Towards an Inclusive and Low-carbon Transit Oriented Development in Indian Cities

CEPT UNIVERSITY
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SHAKTI
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EXECUTIVE SUMMARY

This project is being undertaken by the Centre for Urban Equity, CEPT University, Ahmedabad using funding from Shakti Sustainable Energy Foundation (SSEF), New Delhi. The aim of the study is to develop a planning framework that helps cities arrive at context-specific Transit Oriented Development (TOD)strategies, through a better understanding of the links between transit riders and built form, and hence to maximize the social and environmental benefits of TOD.

TOD is a type of Smart Growth and New Urbanism, which is gaining popularity in India. Today, several cities in India are working on TOD proposals centered on large rapid transit investments in metro-rail or BRTS. Cities such as Delhi, Ahmedabad and Bangalore have already introduced some provisions of TOD into their Development Plans while newer cities like Naya Raipur are trying to incorporate them during inception itself. Unfortunately, the TOD debate in India is limited to piling up massive floor spaces near a transit node and not about attracting transit users to stay in these zones. In already high-density Indian cities, it is not known whether there are any advantages or density gains by adding further FSI within TOD zones. These development bring the fear of TOD turning into another form of transit proximate development - “Transit Adjacent Development” (TAD), which is physically near transit but fails to capitalize on its presence.

Therefore, the objectives of this research are to assess TOD plans and proposals in select Indian cities to reveal their expected benefits (Ahmedabad and Bangalore). The existing TOD regulations in cities are being assessed in terms of transit benefits, land use mix, travel demand management measures and the provision of affordable housing (Ahmedabad and Bangalore). The link between transit riders and built form would be determined and scenarios developed to identify context-specific TOD strategies with an end goal of low-carbon and inclusive urban development (Ahmedabad). Based on the detailed case of Ahmedabad, a planning framework would be developed to arrive at TOD strategies and measures for other Indian cities .

1 TRANSIT ORIENTED DEVELOPMENT - INTRODUCTION

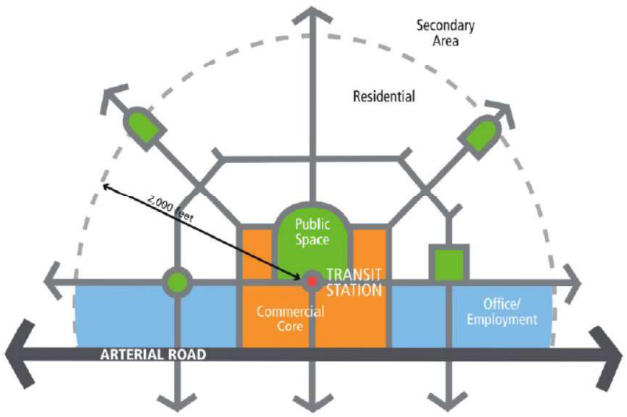
Transit Oriented Development (TOD) has been the buzzword in planning circles internationally since the nineties. Calthorpe (1993) and Cervero (1997) were able to capture American policy-makers' attention through their writings and advocated the adoption along transit of a model of development that was already prevalent in the inner cities. In the Indian context, some of our cities already had the features which came to be associated with TOD at a later stage. It is only much later in the early 2000s when cities started investing in big budget projects like metro-rail that TOD started to be imposed on cities demanding transit. While progress has been patchy, efforts have involved adopting TOD concepts and replicating them in the Indian con-text. In 2017, as the Delhi Metro completes fifteen years of operations and other cities like Bengaluru have one or more phases of their metro-rail commencing operations, there is a need to address the attempts made by Indian cities at achieving TOD. International literature presents several critiques of TODs in American, European and Australian contexts, harping on how in the absence of enabling circumstances, these have turned into Transit Adjacent Development (TAD).

1.1 What is Transit Oriented Development ?

There are multiple definitions of TOD which lies within the concept of new urbanism. New urbanist theory suggests that compact, mixed-use communities are the answer to the suburban problem. Several academics have adopted their own explanations of this new paradigm. One of the original and most popular definitions of the transit-oriented concept came from Peter Calthorpe, an architect and proclaimed urbanist. According to Calthorpe (Calthorpe 1993), TODs are:

Mixed-use community[ies] within an average 2,000-foot walking distance of a transit stop and a core commercial area. TODs mix residential, retail, office, open space, and public uses in a walkable environment, making it convenient for residents and employees to travel by transit, bicycle, foot or car (p. 56).

In addition, the transportation hub should be located in the heart of the neighborhood, within a 400 meter, or 10 minute walk from residents. This central location reflects the importance of transit in the community and in the region as a whole (Picture 1). TOD comprises a mix of commercial, residential, and institutional developments built to support a transportation hub and to encourage non-motor vehicle mobility options, such as biking and walking, within the community. A TOD area could encompass a radius of as little as 0.5 miles or as much as 1 mile from a transit station (Cervero 2002).



Source: Adapted from (Brinklow 2010)

Carlton (2007) presents a rich history of the evolution of TOD tracing it back to as far as Ebenezer Howard's seminal work "Tomorrow: a Peaceful Path to Real Reform" (Howard 1898) and "Garden Cities of Tomorrow" (Howard 1965). In the succeeding decades, American cities like Boston witnessed what may be called as Development-Oriented Transit (DOT) with cities increasingly getting divided into areas of work and stay. The rise of the motor car aided this form of development. As cities grew larger by the 1970s, streetcars came into being which expected suburban dwellers to "park-and-ride." Systems like the Bay Area Rapid Transit (BART) were a product of these times and were called as Auto-Oriented Transit (AOT). Since these were not able to achieve the kind of ridership that were originally envisaged, the government started funding research, which demonstrated that transit ridership was dependent on the intensity of development near transit stations.

Cervero and Zupan (1996) demonstrate that localized densities around transit systems could produce positive synergies. Also, office uses generally attracted high numbers of transit users 3
While housing near transit, both affordable and high-end, also offered synergies. Transit authorities began to see that they could take up the role of land developers and guide the type and scale of development on land near stations to increase ridership. This was called Transit Supportive Development (TSD) and paved the way for TOD later.

Transit-oriented development was a response to current conditions, a) rising energy prices, b) road congestion, c) climate change, d) shrinking household sizes, e) increasing demand for urban living, f) interest in green building and walkable neighborhoods. Home buyers, renters and employers are drawn to areas with convenient access to transit and other urban amenities such as neighborhood shopping and services. At least a quarter of all housing demand in the next 20 years will be for homes and apartments within half a mile of rail transit stations (Austin et al. 2010). This high level of demand is reflected in the prevalence of higher rents and land values near transit across the country.

1.2 The Historical Roots

TOD evolved as a response to the need to provide urban residents with an improved quality of life and reduced household transportation expenditure. It was to be marked by stable mixed-income neighborhoods with reduced environmental impacts and real alternatives to traffic congestion (Dittmar and Ohland 2003). However, as Carlton (1993) puts it, TOD soon began to serve real estate development and not the other way around. One of TOD's foremost precedents was the garden city of Ebenezer Howard where the communities were intended to be planned, self-contained and surrounded by green belts with carefully balanced areas of residences, industry and agriculture (Howard 1965). Master plans were made in the 1880s for workers housing in the United Kingdom with regulations related to the provision of urban amenities like parks which were to closely mimic the rural hinterland. These regulations also restricted the number of factory units that could come up near residential units. Carlton argues that just as these regulations were possible in part due to their being under single ownership, TOD relies heavily on design guidelines that municipalities can incorporate into zoning codes.

Howard's garden cities were followed by the industrial town of Letchworth which had open spaces, tree-lined streets, commercial corridor and a greenbelt surrounding the town. Rules were put into place that encouraged the integration of income groups. Carlton (1993) writes that when the railway station was opened in 1913, the similarities with Calthorpe's ideas of TOD became evident. Calthorpe's ideas of TOD were also influenced by Raymond Unwin who had once said:

"Streets are not a virtue in themselves. In fact, the less area given over to streets, the more chance one has of planning a nice town. To be obsessed with the idea of planning for traffic is a mistake (Unwin, R.; "Columbia University Lectures" found in Carlton, 1993)."

Unwin had a pro-pedestrian, anti-automobile philosophy combined with great regard for natural features which he retained and enhanced in the Letchworth development. The Letchworth experiment was followed by several other examples like Welwyn, Wythenshaw and Vallingby which laid emphasis on their pro-pedestrian and pro-rail biases. Radburn near New Jersey was also an example of natural romanticism. However, after the Second World War, the garden city concept was quickly adapted to the automobile in several cases which may have caused the environment a lot of harm (Carlton 2007).

The Robert Moses versus Jane Jacobs debate on automobile-centric planning in New York is well documented. Jacobs (Jacobs 1961) argued that Howards' paternalistic design program was responsible in part for shortcomings of modern planning. However, till the environmental sustainability movement picked up in the late 70s, America continued to invest in auto-centric cities. Transit agencies which were flush with research funds as a result of the passage of the Intermodal Surface Transportation Efficiency Act, 1991 had determined that high-density development near stations encouraged the use of transit. Environmental groups were promoting high-density, pedestrian-friendly neighborhood design as a means to prevent urban sprawl and reduce automobile dependence (Carlton 2007).

1.3 The Beginning

The TOD agenda first came to the fore with Bay Area rapid Transit (BART)2 commissioning a study in 1989 to examine the case for promoting high-rise housing near transit stations. On discussion were issues like "jobs-housing balance" which are today considered elementary when talking of transit. Research revealed that those living close to transit were more likely than others to use BART. The result was that high-rise housing with densities of 70-90 units per acre and ground floor retail were encouraged in a manner as seen today. Calthorpe's association with Robert Cervero who was a professor at Berkeley helped the former in suggesting land use densities that would help transit ridership. It was Cervero who suggested the name "TOD" with a need to help build a brand. It was clearly an extension of the pedestrian pockets concept described earlier. They would collaborate with others and define what has come to be known as New Urbanism.

"We advocate the restructuring of public policy and development practices to support the fol-lowing principles: neighborhoods should be diverse in use and population; communities should be designed for the pedestrian and transit as well as the car; cities and towns should be shaped by physically defined and universally accessible public spaces and community institutions; urban places should be framed by architecture and landscape design that celebrate local history, climate, ecology, and building practice (Carlton 2007: 20)."

New Urbanism strives to learn from past mistakes in order to revitalize metropolitan cities and stressed on the need for replicable guidelines based on narrow streets, on-street parking, and shops near residences with a view to blunt the damage done by automobile centered planning. The book titled "The Next American Metropolis" (Calthorpe 1993) outlined the key components of TOD as:

- Organize growth on a regional level to be compact and transit-supportive,
- Place commercial, housing, jobs parks, and civic uses within walking distance of transit stops,
- Create pedestrian-friendly street networks that directly connect local destinations,
- Provide a mix of housing types, densities, and costs,
- Preserve sensitive habitat, riparian zones, and high-quality open space,
- Make public spaces the focus of building orientation and neighborhood activity.

These components were based on planning principles that were rooted in the ecological movement while advocating aesthetic, pedestrian-friendly and compact built-form.

1.4 The Present Scenario

Today, TODs have evolved in a way that they show characteristics that could fit under any of the following geographic contexts: a) Single-use corridors where residential and commercial (offices or retail) uses dominate certain areas and people use transit to reach there from the residential areas, b) Mixed-use corridors where single or groups of land parcels feature multiple uses, c) Neo-traditional development as described earlier, where traditional countryside settings are reproduced with reduced setbacks, narrow streets, small plots and detached parking, d) Compact, mixed-use development concentrated near transit stops, e) Village concept characterised by single-family homes around a central green commons, and f) Purlieu, a development of 150 acres and 7,000 residents with regulations on design (and not land use) regulations (White and McDaniel 1999). Contrary to expectations, TODs have not really taken-off in a manner that was expected. This can be attributed to the either the lack of resources or absence of favourable densities in the West. Calthorpe (1993) advocated that governments spend huge amounts of money in getting rapid transit constructed and bringing high-density development around the transit stations. The American milieu was not accustomed to the notion of high densities, used as they were to sprawling cities that could be traversed by car. Factors such as a) freely available parking in abundance, b) lack of walkable environment around transit, c) low levels of service, d) inadequate mixing of land use, e) missing housing-jobs linkages, and f) inability of development codes to cope with the TOD concept have long impeded the growth of TOD in America. The ones that exist are not in accordance with what Calthorpe and Cervero had advocated (Carlton 2007).

Dittmar and Ohland outline the failure of TOD, "Somewhere between the conceptualization and opening day, many projects end up becoming fairly traditional suburban developments that are simply transit-adjacent (Dittmar and Ohland 2003)"

TOD versus "eyes on the street": It is interesting to read the progression of TOD in the light of Jane Jacobs's opposition to the idea of master planning, which she felt killed the sense of community. While Jacobs' argued for improving the public realm through interventions that encouraged people and eyes on the street, the "neo-traditional" approach that TOD took was based on a command-and-control style that was more inspired by Howard. Others have pointed out the disconnect between Calthorpe's pro-pedestrian rhetoric while accommodating and sometimes encouraging the use of motorcars as seen in the light of the pedestrian pocket phase that TOD evolved from. Even as regional planning agencies promoted TOD, nothing was done to discourage the use of motorcars. This fundamental disconnect between the theory and prac-tice of TOD is disconcerting and has led to a lot of disillusionment (Carlton 2007).

TOD and the role of the planner: Another important aspect that needs to be discussed is the inability of regional planning agencies to make the area around transit attractive for the real estate market. If the coming of transit were to make peripheral areas of a city more attractive than the surrounding hinterland, developers would have naturally constructed more floor space around transit stations. This combined with effective development codes could have promoted higher densities in such areas. However, such evidence is rare. TODs are being conceived as infill development and more in an incremental approach.

The complexities and risks of TOD: The presence of multiple stakeholders with varied interests and the collective indifference of the real estate market towards TOD makes TOD a proposition with great risks and more chances of failure than success. The probabilities of getting several things like mix of land use and jobs-housing are very low but important for the success of TOD. This is very different from the Utopian garden cities of Howard. Owing to these challenges, we have seen only partially successful TODs and that too in isolation as against unison.

1.5 The Challenges

Some of these are presented as case studies below. One of the biggest challenges is that the regulatory framework of most municipalities is not supportive of TOD. It is common for cities to have zoning ordinances and land development codes designed for automobile-oriented, single-purpose, suburban-scale development. The physical requirements of zoning ordinances often prohibit the development density necessary for TOD, through such provisions as maximums on floor area ratio (building floor area divided by lot area), height limitations, minimum front setback of buildings, landscaping requirements, lot coverage maximums, and minimum parking requirements.

Resolving the conflict between transit node and desirable place :- issues such as increased residential densities or changes to neighborhood character may provoke strong opposition to a proposed development, the 'Not in My Backyard' or NIMBY reaction, unless predicted and catered for with careful education and promotion backed up by genuine and extensive community consultation processes. The tension between node and place refers to a station's dual role as a node in a regional transportation system and its role as a neighborhood. The key to balancing the development mix is in understanding the station's role in the transit network and metropolitan economy. Stations in predominantly residential neighborhoods will require a different mix of uses from those that are at transit interchanges or major employment centres. The imperative for successful TOD of any size or location re-mains ensuring the walker has precedence (Curtis 2008).

Parking :- developments where car parking ratios for residents, shoppers and commuters remain generous, and private car use continues at former levels, will struggle to develop the sense of place and community to which genuine TOD aspires. Research results show that TOD parking supply and pricing policy seldom are structured to support transit ridership goals (Willson 2005). Parking policy is an important determinant of travel behavior, regardless of proximity to transit (Hess 2001). Critics argue that parking is generally oversupplied and under priced. Researchers have called for reforms in minimum parking requirements and the cashing out of parking sub-sidies (Shoup 2005; Willson 2000).

TODs degenerating into TAD :- development close to transit which is not pedestrian and cyclist friendly, fails the walk-ability test (destinations within a 10 minute walk), does not include a rich mix of uses appropriate to the population it is supposed to serve, is not well served by feeder services or connected to larger regional transport networks, fails to conform to the expectations from a TOD. A development which does not achieve a balance between residential and commercial uses or utilize and expand on existing employment, facilities and social capital is likely to not meet its potential (Irvine 2012).

Gentrification :- The general consensus lately has been that even as most cities continue to sprawl, many young families especially from the middle class prefer returning to the central city resulting in an increase in demand for housing in upmarket neighbourhoods which are usually located around newly ordained public transit projects (Garrett and Taylor 1999). Scholars agree on the prob-lematic shifting of the geography of wealth and employment from the suburbs to the core city. It is gen-

erally agreed that in the American context, average prices for homes near transit may be at least 10 per cent costlier than in the suburbs. In the resultant competition for housing limited by development regulations, invariably those with poor purchasing power may get re-placed by the newly arrived richer households through the process of gentrification (Davis et al. 2012; Dutzik et al. 2014). This exacerbated imbalances in spatial distribution of wealth and concentrations of poverty. This flies in the face of those who advocate for spatial and social equity.

As a result of the above reasons, the low-carbon objective of TODs may not be met. Addition-ally, it may also result in the exclusion of the low-mobility, low-income groups that were lo-cated on the TOD corridor who may be considered captive groups for public transit. These groups may then be replaced by middle-income or high-income groups

1.6 Urban India & TOD

that already own cars and would be reluctant to use public transit in the absence of adequate push factors in the form of high taxation and fuel prices. Indian cities face a multitude of issues such as severe congestion; deteriorating air quality; increasing greenhouse gas (GHG) emissions from the transport sector; increasing road acci-dents; and an exploding growth in the number of private vehicles (largely motorcycles). With the urban population projected to more than double in the next generation, the situation could easily get out of control and thwart India's economic development efforts unless remedial measures are soon taken. The state of public transport in the majority of Indian cities has de-graded over the years. Rising population and underdeveloped mass transport has led to a rapid rise of personal vehicles, traffic congestion and an increase in pollution levels. Moreover, the majority of people do not use public transport simply because of the lack of it and inaccessi-bility to the transit. Therefore, while augmenting public transport, planning for accessibility is the need of the hour. Increased density and improved connectivity through TOD can help achieve that. But, one of the most important reasons for thinking about TOD for Indian cities is the recent emphasis on public transport at all levels of government (EPC 2012). Scholars have argued that transport sector in India is extremely energy intensive and needs massive investments in mass transit to quell the rise of private motorised mobility (Rizvi 2013; Yedla 2015). Post the announcement of mission based programs like Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2005, Atal Mission for Rejuvenation, and Urban Trans-formation (AMRUT) and Smart Cities in 2015, there has been huge emphasis on investments in public transport. Transit systems like metro rail and Bus Rapid Transit (BRT) have found their way into many cities including Delhi, Mumbai, Kolkata, Chennai. Bengaluru, Hyderabad, Ahmedabad, Rajkot, Surat, Pune, Pimpri-Chinchwad, Hubli-Dharwad, Lucknow, Kochi, Jai-pur, Bhopal and Indore among many others. Some of these cities have gone on to leverage the huge potential accorded by the massive investments in public transit and prepared TOD plans for their cities. In western countries, TOD was used for densifying certain areas but in India the cities already have higher densities. Hence TOD in Indian cities should be looked at as a tool for improving quality of life and financial means to provide infrastructure facilities (Petkar and Hamand 2013). India is taking steps towards achieving the TOD guidelines and designing a well-planned city for its people, making itself sustained and pedestrian friendly.

Current debates on TOD in India :- there are several debates surrounding the adoption of TOD in India. Indian cities have al-ways had high densities, especially in the inner core areas. Additionally, the level of diversity of use in these areas is also high, presenting an ideal case for TOD (Munshi, T. 2013). Many of the mainstream debates around TOD have centred on the development potential of the ar-eas along transit corridors. Aspects such as equity and sustainability are unfortunately late en-trants to the debate. The National Urban Transport Policy (NUTP) of 2006 was a response to the massive issues of congestion and resultant loss of productivity in Indian cities. While it mentioned progressive concepts like "cities for people" and "encouraging greater use of pub-lic transport and nonmotorized modes," it also talked of mass transit systems only in the con-text of using "land as a resource for financing investments" (Ministry of Urban Development 2006). It also encouraged cities to pursue the integration of land use and transport plans.

It must be noted that the draft NUTP (2014) stresses on TOD as means to bring about high den-sity urban growth with a view to promoting high levels of accessibility and shortening trip lengths.

"The Government of India would encourage Transit Oriented Development (TOD) with increased [Floor Area Ratio]FAR along transit corridors with high density of population should form a part of planning (2014: 6)."

The report lists TOD as a congregation of housing, jobs, shops and other activities around PT stations. It exhorts the city planners to "[revise] building bye-laws and planning norms… so as to encourage high FAR and ground coverage along major PT corridors (2014: 7)." Additionally, the reports recognises the need for Transportation Demand Management (TDM) and control-ling the use of personal vehicles in line with the philosophy behind TOD. These are indeed progressive indications of the mainstreaming of the concept. The National Mission for Sustain-able Habitat (2011) and Sustainable Urban Transport Project (2013) also stress on the need for greater integration of land use and transport towards achieving sustainability and signal the government's keen resolve in this direction. The Detailed Project Reports (DPR) for metro rail in cities like Kochi (2011), Jaipur (2012) and Pune (2013) take inspiration from national policy only sparingly as only integration of different modes with the metro rail is proposed. Since these reports were produced by Delhi Metro Rail Corporation (DMRC), the shared emphasis on integration may have been common. It is however unclear if planning in these cities allows for preparation of TOD plans.

Cities like Delhi have had the lead in the adoption of mass transit from the early 2000s. There are several publications by Institute for Transportation and Development Policy (ITDP), Uni-fied Traffic and Transportation Infrastructure (Planning & Engineering) Centre UTTIPEC, In-stitute for Urban Transport (IUT), Environment Planning Collaborative (EPC) that discuss in-clusive street design in line with the requirements of TOD (EPC 2012; ITDP and EPC 2011; UTTIPEC 2009). These studies were undertaken in the light of the massive investments in urban transport that followed the JNNURM funding. Overall, the debates have largely centred on realising the value of land through which the metro rail corridor runs and integration of private modes with metro stations. Concrete attempts towards preparation of TOD plans through development plans or standalone local area plans has not been explored in most cities. Among the cities where some amount of progress has been achieved are Delhi, Ahmedabad and Bengaluru. These cases will be explored in detail in part 2.

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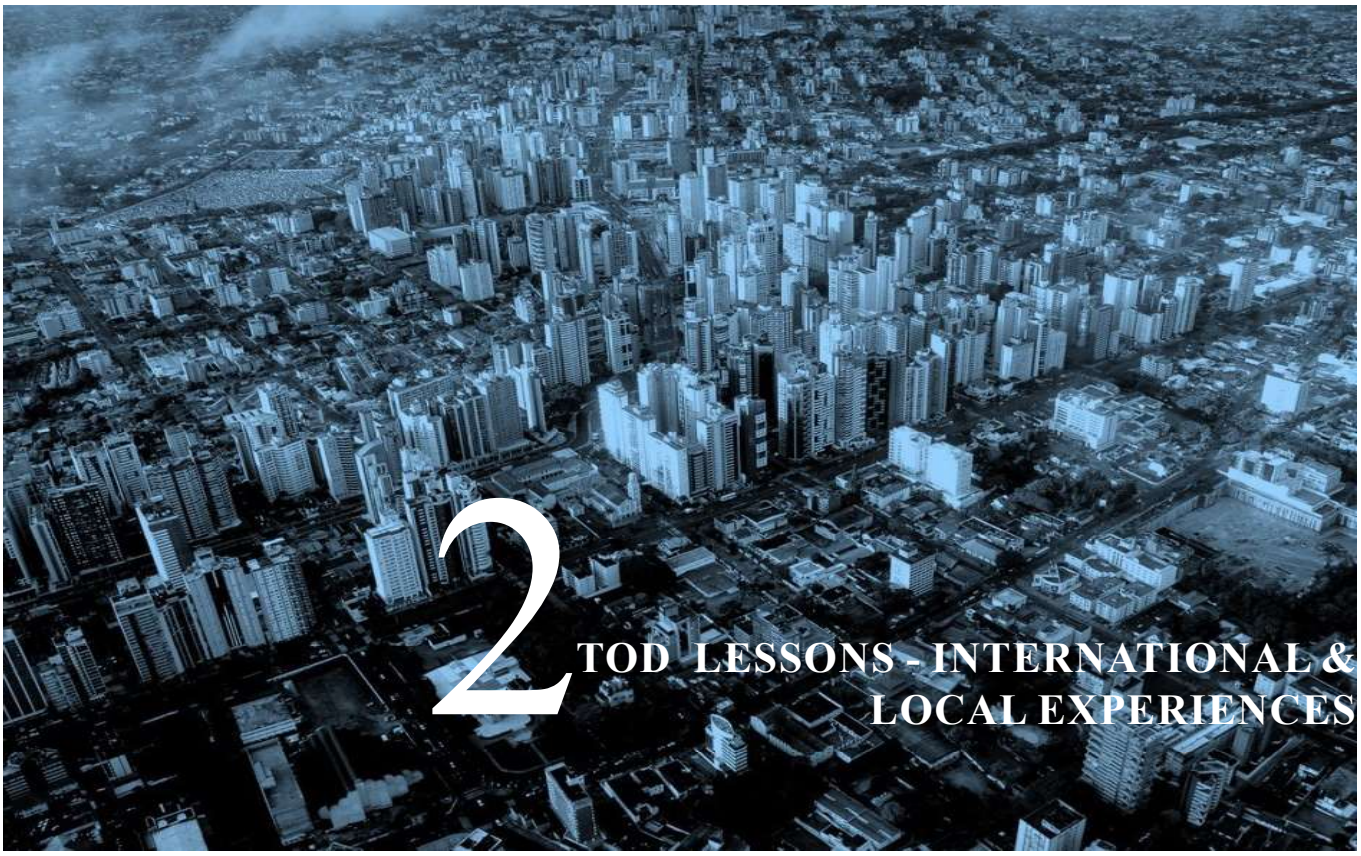


2 TOD LESSONS - INTERNATIONAL & LOCAL EXPERIENCES

This Section is compilation of various international and local endeavors. The aim of this section was to understand best practices and criticisms and to help gain a better understanding of why and how this concept can be rightfully implemented within the Indian context.

2.1 International Experiences

North American Endeavors :-

Setting up a TOD fund ; Denver demonstrated a tool for encouraging equitable development around new investments in transportation. A fund was devised by the Office of Economic Development to take over, retain and redevelop properties whose lease were to expire soon. These properties were then retained or redeveloped as the case may be into affordable housing. The fund was raised by the city council that more than matched the MacArthur Grant of USD 2.25 million in 2004-10. It helped that the economic recession of 2008 had caused a housing market bust. This helped in getting more units at a lesser price.

Non-profit led TOD :- Fruitvale in Oakland is an example of how local nonprofits can promote community development around transit stations and integrate afford- able housing, commercial space, and social services with public transportation in a way that benefits local residents. In 1995, the Unity Council (a local nonprofit) spearheaded local residents' movement against BART's proposal for a multi-level car parking near the transit station. Subsequently, the Unit Council, BART and the City Council were able to work together and evolve a proposal for what was to be done around the transit station. This included affordable housing, senior citizen friendly housing and for-sale at market rates housing and commercial space to fund the affordable housing units. There were challenges that were overcome. Part of this was to find tenants for the commercial space which took a long time. There was not enough foot traffic to attract commercial use. Secondly, the latter part of the project coincided with the housing bubble bust in 2008. This delayed the profitability of this venture. The lesson for other cities is to recognize the interrelated forces at play. It was also of great help that the Unity Council had a long history of having worked in Fruitvale and could therefore easily organize charrettes with the residents easily.

Community benefits agreements :- Longfellow saw a smaller nonprofit (Longfellow Community Council) working with the com-munity and developer(s) to incorporate a legally binding contract that codifies commitments made by the developer with regards to the benefits that TOD projects would bring to the area around them. CBAs typically contain provisions related to affordable housing, living wages, local hiring, environmental justice, and resources for community services. Since the community was concerned about how the development would hurt the local character, they made it binding that in the newly developed commercial space, national chains would not be allowed to consume more than 70 per cent of the total built-up area. Local businesses were to occupy at least 30 per cent. Similarly, the developer was contract-bound to provide space for public art and exhibitions. The process was long and it requires a greater amount of effort to see if all commitments made were going to be met. The key was to moderate the expectations of the community.

- Center Commons in Portland, Oregon: The Center Commons demonstrates inclusivity at multiple levels of income and age. Thereby, it ensures that people from all stages of life are able to benefit from the TOD. The 4.9 acre residential and retail development has senior housing, affordable family housing, day-care facility and pedestrian accessibility to the nearby transit station. The Portland Development Commission which bought the land engaged a master developer that made affordable housing the priority and constructed more affordable units than required. Portland provided developers and residents with property tax abatement, loans, tax credits, revenue bonds and 10 year transit-oriented property tax abatement. The neighbors to the property were also involved in decision making and as a result, a range of housing types,

- income levels, rental/owner ratio reflecting the neighborhood and creation of commercial space was achieved in addition to the preservation of several large oak trees. However, a criticism of the project has been that it was not able do much about social barriers as a result of which despite the mix of income levels, there is segregation among the residents. People be-longing to one income group, age or tenure are generally placed in one building. If a greater mixing had been thought of, things could have been different.

Improved stakeholder powers :- All these case studies suggest high-levels of participation from the local community and a transit agency willing to pay heed and act upon the concerns of

the community. The community benefits agreement cases in particular require median income data and interventions based on such data for families living close to the transit stop. There is also reservation in the new de-velopment for people earning less than the median income of the area.

Singapore (Adaptive City) :- As one of the successful models of development, Singapore has an efficient public transport with some pragmatic policies on the TOD implementation. The city has a ring radial structure with circumferential MRT rail networks and LRT feeder networks with a densely built urban centre. It has major and minor sub centre nodes with high densities at the intersection of MRT lines. Singapore realised its need for a public transport oriented plan when it could no longer expand its road infrastructure to accommodate more cars and being an island it could not sprawl, moreover the Land Transport Authority (LTA) could not tackle problems of congestion. Hence, the new transport plans address the policies regarding parking, integrating jobs and work places through public transit, and co dependence of housing and the expansion of LRT and MRT networks. Singapore complements its public transit with high parking charges and replaced its existing scheme of Area Licensing Scheme (ALS) by Electronic Road Pricing (ERP) in 1998. It 'deducts charges from a stored-value in-vehicle debit card according to time of day and vehicle class' (Barter and Dotson 2013). In addition to this, Singapore also has a Vehicle Quota Scheme (VQS) that limits annual vehicle registrations through an electronic open bidding system with additional supplemental charges for vehicle registration.

The city-state is also reducing its parking requirements per square metre in new developments after 1990s. All the revenue coming from motor vehicle tax goes to a consolidated fund used in various sectors including housing and public transport rather than going directly to highway projects as is the case of United States and many other industrialized parts of the world. The urban structure of Singapore focused on 'new towns' integrated and located around MRT stops with diverse activities of local shopping, other commercial and community services with resi-dential populations envisaged to be about 60,000 to 120,000people in these new towns. About 7 residential neighbourhoods are grouped around the centre with schools, community and rec-reation facilities and NMT routes linked to the neighbourhood. These locations are safeguarded for development which would enhance accessibility and transport capacity by the MRT. This approach enhanced flexibility but has left many of these new town centres unfinished for a long time (Cervero and Murakami 2007).

One critique of the new towns was the balance between employment centres and housing where 80% of the employed residents in new towns travelled to the industrial estates located on the western part of the island near the port or in other new towns (Barter and Dotson 2013). The integration between transport and land use is essential but a balance in employment and hous-ing would reduce the necessity to commute. In the new plans, more residential units were to be built near employment centres such as industrial estates, business parks and commercial cen-tres. Despite the changes which allowed flexibility in still to be identified land uses, it left many plots around the MRT stations in new towns vacant.

The integration of local area planning and transport has been enhanced sporadically but in the process of that integration a human scale built environment lagged behind. Although, pedes-trian networks and cycling tracks have been provided on all major roads accessing the MRT stations, it is adequate but basic. More user friendly access to public transport supporting the local area movement networks was expected in the strategies but a basic infrastructure was provided with most focus on other aspects of the TOD. Singapore is an interesting case because of its geography where it could not no longer expand its road networks for private vehicles and hence focused on an integrated approach to public transport and focused on the various aspects adequately and has been improving and mutable in its plans while identifying its issues and focusing on the strategies accordingly. of its geography where it could not no longer expand its road networks for private vehicles and hence focused on an integrated approach to public transport and focused on the various aspects adequately and has been improving and mutable in its plans while identifying its issues and focusing on the strategies accordingly.

Curitiba :- The current BRT system caters to more than 1.6million people and accounts for about 70% of trips every day. The BRT system helped the city in reducing its air pollution tremendously; lowered traffic jams and lowered per capita cost on transport. The NMT network currently consists of 150km of bikeways with bicycle parking and with most major roads having walk-ways. It is an essential part of implementation of BRT as unsafe walkways and bicycle tracks would discourage the citizens to access the BRT. Curitiba has a trinary system where BRT routes run in one roadway in the center with private vehicles on either side and 2 roads on either side of the main corridor cater to private vehicles. It has 5 major "structural axes" which has the trinary system and caters to high density land use along the roads with feeder lines connect-ing the main corridors. The buildings facing the transit corridors need to be high rise with mixed building use which means they need to have at least half the ground floor and second floors to be of commercial use. Beyond the private vehicle roadway, residential areas are zoned and taper down in density as the distance increases from the main transit corridor. Curitiba controls the use of private vehicles by expensive off street parking around the main corridors and limited on-street parking in location and duration; some of the central areas are also closed off for private vehicles to a degree.

The idea of a minimum density in buildings is easily implementable in Ahmedabad as it is already accommodating high FSIs along the BRT corridor. Some of the transit supportive housing policies include a 'buy up' for developers who can build two extra floors of residential Buildings by contributing to a low income housing fund which are granted to residential parcels in the ZR4, ZR3 and ZR2 zones which lie within walking distance of the transit way. These "buy ups" are offered at 75% of the market value of the extra building area provided. Through this fund the city has housed 20,000 low income families within walking distance of the transit corridor over a period of 25 years. The high density housing being built within the transit corridor is not affordable for low income housing because of increasing land prices, the city bought one of the last largest plot within its limits and gave land to the people to build their own houses. These people were provided a deed, a pair of trees and an hour with the downtown architect. This plot also had a BRT station within it ensuring connectivity for the citizens residing there. It is an interesting response to the market which can work in Ahmedabad because of similar scenarios. The housing board in Ahmedabad has land parcels around the transit corridors or parcels within its city limits to ensure housing for low income families within walking distance of these corridors.

These land parcels could be dedicated to such low income housing which will essentially in-crease the ridership of BRT in Ahmedabad. Special property rights were provided in the city center for heritage buildings to sell their property rights to other parts of the city and developers would receive inducements if they built it on the transit corridor. This is similar to the concept of TDR in the Indian context to sell underutilized FSI to other parts of the city which can further ameliorate if it could be sold within the transit corridor. Other land use integration involves 'zoning reforms, pro-development tax policies, assistance with land assemblage, and supportive infrastructure investments' (Cervero and Dai 2014). The land use planning is done in a way that higher density is concentrated near the corridors with more commercials and decreasing density along the feeder. The system has a stimulating mix of controls and incentives integrated with the trinary road system catering to the transit corridors. In context to the Indian scenario, the finances of Latin American city have a very similar condition to Indian cities' local gov-ernments and with minimal loans and funding coming from cross subsidizing and fuel sur-charges within the city, Curitiba managed to make the BRT system with 1.5 million dollars per kilometre. One major consideration within project implementation is participation from devel-opers as well as citizens from lower income families. People have a sense of pride for their transit systems in Curitiba and this to achieve in India seems to us as a challenge but can be achieved if considerable amount of valuable participation takes place.

Queensland :- Land use planning in Queensland comes under the aegis of the state government and not under the local bodies of cities like Brisbane. This is in accordance with the provisions of the Sus-tainable Planning Act, 2009. Queensland makes no distinction between rail services and bus services as anchors for TOD. Local bodies make Local Growth Planning Schemes (LGPS) that a) identify the strategic outcomes for the area, b) include measures that facilitate achieving the strategic outcomes, c) identify the preferred growth pattern, d) coordinate and integrate community, state and regional interests, and e) include a local government infrastructure plan (LGIP). These planning schemes are reviewed every ten years (Queensland Government 2017).

TOD in Brisbane is guided by a set of principles drawn from its regional plans. The regional plans encourage local government planning to allow for a mix of land uses that generates high demand for public transport within 400 to 800 meters of stops or stations in high-frequency transit corridors. They also advocate that cities adopt the principles listed in Table 2 to facilitate TOD especially in the state of Queensland. The Queensland Government has focused on TODs as a means to influence travel behavior to shift from car-based travel to more sustainable modes of transport. To quantify the extent of needed shifts in travel, in 2006 a 'typical' individual in SEQ made 2.5 walk/bicycle trips, 1.5 trips using public transport (e.g. bus, train, ferry), and 21 trips using the car in an average week. In contrast, the targets in SEQ for 2031 are to: (a) double the share of active transport trips (such as walking and cycling) from 10 per cent to 20 per cent of all trips; (b) double the share of public transport from 7 per cent to 14 per cent of all trips, and (c) reduce the trips by private motor vehicles from 83 per cent to 66 per cent (Kamruzzaman et al. 2014).

The Queensland Government is aiming to develop six types of TODs in Brisbane namely, city centre, activity centre, specialist activity centre, urban, suburban and neighbourhood. TOD around the Brisbane BRT network can be classified in three categories. First, the busways are serving existing areas that had many TOD characteristics, but lacked a dedicated transit con-nection. Second, the busways are serving as a catalyst for new, green field development near stations. Finally, the busways are catalysing urban infill, including significant air rights devel-opment. Most of this TOD activity has been market-driven, with little encouragement by the government. Recently, however, the government has begun actively promoting TOD in the busway station areas (Breakthrough Technologies Institute 2008). Key factors determining the ability of bus-based transit to spur development were permanence; rider demographics; parking availability and parking restraints; transit agency TOD capabilities; urban density; noise and pollution; frequency and speed; and bus stigmatization (Currie 2005, 2006).

Kamruzzaman et al. (2014) conducted a study on developing typologies of neighborhoods with respect to TODs and their effectiveness. Unlike other international studies which are often not developed on the basis of quantitative findings and rely on generalized geographical approaches with little scientific support, this study based on built environmental indicators arrived at some interesting conclusions. Residential type of TODs are more homogeneous neighbor-hoods, whereas activity center type of TODs are more socially and commercially diverse communities. Neighborhoods with more educated residents are less likely to be supportive for activity center types of TODs. Neighborhoods with disproportionately younger aged residents are more likely to be supportive of activity center types of TODs. Neighborhoods with larger sized households are good candidates for potential TODs. Neighborhoods with fewer private dwellings are good candidates for activity centre types of TODs. Residential areas where more than 15 per cent of residents do not own private vehicles are suitable for both residential TODs (15-18%) and activity centre TODs (>18%). Evidence indicates that residential TODs and their residents will engage in travel somewhat differently than residents in an activity center type of TOD. The study also argues that long term strategic planning needs to account for policy indicators like public housing in order to inform TOD design indicators like density and diversity.

Yeerongpilly TOD :- Yeerongpilly is located to the south-west of Brisbane's central business district. The TOD site is located on state government's land with an area of 14.6 hectares and is dominated by heritage listed buildings. The site is bounded to the north by the Brisbane River. The designated TOD site is isolated to its south and east by power easements, road and rail infrastructure. Yeerong-pilly rail station is connected to the site by an overpass (Picture 15). To the west lies the second part

of the TOD—the Queensland Tennis Centre complex and apartments built by a major developer (Searle et al. 2014). The Yeerongpilly TOD plan aims to a) promote economic activity through development, b) achieve a compact urban form and diversity of housing, c) reduce car dependency, and d) create a livable community and desirable spaces (Queensland Government 2016: 20). The TOD plan (Picture 16) has the following features

The mixed-use core incorporates a mix of uses including offices, shops and apartments.

A lively shopping and dining precinct extends through the center of the site.

Access to the Yeerongpilly TOD site is improved with traffic signals improving pedestrian crossings and traffic flow.

Low-rise (2 to 3 storey) apartments and townhouses provide a mix of housing options and a transition to established residential suburbs.

The park providing connectivity for pedestrians and cyclists only.

Existing heritage buildings are retained and the associated curtilages are incorporated into the public realm and open space network.

Direct, safe and clear pedestrian pathways connect the Yeerongpilly railway station and Queensland Tennis Centre through a series of public plazas and open spaces.

Commercial and retail development is located close to the railway station and provides activity around the public plaza.

Extensive parkland accommodates storm water treatment as well as allowing a range of recreational activities to occur.

Pedestrian and cyclist pathway connects the open space with the Brisbane River. Isolated traffic signals have been confirmed in place of a shared zone to provide additional safety for pedestrians in this location.

Attractive and safe local streets provide access for pedestrians, cyclists and vehicles.

Medium-rise (4 to 9 storey) mixed-use residential development provides a transition be-tween the surrounding low-rise residential, high-rise development in the south of the site and the Tennyson Reach development west of the site.

A gradual stepping of building heights also maximizes views to the central open space, Bris-bane River and the Brisbane CBD.

High-rise (9 to 12 storey) mixed-use residential development is located in the south of the site away from the railway corridor, taking advantage of parkland and river views. Building designs minimize impacts of noise, dust and vibration from nearby transport routes.

Opportunities for future expansion are considered (Queensland Government 2016)

The Yeerongpilly plan benefited from a supportive governance arrangement with involvement of the state. The 15 acre land adjoining the transit station is owned by the state which helped the speed of the project. However, one of the challenges to this TOD achieving completion is that the market does not view the project with the same enthusiasm as the Queensland government. As a result, there is little demand for shops and other businesses. Searle et al (2014) opine that special planning and governance arrangements that reduce planning controls over development can greatly assist TOD delivery. Policy issues arising from the need for property amalgamation to produce the large sites needed for economic development are complex and hinder the progress of the project. The state could compulsorily acquire strategic parcels of land where these would allow development to proceed. However, this is a political quagmire. They also opine that the planning ideal of mixed-use TODs may not be economically viable in smaller centres. Plan requirements for minimum percentages of commercial development in such TODs might actually deter developers who are only able to make development economic if it is entirely residential.

2.2 Positive Lessons

Per-capita vehicle travel tends to decline when the following are achieved, a) population and jobs density is high and concentrated in compact activity centres, b) a mix of land use, c) con-nected street networks that support pedestrian and cyclist movement, d) safe and attractive streets that accommodate pedestrians and cyclists where buildings are connected to footpaths and not setback from the parking lots, e) traffic speeds are reduced using traffic calming measures, f) competitive transit system that is well integrated with high-density development within 500 m (walkable distance) of transit stations (VTPI 2008). Since private vehicles con-tribute in a major way to emissions of air pollutants like particulates, ozone and other organic compounds. Therefore, TOD can help restrict the ill-effects of rapid motorization. Additionally, TOD can help a) encourage efficient use of public transport and urban infrastructure, b) reduce costs related to urban congestion, c) revitalise local economies of urban districts, d) increase property values, e) increase physical activity of residents as a result of increased proximity to commercial centres, greens paces and schools.

Diverse communities and TOD :- TOD literature talks about achieving community diversity as a means to achieving successful TOD. The State of Queensland (2010b) defines a diverse TOD community as one where people with diverse demographic, socio-economic, cultural and employment characteristics live in a harmonious manner. There is no consensus on the ideal mix as has been discussed earlier. It depends on the area and the changing dynamics of the area. Earlier research has proved that diverse TOD communities can help achieve social and economic benefits. Social disadvantage when concentrated in small pockets can be problematic. This is especially true when redevel-opment and infill occur in a neighbourhood owing to the coming of transit. Therefore, planning agencies need to ensure a combination of land use, investment and community development strategies. Diverse TOD communities can be achieved through a) urban form, b) housing mix and design, c) economic development, d) provision of community facilities, e) community de-velopment, and f) community engagement. It is seen that revitalisation of historic core cities leads to a decline of diversity owing to gentrification. Long-term investments in social housing, improving infrastructure, incentivising local businesses and efforts towards facilitating integra-tion of incoming communities into existing ones needs to be taken to counter these. In order to promote community diversity, the following factors are said to be most influential: a) urban form and land use, b) housing, c) access to diverse jobs and retail diversity, d) social infrastruc-ture, e) improved access and movement, f) open spaces, recreation and improved public realm, g) community engagement, and h) community development.

- **Urban form and land use :-** Community diversity can be supported through developing transit stations as hubs for the local community. These can be in the form of common facilities or opens spaces. Strong physical linkages need to be established between the existing neighbourhoods and the hubs. Clusters of residential areas with shared access to community facilities and visual relief need to be devel-oped. Design can help in ensuring that the access to such shared facilities remains open for all and their legitimacy is ensured. Land uses that are compatible with each other must be put in close proximity with each other.

- **Housing :-** Research suggests that by providing a range of dwelling unit sizes, different types of housing and tenure and by ensuring flexibility of design, it may be possible to attract and retain a wide variety of residents in the TOD. This helps keep the diversity of the local economy as service-providers like plumbers would be able to live within the close proximity of those that would need their services. TOD regulations could make it a requirement for developers that a certain proportion of the new units must be two-bedroom or lesser. The government could provide funding mechanisms to help developers provide affordable housing in TOD. Also, regulations could ensure that a certain proportion of new units in TOD area are suitable for differently-abled or aged. Design could be used to ensure easy access to open spaces and forced interac-tions between people belonging to different socio-economic groups. Streets must be humanised with a multi-use character fit for use by people belonging to different backgrounds and abilities.

- **Access to diverse jobs :-** Research shows that TOD is often accompanied by the replacement of local low-value busi-nesses by high-value retail chains. This leads to homogenization of economic opportunities which does not augur well for the success of TOD. The local body will need to engage with the existing community to develop local strategies, stimulate investments, negotiate strategic office locations and retain local businesses. Additionally, land use measures can be used to generate building footprints of varying character that can support businesses of different scales. Housing that encourages home-based businesses will also be ideal to stimulate local economy and provide more opportunities for those from the neighborhood and beyond.

- **Social infrastructure :-** Social infrastructure like schools, hospitals and gardens encourages people to take part in community life, builds belonging, reduces social isolation and meets basic needs. TOD places a premium on private space. Social infrastructure could potentially help communities in adding value to their lives by use of shared facilities for community purposes. These need to be provided in a manner that they are convenient, multi-use, flexible, easily accessible and economically viable.

- **Improved access and movement :-** By providing an easily accessible TOD precincts, the community will find it comfortable to negotiate the public realm. Direct, attractive, safe pedestrian and cycling linkages with great sign-age need to be provided. This would incentivise even the low-income groups in living close to transit. Inter-modal transfers should be made convenient by design. Those that have special needs must be able to move around in a convenient manner.

- **Open spaces, recreation and improved public realm :-** The quality of the public realm is determined by its availability, diversity, utility and meaning to users. Such spaces help people come in contact with not only nature but also people from groups that they would not normally identify themselves with. Safe, convenient and equitable access to places of vitality are essential to ensure the welfare of the community. The public realm must be designed in a manner that prioritises pedestrian and cyclist over the automobile. Flexible and versatile spaces that could host a variety of uses are needed. There must a physical and visual access to nature. Open spaces must be easy to access and completely safe for various user groups.

- **Community engagement and development :-** Only a high degree of engagement with the community can ensure a sense of ownership and belongingness among the community. TOD plans and outcomes must be shared with the di-verse stakeholders and feedback sought and acted upon. A collaborative approach that har-nesses the wide range of skills available in the local community can help the TOD. Long-term commitment to the idea of engagement must be shown and accompanied by a flexible planning framework. The process must be open and accountable and should help develop the capacities of the local community members. TOD plans must foster local community cultural values and their expression through the creation of accessible public spaces. A fine-grained street network would add a lot to the complexities of the area thereby making it diverse and interesting. In-volve local communities in seeking solutions to local problems and regulating anti-social be-haviour.

Equitable and inclusive TOD? :- There appears to be a great syntaxical variety in how literature refers to equity aspects of TOD. Some like Soursourian (2010) have referred to the this development as equitable TOD (eTOD) while some others have referred to affordable TOD (aTOD). Greg LeRoy writes that “the benchmark for proximate affordable housing is median monthly rent or median monthly mort-gage debt service that does not exceed 35 percent of the median workplace wage or salary, which is computed exclusive of the highest 10 percent of salaries. Housing costs are derived from either the municipality in which the workplace is located”(Soursourian 2010: 16). An altogether different set of people have referred to what is called as inclusive TODs.

In order to achieve an equitable and inclusive TOD, literature points towards achieving a) re-vitalization and intensification, b) neighbourhood preservation, and c) access and connectivity. Table 1 below shows approaches that can contribute towards making a TOD more inclusive. These are essentially a combination of the neo-traditional ap-

proach advocated by Calthorpe (1993) - in postulating the pedestrian pockets and later TOD - and the more humane approach advocated by Jane Jacobs (1961) in imagining a liveable neighbourhood that displays a strong sense of community.

Table 1: Factors that contribute towards an inclusive TOD

Theme	Approaches
Revitalization and intensification	Increase density/development
	Revitalize commercial corridors
	Develop affordable housing
	Assist existing residents economically
	Enhance economic (jobs) growth
Neighbourhood preservation	Prevent displacement of vulnerable HHs
	Preserve historic buildings
	Enhance community activities (parks)
	Maintain/enhance local identity
Access and connectivity	Increase transit ridership
	Overcome barriers to using NMT
	Improve safety
	Improve urban design

Source: based on (Soursourian 2010)

TOD is in a position where it can help the low-income and middle-income groups in accessing employment, recreation and health services. TOD can also help bring investment and renew inner city areas that have borne the ill-effects of economic and planning neglect. However, it is seen that TODs help high-income communities, many of whom are interested in moving back into the city centres from the suburbs. The commercial success of TOD depends to a large extent on the spike in land price that follows its announcement and later implementation. This spike in land prices allows the implementing authority to fund infrastructure provision in the receiving area by charging higher land development fee/tax. The improvement in the area sub-sequent to the coming of TOD attracts richer communities who then price out lower and middle income communities already living in the city centre. As a result, the lower and middle income communities are forced to move to the peripheries, far away from jobs and transit. The TOD therefore may disrupt instead of helping these communities who are more likely to use transit in the first place.

2.3 Indian Experiences

As mentioned earlier, while many Indian cities have invested in mass transit systems like BRT and metro rail, not many have adapted the concept of TOD. This, despite the presence of enabling factors like density and diversity of activities, especially in the inner core areas of cities. Even in the cities where there has been talk of TOD, progress has been tardy. Delhi has made some progress and its master plan has an entire section dealing with TOD provisions (UTTIPEC 2012). Ahmedabad has delineated Transit Oriented Zones (TOZ) as part of the de-velopment plan and is in the process of preparing detailed Local Area Plans (LAP). Bengaluru has prepared some and is in the process of preparation of Station Area Plans (SAP).

Delhi :- The National Capital Territory (NCT) is located at the core of the National Capital Region (NCR). It has a population of 16.32 million within the NCR which has a population of 45.2 million (Registrar General of India 2011). NCT Delhi is highly urbanized with 93.18 percent of its population living in urban areas as against the national average of 27.81 percent. During 1991-2001, the urban population of Delhi increased at 3.87 percent annual growth rate. This rate of growth of population stabilized to around 1.8 percent in the next decade. The 2021 Master Plan for Delhi (2005) is currently in force. It was prepared by the Delhi Development Authority (DDA) under the provisions of the Delhi Development Act 1957. It sits within the larger context of the 2021 National Capital Region Plan (2013) prepared by the National Cap-ital Region Planning Board (NCRPB) which was formed under the NCPRB act of 1985. As indicated in Table 5, the DDA is in charge of the preparation of the master plan and TOD plans.

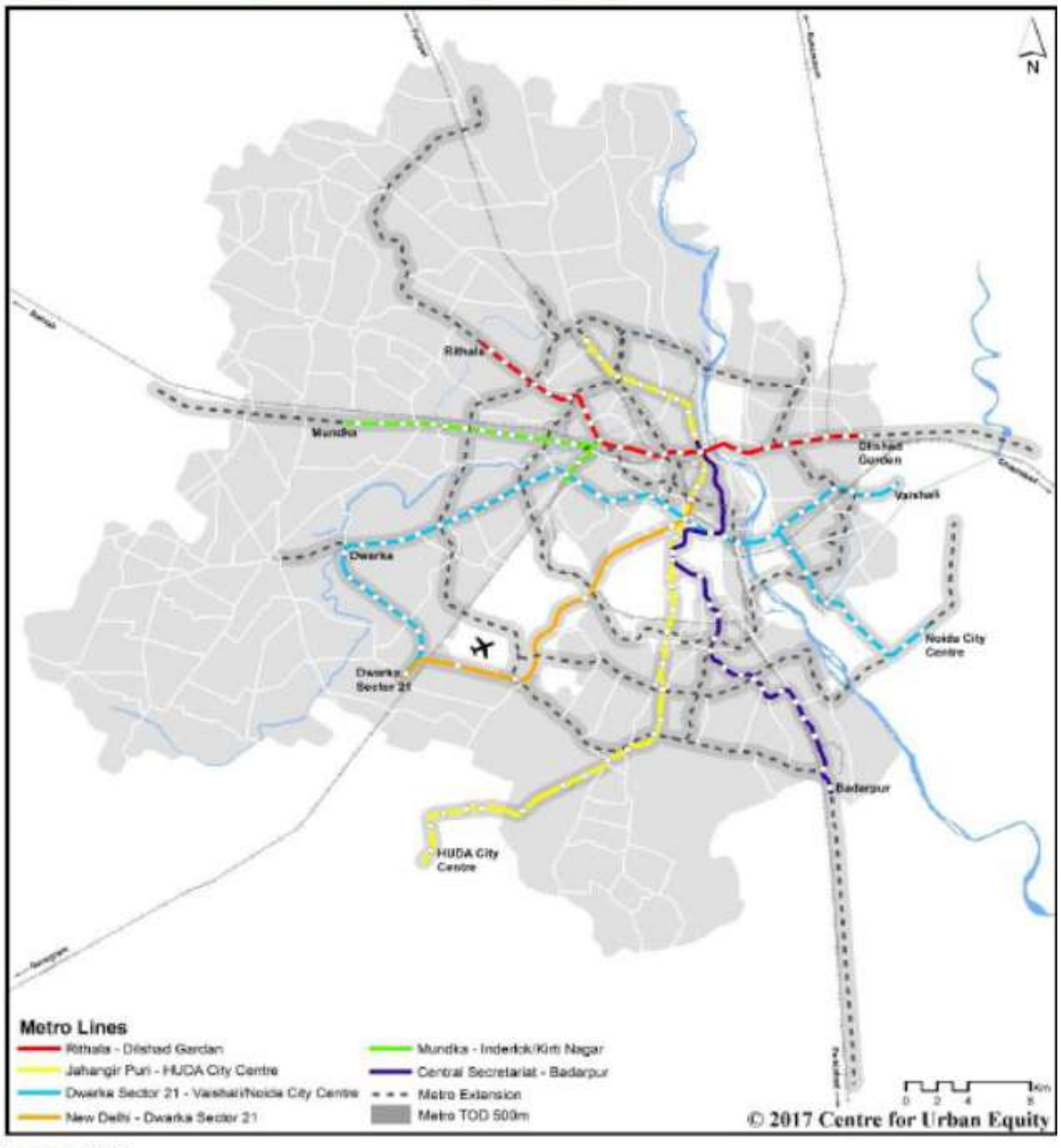
The Delhi Master Plan defines TOD as "any development, macro or micro that is focused around a transit node, and facilitates complete ease of access to the transit facility, thereby inducing people to prefer to walk and use public transportation over personal modes of transport" (WRI 2016). DDA identifies TOD as

"Key for low-carbon, compact development with mixed land use that allows for optimized development along transit corridor. TOD increases densities and places high-rises along the transit corridors to accommodate a wide variety of uses. It is an ideal tool for governments to address inclusivity by citing minimum caps for housing for various segments. With the policy capturing the essential elements of mixed-use development, non-motorized transport and pedestrian priority, and encouraging a walk-to-work culture, Delhi in particular is looking at TOD as a solution to its mobility and air quality challenges by developing the areas around metro stations." (WRI 2014: 5)

The stress on inclusivity, sustainability and public health is evident in the words quoted above. Apart from a dedicated chapter in the master plan for TOD, a TOD manual that looks at the Delhi TOD policy1 and helps in the interpretation of regulations was developed by UTTIPEC and WRI (UTTIPEC 2012; WRI 2014). The TOD policy exempts the following areas, namely a) Lutyen's Delhi and Chanakya Puri, b) Civil Lines area, c) Areas under ASI, d) Zone-O, and e) Low-density residential areas notified by DDA. picture 3 shows the metro rail net-work in Delhi and TOD zones around the transit stations.

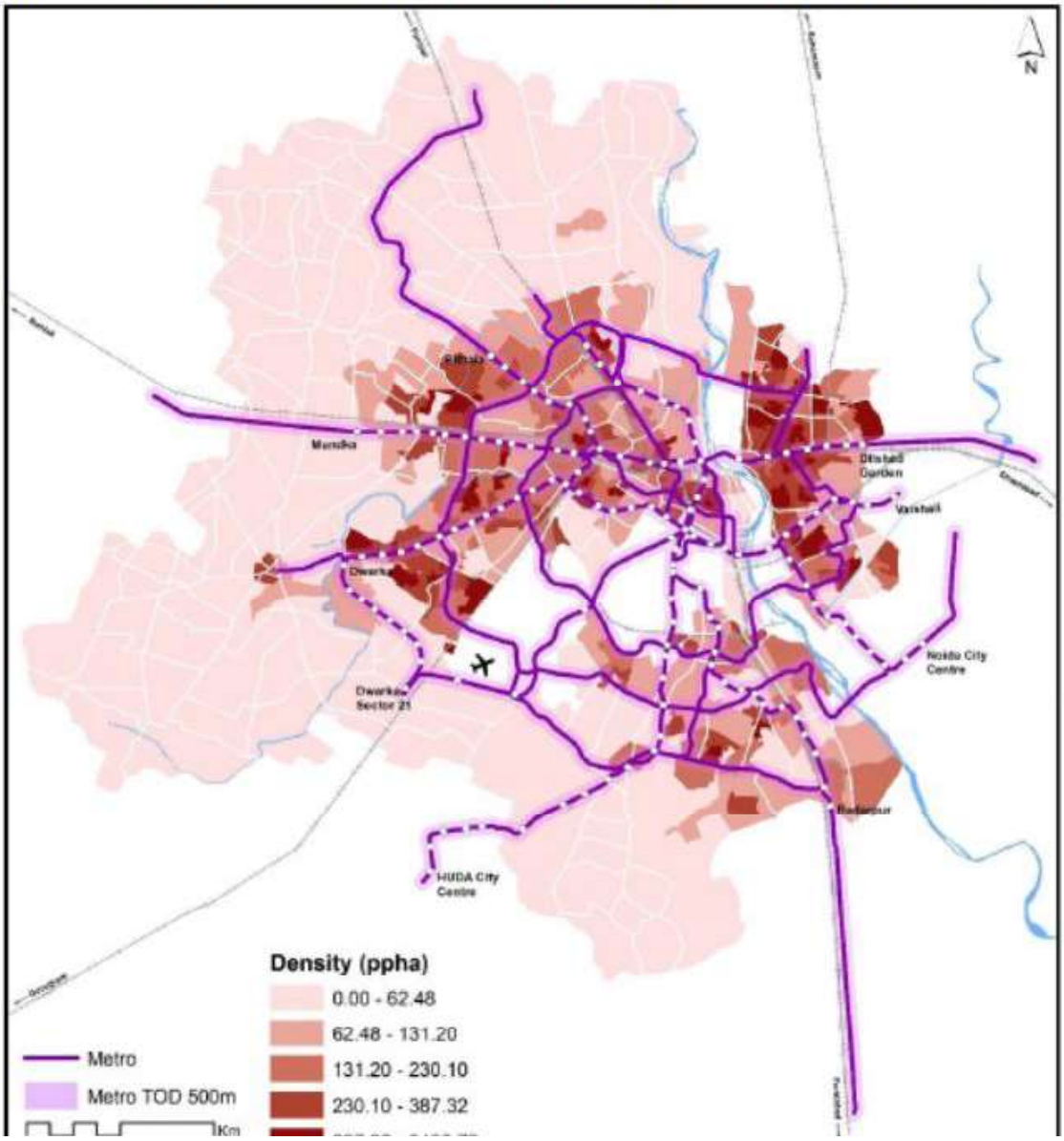
The UTTPEC document on TOD policy advocates the adoption of TOD through its principles: a) NMT friendly environment, b) connectivity and network density, c) multi-modal inter-change, d) inducing modal shift, e) placemaking and ensuring safety, and f) high density, mixed use, mixed income development near stations. In terms of redevelopment, the policy advocates the redensification of low density areas and redevelopment of other developed areas in addition to the influence zone along MRTS corridor shown above. About 500 m wide belt on both sides of centre line of the existing and planned/approved MRTS Corridors is designated as Influence Zone which has been identified in the respective Zonal Development Plans, along with stations. Entire approved plan of a TOD integrated scheme will be included in the zone if more that 50% of the plan area falls inside the influence zone. Higher FAR and height can be availed through the preparation and

Picture 3: Transit network and TOD zones in Delhi



Source: CUE

Picture 4: Transit network and TOD zones overlaid on population density in Delhi



approval of comprehensive TOD integrated scheme. Wherever height is restricted by any regulatory authorities like AAI, NMA; in order to enable the DE to utilize the permissible FAR, a relaxation in ground coverage and setbacks, without compromising the green public open space of 20%, in such TOD integrated scheme shall be allowed (WRI 2014).

Amalgamation and reconstitution of the plots for planning purpose is permitted in all redevelopment schemes, including TOD. In order to participate in TOD, individual/ group of owners may need to partner with other adjoining land owners/ property owners to form a Developer Entity (DE), and prepare a single contiguous scheme of minimum 1 Ha. The main building facade shall face the public street without setback and an active frontage to facilitate visual surveillance of streets. There is no minimum active frontage requirement when RoW is ≤12 m. Active frontages include arcades, shop-fronts, entrance doorways, access points, entry/exits and transparent windows of active areas facing the main street. Commercial frontages shall have minimum 50% transparency at ground floor level.

For any integrated scheme, a max. FAR of 400 and a maximum density of 2000 persons per hectare (ppHa) i.e. approx. 450 du/ha is permissible. The entire amalgamated plot will be considered for calculating the FAR and density. FAR utilization shall not be less than 200. Mandatory EWS FAR of 15% over and above the maximum permissible FAR shall be applicable. In all integrated schemes, a minimum of 30% of overall FAR shall be mandatory for Residential use, a minimum 5% of FAR for commercial use and minimum 10% of FAR for community facilities. At least 50% of the total FAR shall be as per ZDP use. See graphic below.

In TOD zones, the permissible ECS2 (Permissible Equivalent Car Spaces) per 100 sq m of floor area is 1.33. Additional parking may be created within integrated schemes only as paid, shared parking facilities accessible to general public at all times. 20% of the area of the amalgamated plot in TOD integrated scheme (TODIS) of 4 Ha and above, shall be designated as green Public Open Space which shall be designed, developed and maintained by the DE/agency and will remain un-gated and open for general public at all times, failing which it will be taken over by Public agency. In addition to the above, at least 10% of plot area shall be in the form of Green/ Recreational area for the exclusive use that includes circulation and common areas.

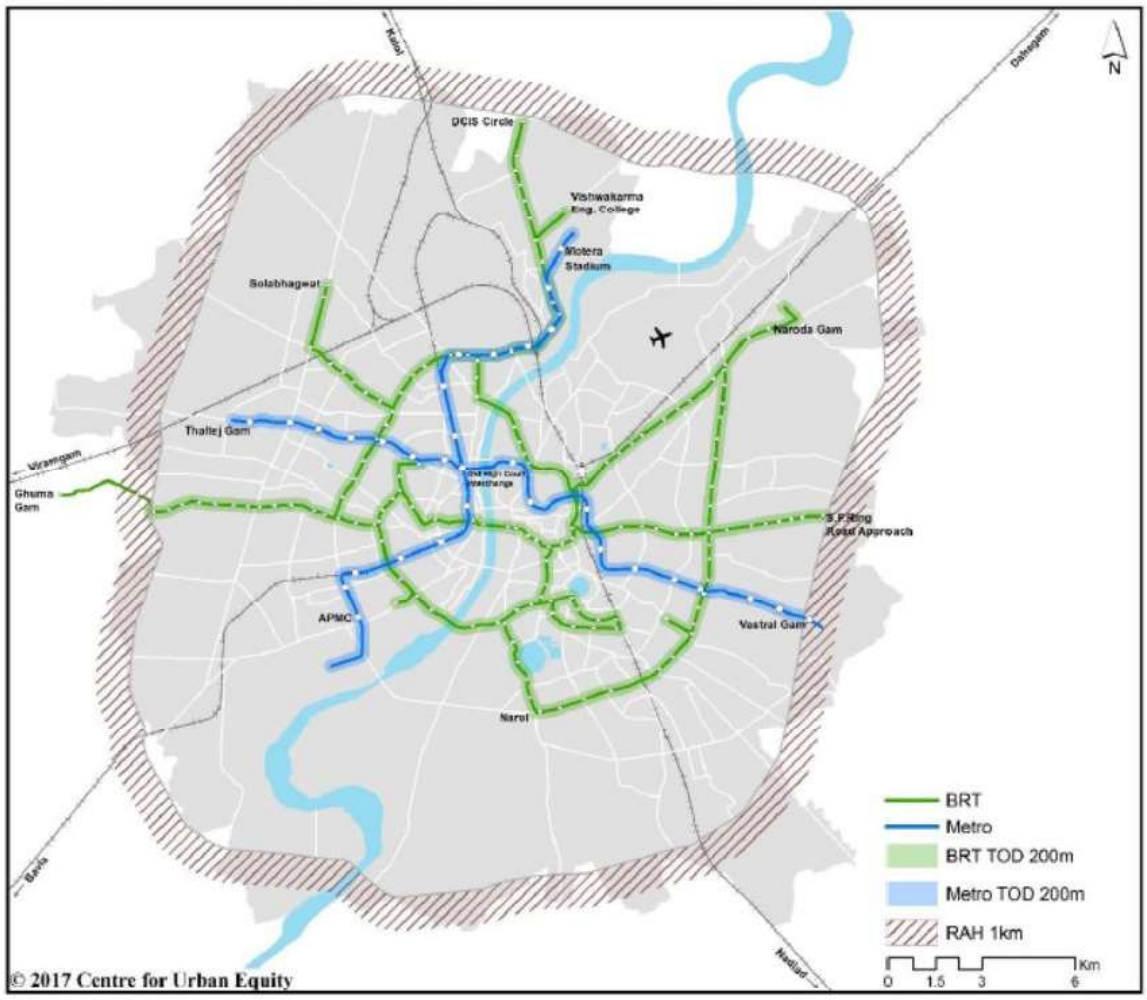
Criticism :- TOD policy and EIA provision does not harmonize with each other. Green areas for 1 hectare plots falling in TOD zones, Parking ECS for TOD plots is less compared to the pro-visions prescribed in construction manual of EIA. EIA provisions needs amendment for incorporating TOD concept provisions so that TOD projects can be facilitated for implementation. Though it is mentioned in the policy that adequate space for IPT, Bus, private bus, truck and commercial parking must be provided for all layout plans, the policy does not provide for or mention any standards that may be referred for making such provisions. The policy does not specify that the social infrastructure ought to compliment the larger catchment area or neighborhood and the missing services need to be provided. Setback: Of the area taken up for development as integrated scheme, at least 20% of land shall be used as un-gated constructed roads/ circulation areas for common use versus Setback to be handed back to local body as public roads (at least 20% of plot/scheme area): should this 20% public road area be restricted to the setbacks only. To what extent can the basement be utilized for parking purposes when there is zero setback (WRI 2016).

Ahmedabad :- is the largest city in Gujarat with a population of 5.57 million in an area of 450 square kilometers (Registrar General of India 2011). The Ahmedabad Municipal Corporation (AMC) was established in 1950 under the Bombay Provincial Municipal Corporation (BPMC) Act, 1949. In the year 2008, around 180 square kilometers in the west and 80 square kilometers in the east were added to the city, bringing the total area of the city to 450 square kilometers. Apart from the area under AMC, growth centers of Kalol, Dehgam, Sanand, Mehmedabad and Bareja, 169 villages fall within the jurisdiction of Ahmedabad Urban Development Authority (AUDA) which is responsible for planning and development functions in its jurisdiction. As of 2011, the area within AUDA's jurisdiction has a population of 6.35 million in an area of 2,433 square kilometers. Currently, the 2021 Comprehensive Development Plan (Second Revised) (Ahmedabad Urban Development Authority 2013; AUDA 2013a, 2013b) is in force. It presents immense opportunities for inner city densification and compact development centered on the BRT network in place and proposed metro rail alignment.

While the base FSI in Ahmedabad is 1.8, a 400m wide band around the BRT network and proposed metro rail is termed as Transit-Oriented Zone (TOZ) and allowed higher FSI of 4 and the central business district in close proximity to the two networks is allowed a much higher FSI of 5.4 (Picture 6). These areas currently consume an FSI of less than one on an average (Ballaney et al. 2013). In order to realize an FSI of 4 or 5.4, these areas will require rapid infill development. Gujarat has already in place a progressive land pooling mechanism in the form of Town Planning Schemes (TPS) through the landmark Gujarat Town Planning and Urban Development Act, 1976 (Ballaney 2008; Ballaney and Patel 2009; Deuskar 2011; Nallathiga 2010). The TPS mechanism has been used in the provision of serviced land for development, especially in the urban periphery of Ahmedabad and other towns of Gujarat. While this mechanism has largely worked in the peripheral area, there has been some criticism on the socio-political dimensions of this mechanism especially when seen in the context of realization of new ventures like smart cities (Datta 2015).

There have been reservations on how to use this progressive mechanism in inner city areas for redevelopment of existing areas. The recent amendment to GTPUDA, 1976 allows for preparation of local area plans to address this lacuna (TCPO 2013). The Ahmedabad Urban Devel-opment Authority (AUDA) has commissioned planning firms to prepare Local Area Plans (LAPs) for the areas that come under the TOZ. Some of these plans have been prepared and public opinion sought on them. These are currently pending with the state-level planning agency for approval. We have not yet

Picture 6: Transit network and TOD zones in Ahmedabad city

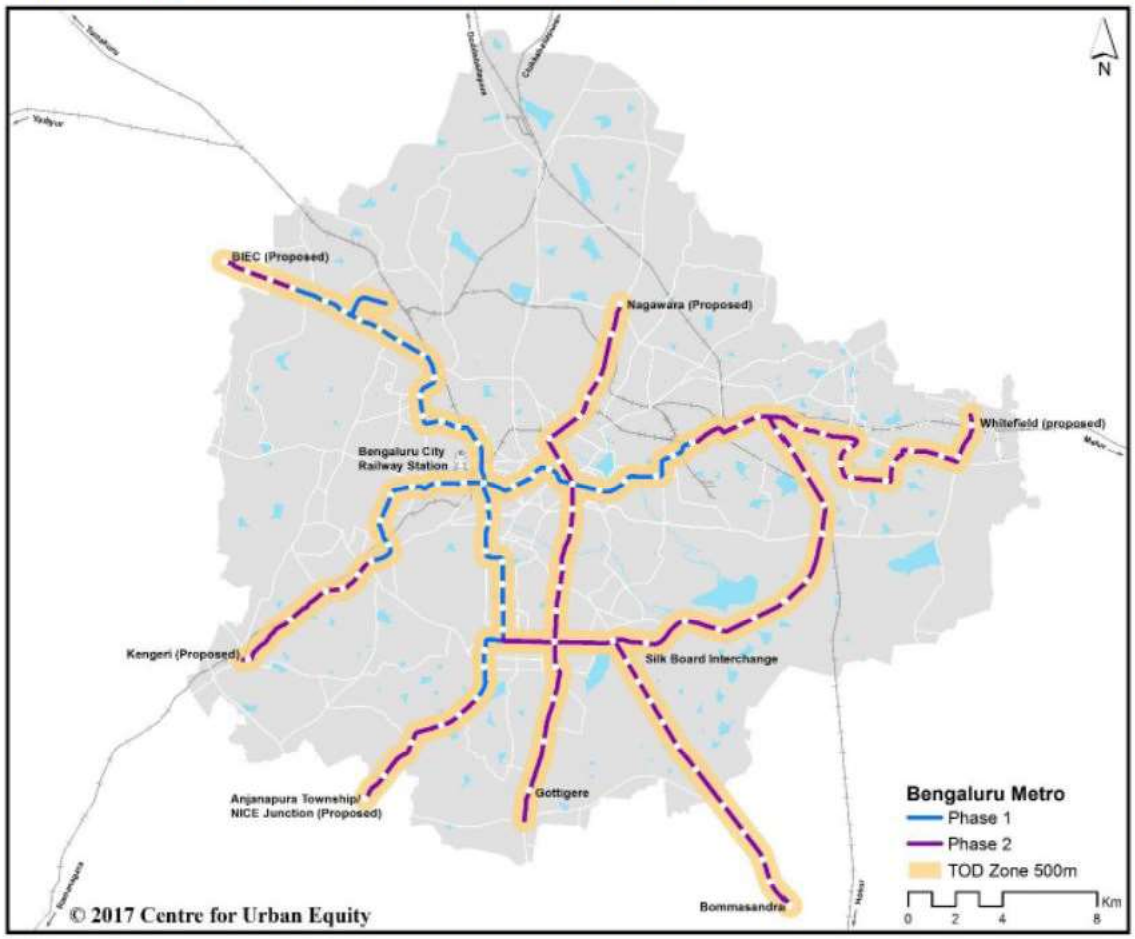


Source: CUE

managed to scrutinize these plans but hope to do so at the earliest. The LAP for the Central Business District (CBD) seeks the implementation of local area plan with part of the front margin used for pedestrian movement as part of the public domain. Connectivity within two buildings in the same block is sought to be enhanced. New pedestrian walkways are allowed within the block. Sharing of underground parking facilities is encouraged.

Bengaluru :- the largest city in Karnataka and is the fourth most populous city in India with a population of 8.43 million and area of 741 square kilometers. It is administered by the Bruhat Bengaluru Mahanagara Palike (BBMP). It forms part of the Bangalore Metropolitan Area (BMA) which has a combined population of 8.49 million and area of 1,320 square kilometers. The Bangalore Development Authority (BDA) is responsible for planning and development functions in BMA. Its stated vision is to 'plan, regulate, control, monitor and facilitate urban development in BMA, to ensure sustainable and orderly growth' (Bangalore Development Authority 2015). The BDA uses the 2015 Revised Master Plan for Bangalore (2007) to regulate and facilitate urban development in the area under its jurisdiction. In addition, the Bengaluru Metropolitan Region Development Authority (BMRDA) plans and coordinates development in the Bengaluru Metropolitan Region (BMR) measuring 8,005 square kilometres comprised of Bengaluru urban, Bengaluru rural and Ramanagara districts As of 2011, some 10.70 million people live in the BMR. The BMRDA aims at integrating development in the BMR through the 2031 Revised Structure Plan (2013). Planning in areas outside the BMA is undertaken in accordance with the provisions of the Karnataka Town & Country Planning Act, 1961.

Picture 9: Transit network and TOD zones in Bengaluru

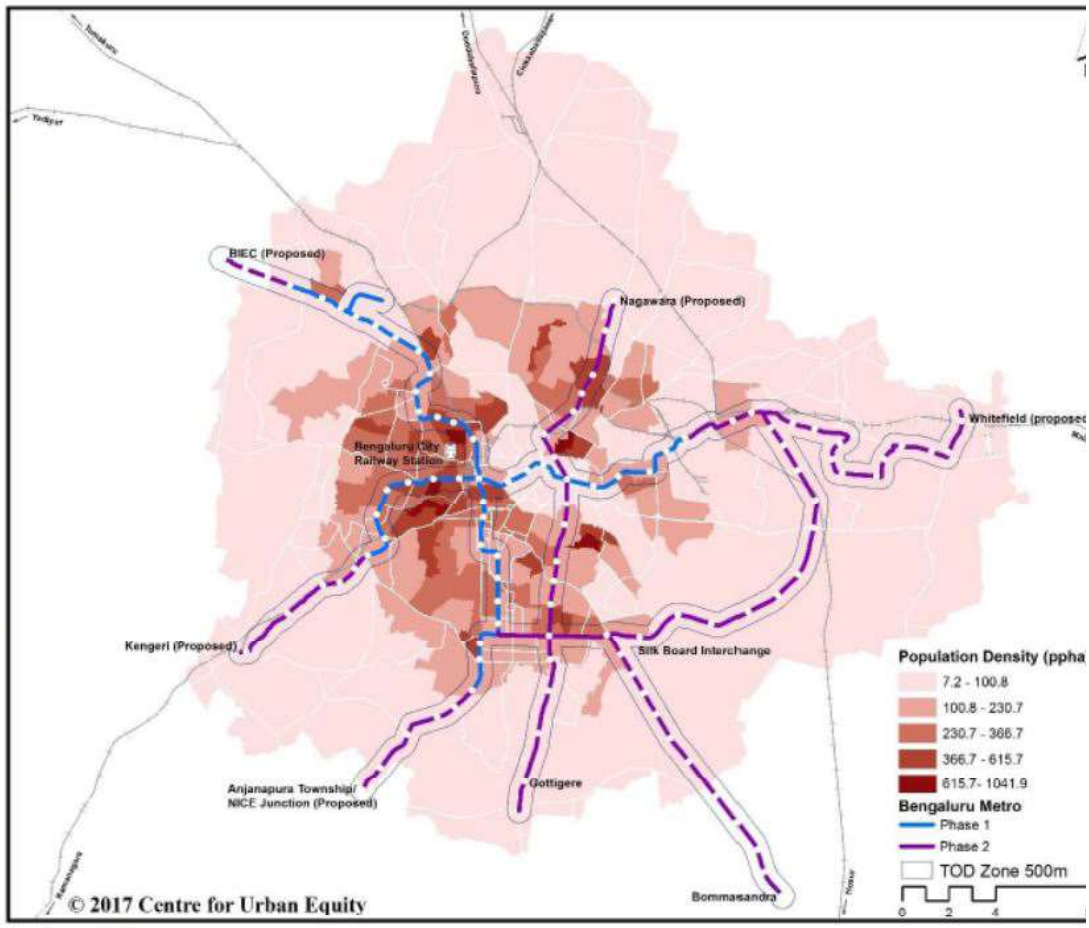


Source: CUE

The new master plan is under revision and is said to have provisions in the form of TOD policies. However, these are not yet in the public domain. Till the new plan comes into fruition, the Revised Master Plan of 2015 is in play. A notification from the Karnataka Urban Develop-ment Department (No.UDD 93 MNJ 2008) was passed in 2009 stating that the maximum permissible FAR is increased to 4 for all land uses with the exception of Traffic and Transportation Zone within a distance of 150m from the outer edges of the Metro Station (Picture 9). However, it does not prescribe any change to the other regulations of the RMP 2015. The current regulations fail to address the issues that accompany the transformations brought on by the introduction of the metro system and the UDD notification itself. Since each of the areas through which the metro line passes differ from the rest in many aspects, they have responded differently to the transformations triggered by these developments. Hence a blanket rule cannot be applied to all areas without assessing their potential and limitations in supporting these new developments (Embarq 2014).

The existing uses around the metro stations are diverse and of varying densities. Very few stations will be able to accommodate additional density. Institutional uses, large commercial uses, large industrial uses and existing older commercial areas will remain. Depending on the station, the opportunities for densification of land uses and transportation connectivity will vary and in some cases will be very limited (Picture 10). The public transport, feeder services, walk-ability and accessibility around these metro stations are yet to be developed for overall transportation connectivity (Nagaraj 2013). Additionally, the Directorate of Urban Land Transport and Embarq India have come out with development control regulations for station areas, an example being the one for Indiranagar Metro Station area. These plans present a critique of the UDD notification mentioned above.

Picture 10: Transit network and TOD zones overlaid on population density in Bengal



Source: CUE

Criticism:

- **Incompatibility with smaller plots:** An FAR of 4 translates to a building height of at least 5 floors (15m). As per existing regulations, for buildings taller than 11.5m, the setback increases with the addition of every floor. This results either in the decrease of the building footprint to impractical extents or under-utilization of the FAR due to the restricted height the building should be limited to in order to avoid reducing its ground coverage. This issue is faced by 92% of the plots in Indiranagar which are smaller than 1000sqm (Embarq 2014).

- **Lack of light and ventilation:** While the maximum FAR limit of 4 can be achieved by most plots by adding two or more floors and maintaining the existing setbacks, it will create a series of tall structures with very little space between the buildings due to which sufficient natural light and ventilation cannot reach the lower floors (see Picture 11). This is applicable to at least 75% of plots that currently have a maximum FAR of 1.75 and setback of approximately 1.4m on all sides (Embarq 2014).

- **Insufficient pedestrian infrastructure like pavements to support increased densities:** Application of 4 FAR to the 150m zone results in a 95% increase in built-up area and an equivalent increase in the number of households and hence number of vehicles. With most roads having width lesser than 15m and the wider roads already being congested with traffic, the increased demand for parking and road space cannot be accommodated on the existing streets. A 95% increase in built-up area also translates to a near doubling of the population and pedestrian volumes within the 150m zone. This makes it imperative to address issues pertaining to walk-ability and easy access around the metro station; including effective design of building facades, creation of more pedestrian-friendly streets and zones and ensuring a safe environment for pedestrians at all times of the day (Embarq 2014).

- **Area Character:** The constraints placed by the existing regulations on the smaller plots forces them to either amalgamate or fore-go the additional FAR they are entitled to. Due to the high real estate values in Indiranagar and proxim-

ity to the Metro, amalgamation is more likely to take place across the 150m zone, whereby independent homes cannot be maintained on amalgamated plots and will have to give way to either multi-storeyed apartments or commercial structures. Since, currently, in this zone 89% of residential plots have independent homes, such a transformation will completely change the scale and function of buildings in the neighbor-hood. The increased rate of commercialization taking place in close proximity to the Metro may result in the creation of mono-functional commercial areas that are dead spaces beyond working hours and hence unsafe for pedestrians (Embarq 2014).

- **Concentration of densities:** The UDD notification concentrates all the development within 150m of the metro station. The proposed incentive will result in a 95% increase in density when the 4FAR is completely achieved. This doubles the load on the infrastructure within this limited area. On the other hand, a number of activity generators that make Indiranagar a city level destination for high-end retail and commercial activities are located beyond the 150m zone but within walking distance of the Metro Station. These areas have high potential for growth but are underutilized due to the limited FAR they are entitled to (Embarq 2014).

- **Other opportunities in Indiranagar:** Indiranagar is a city level destination for high end commercial and retail activity as well as a much sought after location for residential properties. A study of the real estate market indicates that the property rates in Indiranagar are one of the highest in the city. This is further expected to rise with the completion of the metro lines which will provide better connectivity to all parts of the city. Hence, the development in this area must be planned to make best use of the Metro system and the supporting incentives while ensuring that a safe and attractive environment is created for the residents, visitors and users of the public transportation systems (Embarq 2014).

- **Parking:** Indiranagar presents huge challenges in terms of availability of free parking. Our discussions with stakeholders presents a clear picture of how the arrival of new developments, esp. Commercial land use has put immense pressure on the available street scape. The huge spurt for parking that cannot be met within the premises of these commercial developments spills over on the streets making it difficult for those living in the area to use the streets safely for walking and cycling. Our surveys present the encroachment of footpaths by motorbikes and cars (Picture 13). This has had a debilitating effect on the accessibility to the metro station itself, putting pedestrians and cyclists at risk.

- **Visual aesthetics:** Indiranagar, in the absence of any regulations on the nature of development coming in the area has become a mishmash of all kinds of buildings with little concern for the users of the public spaces. In becoming so, Indiranagar presents itself as an eyesore than a planned urban space.

2.4 Discussion - Way forward

International experiences & Case Studies

If TOD has to achieve success, cities must commit themselves to long-run strategic planning at multiple scales - regional, corridors, and station areas (Cervero and Dai 2014). The case studies discussed as part of this research highlight the important role played by the collaboration between the State and developers in the success of TOD. Some of the other factors which are seen to influence the success or failure of TOD are discussed below:

- **The TOD Market :-** One of the threats associated with TOD is the market experiencing a lull and not building the kind of floor space that was being expected by the development authority. For example, one of the earliest prototypes of TOD namely Laguna West in Sacramento, California failed to materialize owing to lack of interest from the real estate developers. In North America, developers were not very upbeat about the prospects of development around light-rail stops In St. Louis, Pittsburgh and Buffalo. This led to delays in realizing TOD built-form (Cervero et al. 2002). Cervero et al. Opine that for TOD to work, a proactive public sector is a prerequisite. When the State works in tandem with developers, the probability of realizing TOD vastly improves (Guthrie and Fan 2016). TOD plans require the participation

and eventual buy-in from the community. The State enjoys the kind of legitimacy that could help in this kind of processes. The large plots required for TOD can be easily assembled or made ready for assembly by the State. The State could also write down the value of land under its control for a share in project revenue. Provision of infrastructure through investments and creating incentives for (re)development such as tax-holidays are the State's forte. Subsidies at the initial stage in order to inter-est developers can go a long way in the success of the TOD.

- **Regulatory and governance policies :-** Grants can help in propelling a TOD project forward quickly. Governments are the chief conduits of grant assistance, effectively transferring resources to the private sector and some of the risks to the public sector. Assistance from private foundations can also be helpful. Impact fees relieve municipalities of fiscal burdens by passing on public-facility charges to developers, they can work against affordable housing goals. One way to cushion the burdensome effects of impact fees, on both developers and consumers, is to provide financial relief and even exemptions for projects like TODs. The responsibility for building, operating and maintaining transit services and the regulatory control of land use is not often held by the same governmental body, a transit agency is rarely able to have regulatory authority on land uses surrounding its right- of-way. Tax relief can entice developers to site projects near transit stops. Portland has used this meas-ure to encourage multi-family housing projects. Tax credits effectively subsidize development, critics charge that such initiatives are inequitable. Equity participation often takes the form of a transit agency or redevelopment authority writing down land costs in return for future cash flow. Public entities can also lure developers to station areas by providing loans, usually either below market rate or in the form of guarantees for securing funding from commercial lenders. San Diego. Interest-cuts also help in incentivising the developers in creating built space around transit stations.

- **Land-based initiatives :-** Land assembly is an important prerequisite as far as redevelopment is concerned. Redevelopment takes time as the land ownership is split among multiple stakeholders. If the government were to be involved in land assembly, either eminent domain or voluntary land pooling exercises could be invoked to get the land assembled, before it is handed over to the developers for development. This works in the provision of social housing, especially when the government bodies have land around transit stations. Land swaps could also help bring in transit-oriented development around stations while shifting those that don't fit in the context to the peripheries. Land banks involve the transit agencies investing in land that may fall in the expected direction of growth of the city. As this growth happens or transit is provided, the agency may monetize this land or sell them to developers conditionally with regard to the provision of transit-oriented development. Cities like Copenhagen have undertaken this kind of development which has benefited them in the long term. Sale-able development rights over land or air rights that belong to the transit agency helps in making the developers invest in projects that may help the transit in the long term. American cities like Santa Cruz, California have used this means very efficiently. Also, strategic siting of government facilities such as major medical colleges can help spur development in an area in a manner that helps the transit. Land value capture can be used to reap the benefits of increasing land values as a result of facility investments.

- **Zoning regulations :-** Zoning areas close to transit corridors for development that augurs well for transit, can help in realising the benefits of TOD. Cities have used incentive zoning, inclusionary zoning, floating zones, performance zoning and interim zoning as means to achieving the right kind of devel-opment (Cervero et al. 2002). Incentive zoning uses measures like FSI bonuses for developers that create public benefits like parks and connectivity. Portland has used inclusionary zoning to prevent auto-oriented landscapes from dominating transit vicinities. It uses measures like caps on parking, provision of pedestrian and cycling infrastructure to dissuade car use. Cities like San-Diego have used floating zones to allow mixed uses, higher FSIs and reduced parking requirements. This has had a positive effect on TOD premiums as Duncan (2011) demonstrates.

Planned development around stations can be used

to drive demand for affordable housing near transit stations. The Yeerongpilly TOD in Queensland is an example of how this is being ad-dressed (Queensland Government 2016). Other cities like San Jose have also tried their hand at spurring TOD through individual planned projects. Transfer of development rights help builders build more in areas where the market demand exceeds the provisions of the development plan in exchange for incomes from historically important buildings elsewhere. Toronto and New York have used this measure to retain the character of their inner cores while driving development around metro rail stations.

Expanding housing choices :- Provision of affordable housing can help in the availability of diverse housing options, especially for those that tend to use transit modes. If a healthy mix of income groups can be facilitated around metro stations, transit benefits accrue as also do social benefits. Conventional approaches have centered on providing extra FSI, based on the assumption that doing so would incentivise the supply of affordable housing in close vicinity of the transit station. However, international experience has shown that merely the absence of FSI limits won't help address the issue. In fact there is evidence to prove that FSI caps may actually work in favor of community diversity. The key may lie in treating FSI like a scarce market commodity in a manner that mobile phone transmission spectrum is treated (Express News Service 2011). International experiences point towards the need for state intervention to ensure that a good mix of social groups is ensured around transit stations.

Housing vouchers have been long used in North America as a means for deconcentrating the poor and encouraging upward mobility (Hartung and Henig 1997). The United States uses Section 8 program to encourage housing vouchers. As Varady and Walker (2003) argue, these have resulted in positive impacts on the communities resolve to help themselves as well as their children. While the current housing sector policies in India are centered on creation of socio-economic group specific housing units and debates on FSI, it remains worthwhile to consider measures such as the housing vouchers program to improve access to affordable housing. An-other measure worth considering is linking the availability of FSI to the levels of service of public transport in the area. This logic may be extended also to the extent or likelihood of provision of infrastructure in the area. As Joshi et al. (2017) have noted, Ahmedabad has chosen to encourage the provision of affordable housing in a zone called "affordable housing zone" on the periphery of the city. However, the quality of public transit connectivity to these areas is under par. This combined with growing speculation among the developers on the peripheral lands is bound to put these peripheral lands out of the reach of those that need affordable housing. If the city could provide good transit connectivity between these areas and the centers of economic activity, people may be more inclined to seek housing there. The state, if it were serious must make the choice between its commitments to affordable housing for all and pandering to the interests of the developers.

In this respect, the Pradhan Mantri Awas Yojana (PMAY) presents a great ray of hope. It takes a more liberal view of who qualifies to be categorized as part of economically weaker sections and low-income groups4 (MoHUPA 2016). Additionally, it also covers the middle classes who are now eligible as part of the PMAY to receive interest benefits with loan quantum up to 12 lakhs coming under its coverage. Through addressing the biggest bottlenecks of affordable housing supply, namely land shortage and lengthy approval processes, it hopes make it easier for people to access affordable housing. The PMAY encourages cities to earmark land for affordable housing as part of the master plans. It also mandates that cities put into place single-window, time-bound clearance for building permissions while advocating additional FSI, TDR and relaxed density norms for slum redevelopment and low-cost housing. Through slum-redevelopment, affordable housing in partnership, credit-linked interest subsidy and subsidies for beneficiary-led construction, a multi-pronged approach is taken to address the demand for affordable housing. Additionally, the Union Budget of 2017 grants the affordable housing sector the status of a priority sector. Affordable housing projects are to be seen as infrastructure (Express News Service 2017; Nandy and Sapam 2017). When seen in the context of TOZ, these provisions can be used to improve the supply of affordable housing.

Parking reforms :- Parking is an important issue that can make or break TOD. As Willson (2005) notes, the TOD objectives are not served well by a culture of free supply of parking and inadequate regulation. While a case is made for better transit, first and last-mile connectivity and feeder services,

planners must also frame strong parking policies to ensure successful TODs. Researchers have argued for stricter parking norms for achieving best TOD results (Arrington and Cervero 2008; Shoup 2005). Barter (2016) presents institutional, physical design, management and enforcement level reforms in order to use parking as a means to achieving greater discipline in the use of street space. The Asian Development Bank (2010) has also brought out convincing literature on the need to adequately regulate and price parking. In the Indian context, there are several reasons to rethink parking policies including, a) enormous costs and car dependency, b) stressed roads and footpaths, c) perverse subsidizing of car owners, and d) iniquitous use of expensive land (CSE 2008).

Currently, it is seen that developers tend to bundle parking costs along with the cost of the dwelling unit and market their project as providing free parking. Not only does this raise the cost of housing, it also incentivises the perverse notion of parking as free commodity. This can be highly problematic in a context where the public realm is scare and land rents are high. In this context Willson's research (Willson 2005) on parking in TOD cities is highly relevant. He advocates cities to, a) adopt demand-based TOD parking requirements that reflect transit shares and automobile ownership, b) promote share parking, c) promote multi-property owner strategies to deal with parking in shared station-areas, d) encourage unbundling of parking charges from space-leases, and e) discourage long-term parking while encouraging monetization of short-term parking and using the proceeds to fund local neighborhood improvements. Willson advises transit agencies to, a) place housing and mixed-use development in close proximity to stations, b) convert parking lots along transit into TODs that turn out with less-than-before number of parking slots, c) adopt an access perspective instead of parking-supply perspective while developing parking policies, and d) encourage use of nonmotorized modes of station access.

Local Experiences & Case Studies :-

While DDA has gone on to produce TOD policies and has prepared manuals for practitioners to engage with the TOD regulations, Ahmedabad has recently amended their town planning legislation to allow the preparation of local area plans. The Delhi experience has enabling regulations to encourage the development of a TOD friendly built form. There are some internal contradictions in the TOD policy regarding the provision of inclusive housing. The Ahmedabad local area plans subscribe to the new urbanism principles of improving accessibility, walkable environments, high density-high quality development, mixed use activities, transit friendly design and alternative modes of transportation. The plans are still not concrete. In Bengaluru, development plan which addresses the city at an aggregate scale does not address the 'nitty-gritties' of street design and accessibility but rather deals with land utilization and its related regulations within plots. This is often a challenge in the Indian context wherein the use of private land has city level regulations and restrictions but regulations for the public realm how-ever are neither comprehensive nor binding on any particular government agency. This is a scenario when more than 45% of the city's land is publically owned such as highways, urban roads, street networks, parks, water bodies, beaches etc. Also since a plethora of agencies act in this public realm no single agency can be assigned the onus of its design and upkeep (Rangwala et al. 2014).

Indian cities need to explore Station Area Planning (SAP) to achieve densification. Addition-ally, special overlay zones may be provided to supplement existing regulations. Differential FSI may be explored to adjust for variations in context. For densification and redevelopment, especially in the inner city, land-pooling may be explored. Incremental addition of FSI and promotion of mixed-use development is recommended. Parking reform is also essential in order to encourage walkable TOD neighborhoods. Parking needs to be controlled through effective parking management. Areas around transit stations must be made parking unfriendly to discourage the "park and ride" experience. It would also help reclaim more public space. Parking must not come attached with residential space and should be sold at high rates. TOD policies must deal with parking specifically and discouraged along transit corridors, especially around stations. Overall, policymakers must realize that unlike housing, parking need not be thought of as an unalienable right but a commodity that can be bought, albeit at high prices.

The table below presents a comparison of various indices in the case cities of Delhi, Ahmedabad and Bengaluru. Cities must commission studies of their mode shares and identify the factors that lead to higher ridership on the transit systems.

Parameters/City	Delhi	Ahmedabad	Bengaluru
PT accessibility index[3]	1.09	2.49	1.01
Service accessibility index	16.36	21.54	13.00
Congestion index	0.47	0.30	0.40
Walkability index	0.87	0.85	0.63
City bus transport index	43.86	12.99	39.22
Safety index	0.32	0.14	0.11
Paratransit index	75.60	73.90	89.70
On-street parking interference index	2.82	2.03	1.28
Mode split (NMT:PT:IPT:M2W+4W)[5]	33 : 43 : 5 : 19	36 : 16 : 6 : 42	33 : 35 : 7 : 25
Type of transit	Metrorail	BRT / Metrorail	Metrorail
Operational since	2002	2009 / -	2011
Extent (km) (2015-16)	213	89 / 39.2*	31.52 (42.3^)
Number of stations	160	150 / 32	30 (41^)
Ridership (lakhs) (2015-16)	25.6	1.32 / 5.0*	1.70
Transit agency	DMRC	Janmarg / MEGA	BMRC
UMTA function performed by	DMRC	AUDA	DULT
FSI/FAR along transit	4.0 (max); 2.0 (min)	4.0	4.0 (in 150 m radius)
FSI/FAR elsewhere (base:paid)	1.20 : 3.50	1.80 : 2.25	1.75 : 3.25
Densities along transit	450 DU/Ha (max)	-	-
Mix of land-use proposed in TOZ	30%[R], 20%[C+I], 15% EWS	Specifics unclear	Specifics unclear
Unbundling of parking	Yes	Yes	Yes
Limits on unpaid parking	Yes	Yes	Yes

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3 INCLUSIVE & LOW-CARBON TOD - THE WAY AHEAD

TOD debate in India has been limited to piling up massive floor spaces near a transit node and not about attracting greater transit ridership. Most cities have responded by increasing the FSI along rapid transit. In already high-density Indian cities, it is not known whether there is any significant advantage by simply adding further FSI near transit. The benefits of this strategy and other strategies that have been planned in Indian cities is yet to be studied. India has recognized the contribution of urban transport and urban centers in achieving a low carbon development, required to achieve our "intended nationally determined contributions" towards climate change (MoEF, 2015). This requires that the contribution of land-use management strategies such as TOD towards environmental benefits becomes quantifiable. Therefore, this research determines the nature of the link between built environment and travel behaviour in the Indian city of Ahmedabad. Ahmedabad city is chosen as it is in an advanced stage of developing its TOD regulations and local area plans. The established links are then utilized to assess the inclusiveness and carbon impacts of Ahmedabad's TOD plans. The efficacy of the assessment may be ascertained by comparing the levels of inclusion and carbon benefits accrued through Ahmedabad's TOD plan, to those from a business as usual scenario and a prospective high inclusive and low carbon scenario. The scenarios would reveal, specific TOD strategies that are beneficial in transitioning to an inclusive low-carbon future.

3.1 Methodology

The methodology of this study is composed of three parts. The first part identifies the relation-ships between mode choice and its determinants for Ahmedabad, namely socio-economic characteristics of individuals, build environment characteristics of their surroundings and travel behavior of the respondent. In the second part, these relationships are used to preempt the mode choice of individuals under varying built environment scenarios, namely Business as Usual (BAU), Ahmedabad's Transit Oriented Zone – Local Area Plan (ATOZ) and an Inclusive – Low Carbon Transit Oriented Development (I-LC) scenario. Subsequently, carbon emissions are calculated based on the mode shares resulting from the various built environment scenarios. A comparison of the carbon emissions from the various scenarios, would reveal the strategic measures that may be followed for a more inclusive – low carbon development in our cities.

Modeling mode choice and built environment relations :-

The modeling of mode choice and built form relations is informed by theories of consumer choice from economics and psychology. More specifically, the discrete choice model is em-ployed, which is based on the tenet that people make rational choices to maximize their utility from among a finite set of alternatives (Ben-Akiva and Lerman, 1985; McFadden, 1976). Logistic Regression (LR) and its variants are commonly utilized to study the relationship between built form and mode choice.

Over the years, there have been several improvements to built form and travel behavior studies. Cervero (2002) identified the need for greater inclusion of the effects of generalized cost (travel cost and travel time) on mode choice. Boarnet & Crane (Boarnet and Crane, 2001) argued the need for residential location decisions (self-selection) to be incorporated in the explanation of travel behavior. Cao et al. (2009) proved empirically the existence of the self-selection bias, in built form and travel behavior relations. Even so, they found significant associations between the two. Ewing & Cervero (2010, 2001) through their meta-analysis of studies relating built environment and travel bhaviour, expanded the list of built environment attributes that where known to explain travel behaviour.

Description of variables explaining Mode Choice :- This study has used various types of data to quantify build environment, travel behavior and socio-economics of users. The following section describes these various types of data used in this study.

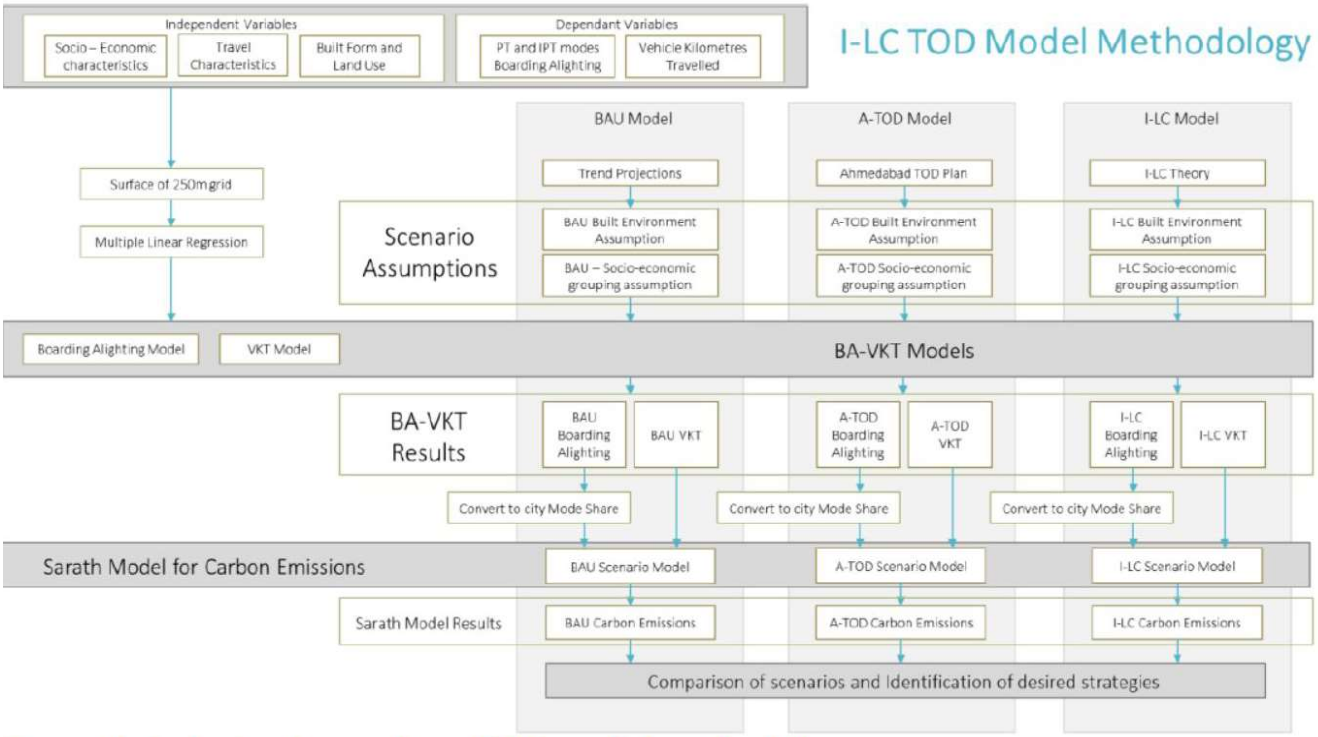
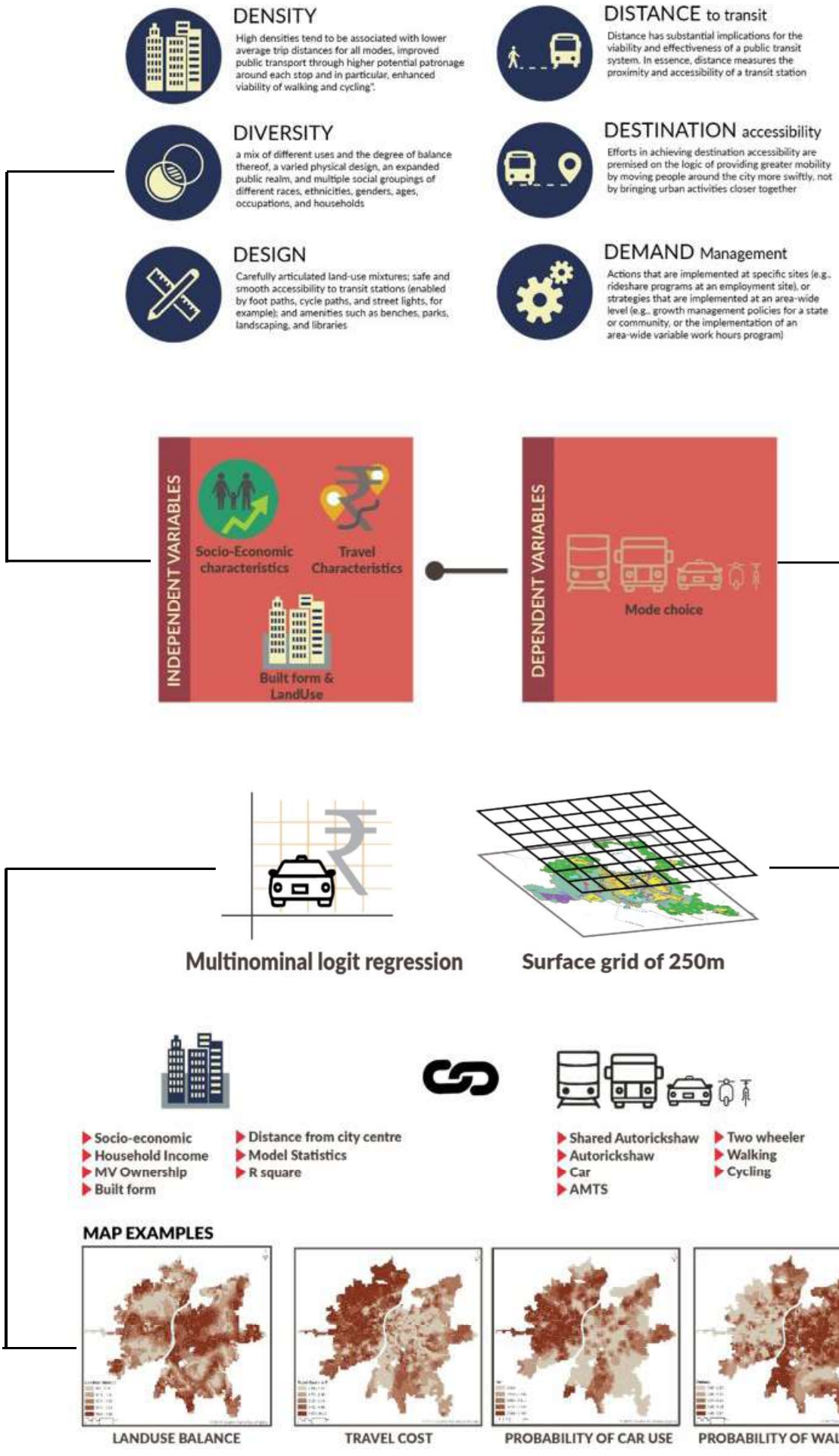


Figure 1: Inclusive low-carbon TOD model methodology

TOWARDS AN INCLUSIVE & LOW CARBON TOD



- **Travel behavior and socio-economic data:** The data for travel behavior comes from house-hold surveys conducted of residents in Ahmedabad. Respondents were asked to recollect their travel from the previous day, and report their mode choice, trip purpose, trip length, trip cost and trip duration. This survey also captured data regarding the respondent's socio-economic characteristics, reported as their household income and vehicle ownership.
- **Travel Behavior :- Mode choice,Trip Distance,Travel Cost,Travel Time.**
- **Socio Economic Data :- Motor Vehicle, Household Income, Housing Typology**

- **Built environment data:** Ewing and Cervero (2010) identified six indicators of built environment that influenced mode choice, compiled from previous empirical studies. These six indicators are density, diversity, design, destination accessibility, and distance to transit and demand management. Due to a lack of demand management measures such as priced parking or congestion charging, this indicator was left out.

1. Density: In this study, net population density and job density represents Density. Popula-tion density is the ratio of population to total area under residential use.

2. Diversity: In this study, land use balance represented Diversity. It was calculated using the floor space entropy index. Five land use classifications were created. The value of the index ranged from 0 to 1. If a perfect mix of land uses existed, the index would have a value of 1, and if there is only a single land use, the value would be 0.

3. Design was represented using junction density. The impact of junction density was best computed by the use of kernel density of junctions. It is computed with a radius of 750 meters indicative of 10 minutes walking distance. The width of the streets (right of way) was used in the population field.

4. Destination Accessibility: This variable is represented as the distance to jobs. As most jobs are concentrated in the center of the city, it was considered the distance to the city center, considered the Nehru Bridge area.

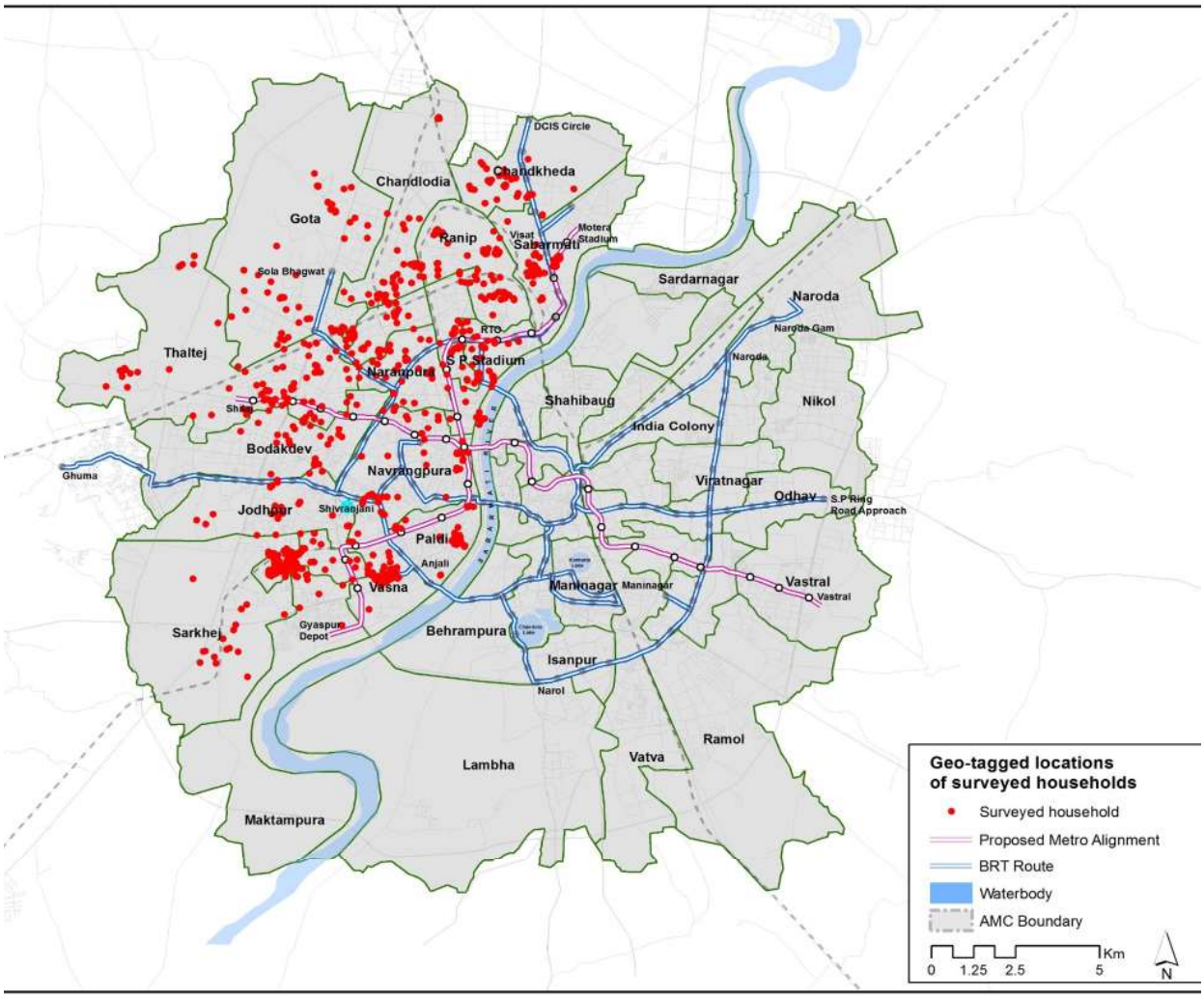
Data Processing :- Data on street network, built-up area and building uses were mapped on GIS, as lines and polygons. The household survey data was represented spatially in GIS as points that indicated the residential location of the respondent. Subsequently indicators such as distance to transport, to the center of the city, kernel densities were calculated using Geo-statistical analytical tools in GIS. The various disaggregate types of spatial data, were brought together for each respondent, using a uniform grid of 250 m. x 250 m. Overlay function was used to combine the built form, travel behavior and socio-economic data.

Analysis :- Eleven socio-economic and built form variables were identified to have a significant correlation with the dependent mode choice variable. This was after removing those variables that did not have a significant correlation with mode choice, or had multi-co-linearity with other variables. Binomial logistical regression was used to analyze the mode choice probabilities of the population of Ahmedabad. A step-wise logistical regression method was used, that introduced the various variables in three blocks, in forward step. The first block consists of socio-economic variables that's address the issue of residential self-selection. Hence, this block becomes the control block for this analysis. The second block introduces the built form variables. These variables together with the control variables make the build-form model. In the last step, distance to city center was introduced.

3.2 Findings

To carry out the study 1100 household surveys where carried out across western Ahmedabad. Inferences where drawn based on these.

The map on the next page, denotes all locations surveyed within the study area and the table gives a detailed break up of the house hold surveys carried out on site.



Breakup of samples to be captured (by HHs by number of rooms) by municipal wards

Ward*	Zone [see map]	Number of HHs [2011]	Area [Ha]	Population Density [ppHa]	Number of samples to be captured							
					No exclusive room	One room	Two rooms	Three rooms	Four rooms	Five rooms	Six and more	Total samples per ward
					Mostly slums	Low-income housing	1 Room Kitchen	1 BHK	2 BHK	3 BHK	4 BHK and more	
Sarkhej	1	14,260	3,687	20	1	14	12	8	3	1	1	40
Vejalpur		57,858	374	788	4	57	50	31	12	4	3	162
Vasna		24,140	507	243	2	24	21	13	5	2	1	68
Thaltej	2	19,263	2,052	48	1	19	17	10	4	1	1	54
Bodakdev		15,015	1,249	61	1	15	13	8	3	1	1	42
Jodhpur		18,715	2,210	43	1	18	16	10	4	1	1	53
Gota	3	23,775	5,150	24	2	24	21	13	5	2	1	67
Kali		18,446	849	111	1	18	16	10	4	1	1	52
Chandkheda_Motera		18,876	1,395	69	1	19	16	10	4	1	1	53
Sabarmati		13,444	542	126	1	13	12	7	3	1	1	38
Chandlodiya	4	19,635	376	266	2	19	17	11	4	1	1	55
Ranip		21,598	321	344	2	21	19	12	4	2	1	61
Ghatlodiya		30,763	299	525	2	30	27	17	6	2	2	86
Naranpura		17,261	329	268	1	17	15	9	4	1	1	48
Nava Vadaj		13,297	212	320	1	13	11	7	3	1	1	37
Juna Vadaj		12,880	341	193	1	13	11	7	3	1	1	36
S.P Stadium	5	14,716	337	222	1	15	13	8	3	1	1	41
Aambawadi		10,963	644	87	1	11	9	6	2	1	1	31
Navarangpura		10,911	723	77	1	11	9	6	2	1	1	31
Paldi		16,296	459	181	1	16	14	9	3	1	1	46
Total		**3,92,112**	**22,058**		**30**	**388**	**339**	**213**	**81**	**29**	**22**	**1,100**
					3%	**35%**	**31%**	**19%**	**7%**	**3%**	**2%**	
Population		18,42,926										

Consumption of Carpet Area Within Income Groups

Category (as per GHB guidelines for housing)	0-30 m^2	30-50 m^2	51-94 m^2	> 95 m^2	Total
Less than ₹ 8,000 per month (EWS)	84.2%	8.8%	6.9%	0.0%	**100.0%**
Between ₹ 8,001 and ₹ 20,000 (LIG)	27.2%	56.5%	14.7%	1.5%	**100.0%**
Between ₹ 20,001 and ₹ 40,000 (L-MIG)	3.5%	48.2%	41.6%	6.6%	**100.0%**
Between ₹ 40,001 and ₹ 80,000 (U-MIG)	1.7%	6.8%	55.9%	35.6%	**100.0%**
Above ₹ 80,000 (HIG)	0.0%	0.0%	25.0%	75.0%	**100.0%**
Total	**36.1%**	**39.1%**	**20.6%**	**4.2%**	100.0%

Income group versus housing typology

Category (as per GHB guidelines for housing)	Slums	Chawl	Row House	Tenement	Apartment	Bungalow	Total
Less than ₹ 8,000 per month (EWS)	6.9%	57.7%	26.8%	6.0%	2.5%	0.0%	**100.0%**
Between ₹ 8,001 and ₹ 20,000 (LIG)	3.4%	38.8%	28.9%	10.1%	18.8%	0.0%	**100.0%**
Between ₹ 20,001 and ₹ 40,000 (L-MIG)	0.8%	12.5%	32.3%	11.3%	40.1%	3.1%	**100.0%**
Between ₹ 40,001 and ₹ 80,000 (U-MIG)	0.0%	3.4%	6.8%	23.7%	45.8%	20.3%	**100.0%**
Above ₹ 80,000 (HIG)	0.0%	0.0%	0.0%	75.0%	25.0%	0.0%	**100.0%**
Total	**3.6%**	**36.2%**	**27.9%**	**10.1%**	**20.5%**	**1.7%**	100.0%

Income group versus Parking behaviour

Category (as per GHB guidelines for housing)	Public ROW	Society Road	Own Compound	Not Applicable	Grand Total
Less than ₹ 8,000 per month (EWS)	31.1%	27.0%	10.5%	31.4%	**100.0%**
Between ₹ 8,001 and ₹ 20,000 (LIG)	45.0%	36.3%	5.6%	13.1%	**100.0%**
Between ₹ 20,001 and ₹ 40,000 (L-MIG)	27.2%	60.3%	10.1%	2.3%	**100.0%**
Between ₹ 40,001 and ₹ 80,000 (U-MIG)	11.9%	59.3%	28.8%	0.0%	**100.0%**
Above ₹ 80,000 (HIG)	0.0%	75.0%	25.0%	0.0%	**100.0%**
Total	**35.6%**	**40.3%**	**9.1%**	**15.0%**	100.0%

Housing typology versus parking behaviour

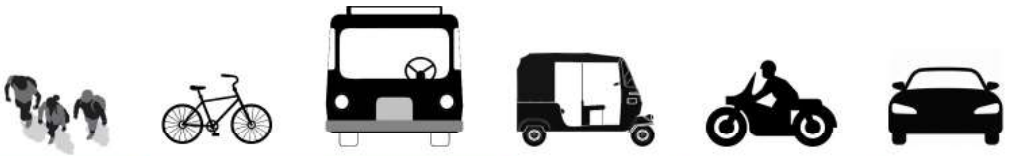
Category	Public ROW	Society parking	Own compound	Total
Chawl	74.1%	15.6%	10.30%	100.0%
Slum	68.8%	25.0%	6.30%	100.0%
Row House	44.4%	45.5%	10.00%	100.0%
Tenement	**20.9%**	**58.3%**	**20.90%**	**100.0%**
Tenement (LIG)	21.2%	75.8%	3.00%	100.0%
Tenement (MIG)	20.8%	55.6%	23.60%	100.0%
Tenement (HIG)	20.0%	20.0%	60.00%	100.0%
Apartment	**3.9%**	**95.2%**	**0.90%**	**100.0%**
Apartment (LIG)	3.6%	96.4%	0.00%	100.0%
Apartment (MIG)	4.4%	94.7%	0.90%	100.0%
Apartment (HIG)	0.0%	80.0%	20.00%	100.0%
Bungalow	0.0%	10.0%	90.00%	100.0%
Total	**41.8%**	**47.4%**	**10.80%**	**100.0%**

Mode share by trips | Income groups

EWS	47% 389	11% 89	18% 151	5% 39	18% 145	1% 7
LIG	26% 450	8% 128	12% 206	6% 104	46% 778	2% 40
MIG	9% 89	1% 14	2% 23	1% 12	70% 677	15% 149
HIG	26% 5	0%	0%	0%	21% 4	53% 10
All	27% 933	7% 231	11% 380	4% 155	46% 1,604	6% 206

Note: **EWS**: Less than ₹ 8,000 per month; **LIG**: Between ₹ 8,001 and ₹ 20,000; **MIG**: Between ₹ 20,001 and ₹ 80,000; **HIG**: Above ₹ 80,000 per month

Mode share by trips | Housing Typology

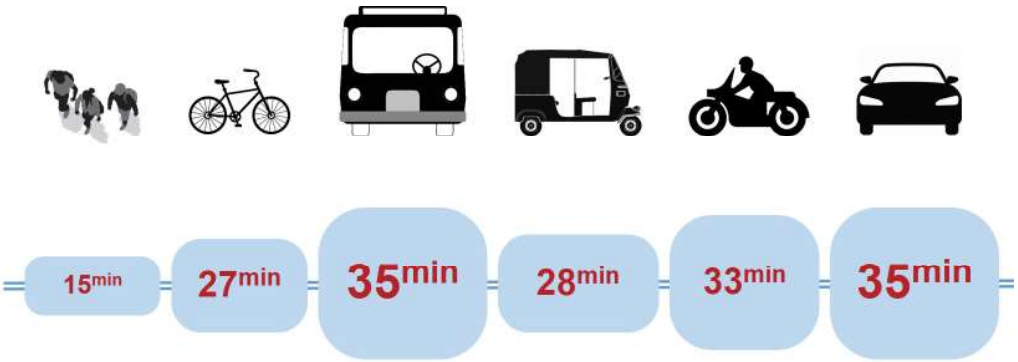


Slum	44% 48	6% 7	16% 18	1% 1	31% 34	2% 2
Chawl	37% 446	12% 149	13% 159	7% 79	29% 349	2% 25
Row House	30% 351	5% 52	14% 159	4% 44	43% 494	5% 55
Tenement	17% 61	4% 15	6% 23	4% 16	56% 200	12% 41
Apartment	5% 35	2% 12	4% 25	2% 15	77% 499	10% 63
Bungalow	3% 2	0% 0	0% 0	0% 0	64% 42	33% 22
Overall	27%	7%	11%	4%	46%	6%

Mode share by trips | Dwelling Unit Size

Mode	Salaried private sector	Salaried public sector	Informal activities	Business	Students	Home-maker	Others	Total
Walking	15%	8%	48%	17%	23%	57%	33%	**27%**
Cycling	7%	10%	10%	3%	8%	1%	12%	**7%**
Public transport (AMTS, BRTS)	9%	15%	14%	3%	13%	11%	21%	**11%**
IPT (Autos, Taxis, Shared)	4%	2%	8%	4%	5%	3%	4%	**4%**
Two-wheelers	63%	54%	18%	55%	46%	26%	28%	**45%**
Four-wheelers	3%	11%	2%	19%	5%	2%	1%	**6%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

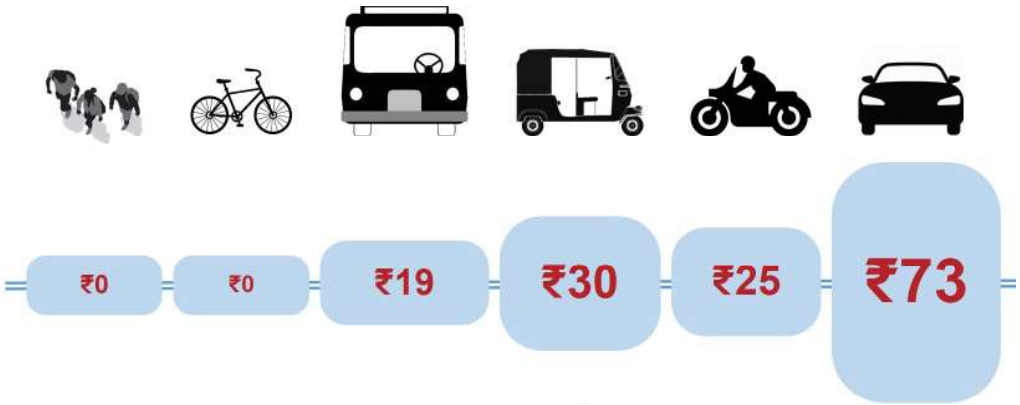
Average trip time by mode



The overall average trip time was found to be

28min

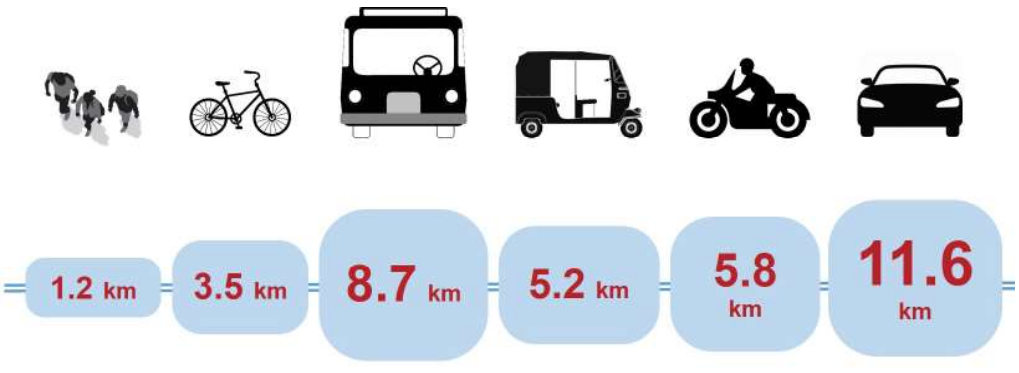
Average trip cost by mode



The overall average trip cost was found to be

₹19

Average trip length by mode



The overall average trip length was found to be

5.1 km

Housing typology versus PT use (revealed)

Category	At least once a week		Don't use		Total
	Frequency	Per cent	Frequency	Per cent	
Slum	23	58.97%	16	41.03%	39
Chawl	228	60.00%	152	40.00%	380
Row House	209	73.08%	77	26.92%	286
Tenement	**56**	**57.73%**	**41**	**42.27%**	**97**
Tenement (LIG)	14	48.28%	15	51.72%	29
Tenement (MIG)	36	61.02%	23	38.98%	59
Tenement (HIG)	6	66.67%	3	33.33%	9
Apartment	**76**	**36.71%**	**131**	**63.29%**	**207**
Apartment (LIG)	37	33.64%	73	66.36%	110
Apartment (MIG)	37	40.22%	55	59.78%	92
Apartment (HIG)	2	40.00%	3	60.00%	5
Bungalow	6	30.00%	14	70.00%	20
Total	**598**	**58.11%**	**431**	**41.89%**	**1029**

Observation :-

A large majority of the Public Transport users or the M2W users live in a certain type of housing.

- PT Users - Slums, Chawls, Row Houses, LIG Tenements, LIG Apartments (DU size <50 m2)
- M2W users: - Tenements (MIG, HIG), Apartments (MIG, HIG), Bungalows (DU size >50 m2)

Public Transport use becomes popular with higher Trip lengths (> 8 Km) and only for the people who live in proximity to transit stations

The Future Challenge is to understand how those preferring M2W , switch modes to Public Transit.

Scenario Building :-

The next step was to understand the willingness of the public in using public transport for their work or shop trip.

referring to the table in page 41 which is relating the willingness to shift of work trips in both BAU as well as TOD scenario.

It is fairly evident that the willingness to shift increases in number and also in category of users from BAU to TOD scenario.

Similarly,when referring to the table in page 42,which is relating the willingness to shift modes of transport for shop trips.

In this too like the previous case there is increase in the number of people willing to shift and also an in crease in the category of users .Pointing to the potential TOD holds.

Willingness to Use Public Transport for Work Trips - BAU

Category	Yes		No		Can't say		Total	
	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
Slum	11	28%	26	67%	2	5%	39	**100%**
Chawl	81	21%	265	70%	34	9%	380	**100%**
Row House	73	25%	199	69%	15	5%	287	**100%**
Tenement	13	14%	76	80%	6	6%	95	**100%**
Tenement (LIG)	4	14%	24	83%	1	3%	29	**100%**
Tenement (MIG)	9	16%	43	75%	5	9%	57	**100%**
Tenement (HIG)	0	0%	9	100%	0	0%	9	**100%**
Apartment	16	8%	188	91%	3	1%	207	**100%**
Apartment (LIG)	14	13%	96	86%	1	1%	111	**100%**
Apartment (MIG)	2	2%	87	96%	2	2%	91	**100%**
Apartment (HIG)	0	0%	5	100%	0	0%	5	**100%**
Bungalow	0	0%	20	100%	0	0%	20	**100%**
Total	**194**	**19%**	**774**	**75%**	**60**	**6%**	**1,028**	**100%**

Willingness to Use Public Transport for Work Trips - TOD

Category	Yes		No		Can't say		Total	
	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
Slum	11	28%	27	69%	1	3%	39	**100%**
Chawl	125	33%	240	63%	15	4%	380	**100%**
Row House	108	38%	174	61%	5	2%	287	**100%**
Tenement	25	26%	69	73%	1	1%	95	**100%**
Tenement (LIG)	10	34%	19	66%	0	0%	29	**100%**
Tenement (MIG)	15	26%	41	72%	1	2%	57	**100%**
Tenement (HIG)	0	0%	9	100%	0	0%	9	**100%**
Apartment	17	8%	187	90%	3	1%	207	**100%**
Apartment (LIG)	15	14%	95	86%	1	1%	111	**100%**
Apartment (MIG)	2	2%	87	96%	2	2%	91	**100%**
Apartment (HIG)	0	0%	5	100%	0	0%	5	**100%**
Bungalow	0	0%	20	100%	0	0%	20	**100%**
Total	**286**	**28%**	**717**	**70%**	**25**	**2%**	**1,028**	**100%**

Willingness to Use Public Transport for ShopTrips - BAU

Category	Yes		No		Can't say		Total	
	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
Slum	13	33%	24	62%	2	5%	39	100%
Chawl	93	24%	254	67%	33	9%	380	100%
Row House	80	28%	190	66%	17	6%	287	100%
Tenement	17	18%	71	75%	7	7%	95	100%
Tenement (LIG)	3	10%	25	86%	1	3%	29	100%
Tenement (MIG)	14	25%	37	65%	6	11%	57	100%
Tenement (HIG)	0	0%	9	100%	0	0%	9	100%
Apartment	27	13%	175	85%	5	2%	207	100%
Apartment (LIG)	21	19%	88	79%	2	2%	111	100%
Apartment (MIG)	6	7%	82	90%	3	3%	91	100%
Apartment (HIG)	0	0%	5	100%	0	0%	5	100%
Bungalow	0	0%	20	100%	0	0%	20	100%
Total	**230**	**22%**	**734**	**71%**	**64**	**6%**	**1,028**	**100%**

Willingness to Use Public Transport for ShopTrips - TOD

Category	Yes		No		Can't say		Total	
	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
Slum	15	38%	23	59%	1	3%	39	100%
Chawl	139	37%	227	60%	14	4%	380	100%
Row House	131	46%	152	53%	4	1%	287	100%
Tenement	23	24%	71	75%	1	1%	95	100%
Tenement (LIG)	7	24%	22	76%	0	0%	29	100%
Tenement (MIG)	16	28%	40	70%	1	2%	57	100%
Tenement (HIG)	0	0%	9	100%	0	0%	9	100%
Apartment	28	14%	174	84%	5	2%	207	100%
Apartment (LIG)	23	21%	86	77%	2	2%	111	100%
Apartment (MIG)	5	5%	83	91%	3	3%	91	100%
Apartment (HIG)	0	0%	5	100%	0	0%	5	100%
Bungalow	0	0%	20	100%	0	0%	20	100%
Total	**336**	**33%**	**667**	**65%**	**25**	**2%**	**1,028**	**100%**

****

3.3 Result

Relations between built form and mode choice :- Mode choice of six different modes of transport used in Ahmedabad was analyzed. These includes public transport modes of AMTS, intermediate public transport modes of shared auto and auto-rickshaws, private vehicular modes of two-wheelers and cars, and lastly the non-motorized modes of walking and cycling.

- **Shared Auto rickshaw :-** Shared auto rickshaw is a form of Intermediate Public Transport present in the city of Ahmedabad. It is an auto rickshaw, which can be hired simultaneously by multiple users traveling in the same direction, much like a stage carrier. These autos run on relatively fixed routes and fares, with undesignated pick up points and notional drop off points. The model explains about 23% of the variability in shared auto-rickshaw choice. The control variables for shared autos reveal relationships on expected lines, with lower household income and those without motor vehicles preferring it.

Binary logistic model estimate for shared autorickshaw

	B	Std. B	Sig.
(Constant)	.117		.000
Socio-Economic			
MV Ownership	-.025	-.290	.000
Household Income	-.016	-.146	.000
Built Form			
Population Density	-4.291E-5	-.157	.000
Junction Density	.000	-.138	.000
Distance from City Centre	.002	.119	.000
Model Statistics			

- Of the three significant built form variables, population density had an inverse relationship with shared auto rickshaw. This may be because, shared auto rickshaws are mostly found on the outskirts of city, in areas that have low densities than central portions. Junction density had little to no-effect on the model with a zero beta value. Shared auto usage increases with increase of distance to city center. This relationship was also on expected lines, as shared autos generally ply on the outer parts of the city, along its arterials and highways.

Auto rickshaw :- is a form of taxi service that may be hired by an individual or a group of individuals, to provide point-to-point service. The model can explain about 2.3% of the variability in shared auto-rickshaw choice. The control variables for auto-rickshaw reveal a significant negative relationship with household income. Among built form indicators, greater distance from city center, and population density were found to increase usage of auto-rickshaw. Greater junction density on the other hand decreased auto-rickshaw usage.

Binary logistic model estimate for autorickshaw

	B	Std. B	Sig.
(Constant)	.056		.000
Socio-Economic			
Household Income	-.010	-.105	.000
Built Form			
Distance from City Centre	.001	.067	.000
Junction Density	-5.775E-5	-.069	.000
Population Density	1.053E-5	.045	.005
Model Statistics			
R Square	.023		

AMTS :- Ahmedabad Municipal Transport Service (AMTS) is the bus service run by the Ahmedabad Municipal Corporation. The model can explain 4.3% of variability in AMTS mode choice. Only one control variable, Motor Vehicle ownership - had significance to AMTS mode choice. Of all built form variables, Distance from city center, was the only significant variable, with an inverse relation to AMTS mode choice. This indicates that AMTS use increase when the distance to city center decreases

Binary logistic model estimate for AMTS

	B	Std. B	Sig.
(Constant)	.056		.000
Socio-Economic			
MV Ownership	-.051	-.208	.000
Built Form			
Distance from City Centre	-.002	-.047	.001
Model Statistics			
R Square	.043		

Car :- Cars in this classification include any privately owned four-wheel transport mode, such as cars and jeeps. The model can explain 22.7% of the variability of mode choice for cars. Two control variables of Household Income and Motor Vehicle Ownership have a significant relationship with car mode choice. As expected, both variables are positively linked to car ownership. Among build form variables, Distance from City center was the only variable with a significant relationship with Car mode choice. It has a negative relationship with car mode choice, indicating that the choice of car as a mode of travel increase with decrease in distance to city center.

Binary logistic model estimate for car

	B	Std. B	Sig.
(Constant)	.056		.000
Socio-Economic			
Household Income	.003	.282	.000
MV Ownership	.002	.240	.000
Built Form			
Distance from City Centre	-9.258E-5	-.058	.000
Model Statistics			
R Square	.227		

Two-wheelers :- Two-wheeler in this classification includes motorcycles, scooters and mopeds. This model can explain a high 48% of the variability of mode choice. Two control variables of Motor Vehicle ownership and household income have a significant relation with two-wheeler mode choice. As with car mode choice and in line with expectations, two wheeler mode choice is positively related to these variables. Three build form variables of Land Use Balance, Junction Density and Distance from city Center were found to be significant. The relations reveal that two wheeler choice would be high in areas closer to the city center, with high junction density and poor mix of land use.

Binary logistic model estimate for two-wheelers

	B	Std. B	Sig.
(Constant)	.198		.000
Socio-Economic			
MV Ownership	.153	.548	.000
Household Income	.063	-.146	.000
Built Form			
Land Use Balance	-.065	-.070	.000
Junction Density	.000	.058	.000
Distance from City Centre	-.003	-.052	.000
Model Statistics			
R Square	.480		

Walking :- The built form model for walking can predict 38.1% of the variability of walking as a mode choice. The control variables of motor vehicle ownership and household income were significantly related to walking. It reveals that walking choice is high for those who don't own a motor vehicle and /or have low household incomes. While a lack of motor vehicle ownership is related to a low household income, it also reveals that those that are walking do not have sufficient income to access PT and IPT services, or even a bicycle. Junction density and land use balance are the two build form variable found to have a significant relationship with walking choice. They are both positively related to walking choice. It indicates that walking choice increase in areas with higher junction density and higher mix of land use. These finding were on expected lines.

Binary logistic model estimate for walking

	B	Std. B	Sig.
(Constant)	.198		.000
Socio-Economic			
MV Ownership	-.027	-.462	.000
Household Income	-.017	-.216	.000
Built Form			
Junction Density	4.534E-5	.068	.000
Land Use Balance	.009	.046	.000
Model Statistics			
R Square	.381		

Cycling :- The built form model for cycling choice can predict variability in cycling choice by 24.8%. Similar to walking, Motor vehicle ownership and household income were the two control variables that were significantly related to cycling choice, with a negative relation. It indicates that cycling choice is higher among those who don't own a motor vehicle and those that don't have the incomes sufficiently high to access either PT or IPT services. Four built form variables, land use balance, distance to city center, population density and junction density were significantly related to cycling mode choice. They were all positively related to cycling choice. It reveals that, cycling is a preferred mode choice in areas with a high mix of land use, further from the city center, with higher population density and junction density.

Binary logistic model estimate for cycling

	B	Std. B	Sig.
(Constant)	.218		.000
Socio-Economic			
MV Ownership	-.053	.548	.000
Household Income	-.022	-.146	.000
Built Form			
Land Use Balance	.044	.095	.000
Distance from City Centre	.002	.085	.000
Population Density	1.706E-5	.038	.000
Junction Density	6.033E-5	.037	.000
Model Statistics			
R Square	.248		

Final Output of Model :-

Model results :-The three scenarios developed for the purpose of testing the model are described below. Vehicle population projections are based on past trends and with inputs from literature. The prediction of income groups is based on secondary literature while floor space calculations are based on the DCRs (FSI, road widths linked DCRs) as well as developers' inputs on typologies in different areas.

Describing the Scenarios

Parameter	Particulars	Business-as-Usual 2031	Ahmedabad TOD 2031	Low-carbon TOD 2031
Motor vehicle ownership	Vehicles per 100 people	36	60	40
Household income	EWS	27.2%	17%	17%
	LIG	45.6%	37%	37%
	MIG	26.9%	42%	42%
	HIG	0.3%	4%	4%
Housing typology	Chawl	36.2%	16.0%	16.0%
	Slum	3.6%	1.0%	1.0%
	Row House	27.9%	15.0%	15.0%
	Tenement	10.1%	5.5%	4.0%
	Tenement (LIG)	3.2%	2.0%	2.0%
	Tenement (MIG)	6.1%	3.0%	1.9%
	Tenement (HIG)	0.9%	5.0%	0.1%
	Apartment	20.5%	45.0%	63.3%
	Apartment (LIG)	10.3%	15.0%	25.0%
	Apartment (MIG)	9.7%	30.0%	30.0%
	Apartment (HIG)	0.4%	16.8%	8.3%
	Bungalow	1.7%	0.7%	0.7%

Probability of use of modes rises/falls by Exp (B) factor

Particulars	Auto choice		Cycle		PT Choice		2W Choice		4w Choice		Walk choice	
	B	*Exp(B)*	*B*	*Exp(B)*	*B*	*Exp(B)*	*B*	*Exp(B)*	*B*	*Exp(B)*	*B*	*Exp(B)*
Chawl	0.13	1.14	0.74	2.09	0.01	1.01	0	1	-1.19	0.3	-0.09	0.92
Row House	-0.09	0.91	-0.36	0.7	0.21	1.24	0.4	1.49	-1.11	0.33	-0.05	0.95
Apartment (LIG)	0.18	1.2	-1.15	0.32	-0.39	0.68	1.28	4.87	-1.71	0.18	-0.55	0.35
Apartment (MIG)	-1.49	0.23	-1.81	0.16	-2.37	0.09	1.18	5.95	-0.18	0.84	-0.99	0.05
Tenement (LIG)	1.13	3.09	-0.59	0.56	0.14	1.15	0.55	1.73	-2.06	0.13	0.52	1.68
Tenement (MIG)	-0.15	0.86	-0.49	0.61	-1.25	0.29	0.8	2.23	-0.49	0.61	-0.38	0.68
Distance to city centre	0.01	1.01	-0.1	0.9	0.11	1.11	0.02	1.02	0.11	1.12	-0.96	0.26
1/Veh. Availability	1.45	4.27	-2.3	0.1	1.49	2.43	-3.79	0.02	-1.8	0.16	1.66	5.25
Constant	-3.67	0.03	-2.09	0.12	-3.02	0.05	-0.32	0.73	-2.34	0.1	2.01	7.5
-2 Log likelihood	945.416		1271.346a		1896.681a		3289.176a		1191.143		1376.582	
Cox & Snell R Square	0.024		0.05		0.057		0.248		0.074		0.466	
Nagelkerke R Square	0.084		0.132		0.114		0.33		0.195		0.702	

** All B value have significance level less than 0.05*

Table above shows the probability of use of various modes for every unit increase in supply of a certain housing typology. The table reveals that for every unit increase in the availability of row houses, the probability of use of public transit increases by 1.24 times. Similarly, decrease in vehicular ownership and increase in the availability of LIG tenements can have positive impacts on the ridership of AMTS and BRTS.

Mode Choice across the 3 Scenarios

Particulars	Business-as-Usual 2031	Ahmedabad TOD 2031	Inclusive Low-carbon TOD 2031
Walk	12.11%	9.69%	13.81%
Cycle	2.47%	4.45%	2.66%
PT (AMTS/BRTS)	13.79%	24.26%	36.22%
IPT (Auto, Uber)	44.26%	33.97%	17.21%
M2W	3.31%	6.96%	8.43%
M4W	24.06%	20.67%	21.66%
Total	100%	100%	100%

3.4 Way Forward

From TAD to TOD :-

The idea of Transit Oriented Development (TOD) is gaining popularity in Indian cities. Transit Oriented Development (TOD) is commonly defined as compact mixed-use development planned around transit hubs and accessible to walkable neighborhoods that are conducive to extensive transit use. Loose definitions and counter-productive planning strategies have caused proponents of TOD to distance themselves from various forms of transit proximate development such as "Transit Adjacent Development" (TAD), which is physically near transit but fails to capitalize on its presence (Renne, 2009). More effective planning strategies focus on the goals of TOD, which is any form of development around a mass transit node, at a macro or micro scale, that induces people to walk, cycle and use public transit (PT) over personal modes of transport (Cervero, Ferrell, & Murphy, 2002; DDA, 2012). Today, several cities in India are working on TOD proposals developed around large rapid transit investments in metro-rail or BRTS. Cities such as Delhi, Ahmedabad and Bangalore have already introduced some provisions of TOD into their Development Plans while newer cities like Naya Raipur are trying to incorporate them during inception itself. A variety of strategies exists to achieve the goals of TOD, which each city is adopting differently based on local planning paradigms and constraints. However, there are very few studies have examined these plans to assess whether they can bring about the desired changes in travel behavior and the social and environmental benefits associated with TOD. There are four inter-related components of the TOD related debates in India; urban design and spatial planning around transit nodes or corridors, built form regulations to achieve more conducive mix of land-uses, travel demand management strategies like on-street or off-street parking and finally, financial and institutional issues linked with the TOD zones. While the TOD as an idea has made significant in-roads amongst the policy makers and planners, there is a great scope for more nuanced discussion, research and innovations around these four inter-related components of the idea of TOD. The debates around TOD is an opportunity to mainstream the urban planning reforms in the Indian cities. Differential FSI values was one good example of reform which was being debated for a long time but it was widely accepted as part of the TOD plans in various cities. However, does the differential FSI values mean piling up massive floor space around transit nodes or it will lead to transit conducive development near transit corridors is yet to be seen. If it will lead to the first then there is a great danger of pricing out the existing transit riders from the proximate locations. TOD interventions tends to raise housing prices, often causing gentrification and making it difficult to attract transit riders who are also users of affordable housing. Cervero et al. (2004) observed an increase in housing prices from 6 to 45% near transit stations. Kahn (2007) also finds that TODs designed as "walk and ride" exhibit higher gentrification than "park and ride" stations. Maintaining a great diversity of income groups within TOD zones have various locational benefits, from access to a variety of services, to closer job opportunities. As part of the current project, we have developed the co-relations between the built form and public transit ridership by modeling the future scenarios for the City of Ahmedabad. The result of this land use – transport modeling effort indicates that higher proportion of affordable housing in the current.

Making TOD work

- Provision of affordable housing: Research proves that expansion of a variety of housing choices helps.
- Progressive parking policies: Charging market rates for parking and discouraging driving.
- Creating an Attractive public realm: Encouraging walking and cycling through the creation of a public realm that's safe, attractive.
- Mainstreaming TOD as part of Statutory plans
- Using innovative Tools and incentives to finance TOD

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