A Local Level Transit Oriented Development Typology: Using Two-Step Clustering Technique

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Abstract: Transit Oriented Development (TOD) is characterized by mixed land uses within the half mile radius around the transit stations with high density development, pedestrian friendly environment and well connected road network with frequent public transportation system. TOD Typology is a way grouping different TODs having a common set of features. The TOD Typology will help local practitioners, decision makers, officials understand the assets and vulnerabilities, and how each transit station area fits within the regional context. No one – size – fits – all, like different implementation strategies are needed for different place types. TOD Typology offers a strategic planning of transportation combination with Land Use and enables comparisons and performance assessments within the station classes. **T**he study is based on the wide parameters namely built – environmental, Network parameters and different transport centers that help in understanding the TOD area characteristics to the greater extent. The 2-Step clustering technique is adapted to develop typology of 20 TODs of Hi-tech city and its surrounding area of Hyderabad into 6 clusters. The study will try to make an attempt of recommendations and time bound implementation strategies for the TOD clusters.

Introduction

TOD

TOD is a concept of managing urban growth in transit corridor which has characteristics of mixed land use, compact, walking-distance, and development focused around public transit area. TOD is generally demarcated as compact, mixed land use development near existing or new public transportation infrastructure that makes provisions of housing, employment, recreation and civic amenities within walking distance from transit. The main objective of TOD is to maximize access to public transport, and assimilate features to encourage transit ridership.

A TOD neighborhood typically has a center also called node, may be transit station, metro station, tram stop, or bus stop surrounded by relatively high-density development with

progressively lower-density development unroll from the center. TODs generally located within a radius of one-quarter to one-half mile i.e. 400 to 800m from a transit node, as this is appraised to be an apt scale for pedestrians, thus solving the last mile problem. TOD is the contemporary fast growing trend in creating livable, vibrant and sustainable communities. This makes the people to live a lower-stress life without complete dependence on a car for mobility and survival [1].

TOD integrates land use and transport planning and aims to prosper planned sustainable urban growth centers, having walkable and livable communities with high density mixed land use development. Citizens have access to open green and public spaces and at the same time transit systems are effectively utilized. TOD enhances pedestrian trips to access various facilities such as shopping, entertainment and work. TOD aims to reduce private vehicle dependency and induce public transport use though proper policy, design, and enforcement measures and to provide public transportation access to the maximum number of people through densification and improved connectivity. The components of TOD are presented in Figure 1 [2].

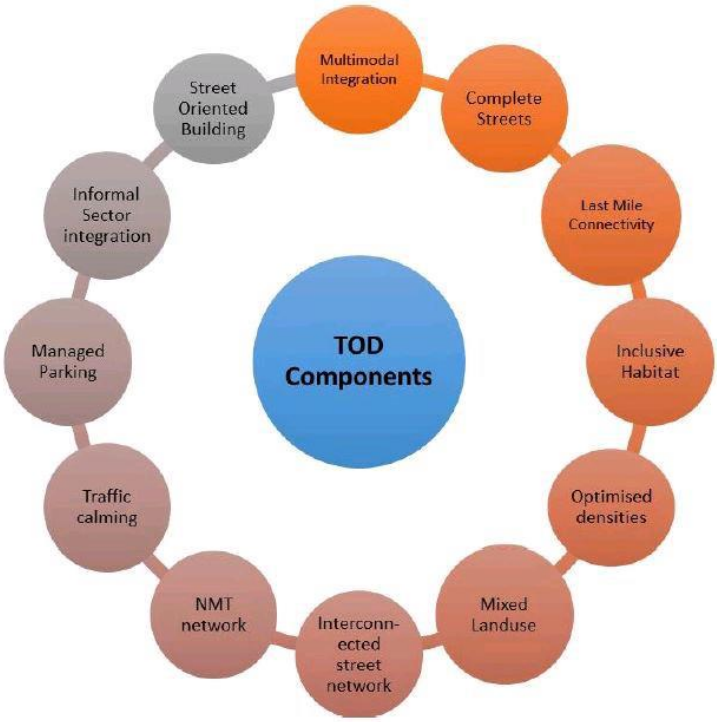


Figure 1: Key Components of Transit Oriented Development.
Source: National TOD Policy Report 2017

TOD Influence Zone

Influence zone is established at transit node (Metro station, MMTS, BRTS, City Bus, or LRT). It is generally up to a radius of nearly 500 – 800 m of the transit node. When the distance between the two successive transit nodes is less than 1 km and overlap in the influence area, it can be identified as a delineated zone (around 500 m) on either side of transit corridor. It is generally 10–12 minutes of walking distance. Center for Transit Oriented Development classifies TOD influence area into 3 categories. First one is Core: Up to 200m, second one is Primary Walking Catchments distance between 200 – 400 m and third one is Secondary Walking Catchments covers distance between 400 – 800 m [3].

Balance between Transit Node and Place

This is analytical framework to describe Transport (node) and Urban Development (place), characteristics of location and their relationships. 5 typical situations proposed, those are Balance, Stress, Dependency, Unsustained Nodes, Unsustained Places. A balance situation offers better positive impacts in development. The schematic frame work is shown in Figure 2. The description of each node – place type in detail as following [4].

- **Balance Condition** will be observed where the node and the place values are likely equally strong, indicating that the development potential of either has been realized.
- **Stress Condition** will be observed where potential for land use development is highest (Strong Node) and it has been realized (Strong Place) the same can be said about the potential for transport development.
- **Dependency Condition** is observed where demand for both land use and transport development is insufficient to generate an autonomous development dynamics.
- **Unsustained Nodes Condition** is observed inareas, where transportation facilities are more developed than urban activities.
- **Unsustained Places Condition** is observed in areas, where urban activities are much more developed than the transportation facilities.

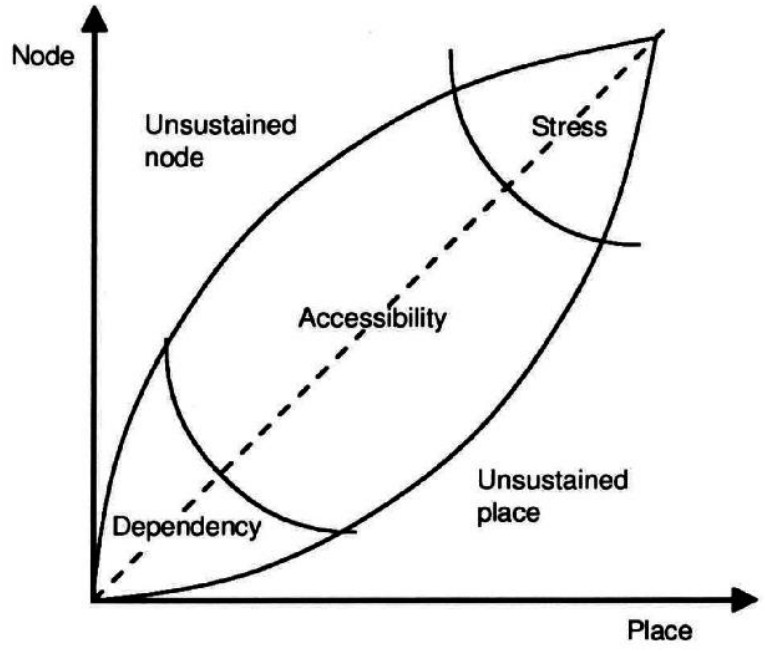


Figure 2: Node – Place Relationship.
(Source: Kamruzzaman et al., 2014)

Purpose of TOD Typology

Purpose of TOD Typology is to reduce management complexity for planners, infrastructure companies by enabling the application of standards in operation and development, and securing consistency of actions. Typology also provides a frame work for understanding what types of implementation strategies are needed in city transit station areas. Each station area has its own set of implementation needs, and the typology offers a basic framework for prioritization and understanding these needs at a glance. Typology provides information of station area's economic potential, and road map of funding and implementation of development activities.

Typology enables comparisons and performance assessments within the station classes, and identifying successful benchmarks or highlighting needs for action [5] and [6].

Goals of TOD Typology

The set of goals of the TOD Typology are:

- It should brief the story of transit station communities
- Identify station areas, which are potentially vulnerable to displacement pressures
- Identify areas where the production and preservation of affordable housing are needed
- Understanding of TOD interventions needed for equitable TOD
- Catalyze TOD in communities where the markets are primed to respond to TOD investments.
- Identify where and what types of infrastructure improvements are needed to support equitable TOD.
- It should specify the investment and return policy on the time scale in the TOD clusters.
- It should brief the clusters of greatest economic potential, and how certain activities can be funded and implemented.

Need for the study

Various aspects such as need, characteristics of TOD, factors driving towards TOD, key components of TOD are understood. Though TOD concept is not a new one in international context, but coming to Indian context proposals are initiating for development/ redevelopment in long term strategies. However, implementation of TOD principles in Indian cities will boost the smart urban areas. The Government of India also started necessary steps for TOD approach implementation in Indian cities, and formulated National Transit Oriented Development Policy recently. Thus, it is understood that in nearby TOD concept will enter in Indian cities also. The present study Transit Oriented Development Typology, i.e. Clustering of TOD areas based on similarities of characteristics will offer flexibility of understanding on a macro level, and enhance the planning, design, and operational activities. Typology supports the identification of general development potentials and necessary future adoptions. The study tries to give the desired densities, mix of land uses, connectivity levels, and functions of transit system and therefore, the present study TOD Typology supports the design of an optimal TOD at a given site. The study will reduce the management complexity for infrastructure companies, town planning authorities by enabling the application of standards in development and operations, and securing consistency of actions across large portfolios and geographic regions.

Clustering technique

The various popular clustering techniques are present like Hierarchical Agglomerative Clustering, K – Means Clustering, Fuzzy C – Means Clustering and Two – Step Clustering Technique. In this study, Two-step clustering technique is choose to do the analysis.

Two-step clustering technique

The SPSS Two-Step Clustering Component is a scalable cluster analysis algorithm designed to handle very large datasets. Capable of handling both continuous and categorical variables or attributes, it requires only one data pass in the procedure. In the first step of the procedure, you pre-cluster the records into many small sub-clusters. Then, cluster the sub-clusters from the

pre-cluster step into the desired number of clusters. If the desired number of clusters is unknown, the SPSS Two-Step Cluster Component will find the proper number of clusters automatically. The results gathered from running a simulation are consistently accurate and scalable in performance. The simulation also shows that the automatic procedure of finding the number of clusters works remarkably well and fast. By clustering, you can group data so that records within a group are similar.

Study Area

Hi-Tech city, Madapur area is one of the leading Information Technology, Engineering, Health informatics and Bioinformatics hubs of India situated in Hyderabad, Telangana. Cyber Towers, L&T Infocity, HICC, Mindspace IT Park, Ascendas IT Park, RMZ Futura IT Park, Tech Mahindra Campuses, Microsoft Hyderabad Campus, Facebook Hyderabad, The TCS Deccan Park Campus, IIIT Hyderabad, Hardware Park etc. offices are in this area. The area has emerged as a symbolic heart of Cosmopolitan Hyderabad. The study area comprises of varieties of transportation facilities, such as city bus, MMTS, and Metro Rail under construction. Thus, the area has diversity of transit services which enables generation of multiple TODs with variety of nodes in the area. The area of 45.73 Sq. km is considered for analysis.

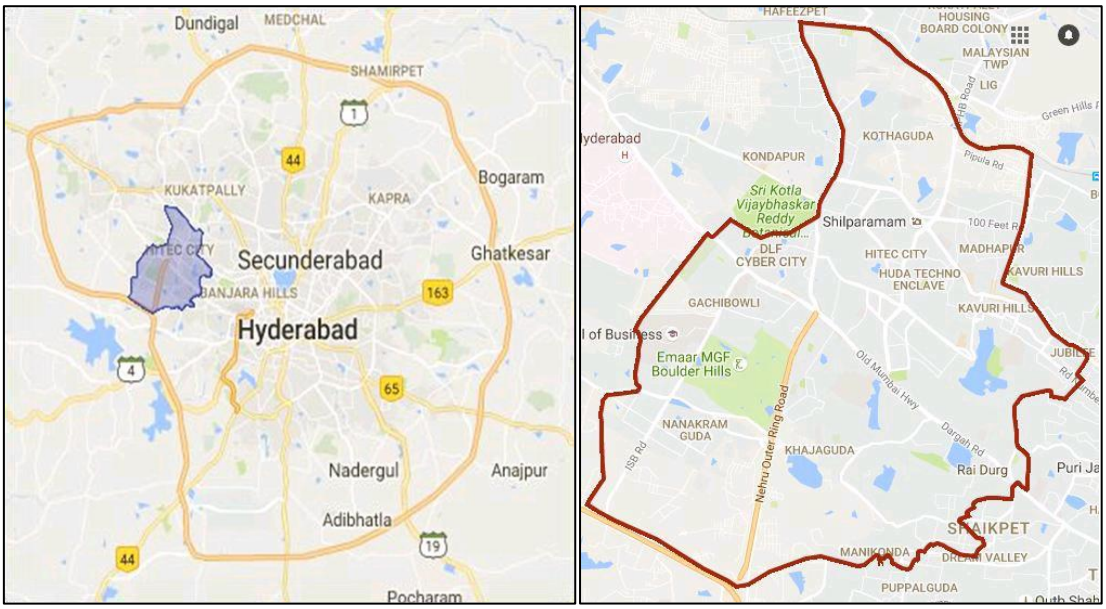


Figure 3: Google map showing the selected study area in Hyderabad.

Figure 4 shows 20 TODs considered for clustering process. In which 13 TODs are falling on Metro line, 5 TODs are of City bus oriented and 2 are of local MMTS station's one.

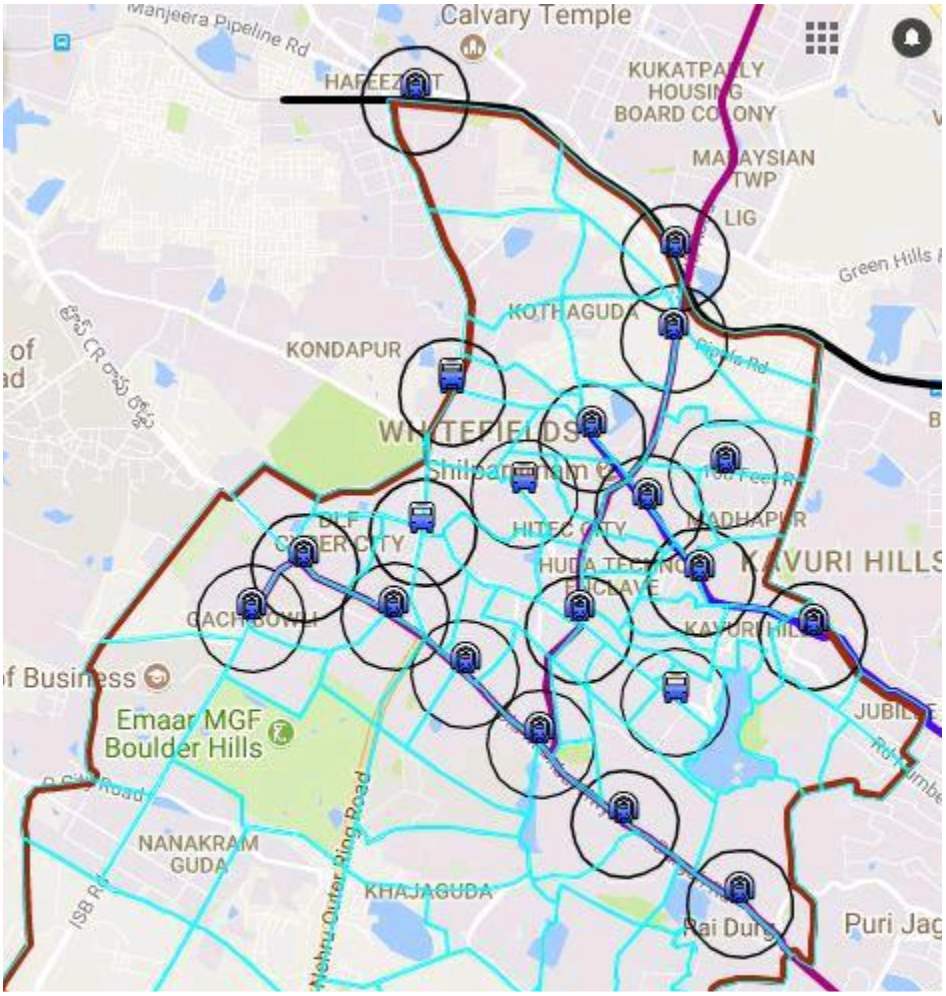


Figure 4: TODs in study area.

Data Collection and Analysis

Primary and secondary data collected for this study. Primary data collected from the field is detailed land use and detailed road inventory. Secondary data collected from the HMDA (Hyderabad Metropolitan Development Authority) like population and employment details etc. Parameters finalized to do analysis are NMT facility indicator (NMTI), Floor Space Index (FSI) [7], Land use mix index (MI), Open land availability Index (OI) and Transport land Index (TI). Table 1 shows the final input data for two-step clustering procedure.

Table 1: List of TODs with data

TOD ID	TOD Name	NMTI	FSI	MI	OI	TI
1	Madhapur Metro Station	0.08	2.05	0.76	0.38	0.25
2	COD Metro Station	0.00	2.02	0.66	0.27	0.20
3	Hi-Tec City Metro Station	0.25	2.75	0.77	0.39	0.15
4	Shilparamam Metro Station	0.28	2.49	0.76	0.73	0.11
5	WS Colony Metro Station	0.65	1.49	0.67	0.91	0.10
6	Mind Space Metro Station	0.27	3.21	0.49	0.42	0.17
7	Gachibowli Metro Station	0.35	2.02	0.44	0.64	0.12
8	IIIT Metro Station	0.25	2.12	0.73	0.35	0.14
9	Indra Nagar Metro Station	0.00	2.16	0.46	0.34	0.25
10	Telecom Nagar Metro Station	0.10	2.33	0.63	0.48	0.13
11	Mistry College Metro Station	0.05	2.93	0.54	0.40	0.18

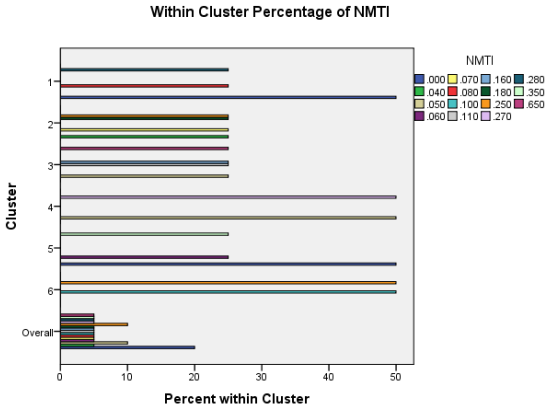
12	Khajaguda X Road Metro Station	0.00	1.37	0.47	0.73	0.12
13	Raidurgam Metro Station	0.00	1.29	0.50	0.53	0.09
14	VBIT Bus Stop	0.16	4.65	0.53	0.40	0.10
15	Siddiq Nagar Bus Stop	0.18	2.32	0.60	0.20	0.16
16	Chota Anjaiah Nagar Bus Stop	0.06	2.58	0.59	0.33	0.22
17	Chandra Naik Bus Stop	0.07	2.15	0.60	0.39	0.23
18	Kothaguda Bus Stop	0.04	3.27	0.52	0.41	0.15
19	Hi-Tec City MMTS Station	0.11	1.63	0.56	0.58	0.32
20	Hafeezpet MMTS Station	0.05	1.06	0.49	0.21	0.26

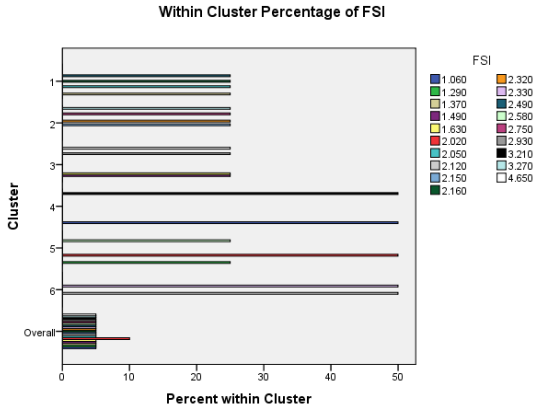
SPSS software is used for clustering. The output obtained is as given in Table 2. Total 6 number of clusters are formed based on given five parameters. In which four clusters are of equal share of having 20% of TODs and two clusters are of 10% each.

Table 2: Two-step cluster output table

Cluster Distribution				
		No of TODs	% of Combined	% of Total
Cluster	1	4	20.00%	20.00%
	2	4	20.00%	20.00%
	3	4	20.00%	20.00%
	4	2	10.00%	10.00%
	5	4	20.00%	20.00%
	6	2	10.00%	10.00%
	Combined	20	100.00%	100.00%
Total		20		100.00%

A brief analysis showing in Figure 5, that with each variable how the percentage of cluster distribution along with the values are presented.





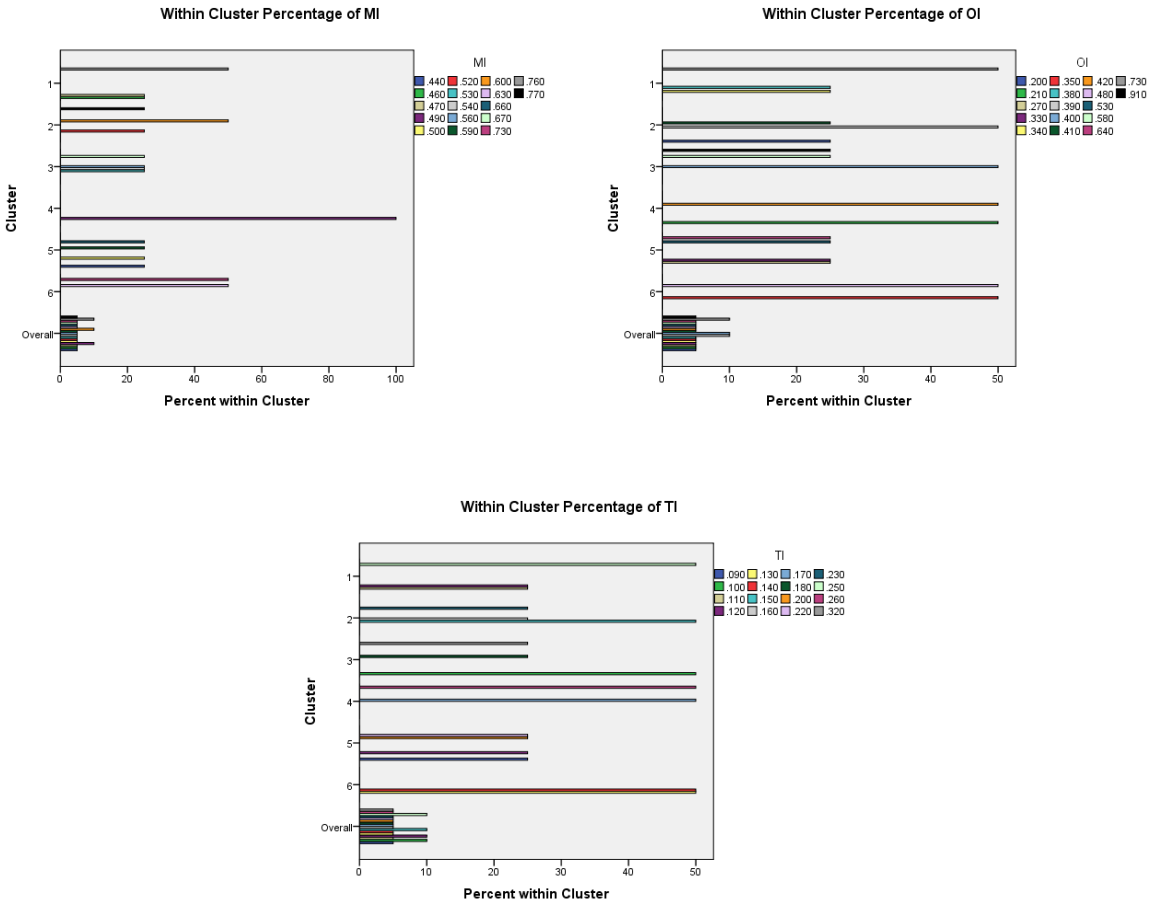


Figure 5: Showing percentages of each varible within cluster

Table 3 show that final list of clusters along with the list of TODs. A total of 6 clusters are formed with the similar characteristics. This typology data is also used for immediate understanding of lack in design facilities and to set the bench marks for the future reference.

Table 3: List of TODs with Proposed typology

Clusters	TOD ID	TOD Name
C-1	1	Madhapur Metro Station
	4	Shilparamam Metro Station
	9	Indra Nagar Metro Station
	12	Khajaguda X Road Metro Station
C-2	3	Hi-Tec City Metro Station
	15	Siddiq Nagar Bus Stop
	17	Chandra Naik Bus Stop
	18	Kothaguda Bus Stop

C-3	5	WS Colony Metro Station
	11	Mistry College Metro Station
	14	VBIT Bus Stop
	19	Hi-Tec City MMTS Station
C-4	6	Mind Space Metro Station
	20	Hafeezpet MMTS Station
C-5	2	COD Metro Station
	7	Gachibowli Metro Station
	13	Raidurgam Metro Station
	16	Chota Anjaiah Nagar Bus Stop
C-6	8	IIIT Metro Station
	10	Telecom Nagar Metro Station

Summary and Conclusions

Transit Oriented Development Typology provides a framework for understanding what types of implementation strategies are needed, and for prioritization and understanding of these needs at a glance. It is observed that there are no specific parameters for deriving typology in an area on universal acceptance. Different authors of different countries considered different parameters for their studies based on the context. As the more number of relevant parameters results in the completeness of TOD typology.

20 TOD areas are identified on the diversity of transit nodes such as City Bus Stops, Metro Stations, MMTS Stations in Gachibowli Financial District. The success of any TOD depends on the balance between node and place. The study has gone in detail aspects covering parameters of Node, Built Environmental and Network parameters. The Hi-tech city and its influence area is a rapidly developing area having compact development, lot of employment, and observed vast vacant land is available in and around. Hence a proper co-ordination measures results in compact, mixed land use development in a short time.

For deriving the Typology five indices were developed, those are NMT facility indicator (NMTI), Floor Space Index (FSI), Land use mix index (MI), Open land availability Index (OI) and Transport land Index (TI). Two-step clustering technique is used for clustering of these 20 TODs resulted in formation of 6 Clusters such as C–1, C–2, C–3, C–4, C–5 and C–6.

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