Contributions of Metro Rail Projects in the Urban Dynamics of Indian Metro Cities: Case Study of Chennai and Bangalore

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1. Introduction

Most Indian metropolitan cities have histories encompassing many centuries of growth, and their complex morphogenetic characteristics go hand in hand with age. Though the city centers predominantly comprise narrow roads, they support bustling economic activities. With the economic boom added by car based sub-urbanization, Indian cities have spread over vast unmanageable areas. Beyond a certain stage or urban boundary, long distance commuting becomes costly, and associated public transport issues of congestion, travel delay etc. dominate. The city centre with its narrow streets built before the invention of the car and bus currently reduces accessibility and attraction, encouraging stand-still traffic across all arterials, and becomes sensitive and uneconomical in terms of road widening. Mass Rail Transport (Transit) Systems (MRTS) solve many of the issues raised in Asian contexts, and support the development of low-carbon, park and ride, walk-able neighborhoods. Of course many Indian cities were planned much earlier than metro rail concepts and possibilities were realized, therefore, much of the anticipated developmental impact of the metro rail projects are not easily integrated into current Master Plans. Meanwhile, the lack of directed and regulated metro rail projects disadvantages effective city growth, especially limiting the city's function and structure. This study attempts to conceptualize better development scenarios in Chennai and Bangalore. It is hypothesized that the introduction of metro rail is likely to change each city's land use pattern and intensity of use, thereby altering overall city structure.

The constitution of India lists 'Urban Planning', and the implementation of urban planning projects as a 'State' subject. Therefore, the efforts of the Government of India towards Urban Planning projects are limited to an advisory role, and to some extent in partly financing these projects. It is left to the State to use these finances or not. Therefore, in India, each State's metropolitan planning stands apart at varying levels of sophistication. This is also the case for urban transport policy and implementation projects. Way back in 2006, National Urban Transport Policy (NUTP) had listed such policies to reduce pollution, promote cleaner technologies, encourage greater use of public transport as the policies of concern to Indian urban transport development, apart from other measures (Ramachandran, 2012). However, it took almost a decade before these policies percolated to state level, and even then few of the metropolitan cities of India initiated metro rail based services.

2. Metro Rail in Chennai City

Chennai (earlier known as Madras) is the capital of the State of Tamil Nadu of the Union of India. Chennai is the 31st largest city of the world having a population of about 9 million in 2012 (Demographia, 2012). Chennai city is also the 4th largest city of India and has the surfaced based rail system covering a limited service area. These surface based rail systems are called Electric Multiple Units (EMUs), also known as the city “local train” to serve the connection between the city and the sub-urban area. It was introduced in Mumbai in 1928, followed by Chennai in 1931. The demand of trips surpasses the existing road and surfaced based rail system. A Comprehensive Traffic and Transportation (CTT) carried indicated that the city needs high capacity metro rail systems (Sekar and Karthigeyan, 2010). Having estimated about 11 million total trips per day in 2011, with ever growing private vehicle use, and growing constraints on augmenting additional capacity with the existing road network, there is a felt need to promote the metro rail system (CMDA, 2008). Followed by the CTT study, and the Detailed Project Report (DPR) prepared by the Chennai Metro Rail Ltd (CMRL) for the six major corridors depicted, Peak Hour Peak Direction Trip (PHPDT) for these corridors exceed 15000. Among this, two corridors have been considered for the metro rail project (Fig 2.1).

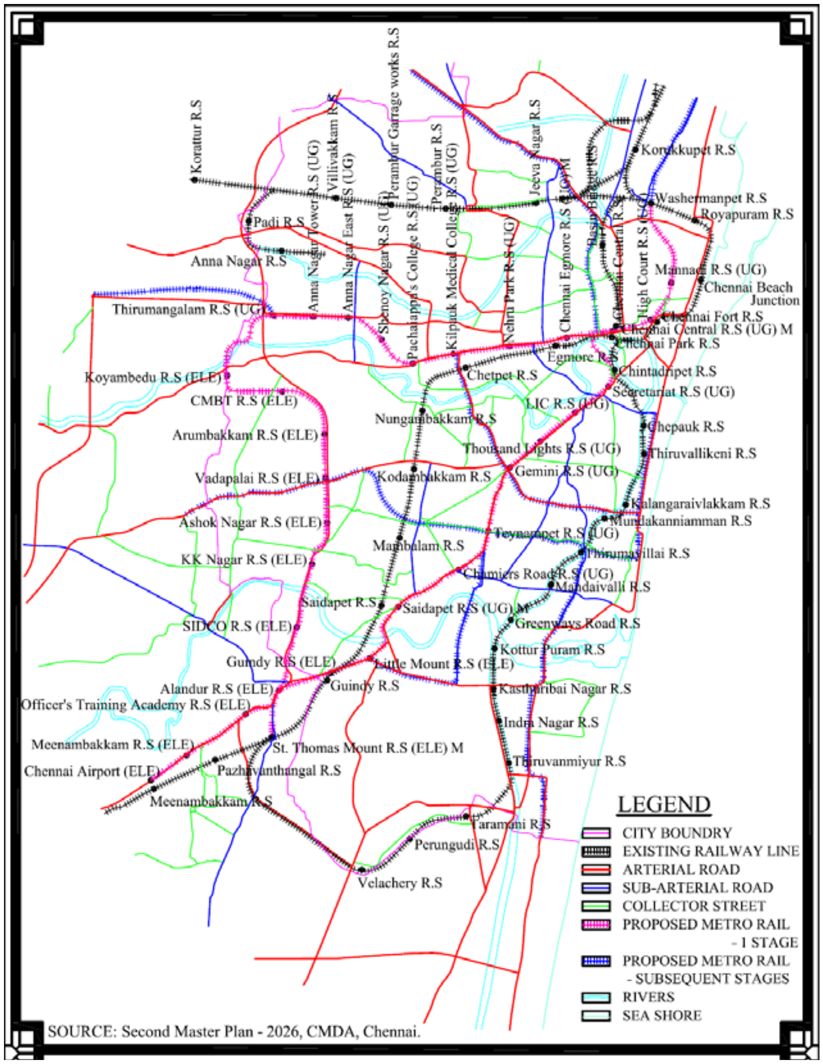


Fig 2.1. Metro Rail Corridors- Phase I in Chennai. Source: Sekar and Karthigeyan, 2010.

Followed by this, a Phase II is also under consideration. Recently, the state government annexed many of the suburban areas within the main city, expanding the city area from 176 sq km to 256 sq km. Having found Phase I and Phase II are not enough to cover the city growth requirements, the state government identified two main corridors aimed to connect the annexed suburbs by a mono rail system. However, this study considers only the old city area and its population, as the metro service covers only the city part.

Corridor 1: Washermanpet to Chennai Airport.

Corridor 2: Chennai Central to St. Thomas mounts

Both these corridors cover about 45 kilometers, with nearly half the distance underground, remaining major portions are elevated, and about 2 kilometers are at-grade level, with an estimated cost of Rs. 1500 million (about US $300 million in 2008). The implementation of the project is on different stages, as shown below (Table 2.1).

DESCRIPTION	UNDERGROUND (KM)	ELEVATED (KM)	AT GRADE (KM)	TOTAL (KM)
Corridor – 1	13.877	8.795	0.413	23.085
Corridor – 2	9.695	11.406	0.860	21.961
Total	**23.572**	**20.201**	**1.273**	**45.046**

Table 2.1. Phase I Metro Rail corridors in Chennai. Source: DMRC, 2008.

3. Metro Rail in Bangalore City

Bangalore city is the capital of the state of Karnataka of the union of India. It recorded a population of about 9 million in 2012 and is the 33rd largest city of the world (Demographia, 2012). Bangalore city, the fifth largest in India, also houses many of the important Information Technology companies and is nicknamed the Silicon Valley of India. In 1994, the state government of Karnataka had incorporated a company called, 'Bangalore Mass Rapid Transit Limited' (BMRTS) to implement a Mass Rapid System. It identified an elevated Light Rail Train (LRT) on 6 corridors. For various reasons this project was abandoned.

In the year 2002, the Karnataka government discussed details with the Delhi Metro Rail Corporation (DMRC) another incorporated company, for preparation of detailed project report (DPR). As part of this in phase I, it identified two major corridors of East-West (18 kilometers) and North – South (14.9 kilometers) with 32 stations.

For all analytical purposes within this paper, the city portion is only considered as the metro rail services cover. The second phase of the route alignment is under progress and details of this are not officially available albeit likely to cover a greater length than phase I. The phase I extends only about 30 km in length and serves an important function of connecting the city center with its suburbs. The cost is estimated around Rs.600 million (US$120 million).

4. Metro Rail – Moving towards High Speed Transit and Low Carbon Livability

Wendell Cox, who served as the Los Angeles County Transportation Commission states, “The test of rail’s success is not the number of people on the train, but the number of cars removed from the road” and “Transits greatest potential for reducing traffic congestion is through attracting peak-hour commuters out of their automobiles” (Cox, 1998). Accordingly, this study focuses on a model shift (private ownership/ automobiles to mass public transportation), and lowering congestion to alleviate financial strains, though DMRC has shown the profitable operation of Delhi Metro right from the commencement of its operation (Ramachandran, 2012). A successful model shift from private automobiles to public transport, like metro rail would have a catalytic effect on lowering carbon emissions and would free the carriageway of roads, which in turn would increase the speed of the remaining traffic, reducing overall emission levels. Going by this standard, a road based mass transport system would be optimal in those corridors, having PHPDT not exceeding 10,000. For corridors with PHPDT exceeding 20,000, the provision of rail based systems is most optimal. When traffic density exceeds 40,000, heavy capacity mass transit systems become necessary (Sreedharan, 2003).

4.1. Phase I: Metro Rail in Chennai

The DPR on Chennai Metro Rail Project estimated that the per capita trips would increase from 1.32 (in the year 2004) to an estimated 1.6 (in the year 2016), and 1.65 (in the year 2026). This translates to 13.31 million trips per day in the year 2011, and this will rise to 20.76 million trips per day in the year 2026. This speaks to the volume that will need to be handled, within the context of the constrained network of roads, and the sensitivity associated with road widenings. With barley 25 percent of the total trips performed by the existing rail system (EMU) and 75 per cent by road (all modes), the projected trips of 20.76 million in 2026 is unimaginable, unless reversing the model spilt of about 75 percent by rail and 25 percent by road (DMRC 2008). The DPR estimates the reduction of daily trips by 28,000 by 2024 because of model shift in all categories, from private to rail. It is estimated that the metro rail would relieve about 2000 buses and 40,000 cars by 2024, apart from relieving 0.2 million two wheelers.

4.2 Phase I: Metro Rail in Bangalore

Bangalore's vehicle population has grown from 1.17 million in 1981, to 1.56 million in 2011, and it is estimated to reach 2 million in the year 2012 (Suresha, 2012). This large vehicle population is causing extreme congestion on this city's roads. Side effects include slower average speeds, fuel wastage, heavy air pollution and a continued rise in the levels of road accidents. In Bangalore, on average 21 road accidents occur every day, resulting in death and injury for many involved. Table 4.1 depicts the distribution of trips by mode and the reasons for these trips (DMRC 2003). It specifies that about 50 percent of the trips are by bus, remaining by car and two wheelers, including a thin distribution by other modes. Though 50 percent of the trips are performed by bus, increased congestion and narrow roads of older parts of the city compels one to look for reliable MRTS. Though the estimated model shift for Bangalore is not available, going by Chennai estimates, it could be expected to relieve a minimum of 25 percent of present day trips. With the proposed Phase II, the estimated model shift of 1.6 million vehicles (of all modes), including the car alone i.e. 0.19 million vehicles (Suresha, 2012).

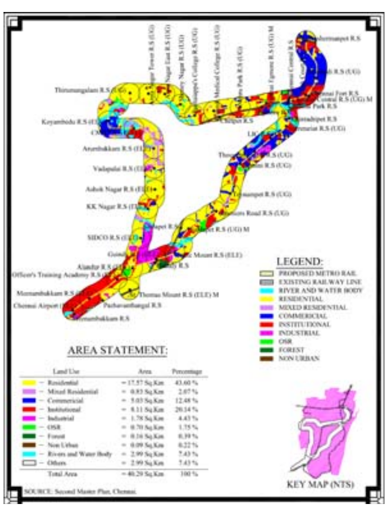
	WORK	EDUCATION	OTHERS	NHB	RETURN	TOTAL
CAR	90607	7789	36468	2514	133484	270862
TWO WHEELER	704629	84535	122507	7028	887952	1806651
AUTO RICKSHAW	133060	17084	51835	15008	126166	343153
BUS	586870	281700	318628	39462	1207253	2433913
BYCYCLE	26476	21151	2105	700	49285	99717
OTHERS	4774	3190	2236	863	10872	21935
TOTAL	1546416	415449	533779	65575	2415012	4976231

Table 4.1 Distribution of trips by mode and purpose (excluding walking and pedestrian trips) in Bangalore 2003. Source DMRC, 2003.

If the above figures are to be considered, the reduction on emission levels in Chennai and Bangalore would enable cumulative benefits, moving towards much valued ideals of low carbon cities. If these vehicles are reduced from the roads, this would compare to a magic "blood thinner" for one, preventing blood clots and reducing the risk of mortality through heart attacks within the city's circulation network.

4.3 *The Metro Rail and Associated Land Use Changes/Implications*

A combination of high population growth rate and economic boom in India encourages an uncontrolled fast paced expansion. An increase in the number of private automobiles on road unfortunately widens the commuter hinterland. The New Urbanism concept of urban planning aimed to introduce mixed land uses, compact developments, and high-rise buildings into city centers, and to achieve this, reliable, fast and frequent high capacity rail systems must be established (Cox, 2011). Tokyo has one of the largest Central Business District (CBD) of the world with 3 million jobs, and this roughly translates to 58600 jobs per sq km. If a high capacity rail system is placed over time in a city with proper connectivity, a very high density of CBD is likely to develop (Dinish, 1990). For example, in India, Mumbai is an example of how the existence of rail system has resulted in south Mumbai developing to become high rise, and eventually supporting it's very high density CBD. It is in this market mechanism, when competition becomes high, and space becomes costly, that buildings develop and become high rise in nature. However, in the cases of Chennai and Bangalore the purpose of introducing metro rail is to de-congest the major arterials, enabling planned compact developments. This is clearly evident in the Master Plans prepared for these two cities. A revised land use plan prepared capitalizes upon the benefits of the metro rail system through the introduction of a higher Floor Space Index (FSI) in the corridors. Therefore, this clearly uses the market on its own, which may not lead to desirable development from the view point of urban planning. To analyze the land use implications of potential metro rail projects, a buffer of 500 meter on either side of the metro rail alignment is considered along the proposed metro rail line of Chennai and Bangalore's phase I project. This being most comfortable walking distance, treated as the direct influence area of metro rail (Fig 4.1 and Fig 4.2).



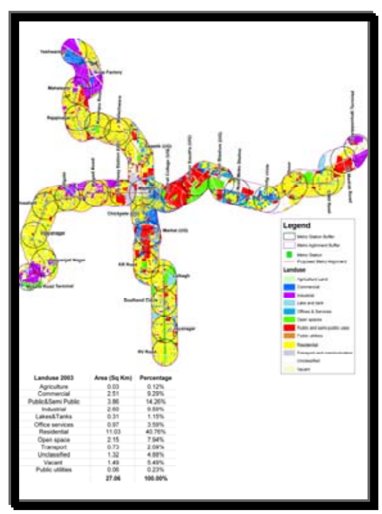
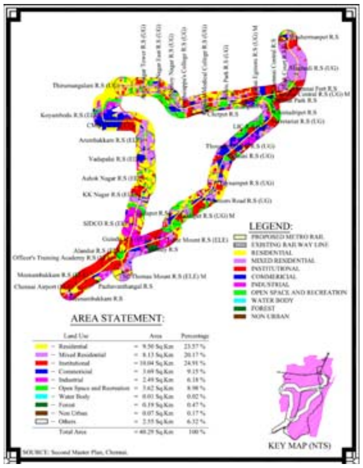


Fig 4.1 and Fig 4.2 Existing land use within 500 m of the corridors of Chennai and Bangalore metro rail lines (Source: Sekar and Karthigeyan, 2010 and Nanjegowda,2011).

These figures represent actual land use in Chennai for 2006, and in Bangalore for the year 2003. Whereas the Figures Fig. 4.3 and Fig. 4.4 indicate the proposed land use for the same buffer area within 500 meters along the metro rail alignment in Chennai (for the year 2026) and Bangalore (in the year 2015). These proposed land use plans are done earlier than the metro rail proposals. Comparative analysis of actual land use to that of proposed land use points to an increasing mixed residential activity and a marginal increase of institutional use. Though the 500 meter influence area covers about 20 percent of Chennai's city area and 13 percent for Bangalore's city area, most of the important commercial areas including the city centre are within this zone, and therefore draw more prominence.



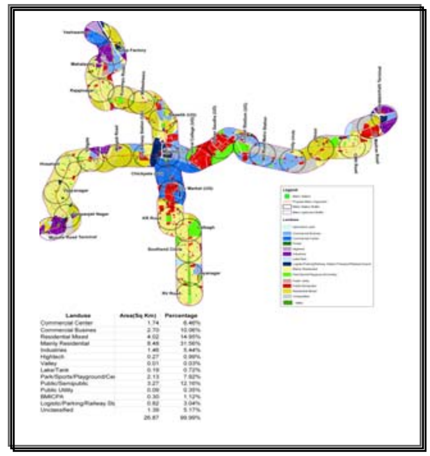


Fig 4.3 and 4.4. Proposed land use within 500m of the corridors of Chennai and Bangalore (Source: Sekar and Karthigeyan, 2010 and Nanjegowda, 2011).

It has to be pointed that this projection is without consideration of the proposed metro rail project. Taking a clue from the aggressive development after the introduction rail based mass transit systems in the Mumbai of India i.e. Tokyo, it is expected that the land use shift would firmly tilt towards more commercial, mixed residential and institutional uses, apart from higher densification. To understand the dynamic nature of land use and it's re-densification implications, a simulated analysis of a metro rail station and its immediate environment is included in the next part of this paper. The land use changes are not without population interaction. Therefore, an analysis of the population that would be under the direct influence of this is undertaken, considering the existing density. It is estimated, that in Chennai, around one million people (about twenty percent of the city population) will be within this direct influence zone (Fig 4.5).

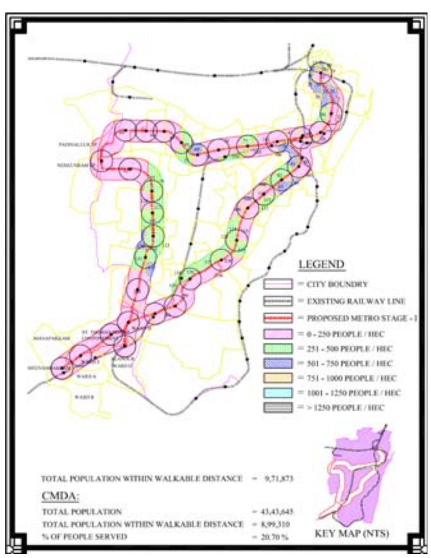


Fig. 4.5 Population within the Direct Influence Zone, Chennai (Sekar and Karthigeyan, 2010).

In Bangalore, phase I extends only 33 km, and its direct influential population is estimated to be 0.7 million, which represents about 15 percent of the total population of the city. With the inclusion of phase II and phase III, the influence area and the population coverage would touch a new height encompassing sixty five percent of the city's population. This part of the analysis clearly indicates that introducing the metro rail system will indicate a physical development shift in land use and re-densification, with a major shift from primary residential to commercial and institutional areas, with high rise buildings.

5. Envisaged Development in Impact Zones

The above analysis hypothesized that there would be a shift in land use, with re-densification along the metro rail alignment. It is not stated that all the proposed 31 metro stations in Bangalore are likely to have the same influence on physical development. To progress this logical analysis, two set of parameters are employed, classifying the stations on impact level (Sekar S P and Karthigeyan 2009). The primary parameters of influences include road width, communication channel, inter model transit facility, population density, available shopping frontage and road inter-junctions, each carry a weightage of 5. The secondary parameters are high visibility from the highway, condition of traffic flow, nearness to a major facility, closeness to workplace, visual quality, environmental characteristics and local labor supply, with each carrying a weightage of 3. Based on the point score, the stations are classified into four categories. (a)the stations which will undergo immediate change, (b)intermediate change, (c)minimal change, and, (d)no change in the next 20 years. The M.G. Road metro station which scored highest (55 out of 100) is selected for further analysis (Nanjegowda, 2011).

NAME OF THE STATION: MG ROAD STATION			
Primary Parameter	Weight Age	Scored	Reason
Road width	5	4	It varies between 25m-35m
Communication channel -by road -by 200 m -by 300 m -by 500 m	5 3 2	5	
Intermodal transit – by train -by 200 m -by 300 m -by 500 m	5 3 2		
Intermodal transit – by bus -by 200 m -by 300 m -by 500 m	5 3 2	5	
Intersection of road at 500m radius Straight T-junction Staggered	2 3 5	5	
Population density	5	1	About 7000peoples within walk able distance
Maximum shopping frontage	5	5	Mg road and Brigade roads
Secondary Parameters :			
High visibility from highway	3	3	Wide straight road
Conditions of traffic flow	3		Traffic jam slow moving

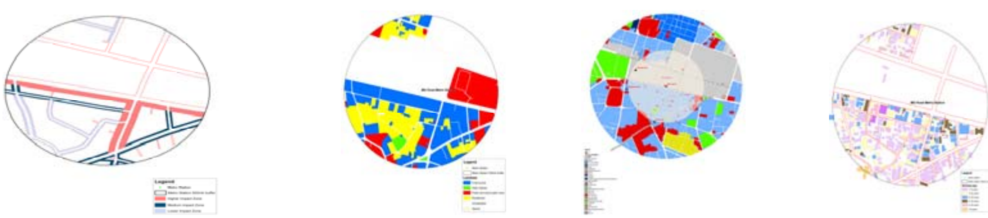
Nearby facilities -500m radius School College Hospital	3 3 3	3 3	Military school St Joseph college
Major recreational facilities - 500m radius Park/playground Multiplex Big bazaar Market / fairs Religious Places	3 3 3 3 3	3 3 3 3 3	Manickshaw parade ground, Central mall Utility building, Brigade and church street shopping areas
Closer to work place	3	2	Mg road nearby residential areas
Social aggregation of houses	3	-	Not found here
Visual quality & Environmental character	3 3	3 3	Mg road Boulevard and smooth flow of traffic and greenery makes looks good
Local labour market	3	-	No slums
Anticipated future development	5	5	Commercial building under construction
Total	**100**	**55**	

The direct influence zones of the M G Road station are classified into three impact zones:

(a) High Impact Zone:
This zone receives the maximum impact, all old buildings (30 to 40 years of age) are assumed to be chosen for the first level of re-development within 5 years (2015-2020);

(b) Medium Impact Zone:
This zone can be accessible from the station only after crossing the higher impact zone. This zone is assumed to be gradually converted from primary residential to mixed residential use. This zone will start redevelopment only when the major potential of high impact zones are mostly used.

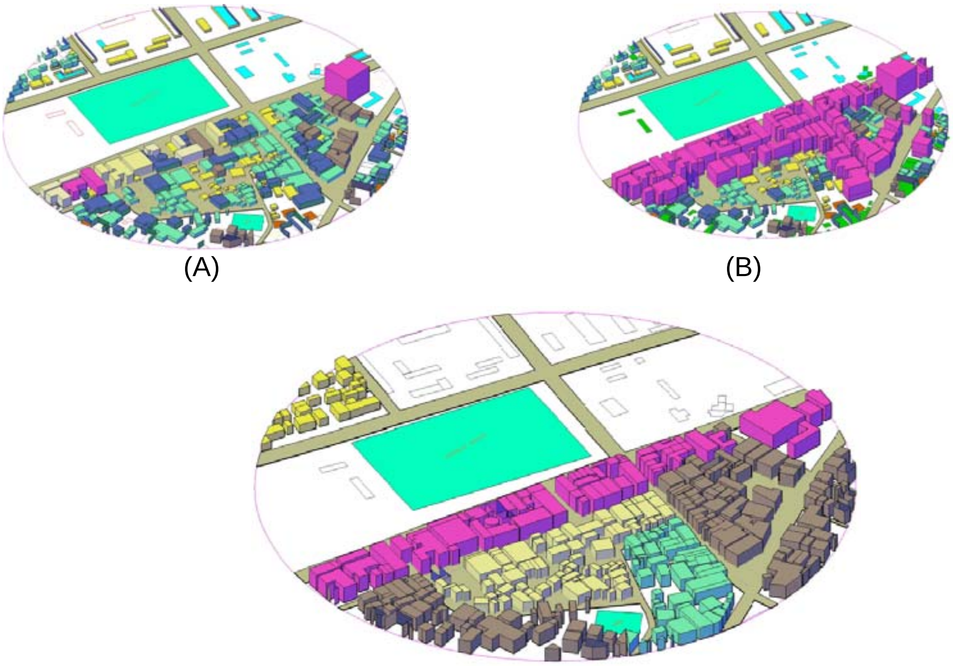
(c) Low Impact Zone:
This zone is located at the far end of the station side. This zone would take at least ten years to pick-up re-development. This zone is likely to retain the primary residential use as seen today, but it will have a higher intensity of development (Fig 5.1 (A)).



(A) (B) (C) (D)

Fig 5.1. Age of the Buildings. MG Road Station (A) Impact Zone (B) Existing Land use (C) Proposed Land use and (D). Source: Nanjegowda, 2011.

To understand them better, a three step scenario is worked out, in scenario one, the existing physical structure of the M G Road station and its surrounding as seen today is shown (Fig 5.1. (A)). In the next step, simulated development after ten years and twenty years are shown in Fig 5.1 (B) and Fig 5.1. (C). It is estimated that at the end of twenty years, this area would have 16 million sq m of commercial use, 0.4 million sq m of residential area with a residential population of 10,000, and floating shoppers of 0.3 millions. Corresponding infrastructure requirement are also computed. To glimpse the pressure of this development, it is estimated it may need about 7.5 million liters of water per day and about 5000 kg of solid waste would need to be attended to.



(A) (B)

(C)

Fig 5.2. MG Road Metro Station. (A) Existing structure, (B) After 10 years, (C) After 20 years Source: Nanjegowda, 2011.

6. Conclusions

It is seen that the road based transport systems in the chosen cities can manage until the city reaches a one million population. At this stage, the Planner or Manager needs to implement a high capacity, dependable, efficient rail based system. Where the corridor's PHPDT exceeds 10,000, the road based system will face delay, congestion etc. and, when PHPDT exceeds 40,000 that corridor will require a very high capacity Mass Transit System. Introducing Metro Rail Systems in mega cities achieves low carbon targets and steers high-speed growth, offering a desirable and preferred mass transit system.

The performance of the metro would also alter, at varying levels, the structure of the city by encouraging compact, high density city centres and by replacing residential uses with commercial and institutional uses. The presented simulated impact confirms this and serves as a challenge for Planners who can harness the opportunities presented by metro rail projects, capitalizing on these to ensure meaningful integration, and therefore enabling desired development patterns.

References

CMDA (2008), Second Master Plan for Chennai Metropolitan Area 2026, Volume III, Sectoral Background, Chennai Metropolitan Development Authority (CMDA), Chennai, pp. 107-132.

Cox, W. (1998), “New Urban Rail in America: Miniscule Impact on Traffic Congestion”, The Public Purpose, Number 23, September.

Cox, W. (2011), Suburban ‘End Times’ Reality Check, The Heartland Institute, Chicago, viewed on 3 June 2012, available at ttp://news.heartland.org/newspaper-article/2011/10/11/suburban-end-times-reality-check.

Demographia (2012), World Urban Areas (World Agglomerations), 8th Annual Edition: Version 2, viewed on 03/7/2012, available at http://www.demographia.com/db-worldua.pdf.

Dinesh, M. (1990), “Public Transportation Systems for Urban Areas A Brief Review”, Transportation Research and Injury Prevention Program, Indian Institute of Technology, New Delhi.

DMRC (2003), Detailed Project Report (DPR) – Bangalore Metro Rail Project (Phase I) Delhi Metro Rail Corporation, New Delhi.

DMRC (2008), Updated Detailed Project Report (DPR) – Chennai Metro Rail Project, Delhi Metro Rail Corporation, New Delhi.

Nanjegowda, N. M. (2011), A study on the Development trends along proposed Bangalore Metro Rail Corridor, Un-published M. Plan Thesis, Department of Planning, School of Architecture and Planning, Anna University, Chennai.

Ramachandran, M. (2012), Metro Rail Projects in India, A study in Project Planning, Oxford University Press, New Delhi.

Sekar, S. P., and Karthigeyan, D. (2010), Chennai Metro – Will it be Boon for Development of Chennai City Urban Transport Journal, Institute of Urban Transport (India), Vol. 9. No 2. December, pp. 54 - 68.

Sekar, S. P. and Karthigeyan, D. (2009), A study on the Development Trends along the Proposed Chennai Metro Rail Corridor, Institute of Town Planners Journal, Vol. 6, No.4, pp. 41-60.

Sreedharan, E. (2003), Need For Urban Mass Rapid Transport System For Our Cities Transportation, Delhi Metro Rail Corporation, New Delhi, 17th April, 2003.

Suresha, H. (2012), A study on Strategic Route Plan of Phase II for Bangalore Metro Rail, Unpublished M. Plan Thesis, Department of Planning, School of Architecture and Planning, Anna University, Chennai.