which Chirag Delhi and Moolchand are the busiest ones. According to a DIMTS Survey, Chirag Delhi is one of the busiest junctions in Delhi.

More than 1.35 lakhs vehicles cross the junction in a day (16 hours). Motorised vehicles consisting of cars, two wheelers and auto rickshaws constitute more than 90% of vehicle traffic, of which number of car/Jeep constitute around 35-40% of total motorized vehicles. These, however, carry only 15-20% of the total commuters. On the other hand, buses account only for 2.0-2.5% of total vehicles, but carry around 55-60% of the total commuters, thus using road space more democratically. Approximately 200-250 buses move on Chirag Delhi Junction (the busiest section) during peak hour, catering to passenger load of about 11,000 - 12,000 on an average day. It has been observed that net throughput of all kinds of vehicles have significantly improved after the implementation of the BRT and the Bus and cycle transit time through the corridor has reduced.

4.8.4 Socio Economic Profile of the commuters

According to a DIMTS commissioned socio-economic survey at the BRT Corridor, it was observed that more than 60% of commuters use BRT Corridor mainly for

work. Most of the respondents showed their discontent with the existing public transportation system. Respondents preferred to use their private vehicles due to inflexibility and unreliability of the bus system.

Regarding perceptions about a good bus system, more than 50% of respondents suggested 'timeliness of bus service', 'clean bus and well behaved staff' and 'certainty of bus service'. The research agency also enquired about the willingness of respondents to use BRT System.

Interestingly, 85% of respondents, who are currently not using public transport system, showed their willingness to use new BRT system if it is good.

The study clearly predicts that commuters are willing to shift to public transport system, if the service delivery is improved and responds to their requirements and expectations.

4.8.5 Problem with the current system

During the trial run, several technical and operational difficulties such as malfunctioning signaling systems, undisciplined private vehicular traffic, jaywalking pedestrians etc. emerged. Corridor Manager also appointed one external consultant to provide guidance in the area of intelligent signaling system in August 2008 and is in the process of improving the signaling system in accordance with their advice. The current issues and challenges in the context of BRT operation are as follows:

a) Design Issues

Delhi BRT System allocates space on an equitable basis for all types of vehicles like motorized vehicles, non-motorized vehicles and buses. However, the introduction of the pilot project led to significant traffic problems, i.e. mainly congestion and queuing at the junctions in motorized vehicle lane. It has been observed that in the peak hours there are some delays and congestion at some locations that are most notable at Chirag Delhi. However, the problem does extend to other junctions as well to some extent.

The junction's holding capacity is less when compared to number of vehicles on the corridor. Moreover, the presence of large population of two-wheelers owners further complicates the situation at all junctions. Due to heavy traffic flow, certain features need modification in road curvature, islands at lane exits and bus platform features.

b) Bus Operation

i. **Low Frequency:** DTC buses are plying on four key routes, covering the BRT Corridor. Corridor Manager is compiling bus operation data on a daily basis. It has been observed that the frequency of buses is almost half in the evening. The company has made repeated request to DTC to introduce more buses on these routes, as buses are very crowded in the evening.

ii. **Untrained Drivers**: The bus operation is very inefficient. Corridor Manager has trained more than 200 DTC drivers to drive buses with a view to ensure the greater discipline in Bus Lane. However, in DTC, buses, route numbers are not matched with Drivers on a stable basis, i.e. drivers are frequently changed on different routes. As a result, it has been observed that very often many un-trained drivers are driving buses in the corridor.

iii. **Slow Speed:** Currently, all types of buses are allowed to use the Bus lane, including many deteriorated buses and RTVs, which cause frequent breakdowns. Only newer buses meeting quality and maintenance standards should be allowed. It is also found that blue line buses sometimes linger at the bus stops. As a result, sometimes passengers board and alight before the bus platform.

Table 4.14: Comparison of Bus Speed and Ridership of Delhi and Foreign BRTS

Line	Speed KPH	Ridership (passengers / hour / direction)
Bogotá TransMilenio	29	42,000
São Paulo 9 de julho	12	34,910
Porto Alegre Assis Brasil	18	28,000
Belo Horizonte Cristiano Machado	15	21.100
Delhi	13	12,000
Curitiba Eixo Sul	21	10,640
Mexico City Metrobus	21	8500
Quito EcoVia	18	10,200
TransJakarta	18	4500
Beijing	15	7500

Source: "Bus Rapid Transit: How Delhi Compares", Walter Hook, ITDP

iv. Traffic Signals

Current traffic signals fail to discharge the traffic at peak hour, as traffic flow is not stable and creates a long queue of cars in motorized vehicle lane as well as the bus Lane. Currently, static traffic signal system is installed at BRT corridor, and on many times it is restored to manual operations of the signals. However, the manual control of signals is incompatible with efficient operations. Manual control tends to operate one phase at a time which is inefficient.

Manual and automatic systems have conflicting/dangerous signal phases, thus, switching system from automatic to manual and vice-versa can be dangerous. Sometime, long cycle time, i.e. more than 240 seconds cycle and unsaturated phases add to inefficient operation. There is a need to install "Intelligent Transport Signaling System" to automate the whole process.

c) Supporting Infrastructure

BRT system cannot be developed in isolation. The agency needs to develop the supporting infrastructure to make BRT successful and popular. There is need to develop the supporting infrastructure like:

i. **Parking facility**: There should be a parking facility at key intersections or interchange points. The parking facility will enable the commuters to park their private vehicles and board bus to reach their destination. The parking facility has subsequently been built upto ease some of the congestion.

ii. **Foot over Bridges (FOB) / Subway**: Most of the people raised question about the pedestrian crossing facility. Experts have observed that at grade pedestrian crossing on BRT Corridor is fine and normal. Moreover, pedestrian facilities at BRT Corridor have set a new high standard for BRT, with tactile tiles facility for visibly-disabled. However, current corridor lies in a high density area, dividing a community. Thus, there is need to build FOBs or subways at certain points to facilitate the crossing. Currently, jaywalking is emerged as the most critical issue for the Corridor Manager. Since April 2008, five fatal road accidents have occurred at the corridor.

One of the key requirements of a successful BRT System is lane discipline among the commuters. Lane discipline on BRT requires users to drive in their respective lane only. Damage to structures by errant drivers is also a problem area. Corridor Manager is compiling the daily list of vehicles entering the Bus lane. Further, a large number of vehicles, mainly scooters and motor cycles are entering into the cycle and pedestrian lane.

Corridor Manager is not authorized to penalize the vehicles violated the traffic laws and lane discipline. The enforcement power is still vested with STA (state transport authority) and Delhi Traffic Police. Both the agency are already grappling with the shortage of manpower, thus enforcement mechanism is very weak.

d) Damage to structures

BRT infrastructure mainly BQS, railing, barriers, traffic signal poles, street lights etc. are prone to accident. A large number of accidents were reported in last five months, resulting in damage to property by errant drivers. In the absence of any stringent laws, the cost of rebuilding or reinstalling the street furniture needs to be borne by GNCTD and the operating agency and expenses on this account keep mounting.

4.8.6 Lesson Learnt

The current BRT stretch is labeled as Pilot-A project where the buses are playing in the middle of the road. The government has decided to put buses back on the left lane on the remaining stretch from Moolchand to Delhi Gate and would be labeled as Pilot-B. Both the system (Pilot-A and Pilot-B) will be mutually compared to decide the suitable model for Delhi roads. Thus, the central or side lane is the real controversy behind Delhi BRT System. There are many lessons that need to be learnt from the existing BRT Corridor. These lessons will not help to improve the future corridors but will also increase its acceptability among different stakeholders – public, media, commuters etc.

The agency involved in building the future BRT System needs to look after the following key issues:

1. BRT Regulation Act

Before introducing the next BRT corridor, the agency should enact a special regulation Act. The act may help to address some key issues like traffic violation, property damage, jaywalking etc. In the absence of any regulation, coordination among different agency becomes difficult. Regulation can infer enforcement power to the operating agency on the BRT Corridor, enabling them to ensure strict lane discipline. Secondly, any vehicle causing damage to the road inventory can be easily penalized under the act. Most of the other countries have enacted a separate BRT Regulation Act for smooth functioning of the corridor.

2. Park and Ride Facility

There should be a complete plan for 'park and ride facility', ensuring parking facility at key interchange points. Parking facility can compensate the feeder services, enabling people to use their private vehicles till the corridor.

There is also a need to design a BRT friendly 'Parking policy'. Currently, the existing BRT corridor is declared as no parking zone barring private vehicle owners to park their vehicles along the corridor. This gives rise to a need to make provision for parking at certain places near the market, business unit etc. abutting the corridor. Thus, the operating agency needs to make provision for parking facility and integrate the same with the BRT corridor.

3. Bus Operation

BRT is the Bus Rapid Transit system, i.e. one cannot think about BRT corridor without an effective bus operation. In a highly populated city like Delhi, Bus system and BRT system cannot be work in isolation. Thus, high bus frequencies, route rationalization, introduction of comfortable buses etc. are the pre-requisite for any BRT System. Building appropriate infrastructure is only as important as bringing in the correct operating norms. Both are overlapping activities and not sequential.

The existing BRT Corridor is facing these challenges. On one hand, the system is promoting the use of buses, whereas on the other hand, there are less number of buses on the corridor during the evening. Bluelines buses were removed from the corridor due to their indiscipline whereas DTC is dealing with the issue of shortage of drivers.

4. Junction Capacity and intelligent traffic signals

BRT corridor throughput is as good as its junction capacity. It is therefore important that the junction capacity is higher and slip roads are created to facilitate the left-turning traffic. Slip roads will help to reduce the junction load. It is not possible to make motorized vehicle lane completely free for all the turning movement as across the world, BRT system aims to give free way to buses and not motorized vehicles. In Delhi, with limited right of way (ROW) available on the road, it is not possible to provide completely free movement in the motorized vehicle lane.

The agency needs to focus on easy free movement rather than complete free movement. The agency should install an intelligent traffic signaling system with vehicle tracking facility. On the existing BRT corridor, it has been observed that there is no set traffic pattern and traffic movement is very unpredictable. The static system of traffic light, therefore, cannot sense the change in traffic pattern resulting in slow throughput and unutilized green time. An intelligent traffic system will not only synchronize the traffic signals on the corridor, but also on connecting routes to the corridor.

5. Restrict left or right movement of the traffic

BRT system aims to give priority to buses. A successful BRT system requires some special measures like restricting the right movement of the traffic on junctions. The Trans Milenio, which is known as the world's best bus rapid transit system, restricts the left turns (right turn in Indian context) movement for other vehicles on the BRT Corridor.

The existing BRT Corridor aims to accommodate and fulfill the requirement of every type of commuters. Delhi BRT system is working with maximum number of signal phase for both three and four arm junction. For example, there are six signal phase at Chirag Delhi Junction (i.e. separate phase for each arm along with bus lane). According to ITDP guidelines, there should not be more than four signal phase in the BRT corridor.

The agency therefore needs to prepare a plan to reduce the number of signal phases in the future corridors, by restricting the left or right movement of the traffic for the future corridor.

6. Connecting FOBs and Subways with BQS

The agency needs to look for the possibility to connect FOBs or Subways directly with the BQS, thus causing little disturbance to the moving traffic in other lanes. Pedestrians movement to or from BQS is the heart of the middle or side bus lane controversy. The agency needs to preplan for additional FOBs and Subways along the corridor to meet current as well as future demand.

The success of the BRT System mainly depends on the willingness to introduce the system, as well as, managing the behavioral changes including the commuting patterns.

4.9 INTRODUCTION TO CASE STUDY AREA

4.9.1 Zone K (Part) Dwarka Sub-City

In the Master Plan for Delhi perspective – 2001, the Union Territory of Delhi has been divided in to 15 zones (Divisions), 8 in Urban Delhi ('A' to 'H'), 6 in Urban Extension/Rural Areas ('J' to 'N') and 1 comprising of River Yamuna & River Front Area ('O').

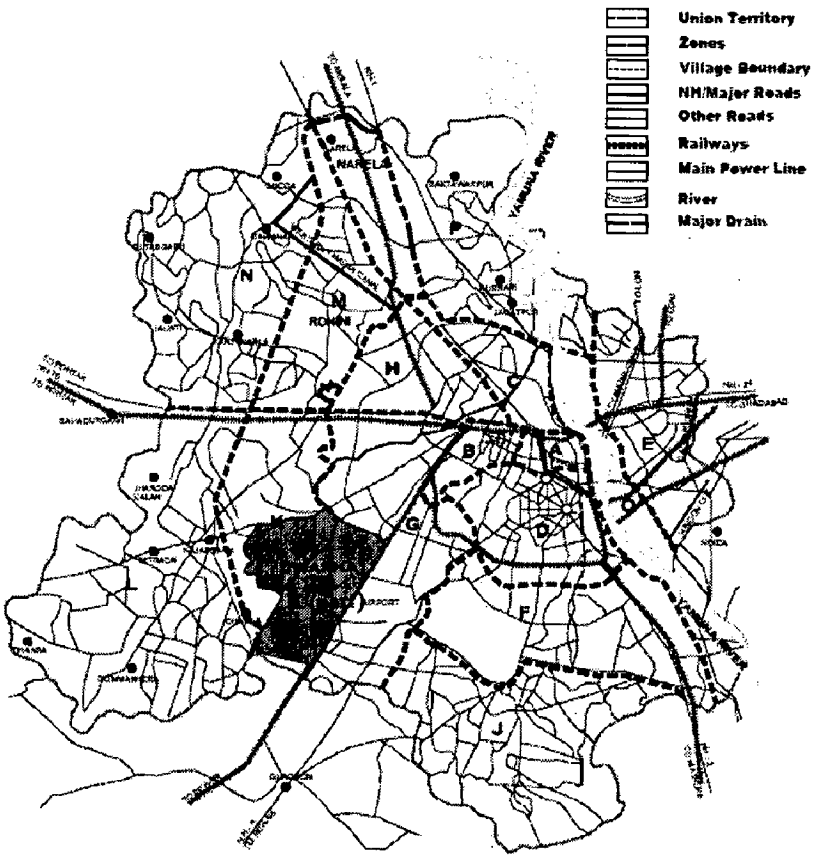
Dwarka sub-city forms part of zone-K and forms part of the urban extension plan approved by the Authority vide Agenda no.79 dt. 30.06.1987 as part of Master Plan of Delhi 2001. The urban extension plan was prepared to accommodate the projected population and was conceived to be developed in four phases Dwarka sub-city forms part of Phase 1A of the Urban extension plan.

4.9.2 Location, Boundaries and Area

The Dwarka Sub-city is situated in the south-west of Delhi and forms part Zone K having an area of 12056 ha. It is bounded by Najafgarh Road on the north-west, Pankha Road on the north-east, the Rewari Railway line on the south-west and the Najafgarh drain on the west.

The total area of the sub-city is 5648 Ha. This is bisected by the underground Mathura-Jullandhar oil pipeline into Phase I on the North-East and Phase II on the South-west. Area under Phase I is 3652 Ha while under phase II, it is 1996 Ha.

Map 33: Location Map of Zone K, Delhi



Location Plan of Zone –K Part (Dwarka)

Source: Zonal Plan Dwarka, Delhi

4.9.3 Population, Area, Employment and Work Force

Population — 10 lakhs

Total area — 5648 ha.

Area (Phase — I) — 1964 ha.

Area (Phase — II) — 1996 ha.

Existing built up — 1688 ha.

As per MPD-2001 the urban extension areas are proposed to be planned with an overall gross density ranging from 160 to 200 persons per Ha. And based on the area

under consideration the proposed population computes to 1.07 million including that of the existing settlements.

MPD-2001 has anticipated a participation rate of 32% and thereby the work-force in this zone works out to about 0.348 millions.

4.9.4 Plan Provisions

Following are the provisions as per MPD-2001. "To accommodate the balance 3-4 million population population, the DUA 81 which could systematically hold 82 lacs population approximately need to be extended by about 18,000 to 24,000 Ha. Over the next two decades to effectively respond to the growth of the capital land required for various developments in the extended time frame by the year 2001 may be acquired from time to time with due regards to the balance development of the city. In the plan 4,000 Ha. (approx.) have been added to DUA-81 urban limits, thus the balance requirement would be of order of about 14,000 to 20,000 Ha.

The land in the Urban Extension (UE) would approximately be distributed under different land uses in the following manner:

Table 4.15: Proposed Land Use for Urban Extension Plan Delhi

LAND USE	% AGE OF LAND
Residential	45-55
Commercial	3-4
Industrial	6-7
Recreational	15-20
Public & Semi Public Facilities	8-10
Circulation	10-12

Source: MPD 2001

Urban Extension Plan Provisions

The DDA approved the urban extension plan which proposed the phasing of the plan based on the population projections given below:

Table 4.16: Phasing of the Urban Extension Plan Delhi

Population Projection by	Population Urban 2001 (in million)	Population accommodation in DUA 81 (in million)	Balance (in million)	Land Need (Ha.)
NCR	11.0	8.2	8.2	18,000
DDA	12.2	8.2	4.0	24,000
As per existing trends	14.4	8.2	6.2	35,000

Source: MPD 2001

4.10 EXISTING PROFILE OF STUDY AREA

4.10.1 Characteristics

Following are the salient features/characteristics within the sub-city area.

1) Dwarka sub-city, located in South-West Delhi is in the vicinity of Janakpuri/Vikaspuri and is about 16kms from Connaught Place.
2) Indira Gandhi International Airport is also close to the sub-city
3) An area measuring about 1688 Ha. Located along Pankha road and Najafgarh Road is heavily built upon with unauthorized colonies.
4) Some of the unauthorized colonies stand regularized under the policy of regularization of unauthorized colonies of 1977 and its subsequent amendments.
5) The area under Dwarka Scheme comprises of revenue estates of more than 20 villages, out of which, village Abadi of 15 villages fall within the sub-city area.
6) Palam Drain running North East to South West almost bisects the sub-city and is a major carrier of sewage and storm water of this area to Najafgarh drain
7) I.O.C. pipeline is also passing through the sub-city & has been identified for dividing the subcity into two phases i.e. Phase I and Phase II.

4.10.2 Existing Development

Following are the major existing developments:

a) Phase I of the sub-city covering an area of about 1964 Ha. (Excluding built up area) is planned and is in the process of development.

b) The built up area of about 1688 (Ha.) is devoid of any physical and social infrastructure worth name.

c) A number of farm houses have come up on Bijwasan Road.

4.11 ZONAL LEVEL PLAN

In consistence with MPD – 2001 frame work the provision and proposal of the Master Plan have been detailed out particularly with reference to various use zone, circulation public and semi-public facilities, infrastructure and recreational etc.

The plan takes care of the need of allocating 2% of the total land (113.0 Ha) for 'Service Industry' as per the DDA resolution. This use has been considered within the land use category of 'commercial' as mentioned in the DDA resolution. Accordingly the land use break up for Phase I and Phase II is given as under.

Table 4.17: Land Use Break up of Dwarka Zonal Plan Phase – 1

S.No.	Use	Area (in Ha.)	Percentage
1.	Residential	2144.87	58.75
2.	Commercial	156.81	4.29
	a) Commercial (111.81Ha.)		
	b) Service Centre (45.00 Ha.)		
3.	Govt. Use	62.51	1.71
4.	Public & Semi Public	265.71	7.27
5.	Utility	43.68	1.20
6.	Recreational	481.10	13.17
7.	Transportation	497.32	13.61
	Total	3652.00	100.00

Source: Zonal Plan Dwarka, Delhi

Table 4.18: Land Use Break up of Dwarka Zonal Plan Phase-II

S.No.	USE	AREA in (Ha.)	PERCENTAGE
1.	Residential	765.12	38.33
2.	Commercial	196.07	9.82
	a) Commercial(128.07 Ha.)		
	b) Service Centre (68.00 Ha.)		
3.	Govt. Use	3.16	0.16
4.	Public & Semi Public	102.61	5.14
5.	Utility	95.08	4.80
6.	Recreational	533.08	26.71
7.	Transportation	300.15	15.04
	Total	1996.00	100.00

Source: Zonal Plan Dwarka, Delhi

4.11.1 Land Use Plan Dwarka Sub-City

Table 4.19: Land Use Break up of Dwarka Sub-City

S.No.	Use	Area (in Ha.)	Percentage
1.	Residential	2909.99	51.52
2.	Commercial	352.88	6.24
	a) Commercial (239.88 Ha.)		
	b) Service Centre (133.00 Ha.)		
3.	Govt. Use	65.67	1.16
4.	Public & Semi Public	368.32	6.52
5.	Utility	138.76	2.45
6.	Recreational	1041.18	17.95
7.	Transportation	797.47	14.11
	Total	5648.00	100.00

Source: Zonal Plan Dwarka, Delhi

1. Residential

Out of total area of about 2909 Ha. In Phase-I. 1228 Ha. is already built up and the balance area of about 916.97 Ha. is in the process of development primarily for allotment to Co-operative Group Housing Societies. DDA Group Housing Schemes, EWS and Janta Housing Scheme squatter resettlements and Institutional Housing.

The residential area in Phase-II may also accommodate second diplomatic enclave besides allotment of land to resettlement squatters, Co-operative Group Housing Societies and DDA housing.

2. Residential Sector

Concepts

Each of the residential sectors has been envisaged to be self contained communities and has been designed for a population of about 30,000 each.

Area of each sector is about 81 ha. (900 m x 900 m)

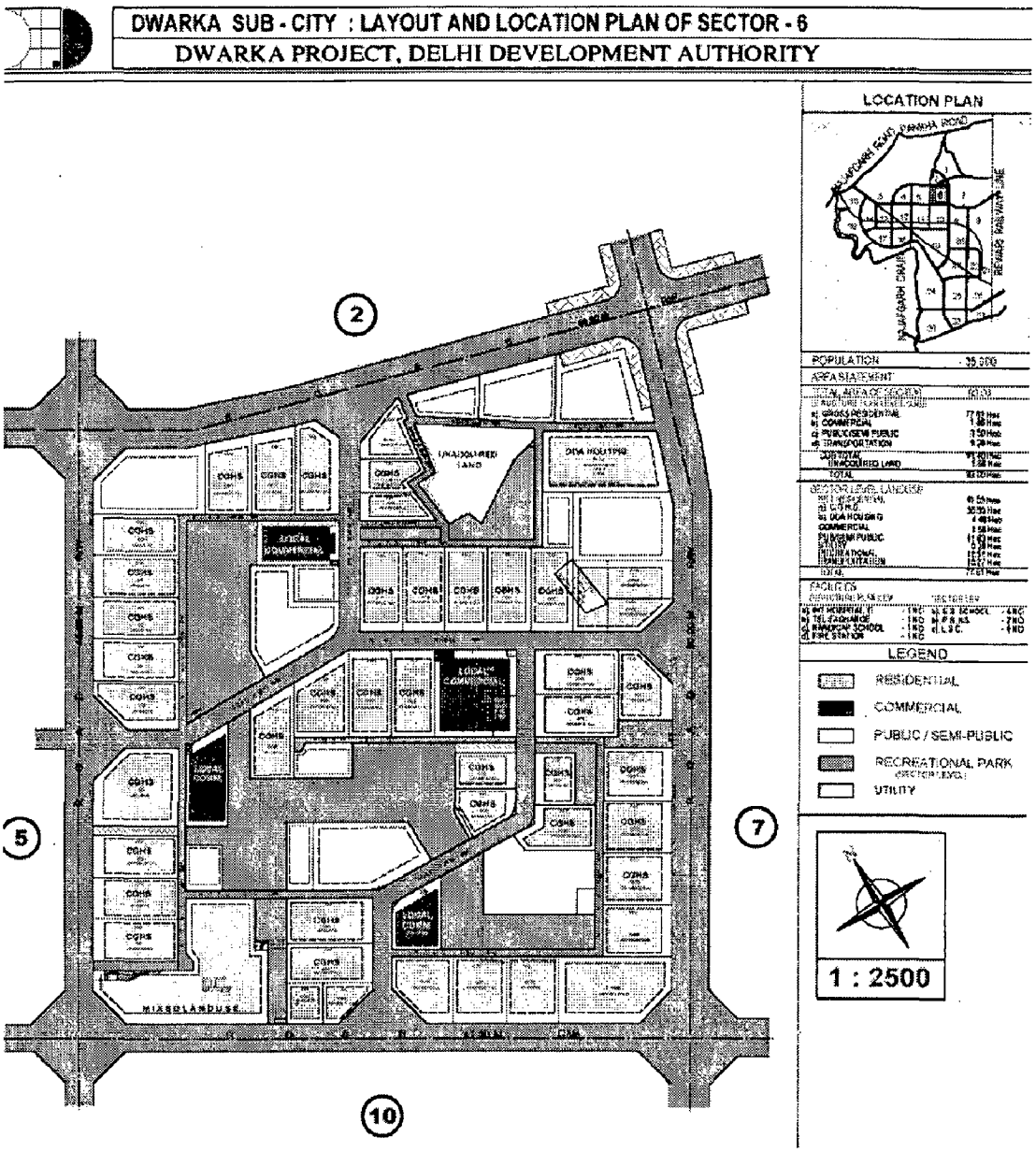
Each sector is bounded on all sides by arterial roads of 45 m and 60 m.wide

From arterial roads only 4 entries have been taken into the sector at a minimum dis-tance of 450 m.

A network of cycle tracks and pedestrian pathways has been proposed within each sector which link the housing clusters and their facilities within each sector.

All sectors are proposed to have a mix of housing of various socio-economic groups.

Map 34: Layout Plan of a Sector in Dwarka



3. Housing

The sub-city provides housing for about 2 lakhs families.

Co-operative Group housing forms a major component of housing type in Dwarka.

Special consideration has been given to the economically weaker sections of the soci-ety.

A number of EWS, LIG and Resettlement housing schemes have been developed.

4. Commercial

The commercial areas are planned in hierarchy as envisaged in MPD-2001, while the District Centre is conceived as a linear development along MRTS in 16 pockets of sizes varying from 1 Ha. To 11 Ha. totaling about 56.0 Ha. In addition 11 numbers of community Centres are proposed to be provided. 3 service centers area are also provided in the plan. Keeping in view of the recommendations of MPD-2001, one site for integrated Freight Complex has been proposed.

About 22 nos of Petrol Pumps and 27 No. of LPG Godown sites are required to be provided in the sub city. The petrol pump filling stations will be provided in all the Community Centre and District Centre apart from the major roads. The gas godowns will be located in service centres. Exact location of Petrol Pumps and LPG godown sites will be worked out at the time of detailed planning.

5. Social Infrastructure

The sub-city has been planned for an environment of convenience which contains essential facilities and services at different levels namely health, education, safety and security, cultural, and communication etc.

6. Recreational

The recreational area constitutes about 18% of the total sub-city area. The recreational area is provided in the form of district park (along with banks of the drain and adjacent to low lying area) and sports complex.

It is proposed to consider the development of an amusement park as a part of the development of subcity recreational area.

7. Landscape

The Landscape concept of Dwarka evolves a system of open spaces which have the potential to develop into a landscape with distinctive visual qualities, fulfilling the required ecological and recreational functions.

The location and alignment of existing landscape features have been used to structure the development. Advantage has been taken of topographic assets such as the natural drainage as well as major city level open spaces along these corridors, integrating existing land-scape and new development. Essentially the proposed landscape comprises of the following interlinked but hierarch-ical distinct components. The informal naturalistic component along Najafgarh drain, serving a regional recreation function. The more formal and organized component serving as a local space system on the East-west drainage corridors. About 20% of Dwarka project area has been planned for development as green area.

8. Transportation

Dwarka sub-city requires a highly efficient mass transportation system for enhancement of intercity and intracity movement. Therefore, a multimode transport system has been envisaged which consists of a hierarchy of road network supported with railway corridor.

Metro based system will be the major mover of the people within core area. 9 Metro stations has been planned in the Dwarka sub-city. 7 Metro stations shall be commenced by the end of March,06. Bus based public transport system will also be the primary mode of transportation of the people in Dwarka. The basic road network has been planned both to supplement and compliment the metro based system. Cycle tracks and pedestrian pathways passing through green areas have been proposed.

The hierarchy of road system adopted in Dwarka sub-city is as under.

1) Express way -100 mts R/w.
2) Primary roads -60 mts R/w
3) Primary Collector-45 mts R/w
4) Secondary Collector – 30 mts
5) Local Streets -20 mts and 12 mts.
6) Cycle track-12 mts.

A total area of 797.47 Ha.(14.11%) is proposed to be under transportation use.

9. Accessibility

Dwarka sub-city have one of the best accessibility options with the mother city. These include both rail based and road based accessibility.

The sub city is connected by metro rail with the city center and other major parts of the city by MRTS. The work on connection with Connaught Place / ITO under progress. The sub city is connected to the mother city 4 major roads from all directions. Northern Approach — A 45 m wide road connecting Pankha road partly by covering Palam drain — work under progress. Western Approach — A 60 m wide road connecting Najafgarh road — road already constructed. Eastern Approach — A 45 m wide road through Cantonment area with a fly-over near Palam. South Eastern Approach– A 60 m wide road from NH-8 (with a rail underpass) — work under progress.

10. Government

Three exclusive locations for Govt. use have been earmarked in Dwarka Sub-city. The district courts will come up in one of the sites. The area earmarked for Government use measures about 65.70 Ha which constitutes 1.16% of the total area.

11. Public & Semi Public

Total area of about 368 Ha which constitutes 6.52% of the total area of sub-city is assigned for public and semi public facilities and will cater for major facilities like University, Delhi institute of Technology, besides the facilities to be provided at neighborhood level/layout plan level.

In the zonal Development Plan, the major facilities of the level of Division (10, 00,000 population), District (5,00,000 population) and community (1,00,000 population) have been shown as listed at Annexure-I. The requirements of facilities of the level of Neighborhood (15,000 population) and Housing Area (5,000 population) based on MPD-2001 norms had earlier been worked out during preparation of sector plans and the provisions for the same were made in the approved sector plans.

4.11.2 Modification

Area bounded Najafgarh Road on North-West, Pankha Road and Janakpuri Scheme on North, Rewari Railway Line on East and Oil-Pipe Line on the South-West, is changed from agricultural and rural use zone' to:-

Table 4.20: Change of Land use in Dwarka – Modification 1

S.No.	Land Use	Total Area in ha.
1.	Residential	2144.87
2.	Commercial	156.81
3.	Govt. Use	62.51
4.	Public/Semi public	265.71
5.	Public Utility	43.68
6.	Recreational	481.10
7.	Transportation	497.32
	Total	3652.00 ha

Source: Zonal Plan Dwarka, Delhi

Area bounded by Oil Pipe Line in the North-East, Rewari Railway Line in the South-East, Bijiwasan Road in the South, Najafgarh Drain in the West and Najafgarh Road in the North, is changed from 'rural use zone' to other landuses in Dwarka Scheme, Phase-II Delhi as per the areas given below:

Table 4.20: Change of Land use in Dwarka – Modification 2

S.No.	Land Use	Area (Hectares)
1.	Residential	765.12
2.	Commercial	196.07
3.	Government Use	3.16
4.	Public and semi public facilities	102.61
5.	Public Utility	95.08
6.	Recreational	533.08
7.	Transportation	300.00
	Total	1996.00

Source: Zonal Plan Dwarka, Delhi

4.12 METRO STATIONS FOR THE STUDY AREA

Dwarka Sector 10

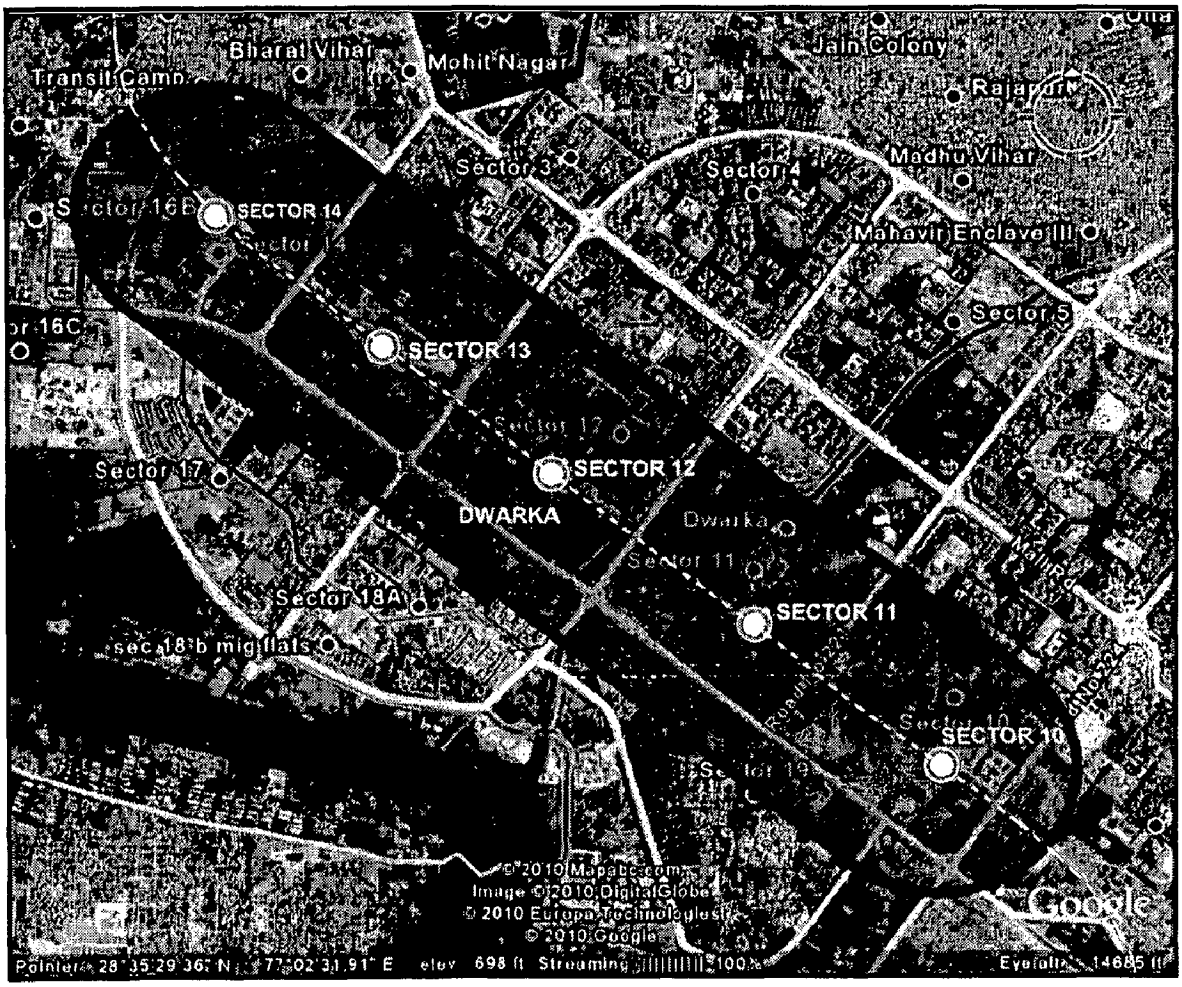
Dwarka Sector 11

Dwarka Sector 12

Dwarka Sector 13

Dwarka Sector 14

Figure 4.5: Satellite image showing the area delineated for study in Dwarka, Delhi

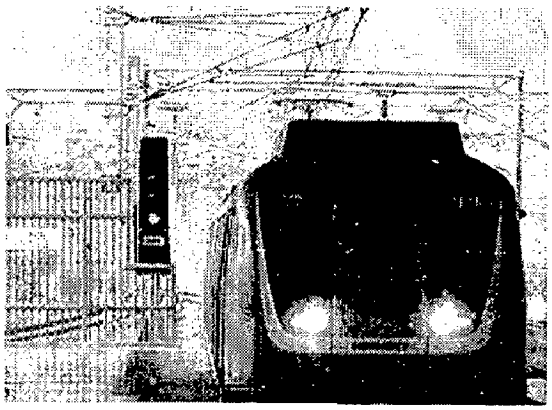


4.13 BLUE LINE (DELHI METRO)

The Blue Line of the Delhi Metro system in Delhi consists of 47 metro stations from Dwarka Sector 9 to Noida City Centre (Sector 32) and Anand Vihar, with a total distance of 53.6 km.

Figure 4.6: Dwarka Sector 9 metro Station

Figure 4.7: Metro Rail at Station



Route	Noida City Centre – Dwarka Sector 9
Number of stations	47
Length	53.6 km
First opened	December 31, 2005
Rolling stock	43 Trains

1) Operations

Trains operate at intervals of 3 to 4.5 minutes between 6:00 to 23:00. Trains operating within the network typically travel at speeds below 80 km/h (50 mph), and stop about 20 seconds at each station. Automated station announcements are recorded in Hindi and English. Many stations have services such as ATMs, food outlets, cafés and convenience stores. Eating, drinking, smoking, and chewing of gum are prohibited in the entire system. Navigation information on is available on Google Transit.

2) Ticketing

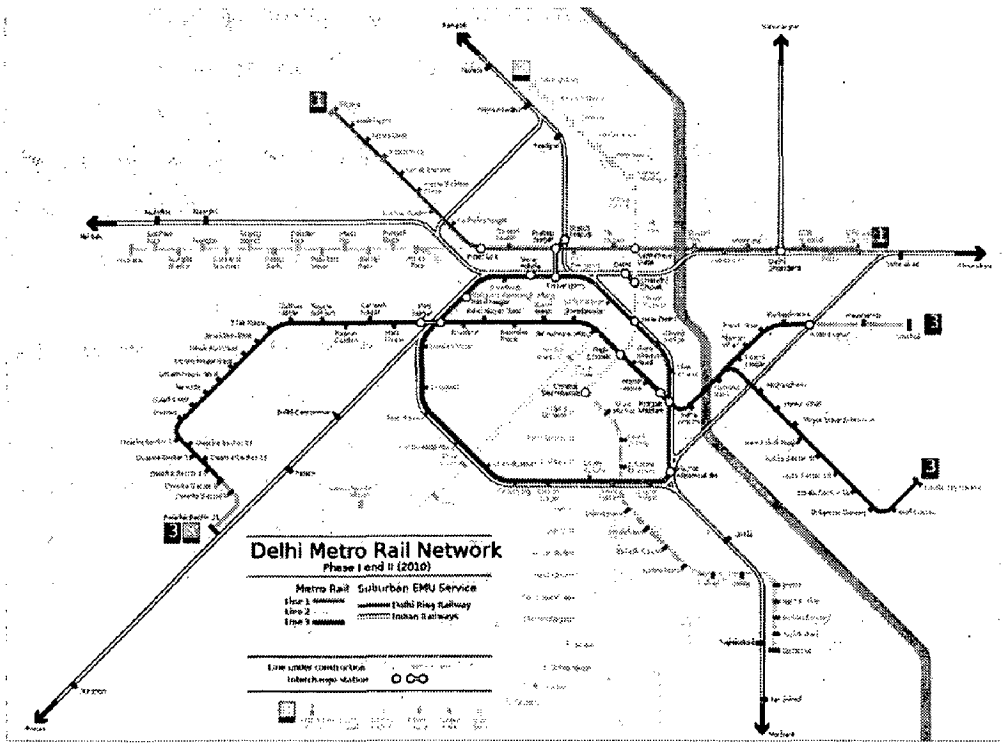
Delhi Metro commuters have three choices for ticket purchase.

RFID tokens are valid only for a single journey on the day of purchase and the value depends on the distance travelled, with fares for a single journey ranging from Rs. 8 (US$ 0.18) to Rs. 30 (US$ 0.67). Fares are calculated based on the origin and destination stations using a fare chart.

Travel cards, which are most convenient for frequent commuters, are valid for one year from the date of purchase or the date of last recharge (whichever is later), and are available in denominations of Rs. 50 (US$ 1.12) to Rs. 800 (US$ 17.84).

Tourist cards can be used for unlimited travel on the Delhi Metro network over short periods of time. There are two kinds of tourist cards — with validities of one and three days respectively. The cost of a 1-day card is Rs. 70 (US$ 1.56) and that of a 3-day card is Rs. 200 (US$ 4.46).

Map 35: Delhi metro rail network showing the Blue Line



Source: http://delhimetrorail.com/commuters/route_map.html

Table 4.21: Overview of Blue Line of the Delhi Metro system

Overview	
Type	Rapid transit
System	Delhi Metro
Termini	Noida City Centre Dwarka Sector 9
Stations	47
Operation	
Opened	December 31, 2005
Operator(s)	Delhi Metro Rail Corporation
Character	At-grade, underground, and elevated
Technical	
Line length	53.6 km
Track gauge	Broad gauge
Electrification	25 kV, 50 Hz AC through overhead catenary

Source: www.wikipedia.com

CHAPTER 5

ANALYSIS

5.1 Introduction

This chapter analyses the primary and secondary data collected by means of case studies, literature reviews and primary surveys. An analysis of the overall development and transportation scenario of Delhi has been presented. Thereafter an analyses of the case study area has been done. Lastly the analysis of the primary survey data has been given.

5.2 TRAFFIC CHARACTERISTICS IN DELHI

5.2.1 Per Capita Trip Rate.

As per the household survey conducted by RITES in Delhi in the year 2001, a total of 176 lakh trips were estimated. The per capita trip rate in the study area has been estimated at 1.27 (PCTR of 1.1 in 1993-94). The per capita trip rate for vehicular trips was observed as 0.87 against a PCTR of 0.76 in 1993-94. Also the study conducted in the year 1993-94 projected the PCTR for vehicular trips to be 1.1 in the year 2001. Thus the actual realization of vehicular trips was not as high as expected.

5.2.2 Modal split

The transport network is based on the modal split for Delhi to move 280 lakh trips by the year 2021 as given below:

Table 5.1: Modal Split of Delhi

Mode	Modal Split (in percent)			
	1969	1981	1986	1994
Bus	41	62	62	62.0
Car	59	38	38	6.9
Two-wheeler				17.6
Bicycle				6.6
Cycle rickshaw				3.5
Others				3.4

Source: Singal 2000.

a) Present Scenario

As per Modal Split (2001) among the vehicular trips, maximum 60% trips are being performed by buses, which include chartered and school buses. The personalized modes of transport are carrying about 35.9% of vehicular trips.

The modal split projected for the years 2011 and 2021 is as follows:

b) Modal Split Projections

Mode Modal Split (%)	2011	2021
Public Transport (including Rail/ Light Rail/ MRTS/ IRBT/ Bus/ Tram)	70.25	80.0
Personal modes (including Personal Fast Modes / Hired Fast Modes/ Hired Slow Modes/ Bicycle)	29.75	20.0

5.2.3 Intercity passenger movement

In 2001, on a normal weekday 56.46% of the commuters visited Delhi by Road, 42.67% by Rail and 0.87% by Air.

Table 5.2: Passenger Trips at Outer Cordons per Day, Delhi

Medium	Total Passengers	Commuters
Road	**15.98 lakh (57.46%)**	**9.59 lakh**
Rail	**12.08 lakh (42.67%)**	**9.06 lakh**
Air	**0.22 lakh (0.87%)**	**N.A.**

Source: Bose and Srinivasachary (1997)

Table 5.3: Fare structures of public bus service and Delhi metro

Bus			*MRTS*
4 kms	Rs 2	Minimum	Rs 6
20 kms	Rs 10	Maximum	Rs 22
30 kms	Rs 10		

Source: RITES Primary Survey Report

Table 5.4: Mode characteristics in Delhi

Vehicle Type	Occupancy	Fuel Efficiency (Km/lit.)	Vehicle Utilization (Km/Year)	Speed (Km/hr)
Car	2.6	10.9	9500	25
Two Wheeler	1.6	44.4	9000	30
Three Wheeler	1.8	20	25000	-
Bus	52	4.3	70000	20

Source: Bose and Srinivasachary (1997)

Table 5.5: Modal Share of Passenger Trips (Percentage)

S. No.	Mode	Passenger Trips (in % age)
		2001
1.	Bus	59.8
2.	Car/ Jeep	10.3
3.	Two-Wheeler	17.2
4.	Auto-Rickshaw	3.1
5.	Cycle	5.3
6.	Train	0.7
7.	Other	3.6

Source: RITES Primary Survey Report

5.2.4 Trip Purpose

The distribution of trips by purpose in the study area is presented in the table given bellow. Out of the total trips, work accounts for about 25%, education about 22% and others account for about 4% of the trips. Among the work trips, about 87% are vehicular trips and 13% are walk trips while this distribution is 42% and 58% for education trips and 94% and 6% for other purpose trips respectively.

Table 5.6: Table: Purpose wise Distribution of Trips, 2001

Purpose	No. of Trips/day (in Lakh)	Percentage
Service	**33**	**18.8**
Business	**11.4**	**6.5**
Education	**39**	**22.2**
Others	**6.7**	**3.8**
Return Home	**85.4**	**48.7**
Total	**175.5**	**100.0**

Source: RITES Primary Survey Report

Table 5.7: Percentage Distribution of Trips by Mode and Travel Time

Mode	Travel Time (in minutes)					
	<15	15-30	30-60	60-90	>90	Average
Sc/Ms	18.9	44.72	31.05	4.84	0.40	27
Car	17.4	42.75	34.07	4.96	0.74	32
Auto	20.1	49.45	25.34	4.36	0.73	29
Cycle	34.3	40.37	18.80	4.93	1.54	25
Rickshaw	42.4	54.87	2.59	-	0.11	16
Bus	2.94	23.42	42.77	24.01	6.86	49
S.Bus	8.43	43.13	43.64	3.97	0.83	32
C.Bus	1.46	10.77	55.66	24.82	7.29	55
Train	8.64	1.23	55.66	25.93	6.17	51
Walk	81.1	18.59	0.19	-	0.10	10

Source: RITES Survey, 2001

Table 5.8: O-D Pattern of Trips at Outer Cordons

Mode	Number of Trips per Day			
	Internal to External	External to Internal	External to External	Total
Buses	458031 (44.5)	441103 (42.8)	130330 (12.7)	1029464 100.0)
Car	152302 (43.8)	147314 (42.4)	47765 (13.8)	347381 (100.0)
Two-Wheeler	67281 (42.9)	67169 (42.8)	22323 (14.2)	156773 (100.0)
Total	677614 (44.2)	655586 (42.7)	200418 (13.1)	1533618 100.0)

Source: RITES Survey, 2005

Table 5.9: Generalized cost for different modes

Modes	Without Metro (Rs)	With Metro (Rs)	Benefit (Rs)	Benefit/month (Rs)
Bus	35	32	3	120
Car	89	80	9	360
Two Wheeler	63	51	12	480
Metro		34		

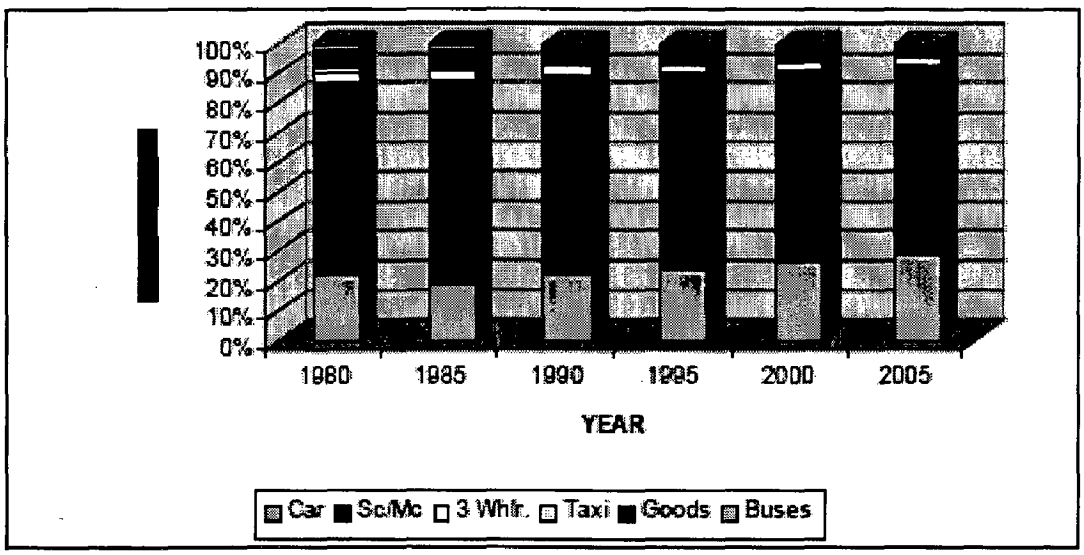
Source: RITES Primary Survey Report

Table 5.10 Registered Motor Vehicle in Delhi

Name of the Vehicle	1995-96	1996-97	1997-98	1998-99	1999-2000
Car and Jeeps	633802	705923	765470	818962	857353
Motor Cycles and Scooters	1741260	1876053	1991710	2011876	2169162
Auto Rickshaws	79011	80210	80210	86985	87785
Taxis	13765	15015	16654	17136	17482
Buses	27889	29572	32333	35254	36933
Goods Vehicles etc	133918	140922	146668	150243	154695
Total	2629645	2847695	3033045	3210456	3323410

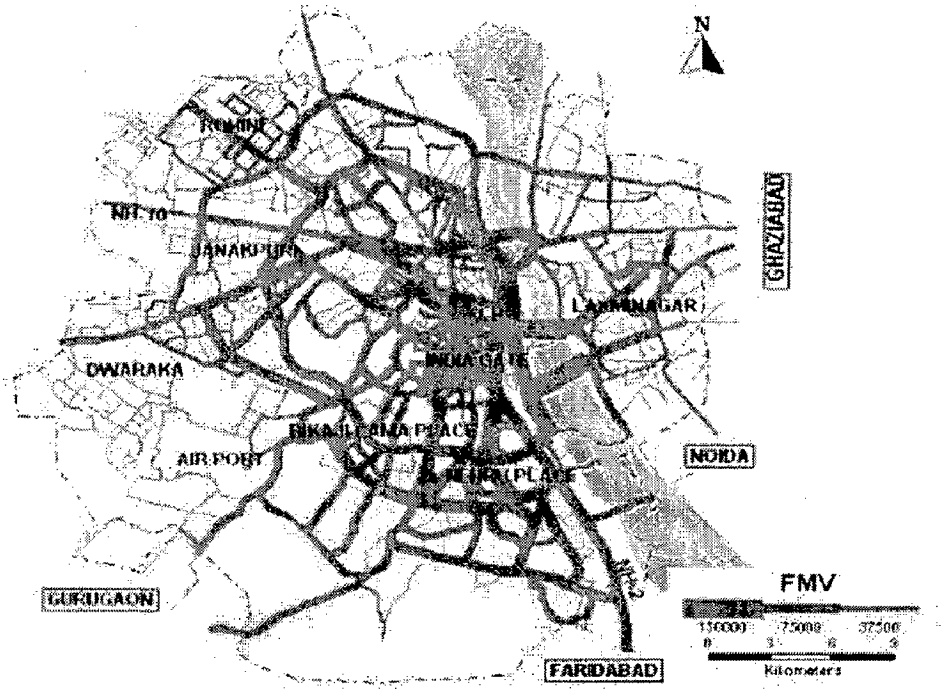
Source: Delhi Statistical Handbook & Transport Dept.

Figure 5.1: Percentage Distribution of motor vehicles in Delhi



Source: Delhi Statistical Handbook & Transport Dept.

Map 36: Traffic Flow Pattern on road network in Delhi



Source: Delhi Statistical Handbook & Transport Dept.

5.3 MRTS TRAFFIC CHARACTERISTICS

The various important system performance parameters for total Metro network as estimated for 2011 and 2021 for both phases are given below in the Table.

Table 5.11: Daily Traffic on Metro Network of Delhi (PHI+PHII Corridors)

S. No.	ITEM	2011	2021
1	Number of originating passengers/day (in lakhs)	26.17	41.17
2	Passenger Km/day (in lakhs)	354.42	601.99
3	Passenger Km/Km (in lakhs)	3.05	5.19
4	Average Trip Length (in Km)	13.66	14.52

Source: DMRC

It can be observed that the total Metro network proposed to be commissioned by the year 2011 would meet daily travel demand of the order of 26.17 lakh in the year 2011 and 41.47 lakh in the year 2021. A total of 354 lakh and 602 lakh passenger kilometers would be carried in the years 2011 and 2021 respectively. The intensity of utilization (pkm/km) is expected to be 3.05 lakh and 5.19 lakh in 2011 and 2021 respectively. Incremental traffic due to phase-II corridors is expected to be 11.07 lakh passengers per day and pkm 188 lakh per day in 2011.

Table 5.12: Transport Scene in Year 2021 (Without MRTS)

S. NO.	ITEM	2003	2011	2021
1	Population (in million)	14.70	19.00	23.00
2	Employment (in million)	5.31	7.73	9.66
3	Per capita trip rate-vehicular (including home based & non home based (in million)	0.87	1.00	1.05
4	Total Daily Trips (in million)	15.30	22.50	28.70
5	Intra-city trips/ day (in million)	13.30	19.37	24.72
6	Inter-city trips/ day (in million)	2.25	3.13	4.08
7	Modal Split for intra city trips (in percentage)	65	75	80
8	Mass public transport trips/ day (intra+inter-city trips) (in million)	10.55	17.32	23.66
9	Peak Hour Factor (in percentage)	9.80	9.80	9.80
10	Peak Direction Factor (in percentage)	58	58	58

Source: DPR of Phase-II, RITES (2004)

The road network of Delhi (30m or wider right of way) is planned to increase from 652 km in 1981: 974 km in 1984 and 1122 km in 2001 to 1340 in 2021. It is also estimated and predicted that 536 km (40%) of roads network will carry trips in excess of 10,000 peak hour peak direction trips (PHPDT) out of which 150 kms of roads will carry trips in excess of 20,000 PHPDT. Based on the carrying capacity of a bus system will not be able to cope with the transport demand in the year 2021.

Table 5.13: The present Phase-I of Delhi MRTS consists of following three corridors of 62.16 kms.

S. NO.	FROM - TO	LENGTH (KM)
1	Shahdara – Trinagar – Rithalka	28.00 kms
2	Vishwa Vidyalaya Central Secretariat	11.00 kms
3	Barakhmba Road – Kirti Nagar – Patel Nagar-Dwarka	23.16 KMS

Source: DMRC

Table5.14: MRTS NETWORK CORRIDORS

S. NO.	FROM - TO	LENGTH (KM)
PHASE-1 (2005)		**62.16**
1	Shahdara-ISBT-Trinagar-Barwala	28.00
2	Vishwa Vidyalaya – Central Secretariat	11.00
3	Barakhamba Road - Patel Nagar – Dwarka	23.16
PHASE-II (2011)		**53.02**
4	Vishwa Vidyalaya – Jahangiri Puri	6.36
5	Central Secretariat – Qutab Minar	10.87
6	Shahdara – Dilshad Garden	3.09
7	Indraprastha – Yamuna Bank – New Ashok Nagar	8.07
8	Yamuna Bank – Anand Vihar ISBT	6.16
9	Kirti Nagar- Mundka	18.47
PHASE-III (2016)		**58.20**
10	Jahangiripuri- Raja Garden – Dhaula Kuan – AIIMS- Nehru Place – Okhla Industrial Area Phase- I	34.60
11	Barwala – Bawana	5.20
12	Rangpuri – IGI Airport-Shahbad Mohammadpur – Dwarka City	8.20
13	Shahbad Mohammadpur – Dwarka – Kakraula Village	10.20
PHASE – IV (2021)		**72.80**
14	Jahangiri Puri – Peeragarhi – Pankha Road	24.20

15	Narela – Bawana –Gheora – Najafgarh	33.00
16	Mehrauli – Gurgaon	11.60
17	Dilshad Garden – Nand Nagri	4.00
TOTAL		**244.86**

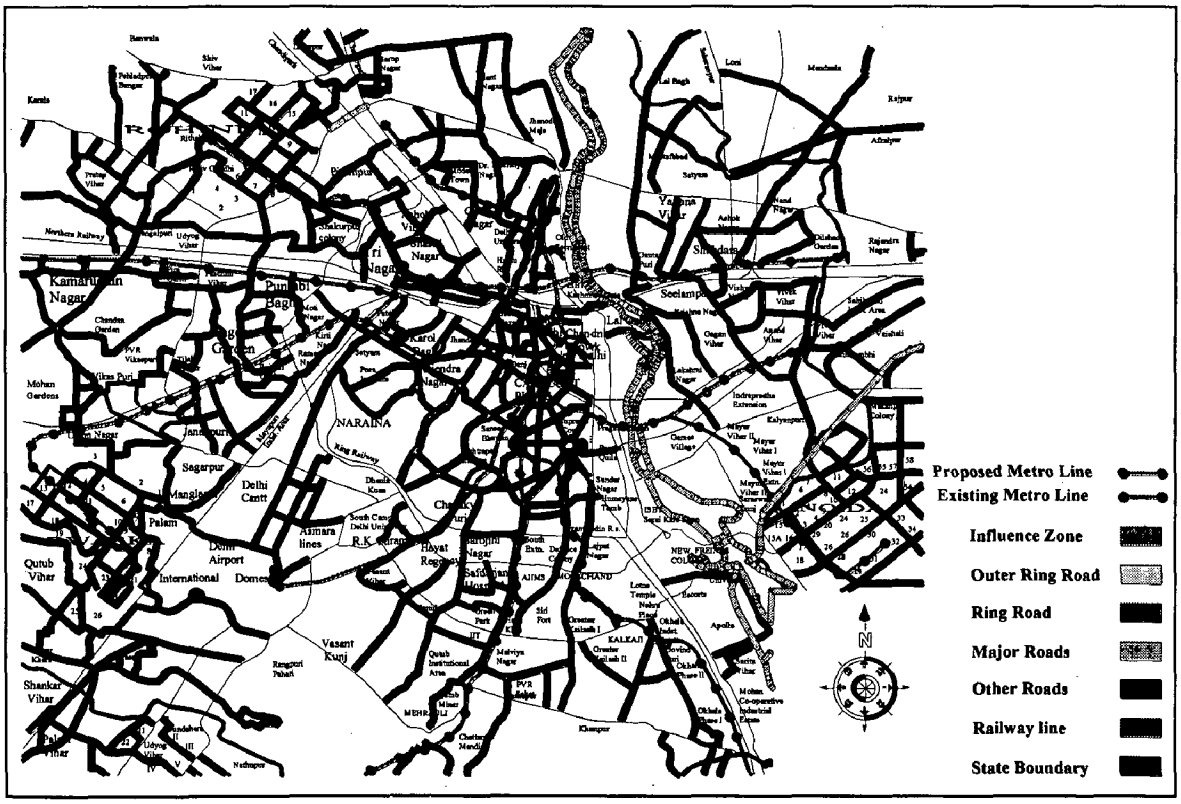
Source: DMRC

Table 5.15: Load of Sections (2021)

S. NO.	SECTION	DAILY	PHPDT
1	Vishwa Vidayalaya – Jahangiri Puri	410,852	23,353
2	Central Secretariat – Qutab Minar	392,162	22,290
3	Shahdara – Dilshad Garden	262,943	14,946
4	Indraprastha – Yamuna Bank – New Ashok Nagar	810,604	46,075
5	Yamuna Bank – Anand Vihar ISBT	235,265	13,372
6	Kirti Nagar – Mundka	986,913	56,096

Source: DPR of Phase II, RITES (2004)

Map 37: Transportation Map of Delhi



Source: Author

5.4 TRAFFIC DEMAND CHARACTERISTICS FOR THE CHOOSEN METRO NETWORK

Section Loads in the tables below gives the section loads in terms of daily passenger and peak hour peak direction trips for the Dwarka metro network for years 2011 and 2021.

Table 5.16: Projected Section Loads on Various Corridors of Delhi Metro Network (Dwarka)

Station From	Station To	2011		2021	
Dwarka- Dwarka Sector 9		**Daily**	**PHPDT**	**Daily**	**PHPDT**
Dwarka	Dwarka Sector 14	29259	6648	40385	10362
Dwarka Sector 14	Dwarka Sector 13	31050	7649	43512	9625
Dwarka Sector 13	Dwarka Sector 12	44628	8226	64431	13574
Dwarka Sector 12	Dwarka Sector 11	34367	7571	57826	10695
Dwarka Sector 11	Dwarka Sector 10	42932	8034	64803	12375
Dwarka Sector 10	Dwarka Sector 9	32989	6443	52838	11916

Source: DMRC

Table 5.17: Existing Section Loads on Various Corridors of Delhi Metro Network (Dwarka)

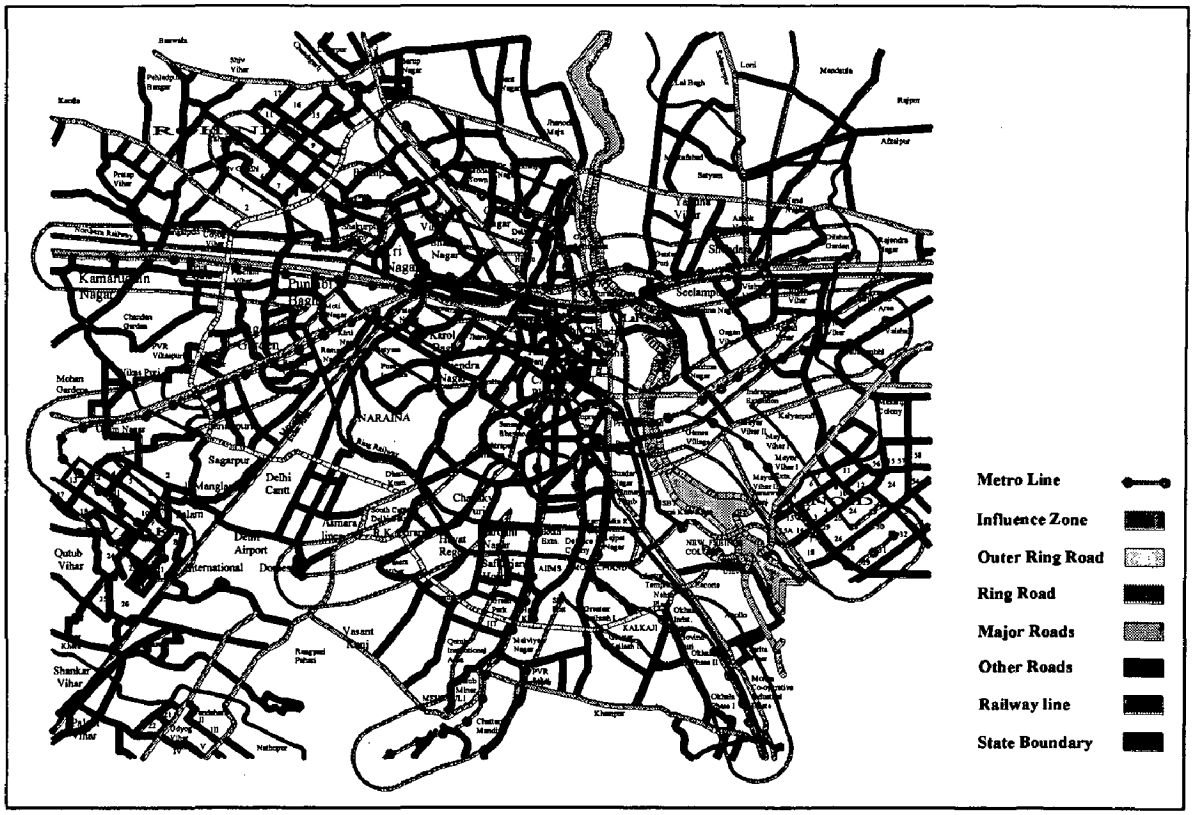
Station From	Station To	2007	
Dwarka- Dwarka Sector 9		**Daily**	**PHPDT**
Dwarka	Dwarka Sector 14	24622	5329
Dwarka Sector 14	Dwarka Sector 13	25914	4296
Dwarka Sector 13	Dwarka Sector 12	41664	6530
Dwarka Sector 12	Dwarka Sector 11	30382	5732
Dwarka Sector 11	Dwarka Sector 10	37692	6427
Dwarka Sector 10	Dwarka Sector 9	28529	5751

Source: DMRC

5.5 INFLUENCE ZONE

Public transport service has to meet the needs of commuters. This includes accessible stations, minimum affordable time loss at interchanges, safer and reliable services. Since 500 m. is an ideal walking distance, population residing along the metro within walking distance has the highest accessibility to metro. This area within 500 m from the metro corridor is known as the Influence Zone.

Map 38: Transportation Map of Delhi showing the 500m Influence Zone of Metro



Source: Author

Given that the total length of the metro corridor is 244.86 Km.the total area of the Influence Zone calculates to be (244.86 X 0.5 X 2) 244.86 Sq.Km. considering that the total urban area of Delhi is 640 sq.km. The Influence Zone (as shown in Map 37) amounts to be 38% of the total urban area of Delhi thus, after the implementation of the complete system 62% area of Delhi will remain beyond walking distance of metro. Expansion of metro influence zone beyond 38% will have to rely on feeder system. This is not easy because of the inherent transfer costs and wait times at interchanges.

Shukla (2004) has estimated that population residing within a distance of 0.5 km, 1 km and 2.5 km from the metro station and trips originating from these regions for phase 1, Shahadara – Barwala metro line of length 23.8 km. Population residing within 0.5 km can reach metro by walking but people residing at more than this distance have to use rickshaw or feeder bus. Population residing within the area of walking distance is 346560 for the corridor length of 23.8 km. Total length of metro line is 198.5 km, applying the same methodology for accessible population as line 1, total population residing within the

distance of 0.5 km is 2890426. This is approximately 2.2 % of the total population of Delhi.

Trips originating in the region of 0.5 km distance i.e. walking distance are approximately 374939 for metro length of 23.8 km. Applying same weight to the total length of 198.5 km, number of trips originating in the region of 0.5 km distance is 3127117. This shows that only 3127117 trips can be shifted to metro if all the persons have destination along the metro corridor. This may not be true.

Figure 5.2: Total base population along the Metro line residing in the region for different catchments radii. (Refer Map 39) *Source Author*

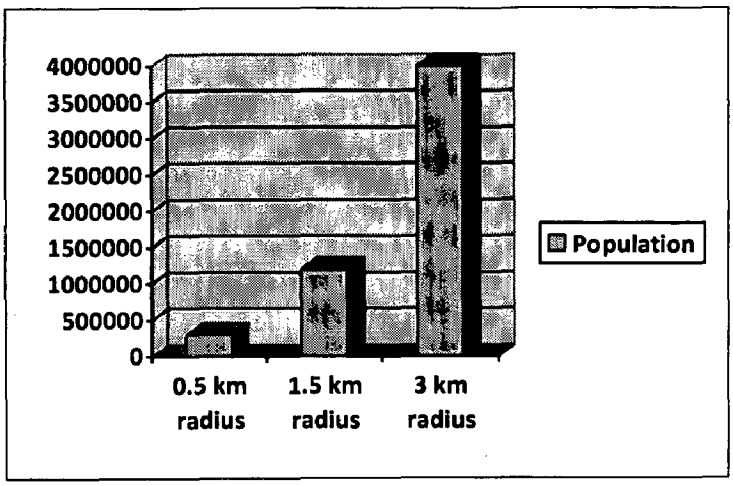
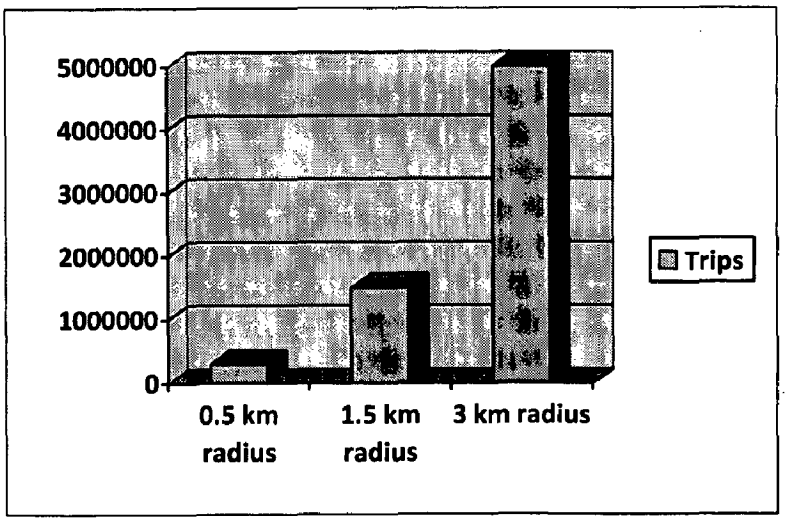
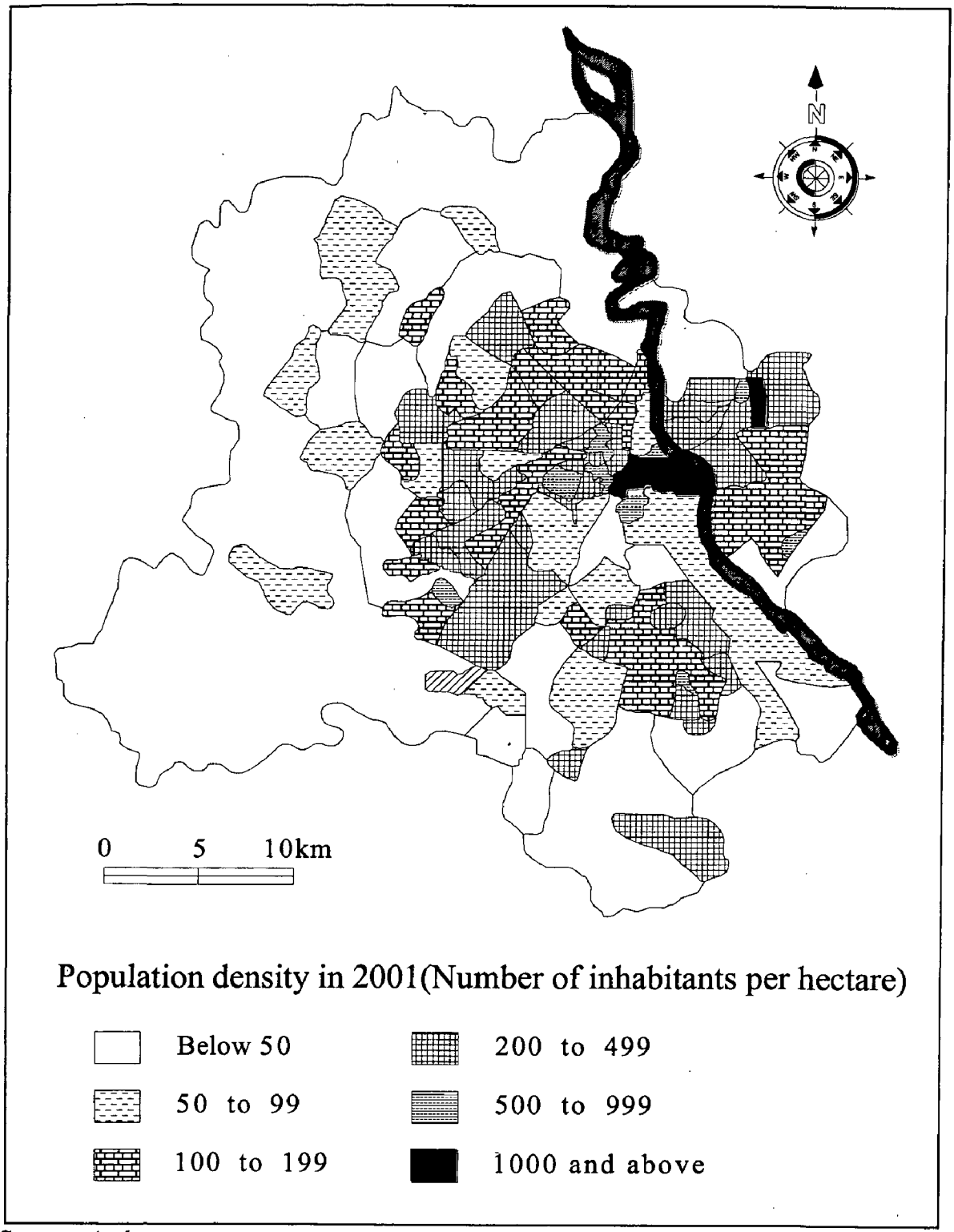


Figure 5.3: Total number of trips originating in the region for different catchments radius. (Refer Map 39) *Source: Author*

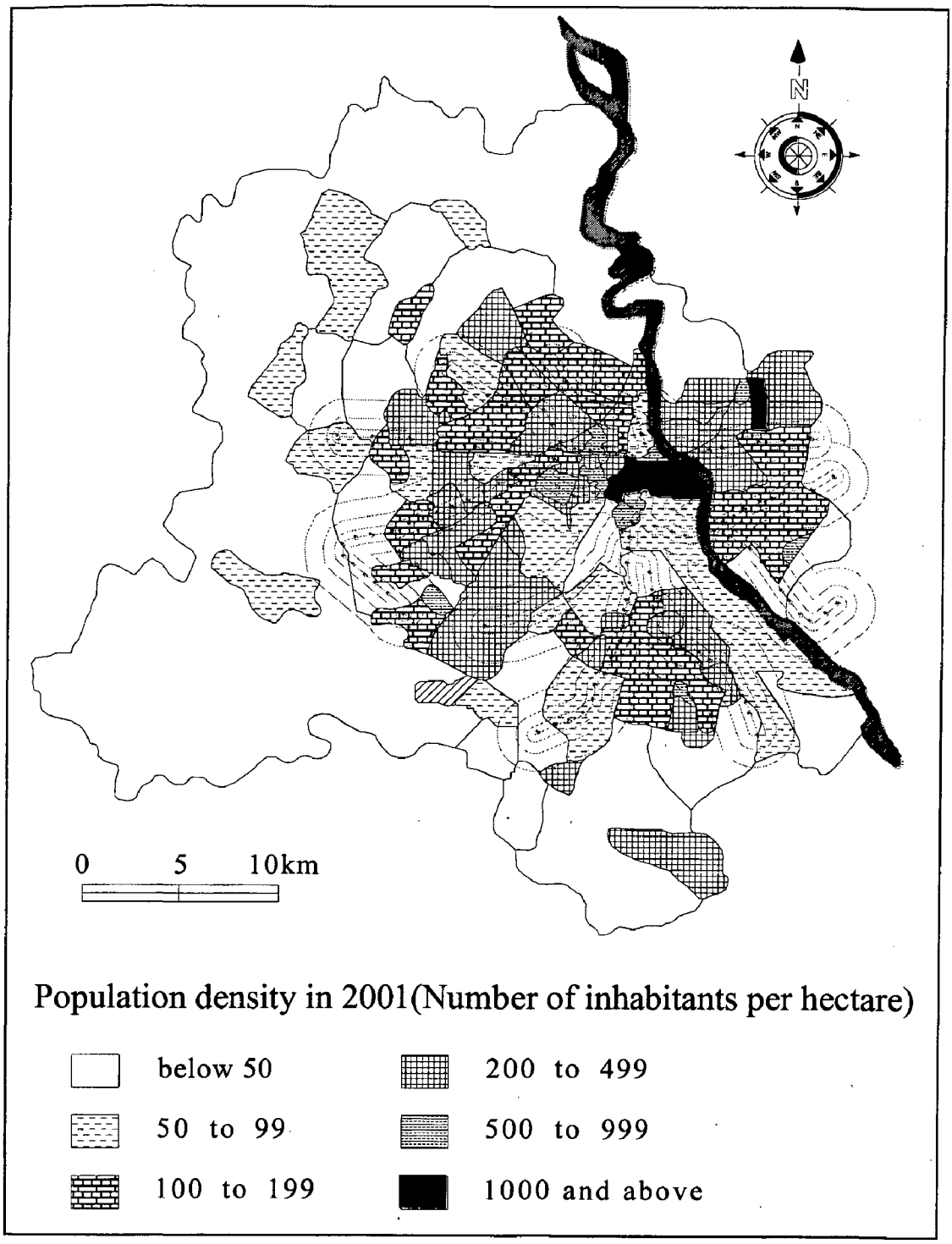


Map 39: Map showing population density in 2001
(Number of inhabitants per Hectare)



Source: Author

Map 40: Influence Zone of Metro (500m, 1.5km, 3km) superimposed on population density Map (Number of inhabitants per Hectare)



Source: Author

The Influence Zone amounts to be 38% of the total urban area of Delhi. Which accommodates only 2.2 % of the total population of Delhi.

5.6 METRO INFLUENCE ZONE ANALYSES FOR DELHI

An analysis of the influence zone has been done for three ranges of influence zone (500m, 1.5km and 3km: Refer Map 39) to find out the total area of influence zone along with the population that resides in these influence zones and their average population densities.

Table 5.18: Influence Zone Population for 500 meter Influence Zone

Mode	Total Length of Corridor (Km)	Influence Zone Area (Ha)	Influence Zone Population	Average Density
Metro	244.86	24486	1854861	75.75
Rail	86.5	8650	549275	63.50
BRTS	136.5	13650	989725	72.51

Table 5.19: Influence Zone Population for 1.5 Km Influence Zone

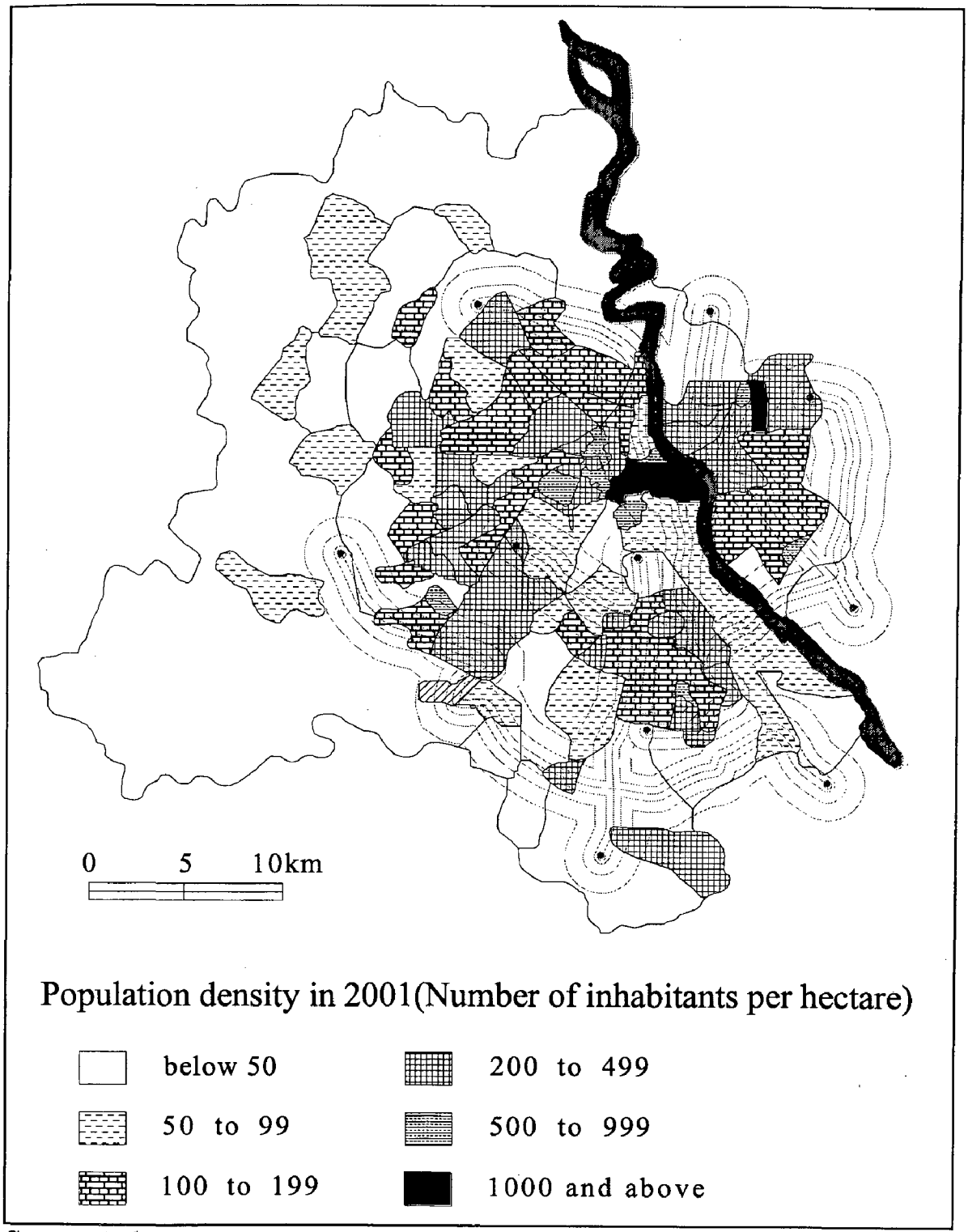
Mode	Total Length of Corridor (Km)	Influence Zone Area (Ha)	Influence Zone Population	Average Density
Metro	244.86	73458	35960778	489.54
Rail	86.5	25950	6934025	267.21
BRTS	136.5	40950	16769025	409.50

Table 5.20: Influence Zone Population for 3 Km Influence Zone

Mode	Total Length of Corridor (Km)	Influence Zone Area (Ha)	Influence Zone Population	Average Density
Metro	244.86	146916	92479166	629.47
Rail	86.5	51900	26936100	519.00
BRTS	136.5	81900	67076100	819.00

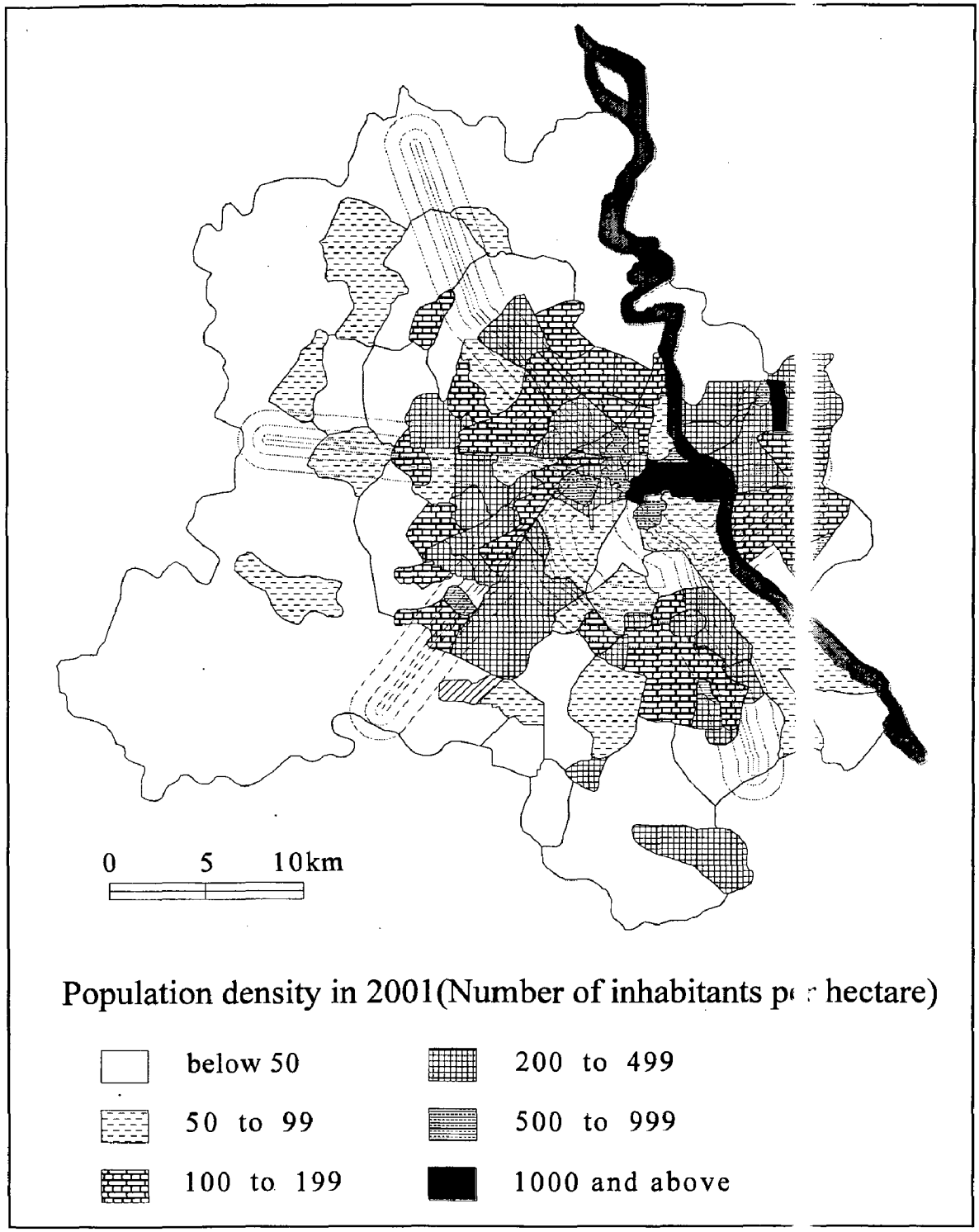
Average Population density is 371.72 persons per hectare.

Map 41: Influence Zone of BRTS corridor Phase-1 (500m, 1.5km, 3km) superimposed on population density Map (Number of inhabitants per Hectare)



Source: Author

Map 42: Influence Zone of sub-urban Railway corridor (500m 1.5km, 3km) superimposed on population density Map (Number of inhabitants per Hectare)



Source: Author

5.7 METRO INFLUENCE ZONE ANALYSES FOR THE SELECTED STRETCH

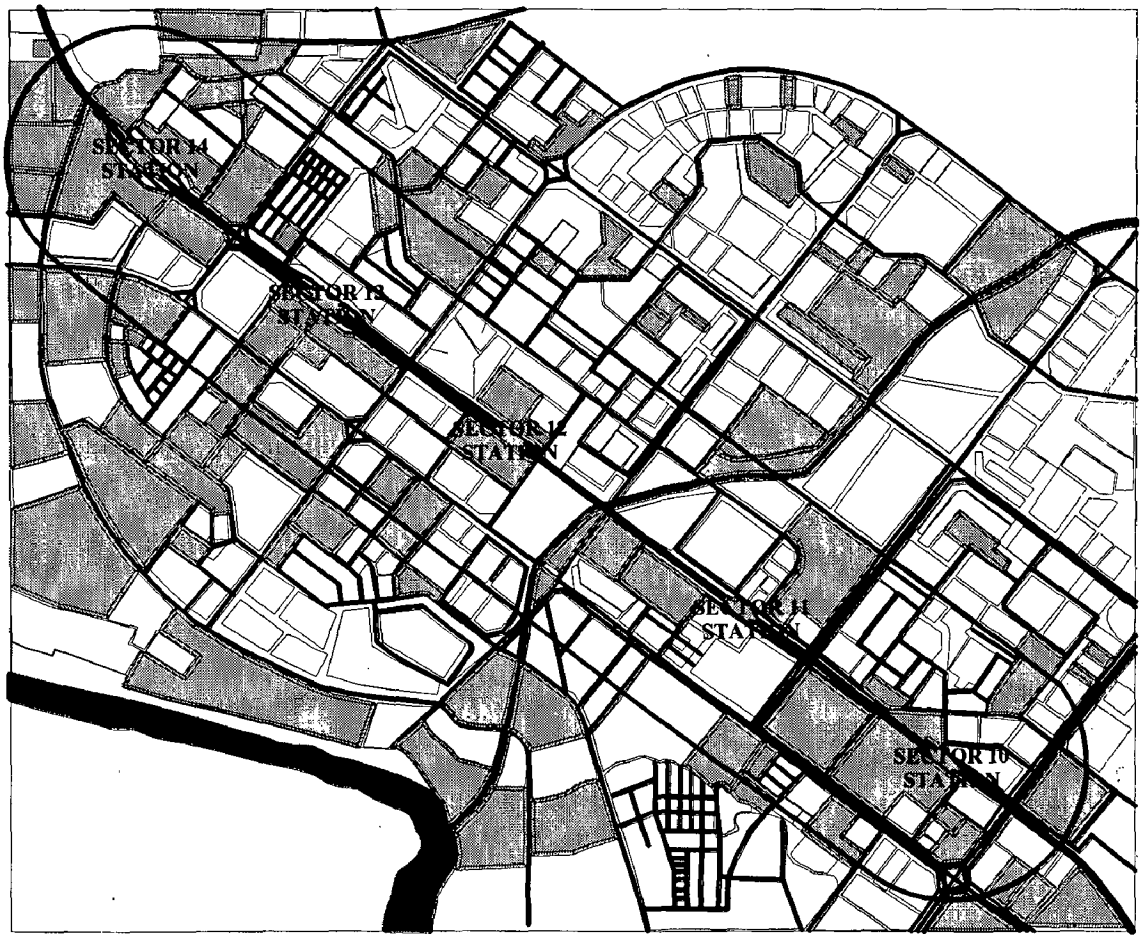
- Length of the selected stretch – 4.7 km.
- Metro stations selected for the study
  - Dwarka Sector 10
  - Dwarka Sector 11
  - Dwarka Sector 12
  - Dwarka Sector 13
  - Dwarka Sector 14
- Total Population of Dwarka Sub-city – 10 lakhs
- Total Area of Dwarka Sub-city – 56.48 Sq.km.
- Area of Phase I – 36.52 Sq.km.
- Area of Phase II – 19.96 Sq.km.
- Existing Built up Area – 16.88Sq.km.
- Area of each sector – 0.81 Sq.km. (900m X 900m)
- Population of each sector – 30,000
- Area of Influence Zone – 4.5 Sq.km.
- 12.32 % area of Dwarka Phase I is under Influence Zone.
- Built up area of the Influence Zone is 12.32% of the total built up area of Dwarka Phase I.
- Built up area of the Influence Zone – 2.07 Sq.km.
- Population of Influence Zone – 229122
- Population Density of Influence Zone – 50916 or 509 pph.

Table 5.21: Influence Zone Landuse Breakup

Landuse	Area(Sq.km.)	Percentage
Gross Residential	2.640	58.75%
Commercial	0.193	4.29%
Government	0.076	1.71%
Public/Semi Public	0.327	7.27%
Recreational	0.590	13.17%
Transport	0.610	13.61%
Utilities	0.054	1.2%
Total	4.5	100%

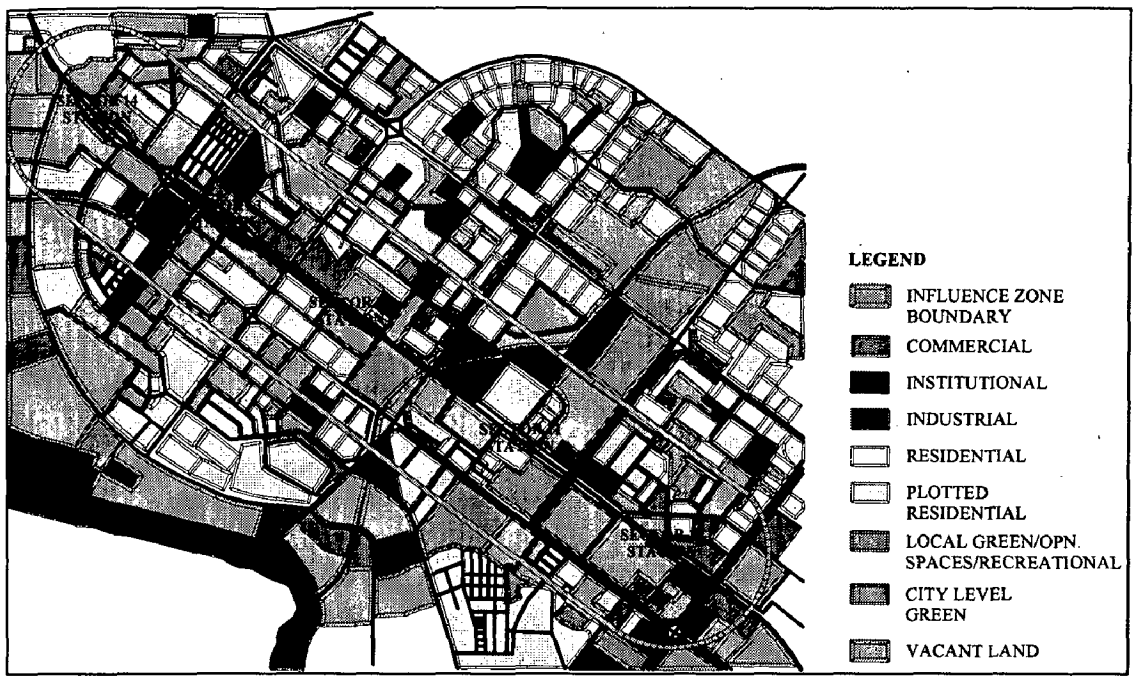
Source: Author

Map 43: Vacant Land in the Immediate Influence Zone, Dwarka - Delhi



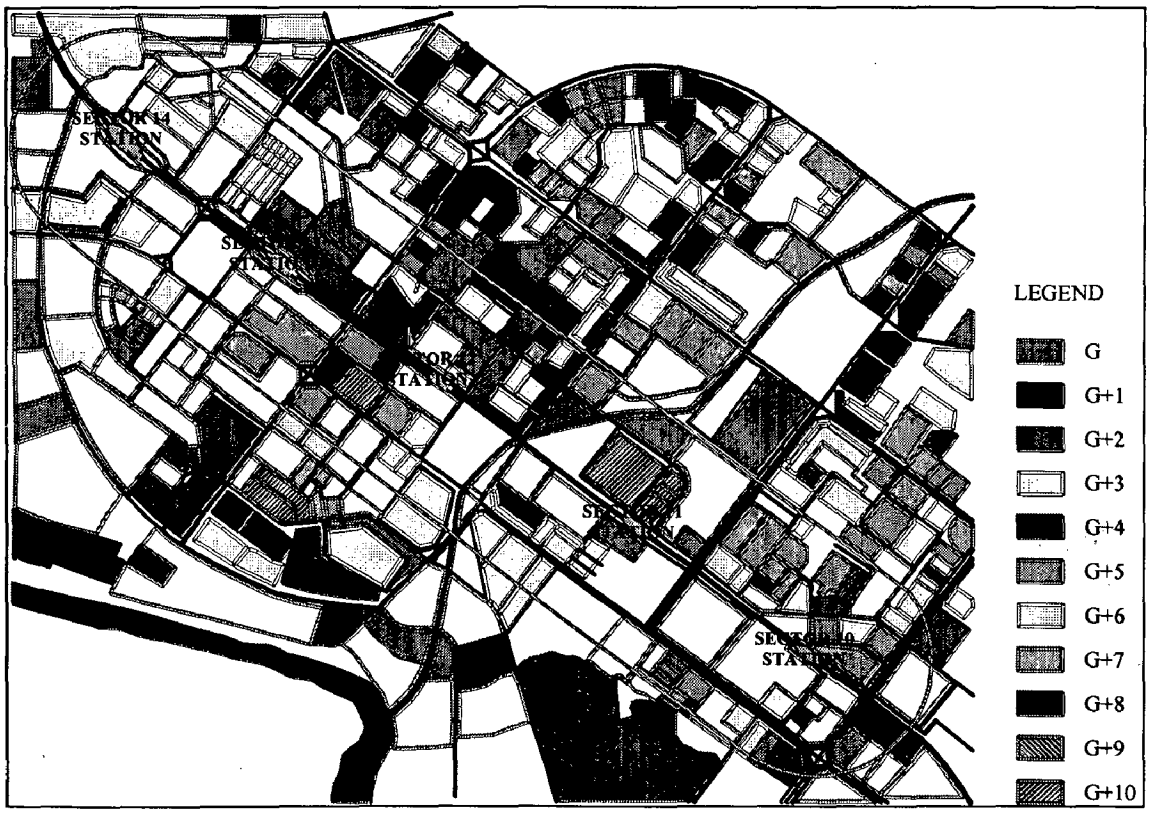
Source: Author

Map 44: Influence Zone Landuse Plan



Source: Author

Map 45: Building Heights



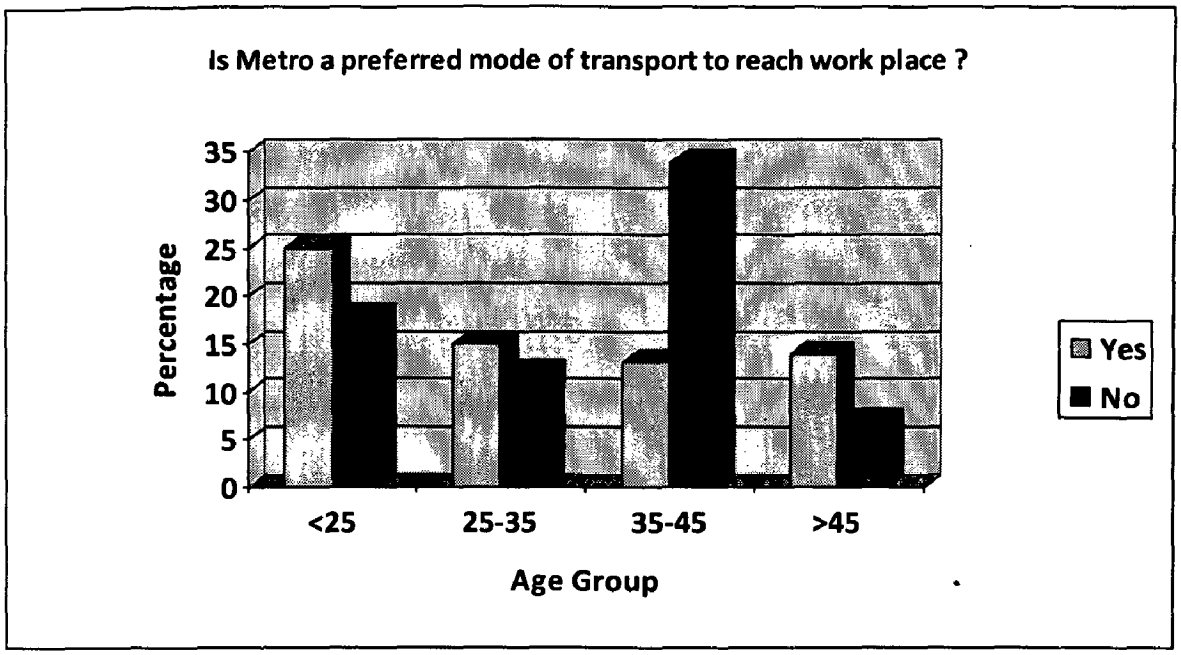
Source: Author

5.8 INFERENCES FROM SITE AREA ANALYSES

1. A greater modal shift frm automobiles to public transport needs to be achieved.
2. Trnsit system in Dwarka is not being utilised to its full capacity.
3. Transit stations are not easily accessible for majority of the popultion.
4. Only 38% of the urban area is under influence zone
5. The residential areas are having medium population densities.
6. There are lots of vacant lands around the transit stations that could be developed.
7. Commercial areas near the transit stations need to be intensified.
8. Only 2.2% of the total population of delhi lives in the influence zone of 500m.
9. Residential areas not making proper use of FSI provided.
10. Open spaces are less and too small.

5.9 CASE STUDY AREA COMMUTER SURVEY ANALYSIS

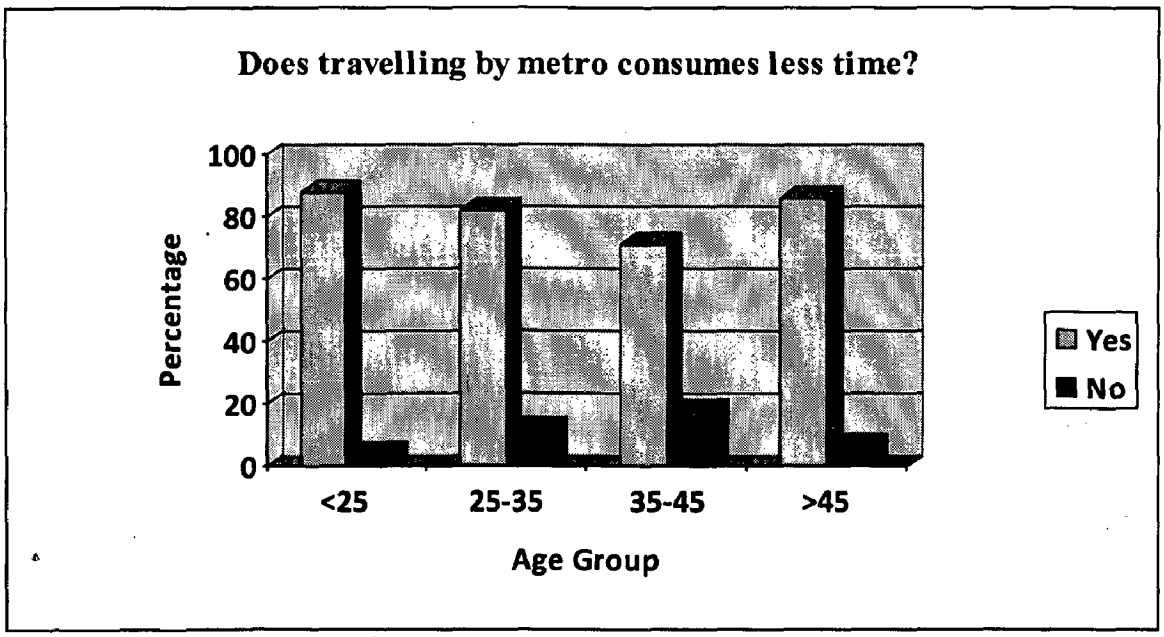
Figure 5.4: Graph showing Metro is a preferred mode to reach work place



Source: Primary Survey, Author

25% Commuters below the age of 25 prefer Metro as a mode of transport to reach work place where as 34% commuters in the age group 35-45 do not prefer Metro.

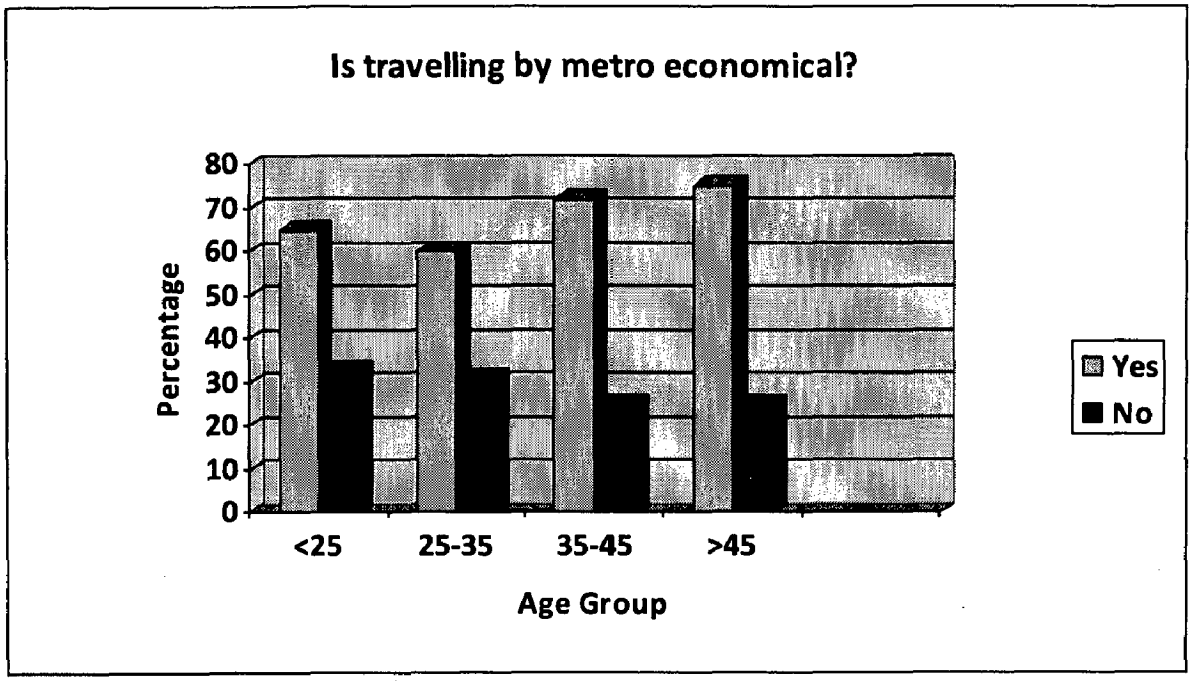
Figure 5.5: Graph showing travelling by Metro consumes less time



Source: Primary Survey, Author

More than 80% of the commuters believe that travelling by Metro consumes less time.

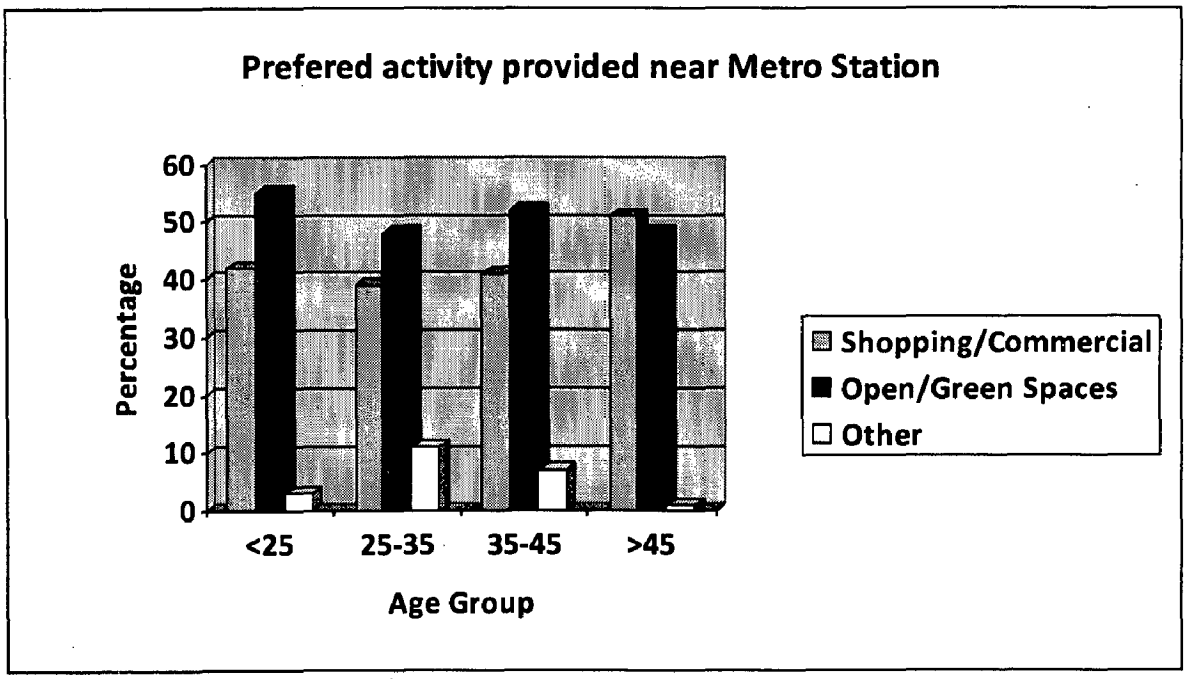
Figure 5.6: Graph showing that travelling by Metro is economical



Source: Primary Survey, Author

Around 65% of the commuters believe that travelling by Metro is economical.

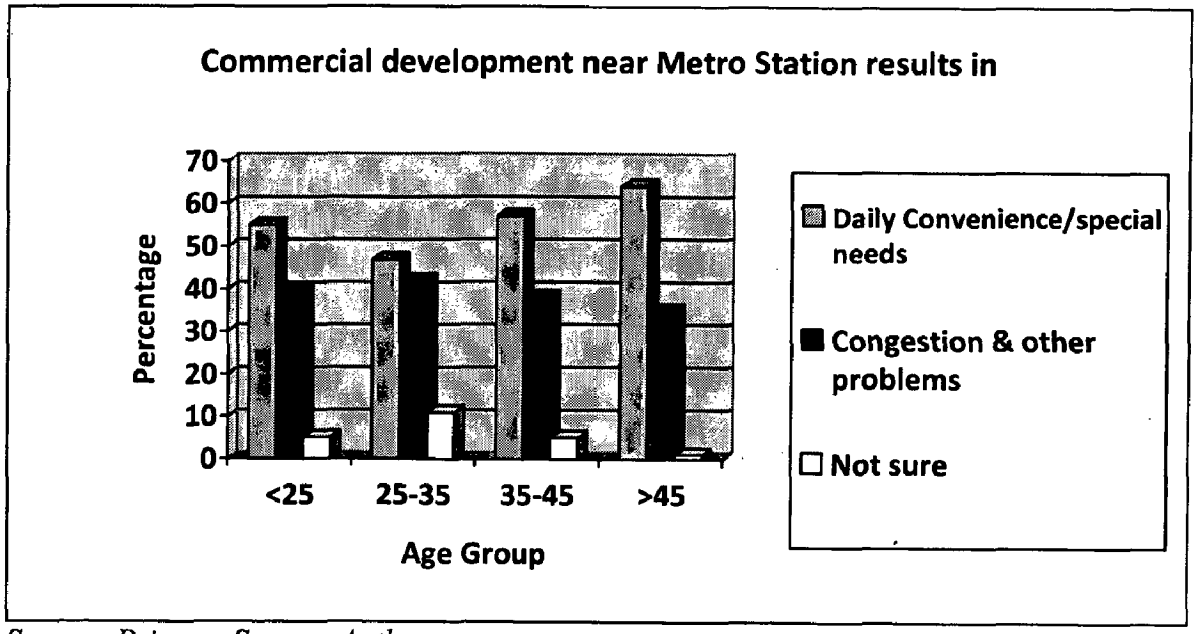
Figure 5.7: Graph showing preferred activity near Metro Station



Source: Primary Survey, Author

Around 40% of the commuters believe that shopping/ commercial are preferred activities near Metro Stations where as 50% believe that open/green spaces are preferred.

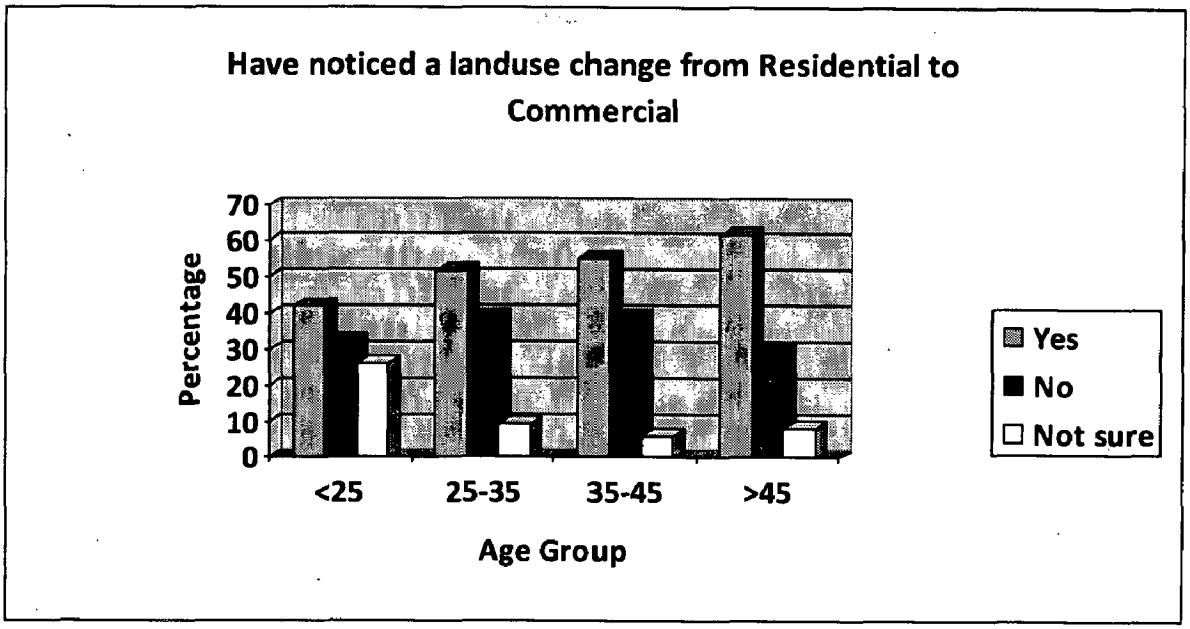
Figure 5.8: Graph for results near Metro having commercial development



Source: Primary Survey, Author

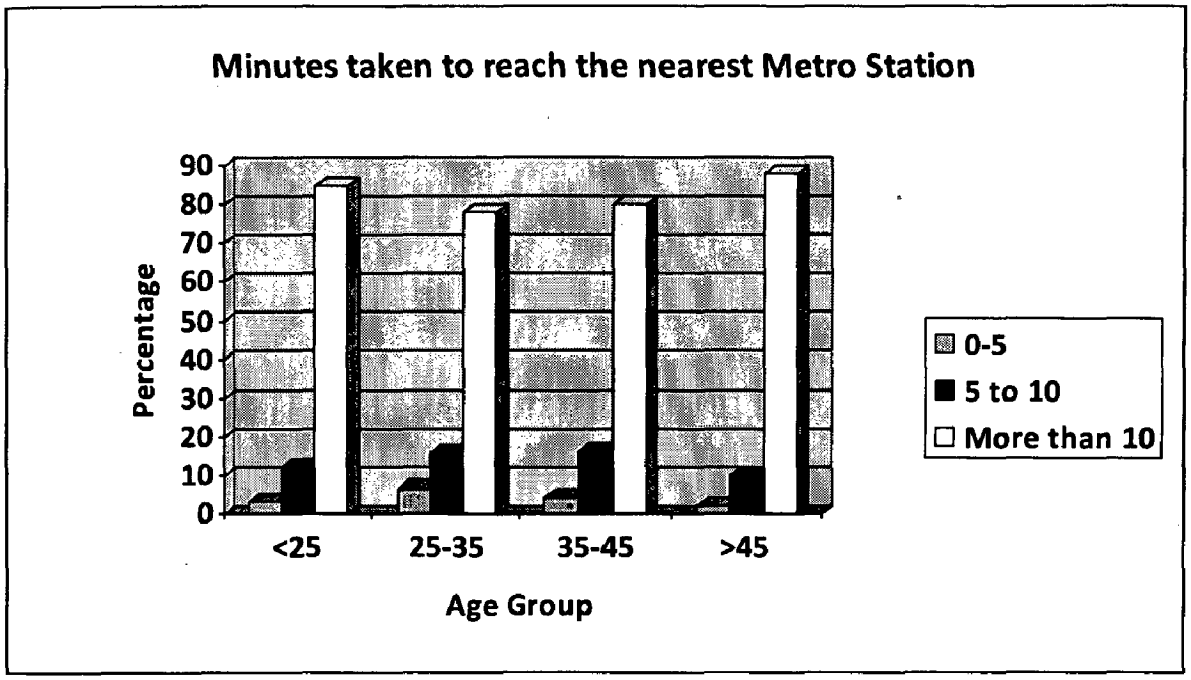
Around 55% of the commuters believe that commercial development near Metro Stations results in daily convenience/ special needs where as more than 35% believe that it results in congestion and other problems.

Figure 5.9: Graph showing change in Land Use



Source: Primary Survey, Author More than 50% of the commuters have noticed a landuse change from residential to commercial whereas around 35% have not noticed any such landuse change.

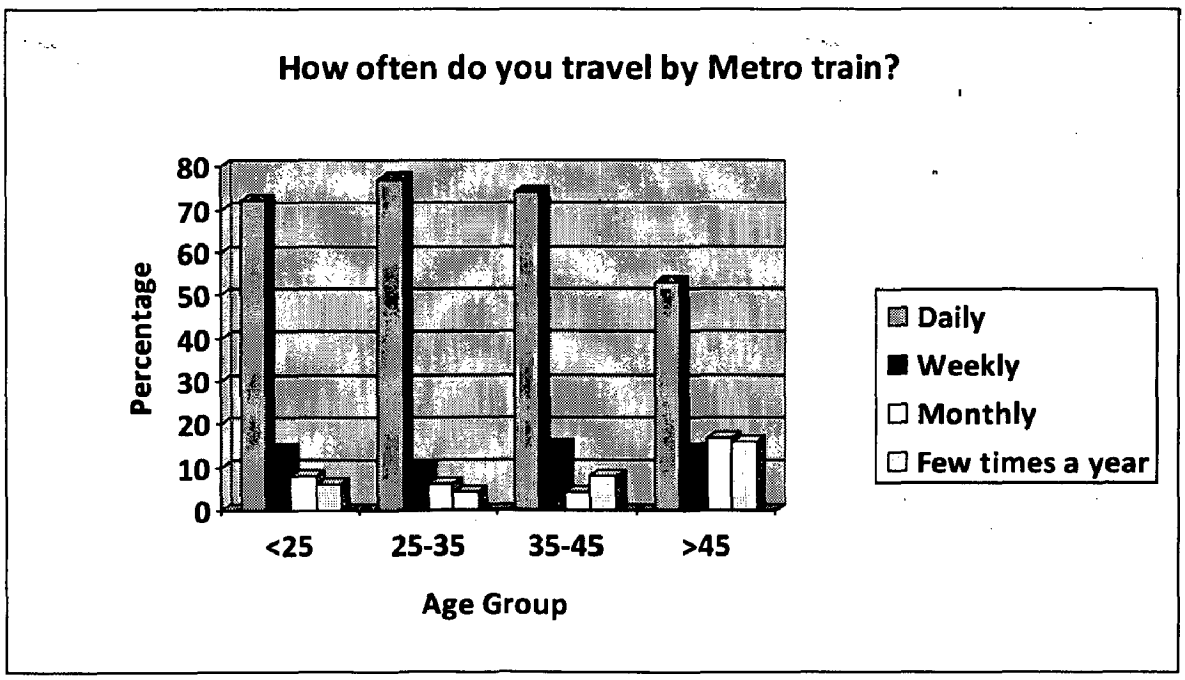
Figure 5.10: Graph showing minutes to reach the nearest Metro Station



Source: Primary Survey, Author

More than 80% of the commuters take more than 10 minutes to reach the Metro Station.

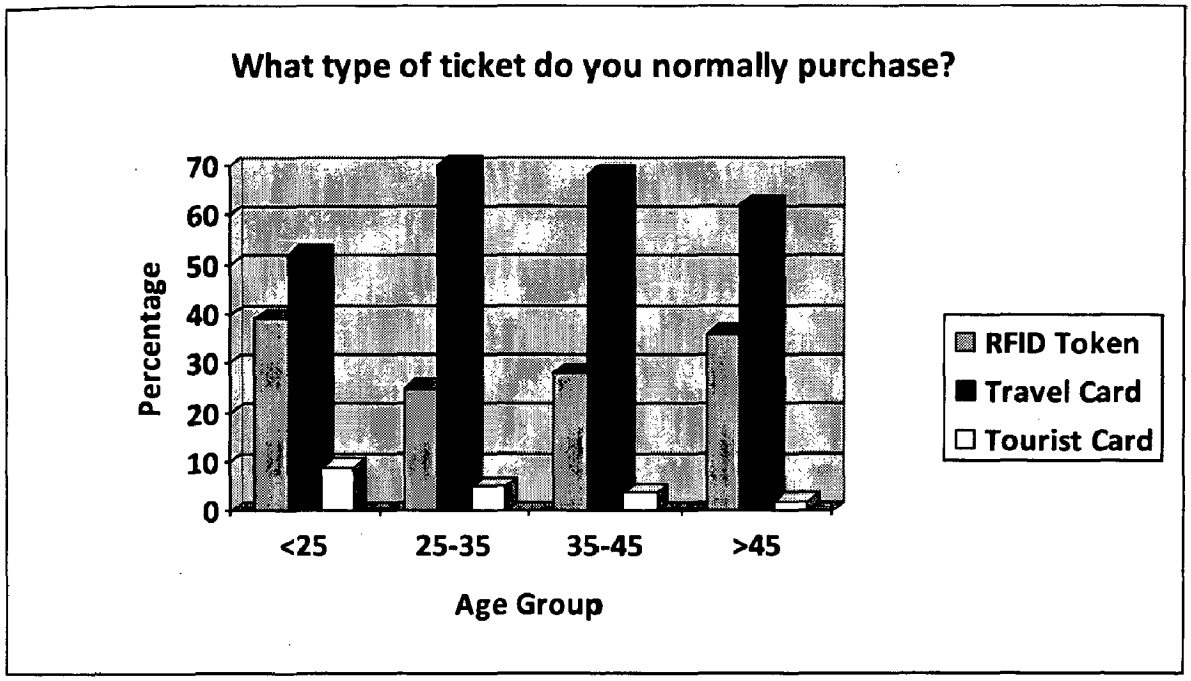
Figure 5.11: Graph showing how often people travel by Metro train



Source: Primary Survey, Author

Around 65% of the commuters travel daily by Metro train. Specially the working population.

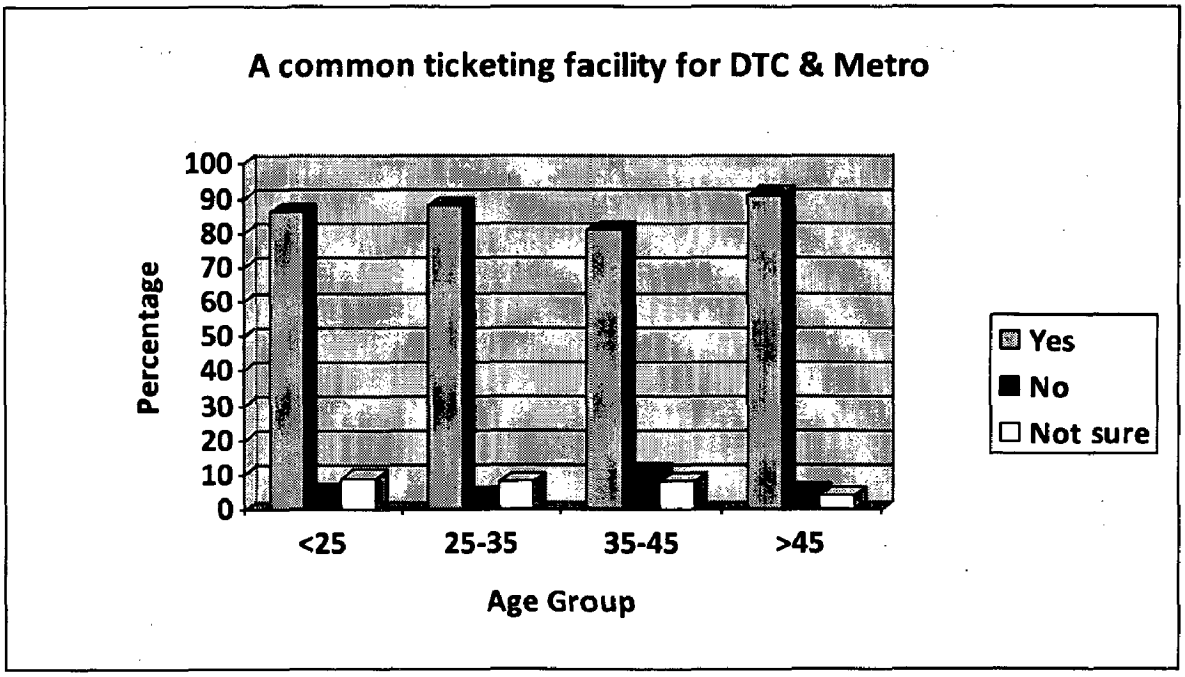
Figure 5.12: Graph showing type of ticket



Source: Primary Survey, Author

More than 60% of the commuters have a travel card.

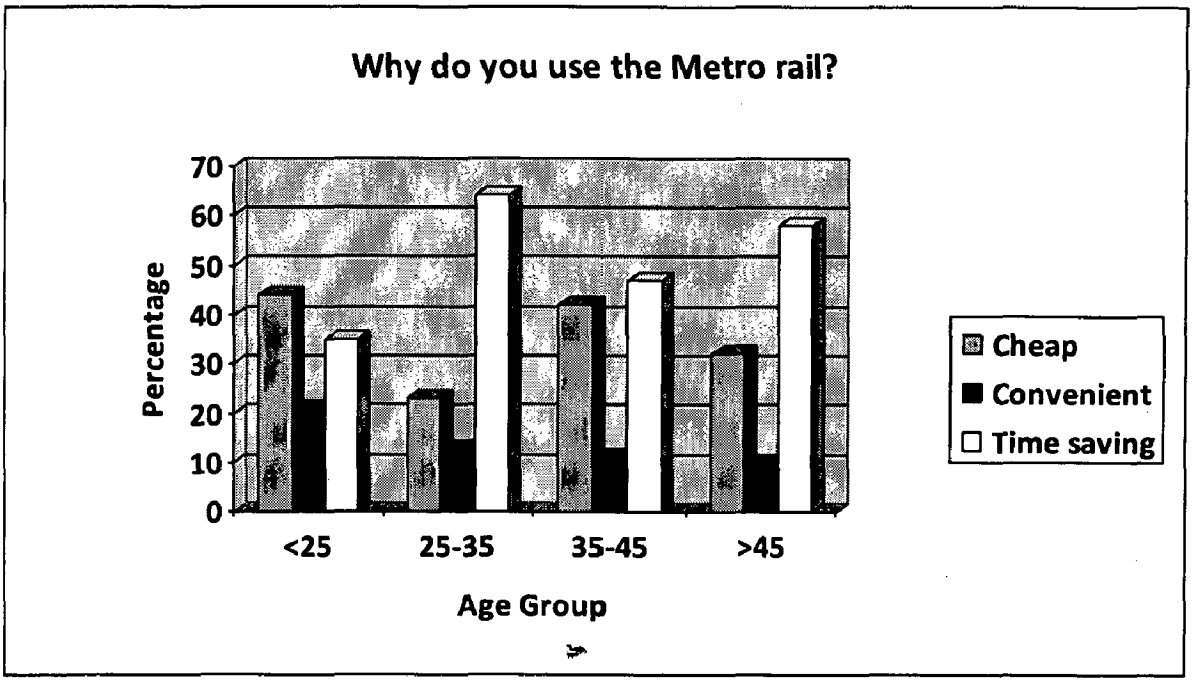
Figure 5.13: Graph showing willingness for common ticketing for DTC and Metro



Source: Primary Survey, Author

About 85% of the commuters would prefer a common ticketing facility for DTC & Metro

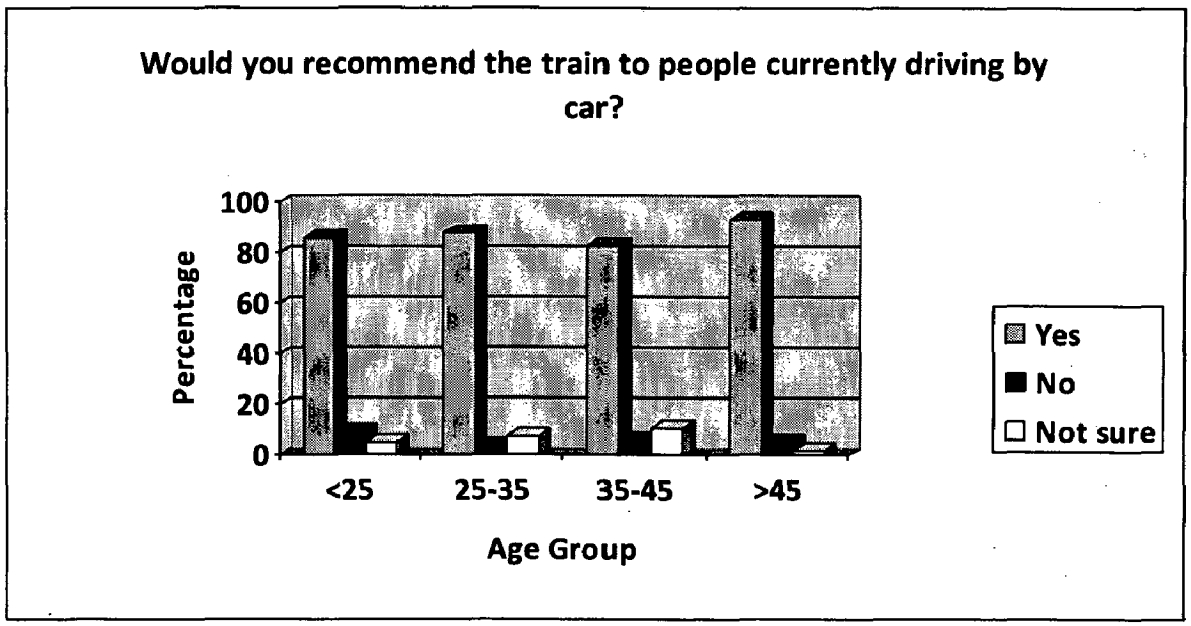
Figure 5.14: Graph showing purpose of using Metro rail



Source: Primary Survey, Author

Around 50% of the commuters use Metro rail because it is time saving and 35% use it because it is cheap.

Figure 5.15: Graph showing willingness to recommend Metro to car users



Source: Primary Survey, Author

Around 85% of the commuters would recommend the Metro train to people currently driving by car.

5.10 INFERENCES FROM PRIMARY SURVEY

- In general commuters prefer public transport if its time saving, cheap and convenient.
- Full potential of the public transport system (specially the MRTS) has not been exploited.
- To exploit the full potential of the Metro train landuse restructuring and population density intensification is required.
- The Metro does seem like a preferred mode of travel because of which the mobility has been eased and people do travel long distances for work inside or outside Dwarka.
- With the prospects of new office spaces coming up in the area, around 20% of the working population were keen on having office spaces near the Metro Stations.
- More than 80% of the commuters take more than 10 minutes to reach the Metro Station which affects the total ridership of the Metro.
- Metro ridership data shows that the traffic flow is unidirectional due to segregation of landuses.
- The present population density of the study area is too low to utilize the full capacity of the Metro.

5.11 Conclusion

Delhi as a metropolitan city has a great potential for development by application of the Compact Transport-Oriented development principles. The site already has neighbourhoods and town centre and excellent mass transit facility. These activity centres and neighbourhoods need to be developed in a transit supportive manner which can be done by making the transit system more accessible. To increase accessibility to transit system it is necessary to accommodate maximum population in close proximity to the transit stations and corridors as a whole. The case study site of Dwarka is a medium density residential neighbourhood that can be made self sufficient by providing a mix of high intensity commercial and a high density residential development.

CHAPTER - 6

RECOMMENDATIONS AND CONCLUSION

6.1 INTRODUCTION

On the basis of a detailed study of the Compact City and TOD concept through literature review and case studies a set of planning guidelines has been evolved for compact transport-oriented development in Indian cities. Firstly the chapter enumerates a set of strategies evolved from the inferences of the literature review and the case studies. These strategies are aimed at solving the problems that has been analyzed in the previous chapter.

The strategies are based on the key elements of the Compact city and the TOD concept that were found to be critical to the success of these concepts. There after a detailed guideline for implementing these concepts has been provided. As part of the strategy for implementation these concepts in the Indian context it has been identified that why transit oriented development is not prevalent in Indian cities? The chapter first provides planning guidelines for compact transport-oriented development of Delhi and then provides a set of general guidelines that can be applicable to any city in India.

These recommendations are only on a policy guidelines basis and need to detail out as per the requirements of the specific project through inclusive planning process.

6.2 STRATEGIES

6.2.1 Strategy for Transport Oriented Development

Transit oriented development is a concept which involves the functional integration of land use and transit through the creation of compact, walkable, multi modal, mixed-use communities within ¼ to ½ mile of a transit stop or station. It is designed to maximize access to public transport, and often incorporates features to encourage transit ridership.

The distance that a person is willing to walk to take transit defines the primary area within which TOD should occur. This distance is equivalent to roughly a 5 minute walk, or 400 to 600 metres. At these radii around a station, there is potential for 125 to 250 acres of land for transit oriented development.

6.2.2 Major Elements of Transit Oriented Development

On the basis of the case studies the prime constituents of a Transit Oriented Development have been defined as under:

Compact or high density development within 10-minute walk circle surrounding transit station. The concentration of jobs, shops, schools and other public and commercial services, and a variety of housing types and prices, within each neighborhood generates high pedestrian movement and transit ridership.

- The neighborhood is designed for cycling and walking, with adequate facilities and attractive street conditions. The planning should reduce conflict between pedestrian and vehicular movement.
- Planning for an integrated transport system that has multi modal access and circulation accommodate the needs of cars, transit vehicles, bicycles and pedestrians thus offering people more choices to meet their various transportation needs.
- A mix of residential, office and supporting services in station areas can generate transit trips throughout the day. It provides opportunities for people to live closer to their jobs or to take advantage of reverse flow transit capacities. Workers can run daily errands within walking distance of their jobs; transit riders can access convenient services while at the station. Residents and visitors can continue a variety of activities in off-peak times.
- Ensure transit supportive uses. Transit supportive uses are high pedestrian generators that directly promote greater transit ridership. They also provide opportunities for multi-purpose trips that can be made as a pedestrian. Medium to high density residential, offices, high schools and colleges are significant transit supportive uses. Appropriate retail, restaurants, personal service and civic functions will support these major uses and generate activity in both peak and off-peak hours.

However, the following key components are commonly found to be critical to the success of any transit oriented development.

- Get the Land Uses Right
- Promote Density

- Create Convenient Pedestrian Connections
- Ensure Good Urban Design
- Create Compact Development Patterns
- Manage Parking
- Make Each Station a "Place"

6.2.3 TOD implementation

The implementation of TOD has not occurred as rapidly as the adoption of other New Urbanist concepts. Calthorpe originally believed that TOD fit within the needs, preferences, and purchasing power of the public but his perceived level of demand has not led to a substantial supply of TOD. As Calthorpe notes in his forward to "New Transit Town", "[TOD] is in its adolescent phase. The concept is developing but the body of work lags a bit behind."

Only a small percentage of the anticipated TOD projects have been developed and what has been produced does not fully incorporate the philosophies Calthorpe outlined.

The following reasons can be outlined for Transit Oriented Development not being prevalent in Indian cities.

- The first and the foremost reason being that most of the Indian cities are ancient and have been developed haphazardly without any proper planning. So in the absence of proper guidelines for implementing TOD it is very difficult for the planners to restructure the land use of the city.
- There is no consensus on the working definition of transit oriented development that encompasses all the components that are critical to the success of a TOD.
- TOD projects should capitalize on the synergy those results from a functional integration of land use and transit, such as reduced auto dependency, which in turn leads to other benefits. Physical characteristics are a means of achieving those desired ends, not ends in and of themselves.
- Adaptation to different locations and situations. Transit systems and locations vary greatly in their characteristics and their suitability for TOD. We should not expect the same results from a project in the core of a metropolitan area and one in the distant suburbs. So the TOD implementations have to be adapted according to different locations and situations.

- Transit-Oriented Development requires the transit stations to function as node and place simultaneously. That is it must achieve a functional integration of transit and surrounding uses. The need for transit-oriented development to function as both node and place affect virtually every aspect of the station area.

6.2.4 Why transit oriented development is not prevalent in Indian cities?

- No working definition of transit-oriented development exists
- Most of the Indian cities are ancient and have been developed haphazardly without any proper planning. So in the absence of proper guidelines for implementing TOD it is very difficult for the planners to restructure the land use of the city.
- Transit-oriented development must deal with the tension between node and place That is, it must achieve a functional integration of transit and the surrounding uses The need for transit-oriented development to function as both node and place affect virtually every aspect of the station area, from physical layout and design to the appropriate development program Yet as the discussion of the first challenge makes clear, the multitude of actors and goals to be found in any TOO project makes integration of node and place extremely difficult.
- Planners have no guidelines for translating the concept of location efficiency into concrete prescriptions for TOO in different settings
- TOD requires synergy among many different uses and functions, but this synergy is extremely difficult to achieve. As a result, TOD almost always involves more complexity, greater uncertainty, and higher costs than other forms of infill development.
- Transit oriented development typically occurs in a very fragmented regulatory and policy environment. There is often no comprehensive plan or vision, and many local governments suffer from a significant leadership gap.
- Transit-Oriented Development requires the transit stations to function as node and place simultaneously. That is it must achieve a functional integration of transit and surrounding uses. The need for transit-oriented development to function as both node and place affect virtually every aspect of the station area.

6.2.5 Strategy for Compact City

Compact Development and Household Trips

Improving energy security and environmental sustainability requires looking beyond peak-hour congestion and infrastructure-only solutions. Because less than 25 percent of household trips are work–home commuting trips, reducing the number of vehicle trips and miles traveled— key to reducing greenhouse gas emissions and oil consumption—means addressing the other 75 percent of trips. It means thinking holistically about trips throughout an entire day, week, and year.

Compact development is an important part of the energy and environment equation.

Case studies show that compact development results in fewer miles traveled, reducing fuel consumption and emissions. In areas where housing, employment, shopping, or services are close by even in low-density places without high-quality transit service people walk more. Compact development can reduce the cost of public infrastructure and encourage healthy habits such as incorporating walking and biking into daily routines.

6.2.6 Major Elements of Compact City

On the basis of the case studies the prime constituents of a Compact Development has been identified as under:

Compact development is neighborhoods or employment centers with most or all of the following:

- Concentrations of population and/or employment.
- Medium to high densities appropriate to the context.
- A mix of uses.
- Interconnected streets.
- Creative approaches to parking.
- Pedestrian, bicycle, and transit-friendly design.
- Access and proximity to transit.

6.2.7 Increasing Density

A central strategy for accommodating regional growth is to attract new jobs and housing into centers and corridors, which should be, identified in the future Growth Plans. As a result of this strategy, the density in centers and corridors will gradually increase over time.

The region will benefits from this approach in several ways:

- It reduces the need to expand the Urban Growth Boundary (UGB) and protects farmland and open space. If some of the projected growth is directed into centers and corridors it will promote vitalization of business districts and neighborhoods by directing investment into existing and emerging areas.
- A compact UGB helps stimulate economic growth in regional centers, town centers, station communities, main streets, and corridors. As population and employment growth occurs within the UGB, existing market areas intensify, increasing the attractiveness of centers and corridors for economic investment.
- As the economics of infill redevelopment improve, higher density development projects become increasingly more feasible. Supports better transit service. The concentration of jobs and housing provides a larger base from which to draw transit customers. The larger customer base promotes
- More frequent transit service throughout the day. As a result more frequent transit service attracts additional customers, particularly customers sensitive to time and convenience factors.
- Uses existing public investments more efficiently. Infill and redevelopment can often utilize existing sewer and water systems, schools, etc., thus reducing the need to make new public investments.

6.2.8 Mixed Use

Mixed-use business districts and neighborhoods bring together a variety of complementary land uses within easy walking distance of one another. The mix may include retail businesses, aches, commercial services, entertainment centers, restaurants, and a variety of residential uses. The most direct form of mixed use is to combine multiple uses in a single development project, either vertically or horizontally. Mixed use can also be achieved by linking single-use developments with a system of safe, convenient, and attractive pedestrian walkways- some of the benefits of mixed use are:

- Supports walking, ridesharing, cycling, and transit use by enabling people who use these travel modes to run errands, go out to lunch, and make other trips conveniently. Consequently, vehicle trips and dependence on cars are reduced.
- Generates off-peak transit use because trips to and from mixed-use developments

occur throughout the day and night. As a result, higher transit frequendes can be sustained all day, further increasing the attractiveness of transit.

- Adds to the economic vitality of business districts by increasing the diversity of retail and commercial services offered. Mixed-use districts attract visitors who enjoy exploring the diversity of unique business districts. Also, they provide a convenient mix of goods and services to employees during the day and residents in the evening. As a result, many businesses have a steady flow of customers all day.
- Contributes to neighborhood livability by providing activities within easy walking distance of neighborhoods. Residents in or near mixed-use areas can combine exercise (walking), errands (food shopping, shoe repair, video rentals), and entertainment (dining out, movies, live music). With these choices available, residents tend to walk more in their neighborhoods, increasing the area's safety, friendliness, and livability.

6.2.9 Pedestrian-Oriented Design

Providing for the safety, convenience, and comfort of pedestrians is a basic goal of transit supportive development. Each new development project or transportation improvement provides an opportunity to improve the environment for pedestrians. Some of the benefits of pedestrian oriented design are:

- Encourages transit use by providing safe and direct connections between transit stops or stations and destinations in the zone.
- Enhances all transportation choices because, with few exceptions, all other travel modes involve a pedestrian element.
- Reduces the impact of large land uses, such as shopping centers, apartment complexes, or entertainment centers, by designing these projects to Wend visually and functionally with adjoining development.

6.2.10 Multimodal Street Design

To assure regional mobility in the future, an extensive network of multimodal streets is needed. Multimodal streets balance the needs of pedestrians, bicycles, cars, trucks, and transit vehicles in a way appropriate to the particular function and location of a road or street. Some roads may give more priority to cars and trucks; others may give

6.3 PLANNING GUIDELINES FOR COMPACT TRANSPORT-ORIENTED DEVELOPMENT IN DELHI

Delhi along with other growing metropolitan cities throughout the country, is increasingly faced with a crisis of many dimensions: mounting traffic congestion, diminishing affordable housing, receding open space, threatened wildlife, urban sprawl, air pollution and socially isolated communities. Reliance upon typical patterns of low density urban development will perpetuate these problems. The goal of this dissertation is to evolve planning guidelines for compact transport-oriented urban development in Indian cities by redirecting urban growth to patterns which reduce automobile dependence and support public transportation, while minimizing impacts on existing community character.

The Planning Guidelines for Compact Transport-Oriented Development represent strategies to accommodate projected growth within Delhi, maintain the city's present quality of life, and allow for continued economic vitality. Consistent with these concerns, these Planning Guidelines are based on the following guiding principles:

- Maximize the use of existing urbanized areas accessible to transit through infrastructure-sensitive infill and redevelopment.
- Reduce consumption of non-urban areas by designing the urban area efficiently.
- Employ land use strategies to reinforce transit.
- Reduce the number of auto trips and regional'vehicle miles traveled by creating opportunities to walk and bike.
- Protect the natural environment and community character by reducing the need for roadway expansions.
- Reduce air pollutant emissions and conserve limited energy resources.
- Provide a diversity of housing types

The entire TOD site must be within an average 500m walking distance of a transit stop. Secondary Areas of lower density housing, schools, parks, and commercial and employment uses surround TODs for up to 3 km.

Retail and office uses in the commercial core of the TOD will vary depending on its location, purpose, and market demand. For example, some TODs may focus on shopping centers with both employment centers and supporting retail and services; commercial core areas in other TODs will be made up of existing commercial shopping

streets or a typical neighborhood shopping center with a standard grocery/drug store anchor; and finally, the smallest TODs will focus on a convenience center. Additional TOD uses will also vary based on their location. TODs with high frequency transit service are most appropriate for intensive employment and housing uses; TODs with less frequent transit service will have lower density residential and neighborhood uses. The residential densities and building intensities specified by these guidelines are designed to allow a service-oriented transit system that runs at frequent headways to important destinations in the region.

6.3.1 Proximity to Transit

Locating a majority of transit-supportive uses within a 400 to 600 m walking distance of the LRT station makes transit the most convenient and attractive travel mode for the site.

Description:

Proximity to transit is a key factor in determining the suitability of a site for higher density, mixed-use developments. Convenient transit service is necessary to reduce traffic congestion during commute hours; added benefit can be gained by capturing local trips on-site before they reach arterial streets. A fundamental purpose of the TOD concept is to create a land use pattern which will ultimately support transit. In order for TODs to successfully reduce auto travel throughout Delhi, they must be located within easy walking distance of, or within convenient feeder bus connections to dedicated transit lines.

Justification:

As per the data analysis and primary survey results of Delhi more than 80% of the passengers take more than 10 minutes to reach the metro station. So it is the primary objective to increase the population density within the influence zone. It is also important that destinations on either end of the trip are pedestrian-oriented and mixed-use. The City of Delhi is fortunate to have an established transit system that is well-used with opportunities for growth. The transit system in Delhi has three broad levels of service: the MRTS consisting of high speed Meetro trains, the BRTS and the LRTS or the sub urban railway which connect neighborhoods with major destinations in Delhi, and the "Feeder Bus Network" made up of local bus lines that connect with the Metro network or bus

priority to transit vehicles and pedestrians. Some of the benefits of multi modal street design are:

- Preserves mobility by encouraging transportation facilities and development patterns that make walking, bicycling, and buses competitive choices compared with private mode driving.
- Encourages more efficient movement of people in roadways, rather than the addition of more vehicles.
- Increases the capacity of the existing street system.

6.2.11 Planning Considerations

For any development to occur community and stakeholders collaboration is essential for this an ad-hoc smart growth plan committee comprising of members from residents, industries, municipality and development authority should be constituted.

- The aim of the development must be to provide transit- oriented development.
- The rural area and the forest land should not be encroached upon for development.
- Mixed land use should be permitted.
- Mixed use high density development should be permitted for the development along the main road.
- The township needs to improve upon the site development standards to insist on functional and attractive landscaping, development of pedestrian and bicycle pathways, street trees, street lights and proper use of signage.
- Protect open space and create some recreational use.

The following features activities enable the use of a transit station in the above Mentioned manner:

- Park and ride
- To ensure quick and easy transfer
- Adequate transport access at transfer points parking areas
- Facilitate free circulation to all modes
- Inter change facilities
- Kiss and ride
- Para transit stands

corridors that run through the city. TODs must be located on a segment of the Metro corridor, BRTS corridor and sub urban railway network. These locations offer the greatest opportunity for creating mixed-use destinations that reflect the significant investment necessary to construct the transit system and generate the greatest number of transit-bound trips.

6.3.2 Relationship to Transit and Circulation

The TOD site must be located on: 1) an existing or designated transit line network; 2) on a high-frequency bus corridor; or 3) on a feeder bus line network within 10 minutes transit travel time from a stop on the trunk line network. Where transit may not occur for a period of time, the.land use and street patterns within a TOD must function effectively in the interim and guide the timing and location of future transit lines.

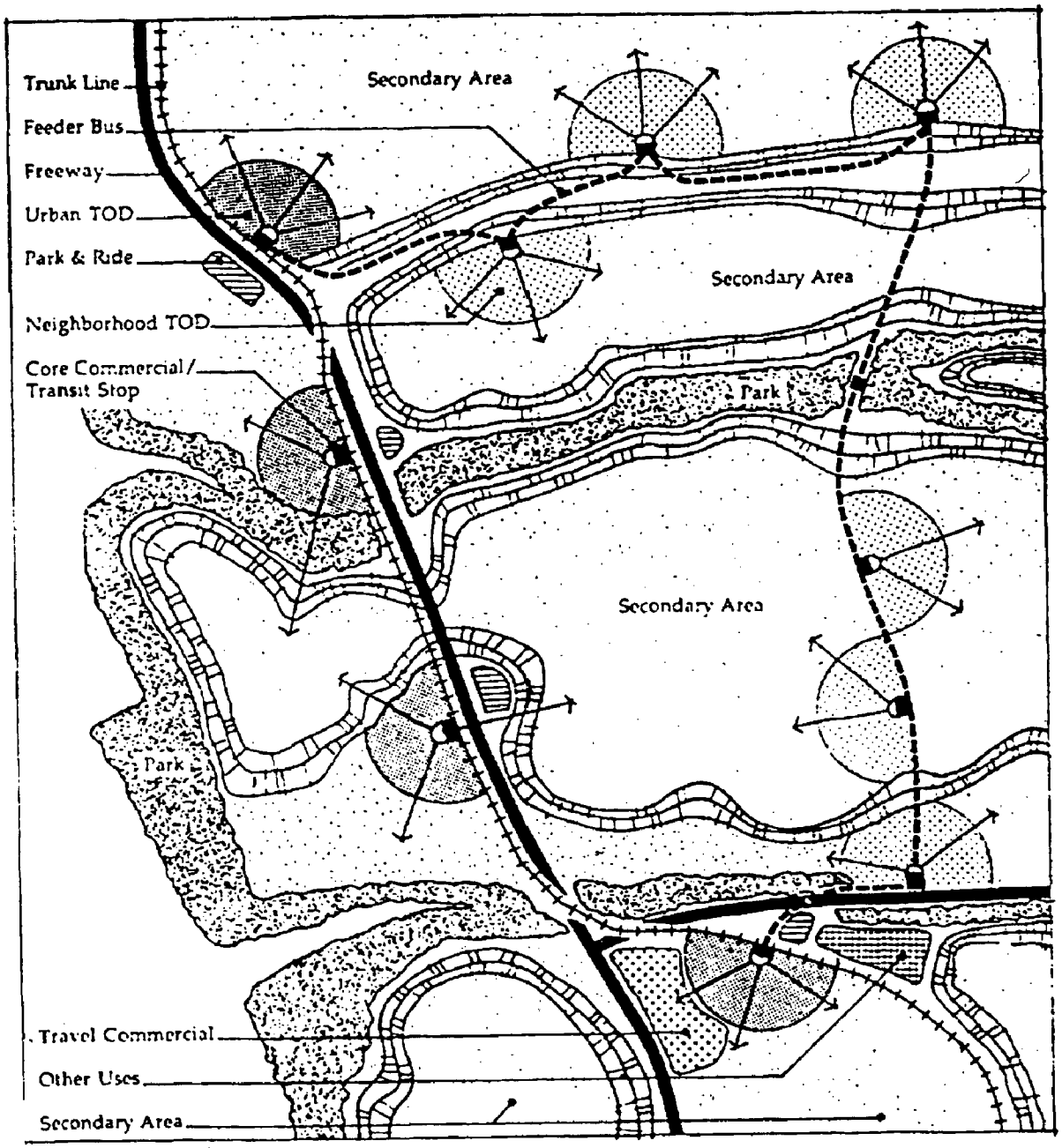
Description:

The transit line network of Delhi consists of Metro rail, light rail lines or high speed limited stop bus service, with at least a 15 minute frequency of service. TODs will be located either at Metro stations, light rail stations or BRTS stations. The feeder bus line network is a system of timed transfer local bus routes which link to the transit line. Transit stops on the feeder bus line network that serve as links to the transit line, should be within 10 minutes transit travel time (approximately 2 to 3 miles), from a transit station, with buses running at least a 15 minute frequency of service.

Justification:

A fundamental purpose of TODs is to create a land use pattern which will support transit. Studies by RITES, Gurgao and other transit agencies have shown that the greatest pedestrian "capture rate" for public transit occurs when transit stops are within a 10 minute walking distance from home or office, have frequent headways, and are close to a dedicated transit right-of-way. It is also important that the destinations are pedestrian-oriented and offer a mix of land uses.

Figure 6.1: Showing the relationship between transit and circulation pattern



Source: Calthorpe Associates

6.3.3 Urban TOD

Urban TODs are located on the transit lines, at light rail or at bus stops, and may be developed at high commercial intensities and residential densities.

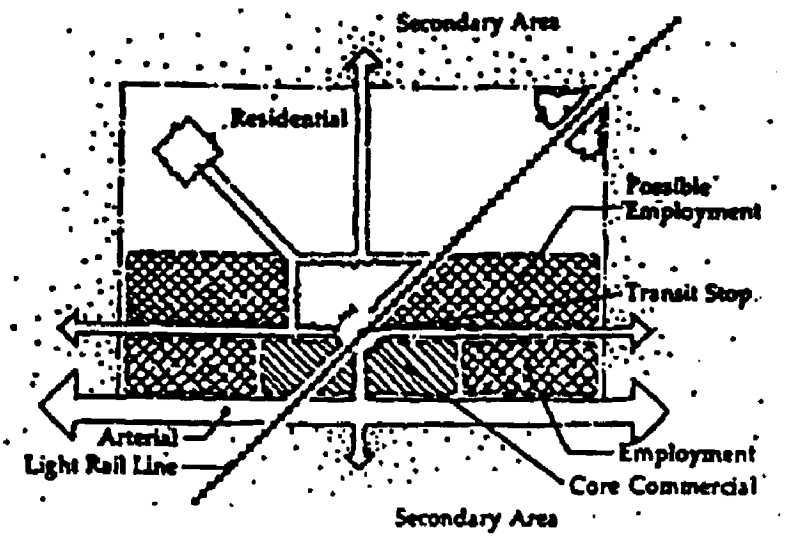
Description:

Special site development guidelines are recommended for TODs that are highly accessible by transit to permit higher density residential development and **to** encourage a higher percentage of job-generating uses. Where Urban TODs are located in existing developed neighborhoods, it may be appropriate to apply the densities and mix of uses recommended for Neighborhood TODs. Urban TODs are typically sited approximately 1 km apart to meet Metro station spacing guidelines, although they could be sited closer together in certain circumstances. Examples of potential Urban TOD include sites within the Old Delhi area, Rajiv Chowk, Canaught Place and Delhi University.

Justification:

Each TOD may assume a different character and mix of uses depending on its location within the region and the surrounding land uses. Urban TODs are suitable for job-generating and high intensity uses, such as offices, large-scale shopping centers, and high density housing, because, they allow direct access from any location within the transit system without requiring passengers to transfer between modes. Similarly, the intensity of development along the transit line should reflect the significant investment necessary to construct the transit system and should generate the greatest number of transit-bound trips.

Figure 6.2: Urban TOD



Source: Calthorpe Associates

6.3.4 Neighborhood TOD

Neighborhood TODs are located on the transit lines or the feeder bus line network within 10 minutes transit travel time (no more than 3 miles) from a light rail stop or express bus stop, or along high frequency bus lines that pass through residential neighborhoods. They should place an emphasis on residential uses and local-serving shopping.

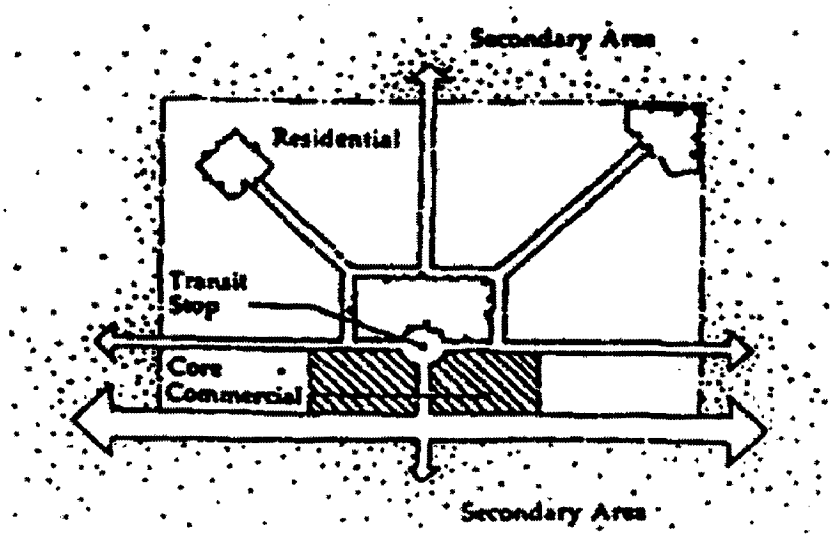
Description:

Land use proportions and density standards for Neighborhood TODs encourage sites which are served by local feeder buses or along high frequency bus lines, but are not located along the trunk transit line network. Neighborhood TODs should have a residential and local-serving shopping focus. Neighborhood TODs will typically cluster around a bus stop. Where bus stops are frequent, TODs can be sited close together and form a "corridor" of higher density, mixed-use nodes Potential Neighborhood TOD sites in Delhi include parts of Narela, Dwarka and Rohini.

Justification:

Neighborhood TODs can help provide affordable communities because they include a variety of housing types to meets the needs of an increasingly diverse population of the city in a land use pattern that minimizes the need for multiple car households. If properly designed, Neighborhood TODs can meet local needs for public facilities and parks, respect the character and quality of existing neighborhoods, and limit inter-community traffic through residential areas.

Figure 6.3:
Neighborhood TOD



Source: Calthorpe Associates

6.3.5 Redevelopable, Urbanizing and New Growth Areas

TODs may be developed on Redevelopable and Urbanizing Sites and in New Growth Areas. Redevelopable sites are developed areas of the city that could be revitalized with new uses and transit service. Urbanizing sites are vacant sites surrounded by existing urban development New Growth Areas are larger, undeveloped properties on periphery of the city. Community plans, specific plans, and plans for transit corridors should identify appropriate sites in each of these settings for TODs and transit service.

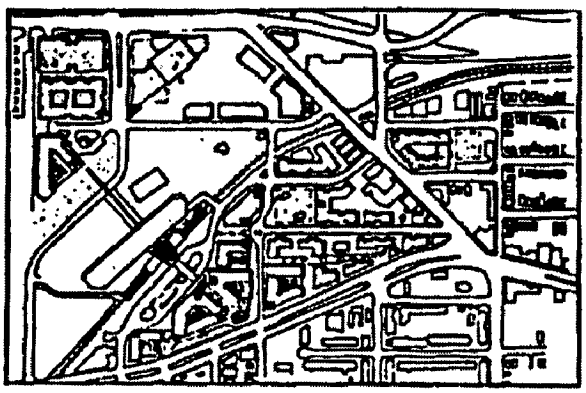
Description:

Three types of settings have been identified which broadly characterize the physical pattern of development throughout the city: Redevelopable Sites, Urbanizing Sites, and New Growth Areas. These three functional settings represent the range of conditions where TODs could be located. The characteristics of these settings are summarized below:

1) **Redevelopable Sites**

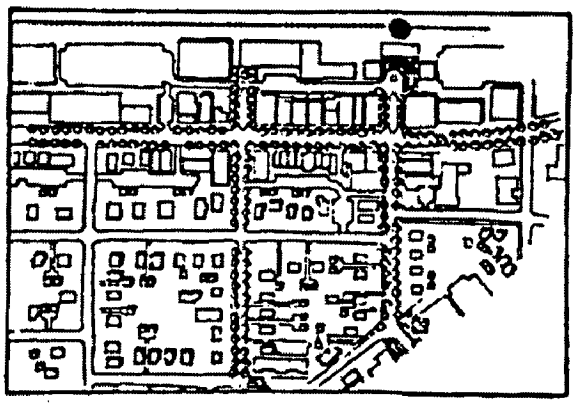
A majority of Delhi is urbanized and fully built-out. As land values increase over time, older neighborhoods may gradually transition to new uses and economically underutilized areas may redevelop to more intensive uses. TODs may be able to take advantage of this change to reinforce the transit system with land uses that provide riders and provide incentives to creating pedestrian-oriented environments.

Figure 6.4: Redevelopable Sites



Source: Calthorpe Associates

Figure 6.5: Urbanizing Sites



Source: Calthorpe Associates

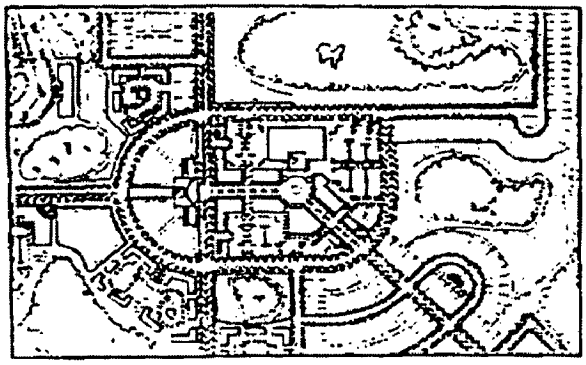
1) Urbanizing Sites

This category represents undeveloped parcels of land that have been "skipped over" in the process of growth and are surrounded by existing development. In many cases these parcels do not have an established street system on-site, but are connected to surrounding neighborhoods or adjacent to existing commercial developments. These sites are often large enough to develop all or a major portion of a TOD; the existing surrounding neighborhoods will then function as its Secondary Area. Many of these sites are still vacant because their landuse has been recently changed from agricultural and rural to urban.

2) New Growth Areas

There are a number of large undeveloped sites within the Planned Urbanizing and Future Urbanizing Areas with planned or potentially viable transit service. These sites should be developed as one or more TODs, with associated Secondary Areas, under the guidance of these Design Guidelines. While New Growth Areas are the easiest to develop with transit- and pedestrian-oriented patterns, they are generally located at the edge of urban development and may ultimately spread the size of the city.

Figure 6.6: New Growth Areas

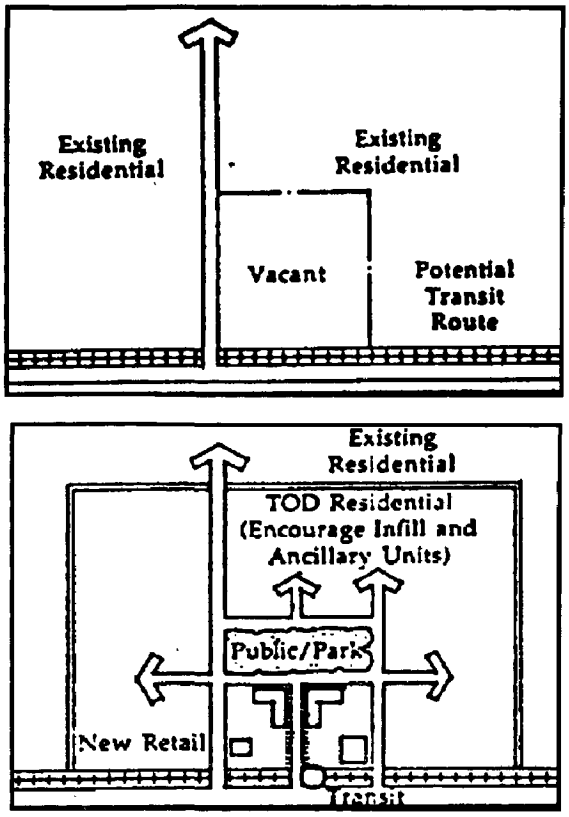


Source: Calthorpe Associates

Justification:

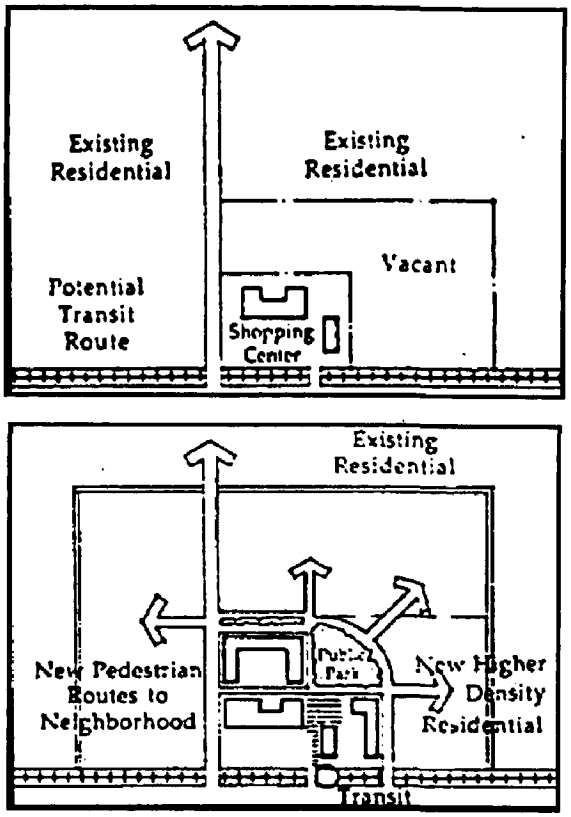
TODs are an opportunity to promote efficient development patterns, both in the existing urbanized fabric of the city and in growth areas. Efficient development patterns provide a number of benefits, including minimizing urban sprawl, reducing vehicle miles traveled, improving air quality, and enhancing the social aspect of neighborhoods

Figure 6.8: Complement existing residential areas with new commercial and public uses



Source: Calthorpe Associates

Figure 6.9: Complement existing commercial centers with high density residential areas



Source: Calthorpe Associates

Justification:

A neighborhood or employment area has local destinations within convenient walking distance, residents and employees are more likely to walk or bicycle. Furthermore, if local destinations are accessible to drivers without requiring use of the arterial street system, congestion can be reduced.

Vertical mixed-use buildings do contribute to a healthy pedestrian environment, but are much more difficult to implement due to common real estate practices that encourage single-use buildings. For this reason, the TOD concept does not rely on vertical mixed-use to create pedestrian-oriented places.

6.3.7 Ensure transit supportive uses

Description:

Transit supportive uses are high pedestrian generators that directly promote greater transit ridership. They also provide opportunities for multi-purpose trips that can be made as a pedestrian. Medium to high density residential, offices, high schools and

colleges are significant transit supportive uses. Appropriate retail, restaurants, personal service and civic functions will support these major uses and generate activity in both peak and off-peak hours.

Justification:

A bidirectional traffic flow is essential to utilize the full capacity of a transit system and make it financially sustainable. Transit supportive use not only promotes greater ridership but also results in bidirectional traffic flow.

6.3.8 Limit non transit-supportive land uses

Description:

As the focus of TOD is the transit rider and pedestrian, it is important that auto-oriented development does not overwhelm the station area. Non-transit supportive land uses are oriented primarily to the automobile and not the pedestrian or transit user. These types of land uses:

- generate high levels of vehicle activity
- are oriented towards automobile use
- consume a large amount of land through low-density form
- require extensive surface parking areas
- Create negative impacts for pedestrians such as isolation from building frontages, long windswept walks, and numerous vehicle crossings on sidewalks, and/or typically does not attract extended hours of activity.

Uses that are typically considered as "non-transit supportive" are: stand-alone auto-oriented uses and formats automotive parts, repair and service car dealerships, car washes, drive through facilities, gas/service stations, commercial surface parking, low intensity industrial bottle depot, warehouse storage and movement of goods.

Justification:

Non transit-supportive land uses should not be located in the immediate station area where there is high pedestrian activity and bus traffic. These uses may be considered towards the edge of a station planning area where higher intensity uses may not be feasible, or as part of a larger comprehensive transit-supportive development. In all cases, key pedestrian and urban design elements discussed in this document should be employed.

6.3.10 Street and Circulation System

The TOD street system should be clear, formalized, and inter-connected, converging to transit stops, core commercial areas, schools and parks. Cul-de-sac and "dead end" streets should be avoided or connected by pedestrian passages and/or bicycle paths. Multiple and parallel routes between the core commercial area, the TOD, and surrounding Secondary Areas must be provided so that local trips are not forced onto arterial streets.

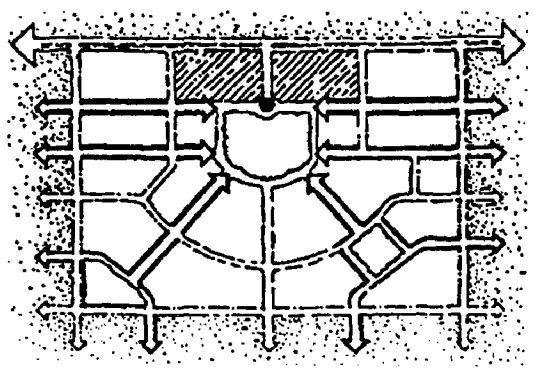
Description:

The street pattern should be simple, memorable and direct, and avoid circuitous routes. Streets should converge near common destinations, such as transit stops, core commercial areas, schools and parks. They should allow autos, bikes, and pedestrians to travel on small local streets to any location in the TOD and to the Secondary Area. Street connections should be designed to keep through community trips on arterial streets and local trips within TODs. The TOD street system should focus streets into the core commercial area, yet minimize the number of light rail at-grade crossings. At no time should an arterial street be the only route to and from an area of the TOD

Justification:

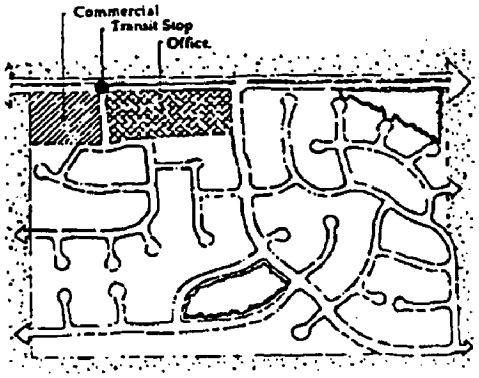
Clear, formalized, and inter-connected street systems make common destinations visible, and provide the shortest and most direct path for pedestrians and bicyclists. With an inter-connected street system, any single street will be less likely to be overburdened by excessive traffic, thus reducing the need for cul-de-sacs. A street pattern which is circuitous and complex will discourage pedestrians; a street system with landmarks and a simple form will be memorable and familiar.

Figure 6.12: Preferred Street pattern



Source: Calthorpe Associates

Figure 6.13: Discouraged street pattern



Source: Calthorpe Associates

6.3.11 General Design criteria

TODs should create pedestrian-oriented environments. In general, buildings should address the street and sidewalk with entries, features and activities, to enliven streets and to create safe, pleasant walking environments. Building intensities and densities should exceed minimum requirements to promote more active commercial centers, to support transit, and to encourage development that addresses the street Variation is encouraged.

Description:

Create convenient, comfortable, direct, and safe pedestrian linkages to and from all Transit Stations in order to support a walkable station area and promote the use of transit. With the possible exception of anchor retail stores, primary building entrances should be physically and visually oriented toward streets, parks and plazas, and not to the interior of blocks or to parking lots or garages. Secondary building entrances oriented toward parking lots are permitted. Where existing viable uses are separated from the street by large parking lots, infill is encouraged at the street. In addition, new internal streets may be constructed closer to existing entries, thus creating a "main street" pedestrian setting.

Justification:

Highest commercial intensities and residential densities should occur in the TODs. Core commercial areas should be intensive enough to provide a "main street" shopping spine. Furthermore, multi-storied buildings and structured parking are strongly encouraged near transit stops to better utilize the lands adjacent to the transit line and to provide additional transit ridership.

6.3.12 Ensure Good Urban Design

Description:

1) **Create high quality streets**

A pedestrian-friendly street is visually interesting and makes walking enjoyable. Trees, landscaping, wide, separate sidewalks and on-street parking protect people from vehicle traffic and create a pleasant pedestrian zone. Benches provide places for people to rest and relax.

2) Make the most of architecture

The Architectural variety on the lower three to four stories can define an interesting public realm. Articulated building facades incorporate attractive windows and varied architectural elements, and are built to the sidewalk. Upper floors of tall buildings can be set back to allow sunlight to reach the street and help reduce the sense of scale of the building.

Figure 6.14: Architecture and street related uses can make street interesting

Source: TOD Best practices Handbook

3) Locate pedestrian-oriented uses at the ground level

As TOD is focused on pedestrian comfort, the ground floor should contain uses that are appealing to pedestrians, such as retail, personal service, restaurants, outdoor cafes, and residences. Foot travellers tend to relate to the ground storey of buildings. This level accommodates residential units, building entrances and retail shops oriented to the sidewalk. Surface parking lots, parkade accesses and blank exterior walls are limited along major pedestrian streets.

4) All season design

Where possible, pedestrian connections and transit waiting areas provide weather protection in the form of awnings, building projections and colonnades. Ample enclosed shelters make waiting for transit more comfortable.

5) Lighting, landscaping, and signs

Stations are well-lit and designed to accommodate "around-the-clock" activity. Landscaping features can define special precincts and encourage transit patrons to linger and explore the station area. Convenient and legible signs orient visitors to buildings and activities around the station.

6.3.13 Provide a compact development pattern

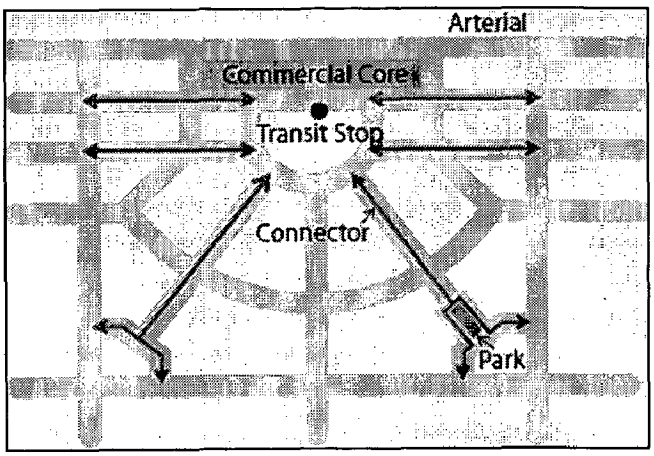
Description:

1) Compact Street Network

Frequent, interconnected streets increase the efficiency of transit circulation and offer more choices for pedestrians. Blocks of 100 to 150m in length keep walking distances short and provide alternative route options. A grid based street pattern offers

multiple accesses to the station and forms the overall development framework for long term transit supportive uses.

Figure 6.15: Compact development pattern



Source: TOD Best practices Handbook

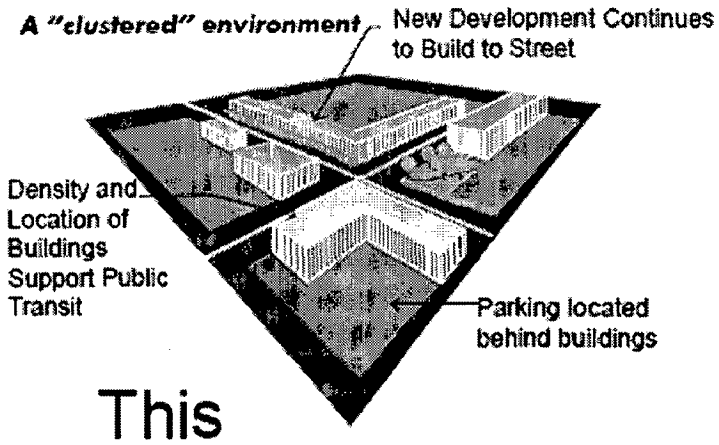
2) Cluster buildings

Buildings that are grouped together, or clustered, offer a "one-stop" opportunity to conveniently access a variety of destinations on foot. Clustered buildings can frame distinct character areas and create an easily navigable walking environment.

3) Leave room to grow

Buildings can be thoughtfully sited on a property to accommodate future intensification. Placing buildings to one side of a parcel, instead of in the centre, leaves sufficient land that can be developed later. This will allow an initially low density area around a transit station to intensify over time.

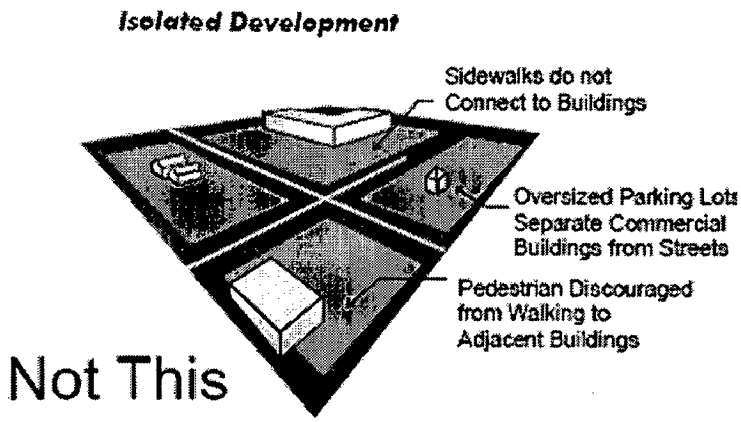
Figure 6.16: Clustered development



Orient building along the street helps establish a "park once" environment where people are encouraged to walk between buildings.

Source: TOD Best practices Handbook

Figure 6.17: Isolated Development



Building too far from street, resulting in long walks through parking areas.

Source: TOD Best practices Handbook

Justification:

As Delhi continues to grow, land economics may make future intensification desirable. Commercial area development plans should include long-term strategies for additional stories and buildings, as well as structured parking.

Buildings must be of a sufficient intensity and density to create safe and active streets enhanced by a sense of enclosure and visual interest, and to support transit. Orienting buildings to public streets will encourage walking by providing easy pedestrian connections, by bringing activities and visually interesting features closer to the street, and by providing safety through watchful eyes and activity day and night. Moderate to high intensities and densities also support frequent and convenient transit service; and retail centers can provide a greater variety of goods and services if more residents and employees are within close proximity.

6.3.14 Pedestrian-Oriented Design

Description:

1) Provide quality pedestrian connections

A convenient, comfortable pedestrian-oriented route has the following qualities:

- Routes are short
- Routes are continuous and barrier-free
- Routes are direct
- Routes are safe
- Routes are easily navigable

a) Walking distances are short

Pedestrian routes between the station and key destinations are short and direct. Key destinations are located within a 400 to 600 meter radius of the station. Circuitous routes are avoided.

b) Pedestrian connections are continuous

Sidewalks and pathways are continuous routes that are easy to find and follow. Major connections to the station for pedestrians and bicycles are constructed at the outset. Routes are universally accessible to wheelchairs, strollers, scooters and other mobility aids.

c) Access is direct

Sidewalks connect directly to the entrances of the station and buildings. Bus stops are located as close as possible to building entrances. Walking distances from the station to the nearest bus stop are generally shorter than the distance to the nearest parking space.

d) People are at street level

Pedestrian routes are at ground level, with minimal stairs and grade changes. Adjacent buildings provide "eyes on the street" and informal security here. Pedestrian routes are located on public streets unless there are good opportunities to tie in to a safe, existing above-grade system

Figure 6.18: Foot over bridges

Source: TOD Best practices Handbook

e) Separate vehicular and pedestrian functions

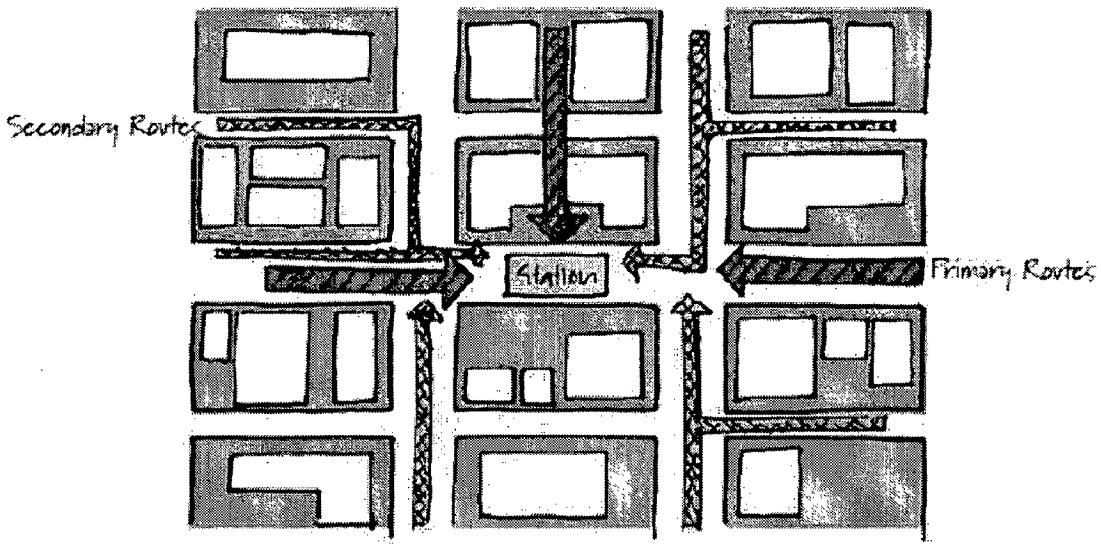
Vehicular and pedestrian ways are designed to minimize points of conflict. Sidewalk and pathway routes have as few driveway or parking lot crossings as possible.

Primary and secondary pedestrian routes should be identified in the TOD station area.

i. ***Primary Pedestrian Routes***– These routes run directly between the LRT platform and station site and major pedestrian destinations in the surrounding community. These routes will attract high pedestrian volumes, associated pedestrian oriented services and act as the major connections to the station. Primary routes would typically include wider sidewalks and may include station access bridges, public easements, and regional pathways. In addition, buildings along these primary routes would be oriented to the street – buildings built to the street with minimal setbacks and direct building entrances oriented to, and connected from the sidewalk.

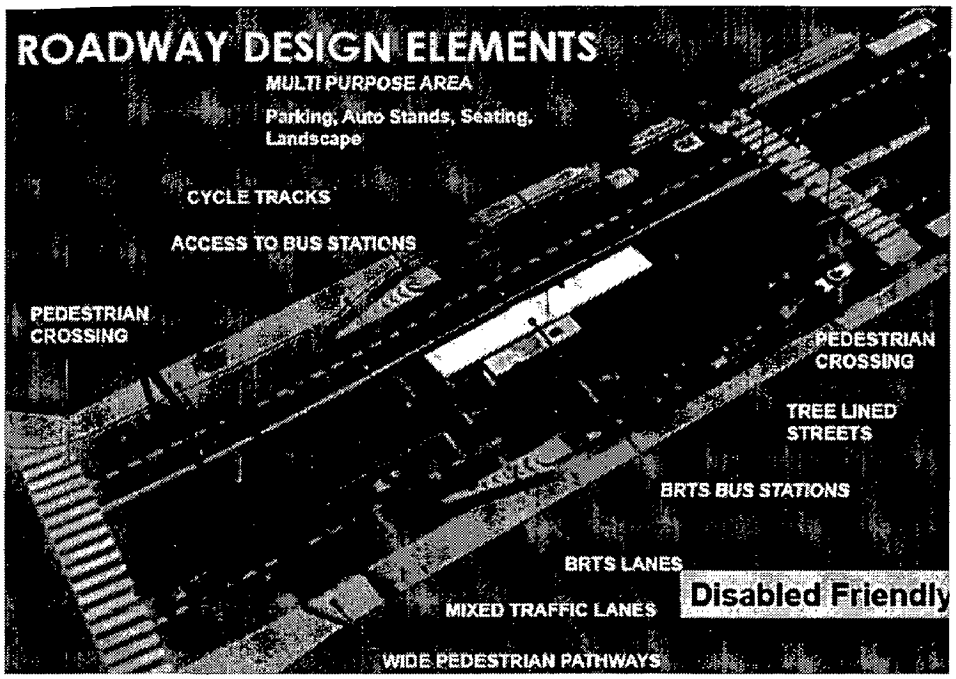
ii. ***Secondary Pedestrian Routes*** – These routes do not provide a direct link to the LRT station site but feed into the primary routes. These routes would typically be at ground level and include standard sidewalks and private accesses to individual buildings.

Figure 6.19: Primary and secondary pedestrian connections provide access to the Station and throughout the area.



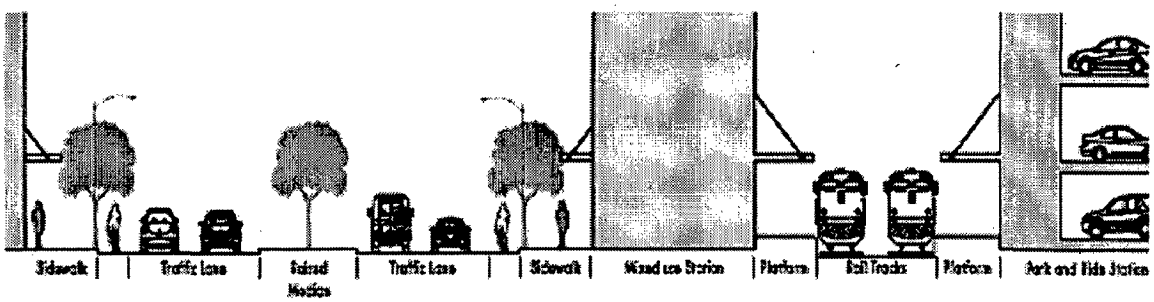
Source: TOD Best practices Handbook

Figure 6.20: BRTS station area street design



Source: TOD Best practices Handbook

Figure 6.21: MRTS station area street design cross section



Source: TOD Best practices Handbook

6.3.15 Provide integrated public systems

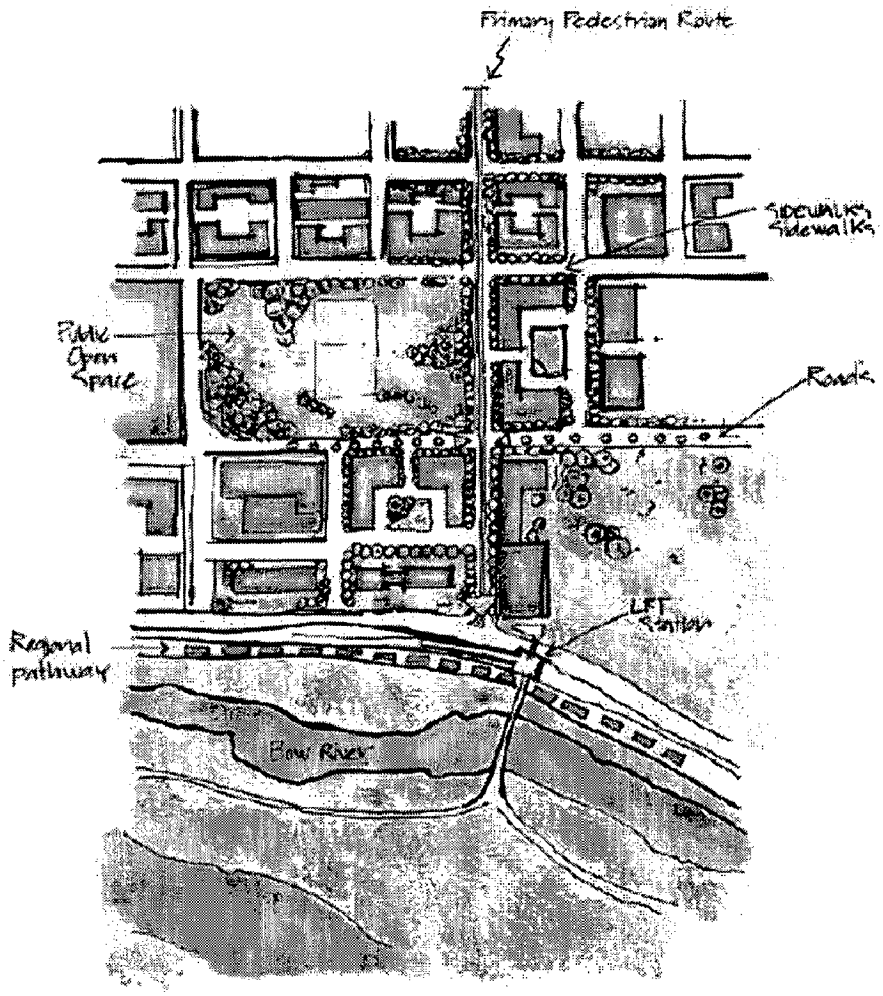
Public systems are essential to ensure a fully integrated station area. Elements of the public systems should include:

- Primary and secondary pedestrian routes
- Bicycle routes
- Roads
- Sidewalks
- Regional pathways and local walkways (both public and private)
- Pedestrian/cycle overpasses and underpasses
- Public open space

- Transit stations
- Bus stops
- Development should be integrated with all elements of the public system in order to create pedestrian comfort and an effective network for all travel modes within the station area.

- Regional pathways and bicycle routes should be located close to, but physically separated from a Transit Station, vehicle drop-off zones or bus stops to avoid potential conflicts with cyclists and transit passengers. This allows for thru-traffic by cyclists, with local linkages connecting directly to the Station and bicycle parking.

Figure 6.21: An integrated public system is essential for TOD.
The Bridges development, Calgary, AB.



Source: TOD Best practices Handbook

6.3.16 Human scaled architecture

Buildings should be designed to ensure that pedestrian comfort is of primary importance in station areas

Doorways and windows should be oriented to the street level in order provide ease of entrance, visual interest and increased security through informal viewing

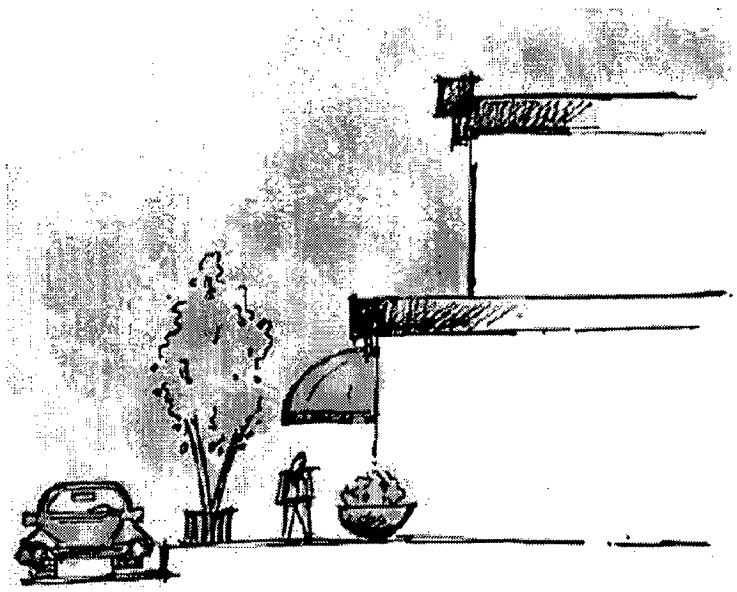
Architectural variety (windows, variety of building materials, projections) should be used on the lower stories of a building in a TOD station area in order to provide visual interest to the pedestrian.

Buildings higher than 4 to 5 stories should step back higher floors in order to maintain the more human scale along the sidewalk and reduce shadow impacts on the public street.

6.3.17 Incorporate all-season design

Primary pedestrian routes, developments and transit facilities should incorporate climate and weather protection. This can include covered waiting areas, building projections and colonnades, awnings, bus stops, use of landscaping etc. These design elements will make waiting for, and getting to and from transit stops more comfortable.

Figure 6.22: Buildings in TOD stations areas should create a comfortable environment for the pedestrian.



Source: TOD Best practices Handbook

6.3.18 Core Commercial Areas

Each TOD must have a mixed-use core area containing ground floor retail and commercial space that occupies at least 10 percent of the total TOD site area adjacent to an anticipated transit stop. A minimum of 1000 sq.m. of retail space must be provided within 200 m of the transit stop. The location of the core commercial area within the TOD is flexible.

Description:

Core commercial areas are required in every TOD and must be located adjacent to an anticipated transit stop. Street-level retail and service commercial space should form a pedestrian-oriented "main street" that is accessible from the surrounding TOD without requiring pedestrians or autos to use an arterial street. Stand-alone office and employee-intensive light industrial uses should be located adjacent to the shopping portion of the core commercial area.

The size and mix of uses in each core commercial area can vary, depending on the size, location, and overall function of the TOD in the region. It should, at a minimum, serve as a transit destination and convenience shopping area for TOD and Secondary Area residents and employees. Appropriate uses include retail shops, professional offices, service commercial uses, restaurants, cinemas, health clubs, and other entertainment facilities.

Types of commercial centers that can occur in TODs include: convenience shopping and services (1000 to 1500 sq.m.); neighborhood centers with a supermarket, drugstore and supporting uses (7500 to 13,000 sq.m.); specialty retail centers (5000 to 120,000 sf); and community centers with convenience shopping and department stores (12000 sq.m. or greater). Other employment-generating uses can be located within the core commercial area to provide a balance to shopping and residential uses.

Justification:

Mixed-use core commercial areas are the primary link between transit and land use. A TOD must have sufficient retail and commercial space to form a useful shopping center and provide opportunities for residents and employees to run errands, during lunch-time or to and from work. Without shopping opportunities within convenient walking distance, residents and workers will use their cars for more trips and will lose an

incentive to use transit. Core commercial areas must vary in size and character to respond to market considerations

6.3.19 Office Intensities

Office intensities in core commercial areas without structured parking must have a minimum 035 Floor Area Ratio (FAR) and may not exceed 0.60 FAR. Structured parking is strongly encouraged in both Neighborhood and Urban TODs; maximum FARs should be set by community plans.

Description:

As land values in the Dilhi region rise, structured parking in a number of locations will become economically feasible. This guideline encourages development of multi-story buildings with structured parking, thereby allowing more efficient use of land in the TOD

Justification:

Office areas should promote efficient utilization of land near transit stops. These floor area ratios encourage multi-story buildings and structured parking whenever possible. Larger office areas should be located in Urban TODs to create a major focus of symbiotic uses. Smaller, local-serving office areas create opportunities for small businesses in close proximity to retail and transit.

6.3.20 Commercial Building Setbacks

Building setbacks from public streets should be minimized. Setbacks should reflect the desired character of the area and bring buildings close to the sidewalk.

Description:

Buildings in core commercial areas should be encouraged to build to the sidewalk edge whenever possible Parking areas and parking garages should be recessed or placed to the rear of buildings. Larger setbacks of up to 20 feet should be permitted for office buildings and streetside outdoor cafes and patios in core commercial areas

Justification:

The street and sidewalk is the main pedestrian activity center. Minimal setbacks bring buildings close to the street and the pedestrians. This defined and close edge enlivens commercial areas by encouraging window shopping and streetside activity.

6.3.21 Commercial Building Facades

Building facades should be varied and articulated to provide visual interest to pedestrians. Street level windows and numerous building entries are required in the core commercial area. Arcades, porches, bays, and balconies are encouraged. In no case shall the streetside facade of a building consist of an unarticulated blank wall or an unbroken series of garage doors.

Description:

Varied and interesting building facades are key to making a place "pedestrian-oriented." Building designs should provide as much visual stimulus as possible, without creating a chaotic image. Buildings should incorporate design elements at the street level that draw in pedestrians and reinforce street activity. Facades should vary from one building to the next, rather than create an overly unified frontage. Building materials such as concrete, masonry, tile, stone, and wood should be encouraged; glass curtain walls and all reflective glass should be discouraged

Justification:

Streets with monotonous and unarticulated building frontages are not conducive to pedestrian activity and make walking less appealing. Streetside buildings should encourage window shopping, heavy foot traffic in and out of stores, and people-watching from outdoor seating areas

6.3.22 Upper Story Uses in Core Commercial Areas

Retail developments in the core commercial area may add two additional floors of residential and/or office uses, as determined by community plans. When using this bonus, the intensity of the retail use must not be reduced, required retail parking may be reduced or eliminated, parking for residential units and office space must be added, and the buildings must be consistent with these design guidelines

Description:

This density bonus for retail buildings is designed as an incentive for developers to provide office and residential uses in the core commercial areas. The amount of upper floor office or residential uses may be determined on a site-specific basis through the community plan or specific plan process. Special care must be given to the design of residential units to ensure privacy and security.

Justification:

Taller buildings are encouraged in the core commercial areas to provide visual interest, a more urban character, street security at night, and to concentrate pedestrian activity. In addition, upper floor residentialand/or office space can support the retail by bringing a greater number of lunch-time and after-work shoppers.

6.3.23 Residential Mix

A mix of housing densities, ownership patterns, price, and building types is desirable in a TOD.

Description:

While each TOD will take on a different character and will have a different proportion of single-family and multi-family densities, care should be taken to provide a variety of housing types, costs, and ownership opportunities within each TOD. The residential portion of the TOD can be a combination of small lot single-family units duplexes, townhouses, and apartment buildings.

Justification:

In order for TODs to be affordable to the diverse range of households in San Diego, TODs must provide a mix of housing types. Single-family housing has, and will continue to have, strong market demand. Higher density townhouses and multi-family units are, however, gaining an increasing proportion of the market share. The range of permissible residential densities in TODs can accommodate all of these household needs. Providing a mix of housing types will also result in more "cosmopolitan " communities

6.3.24 Make Each Station Area a "Place"

Each station area should be developed as a unique environment, transforming a utilitarian transit node into a community gateway and a vibrant mixed-use hub of activity.

1) **Create a Destination**

A transit station is a destination in its own right, as well as a gateway to the rest of the city. A station area with a collection of unique places will attract visitors, while also serving transit patrons and the local community.

2) Emphasize important buildings

- Public or high profile buildings (i.e. MRT station, large commercial, prominent residential) should be highly visible landmarks within the TOD area.
- These buildings should have distinctive design features that can be easily identified and be located on high exposure sites, at the terminus of a sight line or view
- Taller buildings should have distinctive rooflines to further create a landmark location

3) Sightlines and views

Sight lines to and from the station help orient pedestrians to their surroundings. Views are critical for pedestrians to find their way. Sight lines can be terminated by important features such as the station, a community building, monument or public art.

4) Orient buildings to the street

Buildings that are adjacent to and overlook public areas create a visually interesting and safer pedestrian environment. Buildings oriented towards the street edge can enclose important vistas and shape the public realm.

5) Public open spaces

Open spaces near an LRT station emphasize the station as a public place. They provide comfortable waiting and drop-off areas for users and act as central activity and gathering points for the local community. The station area can be strategically punctuated with small parks or plazas, which might incorporate fountains or other landmark features.

6) Street and block layout

- New streets and walkways should be incorporated into the existing local road pattern
- Streets should have sidewalks on both sides of the road that can accommodate high-volume pedestrian activity
- Street layout should be oriented toward the transit station.
- Where possible, street and building configuration should be designed to create vistas, or to terminate views with a landmark feature, building, or public space.

6.3.25 Manage Parking, Bus and Vehicular Traffic

Accommodate transit bus and private automobile circulation and parking needs, while creating a comfortable pedestrian environment. Reduced parking standards should be applied to Urban TODs in recognition of their proximity to high frequency transit service and their walkable environment and mix of uses.

Description:

1) **Accommodate the automobile**

By design, TOD lessens the need for automobile use in a station area. However, accommodating vehicles is still critical to the success of a vibrant TOD district. Convenient parking and drop-off zones need to be planned for in all station area plans.

2) **Consider reduced parking requirements**

Transit Oriented Development, through its transit-supportive uses, increased density and pedestrian design provides mobility options and reduces automobile trips through increased transit ridership and potential for decreased vehicle ownership. As such, the reduction of standard parking requirements should be strongly considered in TOD station areas.

- A reduction of the required Bylawed parking stalls should be considered in TOD station areas.
- In addition to proximity to a Transit Station, parking relaxations should be considered when a site "earns" further locational/parking management benefits such as:
- Shared parking where different uses require parking at different times of the day
- Proximity to Park n' Ride sites which could be considered for accommodating parking during off-peak hours
- On-street parking within TOD station areas as part of the parking supply for a development
- Longer-term (class 1) secure bike parking with shower and locker facilities
- A cash-in-lieu policy for parking in TOD areas should be considered as part of a parking management strategy for a station area

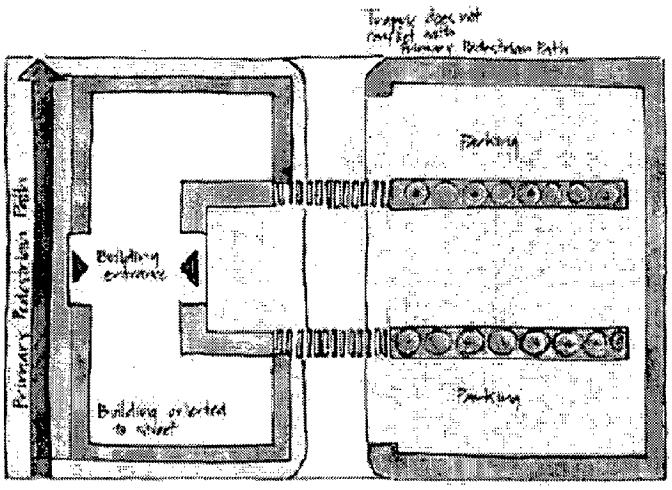
3) Place parking in appropriate locations

Parking lots should not dominate the frontage of pedestrian-oriented streets, interrupt pedestrian routes or negatively impact surrounding neighborhoods. Lots should be located behind buildings or in the interior of a block, whenever possible. Structured parking is also encouraged and future intensification with structured parking should be considered when deigning development plans. The placement of bicycle parking facilities within automobile parking lots should be considered.

Parking areas should be designed appropriately in order to maintain the pedestrian comfort in the TOD station area.

- Parking lots that serve the buildings facing pedestrian-oriented streets should be located to the rear of buildings. Parking lots should not occupy more than roughly 1/3 of the frontage, or no more than 75 feet, of a pedestrian-orinted street, such as retail "main streets" and local streets.
- Major parking areas should be accessed from collector and arterial roads around the station areas, without impacting existing communities or the pedestrian environment closest to the station. Direct and convenient pedestrian connections should lead from these parking areas to primary destinations such as the Transit Station, major office areas, high-density residential, etc.
- Along Primary Pedestrian Routes that lead to Transit Stations, parking lots should be located to the rear or side of the building.
- Parking lots should be designed and located to minimize the number of vehicle crossings over Primary Pedestrian Routes.

Figure 6.23: Parking areas should be located to minimize conflict with pedestrian.

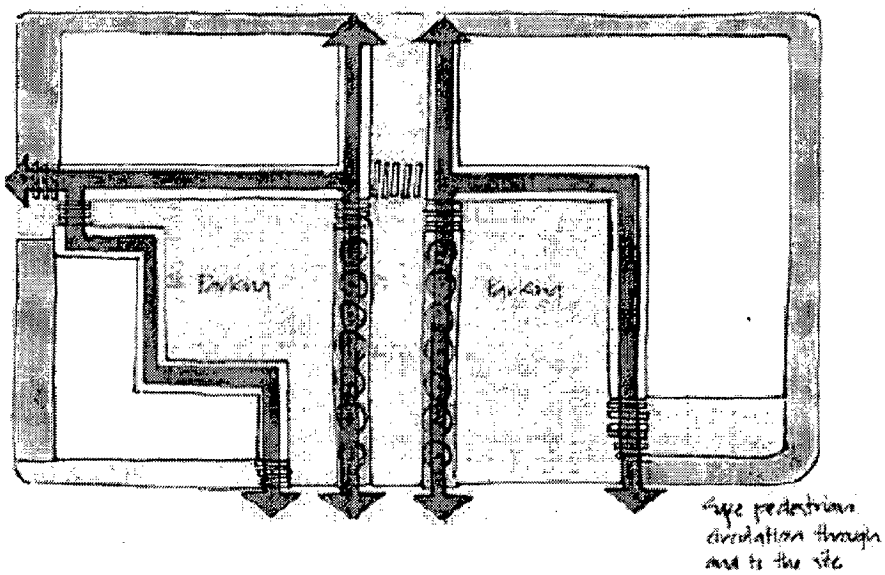


Source:
www.calgary.ca/planning/landuse go to Publications

4) Develop parking forms that complement the pedestrian nature of the area

- Surface parking should be broken into smaller cells through landscaping and walkways
- Lighting in surface parking areas should be directed within the site
- Surface parking areas should accommodate safe, direct pedestrian traffic through the provision of landscaped walkways to and from, as well as through the site.
- Parking structures should have active street-level facades, including commercial uses and/or building articulation and glazing.

Figure 6.24: Parking areas should provide safe pedestrian access to the site, and safe circulation internationally.



Source: www.calgary.ca/planning/landuse go to Publications

5) Surface parking redevelopment

Land devoted to surface parking lots should be reduced through redevelopment and construction of structured parking facilities. Surface parking lots in TODs should be redeveloped to more intensive uses in the future.

6) Encourage Transportation Demand Management strategies

Other strategies may assist in reducing the need for on-site parking in TOD areas. When present, these strategies should be considered in the evaluation of developments in station areas:

- Encouraging local shuttle service for employment centres or shopping centres

- Facilitating community car-sharing and car-pooling by providing preferential parking spots for car-share/car-pool vehicles
- Promoting Transportation Demand Management (TDM) initiatives such as flex-time hours, telework, bike/walk to work programs, etc.
- Work with businesses to encourage transit ridership programs for employees

7) Integrate design for transit circulation and drop-off zones

- Park n' Ride sites will be accommodated in station areas in accordance with approved Council policy. Parking facilities should be located and designed following the guidelines for parking provided above.
- Bus access to station areas should be a primary consideration in the design of the station and local roadways. This provides a more comfortable transition between modes of public transportation. Where possible, bus drop-off areas should be from local roadways with quick and direct access to the station platform.
- Kiss & Ride drop-off sites, where motorists can drop off or wait for a transit passenger, should be provided where feasible. These facilities should provide quick and direct access to the station platform, but not be the focus of the public systems design. These should avoid being placed prominently at the station, but rather placed in locations where the vehicle can enter and exit the station area conveniently and the passenger has a direct connection to the station.

8) Bicycle parking

Bicycles can extend the local commuting range beyond the typical 600 m. Ample, convenient and secured bicycle storage locations are provided at each station, close to the entrance of the transit station.

Justicifation:

Limited rateher than ample parking upplies encourage commuter use of transit service. Minimum requirements help to avoid spillover parking in retail areas or nearby neighbourhoods; maximums guard against overloy generous parking supplies that discourage transit use and contribute to construction of large surface parking lots.

Land in vicinity of the transit stop should be developd with the greatest intensity in order to provide the most opportunities for transit ridership.

6.3.26 Public Uses

Public uses are required in each TOD to serve residents and workers in the TODs and neighboring areas. Parks, plazas, and public services may be used in any combination to fulfill these requirement Small public parks and plazas must be provided at a minimum within TODs to meet local population needs. Roadways and park-and-ride facilities are not applicable towards fulfilling the public use requirement.

Description:

Each TOD must contain open space areas available **to** the public and facilities which serve the needs of the surrounding community. Varying sizes **and** types of TODs will require or justify inclusion of civic buildings and public facilities. Appropriate public facilities include daycare, libraries, community buildings, police and fire stations, post offices, and governmental services. Public buildings should be placed in central locations, as highly visible focal points, or adjacent to public parks and plazas. Civic uses such as an urban plaza, community center, post office, and library, are best located in the core area in conjunction with retail businesses and offices. Recreation-oriented uses, such as parks, recreation facilities, and community buildings, as well as large parks and schools, should be centrally located with easy access from TOD and Secondary Area residences and the core area. Schools should be placed at the perimeter of TODs and their Secondary Area.

Justification:

The structure of a TOD is built around accessible and convenient public facilities and spaces. A strong sense of community, participation, identity, and conviviality is important to support the sense of safety and comfort within a TOD. Public uses in TODs serve this role by providing meeting places, recreation opportunities and lunchtime picnic spots essential to the vitality of TODs.

6.3.27 Urban Open Spaces

Access to urban open space should be a priority in planning future developments on every scale level: urban block level, neighborhood level and city level. Since paths, streets and boulevards may be a source of benefits more attention should be addressed to those public spaces which promote walking and cycling. Public space privatization on large sites is a trend which needs to be considered and regulated

otherwise it will be a barrier for a compact city. Privately owned accessible open public spaces might be better solution than gated estates.

Innovative technologies for buildings sustainability should be visually and physically exposed in new commercial developments to demonstrate and promote care for better future. Public spaces outside and inside shopping malls and leisure centers could be most recognized spots for such a manifesto. Both case studies that have been presented in the thesis are evidence that achieving a compact city depends on a proper mix of all its key elements.

Density is not the only key issue of the compactness. Pedestrian friendly urban open spaces, energy sufficient sustainable design, mix of use and mix of tenures within new developments are obligatory to achieve truly compact city.

6.3.28 Station Area Planning

Station area planning efforts are led by local governments. These plans should include a vision for the station area's future identifying desired future land uses, opportunity areas for redevelopment, an infrastructure framework for development (i.e., streets, pedestrian/bike connections, and other infrastructure to support development), areas desired for preservation, challenges and constraints for achieving desired changes, a transportation demand management plan, and an evaluation of available and desired implementation tools. Station area plans should be created with the collaboration of community residents and other local stakeholders. These plans should identify what future actions are needed to accomplish TOD, such as zoning changes, and need to be formally adopted by the local jurisdiction.

6.3.29 Other Uses

Uses which rely extensively upon autos or trucks for their business are not appropriate uses for TODs or Secondary Areas. Rural residential, industrial uses, and travel commercial complexes should be located outside of TODs or Secondary Areas.

Description:

Many uses typically allowed in commercial areas rely predominantly upon auto travel to generate business patrons. These uses, such as auto dealers, freestanding **car**

washes, mini-storage facilities, highway commercial uses, and motels (not including destination resorts), should not be permitted in TODs or Secondary Areas

Justification:

In order for more frequent transit to be ecotiomically viable, uses near transit stops must have a minimum residential densities and commercial uses must create a high level of pedestrian activity. Land near the transit stop should reinforce transit use by supporting higher density, pedestrian-oriented uses and development patterns. Uses which are primarily auto-oriented are not appropriate for TODs and are better located near major highways

6.3.30 Secondary Areas

Each TOD will have a Secondary Area adjacent to it which includes lands no further than one mile from the proposed transit stop. The Secondary Area street network must provide multiple direct street and bicycle connections to the transit stop and core area without use of an arterial. Secondary Areas may have lower density single family housing, public schools, community parks, less intensive employment- generating uses, and park and ride lots. Competing retail uses are not allowed in the Secondary Area.

Description:

The Secondary Area provides for uses which are not appropriate in TODs because they are more auto-oriented. These areas will, however, provide market support for TOD businesses because Secondary Area residents and workers will shop in the TOD core commercial area and generate riders for the transit system. Employment-generating uses should be located across the street from the TOD transit stop

Justification:

Single-family residential development is and will continue to be an important land use within the city. These areas typically have too low a density to be adequately serviced by transit. By maximizing street connections to TODs and making it convenient for residents to bike to the transit stop, transit utilization in single-family areas may increase. This is important both in nexo growth areas and in existing neighborhoods where streets may need to be retrofit. Providing multiple interior street connections between TODs and Secondary Areas will keep many auto trips off arteriais. Locating public schools in Secondary Areas will provide a service for the TOD -without using valuable transit-accessible land

6.5 PERFORMANCE CRITERIA

Activity centers best meet vision, principles of Compact city and TOD when they fulfil integrated performance criteria, as follows:

1) **Social**
   - improve the liveability (safety, convenience, comfort, aesthetics) of the area
   - increase opportunities for social interaction and provide a focus for the community
   - contribute to the area's natural, cultural and historical heritage
   - make a wide range of services and facilities more accessible to all
   - relate well to surrounding development, land uses and landscapes
   - meet the needs of all segments of the population
   - maintain or improve transport choice for all
   - maintain or improve public health

2) **Economic**
   - contribute to economic competitiveness of the network of centres that provides wide community benefit
   - promote urban forms that minimize overall land and transport requirements
   - ensure more efficient use of land and provision of infrastructure
   - improve freight movement and business logistics
   - improve business and employment opportunities

3) **Environmental**
   - encourage the development of urban transport systems that will limit pollution
   - from fossil fuels and reduce greenhouse gas emissions
   - improve energy-efficient building designand layout
   - limit the amount of waste generated for disposal off-site
   - increase water conservation, including water-sensitive urban design
   - control noise emissions to achieve reasonable levels near sensitive uses.

As crucial criteria for compact city policy, the following components have been identified:

1) **Minimum densities**

Desities that guarantee the viability of user-friendly (i.e. frequent and accessible) public transit and of neighbourhood retail and services within walking distance. These are set at 40 residential units per net hectare, equivalent to a settlement pattern of two-storey,

garden-oriented terraced houses, but are recommended to rise to about 80 units per net hectare - read as three- to four-storey perimeter development with a variety of apartment types - in urban areas.

2) Multi-functionality through integration of land uses.

This is regarded as crucial to generate both pedestrian and stationary activities in the streets, contributing to a sense of publicness, social cohesion and the replacement of vehicular trips.

3) Concentration of development in nodes.

The compact city structure is ideally envisioned as hierarchical - monocentric (star-shaped) up to a metropolitan area population of about 200,000 - 500,000, polycentric (net-shaped) if larger - with each node attempting to strike a balance of housing, employment and subsidiary functions to maximise the share of activities that can be pursued locally.

4) Transformation of urban mobility.

It is recognised that urban compactness that translates into higher liveability cannot physically be achieved with current levels of car ownership and use, since the severance of highly trafficked roads and the spatial demand of parked vehicles would work to its detriment. Guided by the experience of low motorisation in existing high-density, mixed-use districts in European cities, it is recommended that traffic be calmed by both speed and volume and parking provision be considerably reduced. This will deliver attractive street environments that encourage non-motorised mobility and preserve green spaces even at relatively high densities.

5) Congruence of spatial-functional structure and public transit system.

This implies a more pronounced orientation of future urban development around existing transport routes as well as their extension to cater for presently under-served nodes and travel relations.

6) Station areas as catalysts for development.

Nodes around rail stations are a viable model towards sustainable settlements even for smaller communities in the wider metropolitan region. They can enhance self-containment at a local scale and provide intermodal links, both of which feeds back into the viability of the rail system at large.

Apart from these general criteria each site should be judged against stated goals set forth for it through an inclusive planning process.

6.6 Planning Guidelines for Compact Transport-Oriented Development of the Study Area

As per the analyses of the study area the following guidelines have been proposed for land use restructuring so as to increase the population density of the residential areas and intensification of the commercial areas along the selected Metro corridor.

6.6.1 Land Use Restructuring

Table 6.1: Landuse analysis for the Influence Zone of the Metro stations selected.

Sr. No	Name of Station	Res.	Com.	Mixed Landuse	Inst.	Ind.	Open Space	Density Groups	Station Loads
1	Dwarka Sector 14		Yes			Yes	Yes	4 – 49	24622
2	Dwarka Sector 13	Yes	Yes		Yes		Yes	4 – 49	25914
3	Dwarka Sector 12	Yes	Yes	Yes	Yes		Yes	4 – 49	41664
4	Dwarka Sector 11	Yes	Yes	Yes	Yes		Yes	4 – 49 100 - 199	30382
5	Dwarka Sector 10	Yes	Yes			Yes		4 – 49 100 - 199	37692

T able 6.2: Influence Zone Landuse Breakup

Landuse	Area(Sq.km.)	Percentage
Gross Residential	2.64	58.75%
Commercial	0.19	4.29%
Government	0.07	1.71%
Public/Semi Public	0.32	7.27%
Recreational	0.59	13.17%
Transport	0.61	13.61%
Utilities	0.05	1.2%
Total	4.5	100%

Area of Influence Zone – 4.5 Sq.km.

12.32 % area of Dwarka Phase I is under Influence Zone.

Built up area of the Influence Zone is 12.32% of the total built up area of Dwarka Phase I.

Built up area of the Influence Zone – 2.07 Sq.km.

Population of Influence Zone – 229122

Population Density of Influence Zone – 50916 or 509 pph

Table 6.3: Residential Land Use

Proposed for 2011	Total Area	Area Under Residential	FSI	Built-up Residential	Population	Gross Density
Existing	4.5 Sq.km.	2.64 Sq.km.	0.80	1.2 Sq.km.	229122	509 pph
Proposed	4.5 Sq.km.	2.64 Sq.km.	2.25	5.94 Sq.km.	343683	1300 pph

Table 6.4: Commercial Land Use

Proposed for 2011	Total Area	Area Under Commercial	FSI	Built-up Commercial
Existing	4.5 Sq.km.	0.19 Sq.km.	1.00	0.19 Sq.km.
Proposed	4.5 Sq.km.	0.5 Sq.km.	1.75	0.87 Sq.km.

enough to support higher frequency transit service and to foster lively, walkable communities.

2) The highest densities are ideally located closest to the station, to optimize transit rider convenience. This includes high-density housing and offices. Intensity of development can taper off away from the station, to create an appropriate transition and interface with the surrounding community.
3) Plans for areas around LRT stations should address the ability to increase density over time. Vacant lots, surface parking lots and existing low intensity uses present opportunities for future infill development. A phasing plan that demonstrates how the station area can intensify over time offers flexibility to meet changing community needs and provides a vision for this transition.

6.7.3 Create Convenient Pedestrian Connections

1) Walking distances are short. Pedestrian routes between the station and key destinations are short and direct. Key destinations are located within a 400 to 600 meter radius of the station. Circuitous routes are avoided.
2) Pedestrian connections are continuous. Sidewalks and pathways are continuous routes that are easy to find and follow. Major connections to the station for pedestrians and bicycles are constructed at the outset.
3) Access is direct. Sidewalks connect directly to the entrances of the station and buildings. Bus stops are located as close as possible to building entrances.
4) People are at street level. Pedestrian routes are at ground level, with minimal stairs and grade changes. Adjacent buildings provide "eyes on the street" and informal security here.
5) Separate vehicular and pedestrian functions. Vehicular and pedestrian ways are designed to minimize points of conflict. Sidewalk and pathway routes have as few driveway or parking lot crossings as possible.

6.7.4 Ensure Good Urban Design

1) Create high quality streets A pedestrian-friendly street is visually interesting and makes walking enjoyable. Trees, landscaping, wide, separate sidewalks and on-street parking protect people from vehicle traffic and create a pleasant pedestrian zone.
2) Make the most of architecture. Architectural variety on the lower three to four storeys can define an interesting public realm. Articulated building facades

incorporate attractive windows and varied architectural elements, and are built to the sidewalk.

3) Relate the ground level to pedestrian uses. Foot travellers tend to relate to the ground storey of buildings. This level accommodates residential units, building entrances and retail shops oriented to the sidewalk.
4) All season design. Where possible, pedestrian connections and transit waiting areas provide weather protection in the form of awnings, building projections and colonnades.
5) Adequate Lighting, landscaping, and signs. Stations are well-lit and designed to accommodate "around-the-clock" activity. Landscaping features can define special precincts and encourage transit patrons to linger and explore the station area.

6.7.5 Create Compact Development Patterns

1) Plan for compact street network. Frequent, interconnected streets increase the efficiency of transit circulation and offer more choices for pedestrians. Blocks of 100 to 150m in length keep walking distances short and provide alternative route options. A grid based street pattern offers multiple accesses to the station.
2) Cluster the buildings together. Buildings that are grouped together, or clustered, offer a "one-stop" opportunity to conveniently access a variety of destinations on foot.
3) Leave room to grow. Buildings can be thoughtfully sited on a property to accommodate future intensification. Placing buildings to one side of a parcel, instead of in the centre, leaves sufficient land that can be developed later.

6.7.6 Manage Parking

1) Accommodate the automobiles. Convenient parking and drop-off zones need to be planned for in all station area plans.
2) Parking Reduced to minimum. Setting both minimum and maximum parking standards can help ensure the success of a station area as well as optimize transit ridership.
3) Locate parking to the rear and sides of Buildings. Parking lots are located at the periphery of the station area and to the rear or sides of buildings.

4) Create smaller parking lots. Larger parking lots can be divided into smaller lots and separated by landscaped walkways.
5) Phased parking from surface lots to structures. Structured parking consumes less land than surface parking and allows maximum development.
6) Provide for Bicycle parking. Bicycles can extend the local commuting range beyond the typical 600 m.

6.7.7 Make Each Station a "Place"

1) Create a destination. A station area with a collection of unique places will attract visitors, while also serving transit patrons and the local community.
2) Make buildings landmarks. Landmarks create notable places and aid in local way finding.
3) Sightlines and views. Sight lines to and from the station help orient pedestrians to their surroundings. Views are critical for pedestrians to find their way.
4) Orient buildings to the street. Buildings that are adjacent to and overlook public areas create a visually interesting and safer pedestrian environment.
5) Provide public open spaces. Open spaces near an LRT station emphasize the station as a public place. They provide comfortable waiting and drop-off areas for users and act as central activity and gathering points for the local community.

6.8 Conclusion

Compact Transit-oriented development should be both place-based and market-oriented. It needs to work for communities and for people, for employers and for employees, and for all those who are keeping an eye on the future such as planners, civic and community leaders, and politicians. Like all other place-based assets, no single agency or interest can make it work by itself. In order to fulfill its potential, then, TOD needs to have the benefit of conditions, resources and policies that are highly, dependably, and accountably aligned around the task at hand. There must also be a high degree of flexibility during the planning and development process to embrace different approaches depending on the particular context, whether it is Metro rail, light rail or BRTS, low-density or high-density areas, strong or weak real estate markets.

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Annexure - I

Classification of Impact of a Transit System.

A large scale transportation infrastructure will have a hierarchy of impacts that can be classified as follows:

1. Primary: Changes in people's travel pattern or Modal Split.
2. Secondary: Effects on activity centers or Accessibility.
3. Tertiary: Impacts like land use and land value changes.

The primary impact of a transit system is the purpose or basic intent of introducing the new system. Once this modal shift is achieved it will trigger the changes in the land surrounding it. The primary impacts resulting from different transit systems have been discussed in the following section and further analyzed in the proceeding section.

The secondary impact deals with the effects on activity centers or accessibility. Public transit is a practical means to access employment, education and public services, therefore the land use can be enhanced such that its restructuring to an extent brings about changes in the sprawl of population and the mobility needs of the people are served. In the process there is also scope for rationalizing the land use and improving living environment. Community benefits could be optimized in terms of improvement of landscaping, infrastructure and environment.

The tertiary impacts are like land use and land value changes, which can be further classified in as direct and indirect land use impacts.

Direct land use impacts

Occur in the short-run (usually during construction, as residences and businesses are displaced) and adjacent to transportation improvement. It also includes the actual conversion of productive land to transportation use. The removal of existing land use to accommodate the facility and any immediate changes to the overall character of the affected area.

Indirect land use impacts

Attributes to long run and widespread changes to development patterns and planning that are induced by the transportation improvement. Indirect or secondary impacts of transportation projects on the land use tend to occur, over a long period and

may involve changes in the overall development and growth of an area. These impacts will vary depending upon the nature of the transportation improvement and other characteristics of an area that affects growth rates.

Land attributed impact

Land uses impacts are changes in how land is used that are directly or indirectly related to accessibility.

Population and employment growth may demand new or rehabilitated spaces, leading to land development or redevelopment, which is a land use impact. A transit project has an impact on a business by changing the performance of the transportation system and that change in performance affects business profitability, and that change in profitability gets capitalized (to a greater or lesser degree) into property values which then simulates changes in land use.

The goal is to be able to analyze these land use impacts and evolve planning guidelines for compact transport oriented development of the influence zone.

The key variables that might contribute to considerable changes in development patterns in response to transit are:

1. Change in accessibility this is the varialble that most affects land use by changing average trip time, volumes and mobility/density change.
2. Change in property value: Such estimates are another count of the potential created by the travel improvement (the improved accessibility of the transportation improvement makes the land more valuable and creates potential for it to be used more intensively)
3. Expected growth: A growing city experiences pressure to develop where good access and services are available.
4. Relationship between land supply and demand: How much vacant, buildable land is there in the study area compared to the rest of the city or larger region? What is the demand for land at the regional, city and study area level? The more limited is the supply relative to demand, the more likely improved access would increase the probability of development.
5. Availability of other services: The case studies demonstrated that access alone was not sufficient to trigger development: other key public facilities like sewer

and water had to be available at reasonable cost. If they are, access improvements are more likely to facilitate land use change.

6. Other market forces: Where has growth been going and where do local real estate experts expect it to go? How does the study area market compare to other markets in the other subareas? What is the extent of under building relative to the allowed densities? Is travel time is a limiting condition on the development of the study area.
7. Public policy/Land use policy: All the previous factors are indicators of the potential for land use change, most are market driven. But for that potential to result in change the land use policies should facilitate compact high density development which is much more amicable for the given transit system. The land use policy should not only promote proper land use development but should also be supportive of the transit system as transit systems efficiency is directly affected by the change in surrounding land use.

Annexure – II

Beneficial Impacts of the Delhi Metro

Table 1: Fare Sensitivity of Ridership on the Metro

Fare Rate (In Rs/Passenger trip)	Percentage Ridership
3	100%
4	90%
5	75%
6	50%

Source: RITES (1995b)

Table 2: Estimates of Daily Passenger Trips by Metro (in lakhs)

Year	Daily Passenger Trips
2002	12.63
2003	20.15
2004	23.86
2005	31.85
2006	33.17
2007	34.55
2008	35.97
2009	37.46
2010	39.01
2011	40.63
2012	41.81
2013	43.03
2014	44.29
2015	45.58
2016	46.91
2017	48.28
2018	49.69
2019	51.14
2020	52.63
2021	54.17

Source: RITES (1995b, 2005b)

Table 3: Reduction in Vehicles Due to Metro (Phases I & II)

Year	Cars & Jeeps	Two wheelers	Buses	Total
2005-06	50586	284433	3398	338418
2010-11	80731	479286	4767	564784
2015-16	238737	1496497	12388	1747622
2020-21	381006	2521685	17374	2920065
2025-26	608055	4249185	24368	4881609
2030-31	970409	7160124	34178	8164711
2035-36	1548697	12065226	47936	13661859
2040-41	2471600	20330607	67233	22869440
2042-43	2979770	25049341	76975	28106087

Source: RITES Gurgaon

The economic benefits from the reduced number of vehicles on Delhi roads due to the Metro could be identified as the following:

- Savings in Foreign Exchange due to reduced Fuel Consumption
- Reduction in Pollution
- Savings in Time for all passengers using Metro and Roads
- Savings in Accidents
- Savings in Vehicle Operating Cost (VOC) due to decongestion for residual traffic
- Savings in Capital and Operating cost of diverted vehicles
- Savings in the cost of Road Infrastructure

Savings in fuel consumption

There are savings in fuel consumption (inclusive of both CNG and petrol) due to the diversion of a part of the Delhi road traffic to Metro and reduced congestion to vehicles till operating on the roads. There is an inter-fuel substitution of petrol and CNG to electricity that could result in savings of foreign exchange and a reduction of air pollution. Fuel saved due to traffic diverted to the Metro is estimated given the estimates of diverted traffic described above and the annual run and fuel consumption norms of different vehicles.

Table 6: Annual Run and Fuel Consumption Norms

Traffic Mode	Diverted Traffic	Fuel Consumption Norm	Daily Run	Fuel Savings	Value of Fuel savings (million)
Cars	164252	13	30	138350586	5257
two-wheelers	985789	35	25	257009274	9766
Buses	9450	18	209	39651154	714

Source: RITES Gurgaon

Notes: For cars and two-wheelers using petrol, price is Rs. 38/ltr, For buses using CNG, price is Rs. 18/kg.

Reduction in air pollution

Fewer vehicles and the decongestion for the residual traffic on Delhi roads due to Metro could lead to reduced air pollution. The distance saved due to decongestion is estimated by multiplying the time saved with the speed of a vehicle in a decongested situation. An estimate of the pollution reduction by a vehicle in this context could be obtained by multiplying the distance saved by the relevant emission coefficient for different pollutants for each category of vehicle.

Table 7: Reduction in Pollution Load due to decongestion and its Monetary Value for the Year 2011-12 with the Assumption that All Vehicles Use EURO II Technology without Metro

Reduction in Pollution Load	HC	PM	NO_X	CO_2
Due to decongestion	643	77	514	8008
Shadow Prices (Rs)	502	4777	6724	448
Value (Rs. Million)	32	0.37	4	4

Source: RITES Gurgaon

Table 8: Time Savings and Value of Time for Passengers

	Bus	Metro
Daily passengers carried (million)	3.3	3.2
Time saved on average lead (hours)	0.21	0.31
Value of time per passenger (Rs.)	5.96	5.96
Value of daily time saving (Rs. million)	4.13	5.91

Source: RITES (1995a)

Savings due to fewer accidents

The Road User Cost Study (CRRI, 1982) later updated by Dr. L. R. Kadiyali et. al. in association with the Loss Prevention Association of India provides estimates of the cost of various accidents on road. Components like gross loss of future output due to death/major injury, medical treatment expenses, legal expenses, administrative expenses on police, insurance companies and the intangible psychosomatic cost of pain were included in the estimation.

Table 9: Compensation Values

Cost Component	Value (Rs.)	Reduction in injuries, fatalities and damage to vehicles	Compensation for 2011-12 (Rs. million)
Cost of fatal accident	437342	573	250
Cost of major accident	64256	2980	190
Cost of damage to cars in road accidents	9763	236	2.3
Cost of damage to two wheelers in road accidents	2286	1416	3.2
Cost of damage to buses in road accidents	32818	14	0.4

ITES (1995a)

Annexure – III

Delhi Metro Commuter Survey

Indian Institute of Technology – Roorkee

Department of Architecture and Planning

Delhi Metro Commuter Survey Date: _____

Participant Name:_____ **Age**: _____

Sex: Male ☐ Female ☐

Conclusion

The Delhi Metro planned in four phases is part of an Integrated Multi Mode Mass Rapid Transport System (MRTS) planned for dealing with the fast growing passenger traffic demand in Delhi. It provides an alternative safe and comfortable mode of transport by rail to a large fraction of passengers using the road transport in Delhi. It reduces the travel time of people using the road and Metro, number of accidents on roads and the atmospheric pollution.

1. Do you use Metro for daily commuting to office?
   (1) Yes
   (2) No

2. Is the Bus Stop or Metro Station nearest to your home in walking distance or would you have to drive or get a ride there?
   (1) Walking distance
   (2) Drive
   (3) Get a ride

3. How many minutes does it take you to get there?
   (1) 0-5
   (2) 5-10
   (3) More than 10

4. How often do you travel by Metro train?
   (1) Daily
   (2) Weekly
   (3) Monthly
   (4) A few times a year

5. Is Metro a preferred mode of transport to reach work place?
   (1) Yes
   (2) No

6. Is travelling by Metro rail economical?
   (1) Yes
   (2) No

7. What type of ticket do you normally purchase?
   (1) RFID Token
   (2) Travel Card
   (3) Tourist Card

8. A common ticketing facility for commuters travelling on Delhi Transport Corporation (DTC) buses and the Metro should be introduced?
   (1) Yes
   (2) No

9. What kind of activity would you prefer near Metro Station?
   (1) Shopping/ Commercial
   (2) Open green spaces/ Plaza
   (3) Other

10. Commercial development near Metro Station results in:
   (1) Convenience daily/ special needs
   (2) Congestion and other problems
   (3) Not sure

11. Have you noticed change in landuse from Residential to Commercial?
   (1) Yes
   (2) No
   (3) Not sure

12. Why do you use the Metro rail?
   (1) Cheap
   (2) Convenient
   (3) Time saving

13. Would you recommend the train to people currently driving by car?
   (1) Yes
   (2) No