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A Study on Growth Pattern of Vellore Urban Agglomerations- A Systems Approach

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Abstract

A city is considered as a complex system. It consists of numerous interactive sub-systems and is affected by various factors including governmental land policies, population growth, and transportation infrastructure. Land use and transport are considered as the most important factors determining the urban form and its structure. Vellore district is one of the 32 districts in the Tamil Nadu state of India. Vellore City is the headquarters of this district. As of 2011 it was the third most populous district of Tamil Nadu (out of 30), after Chennai and Kanchipuram. The Gudiyattam and Vaniyambadi were the two urban agglomerations of the Vellore district with the population of 1,89,681 and 1,36,548 respectively. As per the UDPFI guidelines, these two urban agglomerations are classified under the medium city. In order to regulate the growth of the study area in an orderly manner for the present and the foreseeable future, this paper make an attempt to study and appreciate the development trends in study area and to suggest the strategies to plan city towards sustainability. For Gudiyattam, the population is restricted to achieve the population below 500,000 so that the city will be under the medium city itself. The land available for the development is minimum so the vicinity area like Peranampattu and Pallikonda could be development to improve the quality of life. For Vaniyambadi, the population is about 4,42,879 and available land area is 957.21 hectares. The area under industrial use is 49.33 hectareswhich constitutes about 11.06% of the industrial area. Tanneries occupy the maximum area under industrial use. As per the records, there are 77 tanneries, 9 flourmills, 2 engineering industries in Vaniyambadi. The land area available is maximum but the residential area is minimum where people are not willing to settle in Vaniyambadi. The analysis results predict that the Gudiyattam and Vaniyambadi are not capable to become the large cities. The boundary of vicinity area gets increase Gudiyattam may able to become large city in future. In case of Vaniyambadi, the residential area should be planned in such a way that it should be free from industrial area to improve the quality of life.

Keywords:

1. Introduction

A city is considered as a complex system. It consists of numerous interactive sub-systems and is affected by various factors including governmental land policies, population growth, and transportation infrastructure. Land use and transport are considered as the most important factors determining the urban form and its structure. Transport systems in developing cities face major challenges due to the continuous growth of urban population, private vehicle ownership, congestion, and the fragility of public transportation systems. When the urban transport system experiences major difficulties, consequences are felt by households, by businesses, and by the urban community at large. Transport may become a binding constraint on both economic growth and social development and inclusion, along with increased negative impacts on health and on the environment. In this regard, Vellore district is one of the 32 districts in the Tamil Nadu state of India. Vellore City is the headquarters of this district. As of 2011it was the third most populous district of Tamil Nadu (out of 32),after

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Chennai and Kanchipuram. The 2011 census recorded Vellore districtwith a population of 3,936,331 an increase of 489,014 from the 2001 figure of3,477,317. The district had a population density of 646 inhabitants per squarekilometer.

To conduct our investigation, develop a simple dynamic model of the relationship between transportation infrastructure and urban growth. This model implies a relationship between a city's population growth, its level of population and its supply of transportation infrastructure. It also implies that the transportation infrastructure of a city depends on its past level of population, its initial level of transportation infrastructure, and the suitability of its geography for building roads.

2. Data Collection

The population details, land use details and Transport details for the study area are given in the Table 1, 2 and 3 respectively.

Table 1. Population details of Vellore District (as per 2011)

Name of the town	Population
Vellore District	3,936,331
West Side of Vellore Town	
Gudiyattam (UA)	1,89,681
South - West Side of Vellore Town	
Vaniyambadi	1,36,548
North - East Side of Vellore Town	
Ranipet	50,764
Arakonam	1,54,385

Source: Corporation Office, Chennai.

Table 2. Gudiyattamland use break up (as per 2011)

Land use	Area in Hec	% of land area	% of land area as per UDPFI	% Variation
Developed Area				
Residential	173.79	32.89	40 to 45	36.43
Commercial	13.38	2.53	3 to 4	2.80
Industrial	27.53	5.21	8 to 10	5.77
Public and Semi Public	23.17	4.39	10 to 12	4.86
Total Developed	**237.91**	-	-	-
Undeveloped Area				
Agricultural	239.17	-	-	-
Total Undeveloped	**239.17**	-	-	-
Total Area	**477.04**	-	-	-

Source: Master Plan, Gudiyattam.

Table 3. Vaniyambadiland use break up (as per 2011)

Land use	Area in Hec	% of land area	% of land area as per UDPFI	% Variation
Developed Area				
Residential	315.53	31.46	40 to 45	32.96
Commercial	38.75	3.86	3 to 4	4.05
Industrial	49.33	4.92	8 to 10	5.15
Public and Semi Public	45.15	4.50	10 to 12	4.79
Total Developed	**449.46**	-	-	-
Undeveloped Area				
Agricultural	324.18	-	-	-
Water Bodies	183.56	-	-	-
Total Undeveloped	**507.75**	-	-	-
Total Area	**957.20**	-	-	-

Source: Master Plan, Vaniyambadi.

Table 4. Transport details (as per 2011)

Name of the City	Public	IPT	Car	Two-Wheeler
Gudiyattam	62	1229	3271	36960
Vaniyambadi	113	3104	5994	93687
Ranipet	262	2807	8090	48409

3. System Concepts

The model presented in this study, using the System Dynamics (SD) approach, has been implemented in the 'STELLA' Environment. The study is contemplated to comprehensively cover the following major sectors namely, Population Sector, Land use Sector and Transport Sector.Population models explain the relation between population and demographic characteristics of natural increase and the social increase. The natural increase includes birth rate and death rate. The social increase includes the immigration rate and outmigration rate.

Land use models explains the relation between land use and growth factor of its separate land use pattern. The density depends upon the available land area and existing population level.

The model conception for transport sector explains the relation between trips made by public transport, intermediate public transport, and private vehicles. In private transport, two wheeler and car have been considered. In this sector, the trips generated by the

vehicle population have been calculated by using the growth rate and per capita trip rate.

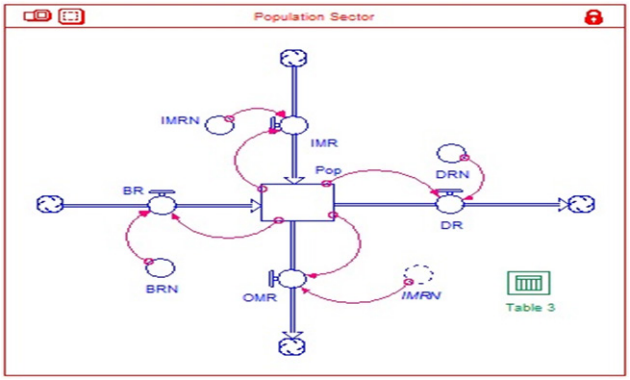

Figure 1. Model representation for population sector.

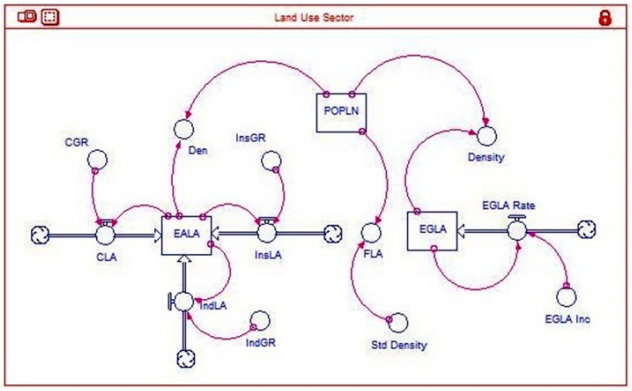

Figure 2. Model representation for land use sector.

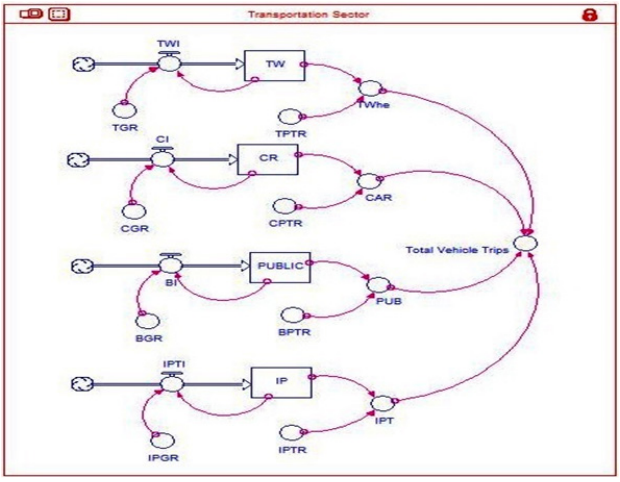

Figure 3. Model representation for transport sector.

There is no universal model that can run for all conditions with an unaltered set of parameters. Parameters must be checked and adjusted within the known range to avoid unrealistic projections. The population model was back simulated with the previous data (2001) and compared with the present population and simulated values. The variation is about 7 to 8 percent.

4. Model Validation

4.1 Structure Verification Test

The model consists of physical flows of population, land use and transport sectors. Figure 1, Figure 2 and Figure 3 show the structure of the model indicating important flows, the levels and the constants. The whole structures have been evolved after the structures have been allowed to undergo more number of modifications or combinations in each of 2 sectors. These structures are quite common and easily verifiable in real systems.

4.2 Parameter Verification Test

There are few parameters namely in migration normal, out migration normal, growth factor, existing generating land area, total vehicle trips etc. These parameters are verifiable in real life systems. These parameters have real life meaning.

4.3 Dimensional Consistency Test

Dimensional analysis is one of the important verification and validation tool for this system dynamics modeling. For the purpose of dimensional analysis, the primary quantities or equations in each of the two sectors namely population and land use are taken to test the dimensional consistency. The dimensions of physical quantities are independent of the system of units employed. All physical quantities are expressed by magnitude and units. Since all physical quantities are expressed in terms of primary physical quantities, their dimensions are likewise expressible in terms of M, L and T. L and area in a city may be measured in Length (L). But in population (No. of persons) is dimensionless quantity.

Primary Equations for Population Model

Population = Population + (Birth Rate+ In Migration Rate – Death Rate – Out Migration Rate)

(No. of Persons) = (all variables are in No. of persons)

$M^0L^0T^0 = M^0L^0T^0 + (M^0L^0T^0 + M^0L^0T^0 - M^0L^0T^0 - M^0L^0T^0)$

M 0 = 0

L 0 = 0

T 0 = 0

Therefore the equation satisfies the dimensional consistency. In this equation, other quantities are dimensionless.

Primary Equations for Land use Model

Density = Population/Required Land area (2)

(No. of Persons/unit are) = (No. of persons/Area)

$M^0L^{-2}T^0 = M^0L^0T^0/(M^0L^1T^0) + (M^0L^1T^0)$

M 0 = 0

L -2 = -2

T 0 = 0

Therefore the equation satisfies the dimensional consistency. The model is tested for its results. Based on real world data on population and land use data for the models are validated. It is observed from the model validation that the model results have good compromise between actual and simulated values. Hence the simulated result reveals good approach to actual, white quite tolerable deviation. This compromise is considered well enough for limited data used in this study.

5. Conclusions

5.1 Gudiyattam

5.1.1 Do – Minimum Scenario

The parameters considered for the population model projection are birth rate, death rate, in migration and out migration. Total population of Gudiyattam is 1,89,681 as per records of 2011. Birth rate of the area is 1.85percent and death rate is 0.45 percent**.** In migration rate is found to be 3.0 percent and out migration rate is 0.15 percent. The model is developed with these parameters.

Do – Minimum Scenario for the Gudiyattam shows that 6,61,158 population can be achieved by 2041 for existing growth rate and , Existing Attracting Land Area, Existing Generating Land Area are 85.6 and 207.95 respectively. The Future land area required to hold density 275 and 500 persons per hectares are 2448.74 and 1322.32 respectively. The total vehicle trips have projected from 58664 to 983674 with the percentage of 94.03%.

5.1.2 Desirable Scenario

In desirable scenario the existing condition is revised by strictly implementation on the restriction of population. The population can be restricted so that the city will be in medium city as per UDPFI guidelines.Land use proportion is adjusted to full fill the medium city land use proportion as per the UDPFI guidelines. The prevailing density norms have been considered to meet the population demand. From this scenario is found that the population density minimised but the agricultural land starts to degrade and vacant land is not planned properly. This leads to improper development pattern of settlements. Commercial activity seems to happening more with increase in land area. The analysed land use proportion for the Gudiyattam satisfies the UDPFI guidelines but the density will be high for this proportion which will spoil the quality of life of the people. The model results show that the increase in land area is not sufficient and the area required for the minimum density is more. But the area available in Gudiyattam is small so the vicinity area can be added with the Gudiyattam by extending the boundary of the Gudiyattam.

Desirable scenario for the Gudiyattam shows that 4,80,951 population can be achieved by 2041 by which the population is restricted to achieve the population below 5,00,000 so that the city can under the medium city itself. The existing Generating Land area was projected 1136.16 hectares which can hold 408 persons/ hectares. The total vehicle trips have projected from 58664 to 568746.

5.2 Vaniyambadi

5.2.1 Do-Minimum Scenario

Total population of Vaniyambadi is 1,36,548 as per records of 2011. Birth rate of the area is 2.15percent and death rate is 0.45 percent**.** In migration is found to be 3.5 percent and out migration as 0.175 percent**.** The model is developed with these parameters.The total land area is 957.04 hectares, in which the residential area is 315.53 hectares, commercial area is 38.75 hectares, industrial area 49.33 hectares and Semipublic and Public area is 45.85 hectares. Density for the Vaniyambadi is calculated based on predicted population for horizon year using the growth factor.

Do – Minimum Scenario for the Vaniyambadi shows that 5,94,382 population can be achieved by 2041 for existing growth rate and the, existing generating land area and existing attracting land area are 377.55 and 178.92 hectares. The future land area required to hold density 275 and 500 persons per hectares are 2201.42 and 1698.24 hecatres. The total vehicle trips have projected from 136075 to 878907 with the percentage of 84.52%.

5.2.2 Desirable Scenario

In desirable scenario the existing condition is revised by strictly implementation on the restriction of population. The population can be restricted so that the city will be in medium city as per UDPFI guidelines. Desirable Scenario for Vaniyambadi model in which the population is restricted to 4,42,879 lakhs.

Desirable Scenario for the Vaniyambadi show that 4,42,879 population can be achieved by 2041 by which the population is restricted to achieve the population below 5,00,000 so that the city can under the medium city itself. The total vehicle trips have projected from 1,36,075 to 4,99,990. The land area available is maximum but the residential area is minimum because the city has lot of industries where people are not willing to settle in Vaniyambadi.

6. Recommendations

- The study area has almost good infrastructural facilities to achieve self sustainability. But due to rapid conversion of land use with improper development will lead to deterioration of area. Planning for proper land use will enable sustainability.
- Retaining existing agricultural base in the surrounding rural areas for equitable growth is a must. Controlling and guiding urban sprawl in a phased manner applying modern principles of physical planning and growth management is suggested.
- Necessary basic infrastructure facilities including housing, health, education and recreational facilities need to be provided to achieve better standard of living. Need for strengthening of regional linkages for capitalizing on the economic development of the region.
- There is an immediate need to restrict the growth of personalized vehicles and augment the public transport. This could be done by increasing the number of buses and improve the facilities. For planning transportation facilities in a long run, it is necessary to perform a detailed modeling.

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