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Measuring Transit Oriented Development of Existing Urban Areas around Metro Stations in Faridabad City

Sat Pal
Department of Architecture, Deenbandhu Chhotu Ram University of Science and Technology, Haryana, India.
Email: Satpal2025@gmail.com

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ABSTRACT

Urban population in Indian cities is encouraging auto reliance and having unsafe economic, social and environmental consequences. Land-use-change patterns are the outcome of the complex relations between the human and the physical surroundings. To address these issues the planners are moving beyond land use planning to a sustainable development. Transit and Land use planning are important components to achieve sustainable future of urban development. TOD is a planning tool to encourage this integration. This paper discusses the land use scenario and opportunity around four Metro transit stations in Faridabad city. Different methods and various sets of indicators are considered to evaluate and measure TOD index in this study. This study will evaluate and measure the Faridabad city in the context of land use around Metro Stations to support TOD. This paper seeks to answer how to promote walkable communities, compact and transit-oriented development (TOD) that incorporates mixed land use development, including neighbourhood schools, retail and business-related space and a mix range of housing types within walkable distance. This paper concludes that the stations area which had a low TOD score needs to have policy for improvement. If planned efficiently, TODs can realize the sustainable development with considerable change in the urban development that focuses on pedestrian based neighbourhood planning.

1. Introduction

The urban population is increasing worldwide at an alarming rate. Cities are expending very fast, in terms of population as well as size, spreading on the periphery of the city and beyond municipal limits. Urban areas in the first few decades of the 20th century in India were compact, mixed-use and walkable concentrations of activity. Over four decades of automobile oriented development the world over has necessitated the need to search for a new urban development model that is able to respond to the challenges of the 21st century cities.

Delhi National Capital Region (NCR) has observed a rapid escalation in car ownership over the last two decades. The economic growth of NCR and its satellite town Faridabad have been built around an automobile culture, where attempts have been made to make provisions for the growing number of vehicles via measures such, flyovers under passes and widening of roads. From year 2000 onwards there have been huge investment in Delhi Metro although it has not been able to have a major impact in multimodal integration and appropriate connectivity to station. This has led to change in city's planning and development approach by looking for more innovative and sustainable solutions such as Transit Oriented Development (TOD) (Drive, 2006).

TOD has been rediscovered as one "smart growth" alternative. TOD provides one such tool to organize integrated community planning principles. It relates to spatial planning for development around transit stations. This tool is expected to integrate the land use and transport systems, thereby creating sustainable development,

pedestrian and non motorized friendly areas and neighbourhood. With the Metro reaches in Faridabad city it has potential to change the planning strategy and work with the new theory of urban development and explore the potential the Transit Oriented Development.

A city like Faridabad is certainly very dense from a population perspective but this density is being achieved through an inhuman compromise of space and quality of life. Yet, there are large tracts of space in Faridabad – such as the land along the railway line – that lies unused or unauthorised occupied by the squatter settlement. Yes, even Faridabad city can support more built-up space if it is properly redesigned. These areas have great potential in terms of redevelopment.

2. Research Objectives and Framework

The aim of this research is to investigate planning that support TOD by measuring the existing TOD levels of the transit station area using TOD index. The objectives of this research are (1) to understand the concept of TOD through literature of National and International Best Practices (2) to define the catchment area of transit station and explore the opportunities and limitations of the local situation (3) to identify the indicators for measuring the TOD index around the current transit station (3) to categorize the elements based on the TOD index which needs to be improved around the transit stations.

The conceptual framework of this research is presented in the Figure 1.

3. Background Evidence-TOD

Transit oriented development has been defined by various planners at different period and places. This concept arisen in USA in 90's is the most rational and acceptable form of urban development. The American architect Calthorpe was considered a pioneer and the first one who proposed the concept of TOD (1993). Later, many authors argue this idea and it starts gaining attention in Europe and Asia. It is an interesting tool to reduce car use by developing compact, mixed-use neighbourhoods around existing or new public transit stops offering frequent and high-quality public transportation (Barker et al., 2004). The concept of Transit Oriented Development is not necessarily a new idea but a strategy to mitigate the negative impacts of urban sprawl and auto-dependence. TOD is an approach that promotes high-density, mixed-use development, walkable neighbourhood clustered around transit stations and corridors. It is considered a "smart growth" strategy, because it both tackles the issue of where growth should occur from a regional "sustainability" perspective; and efficiently use of land and infrastructure while coordinating with land use and transit planning (Curtis, Renne, & Bertolini, 2009).

The most important ingredient to success of TOD planning is land and transit integration. Unless the development interacts with the mass rapid transit system, the two systems (land use and transit) stand alone and independent. It has been increasingly promoted and implemented as a solution to mitigate the urban sprawl and to save the agriculture land acquired for urban development.

Many researchers and practitioners have characterized the "TOD-ness" of projects around transit stations in various forms. The "TOD Index" was envisioned as an approach to describe the capacities of a project as TOD. The critical components of "effective" TOD would be caught in such an

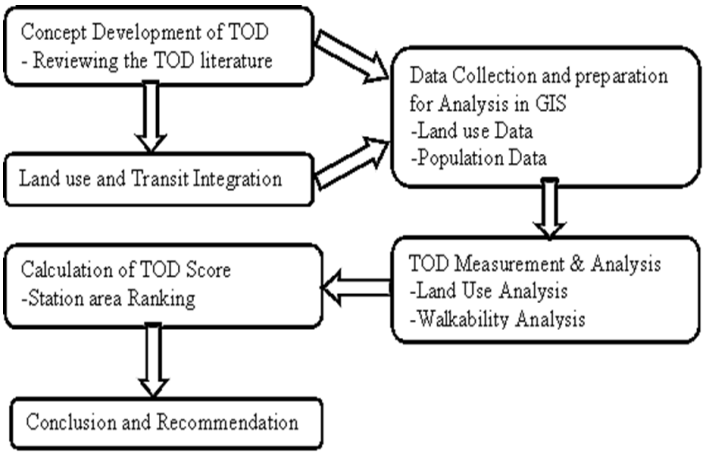


Figure 1: *Conceptual Framework*

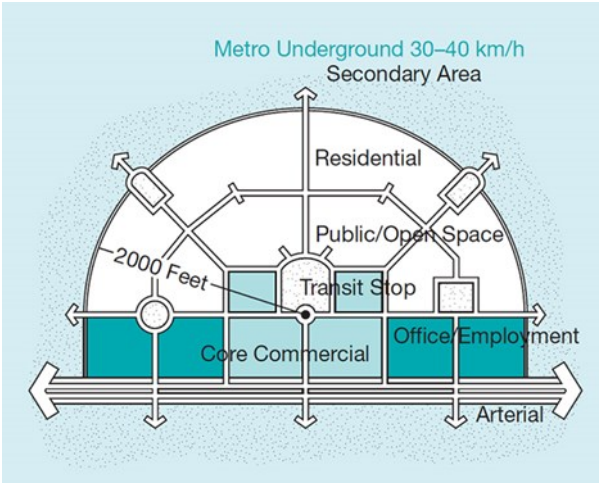


Figure 2: Illustration of TOD based on Calthorpe (1993)

index (Lee et al., 2007). The research by TRB (2007) selected 10 indicators to measure the success of TOD, which are density, design, mixed use, pedestrian activity, ridership, increase in property value, public perception, mode of connection at the transit station and parking. Yamini Jain Singh, (2015) proposed a design framework to measure the TOD level.

3.1 TOD Scenarios in India

Indian cities usually have high density and mixed use type of development and in some form or other TOD might already be a reality. Especially the inner walled city used to have high density and mixed use type of development within walkable distance but most of the areas lack the hierarchy of street to meet the demand of growing population needs. The government of India's policy on TOD states that it is a key policy initiative for low-carbon, high-density, compact, mixed land use and sustainable development by minimizing travel time for citizens, promoting use of public transport, reducing pollution and congestion, creating more homogeneous neighbourhoods, having work places near residences, creating public amenities within walking distances and providing safe environment through redevelopment along MRTS (Mass Rapid Transport System) corridors (Jadhav, 2015). The Indian cities also in general have diverse neighbourhoods, densities and land uses. To address these issues, many cities have strengthened their public transport by developing mass rapid transit systems (MRTS) such as metro rails and Bus Rapid Transit Systems (BRTS) (Singal, 2014).

There is a shift from a poly-nodal, polycentric, distributed city development approach to small, dense, urban development along transportation and transit corridor due to TOD. As the cities are experiencing rapid growth, transit systems like metro rail, BRTS, etc. are being implemented to cater to the growing travel demand. It has thus become inevitable to have TOD for all such cities which have an existing mass transit system or are planning to do so.

In Mumbai; a strategy to eliminate low density, outward expansion, the City Development Plan proposed for higher FSI up to 8 along rapid transit corridors and commercial districts, while restricting FSI to 2 or less in areas without transit access. (Bhatt & Paradkar, 2012). In Ahmedabad; the policy is to allow higher densities for developments along transit corridors, with Central Business District having an FSI of 5.4, better streets, an improved public realm and upgraded infrastructure (Rangwala & Mathews, 2014). Delhi allow higher densities In a TOD zone, which extends 500 meter on either side of an identified Delhi Metro corridor, to avail 400 FAR, mandate mixed use, and eliminate setbacks and compound walls for developments near public transport hubs. (Debajeet Baruah, 2015). Haryana Government had conveyed its 'in-principle' decision to provide higher FAR of 3.5 including 0.5 FAR for parking purposes, for property development along transport corridors (Planning, 2014).

3.2 Planning initiatives in India

Typically, planning for transit happens at various scales and at different times in the development process of a city. These plans are prepared by different agencies (private, public, or collaborative venture) and often enabled through different legislations. In India, most of the states prepared a perspective plan (20-25 year) for the cities based on the relevant Town and Country Planning act of the state. Such a plan offers the first opportunity for integrating the growth plans of the city with the vision of a new / expanded transit network. NCR Planning board at the regional scale integrate the regional goals (such as decreasing traffic congestion, decreasing pollution levels and improving public health) with regional contexts (such as the consideration of population growth and the location of major employment centers).

For JNNURM scheme, Faridabad city also prepare a Comprehensive Mobility Plan (CMP) so as to integrate mobility needs of the city with the existing future growth trends. However, in reality the ideas for introduction of new transit are often separated from the regional / metropolitan planning process. Regardless, planning for transit (new or enhancement of existing) happens at a regional scale when the vision for improved connectivity in a growing city emerges. While the vision establishes a preliminary need for the transit, a detailed feasibility study is not usually included with this vision. A regional development authority or equivalent is responsible for translating this vision into a clearly delineated Development Plan / Master Plan for the urban area. The regional authority will also update and adjust the Plan over time as the vision shifts. In order to understand and plan for Transit Oriented Development, it is important to first understand the overall process of planning for transit and where TOD planning fits into the city's or metropolitan area's overall planning processes (Bhatt & Paradkar, 2012).

4. Study Area

4.1 Faridabad City Profile

Faridabad in Haryana state is one of the most populated city, it is the major hub for educational, administrative,

Table 1: *Population in the Study Area*

Year	Population	Density (Persons/sq. Km)
1981	330,864	2,111
1991	617,717	3,988
2001	1,055,938	6,736
2011	1,438,855	9,723
2021*	2,438,000	11,300

Source: Faridabad Development Plan

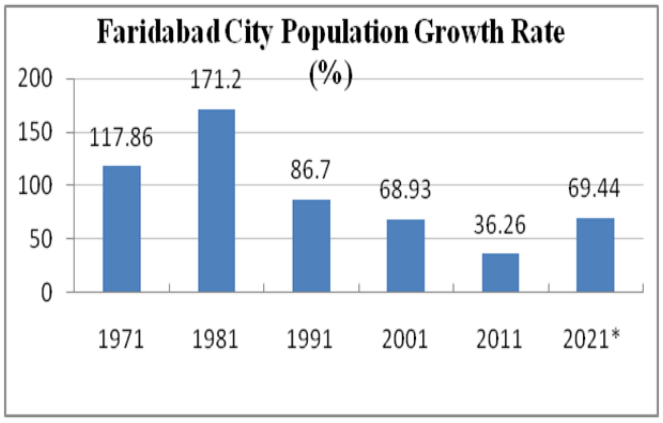


Figure 3: *Population, Growth Rate (%) as per Master Plan*

political and industrial centre of the state (Haryana, 1991). As per Government of India classification, Faridabad city classified as class I category city constituting a population of 617,000 in 1991 which was increased to 1,055,000 in 2001 and 1,438,000 in 2011 (Table 1). Besides this, due to creation of Faridabad as District in 1979, there is found a large variation in the growth of population in the city as is evidenced in year 1981 as 171.2% highest among all. The density variation in the development is illustrated in the map shown in Figure 3 (Associates, 2010).

Table 2: *Land Use Faridabad*

Sr. No.	Land Use	Total area 2001	DP-2001	Total area 2011	DP-2011
		Ha	%	Ha	%
1	Residential	7,705	49.71	14,328	41.69
2	Commercial	3,100	20.00	2,069	06.02
3	Industrial	764	4.93	6,179	17.98
4	Transport & Communication	1,536	9.91	4,020	11.70
5	Public Utility	153	0.99	638	01.86
6	Public & Semi Public Uses	524	3.38	1,299	03.78
7	Open Spaces, Parks & Green Belts	-	-	5,314	15.46
8	Special Zone	436	2.82	448	01.30
9	Mixed Land Use			73	00.21
	Total	20,525	**100.00**	**34,368**	**100.00**

4.2 Land use and Density

The population density of Faridabad in year 1991 was 3,988 persons per sq. kms that become 6,736 persons per sq. kms in 2001. In year 2011 the population density of Faridabad Urban Complex grew to 9,723 persons per sq.km. The development plan 2011 of Faridabad has proposed population density of 11,300 persons per sq. kms in 2021, and by 2031 to accommodate 3,886,000 persons by 2031 (Town and Country Planning Department, 2014). The extent of various land uses is shown in Table 2.

There are 12 wards are having less than 10,000 and 9 wards are having more than 25,000 population per sq km. High density areas are Faridabad Old Town, Ballabgarh Old town, New Industrial area (Figure 4). Present development in Faridabad city is taking place towards Naharpaar area on eastern side, south and South-West direction. Similarly,

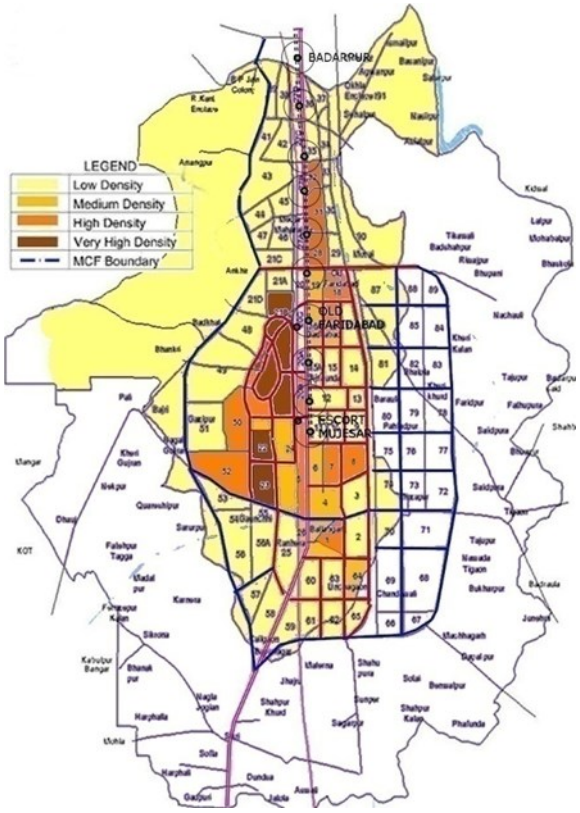


Figure 4: *Faridabad City Density Map*

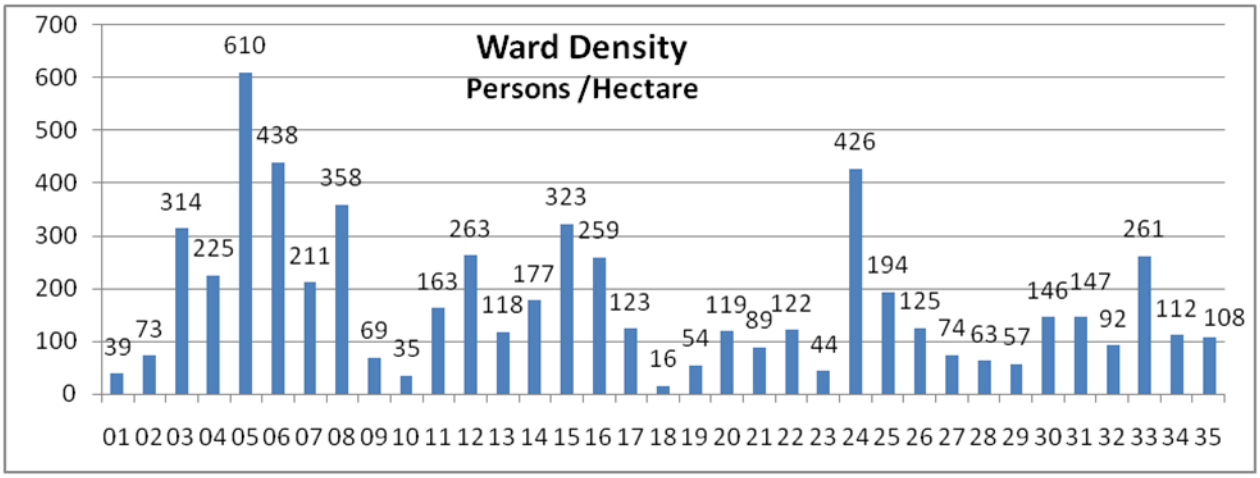


Figure 5: *Faridabad Ward Density*

this town cannot be expanded towards its north due to the constraint of Haryana-Delhi border and on western side there is a rocky undulating area. The population density in the study area is very less because of vacant land lying between National Highway and Railway line.

As per development plan of the city, the land use analysis indicates that there is reduction in the residential and commercial land use form 2001 to 2011whereas there is increase in land use of Industrial, transport & communication and open space in 2011 (Figure 4). Realty segment's development in Faridabad has been an unmistakable evidence of how much a Metro route contributes towards the success of any region's real estate market. The presence of Metro rail in Faridabad city helps in expanding the footfall, aside from making the place more liveable and fit for commutation, which additionally promotes real estate development

4.3 Public Transport connectivity

Faridabad is very well connected with Delhi by NH2 (Mathura Road), Mehrauli-Badarpur Road, and the Mathura Railway line running along National Highway. Most of the sector roads connecting to the National Highway are 32metre wide. Delhi Metro connects the capital with its satellite city of Faridabad on 6th September 2015. The total length of Badarpur-Faridabad Metro is 13.9 km. and 9 metro stations, ending point at Escort Mujesar. It hopes to improve the economic growth in the region; this section could boost employment opportunities in this key industrial hub. The Faridabad Metro section (Badarpur to Escorts Mujesar) load (daily passengers) could grow to 150,000 i.e.: PPHPD (Peak passengers per hour per direction) by year 2021 due to the extension (Associates, 2010). Parking facility at all the metro station is not sufficient, most of the time parking lots are full.

As shown in the Figure 6, the entire transit route in Faridabad is very well connected with interstate bus and local bus, covers all the metro stations. Super fast and mail train stops at Old Faridabad railway station local train cover the NIT Bata Chowk Railway Station which has frequency of about one hour. Local bus service in Faridabad is not sufficiently catering the needs of intra-transit requirement of the population and most of the people depend on the auto and rickshaw ply on the road without any regulations.

One of the important aspects in understanding the relationship between public transport and land use is the network of the mass rapid transit. The basic theory behind the correlation between land use and transportation is accessibility to urban areas. The foremost land use factors affecting public transport use are density, diversity and design (Gu, 2013). Transportation infrastructure increases the potential of land development and tends to increase the price of land parcels that enjoy significant gains in accessibility and over longer period the land use adjustments can occur. While land-price impacts can be immediate, land use changes tend to be slower and are sensitive to policy, zoning and development requirements (Hyde & Smith, 2017).

An increase in property prices linked with an increase in accessibility from transport results in a shift in development from one location to another in what is called a redistributive impact. Public transport systems have the potential to impact on development by changing the relative accessibility. An increase in property values in the vicinity of Faridabad Metro transit corridor is seen that may

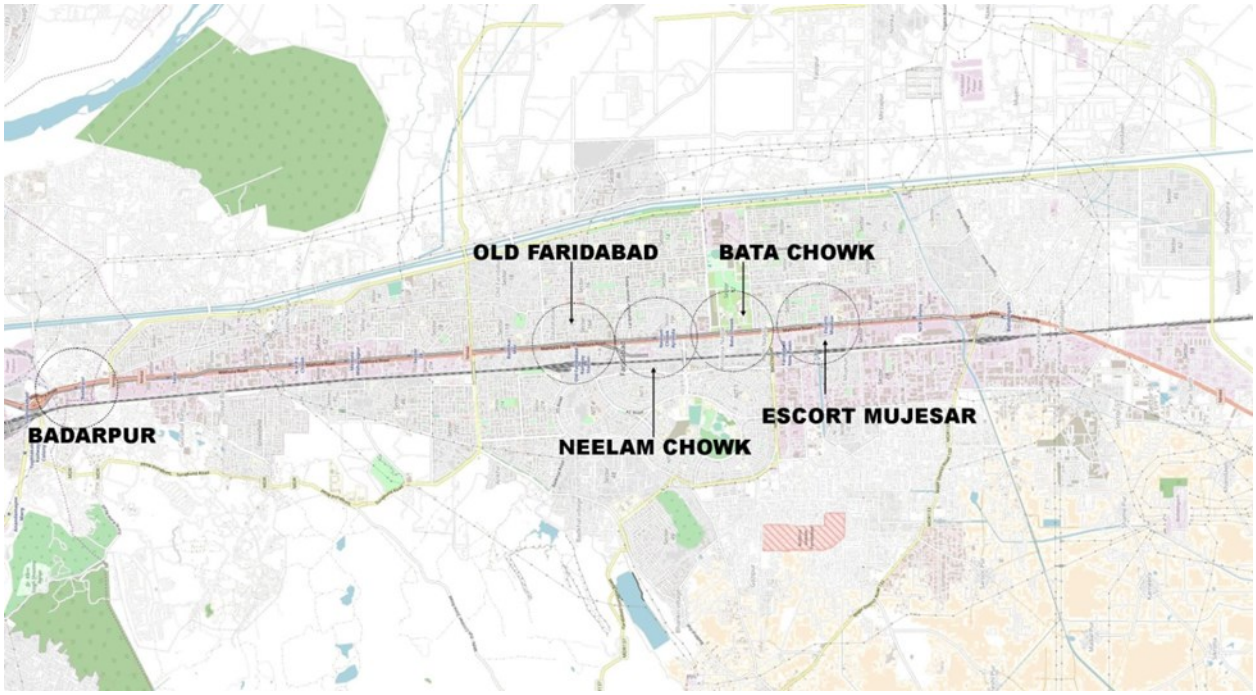


Figure 6: *Faridabad Metro Route (Source: openstreetmap.org)*

be equalizing by reductions in different places. Over the long period this MRT system will have an overall positive and visible impact on property values in Faridabad that are close station nodes and situated on transport corridors. We need to consider whether the increase in the value of a property is due to its close proximity to public transit system or other neighbourhood characteristics of that area. Metro system will not serve the purpose of connectivity but there is need to promote a variety of transport system in Faridabad.

5. Identification of TOD Indicators

There are many ways for identification of TOD indicators based on various literatures. Numerous authors mentioned that the indicators should be independent, distinctive, comprehensive, and measurable. To identify TOD potential location and its opportunity in Faridabad area, it needs an analysis to determine the best criteria and indicators that are suitable for the characteristic of Faridabad area The present study considers variables such as density, diversity and design (called as 3D) from land use side..

Therefore, the criteria and indicators for this research were chosen through an extensive review of TOD literature and the assessment of data availability. Using TOD indicators we can suggest how TOD can be improved in certain areas and which area may be considered for better transit connectivity. State Government or Civic bodies who are the real decision maker will then decide on detailed TOD planning proposals. In this research first we identify the criteria and then we do the land use assessment based on TOD. Besides the transit criteria and land use characteristics, the relationships between these variables were analyzed.

The transit ridership as one of the main aspect of TOD as stated in several studies. It argues that the relationship between transit ridership and TOD planning factors such as land use characteristics, built environment, and design characteristics. The transit system node serves various purposes, however it has relation with transit ridership. Transit system with optimal capacity utilization has higher level of TOD.

The quality of transit system is one of most important aspect in TOD evaluation. The main purpose of TOD planning is to encourage the use of public transport system. To make TOD planning attractive and easy to implement, the Transit nodes should be user friendly. The Transit nodes must have good accessibility for neighborhood area. Parking facility is considered as one of most useful indicators to evaluate TOD. Most of the population in Faridabad use two wheelers to commute and the availability of parking space for different modes encourage the use of Metro system as it will encourage higher level of TOD. TOD area must have a minimum transit supportive density.

Table 3: *Land Use Analysis of Faridabad Metro Stations*

Land Use	Escorts Mujesar (%)	Bata Chowk (%)	Neelam Chowk Ajronda (%)	Old Faridabad (%)
Residential	17.91	8.61	20.32	18.68
Commercial	2.17	6.92	3.35	3.85
Industrial	28.70	6.55	8.58	7.94
Public & Semi Public	6.28	3.43	10.25	15.00
Green/ Park	6.90	1.73	1.39	3.56
Unauthorized Area	0.53	7.89	5.98	0.00
Vacant Land	11.38	42.07	6.01	13.84
Village Abadi	5.75	0.00	6.85	7.58
Metro Yard	0.00	0.00	11.90	0.00
Beyond Railway line	20.37	22.80	25.37	29.56
Total	100.00	100.00	100.00	100.00

If densities are less, then efforts are required to bring them up to a certain level. Land use diversity is very important indicator as it helps in creating vibrant and liveable surroundings within the walking distance.

6. Calculation of TOD Index

To evaluate the land use planning along the transit corridor of Faridabad city, the land use characteristic of four stations namely; old Faridabad, Neelam Chowk, Bata Chowk and Escort Mujesar metro stations were analyzed. The land use data of year 2016 was considered for analysis with the help of ArchGIS 10.2. The catchment area as a radius of 800 metre around a transit station as the Metro station at their

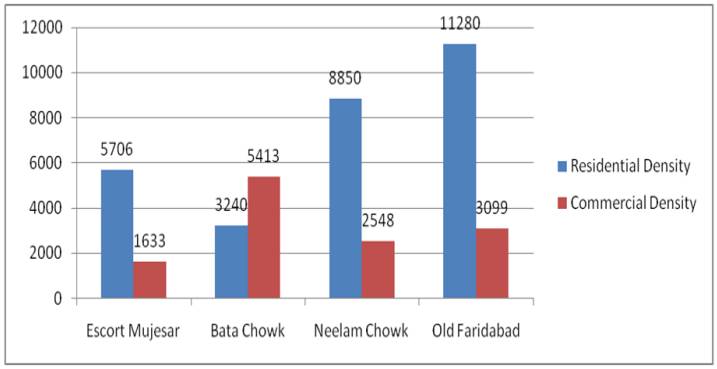


Figure 8: *Population Density Analysis (Residential and Commercial Area)*

centre was considered for the purpose of this analysis. This 800 metre radius represents a comfortable ten minute walking distance.

The study area has major land use of industrial (28.70%), residential (17.91%) and 11.38 % of the land is lying vacant which is meant for public & semi public land uses area as per Master plan 2011 at Escort Mujesar metro station area (Table 3). The residential density at Escort Mujesar station area zone is not sufficient to support TOD. Bata Chowk metro station area has major land use of residential (8.61%), commercial (6.92%) and 42.07% of the land is lying vacant. Neelam Chowk Ajronda metro station area has major land use of residential (20.32%), public and semi public (10.90 %), and 11.90 % of the land is within the jurisdiction of Metro.

Old Faridabad metro station has major land use of residential (18.68%), public & semi public (15 %) and 13.84 % of the land is lying vacant. The land between National Highway and Railway line is being encroached and unauthorized development has taken the major chunk of

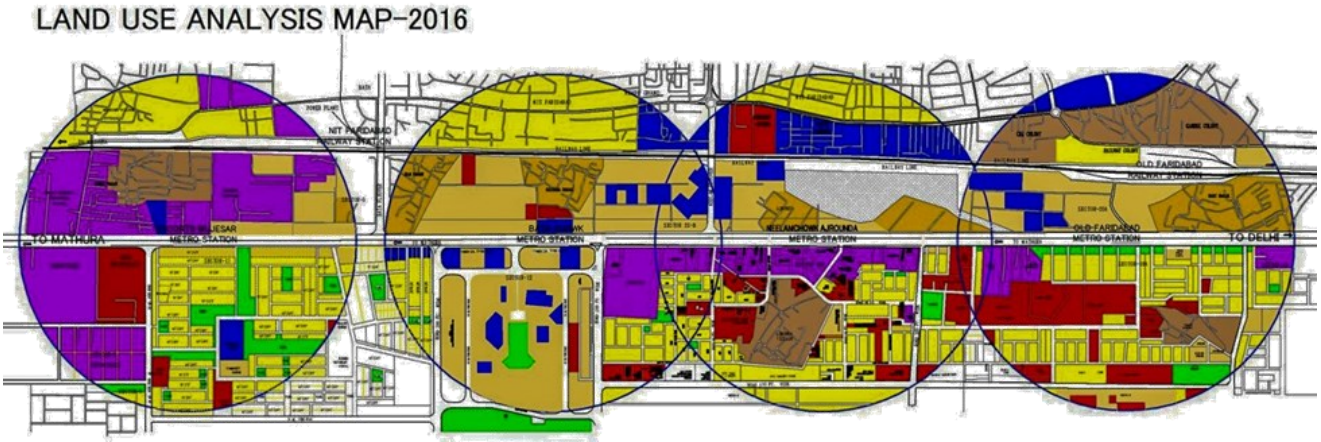


Figure 7: *Land use Plan 2016 of Study Area*

land. The major portion of land about 20% to 30% is beyond the existing railway line which lack the connection to the Metro stations.

Bata station area has potentials to develop as regional, local and community scale commercial market. Sector-12 is planned for commercial and public & semi public use as per development plan of 2011-31. The sector-12 is not fully developed. The land between Metro station and Railway line is being encroached and unauthorized development is taking place.

6.1 Population Density Analysis

The estimation of residential dwellings was based on the land use map of the study area. The estimation of density of residential dwellings in each sector is done on the basis of actual building footprints based on present development. Those were obtained through digitizing the aforementioned map of the study area. Residential buildings were extracted by clipping all buildings footprints in the study area to residential land use category**.** The density of residential dwellings was obtained as the number of residential buildings in area divided by the total surface area.

6.2 Calculation of Land use diversity index

The Simpson index was introduced in 1949 by Edward H. Simpson to measure the degree of concentration when individuals are classified into types. Diversity index generally quantifies how homogeneous or heterogeneous land-uses types are within the walkable distance to transit station (Table 4). This is the most widely accepted and commonly used index for representing the land-use mix. The Score fall between 0 and 1, where 1 indicates a perfect mixture of all land uses in a given area (Aston, Currie, Pavkova, Aston, & Currie, 2015). This indicator is intended to measure the number of different land uses in a given area and the degree to which they are represented in that land area. This study used radius of 800 meters around the designated Metro Station areas. In this study land use data of year 2016 were used. Five land uses were considered, namely residential, commercial, industrial, Public and Semi Public, and parks. Higher the value of Simpson's Diversity Index, greater the diversity.

Simpson Diversity Index is given by:

Where: $$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

n the number of individuals of each different land uses
N the total number of individuals of all the land uses

As previously discussed, Faridabad has 9 metro stations, out of that four metro stations namely Old Faridabad, Ajronda Neelam Chowk, Bata Chowk and Escort Mujesar metro station areas were analyzed and designated ranks based on their transit-supportive quality in relation to the New Starts criteria. Bata Chowk Metro Station area has greater Diversity Index and Escort Mujesar Metro Station area has lowest Diversity Index. Some of these station areas have more chances and better opportunities to develop, because of their well-accessible location and available open space.

6.3 Walkability analysis

Ped-sheds measure the accessibility of a given location based on a ratio of Euclidean distance to street network distance. This analysis calculates a number that represents

Table 4: *Diversity Index*

Land Use -Escort Mujesar	n	(n-1)	n(n-1)
Residential	17.91	16.91	302.858
Commercial	2.17	1.17	2.539
Industrial	28.7	27.7	794.990
Public & Semi Public	6.28	5.28	33.158
Green	6.9	5.9	40.710
Total (N)	61.96	60.96	1174.255
Simpson Diversity Index, Escort Mujesar		D	0.689
Land Use -Bata Chowk	n	(n-1)	n(n-1)
Residential	8.61	7.61	65.522
Commercial	6.92	5.92	40.966
Industrial	6.55	5.55	36.353
Public & Semi Public	3.43	2.43	8.335
Green	1.73	0.73	1.263
Total (N)	27.24	26.24	152.439
Simpson Diversity Index, Bata Chowk		D	0.787
Land Use -Neelam Chowk	n	(n-1)	n(n-1)
Residential	20.32	19.32	392.582
Commercial	3.35	2.35	7.873
Industrial	8.58	7.58	65.036
Public & Semi Public	10.25	9.25	94.813
Green	1.39	0.39	0.542
Total (N)	43.89	42.89	560.846
Simpson Diversity Index, Neelam Chowk		D	0.702
Land Use -Old Faridabad	n	(n-1)	n(n-1)
Residential	18.69	17.69	330.626
Commercial	3.85	2.85	10.973
Industrial	7.94	6.94	55.104
Public & Semi Public	15.01	14.01	210.290
Green	3.56	2.56	9.114
Total (N)	49.05	48.05	616.106
Simpson Diversity Index, Old Faridabad		D	0.739

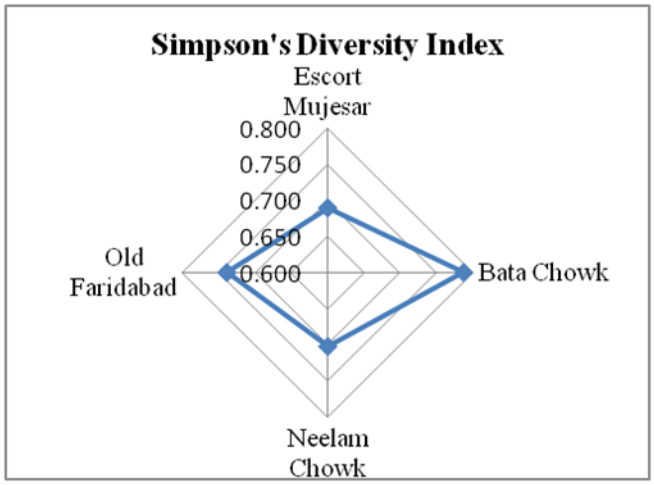


Figure 9: *Diversity Index*

how walkable a space is. This analysis was to be conducted for the TOD areas prior to and after construction/ designation. "Pedestrian Catchment Areas," (also known as Ped-Sheds) are theoretical walkable zones that can be mapped to show the actual area and network within a five-minute (quarter-mile) or ten minute (half-mile) walking distance from a transit stop. The data is presented as a ratio between the Euclidean distance and the network distance from a given point (e.g. transit station).

The street networks of New Urbanism designs deliver similar benefits over conventional suburban development. Pedestrian generators are houses, retail, commercial and industrial workplaces with high worker density. Most people will walk 400m or for five minutes to a station area, and 800m or for ten minutes to a major transit stop if they live close enough and the streets are pleasant and direct. The resulting maps are also highly visual estimates of an area's walkability. The figure 10, shows the pedshed area (400M and 800M radius) at Faridabad four metro stations

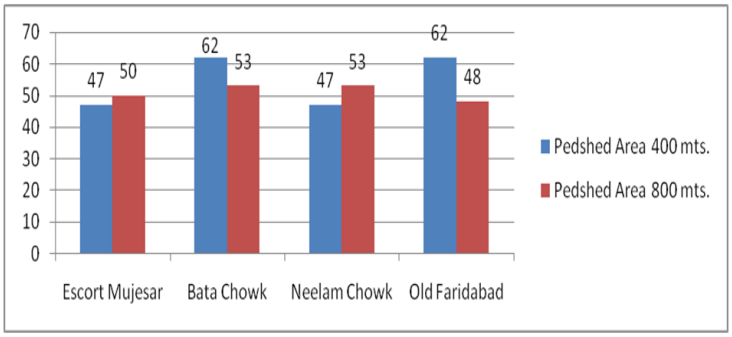


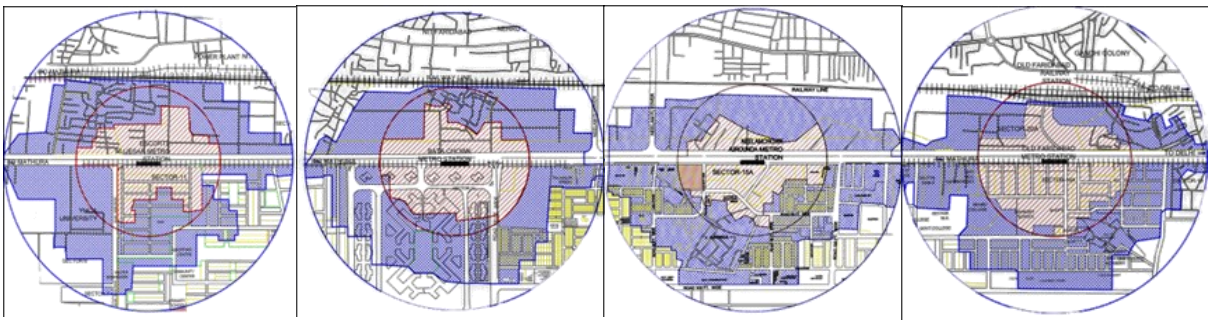
Figure 11: *Pedshed Analysis Result*

namely, Escorts Mujesar Metro Station, Bata Chowk Metro Station, Neelam Chowk Ajronda Metro Station and Old Faridabad Metro Station.

Pedshed efficiency is computed from the Area of the actual mapped pedshed polygon (ha) divided by Area theoretical maximum 400m or 800m radius pedshed loci (ha) and multiplied by 100%.

Higher walkability is associated with a higher proportion of the maximum area. Areas with good accessibility and walkability have a ped-shed access ratio of >= 60% of an area within a five-minute walk, or a ten-minute walk to a transit station. From the ped-sheds analysis, it appears that at Escorts Mujesar Metro Station and Neelam Chowk Ajronda Metro Station are grossly underutilized with 47% of the area accessible within the theoretical maximum 400m pedshed, and all areas are underutilized with 48-53% of the area accessible within the 800m.

A five-point ranking system is considered for this analysis: a brief explanation of the ranking criteria is presented below. The rankings help to assess the overall transit supportive environment in a station area based on existing conditions and policies. Criteria used to establish station area rankings:



Escorts Mujesar | Bata Chowk | Neelam Chowk | Old Faridabad

Figure 10: *Pedshed Analysis of Faridabad Metro Station*

Table 5: *Transit Oriented Development Score*

	Metro Stations			
	Old Farida-bad	**Neelam Chowk Ajronda**	**Bata Chowk**	**Escorts Muje-sar**
Diversity of Land use	3.45	3.94	3.51	3.70
Residential Density	2.28	1.30	3.54	4.51
Commercial Density	1.09	3.61	1.70	2.07
Walkability (Catchment Area 400M radius)	3.13	4.13	3.13	4.13
Walkability (Catchment Area 800M radius)	3.33	3.53	3.53	3.20
Summary Points	13.28	16.51	15.42	17.61
Average Station Ranking	2.66	3.30	3.08	3.52

(Note: Rankings are based on a scale of 1 to 5; 1 indicates a "low" rank, 3 indicate a "medium" rank, and 5 indicate a "high" rank) (KCATA, 2008).

The pedshed analysis suggests that each of the case study areas had potential for significant improvement in terms of the directness of the pedestrian network, and ease of access to the total pedestrian network length. This shortcoming could be rectified through the development of new roads and pedestrian links, particularly where pedestrians are forced to take unnecessarily circuitous routes to the Metro Station from their home in the pedshed areas. Escort Mujesar station area has highest TOD score and Old Faridabad Station area has lowest TOD score (Table 5).

7 Conclusion

The range of TOD score values of four MRT stations in Faridabad is ranging from 2.66 to 3.52 at scale of 1 to 5. It can be concluded that a high index value of transit station tends to be eligible for improvement should apply the concept of TOD well. The level of improvement in each of these stations can be adjusted to the value of the success of criteria and indicator. Planning for TOD can be considered to achieve the sustainable development that would in fact support the variety of uses within walking distance of MRT stations. Faridabad City should consider creating Transit-Oriented Development zones within 400 m and 800 m radius of around MRT stations. This would allow city to maintain the residential identity of existing sectors, while allowing for commercial uses in sector-12, and protecting industrial and manufacturing uses at the Escort Mujesar

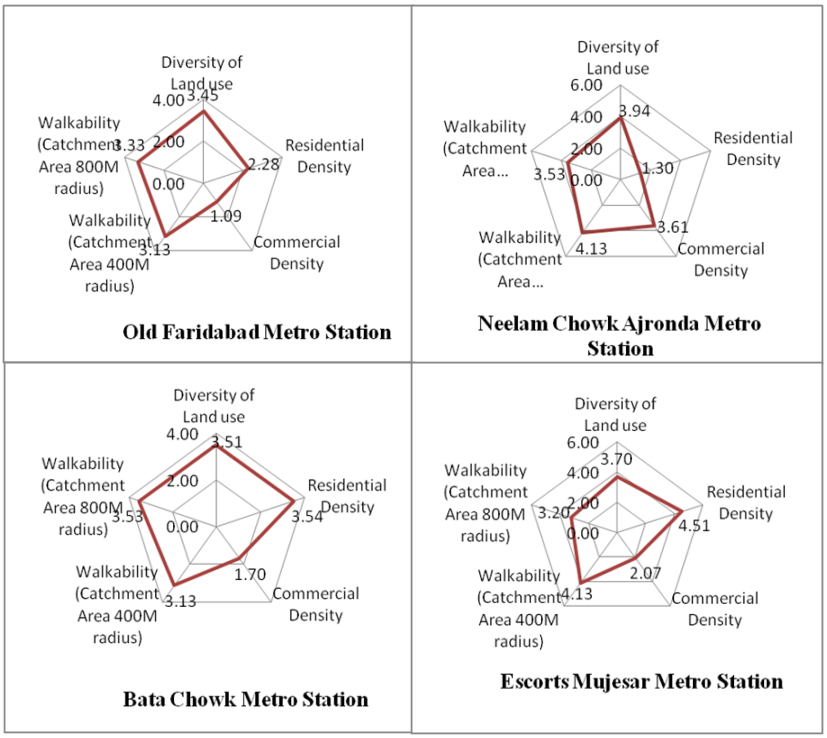


Figure 12: *TOD Score of Faridabad Metro Stations*

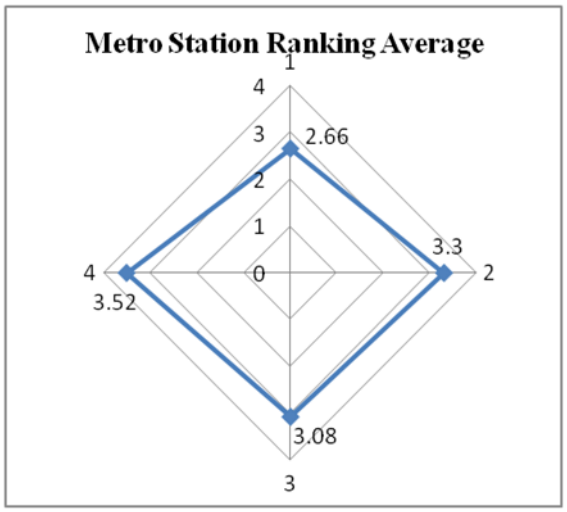


Figure 13: *Faridabad Metro Stations Ranking*

station area, integration of all elements of transit-supportive development, including density, mix of uses, walkability, and pedestrian-scale design. Public engagement is critical to the success of planning for TOD. This will ensure that the new policies and plan being prepared are aligned with the broader vision of the community.

There is need to convert vacant and underutilized land (mentioned in land use plan 2016) to accommodate mixed use development along the MRT route. In order to accommodate projected growth rates Faridabad city could offer density bonuses and incentives to encourage development along the transit route. Multi-family residential apartment buildings with 20 % commercial/ office space & FAR of 3.5 to 4.0 and density of 600-900 may be allowed in accordance to TOD zone to boost ridership and provide a wider range of housing opportunities for Faridabad's residents. Specifically, the City may consider targeting affordable housing development to the area surrounding the MRT stations: easy access to multiple modes of public transit would increase a household's budget for housing by eliminating the financial burden of owning a car. There is a growing requirement of parking at the transit station. Development authority may consider developing multistory parking. City must create a mechanism to encourage the redevelopment of abandoned or underutilized commercial and industrial sites.

8. Recommendations for Future Works

The result of the TOD index is vital in understanding the character of an area as 'TOD'. The development of areas around transit station are expensive than those farther from the station. The dynamics of market for the station areas are very complicated and differ from place to place. The high value of land around station area can be captured by allowing luxury housing or by allowing affordable housing. But some researcher argue that the people living in luxury housing within close proximity to stations and drive their luxury cars, these people don't use transit at all. The policies of the government, land ownership and demography of the area all have impact on the business and people living in proximity to a transit station.

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