Editorial

In this Issue of the Journal, the first paper on 'Institutional Greens : Illustrations from the City of Mysore, India' jointly authored by Dr. Krishne Gowda, Prof. Sridhara M. V. and Dr. B. Mahendra; it is underlined that from the point of view of urban green endowments, Mysore City is relatively rich, although much needs to be achieved. Contributions to these endowments are substantially from large and long standing institutions, generally maintained with government munificence; members of the general public and the private sector. A study of these green contributions is the principal objective of this paper. An attempt has been made to describe the green elements maintained by some of the well known Mysore Institutions, their rarity hugeness and variety. It has been suggested that coordination among these institutions regarding their respective green managements and experiences will make Mysore further upgraded. In the process, technology, calibration and measurements of eco-upgradation can be developed and may become a model for adaptation in the general context of urban green management.

The 2nd paper on 'Planning New Bus Routes for Un-Served Areas - A Case Study of Chennai' jointly written by P. Revathy, Dr. S. Lakshmi, and K. P. Subramaniam; it is argued that public transportation network caters to the needs of all sections of the society irrespective of their economic status. This article explains the process of identifying the areas, which are not served by public transportation through Stop Coverage Ratio Index Method, a different technique to serve those un-served areas using Network analysis.

In the 3rd paper on 'Livability Perception in Residential Areasof India: Comparative Analysis of Planners and Inhabitants Outlook' Rama U Pandey, Dr. Yogesh K Garg, and Dr. Alka Bharat; aims to identify the gap between understandings of livability performance parameters for evaluating livability of residential areas in the upcoming cities of India. For the evaluation through reconnaissance survey, residential areas of Bhopal were broadly divided through timeline in six categories viz. the areas that were more than 50 years old; the areas that were 40 to 50 years old; 30 to 40 years old; 20 to 30 years old; 10 to 20 years old and residential areas less than 10 years old. Randomly selected 628 inhabitants from 35 residential colonies were asked to express their opinion on importance of each livability indicators and the ratings of Inhabitant's perception for successful livability performance were then compared to identify appropriate livability indicators in Indian context.

The objective of the 4th paper written by A. Azhaginiyal and Dr. G. Umadevi on the theme 'Transport and Energy Interaction – A Systems Approach' is to study and appreciate the existing transport demand and supply in Chennai city; to procure data through inventory on energy requirement from transportation sector and to build a System Dynamics (SD) Model using STELLA to determine the energy requirement levels from the transport sector for the year 2026. When the existing growth trend was assumed to be continued over the horizon year it was found that the Public Transport sector contributed to only 18% of the total trips, whereas, the personalised modes contributed to about 80% of the trips with about 300% increase in fuel demand. A scenario of augmenting the public transportation and simultaneously restricting

the growth of personalized vehicles showed a substantial decrease of nearly 65% in energy consumption.

In the 5th paper on 'Delivery of Housing to Urban Poor through Partnerships: Review of Enabling Policies and Emerging Government Role' Dipti Parashar argued that a plethora of policies and emphasis does little for implementation which would be observed only when the government shifts its role from a 'zero-cost policy' making approach to being in the forefront in provision of housing through PPPs. Despite the debates against PPPs, fact remains that they have an inherent potential for housing provision as neither the Government nor the Private Sector can shoulder the responsibility by themselves alone. An enhanced role of the Government is crucial along with innovative approaches and appropriate models along with clear institutional support to meet the desired demand.

The 6th paper jointly written by Sumana Gupta and R. N. Datta on the theme 'Passenger Dispersal Plan for the Proposed East-West Mass Rapid Transit Corridor in East Kolkata' it is underlined that surface transport in metropolitan cities gets reoriented with the implementation of grade separated high speed Mass Rapid Transit System (MRTS) along specific corridors. To some extent the reoriented surface transport integrates with the MRTS to acts as feeder service. For making this integration harmonious and effective in east of Kolkata, this article presents dispersal plans for MRTS passengers along proposed east-west MRTS corridor. The attempt has been to plan for feeder bus routes, identification of suitable locations for park and ride facilities, locating foot over bridges and subways for uninterrupted pedestrian movement to and from the eight proposed MRTS stations in the east of Kolkata.

The 7th paper on the theme 'Core Area Demarcation specifically Planned to Decongest the City Traffic – A Case Study Dehradun City' written by Jugmohan Singh argues that after the creation of Uttarakhand State and declaring Dehradun as the interim capital in 2000, the city of Dehradun has developed manifolds. The city has grown at a pace where demand and supply ratio balance cannot be maintained in the city core area itself. The demand for parking, more road network, commercial area, flyovers, Traffic Control Device, BRT, and PRT system, etc, has increased and on the other hand the supply rate is minimal in nature. The congestion and the traffic jams in city core area have forced traffic to move at a snail's pace in the city area. This paper provides a frame work on how a specific activity can be shifted from city core area to a planned area in the city outskirts / city peripheral area to decrease traffic jam caused due to those activities.

Dr. Ashok Kumar,
Editor, ITPI Journal

Content

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Institutional Greens : Illustrations from the City of Mysore, India

Dr. Krishne Gowda, Prof. Sridhara M. V. and Dr. B. Mahendra

Abstract

From the point of view of urban green endowments, Mysore City is relatively rich, although much needs to be achieved. Contributions to these endowments are substantially from large and long standing institutions, generally maintained with government munificence; members of the general public and the private sector. A study of these green contributions is the principal objective of this paper. An attempt has been made to describe the green elements maintained by some of the well known Mysore Institutions, their rarity, hugeness and variety. It has been suggested that coordination among these institutions regarding their respective green managements and experiences will make Mysore further upgraded. In the process, technology, calibration and measurements of eco-upgradation can be developed and may become a model for adaptation in the general context of urban green management.

1. INTRODUCTION

Cities are already home for almost half the world's population. In the next thirty years, the contribution to the growth of population is expected to become confined to cities only. Since, the major features of cities are high and increasing population density, they become more and more vulnerable to ecological damage, particularly in view of the fact that cities constitute hardly 3 percent of the earth's land area. Further, because of this proportionate smallness, recording of land use patterns of cities is relatively more discernible, definite and less ambiguous.

Since, the beginnings of civilization, preservation and imaginative augmentation of green areas in urban centres are the cherished traditions. Well maintained green areas are the part of civilized living from ancient times, in India too this tradition is adhered to. In addition, trees and plants are often worshipped in various form on various occasions, as a part of Indian ritualistic religion. A practice is also groomed to raise forests by planting plants and trees, used frequently for religious rituals.

Greenery means not just fresh air, it also means aesthetics, beauty and taste. To capture these in a demarcated area is one of the main purposes of green

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spaces: Socially - greenery in a diverse landscape within the city can foster a sense of wellbeing, pleasantness, belonging and self-esteem; Economically - greenery is important to enrich environmental quality. It can also influence tourism wholesomely and promote employment activities. Income and inputs for living can be generated from lopping of tree branches, vermin-culture, and compost manure production; Educationally - it provides an opportunity for understanding and appreciation of nature and the need to conserve it; interest in ecological studies and research in environmental science may be promoted; and Conservation of wild life and natural open space can safeguard eco-assets re-establishing symbiotic links for future generations.

A green area has to create value, civic pride and improved quality of life for residents. The value of green spaces for human beings is not restricted to merely recreational functions. They also contribute substantially towards improving the general standards and patterns of life in the city. This contribution ranges from tangibly clean and healthful endowments to sound insulation and environmental purification (Gowda, K and Sridhara M. V. 1999, p. 3). The present study is limited to institutional greenery in the city of Mysore. The focus of this paper has been to highlight green development in the erstwhile princely Mysore and later, an assessment of the existing situation and suggesting the different ways of prospective development of institutional green. This is an empirical study based on personal visits.

Definitions - There are many areas which contribute greenery and openness to the city. Public and semi-public zones like universities, government offices, recreational places, schools and colleges and many other such campuses have significant green areas. Institutional greens are rather empirical observable; not so much as a definitional concept.

Functions of Green Areas - Trees and plants can actually clean the air of not just carbon dioxide, but also particulate pollutants, and noxious gases like sulphur dioxide (SO^2) emanating from burning of coal and combustion of petroleum products; ozone (O^3) and peroxyacetylnitrate (PAN) from the emissions of automobiles and industries and nitrogen oxides from automotive exhaust. In addition, trees can alleviate water pollution, noise, heat and light pollution too. Trees and shrubs, particularly when they are densely spread over significantly large areas, can contribute to prevent erosion of soil and increase fertility.

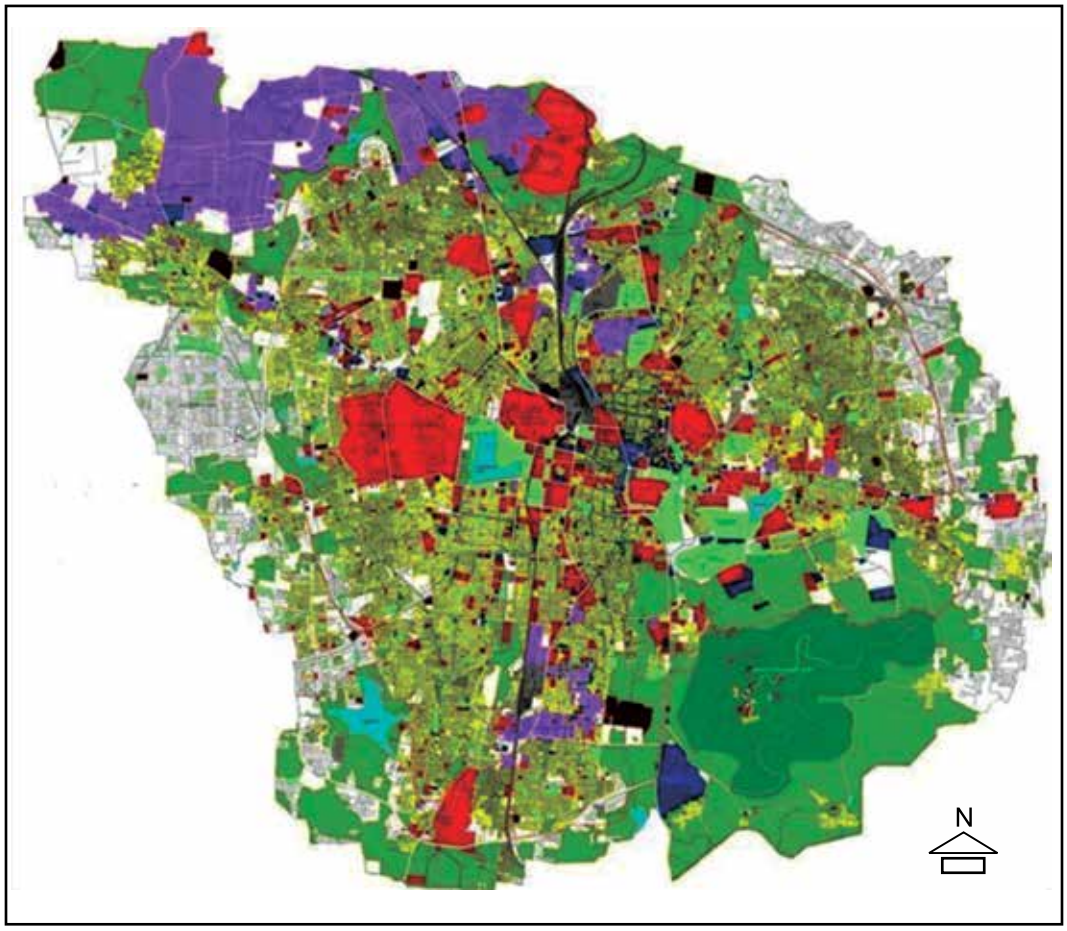
There are evidences that properly designed greenery in open space can create a better quality of life while providing a platform for long term economic benefits. It will create value, civic pride and improved quality of life for residents. The value of green and open spaces for human beings is not restricted to merely recreational functions.

Miscellaneous green areas are important from the point of new botanical and zoological gardens functioning as cultural and educational facilities and to horticultural shows as the events of regional significance. Aesthetics of trees, their flowering seasons, and the range of uses can be put to, medicinal value, planting techniques and tree-care are adding value to the urban living. The management of green spaces and benefits of caring for these trees, and the emphasis on education, training and publicity are very much needed and are all a part of urban up-gradation. Plant species that bear edible berries, fruits and nectar will have to be raised for attracting and providing the birds with suitable habitat. In the Indian context of economic development, maintenance of green areas contributes substantially towards the creation of employment.

2. THE STUDY AREA – MYSORE CITY

Mysore is known for its magnificent palaces and other majestic buildings, well laid out gardens and tree lined boulevards, shimmering silks and sandalwood; the 'City Royalty' always figures in the tourist's itinerary. The city has to

Fig. 1 : Existing Land Use Map of Mysore City (2009).



continue to grow in an orderly and environment friendly way and should be growing in aesthetic content – parks, public squares, pretty sidewalks, waterfront promenades and green concourses. Mysore is currently undergoing extensive and varied urban expansion. There is a need for a strategic vision involving adaptive and realistic tools, and new urban planning practices/methods.

Mysore is a planned city and the successive rulers and the Government of Mysore State since 1947 and even before have tried to maintain its original planned form. The adequate vacant land around the traditional buildings and mansions not only act as a lungs space but also provide beautiful environmental surroundings like gardens, parks, promenades, concourses and wooded greenery which enhance the overall beauty and charm of not only each buildings but also the city as a whole (Devanath 2005).

Mysore city is having more than a million population at present. Increase in population and unbridled urbanization of Mysore city has nibbled away green spaces as the city continues to expand horizontally. The Comprehensive Development Plan (CDP) for Mysore city has the Local Planning Area (LPA) of 233.13 sq km and conurbation area of 92.21 sq km (Fig. 1). The present Mysore - Nanjangud Local Planning Area covers 495.32 sq km of which the Mysore city conurbation covers 156.69 sq km (Fig. 2). the proposed Nanjangud town conurbation, 9.2 sq km and green belt, of 329.43 sq km (including the villages and the areas reserved for future expansions). While planning for new residential layouts, existing green spaces may get cleared up and give way to public and semi-public buildings or houses. Here, the need to add on new areas to the green

Fig. 2 : Local Planning Area, Mysore

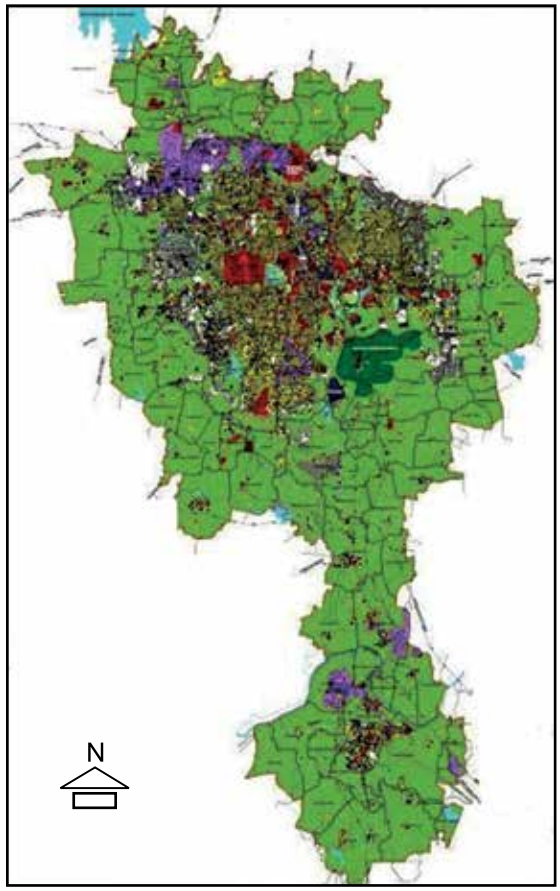


Fig. 3 : Satellite Image of Mysore city

Fig. 4 : Amba Vilas Palace, Mysore

Fig. 5 : Amba Vilas Palace, Mysore

Fig. 6 : Public Open Spaces – Clock Tower and Town Hall in Mysore CBD

belt gains importance. Even as the city grows, green belt also has to expand.

Satellite imagery of the city shows the wide natural valleys with greenery running through the various parts of the city (Fig. 3). On the southeast Chamundihill and its associated ecosystem offer a very huge green area. These valleys facilitate effective drainage and prevention of urban floods and are generally vast green area. These are the areas that need to be declared green areas and protected from adverse urban impact as they open up several eco-endangering economic prospects. It is important to adopt a network or integrated approach for conservation of green areas so that contiguous stretches can be formed and their ecological benefits are enhanced; fragmentation of green areas has to be minimized as far as possible. It is possible to derive synergic benefits from conserving and managing the natural valleys as green areas and make Mysore a sustainable city rather than an urban concrete jungle.

Mysore is known for many institutional and public / civic buildings (Fig. 4, 5 and 6). The major open space and recreational centers are University of Mysore, Sri Jayachamrajendra College of Engineering, Regional Institute of Education, All India Instititute of Speech and Hearing, Telecommunication Offices, Central Food Technological

Research Institute, Zoological Gardens, many schools and colleges, Race Course and Golf Club, hotels and resorts, various administrative offices, quite a number of small institutional areas, cultural and religious centers and so on which provide large scale lung space with preserved greenery in the city. The green belt is for the purpose of protecting and preserving the flora, fauna and scenic sights and as a visual buffer against the often-ungainly industrial or utility areas and sprawls; and as a means to replenish oxygen – mitigation of carbon dioxide and carbon monoxide poisoning.

Another important green space is Chamundihills which is a unique landmark of Mysore city and is considered as one of the rich heritage sites having religious, tourism and ecological importance. It acts as catchments for the more than ten surrounding lakes. It has a rich biodiversity with 450 plant species of which about 50 are medicinal plants, 145 species of birds and 60 species of butterflies. There are remarkable improvements in the raising of various plant species in the western parts of the hill, thanks to the efforts of the Department of Forests.

A city rich in culture and heritage, is also known for its sandal wood art and fragrance, silk, flora, fauna, handicrafts, classical music, architectural wonders and of course Mysore is renowned for its educational and research centers. It is a shoppers' delight offering right from incense sticks to exquisite silk sarees.

Location of the City

Mysore is located at an altitude of 770 meters above mean sea level and situated in the larger south central part of the Indian Deccan Plateau at 12^0 18' North latitude and 76^0 12' East longitude. The gradient within the city ranges from 1 to 100 m to 1 to 50 m. Its situation amidst beautiful sylvan surroundings with majestic Chamundi Hill (1085 m) as a backdrop is indeed unique. The northern part of the city drains into the Cauvery river and the southern part into the Kabini river, a tributary of the Cauvery.

The topography of the city is such that the waste water drains into three valleys viz., northern one into Kesare Valley, and others into the south one into Dalvoy tank feeder valley and another to Malalavadi tank valley.

Fig. 7 : Deciduous Forest Type Nature, in Manasagangotri Campus, Mysore.

Climatic Factors

The climate of Mysore can be described as 'Tropical Monsoon type'. Mysore manifests a very hospitable climate all through

Fig. 8 : Deciduous Type of Forest with Lush Green – Manasagangotri Campus

the year, where temperatures vary between 20^0 C and 30^0 C. Neither too hot nor too cold, it's always pleasant although some climatic changes have become visible as the surrounding forest areas have greatly depleted. The city lies in the rain shadow region of the Western Ghats and, therefore, receives not more than 850 mm rainfall per annum mainly between months of April and November. Even in the rainy season, relative humidity does not exceed 60 percent. April and May are the hottest months. Being located on an undulating plateau, the city and its surroundings have large tracts of land suitable for forests and pastures. Its forests are describable as deciduous (Fig. 7 and 8).

Land Use Pattern

In order to promote health, safety and the general welfare of the community, it is necessary to enforce reasonable and facilitatory norms on the use of land for buildings and other activities and constructions. This is to ensure that the most appropriate economical and healthy development of the city takes place in accordance with a well thought out land use plan. For this purpose, the city is

Table 1 : Land Use in (1995) and Land Use Analysis for 2011 AD, Mysore

No.	Land Use	Area (ha)		% Developed area	
		1995	2011	1995	2011
1	Residential	3075.30	6097.87	40.40	43.45
2	Commercial	182.23	344,07	2.41	2.45
3	Industrial	1021.01	1855.05	13.40	13.22
5	Public/ Govt. Offices	856.45	1180.78	11.32	8.41
6	i. Parks and Open Spaces ii. Chamundi Hill	415.77 -	1055.05 1634.82	5.49 -	7.52 -
7	Traffic and transportation	1530.73	2380.56	20.22	16.96
8	Water Bodies	182.68	178.95	2.41	1.27
9	Public Utility	37.26	43.35	0.49	0.31
10	Agricultural purposes	285.34	898.99	3.73	6.41
11	Total Area	7568.77	15,669.49	100.00	100.00

Source: Mysore Urban Development Authority, Mysore.

divided into a number of use zones, such as residential, commercial, industrial, public, semi-public, etc. Each zone has its own regulations and features as the same set of regulations cannot be applied obviously to all of them.

The objectives of land use planning may in brief be summarized as: improving physical environment, strengthening urban economy, ecological up-gradation and fostering of social values.

An analysis of the land use pattern of Mysore, shows a preference towards residential development which covers a greater portion of the city, and this is expected to increase in the next few years. At present, residential areas account for 2,850 ha and this has increased by a whopping 114 percent covering about 6,098 ha by 2011.

Population Growth

As per the latest 2011 Census the population of Mysore is about one million. Based on the JnNURM forecasts, Mysore's population by 2020 will be around 1.5 million with a medium growth rate of 3.5 percent and 1.9 million with a high growth rate of 4.5 percent. This works out to 2.21 million with a medium growth of 3.5 percent by the year 2030 and 2.95 million with a high growth rate of 4.5 percent.

Adding to the perspective of city growth, we can record the census data from 1871. The city got afflicted with bubonic plague during the early part of the 20th century. Once the after effects of plague were over, Mysore caught up with other cities. It grew by 17.73 percent during 1911-21, and 27.62 percent during 1921-31. The highest growth (126 percent) was recorded during 1931-51. Barring the decade 1951-61, which is known for rapid economic strides made by Bangalore, and the emergence of several growth points around Mysore, the city has been expanding steadily.

Table 2 : Growth of Population, 1871-2011, Mysore:

Year	Population	Variation	%
1871	60,312		-
1881	63,313	3,001	4.90
1891	74,048	10,735	16.95
1901	68,111	- 5,937	- 8.00
1911	71,306	3,195	4.69
1921	83,951	12,645	17.73
1931	107,142	23,191	27.62
1941	150,540	43,398	40.51
1951	244,323	93,883	62.30
1961	253,865	9,542	3.90
1971	335,685	81,820	40.10
1981	479081	143,396	40.00
1991	653,345	174,264	36.30
2001	785,800	132,455	20.30
2011	980,000	194,200	24.71

Source: Census of India and MUDA

3. THE IMPORTANCE OF TREES

Trees and plants can actually clear the air of not just carbon dioxide, but also particulate pollutants, and noxious gases like sulphur dioxide (SO^2) from burning of coal and combustion of petroleum products, ozone (O^3) and peroxyacetylnitrate (PAN) from the

emissions of automobiles and industries, and nitrogen oxides from automotive exhaust. Besides, trees can alleviate water pollution, noise, heat and light pollution too.

The amount of dust reaching the ground is about 27 to 42 percent less under a canopy of trees than in an open area. The tree canopy should be big, so that it becomes a barrier for the incidence and movement of pollutants - filtering them out so that only fresh air moves out from that space. Such trees also filter out pollen and mold spores from the air. A dense canopy of trees contributes to arresting soil erosion and replenishment of ground water resources. Dense greenery will contribute to slowing down the fierceness of rainfall and thus soil erosion gets minimized.

Indirectly of course, trees reduce the greenhouse effect by shading our homes and office spaces, which in turn reduces the need to cool our ambient air artificially. Some estimates suggest that this way, fossil fuel burning may get reduced by nearly 30 percent.

According to research findings recorded in the West, over a 50-year period, a well grown tree provides $62,000 worth of air pollution control, recycles $37,500 worth of water, and controls $31,250 worth of soil erosion (Vijay, Hema 2010, A canopy of trees to fight pollution).

All kinds of native species flourish better; they can withstand the vagaries of local climate and soil conditions. Hardy species need to be chosen and bamboo will be a good choices, because it takes less space. The bamboo is amenable for harvesting and also contribute to meet our timber needs to certain extent. The key focus is to preserve and nurture the heritage and ecological endowments of Mysore.

A city's green cover is priceless. It embodies the various trees and other greenery as they add to the aesthetics of the cityscape, and contribute immensely to a relaxed and healthy ambience. Design of a city's green elements is an important part of urban planning.

Since early 20th century, visionaries such as K. Sheshadri Iyer, Jamsetji Nusserwanji Tata, Sir M Vishveshwaraya, and Sir Mirza Ismail emphasized the importance of trees, parks and green recreational spaces beyond their visual contribution in a cityscape (Fig. 9 and 10). But in our hurry to "modernize" through rapid economic growth and the expediency of ever increasing types and intensity of land use, urban aesthetics and environmental upkeep and enhancement are being sidelined (Janardhan Roye, 2009). Mysore is known for many institutional and public / civic buildings amidst huge open spaces.

Fig. 9 : General View of Residential Green with Prominent Coconut Trees

Fig. 10 : A portion of Mysore City Greenery with the Backdrop of Chamundi Hill

Another important green space is Chamundi Hill which is a unique landmark of Mysore city and is considered as one of the rich heritage sites having religious, tourism, aesthetic and ecological importance (Fig. 11). It acts as a catchment area for more than ten surrounding lakes.

The categories of green areas in Mysore are regional parks, neighborhood parks, city forests, historical landscapes, institutional greens, road side avenues, boulevards, road median greenery, sports complexes, green belts, etc. These green elements provide nests for lots of bird species and some times rabbits also are seen. These quasi-forests keep the campuses cool and provide a welcome sense of retreat for

Fig. 11 : Ecological Endowments of Mysore City

the visitors and workmen, students and staff, etc., there by minimising the psychological stress after routine weak. Aesthetic aspects are generally given priority while planting the saplings. Ornamental trees are planted at the periphery of the green area and trees for yield are planted inside. This program is undertaken by the authorities to develop and maintain bio-diversity and check soil erosion and hold moisture balance in the campus premises.

The gardens are generally neatly planned; lawns, flowering plants and hedge cuts and topiary are ornamentally laid out. It is a delightful experience for the passers by. During summer these exhibit their green foliage and exude fragrance and could well be of economical value; their seeds if conserved yield oil.

4. INSTITUTIONAL GREENS

Mysore is known for many institutional and public / civic buildings. Within Mysore, public and semi-public uses cover an area of 865.45 hectares constituting 11.32 per cent of the total area. There are important and major public institutions which provide large scale lung space with greenery in the city. Particular mention may be made of the University of Mysore, which occupies about 300 hectares including the Kukkarahalli Tank and has well maintained orchards, gardens and woodlands. Nazarbad has a zoological garden. Other major institutions like Karnataka State Open University, Music University, Central Food and Technological Research Institute, Regional Institute of Education, Central Institute of Indian Languages, Defence Food Research Laboratory, Rare Materials Project, All India Institute of Speech and Hearing, Tele Communication Department, Defense Establishments, Krishna Rajendra Hospital, Ayurvedic Hospital, Medical and Engineering Colleges, Central Library, Police Training College, Postal Training Centre, Central Sericulture Research and Training Institute, Administrative Training Institute, resorts, palaces, sports clubs, both public and private guest houses, Religious Places, resorts and hotels, golf and race courses, and a number of schools and Colleges such as Mysore Medical college, JSS Medical College, Dental Colleges, JSS College of Pharmacy, JSS Law College, Vidyavardhaka Law College, Sarada Vilas College, Maharaja's College, Maharani's College, Yuvaraja's College, Sarada Vilas College, Mahajana College, Marimallplapa's College, JSS

College, Teresian College, Regional College of Education, SDM Institute for Management Development including industrial zones within the city and also Kukkarahalli Lake, Karanji Lake, Lingambudhi Lake, Dalvoy Lake, Bogadi Lake and Chamundi Hills which are important and major public utilities, and also provide lung space to the city.

5. CASE STUDIES

Mysore University Campus

It is a large and fairly interesting area, from the point of view of vegetation. It occupies an area of nearly 300 hectares and is almost rectangular extending from the Jhansi Lakshmibai Road on the east, Hunsur Road on the north, Mysore-Bogadi-Gaddige Road on the south and Jayachamarajendra College of Engineering Road on the west (Fig. 12 and 13). It encompasses the famous Maharaja's College and Yuvaraja's College on the eastern-side, Oriental Research Institute, the main Administrative Complex (Crawford Hall), Sports Ground and college of Physical Education almost in the centre and Manasagangotri – the Post-Graduate Campus – including college of Fine Arts on its west.

The campus can broadly be divided into two types of habitats; Aquatic habitat i.e., Kukkarahalli Lake and the terrestrial habitat seen on the east, north and

Fig. 12 : The Mysore University Campus.

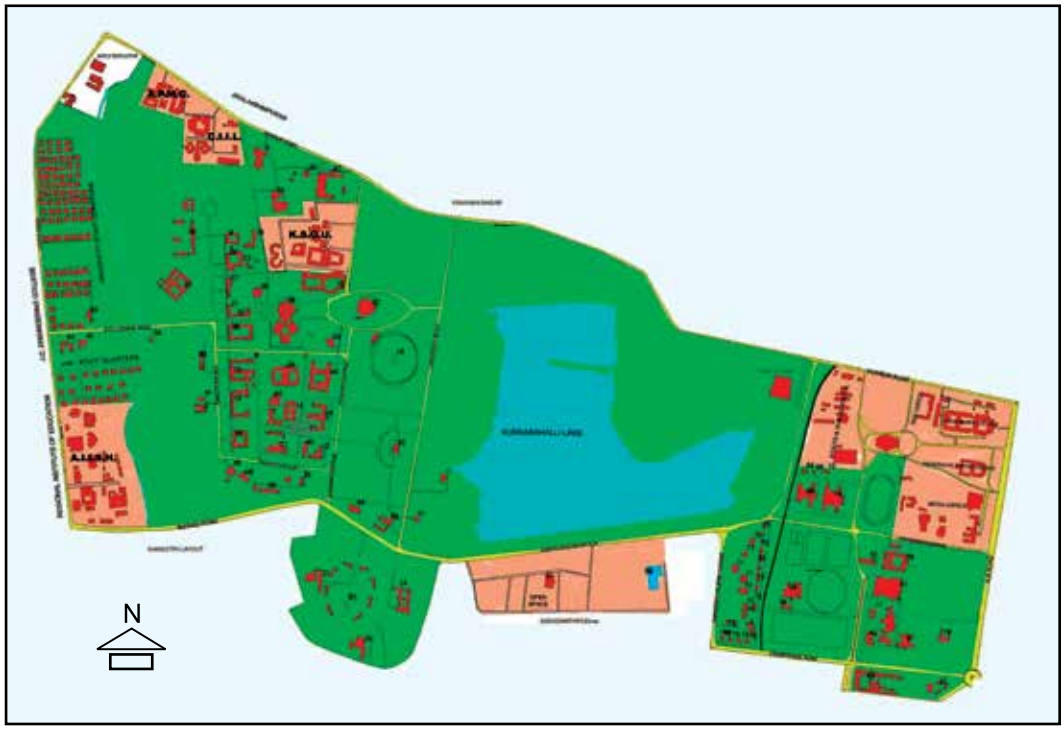


Fig. 13 : Satellite Image of Mysore University Campus

west of the lake. Formerly, the Lake was a public access area with good potable water and catered to the needs of the people of surrounding areas. It was a rain-fed lake with a long feeder channel called Purnaiah Canal which brought fresh water from the western side (its length is said to have been about 22 km). But, in recent years thanks to the unplanned growth of this part of the city growing largely as residential areas, almost the entire canal has disappeared. Since fresh water inflow has become drastically diverted and diminished, the lake water has become stagnant and till recently much of the sewage from Vani Vilas Mohalla and Vinayakanagar was being let into it; the water has become highly polluted. As a result much of the earlier aquatic vegetations have either disappeared or changed.

Till about 1960's the lake water was very clear and the vegetation was virgin and the plants that were common included Water Lilies, Lemna, Azola, Potamogebow, Pistia, Salviania and other floating species like Typha, Cyperus, Polygonum, Ipomea Aquatic, etc., in shallow areas. Nowadays much of them are seldom seen. There was also a small patch of land plants which included species like Morinda, etc. Plants such as Aristolochia Bracteata, Zeuxine (terrestrial orchid), trees such as Schinus Molle have entirely disappered.

With regard to the terrestrial habitat of the University Campus, it is largely seen in and around open air theatre and on the western portion as well as in northern part adjacent to Hunsur Road. This area includes coconut plantation, Mango groves, Sapota and Guava fruit trees. Some of the trees are very old and two species are now given the status of heritage trees. These include Banyan, Peepul, and Tamarind. The giant Peepul tree which is closer to men's hostel on the northwest of the Manasaganotri Campus is one of the heritage trees. The other is a tamarind tree which is located inside the plant nursery of the University which is estimated to be more than 200 years old. The Banyan tree, the one next to the Sericulture Department and another opposite to the Physics Department and yet another nearer to the coffee canteen are really old and arresting.

The neatly laid out roads are avenues with Rain trees, Sissoo trees, Bauhinioas, Bead trees, Mahogany trees, Copper pod trees which make these roads beautiful. The area surrounding the open air theatre and the cricket stadium has been planted with Tabebuias, Bauhinias, Tecomas which add to the greenery of the Campus. However, some of the older tree species like Neem, Gmelina, Streblus, Jujube, Cordia, Morinda, Holoptelea and Bassia which characterized the earlier natural vegetation are not seen now. There are also two-three Bamboo Clumps on the north.

With regard to the greenery on the eastern portion, i.e., closer to Yuvaraja's and Maharaja's Colleges, much of it consists of trees like Gulmohur, Copper pods, Rain trees, etc. There is also a fine patch of Linaloe trees (a perfume yielding plant species) evidently cultivated, just behind the centenary building and by the side of Vice Chancellor's official residence. There are also a few Alstonia trees, Acacia Suma trees, old Neem trees which add to the greenery. The veteran Neem tree to the south of Maharaja's College is a testimony to the centuries old traditions of the institution.

The botanical garden maintained by the Department of Studies in Botany is another interesting area, where some of the rare and endangered plant species are to be seen. These include Cycas, Zamia, Ephedra, Thuja and Agathis which are considered to be rare and endangered. They belong to the ancient, non-flowering vascular plant group with naked seeds i.e., Gymnosperms. There is alsoand ex-situ conservation area for medicinal plants.

There are more than 700 species of plants belonging to 85 families. Of these 87 types are trees, 62 shrubs and 44 species of climbers. Among the trees the most notable ones are Ficus, Madhuca, Mimusops, Michelia, Polyalhia, Annona, Casuarina, Eucalyptus, Bauhinia, Delonix, Thespesia, Santtalumy, Terminalia, Lagershoemia, Arauearia, Syziginum, Pterocarpus, Tamarindus, Aegle, Azadirachta, Adenanthera, Samanea, Albizia, Dalbergia Cordia and Ceiba.

Most of the herbs and shrubs have either been cleared or disappeared on their own and are largely replaced by invasive exotic plants such as Wedilia, Crofalaria pallid, Hyptis, Hibiscus sp, etc. Be it early morning or evening, for walkers or vehicle commuters, Manasagangotri is a uniquely attractive place in Mysore city which has an immediate soothing effect. Marked by a few pink flowers in January and February, the campus is ablaze with copper pod trees in spring. Also some Jacaranda trees in between make a beautiful combination with the yellow. The fragrance of tender leaves and blooming flowers has the power to refresh any tired mind or body. It is a natural span in all senses, from end to end.

Biodiversity of Sri Ramakrishna Vidyashala

Sri Ramakrishna Vidyashala is one of the premier educational institutions of Mysore city which is situated in the northern part of the city. It is a residential institution run by Sri Ramakrishna Ashram, Mysore (a branch of the well known Ramakrishna Math and Mission of Kolkata). It has both high school and pre-university sections and is located on an undulating region within the Yadavagiri extension of Mysore city.

It occupies a total area of 32 hectares with many buildings; roads and play ground for students of which about 20 hectares are utilized for afforestation and horticulture (Fig. 14 and 15). The Vidyashala Campus has over the past 60 years, developed into a vast mini-forest with dense greenery which includes a variety of trees, shrubs, herbs and creepers. Some of them are common ones while a few are rare. Many of the plants are brought from various parts of India.

Flora: Presently the campus flora consists of 393 identified species of plants belonging to 78 families. These include 209 varieties of trees, 64 types of shrubs, 69 species of herbs and the rest of them are creepers, hydrophytes, climbs and succulents. The plants can be broadly classified as uncultivated ones and cultivated ones. The former are generally seen in the central area of 3 to 4 hectares in between the two parallel roads leading to the play

Fig. 14 : Sri Ramakrishna Vidyashala Campus in Mysore

grounds which can be roughly called evergreen – deciduous forest. This comprises several wild forest species, wild shrubs climbers and herbs.

The most notable species here are Honne, Mathi, Nandi, Pride of India, Teak, Impmoeas, Tylophora, Daemia, Acalypha, Phyllanthus, Euphorbia, Tribulus, Asparagus, Vibis, Diplocyclos, Trivospora, Centella, etc. The plants in the cultivated area can be classified as i) Avenue trees, ii) fruit plants, iii) plantation species, iv) ornamentals, v) fodder plants, and vegetable garden.

Fig. 15 : Satellite Image of Sri Ramakrishna Vidyashala with Ample Open Space with Garden

The avenue trees are mostly Grevillea Robusta. The fruit yielding plants include Mango, Sapota, Guava, Jackfruit, Citrus, Custard Apple, Papaya, Banana, Pomegranate, etc.; the plantations are largely Coconut, Arecanut and Coffee. Ornamentals or horicutural plant species are Allamanda, Bignonia sp, Petrea volubilis, Hibiscus, Cardia, Vallaris, Plumeria, Spattrodia, Cassia Renigera, Tabebuia Tecoma, etc. Fodder plants are mostly grasses. Vegetable garden has Beans, Lady's Finger, Cluster Beans, Brinjal, Tomato, and many varieties of greens.

However, most notable plant species that need special mention are the rare Noble Amherstia, Red Sequoia, Brownea, Magnolia, Baobab, Majidea, Elaeocarpus, which can not be seen in the rest of the areas of Mysore city. Equally interesting plants of the campus are the spice plants such as Nutmeg, Cinnamon, Cardamom, Kodum, Clove tree, Camphor tree which are seldom found elsewhere in the city. Thus, the vegetation of Ramakrishna Vidyashala has become a place of attraction for the botanist, agriculturist, horticulturist, and the interested layman.

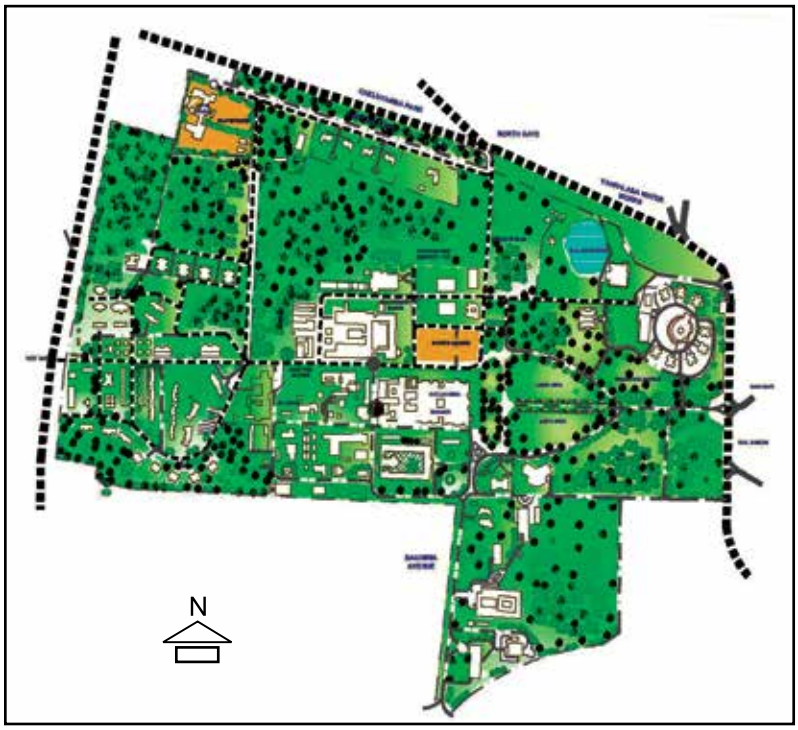
Fauna: Naturally, with such a rich diversity of vegetation, the Vidyashala campus has become a favorite home and suitable habitat for a variety of animals, including birds, butterflies, reptiles and small mammals. The insect life is also very rich. With regard to birds, there are 68 species of them belonging to 36 families. These include both resident and non-resident migratory birds. Most notable ones

are Ashy Drongo, Black-headed Cuckoo Shrike, Golden Oriole, Chloropsis, Indian Pitta, Scarlet Minivet, Paradise Fly Catcher, Tree Pie, Fantail Fly-Catcher, besides the most common ones like Crow, Myna, Sunbirds and Ashy Prinia. Butterflies are quite common and so far 44 species of them belonging to all the five families are identified and listed. Besides tigers, Emigrants, Grass Yellow, Crows the others include Baron, Wanderer and Great Egg Fly. There are 4 or 5 types of snakes, lizards and among mammals squirrels, mongoose, hare are seen. Several types of ants, spiders, coleopteran beetles, dragonflies are also observed and many are yet to be listed. Thus Ramakrishna Vidyashala campus has become a fine habitat where one can see different plants and animals living in harmony. Indeed, an atrractive to the biologist.

Flora and Fauna of Central Food Technological Institute (CFTRI)

In the CFTRI Campus, there are more than 6000 trees constituted by nearly 450 species of herbs, shrubs, climbers and trees. The campus is full with a variety of grasses, ornamental and medicinal plants, flowers and trees within a total area of 60 hectares. The premises has many colorful gardens, fountains and walkways. This floral ambience naturally sustains a variety of beings from the animal kingdom – butterflies, ants, bees, dragon fly, damsel fly and wasps. A number of reptiles live here; lizards and snakes; cobras, rat snakes and kukri snakes. Squirrels and the giant African land snail are also noticed (Fig. 16 and 17).

Fig. 16 : Central Food Technological Research Institute Campus, Mysore Flora and Fauna.



The Institute has planted many new trees and also takes care of nurseries; not even a single species of plant is allowed to be lost. During the last 15 years, the number of trees has almost tripled, thereby keeping the campus cool and pleasant. The Institute has endeavored to list and document the plants and their species and genera – herbs, shrubs, climbers, trees, mushrooms; and several animal genera including insects and birds. Their symbiotic links and interactions with the

environment are also indicated. It is a place of pride in Mysore with innumerable plants, many of which are rare.

Fig. 17 : Satellite image of Central Food Technological Reseach Institute Campus

The widespread and large green cover in the campus provides the evidence for the planning and care, the authorities bestow towards the environment. Construction of roads for convenience has not hampered the greenery owing to coordinated planting of avenue trees. Roads are lined with trees making the green avenues beautiful. Walking through the avenues is a welcome exercise and a pleasant experience. Each path or avenue inside the campus is lined with trees that bloom during different seasons with spectral colors and often carpet the ground with blue, yellow or red hues with their shed flowers or petals. The avenues are named after the trees, like Gulmohar Avenue, Bauhinia Avenue, Rain Tree Avenue, and Cassia Avenue, etc.

A carpet of vegetation covers the entire campus. Weeds are harmless in uncultivated areas. They act as soil cover on the one hand and contribute oxygen to nature in exchange for carbon oxides. Simultaneously they beautify the environment around and support the ambient fauna.

Chamarajendra Zoological Gardens

The Wodeyar Kings had a vision to create a well laid-out city amidst gardens, and founded the famous Chamarajendra Zoological Gardens. This garden has a history of more than 110 years and houses a variety of species not only of this country but from over forty other countries of the World. It has a beautiful landscape with good vegetation cover, providing almost a natural environment (Fig. 18) for the Zoo animals.

Chamarajendra Zoological Gardens is one of the county's best zoos. This is famous for rare animals bred in captivity and is housed in lush green surroundings. Its fauna includes rare and exotic species which are housed in lush, green surroundings. This 40 hectares park houses the Mysore Zoo and is located just 3 km away from the city centre. It is home to some 2,000 animals belonging to 200 different species,

Fig. 18 : Satellite Image of Chamarajendra Zoological Gardens Located in the Eastern part of CBD

Fig. 19 : Bonsai Garden called Kishkindha Vana

fascinating among them being the Royal Bengal Tiger, Giraffe, Indian and African Elephant, White Tiger, Lion, Rhino, Nilgiri langur, Himalayan Brown Bear, Hippopotamus and the Tapir, among many others.

With its profuse cover of vegetation and meticulous landscaping, it provides near-natural environment to the captive animals. 35 species of ornamental plants and 85 species of trees from India and abroad beautify the landscape of the Zoo. About 2 million visitors visit this zoo every year which indicates its popularity. Just as well-maintained zoo can be great assets to a country, gardens too can be of immense value.

Miniature Greens (Bonsai)

Lush greenery is one of the most beautiful forms of nature. In Mysore, a Bonsai Garden called *Kishkindha Vana* is located within the Sri Ganapathi Sachidananda Ashram which is well maintained amidst a highly urbanized setting (Fig. 19).

It may sometimes be very difficult to show a tree which grows in deep

jungles. Although one has access to dedicated magazines and television channels, nothing can replace direct experience. In such circumstances, the Bonsai concept can be of great help. Bonsai technique allows us to have a miniature forest.

Mysore Race Course

The Mysore Race Club (MRC) has 62 hectares of greenery that provides a welcome and attractive lung space for Mysore city (Fig. 20). One must realize there are certain structures in a city that help it to develop as a brand. Mysore is seen as a royal city, and the existence of a beautiful race track with the Chamundi Hills in the backdrop is one jewel in its crown. The only other place in the world where there is a hill view of a race track is Hong Kong where tourists going up the Victoria Hill are taken to a viewing point to show the race course. MRC is a green space which is a non-profit organization. It is an institution and an industry that contributes economically, environmentally and socially along with putting Mysore on the map of popularity.

Fig. 20 : Mysore Race Course

Fig. 21 : Lalitha Mahal Palace Hotel

Lalitha Mahat

The snow-white Lalitha Mahal was built in the 1930s for the guests of the Wodeyars (Mysore King's family). Surrounded by velvety green lawns and stately trees, the Lalitha Mahal is now a prestigious hotel of the India Tourism Development Corporation (Fig. 21).

Fig. 22 : Afforestation: 'Green Mysore' Campaign.

6. TREE PLANTATION PROGRAM

The "Green Mysore" campaign that aims to plant 50,000 saplings in the city got under way with Ms. Salumarada Thimmakka, the well known award winning veteran in green activism showing the way to students in the year 2010 (Fig. 22). The project entails arresting the dwindling of green cover of Mysore through an afforestation programme involving educational institutions, government offices and non-governmental organizations.

For the nearly 2,500 students from various schools who had assembled at the venue, it was an experience of a life-time to meet in person, Thimmakka, the legendary figure who is almost synonymous with trees.

7. AVAILABILITY OF PLANT NURSERIES IN MYSORE

Planting material or saplings may be produced in nurseries run by individuals or all major institutions for their own use. Trees planted on public access lands are often obtained from nurseries run by the Department of Urban Forestry in Mysore Division. The only problem is that limited species are available in public nurseries. Most of the public and semi-public institutions have established their own plant nurseries for their uses. Private nurseries exist in many places in Mysore city; they work on a smaller scale and concentrate on the selling of saplings. As they are often engaged in the production of ornamental and fruit tree species, they may add significantly to the total available choice of species.

8. INSTITUTIONAL IMPROVEMENT PROGRAMS

Palace Garden

The caretakers of the majestic Mysore Palace have set their vision on developing a garden which will be on the lines of the famed Mughal Gardens at Rashtrapati Bhavan, New Delhi. Plans are being drawn up to develop the 9.00 hectares garden which will include lawns and a variety of plants – ornamental and flowering (Fig. 23.).

Fig. 23 : Developing Amba Vilas Palace Garden

There is a lot of scope for developing the unused space on the palace premises. The existing lawn can be beautified and made attractive. Fountains and other attractions are also included in the plan. The total area of the palace premises is around 22.25 hectares. The lawn could be developed on about 9.00 to 10.00 hectares.

A Forest Heritage Centre

This Centre will come up in 'Aloka', a spacious 222.58 hectares area in the western outskirts of the city which will showcase the forest environment system (Fig. 24). It will be developed on the lines of Cubbon Park in Bangalore which will sure turn out into a popular spot for weekend retreat and the project is ready to build a compound at a cost of Rs. 17.5 million. They have proposed a world class museum which will come up there.

Fig. 24 : Aloka – Proposed Forest Heritage Centre

Kukkarahalli Lake

The University of Mysore would be setting up a Botanical Park with the Forest Department supplying plants from its nurseries around the Kukkarahalli Lake (Fig. 25). The University has a funding of Rs. 30 million from the State Government and is now in the process of preparing a Master Plan for the eco-

Fig. 25 : A portion of Kukkarahalli Lake with lush greens within the Mysore University Campus.

restoration. The lake is spread over 58.00 hectares with a shoreline of roughly 5.00 km and according to bird-watchers, it harbors nearly 200 species of birds. A Bamboo Diversity Park and a Botanical Garden will come up in the lake environs as per a recent notification.

9. FUTURE PLANS

Mysore is poised to launch its new Master Plan aimed at beautifying the city. It is appropriately called '*Sundara Mysooru*' (beautiful Mysore) Plan. Rs. 3000 million would come from the JnNURM of the Central Government, Rs. 500 million from the Central Ministry of Tourism and Rs. 3000 million from the Asian Development Bank and World Bank. Work has also started on drawing up an Urban Forestry Strategy and an information pamphlet on this strategy through the Forest Department and NGOs is being circulated.

10. CONCLUSIONS

The city of Mysore is relatively small but is well endowed with its floral riches and arboreal wealth. The various institutions, mostly run with government munificence, are contributing significantly to this city's green status. Overall, the green status requires to be further developed and imaginatively enriched.

In furthering this objective, co-ordinated efforts have to be initiated. All these institutions promoting green activities in a major way, can come together under the convenorship of the Mysore District Horticultural Authority for recording

and sharing their experiences. Periodic meetings may be held say once in every three months to deliberate on sourcing saplings and innovatively indenting them. Related issues may be mutually co-ordinated. Since, all these institutions are area-wise significant or huge, they can further emphasize rainwater harvesting and vermiculture. Efforts to monitor eco-upgradation and green density can be launched alongside of calibrations and measurements. All these efforts will promote not only technical employment but also eco-horticultural – forestry technology.

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Planning New Bus Routes for Un-Served Areas - A Case Study of Chennai

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Abstract

Public transportation network caters to the needs of all sections of the society irrespective of their economic status. This article explains the process of identifying the areas, which are not served by public transportation through Stop Coverage Ratio Index Method, a different technique to serve those un-served areas using Network analysis.

1. INTRODUCTION

Transportation network can be rightly stated as the lifelines of the people that connect both urban and rural areas. In fact they are the indicators of the standard of living. In Metropolitan cities, public transport especially the State Transport Unit buses caters to the need of all the sections of the society irrespective of their economic status. Thus, there is a need for development of infrastructure such as bus routes by ensuring optimum utilization of available resources without spending much. Bus routes refer to the paths regularly traversed by buses carrying passengers. Urban Bus Transport plays a crucial role in movement of people from one part of a city to the other. Bus transport has been an extensive mode of transport and provides door-to-door service. Its affordability is a value addition.

2. NEED FOR STUDY

The Chennai city has been growing in leaps and bounds. It sprawls in all possible directions. The first Master Plan approved in the year 1975, gave a kick-start for the dynamic characteristics of the city, such as economic, social, spatial, landscape and skyscape. The second Master Plan, which came into effect in the year 2008, accentuated the pace of the development. However, the Metropolitan Transport Corporation (MTC) responsible for the intra-city bus services has not undertaken any comprehensive route rationalization. Routes are decided on ad-hoc basis subject to public pressure and collections. Bus routes are the medium, which makes or mars the accessibility. The socio-economic characteristics of the people, land and building use pattern and the population density besides other factors influence the bus routes and stops. The lack of such scientific studies has resulted in certain suburban areas deprived of accessibility through

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bus transport even while certain other areas have saturated bus services. The fallout of such a situation is the runaway growth of personal vehicles leading to congestion, pollution and accidents. One of the most prominent methods to solve the traffic congestion problem is to improve the bus operation. The limitation of bus facilities, such as narrow road network, lacking of parking area and deficiency in road system impact directly to bus route network, area coverage by bus system and number of roads covered by the bus system. There are some urban areas, which have high concurrence of routes, and some suburban areas, which are not served by any buses.

The main purpose of this research study, in the above context is to examine the bus services through the application of Geographic Information System (GIS), which has revolutionized the process of map making and analyses. The specific objectives of this research paper are to investigate the existing bus system; to examine the bus service characteristics; to analyze the deficiencies of bus service by applying GIS and also to provide new buses for un-served areas.

3. DEFINITIONS OF UN-SERVED AREAS

Un-served areas are the areas where any mode of public transportation is not available and people have to rely only on private transportation. In these areas people cannot access the public transportation within a walking distance of 400 m.

4. STUDY AREAS

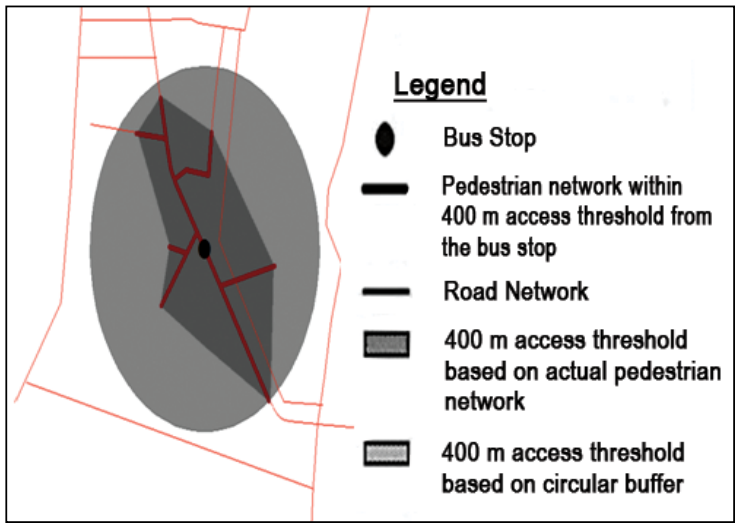
The study areas selected for the present research paper is, located in southern part of the Chennai town in Tamil Nadu state. It is about 15 km away from Central Business District. Study area chosen is a suburban area, comprising parts of Vengaivasal, Madampakkam, Selaiyur and Sembakkam. The reason for choosing these regions as the Study Area is that Chennai city is already congested and suburban areas lying around city are growing at a faster rate. These areas have developed at a faster rate in the past ten years and these areas also have monorail proposal to serve them in future. Therefore, it is necessary to plan these areas with public transport.

Fig. 1 : Study Area

5. IDENTIFYING THE UN-SERVED AREAS

Un-served areas can be simply identified by forming a buffer of 400 m around the existing bus routes and the areas lying outside the buffer are the un-served areas. Buffer can be formed around bus stops instead of bus routes to measure the un-served areas exactly, as the people access the buses only through bus stops.

Fig. 2 : Ideal (Circular) and Actual (Polygonal) Bus Stop Access Coverage



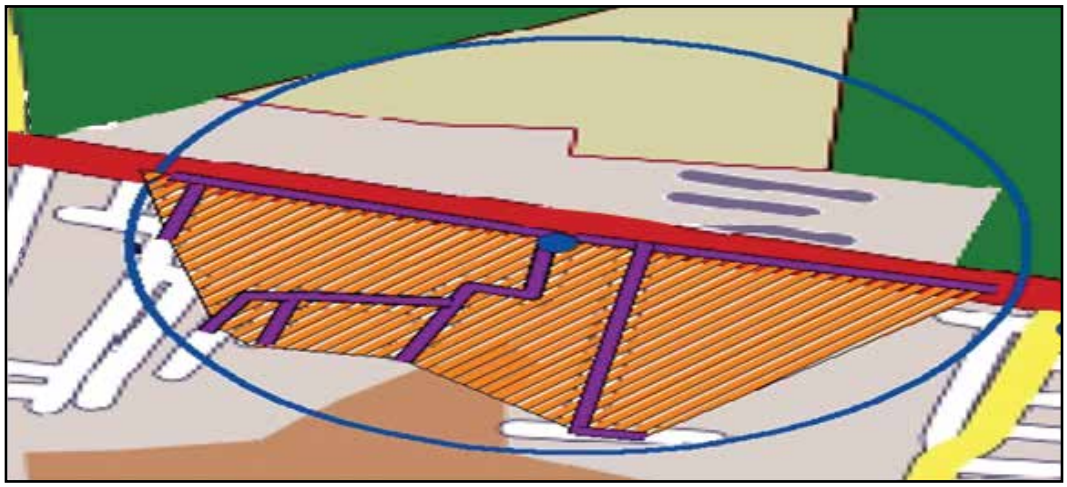
In this research paper, instead of using the normal buffering techniques, "Stop Coverage Ratio Index Method", a different technique is used to identify the un-served areas. It is the ratio of Ideal Stop-Accessibility Index (ISAI) to Actual Stop-Accessibility Index (ASAI). Mohamed A. Foda (2010) in his article has estimated the Stop Access Coverage using a Circular Buffer Analysis with a radius of the access threshold (400 m) around the transit stop in order to identify its coverage area. Knowing this area in addition to the population density, the total number of individuals in a region having suitable access can be determined.

The Ideal Stop-Accessibility Index (ISAI) can be used to evaluate the accessibility to a bus stop through the surrounding pedestrian road network. This is obtained by dividing the total length of the pedestrian road network links lying within a walking distance of 400 m measured along the network paths (km) by the Ideal Access Coverage Area of the bus stop measured as a circle with a radius of 400 m and having the bus stop as its center (sq km).

The Actual Stop-Accessibility Index (ASAI) can be used as a more accurate measure of bus stop accessibility through the surrounding pedestrian road network. The ASAI is obtained by dividing the total length of the pedestrian road network links lying within a walking distance of 400 m measured along the network paths (km) by the actual access coverage area of the bus stop measured on basis of the pedestrian road network serving the same bus stop (sq km).

$$\text{Actual Stop-Accessibility Index (ASAI)} = \frac{\text{Length of Pedestrian Network}}{\text{Area of Polygon Buffer}}$$

Fig. 3 : Ideal (Circular) and Actual (Polygonal) Bus Stop Access Coverage for Sembakkam Bus Stop



The Stop Coverage Ratio Index (SCRI) can be used to evaluate the ratio of actual access coverage to that of the ideal access coverage of a bus stop. This is obtained by dividing the actual access coverage area of the bus stop measured on basis of the pedestrian road network paths (sq km) by the ideal access coverage area measured as a circle with a radius of 400 m and having the bus stop as its center (sq km).

The actual region, which is accessible within a walking distance of 400 m, can be identified from this method. This method is used in this study for identifying the region accessible within 400 m walking distance.

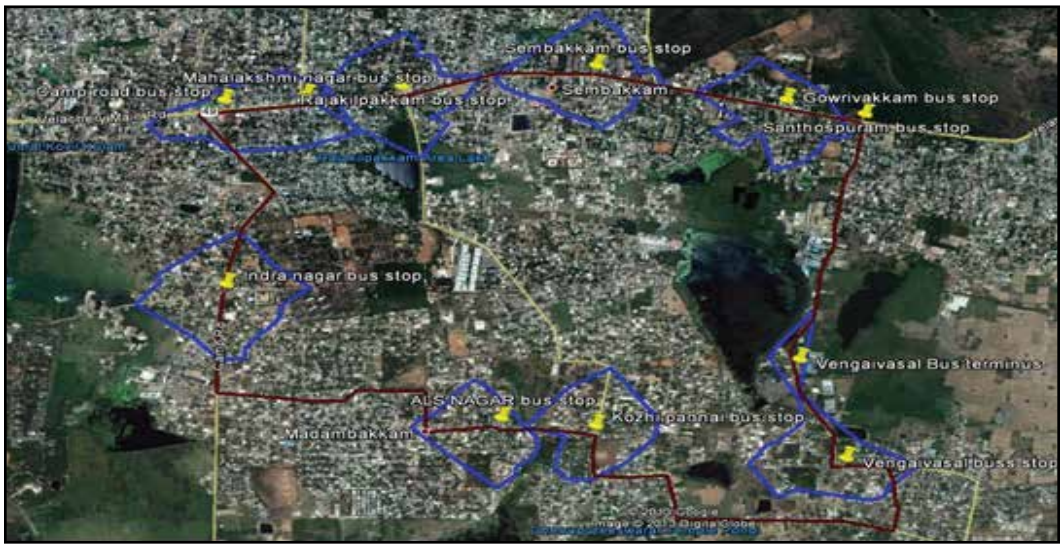
Existing bus stops (numbering around 10) in the Study Area are identified to demark. the service area of these bus stops so that the remaining areas can be termed as un-served areas. For example, Sembakkam bus stop in the study area with its actual pedestrian network polygon is shown in Fig. 3.

$$\text{Stop Coverage Ratio Index (SCRI)} = \frac{\text{Ideal Stop-Accessibility Index (ISAI)}}{\text{Actual Stop-Accessibility Index (ASAI)}}$$

Fig. 4 shows, the existing bus stops with the areas that are served by the within a pedestrian network of 400 m. Although there is a bus network, there remaining region, which can be reached only after walking more than 400 m.

Blue colored polygon in the image shows the areas that are served by public transportation, while areas lying outside the polygon are un-served areas.

Fig. 4 : Existing Bus Stops with their Serving Areas identified using Actual Pedestrian Network



Therefore, these areas need bus services to meet the demand of the population residing in the un-served regions. The area inside the red color polygon in the Fig. 5 shows, the region that are un-served by public transportation. These are the areas, which need to be served by proper planning by the bus routes.

Fig. 5 : Un-served Areas

6. NETWORK ANALYSIS

Network analysis in the Study is used for identifying the shortest path for connecting the trip generating points. Areas, which have high demand for public transportation, are identified from the survey before accomplishing the network analyses. Stakeholders were consulted about possible locations of bus stops and

Fig. 6 : Planned Bus Stops

their accessibility to them. Most trips made are for education and work. Work trips are mostly made to Kamarajapuram, Hasthinapuram, Medavakkam and Tambaram, etc. Thus, location of bus stops in Hasthinapuram, Kamarajapuram and Medavakkam will make them more accessible to their work areas. Fig. 6 shows, bus stops that are planned for the Study Area with their names. Bus stops are planned in such a way that their serving area does not overlap and also they are located near trip attraction and production zones.

Fig. 7 : Planned Bus Route for Un-served Area

Fig. 8 : Planned Bus Routes for Medavakkam

Routes can be identified through network analysis, once bus stops are planned. Network dataset is created for the road network. Creating the network dataset will check for any connection of error in the prepared road network.

First and the last stops are kept as Tambaram so that the planned route will be a circular one. Leaving the Tambaram stop the order of others stops is changed automatically to obtain the shortest path. The routes obtained by network analysis are the shortest path to reach the bus stops. Fig. 7 shows, the region of study with planned bus routes. Points are the bus stops in the region.

Fig. 9 : Planned Bus Routes for Hasthinapuram

Fig. 8 shows, the region of Medavakkam and Hasthinapuram with their planned bus stops and bus routes. Bus routes, which are planned, are the shortest paths to connect these region.

Fig. 9 shows, the planned bus route, which has bus stops at Chitlapakkam and Hasthinapuram Bus Terminus and Heritage Nagar. New bus routes have been identified to served and un-served areas in the study area. These routes are identified using network analysis. Therefore, the accuracy will be more than manual interpretation methods. Bus stops are identified based on the survey results and peoples' convenience after accessing them. This proposal may reduce the usage of private vehicles in future if buses are plied through proposed planned routes.

7. CONCLUSIONS

The main objective of the present study is to identify areas not served by public transportation. This objective is achieved by the application of a new technique called Stop Coverage Ratio Index (SCRI) technique. This method actually considers the actual pedestrian network for calculating the service area, as most of the people access only through pedestrian network. The SCRI technique has also indicated how the service area is over-estimated using earlier employed techniques viz., 400 m buffer around the routes and 400 m buffer around the bus stops. Un-served areas are identified by excluding the served areas, which have no means of public transport and access to them is time consuming.

House-hold survey is conducted in the study area to identify the demand for public transport and also to identify their dependency on transportation which makes them shift towards private transportation. Proper consultations were held with inhabitants to plan for new bus stops in un-served areas. Trip attraction zones such as schools, colleges and offices, are also considered for planning bus stops. Bus stops are also planned with a buffer of 400 m to prevent overlapping of service area.

Network analysis is performed to identify the shortest path to reach planned bus stops. Planned routes more over are circular ones with starting and ending at Tambaram bus terminus. The planned circular routes almost cover all outlying suburbs. SCRI technique is identified as the best technique than the previously employed ones. The un-served areas measured about 2.94 sq km in case of buffer formed around existing bus routes while it was about 4.44 sq km for buffer around bus stops. The SCRI technique measured the un-served area as 5.77 sq km, which is considered as more meaning full.

Planned bus routes identified are more efficient as they passes not only through trip generating points but also through trip attracting points. The proposed new bus routes will encourage people currently using personal transport to shift to public transportation, in a way also controls the pollution. This technique further

averts the transfer from one mode to the other as the planned routes reach the destination points.

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Livability Perception in Residential Areas of India: Comparative Analysis of Planners and Inhabitants Outlook

Rama U Pandey, Dr. Yogesh K Garg, and Dr. Alka Bharat

Abstract

The aim of the paper is to identify the gap between understandings of livability performance parameters for evaluating livability of residential areas in the upcoming cities of India. For the evaluation through reconnaissance survey, residential areas of Bhopal were broadly divided through timeline in six categories viz. the areas that were more than 50 years old; the areas that were 40 to 50 years old; 30 to 40 years old; 20 to 30 years old; 10 to 20 years old and residential areas less than 10 years old. Randomly selected 628 inhabitants from 35 residential colonies were asked to express their opinion on importance of each livability indicators and the ratings of Inhabitant's perception for successful livability performance were then compared to identify appropriate livability indicators in Indian context.

1. INTRODUCTION

Livability refers to the state of living environment, which must offer an acceptable quality of life to the inhabitants of a particular locale. Livability is herein defined as 'quality of life' as experienced by the residents within a city or region (Timmer and Seymoar 2006). In a way, it denotes the sum total of deliverables available to an individual or set of individuals in a particular location, leading to their contentment in day to day life. Livability being a subjective notion, its gamut differs with different economic, social, cultural and local influences (Brook Lyndhurst 2004) there by governing the inhabitants' impression and perception about livability. Though the interpretation of livability varies with time and place but the concept seems to share terms like "quality of life", "well-being" and "life satisfaction" all across. In the US livability refers to overall 'quality of life' and 'wellbeing' whereas in UK, livability focuses strictly on local environment i.e. cleanliness, safety and greenery (Brook Lyndhurst 2004). In Indian context the livability differs slightly from concept of developed countries though the essence remains the same. Developed countries take certain facilities for granted while having the same facilities becomes an attractive preposition for Indian people (CII 2010). For example, a grocery store with home delivery services within walking distance in a colony, easy accessibility to a weekly vegetable market for fresh vegetables and fruits, are some of the important criteria for livability in India, whereas, these issues are not important in developed countries

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as the nearby departmental stores serves the purpose of one stop shop. The fundamental goal of this paper is to identify the gap between understandings of livability performance parameters for evaluating livability of residential areas in the upcoming cities of India.

Bhopal, the capital of Madhya Pradesh, was selected for the study as it is one of the major upcoming city of India with a wide metropolitan background, varied social and economic culture and was a part of Confederation of Indian Industry (CII 2010) study, "Livability index 2010: The best cities in India". For data collection, residential development projects of Bhopal were broadly divided in categories viz. the project that were planned for closed campus with 24 hours security; and, the project that were planned for open campus. Randomly selected inhabitants were asked to provide their own definition of successful livability performance in the selected residential development projects. Due to highly subjective and constantly evolving concept of livability, professionals and academicians were asked to provide their definition of successful livability performance. The definitions thus collected were matched with definition obtained through responses provided by inhabitants. This paper describes the process that was used to define successful livability performance and match the professional's definition against the inhabitant's definitions of livability performance. The inhabitants and professionals opinions about successful livability performance of a residential development could then be used to retrospectively evaluate livability performance.

2. PROBLEM STATEMENT

India will witness a huge urban transformation over the next 20 years, the scale and speed of urbanization and high population growth will pose an unprecedented managerial and policy challenge on livability in residential areas. Currently, Indian cities are home for 340 million people and the number is expected to increase to 590 million by 2030 (McKinsey Global Institute 2010). Provision of housing to the increased urban population by 2030 would create demand for substantial number of residential projects. The upcoming residential projects if not planned for successful livability performance would affect the future livability of these residential areas.

Livability is one of the critical emerging issues in the developing countries and got attention due to low standard of life in metropolitan cities. The cities that have high livability rating are those that have reinvented themselves, and managed growth and changed to provide their citizens with a vibrant and livable environment (Yuen and Ooi 2009). Though, efforts have been done to measure "livability" of Indian cities but little has been provided to gauge the "livability performance" of residential areas.

3. REVIEW OF PREVIOUS RESEARCH

Numerous studies have been conducted throughout the world to identify indicators that influence the livability of a neighborhood, city and a country. Researchers have developed various indices to gauge progress and to make comparisons between and among different cities, regions, and countries. The livability index is a system that monitors quality of life for a given environment using carefully selected social, economic, and environmental indicators (CII 2010). These indicators ultimately help to measure different aspects of society. Though, there is a worldwide consensus on to improve quality of life and standard of living but no consensus on what constitutes the most appropriate index. The selected indicators must represent the social, economical and environmental needs of the local community (Carmichael et al. 2007). A British research has found that livability is related to the daily living environment and livability may conflict with sustainability if promoted with environment unfriendly manner (Brook Lyndhurst 2004).

Livability has become a global necessity for health, economic and social survival in agglomerations everywhere. In the last 10-20 years a massive worldwide movement has transformed countless urban environments to make them far more livable (Brenner and Brenner 2007). In India too, the concept of livability is slowly gaining momentum.

The Confederation of Indian Industry (CII 2010) has recently prepared a livability index 2010 for Indian cities after a comprehensive study of 37 cities. Cities have been ranked on the basis of 8 identified indicators affecting livability in Indian context viz. Infrastructure and public services; Housing options; Economy; Socio cultural political environment; Medical and Health; Safety and Education. However, the study seems generic in the sense that the role of local factors and beliefs influencing livability performance at the grassroots level in residential areas has not been taken into account. The perception of local populace about livability is important in identifying the key factors of livability which in turn will be useful in assessing successful livability performance.

Livability can be measured using a range of 'Livability Indices'. The Economist Intelligence Unit's livability rating quantifies the challenges that might be presented to an individual's lifestyle across 140 cities worldwide. Each city is assigned a score for over 30 qualitative and quantitative factors across five broad categories: stability; healthcare; culture and environment; education; and Infrastructure (Gerrardbown 2006). Other global measures include Mercer's Quality of Living Survey, the International Living Quality of Life Index and the United Nations Human Development Index. The Australian Unity Well-being Index measures personal well-being (e.g. standard of living, health, safety, community inclusion) and national well-being e.g. social conditions, state of environment,

business and national security (Woolcock 2009). These indices produce a quantifiable measure of livability at a broader level than the residential areas, building or dwelling level.

Peter and Lesley Brenner (Brenner and Brenner 2007) developed a Livability Planning Checklist for municipalities of Tasmanian cities to assess whether a proposed development fulfills the requirements of, up to date livability standards. The checklist includes nine broad categories of livability indicators – social interaction; economic viability; tourism and recreation; wellbeing for all; environment; safety and risk management; national and international treaties and guidelines; technical details; and climate change. Though, the Checklist was prepared for guiding the planning decision makers of Tasmanian cities but could be used to identify indicators of livability for residential projects in India.

'The B-Sustainable' (Sustainable Seattle 2008), a project of Sustainable Seattle is working towards achieving its goal of livable neighborhood through identified indicators for livability of residential areas. According, to this project people want to live in neighborhood that are good places to raise their families and provides: good connectivity; varied choices of housing and recreation; shops and services within walking distance; easy access to schools and open space; enough gathering places and parks; sense of safety; distinct character to meet the diverse and unique needs of the region's culture.

4. METHODOLOGY

The common indicators of livability, identified through the literature review of previous research includes: social interaction places; infrastructure; public services; good connectivity; natural environment; safety; education; healthcare; cultural environment; recreation; shops; economy of residential area; housing options; cleanliness; walkability; and distinct characteristics. These selected indicators were then discussed with focus group of 15 professionals related to the field of planning to prioritize the livability indicators which they feel important in Indian context, for assessing successful livability performance. Professionals working in the field of planning for more than 15 years and well versed with local culture and living environment were invited. It included: 5 academicians from the planning field; 5 planners representing the local government departments involved in planning decisions making and 5 were practicing planners in the city.

The focus group was first asked to shortlist the indicators and then asked to rank them in the prioritized order depending on their importance to livability performance in residential areas. The questionnaire was then developed for inhabitants for rating the selected list of indicators by professionals to capture their outlook on importance of each indicator in achieving desired livability in residential colonies. For capturing the data 35 residential colonies from 70 residential wards covering 14 zones of Bhopal, were identified. Residents of

selected residential projects are then grouped according to the plot size ranging from 100 – 240 sq m with built up areas limited to 300 sq m. The data collected through the survey of 20 households from each residential colony satisfying the above criteria were identified randomly for rating the indicators in scale of 1 to 8, where 1 was least important criteria and 8 the most important criteria. These 600 households were approached personally to record their responses. Out of 600 only 497 households participated in the survey and rest denied to participate due to some personal reasons. Questionnaire was filled up by family members who had responsibility for supporting and managing the family affairs. The collected data is then analyzed and results were drawn.

5. DATA AND ITS ANALYSIS

In the first phase of the research, professionals were asked to shortlist the 16 indicators selected through literature review. Professionals and experts regrouped and finalized 8 indicators viz. 1) infrastructure and public services; 2) recreation and amenities; 3) community spaces; 4) good connectivity; 5) cleanliness and natural environment; 6) distinct characteristics; 7) recreation and amenities; and 8) housing options. These 8 indicators were then ranked by them in the scale ranging from 1 to 8 with 1 as minimum and 8 as maximum. Table 1 presents summary of statistical description of professional responses for livability indicators of residential areas of Bhopal. The indicator "Good Connectivity" was rated as most important indicator by the professionals whereas a distinct characteristic was least preferred.

Selected livability indicators, were explained to inhabitants to make them understand their context and meaning so that they can rate indicators accordingly. Following is an excerpt included in questionnaire to provide explanation of all livability indicators. Good connectivity was explained through the location of the

Table 1 : Statistical Description of Professional's Responses for Livability Indicators of Residential Areas of Bhopal

Livability Indicators / Statistical Description	Safety	Recreation and Amenities	Community Spaces	Infrastructure and Public Services	Housing Options	Cleanliness and Natural Environment	Good Connectivity	Distinct Characteristics
Mean	6.07	3.93	4.93	6.93	3.00	2.20	7.40	1.53
Median	6.00	4.00	5.00	7.00	3.00	2.00	8.00	1.00
Mode	6	4	5	7	3	2	8	1
Range	4	6	4	3	2	3	3	3
Minimum	4	1	3	5	2	1	5	1
Maximum	8	7	7	8	4	4	8	4
Std. Deviation	1.100	1.668	.961	.884	.756	1.014	.910	.915
Skewness	.224	.121	.148	-.574	.000	.493	-1.626	1.821
Kurtosis	.106	-.476	1.005	.091	-1.077	-.598	2.359	2.895

residential colony with respect to important amenities of the city, whether, the location is well connected to central business district, education institution, etc. How important are services like, networking and physical conditions of internal roads; regular and adequate supply of water; proper surface drainage; efficiently laid and maintenance free sewer lines; operational rain water harvesting system; regular electricity supply. Safety was explained by psychological comfort inhabitant's feel within the campus. How safe are the roads for elders and kids to walk through the campus and sleep without fear during night time.

Availability and quality of recreation and other amenities includes convenient shops, enough parking lots for inhabitants as well as visitors, nursery and primary school, health centers, green and open space within convenient walking distance. Community spaces include adequate gathering places like parks, clubhouse, temple, pedestrian walkways, playground and garden, etc.; to encourage social cohesion. An efficient collection and disposal of garbage, clean streets and pathways to encourage walking within the campus refers to cleanliness. Availability of options for types of housing to suit the requirements of inhabitants describes housing options. How important is reflection of local culture and unique features within the campus to have residential colonies its own identity?

This explanation was included to minimize the variability in defining the successful livability performance, and to reduce the amount of subjectivity involved in rating livability indicators. Randomly selected inhabitants of 35 residential colonies were then asked to rate the indicators and ratings of 497 respondents was compiled in SPSS. Statistical Analysis of the compiled data was carried out to know inhabitant's perception on livability indicators. Percentage frequencies of responses for all eight livability indicators were summarized in Table 2.

Table 2 : Percentage Frequency Distribution of Inhabitants Responses for Livability Indicators of Residential Areas of Bhopal

Livability Indicators / Response Ratings	Good connectivity	Infrastructure and Public Spaces	Safety	Community spaces	Recreation and Amenities	Housing Options	Cleanliness and Natural Environment	Distinct Characteristics
1	27	4		4	4	60		20
2	48				4	9		20
3	9	4	8	19		11	16	33
4	4		3	60	15	4	20	16
5	0	8	6	13	29		44	4
6	4	23	10	4	44	4	4	
7	8	44	16		4		4	4
8	0	17	58			12	12	4

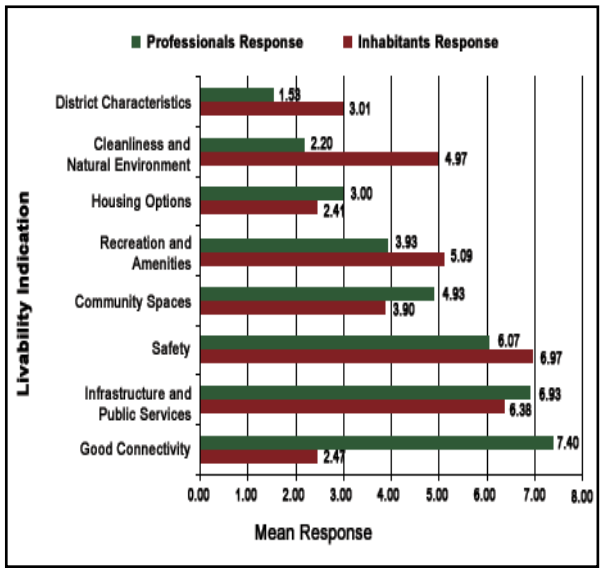
Table 3 : Statistical Description of Inhabitants Responses for Livability Indicators of Residential Areas of Bhopal

Livability Indicators / Statistical Description	Safety	Recreation and Amenities	Community Spaces	Infrastructure and Public Spaces	Housing Options	Cleanliness and Natural Environment	Good Connectivity	Distinct Characteristics
N	497	497	497	497	497	497	497	497
Mean	6.9718	5.0946	3.8994	6.3803	2.4728	4.9718	2.4668	3.0080
Median	8.0000	5.0000	4.0000	7.0000	1.0000	5.0000	2.0000	3.0000
Mode	8	6	4	7	1	5	2	3
Range	5	6	5	7	7	5	6	7
Minimum	3	1	1	1	1	3	1	1
Maximum	8	7	6	8	8	8	7	8
Std. Deviation	1.54607	1.32482	.91247	1.55875	2.37675	1.45470	1.72020	1.72035
Skewness	-1.481	-1.533	-.759	-1.918	1.527	.767	1.689	1.233
Kurtosis	1.036	2.264	2.746	3.940	.858	.022	1.817	1.544

The frequency of responses ratings were tabulated as shown in Table 3, to know the importance of each indicator from inhabitants point of view in contributing the livability of residential colonies. Safety was rated as the most important livability indicator by 58% of the inhabitants, whereas, infrastructure and public spaces were rated second in importance by 44% of the inhabitants. The least important rating was given to housing options by 60% of inhabitants followed by good connectivity. Summary of statistical analysis of inhabitants responses are given in Table 3.

The hierarchy of selected livability indicators for inhabitants analyzing mean, mode and median is : 1) safety 2) infrastructure and public services 3) recreation and amenities; 4) cleanliness and natural environment; 5) community spaces; 6) distinct characteristics, and 7) housing options and good connectivity.

Fig. 1 : Responses of Inhabitants and Professionals for livability indicators



The inhabitants response and professionals response was then compared to find out the difference in the perception of successful livability performance. Fig. 1 illustrates, the comparative mean responses of inhabitants and professionals which indicate that safety, infrastructure and public services were rated highly by both.

The indicators like safety, infrastructure and public services, recreation and cleanliness were consistently considered important for livability performance by the inhabitants. Table

3 clearly illustrates, that inhabitants cited safety as the most important indicator of successful livability performance with mean response of 7 in the scale of 1 to 8. Safe campus encourages walkability which in turn improves social interaction; people can walk without fear at any time of the day, elders and kids walk around independently to parks, playground and grocery shops. Moreover, they can have sound sleep during night. Safety and cleanliness were the two indicators that were not rated to the minimum value, whereas, all other indicators were rated minimum at least for once.

Infrastructure and public services with mean response of 6.38 too was given importance almost equal to safety. Pothole free roads with pedestrian walkways, sufficient street furniture and shade providing trees all along the pedestrian pathways add to the livability performance. Regular and sufficient water supply, electricity, well maintained sewer lines and surface drains, easily accessible communication network all contribute to livability performance. Nursery school, health centre, sufficient parking lots, temple and day to day needs fulfilling shopping centre are the public services rated highly for livability by inhabitants.

Recreation and amenities like clubhouse, green and open spaces, children park, joggers pathway and party hall are also rated with highly (mean response 5.09) along with cleanliness and natural environment (mean response 4.79) indicator by the inhabitants. Neat and clean pathways, lots of green spaces and trees, less of paved surfaces contributes to livability. Inhabitant's responses was positive for various types of community spaces like parks, open spaces, playgrounds and community halls which are good interacting places, encourages community living and social bonding. A distinct characteristic was rated moderately (3.01) followed by good connectivity (mean response 2.47) and housing options (mean response 2.47). All the interviewee had their own vehicles so to them connectivity by means of public transport is not very important indicator to define livability. Standard deviation for housing options is comparatively higher than other indicators which indicate that respondents were inconsistent in rating and suggests that they were not sure whether housing option contributes to livability or not. Housing options in their opinion is least significant in contributing to livability performance as more number of people had rated it lowest.

6. CONCLUSIONS

The comparative of mean responses of inhabitants and professionals indicate that safety, infrastructure and public services were important for professionals and inhabitants confirming the importance of these livability indicators in deciding the livability of a residential project. Recreation and community spaces were also rated both by inhabitants and professionals as moderate contributor to successful livability. The indicators like good connectivity, cleanliness and natural environment, distinct characteristics and housing options were

perceived differently by inhabitants and professionals. Professionals viewed good connectivity and varied housing options as an important indicator, whereas, inhabitants perceived both indicators not so important in contributing for livability of residential areas. However, inhabitant's opinion about cleanliness and distinct characteristics were more positive than professionals. Inhabitants experienced these two as an important contributor to livability.

The utility of the comparative analysis is to understand: how successful livability performance is perceived by professionals and how the identified indicators of livability were judged by inhabitants. This analysis will help the planners and colonizers to improve livability of residential areas by giving due consideration as per the livability performance as perceived by the inhabitants.

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Transport and Energy Interaction – A Systems Approach

A. Azhaginiyal and Dr. G. Umadevi

Abstract

The major objective of the paper is to study and appreciate the existing transport demand and supply in Chennai city; to procure data through inventory on energy requirement from transportation sector and to build a System Dynamics (SD) Model using STELLA to determine the energy requirement levels from the transport sector for the year 2026. When the existing growth trend was assumed to be continued over the horizon year it was found that the Public Transport sector contributed to only 18% of the total trips, whereas, the personalised modes contributed to about 80% of the trips with about 300% increase in fuel demand. A scenario of augmenting the public transportation and simultaneously restricting the growth of personalized vehicles showed a substantial decrease of nearly 65% in energy consumption.

1. INTRODUCTION

India is the sixth largest energy consumer in the world. The transport sector of the country accounts to nearly 19% of global energy use which is projected to reach 50% by 2030. Studies reveal the fact that at the present rate of economic growth, energy needs may increase by 16% and more with respect to the present scenario. This increase in energy use leads to an increase in carbon di-oxide emissions also. It has been projected that the greenhouse gases emission will increase at a rate of 7% per annum (Zhou et al., 2007). Hence, proper planning measures are required in order to ensure developments towards achieving sustainability and efficient transport planning.

2. NEED FOR THE STUDY

In 2005, India's transport sector consumed 11% of its total primary energy demand (16.9 % of commercial energy supply). And 78 % of this demand was consumed by road transport, 11% by aviation, 10% by rail transport and 1 % by inland water. The transport sector is set to grow at over 6% per annum on the back of rising economic activity and a rapid surge in the vehicle stock. By 2030, the share of transport sector is likely to double to about 20% of primary energy demand. Globally, the share of the Indian transport sector is likely to triple from its low as 2% in 2005 to about 6% in 2030. The growth of transport sector, primarily

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driven by road transport and will remain heavily dependent on the availability and affordability of oil. For the energy requirement of the country as a whole, coal will, however, remain a dominant fuel with its share of 48% of total energy needs in 2030, followed by oil at 25%. The total demand of primary energy is likely to increase by 3.5%. This demand is higher than the world average of 1.6% (K. P. Singh, 2009). As a result, India will become more dependent on imports and hence, will be exposed to global supply risks and external price shocks casting a shadow on the long term sustainability, economy and security of its energy requirements. Hence, a collective effort and unified policy direction is the need of the hour to face the challenges.

3. OBJECTIVES OF THE STUDY

- To study and appreciate the existing transport demand and supply in Chennai city;
- To procure data through inventory on energy requirement in transportation sector;
- To build a System Dynamics Model that would address the transport and energy interactions and test the same for various policy and scenario options; and
- To suggest appropriate measures that would ensure developments towards achieving sustainability in Transportation Planning.

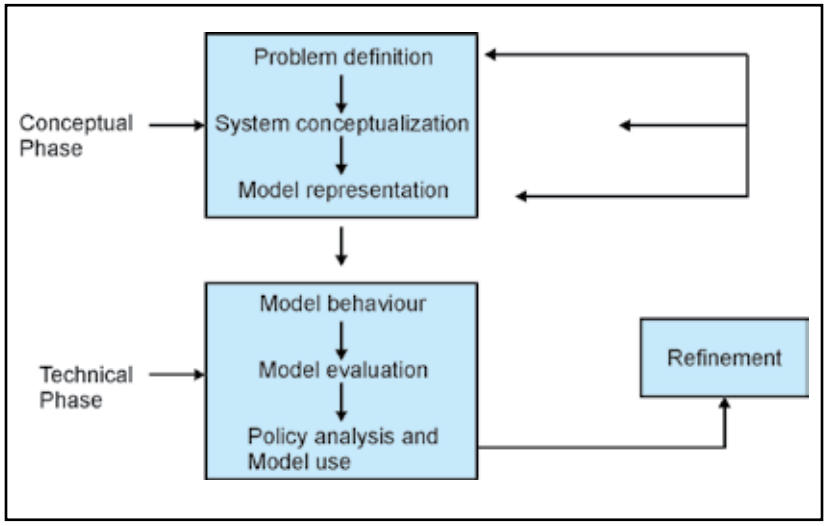
4. SCOPE OF THE STUDY

In this study, a System Dynamics Model relating transport and energy sectors has been built. Data relating to transport energy usage in the present scenario has been collected and simulated to find the future energy demand for the transport sector. The model has been subjected to various scenario analysis aimed at studying the interaction between transport and energy of the study area under various conditions. The impacts of the policies framed by the government to achieve sustainability in transportation with respect to economic development has been analysed at a macro level. A comparison of the results under various scenario options has been carried out to determine the advantages of the policy measures to be adopted. Based on the results, suitable recommendations of policies have been made. The impact of transport, energy and emission on the economy of the nation can also be studied in detail based on the results obtained. Also further research could be carried out to determine the advantages of using alternate fuels instead of petrol and diesel and the advantages of adopting EURO VI emission norms in the near future. The impact of these scenarios on the economy of the nation can also be analysed.

5. SYSTEM DYNAMICS MODEL DEVELOPMENT

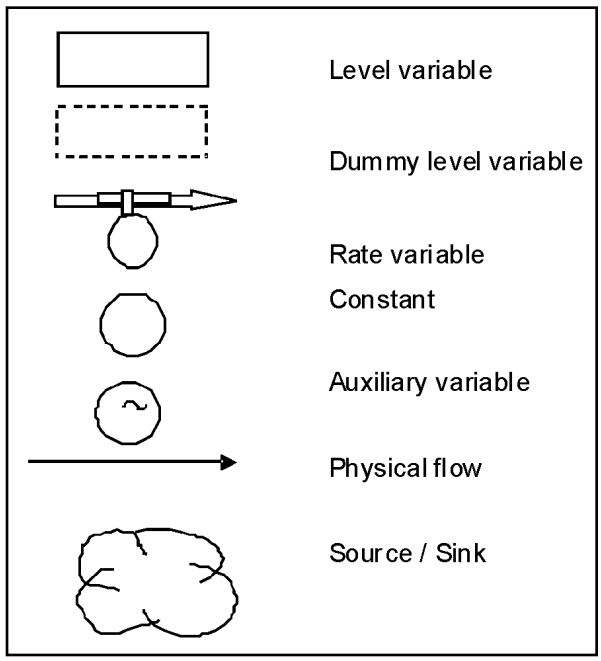
Generally, the model building process can be divided into two phases, namely, the Conceptual Phase and the Technical Phase. It is the process of defining a problem out of a situation; developing various relationships quantitatively; testing the model with several policy options and analysing the behaviour of the model. The various phases for model building process is shown in Fig. 1 and in each phase its characteristics is presented.

Fig. 1 : Phases in Model Building Process



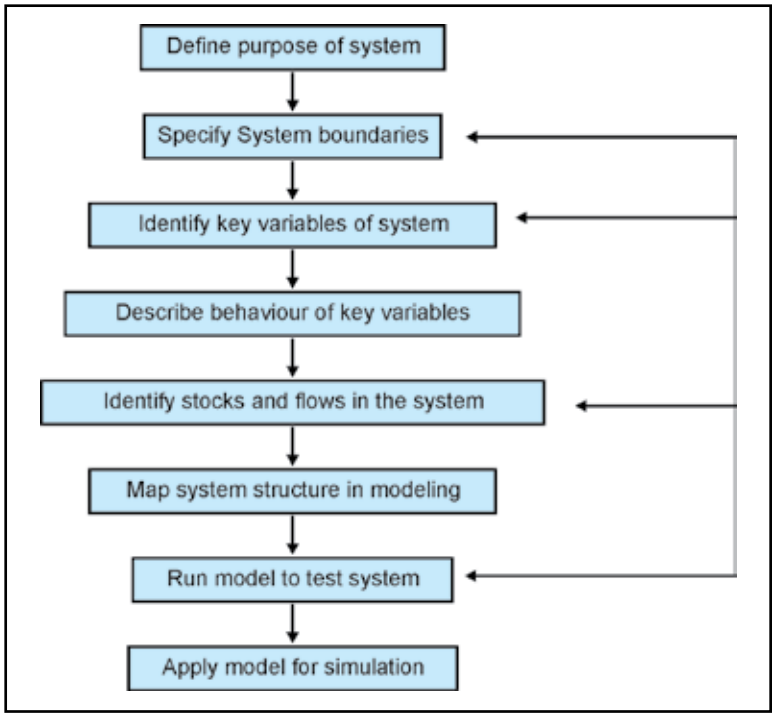
The first phase of problem defining involves, recognizing and also defining a problem. System conceptualization is the important influences believed to be operating within the system mostly in the form of causal-loop diagram. In the next phase, models are represented in the form of computer code that can be fed into the computer in the form of computer programming language. In the model behaviour phase, computer simulation is used to determine, how all the variables within the system behave over a period of time. Numerous tests are to be performed on the model in the model evaluation phase to evaluate its quality and validity. In the final phase, the model is used to test alternative policies that might be implemented in the system under study. Furthermore, the analyst might be able to investigate the possible impacts of government policies.

Fig. 2 : Flow of Diagramming Symbols



The system dynamics tool used in this study, has four basic building blocks namely stock, flow, connector and converter. Stocks or levels are used to represent anything that accumulates. Flows or rates represent activities that increase and decrease stocks. Connectors are used to establish the relationship among variables in the model represented graphically

Fig. 3 : System Dynamics Model Development Life Cycle



as arrows. Converters transform input to output which can accept input in the form of algebraic relationships, graphs and tables. For ease of presentation, the symbols used for flow diagramming of system dynamics are presented in the Fig. 2.

The concept of the stocks and flows in system dynamics is very appropriate to deal with a transport, energy and economy interaction modeling. The system dynamics approach is based on theory of feedback processes. A feedback system is influenced by its own past behaviour. This system has a closed loop structure that brings result from past interactions of the system. Negative feedback seeks a goal and responds as a consequence of failing to achieve the goal. It is a negative feedback or goal - seeking structure of the system that causes balances and stability.

The System Dynamics Model development process is summarised in the schematic diagram of a model life cycle in Fig. 3. The modeling process starts with defining the purpose/goal of the system. Then boundaries of the system to be modelled are specified. This is followed by identification of key variables in the system that affects the system, the most. Then behaviour of the key variable is described, the stocks and flows are identified, and their structure is mapped.

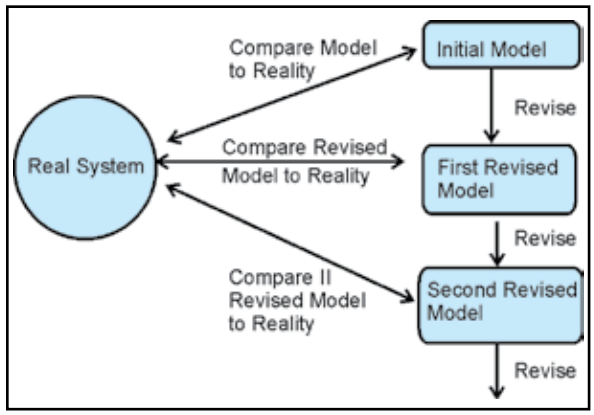
In the modeling tool using basic building blocks. Quantitative information, i.e., equations and data, is included in the model structure. The model is run to test the behaviour. The model is then evaluated and adjustments are made. Once the model is replicating system behaviour, it is ready for simulation modeling.

5.1 Model Verification

The purpose of model verification is to assure that the conceptual model is reflected accurately in the computerized representation. The conceptual model quite often involves some degree of abstraction about system operations, or some amount of simplifications of actual operations. It provides answers to the questions like, Is the conceptual model (assumptions on system components

and system structure parameter values, abstractions and simplification) accurately represented by the operational model (i.e., by the computerized representation). Verification and Validation although conceptually distinct are conducted simultaneously by the modeler.

Fig. 4 : Iterative Process of Calibration of a Model



5.2 Model Calibration

Calibration is the interactive process of comparing the model to the real system, making adjustments (or) manipulations (or even major) changes to the model, comparing the revised model to reality, making additional adjustments comparing again and so on. The model calibration process can be pictorially represented in Fig. 4.

5.3 Model Validation

Validation is the overall process of comparing the model and its behaviour to the real system and its behaviour. After the model has been calibrated using the original system data set, as "final", validation is conducted using the second system of data set. If unacceptable discrepancies between the model and the real system are discovered in the "final" validation effort, the modeler must return to the calibration phase and modify the model until it becomes acceptable. Validation is not an 'either/or proposition'. No model is ever totally representative of the system under study. (Banks and Carson 1996).

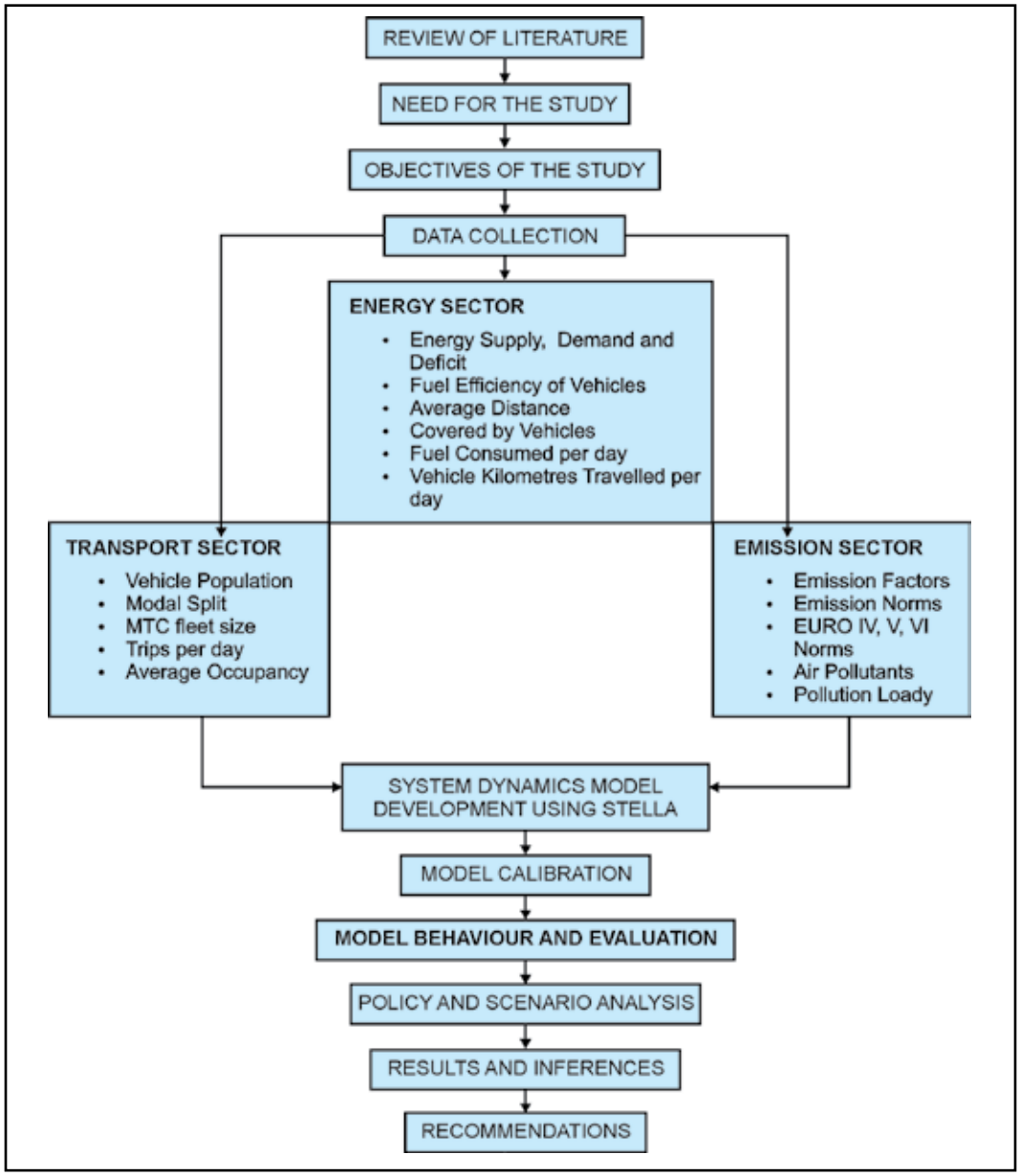
6. METHODOLOGY

The methodology for the model development and analysis of the same has been provided in the form of a flow chart in Fig. 5. Carrying out a review of various literatures in the study area is the initial work required. Based on the review, a methodology to analyse the work to be carried out has been figured. The need for study and the primary objectives to be fulfilled, have been discussed earlier. The analysis starts with the data collection required for the study. As far as this study is concerned, the data required is only secondary data which has been collected from various journals and reports pertaining to the data. After the model conceptualisation has been carried out, model building, analysis and testing the model for various scenario options has been carried out. Based on the results obtained, suitable recommendations for policy options have been given.

7. DESCRIPTION OF STUDY AREA

The area selected for study is Chennai city as shown in Fig. 6. Chennai is the fourth most populous metropolitan area and the sixth most populous city in India. The Chennai Metropolitan Area (CMA) is spread over an area of 1,189

Fig. 5 : Study Methodology for SD Model Development



sq km which consists of Chennai city (174 sq km) and parts of Thiruvallur and Kanchipuram districts. Chennai city is governed by the Chennai Corporation which was established in 1688 and is the oldest municipal corporation in India. In 2011, the jurisdiction of the Chennai Corporation was expanded from 174 sq km to an area of 426 sq km.

The sectors under consideration for this study are Population, Transport (trips), Energy. In spite of the recent expansion of the city, the revised data for the

Fig. 6 : Map of the Study Area – Chennai City

above sectors are not yet available for the new jurisdiction. All the data were available only for the old city, hence this study is limited to the older area of Chennai city with an area of 174 sq km.

As of 2011, Chennai Metropolitan Area (CMA) had a population of 7.34 million and Chennai city had a population of 4.68 million within the area administered by the Chennai Corporation. According to the Transport Department's Report, the city's total vehicle population had increased to 32 lakh from 8 lakh barely 12 years ago. Car and two-wheeler ownership in Chennai per 1000 population is 45 and 181 respectively. The two-wheeler population of the city shot up by 2.58 million in 2011 from 0.93 million in 2001, while the number of four - wheelers jumped to 0.56 million in 2011 from 0.21 million in 2001.

The alarming rise in the vehicular population has a greater impact on the petrol and diesel consumption of the city. Chennai city's total fuel requirement per day is 4,600 kilolitres per day with 2,100 kilolitres of petrol and 2,500 litres of diesel.

8. DATA COLLECTION AND ANALYSIS

8.1 Population Sector

In this section, population of the base year, birth rate, death rate, in migration and out migration are the variables which have been studied. Birth and death rates are the factors useful to estimate the future population in the study area. Total birth and death rates are increasing from decade to decade but their rates are decreasing. The registered birth rate in Chennai city segment was 24.06 in 1991 and reduced to 22.62 in the year 2003. The death rate also declined from 9.20 in 1981 to 8.01 in 2003. However, net natural increase in population had been decreasing from 22.00 in 1981 to 14.61 in 2003.

The long-term demographic goal as laid down in the 'National Health Policy-1983' is to achieve a reproduction rate of unity i.e. Net Reproduction Rate (NRR) equal to one by the year 2000 A.D. this corresponds to achieving a birth rate of 21 per 1000 population, death rate of 9 per 1000 population and annual natural population growth rate of 1.2 percent. But the Eighth Five-Year Plan envisaged that NRR of one would be achievable only during the period 2011 to 2016 A.D. for the whole nation. Surprisingly, the state of Tamil Nadu achieved this target by the year 1991 itself i.e. 10 year ahead of the projected period. This is mainly due to dynamism in demographic situation revealed by the 1991 census rather than stagnation. Tamil Nadu has also achieved a low level of Total Fertility Rate (TFR) as 2.2. Part of the reason can be traced to the strong political will for small family, success of family planning programme and efficiency of the official bureaucracy of the State. The State Family Planning Council for Tamil Nadu projects that the Crude Birth Rate (CBR) of Tamil Nadu is likely to decline from the current level of 21 to 15 per 1000 population by the year 2000 and 10 per 1000 population by 2010.

Table 1 : Migration to Chennai City (person in lakh)

Year	Total Population	Total Migration in the City from							Percent of Total Migrants in the Total Population
		Other Parts of Tamil Nadu		Other Parts of India		Other Countries		Total	
		No.	Percent	No.	Percent	No.	Percent		
1961	17.49	4.47	69.45	1.71	26.6	0.25	3.90	6.44	36.80
1971	26.42	5.51	70.61	2.00	25.63	0.29	3.76	7.80	29.52
1981	32.84	7.19	71.28	2.55	25.31	0.34	3.41	10.08	30.70
1991	38.43	6.44	70.51	2.42	26.47	0.28	3.01	9.18	23.90
2001	43.43	6.98	74.49	2.23	23.80	0.16	1.71	9.37	21.57

Source: www.cmdachennai.gov.in

Table 2 : Composition of Population Growth in Chennai City (in Person)

1	Population in the reference year	32,84,622 (in 1981)	38,43,195 (in 1991)
2	Natural increase	6,40,370 (1981-91)	5,82,745 (1991-01)
3	Inmigration	9,18,298 (1981-91)	9,37,111 (1991-01)
4	Jurisdiction change	-(1981-91)	-(1991-01)
5	Sum of (1) to (4) above	48,43,290	53,63,051
6	Population in the next reference year	38,43,195 (1991)	43,43,645 (2001)
7	Net increase in population	5,58,573 (1981-91)	5,00,450 (1991-01)
8	Outmigration (Arrived)	10,00,085 (1981-91)	10,19,406 (1991-01)

Source: www.cmdachennai.gov.in

According to 2001 census, migrants to Chennai city from other parts of Tamil Nadu state constitute 74.5 percent. The growth of inmigrant population shows a declining trend from 36.80 percent in 1961 to 21.57 percent in 2001. Migrants from other parts of India constitute 23.8 percent and the remaining 1.71 percent of the migrants is from other countries. The migration detail for the Chennai city segment has been presented in Table 1.

The composition of population growth for the Chennai city segment has been presented in Table 2.

8.2 Transport Sector

With respect to the transport sector, the data of prime concern are vehicle population and the existing modal split in the city which have been obtained from the 2nd Master Plan for Chennai, CMDA Report. The modal split between public and private transport trips in the city was 35:65 in the year 2004 which has been projected to reach 55:45 in 2011, 60:40 in 2016 and 70:30 in 2026.The vehicle population in Chennai city as on the month of April between the years 2006 to 2011 was collected from the Statistics of Transport Department, Chennai which gives

Table 3 : Vehicle Population in Chennai City in the years 2006-2011

VEHICLES/ YEAR	2006	2007	2008	2009	2010	2011	% Comp
Public Transport							
Buses	2803	3084	3260	3280	3421	3464	0.11
IPT Vehicles							
Auto Rickshaw	41316	39330	51113	44973	49062	63640	2.00
Taxi	283	284	1165	1252	1259	1268	
Other Vehicles							
Private Bus	883	926	2376	874	2702	2906	0.16
Mini Bus	902	961	1709	1129	2095	2217	
Personal Modes (in lakhs)							
Motor cycles	6.72	7.86	8.96	10.41	13.71	15.63	97.73
Scooters	2.86	2.98	3.12	3.20	3.33	4.03	
Mopeds	4.69	4.76	4.82	4.90	4.97	6.15	
Two Wheelers	14.27	15.60	16.90	18.51	22.01	25.81	
Cars	3.35	3.66	4.00	4.41	4.82	5.80	
Total (in lakhs)	18.08	19.71	21.5	23.43	27.41	32.34	100

Source : www.tn.gov.in

the data regarding the total number of commercial and non-commercial vehicles in the city and the data considered for this study have been given in Table 3. Data pertaining to the total number of trips per day made by the public transportation system comprising the bus and the rail system were also obtained from the 2nd Master Plan of Chennai. The MTC buses, with a fleet size of around 3500 buses cater to 36 lakh trips/day and the train services comprising of three sub-urban routes and MRTS route cater to 3 lakh commuter trips per day. The sub - modal split between bus and rail was 91:9 in the year 2005 which has been projected to reach 75:25 in 2011, 70:30 in 2016, 65:35 in 2021 and 60:40 in 2026. These projected values have been considered for various scenario analysis.

Table 4 : Average Fuel Consumption By Different Classes of Vehicles

Type of Vehicle	Average Distance Covered (km/day)	Fuel Efficiency (km/l)	Fuel Consumed (Litres/veh/year)
Two Wheelers	18	53	124
Three Wheelers	96	21 (Petrol)	1669
Cars	22	13.5 (Petrol) 14.0 (Diesel)	593 571
Mini Bus (Diesel)	22	8.7	897
Bus	151	4.1(Diesel)	13415

Source: Report of the Expert Group, Government of India Report, February 2010

8.3 Energy Sector

With respect to the Energy Sector the fuels of prime concern were petrol and diesel. Hence, data pertaining to the fuel consumption per day by petrol and diesel driven vehicles have been collected from earlier studies and presented in the Table 4 and the respective fuel efficiency values have been used in the model analysis.

9. MODEL DEVELOPMENT

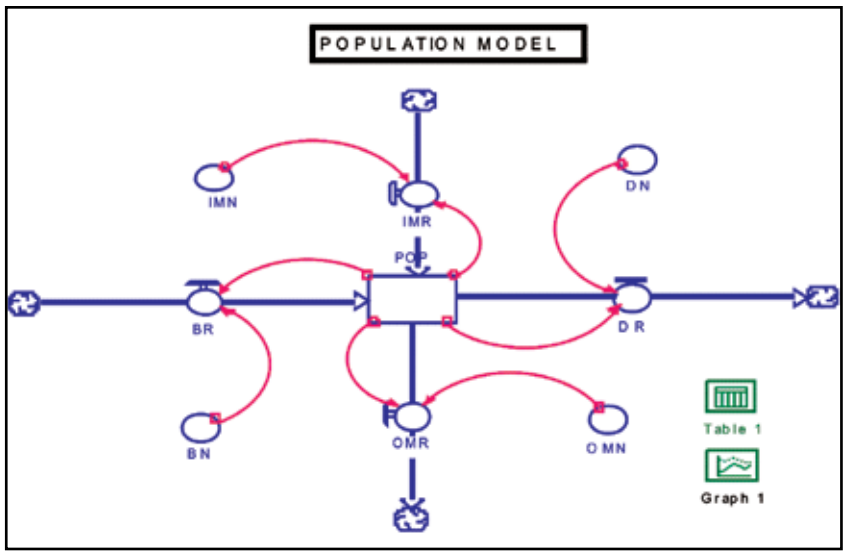
9.1 Population Sector

After the identification of key variables, the model for the population sector has been developed based on the causal loop diagram. The System Dynamics Model for Chennai city segment population sector is shown in Fig. 7. The various parameters considered for building the population sector model are:

POP - Total Population
BR - Birth Rate
DR - Death Rate
IMR - In Migration Rate
OMR - Out Migration Rate
BN - Birth Normal
DN - Death Normal
IMN - In Migration Normal
OMN - Out Migration Normal

In this sector, population of the base year, birth rate, death rate, in migration and outmigration are considered. The size of the population is influenced by both the net birth rate and net migration rate. The net birth rate equals the total number of births per year minus the total number of deaths. Similarly, the net migration rate equals the number of in-migrants minus the number of out migrants. However, the number of births and deaths as well as

Fig. 7 : Population Model for Chennai City



net in-migrants can be defined as a yearly percentage of the population. Hence, the population model contains one level and four rates as stated below:

Population (t) = Population (t-dt) + (Birth_Rate + Inmigration_Rate – Death_Rate – Out_Migration_Rate) * dt

Chennai city segment population is the level variable. The level is influenced by the birth rate, death rate, in-migration and out-migration rate.

Chennai city segment base year population is taken as 43.43 lakh persons as per 2001 census. The birth rate is influenced by the number of births per 1000 population, birth rate normal and initial population. Birth rate is determined by multiplying the birth rate normal by the population. Birth rate normal is expressed in terms of number of births per 1000 of the population. It is taken as 22 per 1000 population as per 2001 census data (CMDA, 2012) and expected to reduce to a value of 10 per 1000 by 2026, based on previous trend and health policy of the government (in 2016). Death rate normal is defined as the number of deaths for every 1000 population. It is considered to be 8 per 1000 population as per 2001 census data (CMDA, 2012) and expected to reduce to a value of 6 per 1000 by 2026.

In Chennai city segment the total migrant population coming from rural and other parts of urban areas was 9.37 lakh per year during 1991-2001, whereas, it was 9.18 lakh during 1981-1991. This implied that 9.37 lakh people migrated to Chennai city segment every year, accounting for 2.15 percent of the total Chennai city segment population. Similarly, out-migration from Chennai city segment to CMA segment is found to be 1.01 lakh per year during 1991-01, whereas, it was 1.00 lakh during 1981-91. Similarly, this implied that 1.01 lakh people migrated from Chennai city to its suburbs and other areas within CMA every year, accounting for 2.34 percent of the total Chennai city population.

The graphical output from the population sector model has been given in Fig. 8, which, shows a declining trend in birth and death rates in accordance with the health policy of the government.

9.2 Transport and Energy Sector

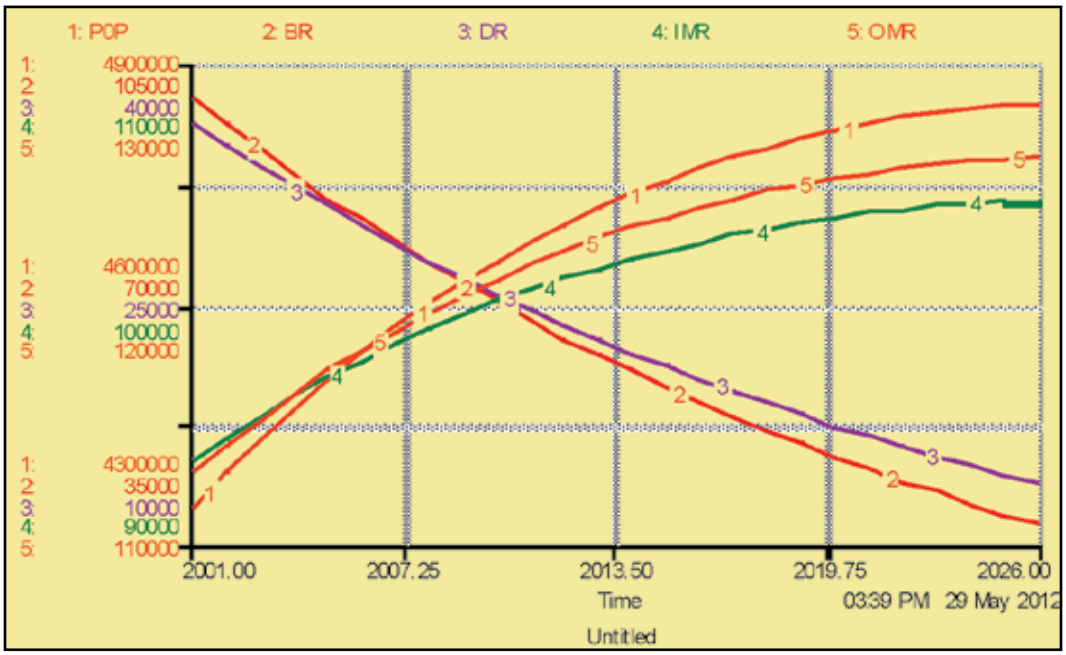
Based on the causal loop diagram the System Dynamics model addressing the interactions between transport and energy sector has been developed which is given in Fig. 9. The various parameters considered for building of transport sector model are as follows:

TOT - Total Vehicle Population

GR - Vehicle Growth Rate

ADT - Average Distance Travelled by the Vehicle per Day

Fig. 8 : Population Growth Trend (2001-2026)



POP - Population BR - Birth Rate DR - Death Rate

IMR - In Migration Rate OMR - Out Migration Rate

FE - Fuel Efficiency of the Vehicle

FC - Total Fuel Consumed by the Vehicle

The vehicles considered under various sectors for the study are : public transport vehicles (Bus), IPT vehicles (auto rickshaw and taxi), personalised vehicles (two

Fig. 9 : Model Representation for Transport sector

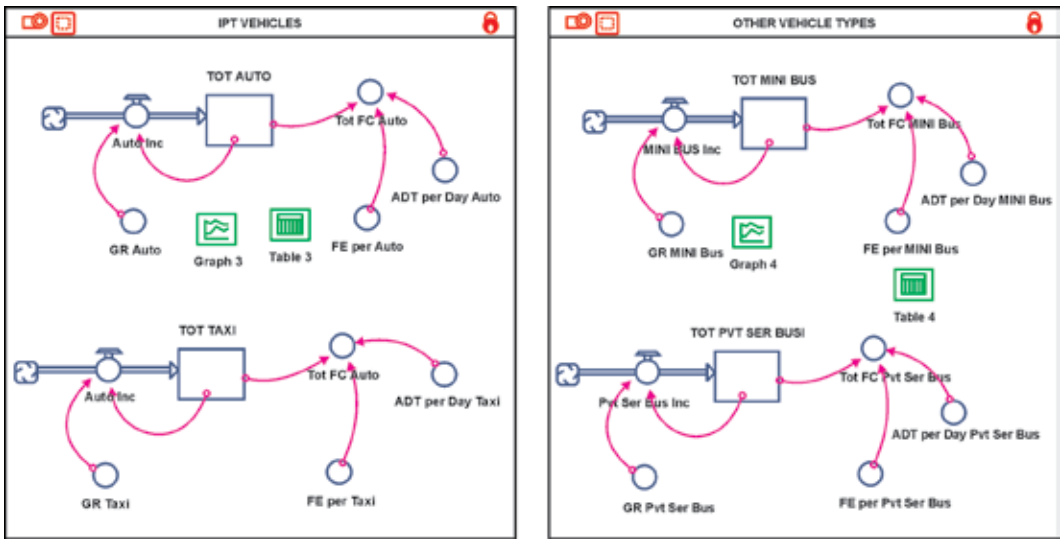


Table 5 : Results of Scenario I – Share of Trips by Modes (%)

Year	Public Transport			Personalised Vehicles Share	Other Trips Share	IPT Share
	Bus Share	Rail share	Total Public Share			
2006	91	09	32	64	1	2
2011	91	09	28	69	1	2
2016	91	09	24	73	1	2
2021	90	10	21	77	1	1
2026	88	12	18	80	1	1

wheelers and cars) and other vehicles sector (private bus and mini bus). The vehicle growth is assumed from the past trend. Using the values of average distance travelled per day and fuel efficiency in km / litre and the projected values of vehicle population, the final value of fuel consumption has been determined. In this study, the total trips made by rail contributing to public transport sector have been analysed. Sub-urban rail system within the city operates on electricity and hence, is devoid of emissions. The demand of electricity by rail sector has not been accounted in this research.

10. SCENARIO ANALYSIS AND MODEL RESULTS

10.1 Results of Scenario I

In the 'Do Minimum Scenario', the existing trend of growth rates of MTC buses, two wheelers, cars, IPT vehicles and mini bus has been allowed to continue till the year 2026. Also the modal split between public and private transport has been taken as 30:70 and the sub - modal split between road and rail has been simulated such that it changes from 91 : 9 to 88 :12. Based on the existing growth rate, the amount of fuel consumed by each transport sector and the corresponding emission levels have been simulated. The result showed that

Table 6 : Results of Scenario I –Fuel Consumed (litres per day)

Year	Bus	Auto	Taxi	Private Bus	Mini Bus	Diesel Cars	Petrol Cars	TW
	(in lakh)					(in lakh)		
2006	2.02	1.88	445	32520	2281	2.90	2.46	4.83
2011	2.28	2.29	467	35905	2518	4.16	3.53	7.27
2016	2.90	2.79	491	39642	2780	5.98	5.07	10.93
2021	3.49	3.40	516	43768	3070	8.59	7.28	16.44
2026	4.20	4.13	543	48323	3389	12.33	10.46	24.72

Table 7 : Results of Scenario II – Share of Trips by Modes (%)

Year	Public Transport			Personalised Vehicles Share	Other Trips share	IPT Share
	Bus Share	Rail share	Total Public Share			
2006	91	9	32	64	2	2
2011	89	11	29	68	1	2
2016	83	17	28	69	1	2
2021	76	24	33	65	1	1
2026	70	30	48	50	1	1

the share of public transport trips amounts to only 18%, whereas, the trips by personalised vehicles constitute the major share of 80% (Table 5).

In accordance with the increase in number of vehicles, the fuel consumed by each modes of transport also increases. The demand for petrol and diesel by personalised modes reaches to a maximum of around 35 lakh litres per day and 12 lakh litres per day in the year 2026. Similar amount of increase has been observed in other vehicle modes too. The fuel consumed by each vehicle type per day has been given in the Table 6. The increase in fuel consumption has concomitant increase in the level of emissions by the vehicles.

10.2 Results of Scenario II

In the partial efforts scenario (Scenario II), simulation has been carried out such that minimal efforts are undertaken by the government to achieve a modal split of 50:50 between public and private mode and a sub-modal split of 70:30 between road and rail transport. In order to facilitate the above condition, the public transport has been augmented in a phase wise manner to reach a growth rate of 17% by 2026 and simultaneously, the growth rate of two wheelers and cars have been restricted to almost half of the existing value i.e. 3% and 3.5% respectively in 2026. The hypothesis considered is that one bus will replace 19 cars and 38 two wheelers. On comparison with Scenario I, a remarkable decrease of 47% and 41% could be observed in Scenario II with regard to the trips made by cars and two wheelers. This decrease leads to a modal split value of 50:50 between public and private modes of travel as depicted in the Table 7.

Table 8 : Results of Scenario II – Energy sector Fuel Consumed (in lakh litres per day)

Year	Bus	Diesel Cars	Petrol Cars	TW
2006	2.02	2.90	2.46	4.83
2011	2.28	3.89	3.30	7.14
2016	2.96	4.98	4.23	9.84
2021	4.21	6.01	5.10	12.62
2026	7.84	6.44	5.46	14.63

Decrease in total number of two wheelers and cars shows a corresponding decrease in fuel consumption as shown in Table 8. The

Table 9 : Comparison of Scenarios I and II – Total vehicles and Fuel Consumed (FC) in 2026

Sector	Scenario I			Scenario III			% Inc/ Dec In FC
	Total Vehicles	FC	Share of Trips (%)	Total Vehicles	FC	Share of Trips (%)	
Bus	5853	4.2	18	18,902	13.57	68	(+) 223
Auto	90528	4.13	1	90528	4.13	1	0
Taxi	345	543		345	543		0
Cars* (Petrol)	6.42	10.46	80	2.21	3.61	30	(-) 65
Cars* (Diesel)	7.84	12.33		2.71	4.25		(-) 65
TW*	72.95	24.72		36.38	12.33		(-) 50
Mini bus	1340	3389	1	1340	3389	1	0
Pvt Bus	1312	48323		1312	48323		0

Note: * in lakh, Fuel Consumption (FC) values in litres per day

total fuel consumed by Two wheelers is 14.63 lakh litres per day which is 40% lesser than the fuel consumption in 'Do Minimum Scenario'. Also, a reduction of 45% and 47% is observed in fuel consumed by petrol and diesel driven cars respectively.

10.3 Results of Scenario III

In this scenario, the policy of government to achieve a modal split of 70:30 between public and private mode and the sub-modal split of 60:40 between road and rail has been achieved. Public transport has been augmented in a phase wise manner and simultaneously, the growth of two wheelers and cars have been restricted to 0.5% and 2% respectively in 2026. The hypothesis considered is that one bus will replace 19 cars and 38 two wheelers. The growth rate of trips by rail has been assumed to reach 21% in the year 2026. This increase can be attributed to the introduction of Metro and Mono Rail in the city and

Table 10 : Results of Scenario III – Share of Trips by Modes (%)

Year	Public Transport			Personalised Vehicles Share	Other Trips share	IPT Share
	Bus Share	Rail share	Total Public Share			
2006	91	9	32	64	2	2
2011	89	11	29	68	1	2
2016	77	23	30	67	1	2
2021	65	35	43	55	1	1
2026	60	40	68	30	1	1

a maximum utilisation of its services. The trend of change in share of trips between public and personalised modes of travel to the proportion of 70:30 can be observed in the results given in Table 10.

With the decrease in the vehicle population, the fuel consumed by personalised vehicles has been found to decrease as shown in the Table 11.

Table 11 : Results of Scenario III – Fuel Consumed (in lakh litres per day)

Year	Bus	Diesel Cars	Petrol Cars	TW
2006	2.02	2.90	2.46	4.83
2011	2.28	3.89	3.30	7.18
2016	3.00	4.92	4.17	10.05
2021	5.28	5.43	4.61	12.39
2026	13.57	4.25	3.61	12.33

Demand of petrol by two wheelers and cars is 12.33 and 3.61 lakh litres per day respectively and the diesel requirement is 4.25 lakh litres per day in diesel driven cars. This implies a reduction of 34% in the demand for diesel, 33% in petrol cars and 12% in two wheelers than Scenario II.

Thus, from the analysis of 'Desirable Scenario', it has been found that achieving a modal split of 70:30 gives very good results in connection with fuel consumption and emission levels. But an important fact to note at this juncture is that the above mentioned scenario is the most desired one and at the same time the most difficult one to be achieved too. On analysing the results of Scenario II (Partial Efforts Scenario) it could be noticed that it gives pragmatic results when compared to both Scenario I (Do- Minimum) and Scenario III (Desirable Scenario). Hence, it could be concluded that even if the desired Modal Split of 70:30 could

Table 12 : Comparison of scenarios I and III – Total vehicles and Fuel Consumed in 2026

Sector	Scenario I			Scenario III			% Inc/ Dec In FC
	Total Vehicles	FC	Share of Trips (%)	Total Vehicles	FC	Share of Trips (%)	
Bus	5853	4.2	18	18,902	13.57	68	(+) 223
Auto	90528	4.13	1	90528	4.13	1	0
Taxi	345	543		345	543		0
Cars* (Petrol)	6.42	10.46	80	2.21	3.61	30	(-) 65
Cars* (Diesel)	7.84	12.33		2.71	4.25		(-) 65
TW*	72.95	24.72		36.38	12.33		(-) 50
Mini bus	1340	3389	1	1340	3389	1	0
Pvt Bus	1312	48323		1312	48323		0

Note: * in lakh, Fuel Consumption (FC) values in litres per day

not be achieved by the government it could strive towards achieving modal split of 50:50 thus enhancing the quality of life of the people and the environment.

10.4 Comparison of Results

Scenario I – Do Minimum (Allowing the existing Trend to Continue)

At the present growth rate of vehicles in Chennai, public transport would share 18% of the total trips whereas personalised transport would share 80% of the total trips in the year 2026. This implies that the policy set by the government in achieving a modal split of 70-30 with respect to public and private transport is highly impossible.

Fuel consumed by the personal modes of travel viz. petrol driven cars, diesel driven cars and two wheelers would up 10.46, 12.33 and 24.72 lakh litres per day respectively in the year 2026.

This shows an alarming increase of about 300% to 400% in the fuel consumption by personalised modes of travel which would correspondingly increase the demand for petrol and diesel.

Scenario II – Partial Efforts Scenario (Augmentation of Public Transport and Restricting Growth OF Personalised Modes)

The Modal Split between public and private modes of travel has been achieved as 50:50 and the sub - modal split between road and the rail trips has been achieved as 70:30. When compared with 'Do Minimum' condition, fuel consumption in personalised mode of travel is found to reduce by about 48% in the case of petrol driven cars, 47% in diesel driven cars and by 41% in two wheelers.

Scenario III – Desirable Scenario (Augmentation of Public Transport and Restricting Growth of Personalised Modes)

Based on this Scenario, the modal split between public and private modes of travel has been achieved as 70:30 and the sub - modal split between road and the rail trips has been achieved as 60:40. This increase in rail trips can be attributed to the introduction of Metro Rail, Mono Rail and increasing the ridership in MRTS.

When compared with 'Do Minimum' condition, fuel consumption in personalised mode of travel is found to reduce by about 65% in the case of petrol driven cars, 65% in diesel driven cars and by 50% in two wheelers. This reduces the load on petrol and diesel demand.

11. CONCLUSIONS

From the study carried out, the following Conclusions are derired :

- There is an immediate need to restrict the growth of personalised vehicles and augment the public transport. This augmentation can be attributed to

increasing the MTC fleet size, introduction of Metro Rail and Mono Rail in the city.

- In order to achieve the modal split of 70:30, the MTC fleet size should be not lesser than 18,000 with efficient services. Also the Metro Rail and Mono Rail services should be implemented on time and operated with maximum efficiency.
- The growth rate of two wheelers and cars should be restricted to 0.05% and 2% respectively implying that the number of vehicles should be contained within 36 lakh and 4.93 lakh in the year 2026 to achieve the above mentioned policy of the government.
- This policy leads to a considerable reduction in pollution load of the city making it a place with reduced environmental hazards.

Since, the results of 'Partial Scenario' proved to be much better than 'Do Minimum' condition, it is recommended that even if the desired condition of achieving a modal split value of 70:30 cannot be done at least the government should strive towards achieving a modal split of 50:50.

12. MODEL EQUATION / OUTPUT (FROM 'STELLA' SIMULATION SOFTWARE)

Scenario I

TOT_AUTO(t) = TOT_AUTO(t - dt) + (Auto_Inc) * dt

INIT TOT_AUTO = 41316

INFLOWS:

Auto_Inc = TOT_AUTO*GR_Auto

TOT_BUS(t) = TOT_BUS(t - dt) + (Bus_Inc) * dt

INIT TOT_BUS = 2803

INFLOWS:

Bus_Inc = TOT_BUS*GR_Bus

TOT_CARS(t) = TOT_CARS(t - dt) + (Car_Inc) * dt

INIT TOT_CARS = 335932

INFLOWS:

Car_Inc = TOT_CARS*GR_Cars

TOT_MINI_BUS(t) = TOT_MINI_BUS(t - dt) + (MINI_Bus_Inc) * dt

INIT TOT_MINI_BUS = 902

INFLOWS:

MINI_Bus_Inc = TOT_MINI_BUS*GR__MINI_Bus

TOT_PVT_SER_BUS(t) = TOT_PVT_SER_BUS(t - dt) + (Pvt_Ser_Bus_Inc) * dt

INIT TOT_PVT_SER_BUS = 883

INFLOWS:

Pvt_Ser_Bus_Inc = TOT_PVT_SER_BUS*GR_Pvt_Ser_Bus

INFLOWS:

TOT_TAXI(t) = TOT_TAXI(t - dt) + (Taxi_Inc) * dt

INIT TOT_TAXI = 283

INFLOWS:

Taxi_Inc = TOT_TAXI*GR_Taxi

ADT_per_day_Auto = 96

ADT_per_day_Bus = 151

ADT_per_day_DC = 22

ADT_per_day_MINI_Bus = 22

ADT_per_day_PC = 22

ADT_per_day_Pvt_Ser_Bus = 151

ADT_per_day_Taxi = 22

ADT_per_day_TW = 18

FE_per_Auto = 34

FE_per_Bus = 4.1

FE_per_DC = 14

FE_per_MINI_Bus = 8.7

FE_per_PC = 13.5

FE_per_Pvt_Ser_Bus = 4.1

FE_per_Taxi = 14

FE_per_TW = 53

GR_Auto = 0.017

GR_Bus = 0.041

GR_Cars = 0.116

GR_Pvt_Ser_Bus = 0.269

GR_Taxi = 0.346

GR__MINI_Bus = 0.2

TOT_DC = 0.55*TOT_CARS

TOT_PC = 0.45*TOT_CARS

TOT_BUS(t) = TOT_BUS(t - dt) + (Bus_Inc) * dt

INIT TOT_BUS = 2803

Bus_Inc = TOT_BUS*GR_Bus

ADT_per_day_Bus = GRAPH(TIME)

(2006, 267), (2008, 267), (2010, 267), (2012, 316), (2014, 316), (2016, 316), (2018, 316), (2020, 316), (2022, 316), (2024, 316), (2026, 316)

FE_per_Bus = GRAPH(TIME)

(2006, 3.70), (2008, 4.00), (2010, 4.20), (2012, 4.40), (2014, 4.40), (2016, 4.40), (2018, 4.40), (2020, 4.40), (2022, 4.40), (2024, 4.40), (2026, 4.40)

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Delivery of Housing to Urban Poor through Partnerships: Review of Enabling Policies and Emerging Government Role

Dipti Parashar

Abstract

A plethora of policies and emphasis does little for implementation which would be observed only when the government shifts its role from a 'zero-cost policy' making approach to being in the forefront in provision of housing through PPPs. Despite the debates against PPPs, fact remains that they have an inherent potential for housing provision as neither the Government nor the Private Sector can shoulder the responsibility by themselves alone. An enhanced role of the Government is crucial along with innovative approaches and appropriate models along with clear institutional support to meet the desired demand.

1. INTRODUCTION

Delivery of housing and infrastructure to the urban poor is a pressing issue for the Government of India given that at the national level, the total housing shortage in urban sector is estimated at 18.78 million, of which over 95 percent shortage is of EWS and LIG housing. The urban population of India is expected to be 500 million by 2020 and the urban poor population is expected to increase from 100 million to 202 million by 2020 (National Population Policy, 2000). There is need for provision of urban housing and services at an unimaginable pace to reduce the current urban poverty levels and poor housing conditions that continue to grow. There is an urgent need to address the issue of slums and adequate housing for the urban poor, failing which there is bound to be an unmanageable urban scenario.

The Government has invested over the decades in the area of housing particularly for the urban poor through directly and indirectly related programmes like upgradation programs which typically included physical infrastructure investments and in other cases interventions and programmes related in terms of tenure security, social infrastructure, house quality and even facilitation of credit for the poor to promote housing ownership. However, the impact of these interventions was limited as the number of urban poor continued to grow and the required rate of housing supply was much higher than that possible for government alone to meet. The private sector was thus roped in to bring in the advantages that lacked with the government sector. The entry of the private sector envisaged faster deliveries, improved qualities in construction and better

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capacities for project implementation along with the much needed financial resources to match the urban services deliveries through facilitation by Policy and other support. Amidst the enabling environments of the past two decades, partnerships have emerged between the public and the private sector with the aim to garner the strength of both sectors and work together as partners for a common purpose.

The present study focuses, at understanding the changing role of the government in housing delivery particularly for the urban poor over the years and to evaluate the role of the government in the PPP model. The study focuses, on the cases of provision of new housing and corresponding evaluation through policies formulated for promoting PPP in housing delivery. The purpose of the research is to understand the models and practices of partnerships currently undertaken and to reflect on the emerging role and evaluate whether the same has potential for delivery of housing in an effective manner required. The research also aims to understand the reasons for limited implementation despite the governments' increased emphasis and policy support to PPPs.

2. CHANGE IN THE ROLE OF THE GOVERNMENT

The government role in provision of housing for the poor as well as the general public as evaluated through the Five Year Plans initially had been that of a 'provider' of housing which very much synced with the social nature of housing the masses. However, though programmes were implemented since the post-independence era, the government failed to scale up the supply and faced tremendous problems in provision of the housing with reasons ranging from lack of resources, financial constraints, lack of expertise and capacity constraints in delivering at the rate of essential demand, resulting in a growing housing shortage and a drop in the performance of housing delivery accompanied by a decline in the quality of housing. The role of the government at the time thus, began to be questioned as the scale of production could not be met (Tipple, 1994; Keivani and Werna, 2001); Owing to financial constraints and inabilities of the industry and administrative systems to cope with rising demand resulted in the problem being aggravated (Chakravarti, 1998; Ogu and Ogbuozobe, 2001). The government intervention as a provider resulted in a qualitative and quantitative shortage as investments and market supply of housing was restricted. Public housing schemes were noted to suffer on account of the same and the need for housing grew alarmingly during the period. There were criticisms against government involvement in housing and a cut back in its participation was sought as its public regulations and the rigid procedures hampered housing development (Malpezzi, 1990; World Bank, 1991).

3. PRIVATE ENABLEMENT AND NEED FOR FORGING PARTNERSHIPS

The National Housing Policy (NHP) formulated in 1994 marked a significant shift in the government's position at the time that propagated increased participation by the private sector whilst the government's role was to be emphasised in creating conditions to boost housing supply such as eliminating legal and regulatory constraints and supporting appropriate infrastructure investments. This was a notable shift in the public sector role from direct housing provision to engaging the private sector in constructing, financing, operating and maintaining housing units - from being a 'provider' to being an 'enabler'. The environment resulted in the government offering incentives for provision of the housing to the urban poor. Post enablement, the private sector was facilitated in reservation of land and housing for the poor and emphasis was laid through reforms for reservation by private began in terms of percentage of land and plots / houses / FAR in various States in lieu of incentives offered. The initial approaches of the government had involved tremendous subsidies and soft loans and there were failures in recoveries resulting in poor implementation of programmes. The private sector involvement anticipated specialised expertise, project sense, financial capacities, improved deliveries, technical expertise, efficient management and effective timelines. This was necessary as housing delivery through public sector failed to meet the needs of the urban centres. A greater role was thus envisaged for the private sector with limited role of the government, bringing in the forefront need for 'partnerships'.

Approaches like virtual land approach, slum rehabilitation approach, subsidy / cross - subsidy approach, rental housing approach, land redevelopment approach, partnership or equity sharing approach and facilitation approach, marked the move towards partnerships. Incentives in return were given to the private developers in the form of density bonus, expedited approval, reduced or no permit fee to avoid double stamp duty or no stamp duty, even commercial density bonus, etc. However, major constraints were observed in terms of land availability and absence of facilitating policies limited private engagement in a large way. The private sector being primarily profit driven had focused post-enablement majorly towards the provision of MIG and HIG housing. The high risks involved in housing deliveries for the EWS and LIG kept them away from providing the same (Rao: 1994). In the context of housing, the main argument for providing housing through a partnership rather than through sole private sector initiative is that housing is thereby made affordable and financially accessible to the poorest sections of society. Given that the commercial private sector tends to invest where the return on investment is high, a PPP would ensure sharing of the resources, responsibilities, risks and profits. The current housing crisis in developing countries has brought to focus the fact that collaborations

between stakeholders in the housing sector have become inevitable (Obeng-Odoom, 2009). PPP is seeking to change the way in which the government views its developmental role in society, in particular to limiting the extent of its investment while facilitating growth in the organizational strength of the private sector. Several studies also observed that purchasing a house under a PPP has generally become more affordable owing (U.Sengupta, 2005). PPPs thus present an avenue for the government to transfer the risks associated with public service delivery by passing its primary responsibilities on to the markets (Bovaird, 2004; Tomlinson, 2005).

4. EMPHASIS ON PRIVATE SECTOR PARTICIPATION

Great emphasis is currently laid in various policies and programmes through PPP models and support has also been put forth in terms of schemes and legal and institutional frameworks being put in place for enabling forging workable PPPs. The private sector emphasis is reflected in the 12th Plan wherein infrastructure investment worth US $1 trillion is anticipated, half of this from the private sector (Deepak Parekh Report, 2007). The National Urban Housing and Habitat Policy, 2007 (NUHHP, 2007) too recognizes the need for private sector involvement through market models to increase the access to urban land for the urban poor. Housing being a State subject in India requires states to formulate its own policies in sync with the national policies and consequently several policies like the ones for the Maharashtra, Rajasthan and Madhya Pradesh too suggest use of PPP models to increase housing supply for the urban poor in particular.

For the purpose of promoting, at the national level, the government has made efforts and mechanisms made available to states, union territories and cities through the Ministry of Finance and other agencies at the central level, to enable the inception, development and delivery of PPPs. Viability gap funding, the India Infrastructure Project Development Fund (IIPDF), the India Infrastructure Finance Company Limited (IIFCL) and creation of a panel of transaction advisors are few such initiatives that have been undertaken to strengthen the abilities of cities and states to structure and execute PPP projects (Department of Economic Affairs, 2007b;2007c;2008). Further, central programmes like Jawaharlal Nehru Urban Renewal Mission (JnNURM) - the national level reforms backed mission programme for development of cities launched in 2005 and the current Rajiv Awas Yojna (RAY) also propose tackling the existing housing shortages and to meet the future requirements, especially for the EWS / LIG that are otherwise forced into extralegal complications. However, despite policies being framed at various levels, the experiences of PPP in housing have not been forthcoming as anticipated making it essential to evaluate the PPP policies in the context of housing and the role of the government.

5. UNDERSTANDING THE ESSENCE AND LIMITATIONS OF PPP THROUGH POLICIES

A directive policy at the national level , the National Public Private Partnership Policy (NPPP) draft, 2011 defines PPP as "provision of public assets and / or public services, through investments being made and / or management being undertaken by the private sector entity, for a specified period of time, where there is well defined allocation of risk between the private sector and the public entity and the private entity receives performance linked payments that conform (or are benchmarked) to specified and pre-determined performance standards, measurable by the public entity or its representative" . The essential conditions listed in the PPP being, an arrangement with private sector entity, it being a public asset or service for public benefit with operations or management for a specified period, necessary definition of risk sharing with the private sector and integrated performance linked payments. The working paper by Department of Economic Affairs, Ministry of Finance (DEA, MoF) reflected that inorder to cater to different objectives and context, each competent government authority that uses the PPP definition to designate projects as PPP would need to specify its own set of essential conditions. Such conditions are in addition to the common definition and should be exclusively for a specific purpose like grant of VGF support, public scrutiny or provisioning of contingent liabilities, etc. In the context of housing, PPP is defined as "a business venture for production and sale or rental of housing involving both private and public sector agencies. Involvement of public agencies may be in the form of active facilitator through supportive policy / regulation or as equity holders" (Task Force on Affordable Housing, 2012).

5.1 State Policies for Private Participation with Suggestive Modes

In India, housing and land being state subjects necessitates formulation of state level policies in sync with the national policy directives for implementation. A review of the various State Policies on Housing, private sector participation and partnerships has been placed below with incentives.

Macro-level Assessment : It is evident that the policies framed by the government over time have depicted inconsistencies in terms of addressing the essential parameters of the PPP itself. The various policies are not synchronized reducing the role of government to only policy formulation. At the macro level there are several issues that exist which restrict picking up of PPPs in housing.

Risk Sharing is Lacking: Most of the policies lack in addressing the risk sharing condition of the PPP. Indian states like Gujarat and Andhra Pradesh and others which have introduced specific legislations for the promotion of Public Private Partnerships consider PPP to rarely involve private investments and though in

sync with government objectives, do not emphasize in risk sharing / transfer. This is lacking even in the recommendations of the 'Task Force on Affordable Housing on PPP' as well as in the State Policies. The major element of 'risk sharing' is crucial as In housing deliveries especially for the urban poor, risks involved are tremendous to cover and are not limited to availability of land, clear formulation of projects, land litigations, identification of beneficiaries and pre and post project management risks.

Affordability is Ambiguous : There is increased emphasis on 'affordability' within the partnership resulting in policies focusing on defining the affordability much more in the policy rather than the models of PPP and working arrangements. However, affordability as a parameter to regulate access of housing to the poor stands weak as it is highly dependent on a number of variables like the type of city, urbanization level in city, land availability in the city, job opportunities and expenditure patterns. Despite several definition proposed and used, there has been evidence of the urban poor falling above the prescribed brackets of affordability are still deprived of housing as the policy has not succeeded in addressing the same. As a result, target beneficiaries are wrongly identified resulting in an under or over estimation of the housing requirements depending on the context.

Support Schemes not Applicable to Housing : The DEA, MoF does not list housing as 'infrastructure' as a result of which much of the schemes and benefits and Viability Gap Funding (VGF) are not relevant to housing projects. The VGF Scheme, has been successfully used by GOI to provide financial support in the form of grants, one time or deferred, to infrastructure projects undertaken through Public Private Partnerships with a view to make them viable. Viability Gap Funding is currently not available for housing projects. Financial support is however, available to specific housing schemes that fall under special economic zone, etc. There has been a demand in recent times to classify housing as Infrastructure and extend VGF to housing projects. Other support to PPPs through creation of India Infrastructure Finance Company and India Infrastructure Project Development Fund, panel of Transaction Advisers and Model Concession Agreements, etc.; developed too are rarely applicable to housing and the inherent nature of housing makes it difficult to standardize procedures as they are contextual with differing problems.

Translation only through State Policies : In India, housing and land are state issues thus, national policies are only directives and most states need to put their own policies in place. There are several states that have not put their housing and PPP policies in place failing which no PPP can be undertaken. If emphasis on PPP is to be translated into mass housing options, there is a need to

Table 1 : Policies on Housing and Recommended Incentives

Policy		Key Incentives to the Developer
National Level Policy		
National Urban Housing and Habitat Policy, 2007		• Ensuring that 20-25 % of the FAR are reserved for EWS / LIG • Issuance of TDR on road widening clearance for transport bottlenecks in the inner-city areas • Relaxation of FAR ,Availability of additional FAR in Outer Zones
State Level Policies		
Rajasthan	Affordable Housing Policy (With focus on EWS/LIG housing: For Urban areas of Rajasthan), 2009	• Double of the normal FAR,TDR facility, for selected projects • Waiver of EDC, building plan approval fee, conversion charges, • 10% of the total land allowed for commercial use, • Fast track approval.
Madhya Pradesh	Housing and Habitat Policy, 2007	• Additional FSI will be given for providing higher developed areas for EWS/LIG housing. • One time transfer of additional FAR to another location prescribed will be permitted under TDR Scheme.
Maharashtra	Maharashtra State Housing policy, 2007	• Developer shall be paid TDR equivalent to FSI the area of land provided for rehabilitation project • TDR is available against the free-sale component which is approved by the SRA.
Uttar Pradesh	Uttar Pradesh Urban Housing Policy, 1995	• Developer cross subsidizes the cost of EWS and LIG houses from HIG and other higher users under the project. For this purpose, developer will get free transferable FAR equivalent to ground coverage of LIG/EWS houses.
Karnataka	Karnataka Housing and Habitat Policy (draft), 2009	• Permission for multi-stored flats for EWS/LIG in core city areas along with commercial component and appropriate incentives for PPP.
Gujarat	Gujarat (draft policy)	• The incentive of additional FSI of 50% of the FSI consumed in slum redevelopment is offered to the land owner/developer for the development on the remaining land
W. Bengal (Kolkata)	No codified policy but initiatives taken to build EWS and LIG housing under the flagship of Joint venture	• Land is provided by State Government • State Government helps with obtaining building plan clearances

Source: Task force on promoting affordable housing on PPP, 2012, Ministry of Housing and Urban Poverty Alleviation.

rapidly put all policies in place. This was emphasized through the reforms driven programme- JnNURM that necessitated even the enactment of a law for PPP.

Faulty Taxation Regimes : The government has not put forth in place a tax regime that effectively incentivizes the creation of affordable housing stock. Taxes account for more than 25% of the final cost to households of affordable housing (Mckinsey, 2010). Even the governments' current 5% interest subsidy scheme (RAY, 2009) is ineffective in the case of lower income groups because these groups do not have the access to the credit they need to afford the houses in the first place.

Ownership Models are Prevalent : It is observed that the predominant model of private participation and PPP undertaken is for the provision of ownership housing to the end-user. Often the units are provided free of cost to the end user. Very few PPPs are towards provision of rental housing as is the case of Mumbai. Despite the Task Force of Affordable Housing to promote PPP recognising rental housing within the ambit of the PPP definition, there have been few encouraged for the purpose of rental tenure. The recent programme of RAY too envisages provision of rental housing but the other policies need to be aligned to enable the same.

Micro - Level Assessment : At the micro level, the observation reveals that the various government policies stated in Table 1, focus at promoting housing through the Private sector and depicts a trend of incentivizing as a principle for facilitating provision of housing to the urban poor by encouraging private sector for land reservations, providing additional FAR and TDR, commercial FAR, incentive FSI, etc., coupled with waivers of external development charges, building plan approval fees, providing concessions for acquiring land and waivers of other fees, provision of equivalent FAR and commercial TDR is also offered, etc. However, the schemes of incentives have limitations.

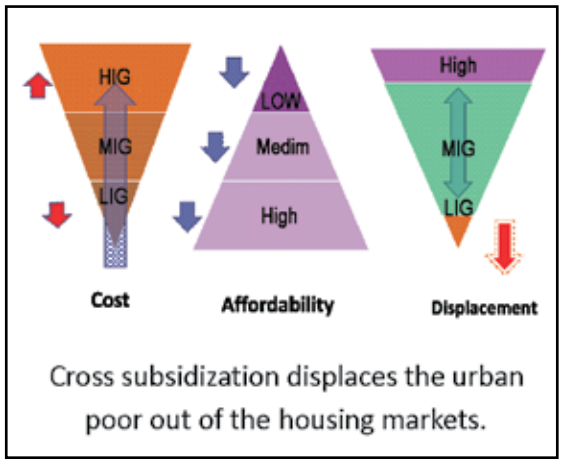
FAR / TDR – A Tool Over used : Translation of FAR and TDR schemes need city Master Plans to be redesigned and replanned to cater to the additional densities being mposed on the land and infrastructure. FAR and TDR concepts entail a greater role for the public sector / government in terms of zoning city plans for receiving such additional FAR / TDR as projects coming up in an ad-hoc manner would lay tremendous stress on the infrastructure as most Indian cities put forth urban land Master Plans generally planned for a vision of twenty years and such concepts would mean replanning these master plans and incorporating the concepts which would mean a lot of investment of time, manpower and financial resources. Though, developers provide some low cost housing as a package as it also allows them to use benefits and land, more intensively in the form of

increased FAR, the large part of the housing problem cannot be solved through these concepts alone. Using incentives and tradable development rights and FAR to provide free housing requires loading the cost of social housing onto the production of new units, by imposing overtax on formal housing making formal housing less affordable. (Annez and Bertaud, 2011). An example elaborated in the paper indicates that if the FAR incentives and TDR only are used for provision of new housing, the city of Mumbai would take twenty three years to provide apartments for the households currently living in slums, at a cost of five lakh by each household and not considering future demand.

Incentives alone cannot do the Math : Policies are based on the assumption that the private sector would be eager for the additional FAR and for the fast track approvals. Unless mandated, the private sector is not keen in accepting the additional benefits in lieu of housing provision for the urban poor within its projects. There is also no evidence that the enablement would facilitate faster approvals and may be counterproductive as there are additional mandates to fulfil, higher expertise in handling such projects and a clear project sense defining respective roles from the initiation of the projects and housing being dynamic tends to vary from city to city, situation to situation, concepts of how and where to use additional FAR, etc.; making it difficult to have universal models. There are several risks which may not be identified and crop up eventually considering the sensitivity of the subject of urban poor.

Cross - Subsidisation Results in more Informal Housing : Application of cross – subsidisation in general has limitations as it has not been proved to be a sustainable approach. It may work in the short run and is counterproductive as it constrains or taxes high end development to "promote" low cost housing and the effect is likely to be just the opposite (Annez and Bertaud, 2011). Production of new housing and taxing it implicitly with cross subsidies has a negative effect on the entire housing supply. Restricting supply pushes higher income groups lower in the pyramid, forcing the EWS and poor out of the formal supply and push them towards informal supply. (Fig. 1) Removing the rigidities that prevent market responses to shifting demands is hence more important to facilitate affordable housing; more important than the direct provision of housing.

Fig. 1 : Cross - Subsidisation Model



Institutional and Regulatory Mechanisms not in place : Institutional arrangements for regulating and ensuring the delivery of the reservations and

stock created to 'actual beneficiaries'. In cases where beneficiary identification criteria are laid through other schemes and policies, include ambiguous listings wherein the entire state urban poor are entitled for application to schemes in particular cities which does little to resolving the problem of the city. In addition, income parameters include requirement of documentation which is often unavailable and inaccessible for individuals to obtain. Thus, ambiguity prevails in ensuring created stock to be directed to the right beneficiaries.

6. CONCLUSIONS

The government role in Housing has undergone a change from 'provider' approach to 'enabler' to the currently much emphasised 'partnership' approach. However, at the policy level, there is little differentiation since enablement given that current PPP policies do not emphasise on the risk sharing aspect. There is no parity between the National Public Private Policy provisions and the directives in the policies on housing through PPP. The role of the government appears at the backhand and only limited to policy formulation. There is little emphasis in the policies to ensure conversion of the same into workable projects. Much of the support of the government extended to PPPs is not applicable to the housing sector. Further, the governments' predominant focus at promoting ownership housing is not a sustainable model as it puts forth greater challenges in terms of land availability and beneficiary identification. Given the few instances of PPP in Housing provision for the urban poor, it is unlikely that the current and future housing needs of the poor would be met in this manner.

TDR schemes, incentive FSI and policies for housing reservations for poor are appealing as they do not imply financial burdens and are proposed often at the cost of cross subsidising with other income groups that ultimately disturbs accessibility to formal housing supply thereby pushing out the urban poor. Concepts of FAR / TDR require greater city level managerial expertise which need to be forseen without which there would be deficiencies and stress on existing city infrastructure. These instruments are tools that set out targets which would never be achieved. With the need for formal housing for the poor growing at a required rate of four percent per annum, there is a need for setting out policies and schemes which would enable translation of the policies into provision in a large scale. Institutional arrangements need to be strengthened ensuring that projects reach the beneficiaries targeted and projects need to be identified and designated to contexts given the dynamic nature of housing for poor. Housing models based on provision of incentives to the developer - in the form of FSI, TDR, commercial TDR, free land in lieu of built units are financial incentives

for the project but it needs to be researched whether the same facilitates the project deliveries and justifies risks undertaken.

Providing concessions to builders for land assembly in lieu of provision of housing for EWS and LIG are zero cost policies which though practiced as PPPs, involve very little risk allocation. The current policies have actually enabled little and exhibit limited potential to help improve accessibility of housing for the urban poor. The policies require that projects are identified before hand and proposals cleared to facilitate provision of mass housing to the poor with faster implementation. This necessitates the government to take a forefront role in identifying relevant risks, evolving situational models, establishing institutional setups and deriving certain standardised models contextually if the scales of production required is to be met. Thus, the government needs to play an enhanced role, beyond providing policy support to make schemes and programmes relevant to housing and concentrate on models which are replicable to suit masses. It is a necessary to take on the larger risks like assigning land, clearing land titles, streamlining beneficiary identification processes and working on sustainable housing supply models to facilitate increase in numbers of PPP in Housing.

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Editor

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Passenger Dispersal Plan for the Proposed East-West Mass Rapid Transit Corridor in East Kolkata

Sumana Gupta and R. N. Datta

Abstract

Surface Transport in metropolitan cities gets reoriented with the implementation of grade separated high speed Mass Rapid Transit System (MRTS) along specific corridors. To some extent the reoriented surface transport integrates with the MRTS to acts as feeder service. For making this integration harmonious and effective in east of Kolkata, this article presents dispersal plans for MRTS passengers along proposed east - west MRTS corridor. The attempt has been to plan for feeder bus routes, identification of suitable locations for park and ride facilities, locating foot over bridges and subways for uninterrupted pedestrian movement to and from the eight proposed MRTS stations in the east of Kolkata.

1. INTRODUCTION

Implementation of the east - west Mass Rapid Transit System (MRTS) corridor in the city of Kolkata will bring in changes in the trip pattern of the city requiring reorientation of surface transit services. The MRTS route has been planned with interchange facilities at Central Station of the existing north - south MRTS. In the last two decades the city's employment zones as well as residential zones have grown in the east leading to increased traffic demand along east - west direction. Introduction of the new east - west MRTS route will bring in changes in land use along the corridor from residential to public and commercial uses. The changes in land use will result in more number of trips. This article attempts to present a dispersal plan for metro passengers along proposed east - west MRTS corridor in the east of Kolkata. The study identifies suitable internal roads that can be developed as feeder links to serve the east - west MRTS route. Feeder bus routes, suitable locations for park and ride facilities, foot over bridges (FOB) connected to the elevated concourse levels of the raised MRTS stations, and subways are suggested for uninterrupted passenger movement to and from the MRTS stations. The proposals take into account the existing transport infrastructures and also those under construction.

2. THE EAST - WEST MRTS ROUTE

The proposed east - west MRTS route (Fig. 1), in its first phase will originate from existing Howrah Maidan Bus Terminal area and pass through the railway terminals at Howrah and Sealdah. At present the two railway stations respectively handle 1.3 million and 1.58 million passengers daily. The route traverses underground

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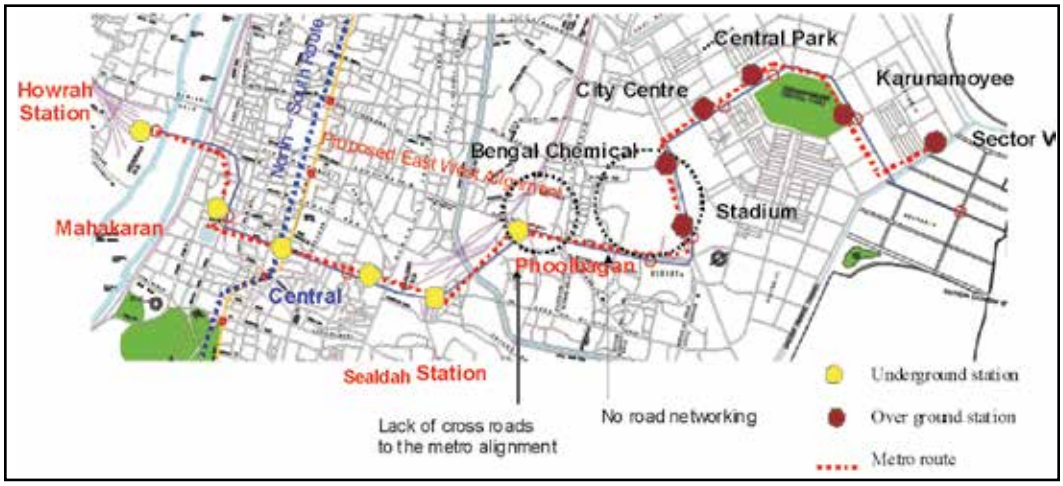
Fig. 1 : Proposed East-West MRTS Route in Kolkata.



along the busy central business district and the old residential areas and then moves over ground at the Eastern Metropolitan Bypass into Salt Lake City. It terminates at Sector V of Salt Lake city and in the near future will be extended to the Netaji Subhas Chandra Bose Airport through the new town, Kolkata. On implementation, the route is expected to improve the travel speed in the city. This can happen only if the feeder services, park and ride facilities and pedestrian dispersal at the MRTS stations are properly planned and implemented.

3. EXISTING LAND USE ALONG THE PROPOSED MRTS CORRIDOR

The breakup of land use in the adjacent areas of the MRTS corridor up to 500 meters on both sides of the corridor is indicated in Table 1. Detailed land use along the route was studied through reconnaissance survey and verified from Atlas of Kolkata (2006). The nature of land use along the proposed east – west MRTS line is indicated in Table 2. Land use Development Control Plan (LUDCP) of Kolkata was also referred to assess the possibility of land use change in the area. The study indicated that these areas have propensity and also legitimacy for land use changes.

Table 1 : Percentage Breakup of Land Use along MRTS Route

Existing Land Use Breakup of the Area	
Commercial	18%
Mixed use	53%
Residence	10%
Religious	5.50%
Institutional	2.50%
Recreational	2.50%
Roads	8.50%

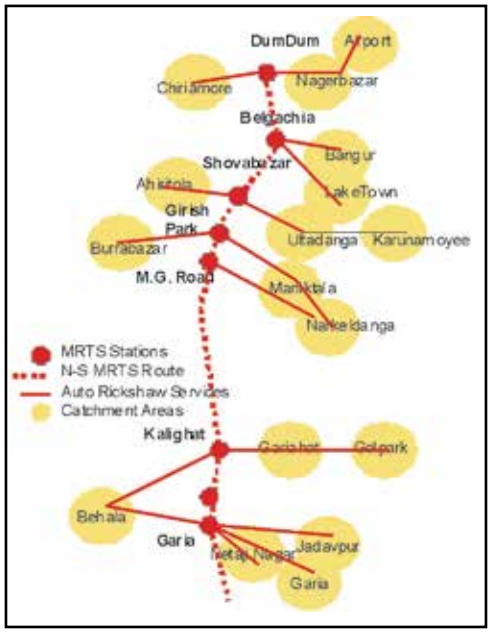
4. EXISTING FEEDER ROUTE ALONG NORTH - SOUTH MRTS ROUTE OF KOLKATA

As a part of this study a primary survey of auto routes connecting the MRTS stations along north - south corridor was conducted in the year 2007. The north - south MRTS route of Kolkata, constructed in 1970's, led to the gradual growth

Table 2 : Nature of Land Use along 500 Meters on Both Sides of the Proposed MRTS Corridor

Metro Station	Approx Percentage Breakup of Land Under Different Uses		Zone as Per Ludcp	Building Condition
	Government Owned Land	Privately Owned Land		
Howrah	Mostly government/ railway property			Moderate
Mahakaran	70% government offices	20%market area 10% mixed land use	Commercial zone	Mixed
Central and Bowbazar	30% schools, colleges, Institutions, 20% market	50% privately owned shops and residence	Commercial and Commercial-Residential zone	Moderate to bad Semi pucca, single storey
Sealdah	80% railway property, 15% College, Hospital and TI	5% residential	Commercial-Residential zone	Railway
Phoolbagan	30% Railway property, 10% Hospital, School, College	50% residential, 10% Industrial	Residential-Industrial zone	Mixed (Bastis, factories), New Apartment Building
Salt Lake Stadium	40% Recreational land and water body	15% vacant (42.73 ha)	Residential-Industrial zone	Good and temporary kuccha
Bengal Chemical	30% residence in good condition	15% Private factory	Land under Thika Tenancy Act	Factory sheds
City Centre	Most of the land is planned development		Under Saltlake Municipality	Good
Karunamoyee	40% land- public and Institutional use	60% land is under residential use	Under Saltlake Municipality	Good
Sector V		40% vacant land (high FAR for IT industries)	Under Nabadiganta	Good

Fig. 2 : Auto Rickshaw Survey Locations



of auto rickshaw services as feeders. This para - transit mode connects the residential as well as employment zones to the MRTS stations. The characteristics of the feeder auto routes are also indicated in Table 3.

Surveys were conducted at the MRTS stations to understand the nature of services provided by the auto rickshaws. The locations of survey are indicated in Fig. 2.

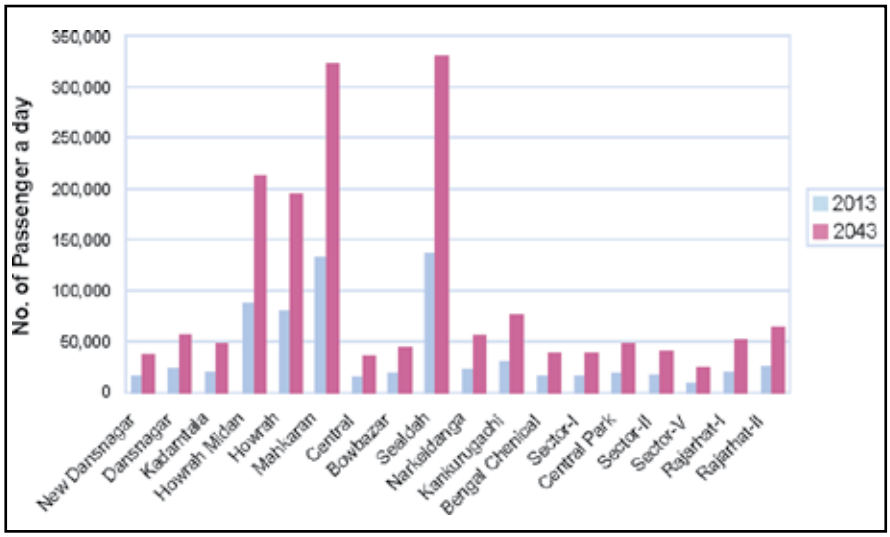
Observations from the survey are:

- At the terminal stations, numbers of auto rickshaw routes are more than that at the intermediate stations.
- Normal peak hours are from 8.00 am to 11.00 am. and 4.00 pm. to 8.00 pm.
- Average route lengths of auto rickshaw services vary from four to eight kilometers. At certain locations

Table 3 : Existing Auto Rickshaw Feeder Routes along North-South MRTS Stations.

Route (Origin-Destination)	Operating Distance	Peak Hour	Frequency	Total No. Autos	Fare Range	Auto Stand Location	Category of Roads through which Route Passes
Nagerbazar to Dum Dum	6km	8am -11am 6pm -8pm	5 per 5 min	40	Rs.4 -Rs.6	Road side	Primary Rd.
Chiria more to Dum Dum	4km	10am - 12am, 4pm - 7pm	5 per 5 min	30	Rs.4 -Rs.6	Road side	Primary Rd.
Airport to Nagerbazar	6km	8am -11am 6pm -8pm	4 per 5 min	25	Rs.4 -Rs.8	Beside bus terminus	Primary Rd.
Belgachia to Bangur	3km	8am -11am 6pm -8pm	6 per 5 min	40	Rs.5	Auto Stand	Primary Rd.
Belgachia to Laketown	2.5km	8am -11am 6pm -8pm	6 per 5 min	40	Rs.4	Auto Stand	Primary Rd.
Belgachia to Dumdum Park	4.5km	8am -11am 6pm -8pm	3 per 5 min	25	Rs.6	Auto Stand	Primary Rd.
Bidhannagar to Ahiritola	8km	8am -11am 5pm -7pm	3 per 5 min	30	Rs.4 - Rs.8	Road side	Primary Rd.
Shyambazar to Bidhannagar	4km	8am -11am 6pm -8pm	6 per 5 min	40	Rs.3 - Rs.5	Road side	Primary Rd.
Karunamoyee to Bidhannagar	4km	8am -11am 4pm -8pm	6 per 5 min	100	Rs.3 - Rs.10	Road side	Primary Rd.
Maniktala to Girish park	2km	8am -11am 5pm -7pm	5 per 5 min	25		Road side	Primary and secondary Rd.
Barabazar to Girish park	2km	8am -11am 5pm -7pm	5 per 5 min	30		On Secondary Road	Primary and secondary Rd.
Phoolbagan to Girish park	5km	8am -11am 5pm -7pm	3 per 5 min	30		Road side	Primary and secondary Rd.
M.G. Rd. to Phoolbagan	6km	10am - 12am, 4pm - 7pm	10 per 5 min	50	Rs. 3.50 - Rs. 6	On Secondary road	Primary and secondary Rd.
Gariahat to Kalighat	2km	8am -11am 5pm -7pm	5 per 5 min	45	Rs.4 - Rs.5	Road side	Primary Rd.
Behala to Kalighat	8km	8am -11am 5pm -7pm	10 per 5 min	60	Rs.4 - Rs.8	Road side	Primary and secondary Rd.
Golpark to Gariahat	5km	8am -11am 5pm -7pm	6 per 5 min	40	Rs.4 - Rs.7	Road side	Primary Rd.
Tollygunge to Garia	8km	8am -11am 6pm -8pm	6 per 5 min		Rs.7	Road side	Primary Rd.
Tollygunge to Hazra	3.5km	9am -11am 5pm -7pm	4 per 5 min	45	Rs.5	Road side	Primary Rd.
Tollygunge to Netaji nagar	3km	8am -11am 6pm -8pm	5 per 5 min	45	Rs.4	Road side	Primary Rd.
Tollygunge to 8B bus stand	3.5km	8am -11am 5pm -7pm	4 per 5 min	45	Rs.5.50	Road side	Secondary Rd.

Fig. 3 : Expected Trips at Proposed Stations along East-West MRTS, Kolkata



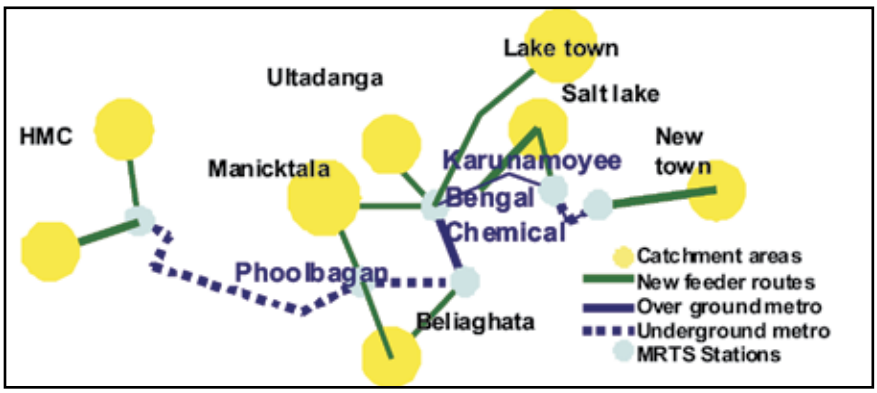
two interconnecting routes cover distances over eight kilometers from the MRTS stations.

- No auto rickshaw routes have developed in the CBD area due to the abundance of bus transit and traffic regulations that do not permit auto rickshaws to operate in the CBD area.
- The auto rickshaw routes in general terminate either at residential areas or transport nodes like the Ultadanga Railway station.
- Most of the routes move along the main roads, as a result intersections along these roads warrant improvements.
- The auto rickshaws do not have fixed stops along their routes; passengers are picked - up and dropped - off at convenient locations.
- In general the auto rickshaws do not follow traffic rules.

4.1 Feeder Route Plans for east - West MRTS Stations in the East of Kolkata

The part of the east - west MRTS line from Central Station to Sector V of Salt Lake has been considered as the eastern part of east - west MRTS in this study. Analysis was carried out for determining the origins of the trips to the metro stations by different access modes. The analysis was based on the data on ward wise population (Census 2001), work force participation ratio (Census 2001), the projected data for population and employment along the corridor for years 2011 and 2021 (DMRC, 2006) the station volumes at the proposed MRTS stations

Fig. 4 : Probable catchment areas of the proposed MRTS stations.



for the years 2013 and year 2043 (Fig. 3) (JBIC, 2007), modal split data (DMRC, 2006) and primary survey, Fig. 4 shows the probable catchment areas.

Table 4; indicates the expected MRTS passengers from the residential areas of Maniktala, Ultadanga, Beliaghata, Lake Town, Salt Lake and New Town that have been worked out from expected modal split and projected population of the areas.

Table 4 : Projected Passengers from Catchment Areas of Proposed MRTS Stations.

Area	Projected population (2021)	Projected MRTS passengers per day (2021)
Maniktala area	1,70,000	5950
Ultadanga area	98,000	3430
Beliaghata area	159,000	5590
Lake Town area	1,10,000	3850
Salt Lake area	30,000	1050
New Town area	7,50,000	26,250

5. PROPOSED PASSENGER DISPERSAL FACILITIES FOR MRTS STATIONS

Eight MRTS stations in the eastern part of the proposed East - West MRTS have been taken up for planning of integrated transit and passenger dispersal facilities. The Central station and the MRTS station at Sealdah Railway Terminal are already well connected by surface transit; however, there is an urgent need for providing pedestrian facilities at these two locations. Phoolbagan, Stadium, Bengal Chemical, City Centre, Karunamoyee, and Sector V MRTS stations would require proper feeder surface transit routes for smooth dispersal of passengers. The movements of pedestrians around the stations is also to be guided by proper facilities like footbridges and subways. There is need for providing park-and-ride facilities at MRTS stations having catchment areas with high vehicle ownerships. Surface transit feeder services, pedestrian facilities, and park-and-ride facilities at different MRTS stations are discussed here after.

5.1 Feeder Transit Routes for Phoolbagan and Bengal Chemical MRTS Stations

The utility of Phoolbagan, Bengal Chemical, and Salt Lake Stadium, metro stations will depend on its level of accessibility to their catchment areas. Catchment area population for these stations are mainly low and medium income group people who reside in

Fig. 5 : Proposed circulation pattern of feeder route for Phoolbagan Metro

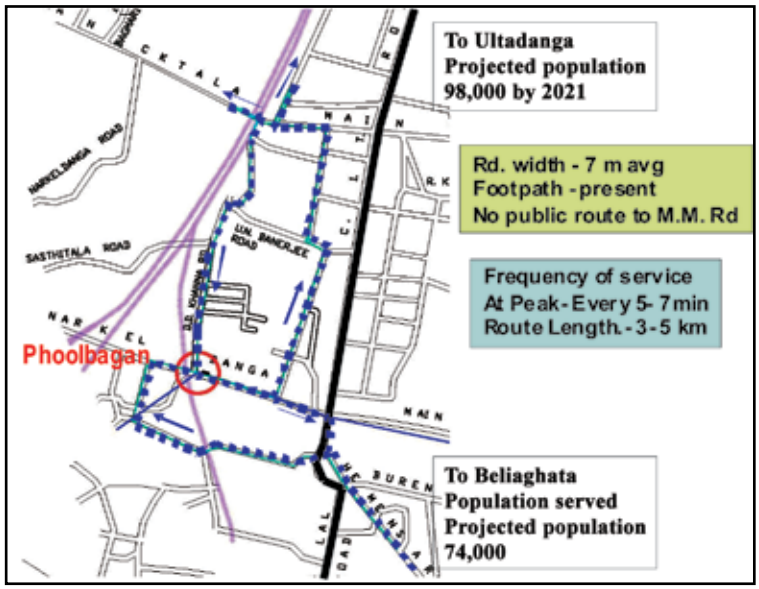
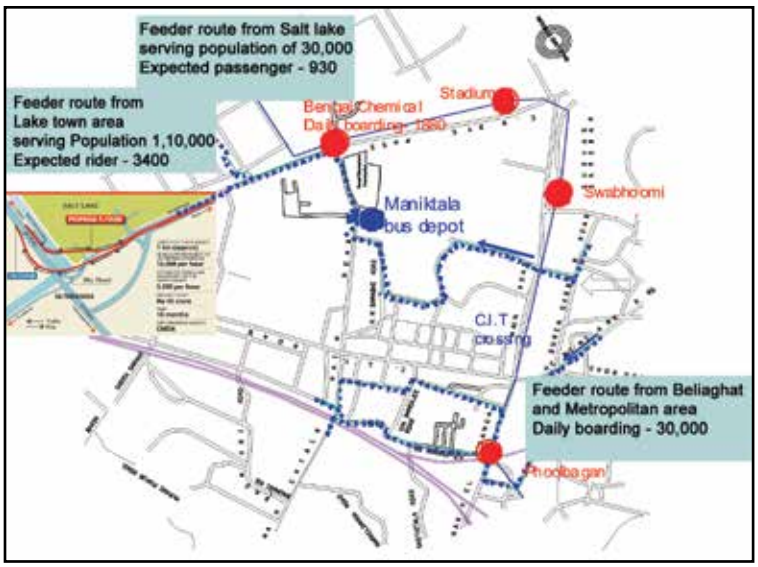


Fig. 6 : Feeder Route Plan to Bengal Chemical MRTS Station



individual small residential houses or group housing, either owned or rented. Connectivity to these residential areas is through narrow access roads of varying widths. Proposed feeder routes through these residential areas (Fig. 4 and 5) aims to reduce travel time to the stations utilizing the relatively wider access roads within the residential areas. Special echo friendly buses are proposed to operate in these routes so that the residential areas do not face increased pollution. The existing state bus terminus near Bengal Chemical station is proposed to be utilized for terminal facilities for the feeder services.

The Routes Proposed for Phoolbagan MRTS Station are:

- From Phoolbagan MRTS station via U.N. Banerjee road and Kankurgachi Main Road to Maniktala Main Road for outward movement. From Maniktala Main Road via Kankurgachi Main Road and D.D. Khanna Road for inward movement to the station.
- From the MRTS station via Haramohan Ghosh Lane and Hemchandra Naskar Road to Beliaghata Main Road and back to the station.

The route lengths are between three to five kilometers and proposed frequency at peak hour is between five to seven minutes as calculated from the daily ridership.

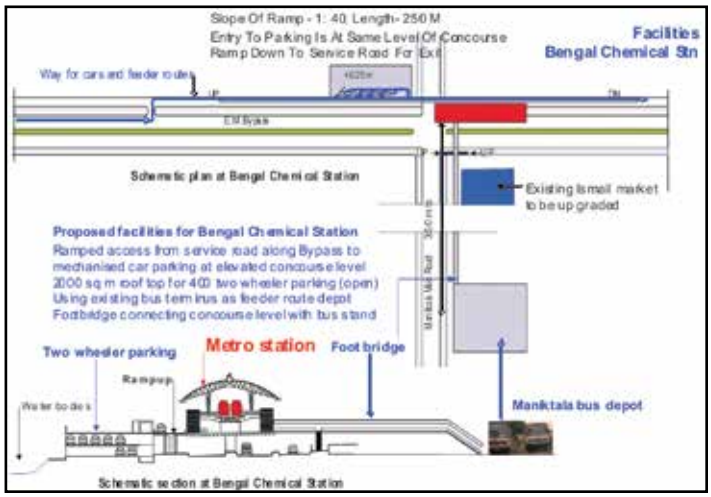
The Routes Proposed for Bengal Chemical MRTS Station are:

- From Maniktala State Bus Terminus near Bengal Chemical MRTS station via Maniktala Main Road and Eastern Metropolitan Bypass for outer movement. For inward movement from V.I.P. Road via newly constructed flyover for Lake Town bound passengers, or from Ultadanga Road via Eastern Metropolitan Bypass for Ultadanga bound passengers. It is suggested and indicated in Fig. 7 that a ramp connecting the elevated station originating and terminating at the service road adjoining Eastern Metropolitan Bypass is to be constructed for convenience of the passengers.
- From Maniktala State Bus Terminus near Bengal Chemical MRTS station via Sib Kristo Daw Lane and Suren Sarkar Road and diverting to other internal roads

of Beliaghata and retracing the same route for connecting to the Bengal Chemical MRTS Station and Salt Lake Stadium MRTS station.

- Fringe areas of Salt Lake City, which are away from the city's internal MRTS stations, are to be supported by Salt Lake bound feeder routes from internal roads of Salt Lake via Eastern Metropolitan Bypass to MRTS station of Bengal Chemical.

Fig. 7 : Schematic plan of the proposed facilities at Bengal Chemical Station.



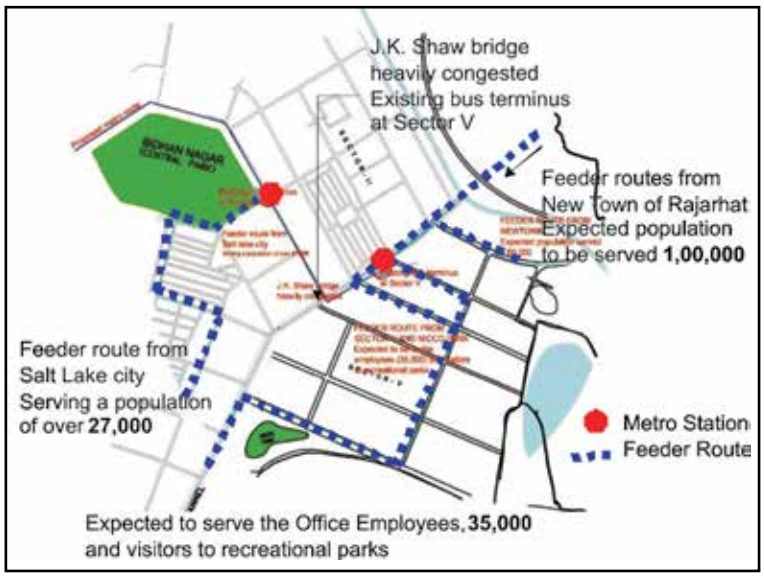
5.2. Feeder Route Plan within Salt Lake City

The City Center, Central and Karunamoyee MRTS stations within Salt Lake are already well connected to their respective catchment areas by public buses and auto rickshaw services. However, there is a need to improve these vehicles to make them environment friendly. The Sector V MRTS station will require feeder surface transit service connecting the station to the catchment areas of Sector V and Rajarhat (Fig. 8).

6. FOOT OVER BRIDGES AT MRTS STATIONS

Six MRTS stations, viz. Sector V, Karunamoyee, Central, City Centre, Bengal Chemical, and Stadium are elevated. These stations are to be provided with proper foot over bridges (FOB) extended over the nearest intersections for convenience of the passengers and for making the intersections efficient in terms of traffic flow. The expected numbers of pedestrians on the FOBs during peak hours vary between the FOBs as indicated in Table No. 5.

Fig. 8 : Feeder Route Plans in Salt Lake



7. PARK AND RIDE FACILITY

The MRTS station at Bengal Chemical has a catchment area extending up to 15 kilometers. It is expected that significant number of commuters will look forward to avail the MRTS route if suitable parking facilities at the MRTS station is accessible to cars and two wheelers. Similar

Table 5 : Expected Pedestrian Flow Over FOBs During Peak Hours

MRTS Station	Number of pedestrians at peak hours
Sector V	2000
Karunamoyee	2700
Central Park	2050
City Centre	1670
Bengal Chemical	1150
Stadium	1000

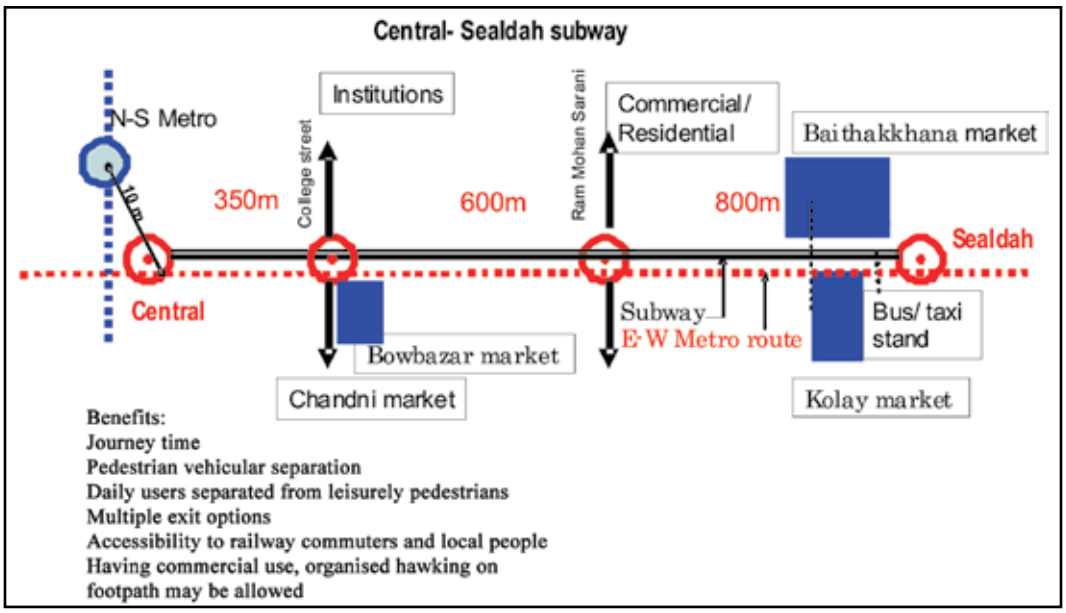
situation is also expected at the Sector V MRTS station till the MRTS route is extended to Netaji Subhas Chandra Bose Airport through new town of Rajarhat. The estimation of the requirements of the parking area at these two locations are based not only on the characteristics of the population in the catchment areas, but also on the growth of vehicle ownership in Kolkata. At the Bengal Chemical MRTS station the estimated parking demands are 200 for cars and 350 for two wheelers considering the catchment areas.

In view of the expected land use change to commercial and institutional use, high land price, and occasional gathering of spectators in the Salt Lake Stadium, it is proposed that mechanized multilevel parking may be adopted through public private partnership adjacent to Bengal Chemical MRTS Station area. The vehicular ramp already proposed to approach the Bengal Chemical MRTS Station may be considered as the approach to the elevated multilevel parking (Fig. 7). A similar multilevel parking may also be constructed within a portion of the existing State Bus Terminus at Sector V with FOB connection to the Sector V MRTS station. It is expected that with the growth of New Town some of the bus routes will be extended till New Town bus terminus.

8. SUBWAY FOR PEDESTRIANS

Sealdah railway station is a major railhead located in the centre of the city. About 1.6 million commuters from the northern and southern parts of the metropolis and beyond it travel through the station every day. From the station commuters normally walk either to the Central MRTS Station to avail the north - south metro or walk down to the adjoining work places including the office areas in Binoy Badal Dinesh Bagh. It is expected that commuters will not normally avail the east - west MRTS route for traversing a distance of 1.7 kilometer to reach the Central MRTS station. Many would prefer to walk down to the Central MRTS station. To aid such commuters it is proposed that a subway with suitably placed travellators may be provided between Sealdah Railway Station and Central MRTS Station. This subway can be constructed at a reduced cost if implemented along with underground MRTS construction. This will also segregate the pedestrian volume on the surface, there by increasing the efficiency of traffic movement along the B.B. Ganguly Street. This will also provide space for on-street parking as the adjoining land use along this road is predominantly commercial with a high concentration of jewellery shops that demand parking of vehicles. Fig. 9 gives an illustration of the subway.

Fig. 9 : The Proposed Subway from Sealdah Station to Central MRTS Station



9. CONCLUSIONS

This article proposes dispersal plans for eight MRTS stations along the proposed east - west MRTS at Kolkata. Specific solutions for each station along the eastern part of the corridor are suggested. The proposals include feeder bus services, park and ride facilities, and pedestrian dispersal at the MRTS stations. The plans are devised from study of land use, employment potential, present and expected population, existing modes and existing infrastructure of the catchment areas of respective stations. Introduction of east - west MTRS along with the above proposals will improve the efficiency of the MRTS resulting into an overall improvement of the present traffic situation in the east - west direction in Kolkata. It is expected that the proposals will also help to lessen the use of private modes to some extent.

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Core Area Demarcation specifically Planned to Decongest the City Traffic – A Case Study Dehradun City

Jugmohan Singh

Abstract

After the creation of Uttarakhand State and declaring Dehradun as the interim capital in 2000, the city of Dehradun has developed manifolds. The city has grown at a pace where demand and supply ratio balance cannot be maintained in the city core area itself. The demand for parking, more road network, commercial area, flyovers, Traffic Control Device, BRT, and PRT system, etc, has increased and on the other hand the supply rate is minimal in nature. The congestion and the traffic jams in city core area have forced traffic to move at a snail's pace in the city area. This paper provides a frame work on how a specific activity can be shifted from city core area to a planned area in the city outskirts / city peripheral area to decrease traffic jam caused due to those activities.

1. INTRODUCTION

Dehradun, the interim capital of Uttarakhand State, houses numerous government and prestigious educational institutions of high repute across the country, namely, Forest Research Institute (FRI), Indian Military Academy (IMA), Indian Institute of Petroleum, Survey of India, Wildlife Institute of India, Indian Institute of Remote Sensing and the Oil and Natural Gas Corporation (ONGC).

Dehradun has urbanized manifolds after being declared as the interim capital of Uttarakhand State in 2000. The municipal corporation area had population of 4.26 lakh as per Census 2001 and has grown to 5.66 lakh in 2011. Considerable growth of population and registered Motor Vehicles coupled with a marginal increase in the transport infrastructure apart from Bus and Truck Terminals has been observed since inception of a new capital. Due to rapid ribbon development, along various corridors and concentration of activities in the core area, traffic problem has increased tremendously and become critical.

Increase in city's traffic due to unprecedented growth in number of registered motor vehicles, influx of motor vehicles on city roads from surrounding areas. Poor conditions of the roads, lack of basic road infrastructure facilities like footpaths, parking area, traffic signs, FOBs, street lights, etc; puts the safety of road users at stake not only this, the traffic jam in the city core area has become a common feature; the average speed of the motor vehicles has approximately decreased to 5 to 15 kmph. The bottle necks in some areas have also aggravated the traffic

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situation. The city traffic rather than moving seems to be crawling during peak hours. Thus, there is a pressing demand to solve the problems which create congestion in the city.

One of the major factors which obstruct the free flow of the traffic is the location of workshops, service and repair shops, go-downs, C and F, in the city core area. These types of activities require lot of parking space and that too for a long duration. The presence of service and repair shops on the major roads and other important locations affects the smooth flow of the traffic movement. These shop owners doesn't possess the space for parking the motor vehicles for the activities they do, on daily basis. The customers who visit these shops park their motor vehicles on the carriageway thus hinder the movement of the other road users. The internal roads of the city are very congested and are not able to cater the parking demand created by the presence of the above said activities.

During the reconnaissance survey carried out at various locations it has been found out that the service and repair shops are located on the major roads of the city having a high traffic volume.

The motor vehicles which come to the service and repair shops for repairing on daily, monthly or annual maintenance park their motor vehicles outside these shops and it takes a long time to repair these motor vehicles, sometimes it can take 1 - 3 days to repair a motor vehicles, therefore the parking done by service and repair shops is of long term duration

Fig. 1 : Vikrams Parked on Carriageway Outside Service and Repair Shop.

Fig. 2 : Long Duration Parking of Vikrams in front of Service and Repair Shops Obstruct the Free Flow of the Traffic in the City

Fig. 3 : Service and Repair Shops in Subash Park Area/Tyagi Road.

and hence covers the area which could have been used by other motor vehicles. So it is very important to formulate a policy and strategy which can solve the above stated problems.

Now the question arises which policy is perfect in nature and if implemented can assist in decongesting the city, Technically implementable approaches, which can be taken up to solve the problem of congestion and traffic jam caused by the presence of service and repair in the city core area are as following.

1. Provide the service and repair shop owners a space in city peripheral areas which are planned and more suitable for these types of activities;
2. The shop owner should change their present activity to a business which requires fewer or no parking spaces; and
3. Provide a parking space to these shop keepers for their activities.

At the outset it is necessary to clear that due to less road width, high volume of traffic, and unavailability of land near these Service and Repair Shops approach number 3 can't be implemented and so the focus has to be either on approach number 1 and 2 or both at a time simultaneously.

2. METHODOLOGY TO ANALYSE THE DATA AND DEMARCATE THE CORE

During the reconnaissance survey carried out by the officials of Mussoorie Dehradun Development Authority it was found that unauthorised / illegal parking done by the owners of service and repair shops in Dehradun city area create traffic jams in the city and obstruct the free flow of the traffic. The parking done by the owners of the service and repair shops is of long term duration, thus create a bottle neck situation, therefore it was decided that the service and repair shops which don't possess enough parking spaces for their activities would be shifted to Transport Nagar. Transport Nagar is a planned area developed by MDDA for such kind of activities. To demarcate the core area of the city it is important that a systematic and scientific procedure is followed which can lead the organisation to attain the objective of decongesting the city traffic. As per the primary data collected there are approximately 188 service and repair shops in Dehradun city, and it's important to earmark the locations from which the service and repair shops need to be shifted . Therefore a conclusively implementable methodology has to be adopted which is scientific and systematic in nature and best suites to all the stake holders involved. The methodology has to be precise in every respect.

The methodology has to be implemented systematically and a set procedure given in the table has to be followed to attain the goal of decongesting the city core area. All the points set in the methodology are explained in Table 1.

Table 1 : Procedure to Demarcate the Core Area and Shifting of Service and Repair Shops from Dehradun City.

2.1 Formulation of the Team for Specific Core Area Demarcation.

To commence the project it is very important to formulate a core area demarcation team, the team shall comprise of an urban planner, transport planner, and draftsman (for mapping), the team should be headed by the Commissioner or an IAS officer. The urban planner and a transport planner should have the experience of at least 3 years in urban planning related issues. Same procedure was followed by MDDA, a team of 3 members was formulated which constituted an urban planner, a transport planner and a draftsman. The team was headed by Vice Chairman MDDA.

2.2 Meeting Among Selected Stakeholders and Core Area Demarcation Team.

After the creation of Core Area Demarcation Team, the next important step is to have a discussion with various stakeholders. The discussions with various stake holders and their valuable suggestions have to be incorporated into the

report after scrutinizing their comments. Therefore, it is very necessary to select the various stakeholders from various departments of city e.g. during core area demarcation of the Dehradun city, Vice-Chairman Dehradun selected the following stakeholders given below.

- Police,
- City magistrate,
- PWD,
- Municipal corporation,
- Town and country planning Department,
- Traffic police, etc.

After the selection of the core and team, a meeting among various stakes holders and the core area team was conducted and during the meeting the comments and suggestion given by the members of the core area team and the stakeholders were incorporated in the report. The focus of the meeting has to be on the specific activity which has to be shifted from the city core area and their impact on the traffic scenario of the city. During the meeting a way forward has to be formulated which will help the core area team to go in a right direction. To increase communication between the core area demarcation team and the various stakeholders contact details and email ids of the core area team and various stakeholders have to distribute among each other and any update on the same has to be communicated among the members. Same system was followed by MDDA and the results were remarkable and inputs received from all the members present in the meeting helped in speeding up the work progress.

2.3 Data Collection

After the meeting between core area team and stakeholders, a surveying consultant has to be hired to collect the data related to the location of service and repair shops in the city. The surveying team has to be very precise about the location and activity of the shop.

The surveyor has to calculate the following details about the service and repair shops

- Locations of the service and repair shops;
- Total area of the service and repair shops;
- Covered area of the service and repair shops;
- Parking space available or not;
- Uncovered area of the service and repair shops;
- Dimensions of the service and repair shops;

- Type of constructions permanent or temporary of the service and repair shops;
- Number of floors of the service and repair shops;
- Owners detail;
- Tenants detail if any; and
- Type of Property / Owner ship (Nazool or Free Hold, private, etc). Some of the details would be used to demarcate the core area of the city and some of the detail would be used during the process of allotment of the shops. In the same manner the surveyor hired by MDDA collected the specific data about the Service and Repair Shops was submitted by the surveyor to core area team constituted.

2.5 Data Compilation

After receiving the data collected by the surveying agency, the data collected has be to be complied for further analysis. The data has to be compiled in a way that it can be easily analysed spatially. The data given by the location of the Service and Repair Shops has to be ranked according to the location and number of service and repair shops. The area which has the highest number of Service and Repair Shops will be on top and the area with lowest number of Service and Repair Shops in the bottom. As shown in the table Table 2. The core area demarcation team of MDDA compiled the data in the prescribed manner.

After compilation of data it is very necessary to analyse the data, present the data in the forms of graphs and tables so as to understand the scenario in a better way. The graphs will help the analysts to analyse the situation in comprehensive manner. The analysis will help the planners in next stage to spatially place the data collected on the maps after which core area can be demarcated.

2.6 Spatial Placement of Data after Analysis

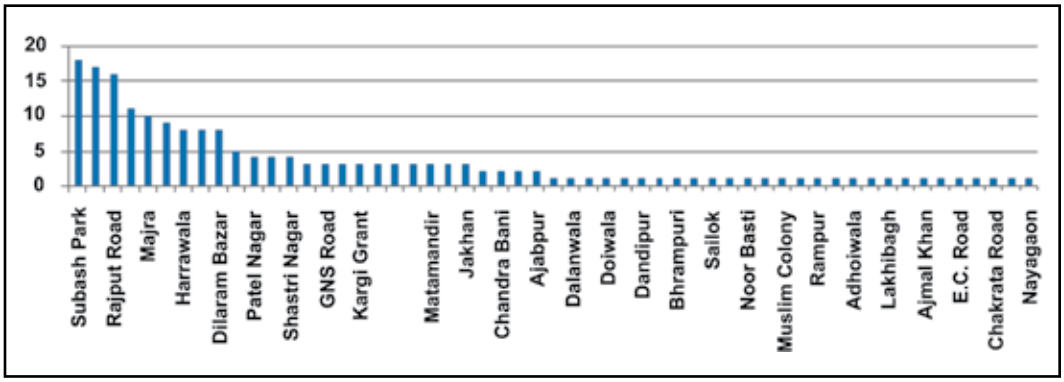
There are approximately 188 service and repair shops in Dehradun city and its peripheral area. After spatially placing of service and repair shops on map one gets to make out that there is no specific area or location where all the Service and Repair Shops are located. The Service and Repair Shops are located all around the city. It is difficult to solve a situation if it is not concentrated to a single area. The problem created by Service and Repair Shops is prevalent all around the city. so it is important to select he areas from which Service and Repair Shops are to be shifted to a specific area outside Core Area of the city, which has been planned for such activities and thus reducing the congestion in the city area. Some of the Service and Repair Shops which are not hindering the traffic movement should not be taken into account during demarcating the core area.

Table 2 : Location of Service and Repair Shops and the Number of Service and Repair Shops

S.No	Location	No
1	Subash Park	18
2	Tyagi Road	17
3	Rajpur Road	16
4	Haridwar Bye Pass	11
5	Majra	10
6	Haridwar Road	9
7	Harrawala	8
8	Chukhuwala	8
9	Dilaram Bazar	8
10	Malsi	5
11	Patel Nagar	4
12	Chander Nagar	4
13	Shastri Nagar	4
14	Shimla Bye Pass Road	3
15	GMS Road	3
16	Bandhari Bagh	3
17	Kargi Grant	3
18	Subash Road	3
19	Raipur Road	3
20	Mohkampur	3
21	Matamandir Road	3
22	Prince Chowk	3
23	Jakhan	3
24	Kanwali Megh Enclave	2
25	Chandra Bani	2
26	Sewla Khurd	2
27	Ajabpur	2

S.No	Location	No
28	Turner Road	1
29	Dalanwala Chander Road	1
30	Mohbbe Wala	1
31	Doiwala	1
32	Green Park	1
33	Dandipur Mohalla	1
34	Khudbura Mohalla	1
35	Bhrampuri	1
36	Devrishi Enclave	1
37	Sailok	1
38	Karbari	1
39	Noor Basti	1
40	Kedarpuram	1
41	Muslim Colony	1
42	Nehru Colony	1
43	Rampur	1
44	Chamanpuri	1
45	Adhoiwala	1
46	Harbanswala	1
47	Lakhibagh	1
48	Harbajwala	1
49	Ajmal Khan Road	1
50	Kishanpur	1
51	E.C. Road	1
52	DBS College	1
53	Chakrata Road	1
54	Kuthal Gate	1
55	Nayagaon	1
Total		**188**

Fig. 4 : Location of Service and Repair Shop



2.7 Scrutinize the data

After spatial placement of data on the map (Fig. 5) it is very important to examine the data by randomly communicating with the shop owners through any media available. This will act as vital evidence that data gathered is full proof and there has been no mistake made in collecting the data from the field.

2.8 Organising the Meeting Among Various Stakeholders

After data collection, compilation, spatial placement of data and analysis of the data collected, a meeting among core area team and various stakeholders have to be organised to discuss the area which has to be demarcated and the comments from all the member present are to be incorporated in finalising the core area.

Fig. 5 : Placement of Data on the Map

Table 3 : Location of Selected Shops

Sr. No	Locations	No
1	Subash Park	18
2	Tyagi Road	17
3	Rajpur Road	16
4	Haridwar Bye Pass	11
5	Haridwar Road	9
7	Dilaram Bazar	8
8	Chander Nagar	4
9	GMS Road	3
10	Bandhari Bagh	3
11	Subash Road	3
12	Raipur Road	3
13	Mohkampur	3
14	Matamandir Road	3
15	Prince Chowk	3
16	Jakhan	3
17	Kanwali Megh Enclave	2
18	Ajabpur	2
19	Kishanpur	1
20	E.C. Road	1
21	Chakrata Road	1
Total		**114**

2.9 Selection of Locations from the Main List

As per the data collected there are approximately 188 Service and Repair Shops in the city area, now it is very important to select the service and repair shops which are to be shifted and which Service and Repair Shops are not to be shifted. After discussion with all the stake holders, a list of shops which are to be shifted has to be prepared. The core area has to be demarcated according to the selected shops. The core area should cover all the locations, given in the Table 3.

2.10 Selection of Land

After selecting the list the next step is to select the piece of land where the Service and Repair Shops would be shifted and is best suited for such kind of activities. The land parcel can be selected in first stages or in the later stages. The area has to be planned according to the total area and number of Service and Repair Shops calculated during survey of the shops. During the selection of land in Dehradun city Transport Nagar area has been selected. Transport Nagar is a planned area in outskirts of city and is planned for such kind of activities.

2.11 Meeting Among Various Stake Holders and Finalisation of Core Area

After selecting the land and demarcating the core area of the city, a final meeting between the various stake holders and core area demarcation team has to be organised and final comments and valuable suggestions if required should be incorporated in the Report. The core area has to be demarcated on the basis of suggestions and comments of all the stakeholders.

2.12 Core Area Boundary Line Detail

The core area as a zone has to have a boundary. To define the core area of the Dehradun city, roads and natural features like river has been chosen specifically.

The core are of the Dehradun city which has been demarcated is bounded by the following features

1. Haridwar Bypass Road in the South

- This road stretch starts from ISBT and ends at Rispina Junction.

- The length of this road stretch is 6.3 kilometre.

2. **NH 72 Road in the South East**
   - This road stretch starts from Rispina Bridge and ends at Nehru Colocy Chowk.
   - The length of this road stretch is .350 kilometre.
3. **Nehru Colony Road in the South East.**
   - This road stretch starts from Nehru Colony Chowk and ends at Balbeer Chowk on Balbeer road.
   - The length of this road stretch is 1.3 kilometere.
4. **Balbeer Road in the East**.
   - This road stretch starts from Balbeer Chowk and ends on EC road Junction.
   - The length of this road stretch is 1kilometre.
5. **Eastern Canal Road in the East**.
   - This road stretch starts from EC road Junction and ends at survey Junction.
   - The length of this road stretch is 1.7kilometre.

Fig. 6 : Core Area Demarcated on Land Use Map of the Dehradun.

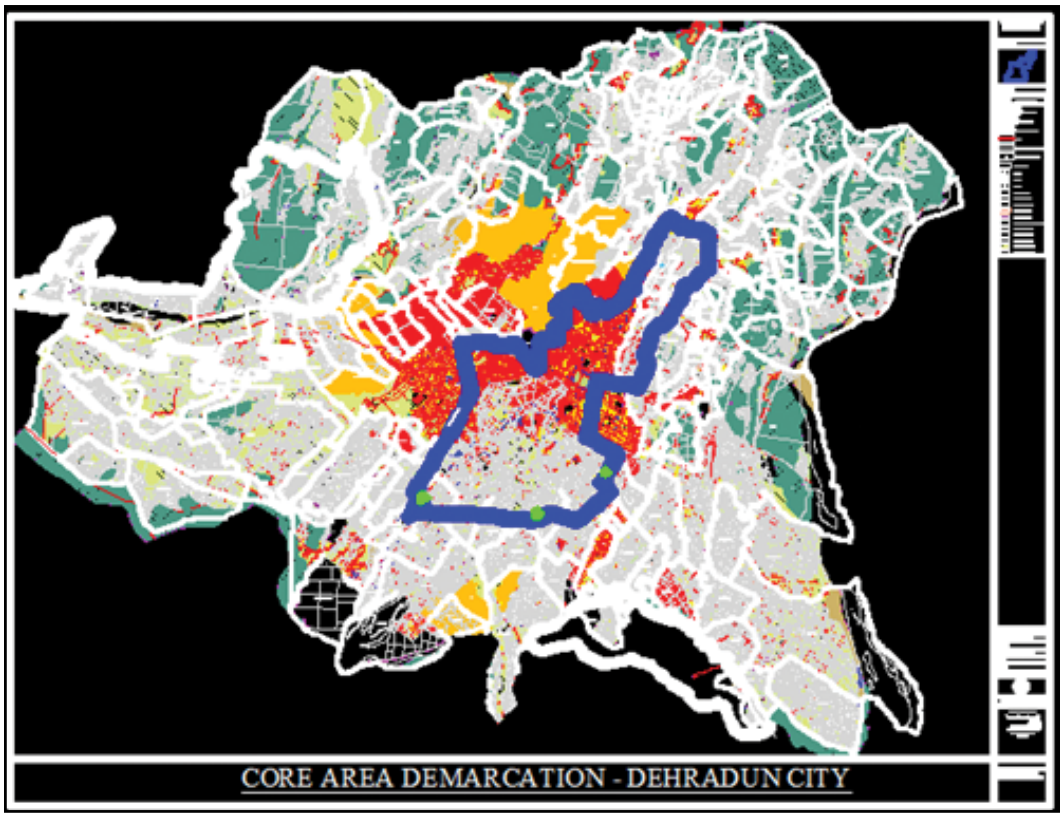
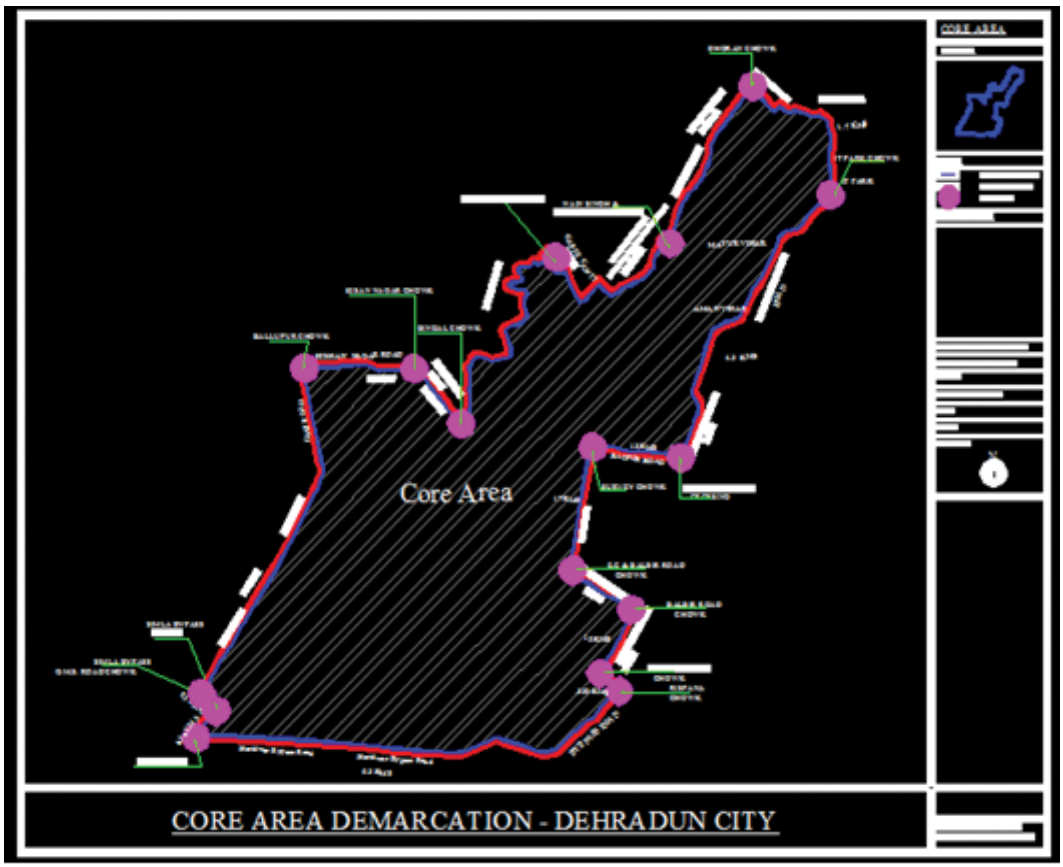


Fig. 7 : Core Area Demarcation for Shifting the Service and Repair Shops from area



6. **Raipur Road in the North East.**
   - This road stretch starts from survey chowk and ends at Sahastradhara crossing.
   - The length of this road stretch is 1.3 kilometre.
7. **Sahastradhara Road in the North.**
   - This road stretch starts from Sahastradhara crossing and ends at IT park
   - The length of this road stretch is 4.3 kilometre.
8. **IT Park Road and Dhoran Road.**
   - This road stretch starts from IT park and ends at Dhoran Junction on Rajpur Road.
   - The length of this road stretch is 1.7 kilometre.
9. **Rajpur Road in the North West**
   - This road stretch starts from Dhoran Junction on Rajpur road and ends at Nain Singh Road / Rajpur Chowk.

- The length of this road stretch is 3.8 kilometre.

10. Nain Singh Road and New Cantonment Road in the East

- This road stretch starts from Nain Singh Road / Rajpur Chowk and ends at Cheerbagh Bridge on Bindal Rao (new cantonment road).
- The length of this road stretch is 2.65 kilometre.

11. Bindal Rao in the East.

- This stretch of core area boundary starts from Cheerbagh Bridge and ends at Bindal Bridge on Chakrata road.
- The core area in the east is bounded by Bindal Rao.
- The core area in this part is curvilinear in nature because the course of the river.

12. Chakrata Road in the East

- This road stretch starts from Bindal Brisge on chakrata rod and ends at Kishan Nagar Chowk.
- The length of this road stretch is 1 kilometre.

13. Ballupur Road in the East

- This road stretch starts from Kishan Nagar Chowk and ends at Ballupur Chowk.
- The length of this road stretch is 2.7 kilometre.

14. General Mahadev Singh Road East and South.

- This road stretch starts from Ballupur Chowk and ends shimla bypass road
- The length of this road stretch is kilometre.

15. Shimla Bypass Road in the South

- This road stretch starts from Shimla bypass road and general Mahadev singh road intersection and ends at Shimla Bypass junction on Saharanpur road.
- The length of this road stretch is 300 metre.

16. Saharanpur Road.

- This road stretch starts from Shimala Bypass junction and ends at ISBT junction.
- The length of this road stretch is 500 metre.

Any policy, strategy or proposal implemented in the core area may also be applied in the 50 metres buffer zone outside the main core.

2.13 Submission of Detailed Core Area Demarcation Report

After the meeting between stakeholders and core area demarcation team and after incorporating al the suggestions and comments the detailed project report has to be submitted to Chairman / Commissioner or Vice Chairman for approval.

2.14 Getting the Report and Core Area Approved

After submission of report to approving authority, the approving authority has to approve the report after examining the Report in every aspect. And if it is felt that some changes are required to be incorporated into the Report the same has to be made.

2.15 Formulating an Agreement and Policy Document for Shop Allotment

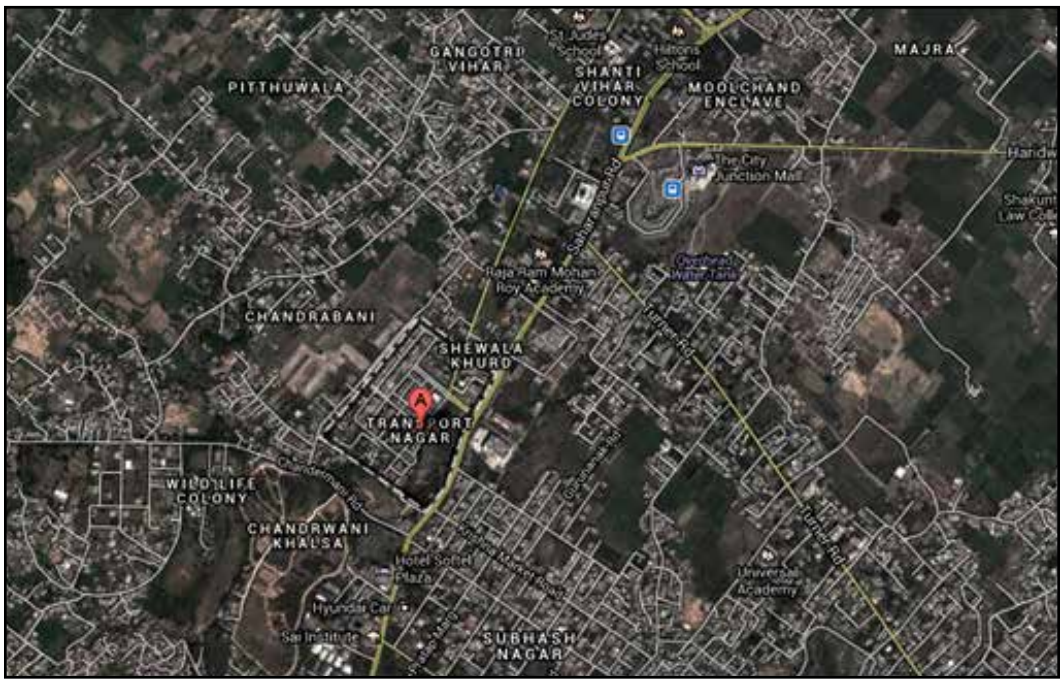
After approval of the Report an Agreement and Policy Document has to be formulated for the allotment of shops to the owners of the shops keepers which would be shifted from core area of the city to planned area in city periphery.

2.16 Allotment of Shops to Shop Keepers

The final stage of the whole process of core area demarcation is to allot the shops to the selected shop keepers

By following this methodology with certain changes according to the prevailing conditions of the area core area, demarcation can be done keeping in

Fig. 8 : Location of Transport Nagar



consideration the job of decongesting the city core area. The process has to be precisely implemented and all the related factors have to be taken into account.

3. CONCLUSIONS

The number of cities has increased so has the area of the cities in India increased. The cities area expanding at a fast rate, core area of the city is becoming congested. The congestion in the core area is forcing the citizens to look for open spaces which are least congested but least congested areas are always in the outskirts of the city. So it is very important to demarcate the core area of the city. Implement the plans accordingly to decongest the city core area.

Rules and regulations, precise primary and secondary surveys, stakeholder involvement, good administrative advices, innovative ideas, discussions, full proof methodology, and scientific analysis of the whole process will definitely help in demarcating the core area of the city scientifically.

The core area demarcation has to be done specifically for specific cities keeping in view the specific problems or issues or any other development. The procedure for core area demarcations for different cities would be always different, because no two cities can be similar to each other in all the aspects. So before demarcating the Core Area, city has to be studied in all aspects. The various aspects or variable which has direct or indirect impact on city which can be positive or negative in nature has to be studied carefully, eliminating any such activity from the study will not help in demarcating the core area in a perfect manner.

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