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Inter-relation of Land Use and Transportation System Based on Lowry Model

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Abstract: ***In an Urban area, land use and transportation system are its essential parts. Land use and transportation is strongly connected with each other. Everything that happens to land use affects transportation and vice versa. In this paper, Lowry model is used in Two Final T.P. Scheme i.e., 12 and 13 of ward No.27 (Adajan), which is located in west zone of Surat city, is selected as a study area. Lowry Model was developed by Ira Lowry in 1964 and it was one of the first transportation- land use model to be developed in 1964 for the Pittsburgh region. The model takes three major components of a city, namely, population, employment and the means of transport between them. Parameters such as residential location, employment location, purpose of trip and mode of trip will be adopted as input for Lowry model. Lowry model analysis will provide future population and employment.***

Keywords: Lowry Model, Land use, Transportation, Lowry Model Sector, Forecast Population

1. Introduction

In an Urban area, land use and transportation system are its essential parts. Land use and transportation is strongly connected with each other.(Mr.Kiran Patel, 2013)

In recognition of the complex dynamics of an urban system, urban planners in the 1950s and 1960s initiated the development of integrated land use-transport (LU-T) models. The first of these models to gain popular notice was Lowry's model of Metropolis in 1964. Since then there have been several integrated LU-T models developed worldwide such as ITLUP (Putman, 1983), MEPLAN (Echenique, 1985), MUSSA Land-Use Transport Model developed for Santiago de Chile by Martinez (1992), and UrbanSim (Waddell, 2002).

This ILUT model gives a better insights of trip generating activities with linkage of land use distributions therefore as planner one can provide the needful changes in land use that can create the effective and flexible transportation service.

In this research work The Lowry Model (1964) is used for the implementation. It was one of the first transportation / land use model to be developed in 1964 for the Pittsburgh region. Even if its formulation is rather simple, it depicts well the relationships between transportation and land use. Its premises were expended by several other models, known as "Lowry-type" models. The core assumption of the Lowry model is that regional and urban growth (or decline) is a function of the expansion (or contraction) of the basic sector. This employment is in turn having impacts on the employment of two other sectors; retail and residential.

The main aim of this study is to assess Land use and Transportation system using Lowry Model for T.P Scheme 12 & 13 of Surat City.

Objectives to accomplish goal are to understand the current scenario of land use and transportation of the study area. Second objective is to analyse data collected using Lowry's Model.

2. Integration of Land Use and Transportation

The recognition that trip and location decisions co-determine each other and that therefore transport and land-use planning needed to be co-ordinate led to the notion of the 'Land-use Transport Feedback Cycle'. The set of relationships implied by this term can be briefly summarized as follows.

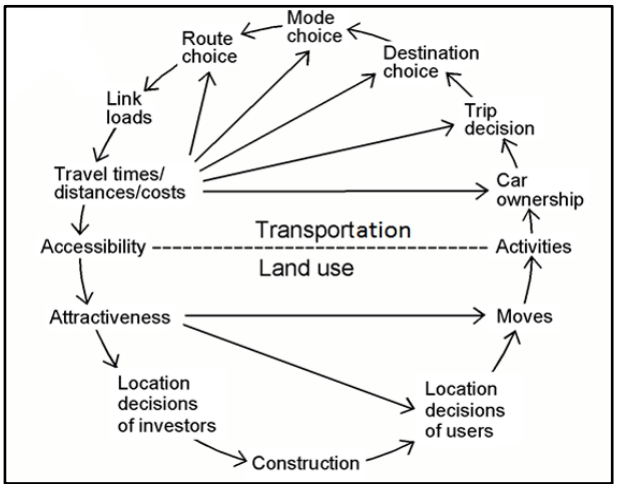


Figure 1: Land use-Transportation Feedback Cycle

The distribution of land uses, such as residential, industrial or commercial, over the urban area determines the locations of human activities such as living, working, shopping, education or leisure.

The distribution of human activities in space requires spatial interactions or trips in the transport system to overcome the distance between the locations of activities.

The distribution of infrastructure in the transport system creates opportunities for spatial interactions and can be measured as accessibility.
The distribution of accessibility in space co-determines location decisions and so results in changes of the land-use system.

In short, land use creates activities, activities create transportation, transport creates accessibility to land and again land use is developed and so on. The major theoretical approaches to explain this two-way interaction of land use and transport in metropolitan areas include technical theories (urban mobility systems), economic theories (cities as markets) and social theories (society and urban space). (Michael Wegener, 1999)

3. Methodology

Study is started with the identification of traffic problem and availability of mixed landuse in Surat city. It was observed that Transportation and Land use have strong inter-relation with each other. After identification of problem, main aim of the study and objectives for achieving that aim are framed. Work was started with learning each and every parameters and sector of Lowry Model and related literature and case study. Primary data was the main parameter of the study, so survey was carried out and secondary data was collected from several sources. Study is concluded with finding and analyzing the data collected.

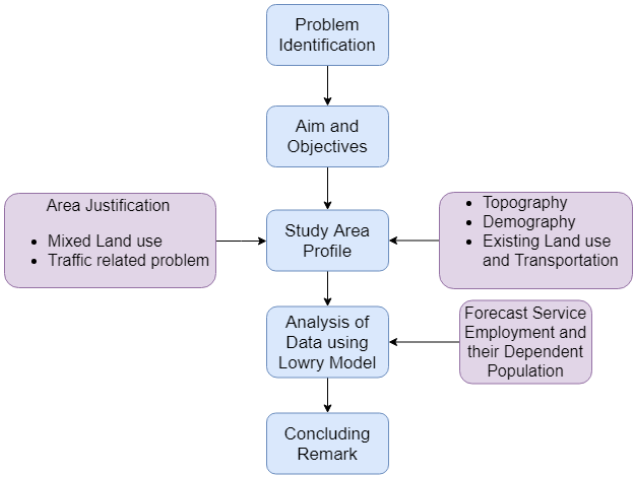


Figure 2: Research Methodology

4. Lowry Model

In 1964, Ira Lowry, an economist, developed a Lowry Model. It was one of the first transportation- land use model to be developed in 1964 for the Pittsburgh region. Lowry model has generated more interest than any other single urban model, as it has been widely used and has introduced two major innovations into the urban modelling research. First, it incorporated within its structure both a forecasting and an allocation procedure and second it relatesthree elements of the urban system together within a single general model frame work. The model takes three major components of a city, namely, population, employment and the means of transport between them, i.e., the transport network as represented by journey times, and describes the interaction between them and that these interactions determine urban change by allocating population and employment across the various zones of the city.

The levels of activities in the Lowry model are determined by the economic base method. In the model, all activities in the city are divided into three groups a basic sector, a service sector and a household sector.

Basic Sector
Employment that meets non-local demand. It produces goods and services, whichare exported outside the urban area. It generates a centripetal capital flows into the city, which results in economic growth and surpluses. Most industrial sector employment is within this category. This sector is usually less constrained by urban market accessibility considerations since the local market is not the main outlet of the output. The basic sector is an exogenous element of the Lowry model and must be provided.

Non – Basic Sector
This employment is to service the local demand such as retailing, food and construction. It does not export any finished goods and services and use the region as its main market area. Since this sector strictly serves the local / regional demand, location is an important consideration. Employment levels are also assumed to be linked with the local population through a multiplier effect. The retail sector is an endogenous element of the Lowry model.

Residential Sector
The number of residents is related to the number of basic and retail jobs available. The choice of a residential area is also closely linked to the place of work, so the model tries to minimize commuting distances. This consideration is an endogenous element of the Lowry model.

Employment in the basic sector influences the spatial distribution of the population and of service employment. Overall, the Lowry model has two assumptions:

1) The assumption that an individual's choice of residential location is strongly influenced by the location of his place of work.
2) Employment centres can be divided into two categories on the basis of their locational requirement. It can be classified as basic employment or service employment.

Major functions of Lowry Model are:
- It relates three elements of the urban/regional system, population, employment and transport and relate their interactions.
- It incorporates within its structure both allocation and forecasting procedures.
- It assumes an economic base mechanism where employment is divided into basic and non-basic(service)sectors.
- The basic employment sector includes those economic activities, the produce of which is utilized mostly outside the region e.g. manufacturing and other heavy government offices, the state headquarters, national financial institutions, university etc. All other are accounted as non-basic (sector population serving employment).
- The model assumes that the basic sector, both its location and magnitude is controlled exogenously.
- The model then determines the level and location of population and service (non-basic) within the region.

Data Process Structure

The model aims to represent the residential structure and the distribution of employment and of services in an urban area. With an exogenous spatial distribution of the basic sector employment and a set of transport costs between zones, the model calculates total population and employment by zone. It is composed of an economic sub model and a spatial allocation sub-model, which are subject to constraints. The economic sub-model provides the impacts of basic employment on non-basic employment and the total population. The spatial allocation sub-model provides the distribution of the population in function of attractiveness and transport costs. This is done by a gravity-type spatial interaction model.

Lowry Model Structure and Logic

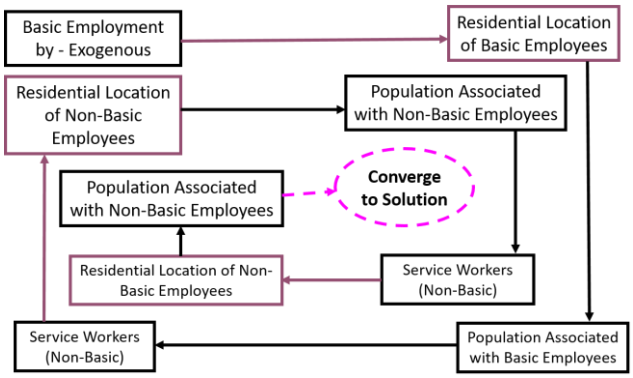


Figure 3: Lowry Model Logic

Formula

The distinction between population dependent on basic employment and service employment is central to the way in which both the forecasting and the locational parts of the model operate and it will be useful to observe how the proportions of the economic base method are expressed in equation form. If economic activity in an urban area is measured by the number of people employed, then the total employment consists of those people employed in basic sector and those people employed in service sector. If the total employment is represented by E, basic employment by B and service employment by S, then we can say

$$E = B + S \quad (1)$$

Planners and policy-makers are interested with relationship between levels of economic activity and population levels. At any one time a given number of total jobs, E. will support a certain number of people, P. The number of people supported by one job is represented by the symbol, α then

$$P = \alpha \times E \quad (2)$$

α is considered as a population multiplier expressing the ratio of total population (P) to total employment (E). It is found at any one time by directing the total population P by total employment (E) as shown below:

$$\alpha = P/E \quad (3)$$

The distinction with which the Lowry model is based is between population that is dependent on basic employment and that dependent upon service employment. Therefore, the equation that expresses population in terms of basic and service employment rather than total employment and B + S is substituted for E which becomes

$$P = \alpha (B + S) \quad (4)$$

In other words, population is some function of (α) of basic plus service employment and thus (4) is rewritten as

$$P = \alpha B + \alpha S \quad (5)$$

Where, αB is population depending upon the basic employment

αS is population depending upon service employment

The important aspect for the operation of Lowry model is the level of service employment determined by the level of population. As population is some function of total employment, service employment is also a function of total population and thus

$$S = \beta \times P \quad (6)$$

β is thought of as a population - serving ratio a factor which expresses the amount of service employment which will be demanded or supported by a given population. It is the ratio of service employment to total population and thus the value of p is found as shown below:

$$P = \beta/P \quad (7)$$

Given values for α and β and α is a forecast of the number of basic jobs, the population dependent on basic employment is found by multiplying the number of basic jobs by the population multiplier. In other words, if B is the number of basic jobs, and P (1) is the population dependent on basic employment, then

$$P(1) = \alpha B \quad (8)$$

This population will indeed generate a demand for and is capable of supporting a number of jobs in service sector and thus the number of service jobs demanded by the basic population is P (1) as follows:

$$D(1) = \beta P(1) \quad (9)$$

These service sector workers will themselves have dependent population and if we call this dependent population P (2), thus we get

$$P(2) = \alpha D \quad (1)$$

This additional population will itself generate a demand for service employment D (2) so that.

$$D(2) = \beta P \quad (2)$$

The latest increment of service employment D (2) will have its own dependent population (P (3)) and this in turn will generate another increment of service employment and so on. In fact, each increment of service employment and service dependent population becomes smaller and smaller until they become insignificant. The sum of the increments of service employment (D (1) + D (2)) = D (3) + ... + D(N) represents the total forecast service employment and the sum of the increments of population is the total service dependent population.

The Lowry model has obviously several limitations. It is notably a static model, which does not tell anything about the evolution of the transportation / land use system. Furthermore, recent economic changes are in the service

(non-basic) sectors, forming the foundation of urban productivity and dynamics in many metropolitan areas, cannot be effectively represented. Under such circumstances the model is likely to be inaccurate in major service-oriented metropolitan areas. A way to overcome this issue is to consider some non-basic service employment as basic.

Advantages

a) Many variations and extension have been subsequently developed.
b) Most of the modern era models are built on foundation of Lowry model.
c) It relates three elements of the urban/regional system, population, employment and transport and relate their interactions

Limitations

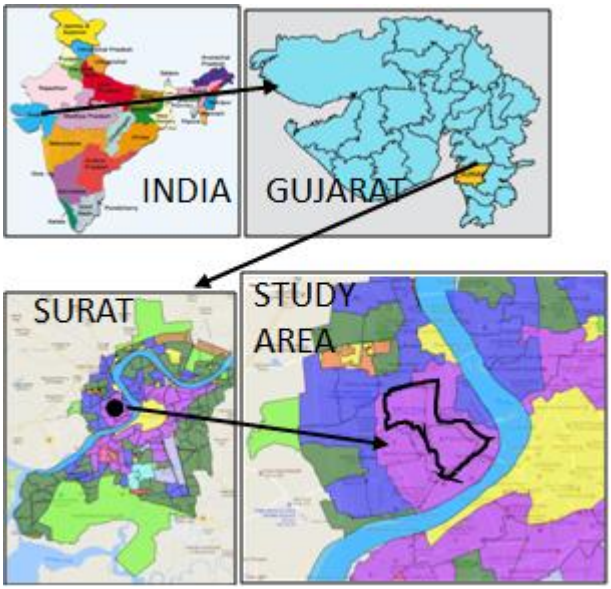
a) It is one of the basic models which is more effectively applicable to the small-medium size towns.
b) It is a Static Model.

5. Study Area

Surat is a city located on the western part of India in the state of Gujarat and situated at latitude 21°12'N and longitude 72°52'E on bank of river Tapi having coastline of Arabian Sea on its West.. It is one of the most dynamic city of India with one of the fastest growth rate due to immigration from various part of Gujarat and other states of India.

Surat is a compact city and has been expanding along transport corridors. A moat divides the older parts of the city, with their narrow streets and historical houses, from the newer suburbs. The growth trends indicate sprawl tendency towards the South and North-East, with growth extending towards the northern side across the river. The residential development in the city covers about 57% of the total land use developments in the city. Peri-urban growth is also a feature of the city, especially along the Surat-Hazira corridor, which has led to associated growth in the periphery. Surat has the highest percentage migrant population in India (more than 50%).

The city has experienced 6+% annual population growths since the 1960s. In recent decades Surat has emerged as a major centre for trade and commerce in the region.



(T.P.SCHEME - SURAT, 2016)

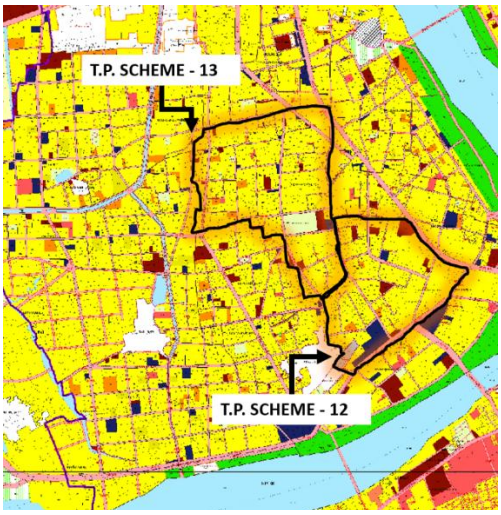
Figure 4 Location of Study Area

Study Area Profile

The Study area is located in West Zone of Surat City.
For data collection and survey two final T.P. Scheme- 12 & 13 are selected.
Area (in hec)
T.P. Scheme 12 – 109.40 ha.
T.P. Scheme 13 – 155.66 ha.
Selected T.P. Scheme is in Ward No. 27 (Adajan)

Table 1: Detail of Study Area

T.P.Scheme	**12 & 13**
Ward No. & Name	27 (Adajan)
Area	2.65 sq.km
Population (2011)	77,594
Density (sq.km)	29,280.7
No. of Household	17,630
No. of Houseless People	795



(DP 2035, 2018)

Figure 5: Land use map in Surat City Development Plan 2035

6. Data Collection and Analysis

In this study, primary data plays an important. Study area is divided into Seven zones. This seven zones will be used in creating origin-destination matrix afterwards.Zones of study area is divided from roads and not based on some criteria. Survey was conducted using random sampling method and samples were collected from each zone of study area. Following image shows the position of each zone in study area in which household survey is conducted.

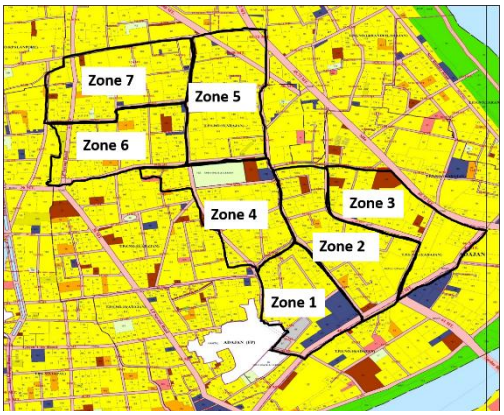


Figure 6: Study Area divided into Zones

For analysis **227 questionnaires** forms were filled up from the study area.

6.1 Lowry Model Sector

The levels of activities in the Lowry model are determined by the economic base method. In the model, all activities in the city are divided into three groups a basic sector, a service sector and a household sector. The pie chart given below indicates percentage of availabilities of different sector in a Study area.

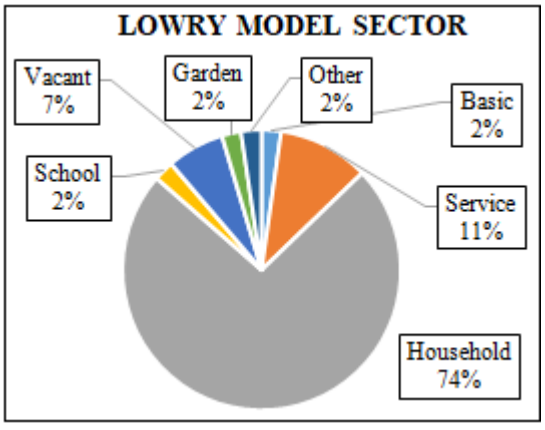


Figure 7: Lowry Model Sector

6.2 Employment Detail and Occupation Type

As per the data collected through primary survey, total member from both the T.P. Scheme is 1006, which include 399 working member (40%) and 607 non-working member (60%). People between age of 18-60 year are considered as a working member. Children and senior citizen are in non-working group.

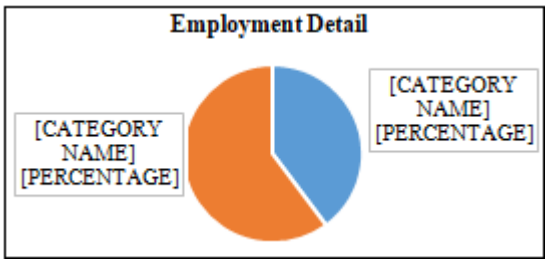


Figure 8: Employment Detail

As in a Lowry Model, there are three sectors; Basic, Service and Household Sector. Working Member of study area is 28% and 72% in basic and Service Sector respectively. People employed in Basic Sector are 112 and in Service Sector are 285.

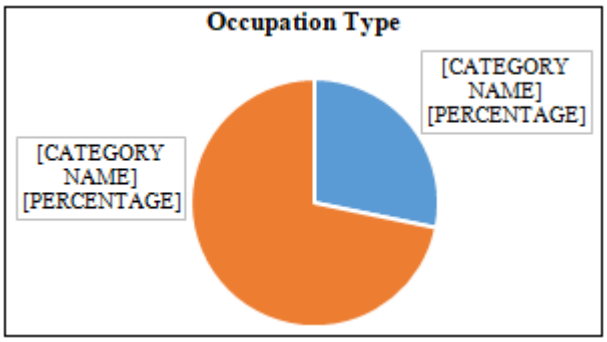


Figure 9: Occupation Type

6.3 Lowry Model Calculation

Parameters such as Total Population, Residence Population and Working Population are adopted as input for Lowry Model calculation.The increment of service employment will have its own dependent population and this in turn will generate another increment of service employment and so on. For 26 increment step total increment for service employmentis 263.035 while total population serve by service employment is increase by 950.755.

6.4 Trip Information

As per the Lowry Model, Employment is categories in Basic and Service sector, so work trip is generated in both the sector. And school based trips are also considered for total number of trip generated.
Total no. of trip generated = Total work trips (basic + Service) + Total school trips
Total work trips = **425**(Service sector = 289, Basic sector = 136);
Total School trip = **279**
Total **704** trip is generated per day.

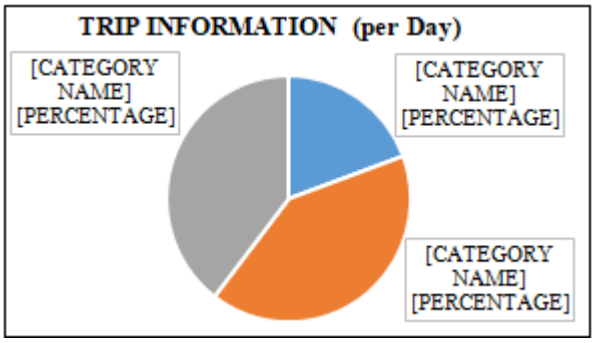


Figure 10: Trip Information

7. Concluding Remarks

Rapid urbanization has already made urban areas more congested. Mode and route of transportation system provide limited solutions to the traffic related problems thus it has become more necessary to look for an innovative approach towards urban planning. The selected study area is one of the congested areas of Surat city in terms of population as well asvehicular traffic. UsingLand use models can also give opportunities to provide vast number of solution.Change in land use can increase the overall accessibility in the urban area that helps to reduce the travel distance as well as travel time and cost. Proposal is made on the basis of Lowry Model equation' result and availability of its sectors as well as vacant spaces.

References

[1] *DP 2035*. (2018). Retrieved from SUDA.
[2] Michael Wegener, F. F. (1999). *Land-Use Transport Interaction:*. Dortmund: Institute of Spatial Planning.
[3] Mr.Kiran Patel, D. J. (2013). An Impact of Land use and Transportation - A case study of Sanand Area. *IJSRD - International Journal for Scientific Research & Development*, 3.
[4] *T.P.SCHEME - SURAT*. (2016). Retrieved from ENAGAR: http://enagar.org/tpscheme-surat.php
[5] *Waddell*. (2002).