Simulation Modeling of Land use and Transportation Interaction with Other Infrastructures

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***Abstract*— Peri urban areas refer to the settlements beyond, about or around cities. The population growth rate of peri urban areas of Chennai is around 3.5 compared to the city growth rate of around 1.25. The current population of Chennai Metropolitan Area is about 8.7 million and is estimated to reach about 12.5 million by 2026. Majority of this increase is expected to settle in suburban and peri urban areas as the city is already reaching saturation. Fundamental root cause for traffic congestion is improper neighbourhood planning which does not account the holding capacity of the basic infrastructures and its impact on transportation infrastructure. So neighbourhood planning should be done in such a way that population holding capacity should be estimated based on all basic infrastructures. The main objective is to develop a system dynamics simulation model for peri urban areas in Chennai. The developed model will be used for assessing its possible and preferable growth directions through various scenario analysis based on economic considerations and suggest the best scenario so as to ensure a growth towards sustainable development in the long run. The model is developed with simple mathematical equation for simulation. The outcome of the study is optimum density norms by considering basic infrastructures such as transportation, water supply, sanitation, electricity and telecommunication.**

Keywords*— *System dynamics simulation; Holding capacity; Optimum density norms; Basic infrastructures.

I. INTRODUCTION

Chennai urban agglomeration had a population of about 6.56 million in 2001 and it has increased by 2.13 million to reach 8.69 million in 2011.Real estate development mushroomed in South Chennai after it was catalogued as the growth corridor of the city. The focus of the state government over the last decade in promoting Old Mahabalipuram Road (OMR) as an IT/ ITeS destination, has created immense employment opportunities in South Chennai. South Chennai leads the Chennai residential market in terms of the number of units launched and absorbed. South Chennai continues to account for the lion's share (69%) in the Chennai residential market.

II. OBJECTIVES

- To study the transportation network and other basic infrastructures of peri urban areasto build appropriate simulation model
- To test and validate the model for various scenario and policy options for ensuring sustainable development.
- To recommend the best scenario for achieving sustainable transportation and infrastructure development to enhance quality of life in the study area.

III. STUDY AREA

Peri Urban settlements along OMR are selected as study area. It includes Perungudi, okkiyamThoraipakkam, karapakam and sholinganallur. Perungudi and Sholinganallur are Town Panchayats and OkkiyamThoraipakkam and karapakkam comes under Village Panchayats of St.Thomas Mount Panchayat union as of old Chennai City limit concerned as depicted in Fig.1. The reason behind the selection of study area is that the southern group consisting of developments from Perungudi to Sholinganallur exhibits a very high growth rate.

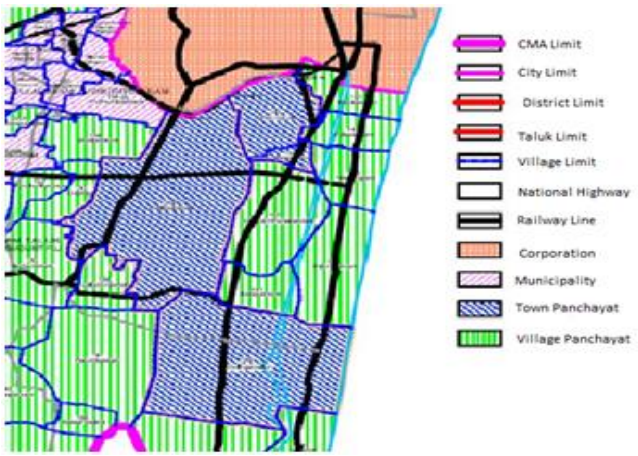

Fig. 1. Study Area (Source : CMDA)

III. METHODOLOGY

The methodology of this work is depicted in the figure 2. Essentially the steps involved are data collection, analysis, model building and to suggest appropriate mitigation measures.

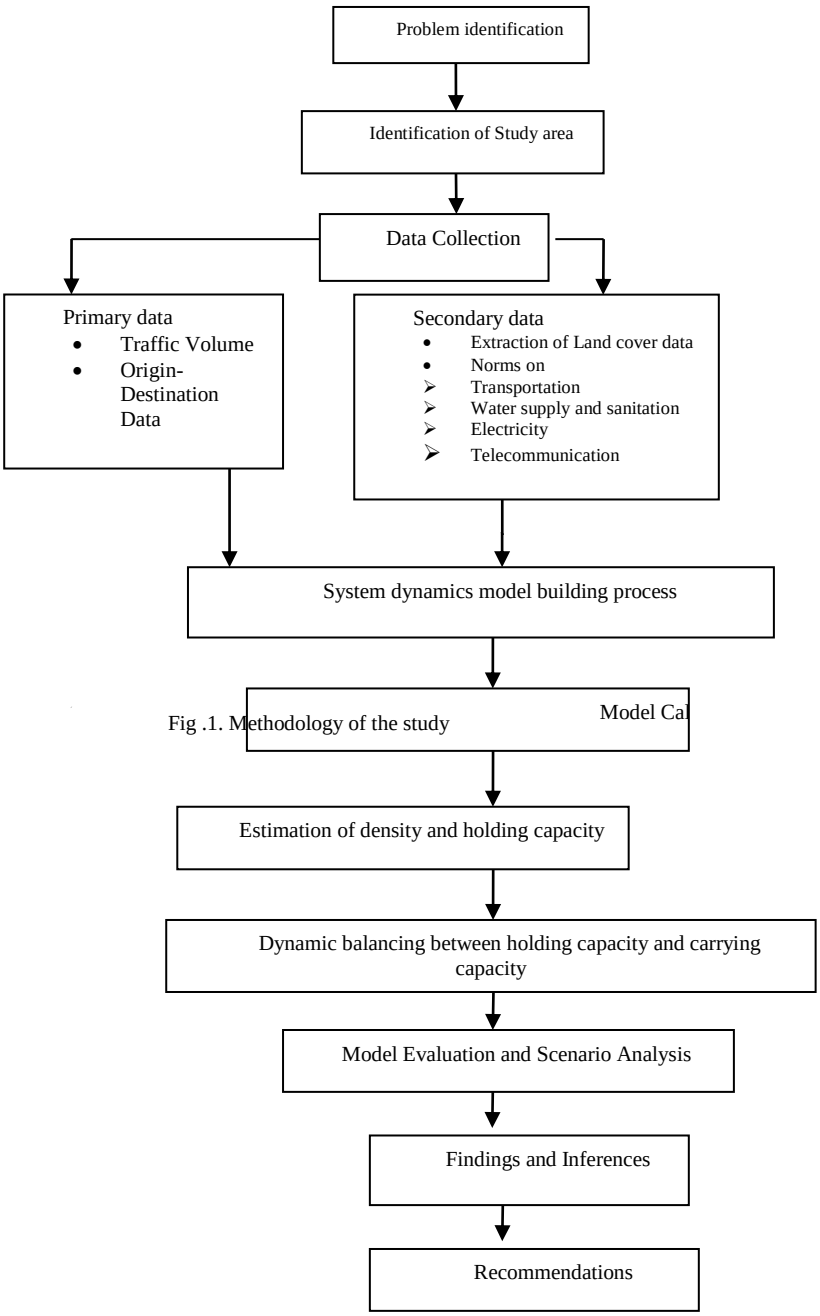

Fig .1. Methodology of the study

Fig. 2. Study Methodology

IV. DATA COLLECTION AND ANALYSIS

A. General

Holding capacity can be determined by considering Traffic volume as primary data and demography, land use and norms on basic infrastructures as secondary data. The collected data are briefly discussed.

B. Primary data collection

Primary data collection involves Local trips bounded in the study area. It is achieved through traffic volume surveys at 3 different locations of Old Mahabalipuram Road between 3.30 p.m and 8.30 p.m. The locations include Perungudi, Thoraipakkam, Sholinganallur.

Fig 3 shows the peak traffic volume observed at 3 survey locations and it depicts that the peak traffic volume is the highest at Perungudi location.

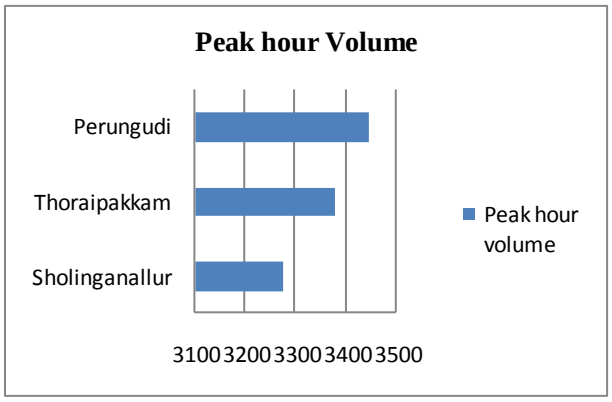

Fig. 3. Peak hour volume

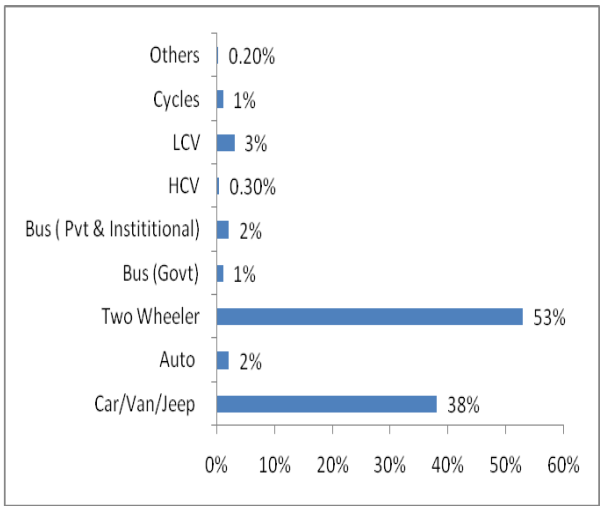

Fig. 4. Vehicle Composition

Figure 4 illustrates the vehicle composition of Chennai IT corridor. Two wheeler and car proportion in the total volumes are observed around 53 and 35 percent and Buses (governments and private & institutional) is around 4 percent only. This seems to be an unhealthy proportion with regard to environment consideration and Level of Service (LOS).

C. Secondary data collection

Collection of secondary data includes Demographic data, Land use data and norms on basic infrastructures such as Water supply and sanitation, Telecommunication and Electricity.

D. Demographic data

Figure 5 shows the demographic profile of study area. From the figure it is observed that Thoraipakkam census town has highest population of 56642 with 14524 households.

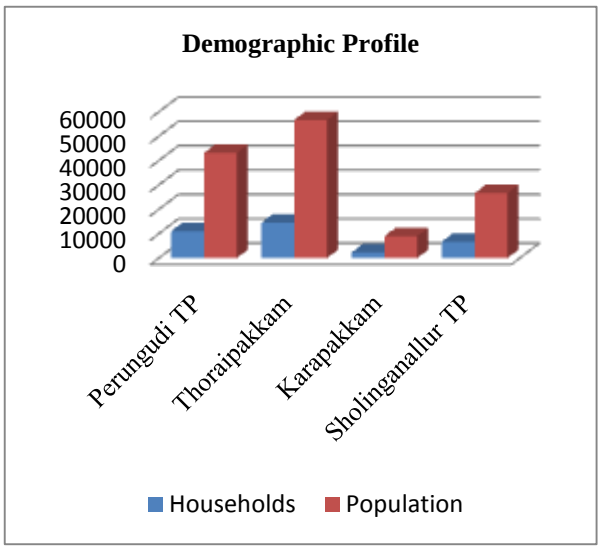

Fig. 5. Demographic profile
(Source: Compiled from census 2011)

E. Telecommunication data

Telecommunication profile was collected from Bharat Sanchar Nigam Limited (BSNL) exchanges and it is given in Fig 4.Karapakkam has highest number of telecommunication network with 3205 broad band connections followed by Perungudi with 1723 broad band connections

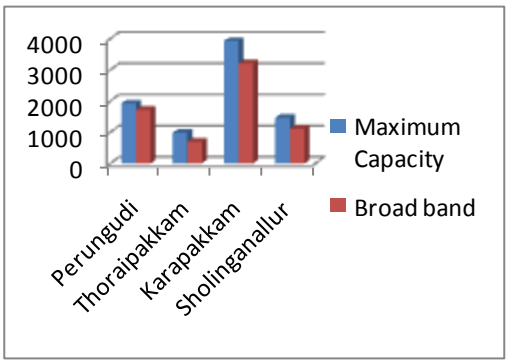

Fig. 6. Telecommunication network
(Source: Compiled from BSNL)

F. Land use data

Land Use	*Perungudi*		*Thoraipakkam*		*Karapakkam*		*Sholinganallur*	
	Ha	%	Ha	%	Ha	%	Ha	%
Primary Residential	152.6	39	289	48	22.4	9	611.4	40
Mixed Residential	51.8	13	79.7	13	34	14	116.4	8
Institutional	84.2	21	17.5	3	18.1	7	32.36	2
Industrial	49.2	12	135.9	23	93.5	39	423.9	28
Water body	17.7	5	48.6	8	9	4	140.29	9
Agricultural	8.6	2	-	-	-	-	-	-
Commercial	-	-	-	-	21	8.7	33.24	2
Non Urban	-	-	-	-	3	1.3	14.11	1
CRZ	-	-	-	-	-	-	140.74	9
Road Network	30.9	8	30.9	5	8.5	3	23.36	1
Total	395	100	601.6	100	242	100	1535.8	100

Table 1.Extent of Land use
(Source: Compiled from CMDA Land use map)

V. MODEL DEVELOPMENT

A. General

Simulation model has been developed for population sector and infrastructures sector using the STELLA simulation software With the System dynamics (SD) model, relationship between the population growth and its level of population and its supply of all basic infrastructures are established and density norm for all basic infrastructures are determined. Optimum density norm is said to be the minimum among all. Holding capacity is calculated based on the optimum density norm.

The existing land use data is used to know the existing area for allocating the projected population and the future land use proportion can be formulated for corresponding population growth. Intuitive scenarios can be analysed for the developed model. The different patterns of possible present and future growth are generated and holding capacity is determined towards achieving sustainable development for the study area.

B. Model Development – Population Sector

Population model has been built to estimate the projected population as given in Fig 7 by accounting birth rate, death rate, immigration and out migration rate.

Equation used:

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

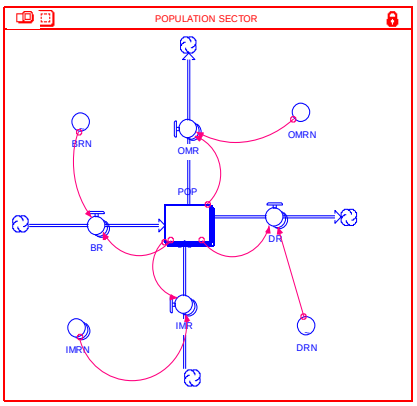

Fig .7.SD Model for Population Sector

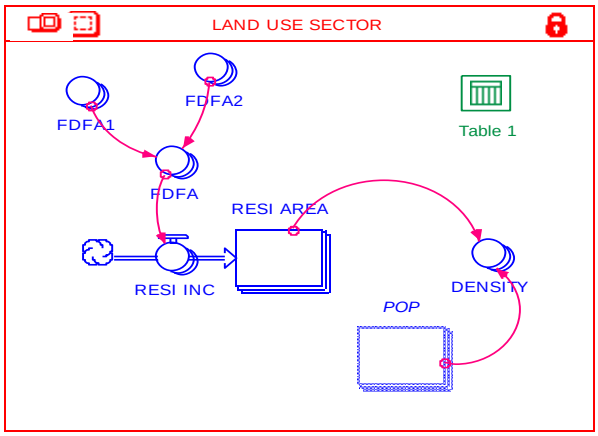

Fig. 8. SD Model for Land Use Sector

C. Model Development – Land use sector

Stella model for land use sector is built by considering existing residential land area and future developable floor area. By accounting residential growth rate extent of land area in projected year is calculated.

Existing residential floor area for every year can be developed with respect to the growth rate of residential

intensity and available residential area of each zone. Residential intensity is inflow into level because of positive polarization.

Equation used :

FDFA1= Existing residential area (Remaining % from already developed) * Plot coverage for constructing house* Undeveloped remaining FSI

FDFA2= Existing residential area (% yet to be developed) * Plot coverage for constructing house* Undeveloped FSI

FDFA = FDFA1 + FDFA2

Residential area= Existing residential area (% from already developed) * Plot coverage for constructing house* Developed FSI.

D. Model Development – Transport sector

Model for transportation sector is built by accounting present vehicular volume and growth rate of vehicles in order to determine the volume/ Capacity ratio and given in Fig 9.

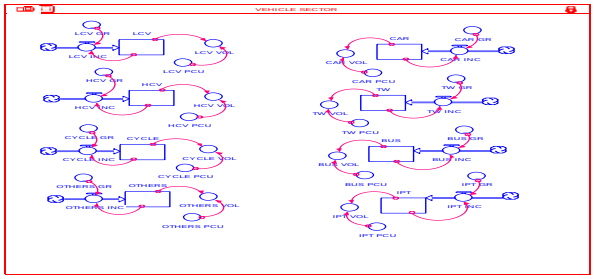

Fig. 9. SD Model for Transport Sector

VI. RESULTS

A. Do Minimum Scenario

In do minimum condition, the existing trend of growth rates has been allowed to continue till the year 2026. It is observed that the v/c ratio varies from 1.26 in the base year 2015 to 2.53 in the horizon year 2026. For basic infrastructures sector, only under construction projects are accounted in do minimum scenario.For water supply sector, the demand supply ratio varies from 1.5 to 1.32 and for Electricity sector a constant D/S ratio of 1.25 continues upto horizon year since there is no power plants under construction.

For sanitation infrastructure, the D/S ratio varies from 0.56 to 1.26 if under construction STPs are alone considered. For Telecom sector, D/S varies from 0.9 to 1.28 by accounting current broadband growth rate. For Land use sector the density varies from 262 persons/hectare to 318 persons/hectare for current trend of Land use intensification.

B. Desirable Scenario

In this scenario, simulation has been carried out such that restricting the growth rate of personalized modes and increasing the capacity of the corridor in terms of providing elevated corridor along the study stretch. A V/C ratio of 0.96 is achieved in desirable scenario. For basic infrastructures sector, all new proposals are introduced in order to make the D/S ratio less than 1.

For telecom sector a D/S ratio of 0.98 is achieved in horizon year by augmenting the rate of increase of exchange capacity. In land use sector a density of 259 persons/hectare is achieved by accelerating the land use intensification trend on par with the population increase.

VII. RECOMMENDATIONS

- Here the mathematical equation is developed and used to develop the model and simulate.
- For Transportation sector, the growth trend of personalised mode has to be decreased by augmenting the public transportation facilities such as BRT.
- For basic infrastructures sector, new proposals like Desalination plant, STP, Power plants and substation has to be implemented to improve the Quality of Life.
- Economy has to be compromised a while for implementing such proposals since these proposals will have lot of intangible benefits like congestion reduction, fuel savings, etc.

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