 CHAPTER - 5
METHODOLOGY FOR TRAFFIC PLANNING STUDY: THE CASE OF TEZPUR TOWN

Over the past decade, the vehicle population has began to grow rapidly even in the small towns of Assam. The likely consequences of motorisation, including the issue of traffic congestion call for management of the use of existing road space, and the construction of new roads. International evidences clearly show that road construction, on its own, provides no solution to traffic problem except for a very short time (Stares and Zhi, 1995). In fact, the general conclusion of all such experience of motorisation, to date, is that if the road system is made more efficient, or of greater capacity, more motorists will be attracted to use it until congestion occurs again. In other words, since most transport improvements are incremental, the effect is that any capacity gained is swallowed up immediately by new traffic putting all effort in vain. Further, in many instances, more elaborate plans for urban networks seem unrealistic, both in terms of what can be afforded (in cost and resettlement), and their impact on traffic congestion. There is, however, no doubt that they may be regarded as supplementary to other policies.

Hence, the conclusion is that the road transport demand will always exceed the supply of road spaces; no matter how well these are managed and efficiently used. Therefore, the towns under study seem to have no alternative but to consider ways of controlling and managing the demand for road space.

Travel demand is a function of the population, per capita trip rate and average trip length. In a progressively urbanizing developing economy such as the ours, there is little possibility of reduction in the per capita trip rate. This is because a larger share of the population would be securing employment and a larger share of children would be attending schools. Efforts at reducing travel demand, therefore, should focus on reducing the average trip length.

The key to reducing trip lengths is through a proper integration of land use and transport planning. Business and residential districts that are well interspersed entail shorter trip lengths as compared to an urban form that has a single business district surrounded by sprawling residential suburbs. Small, self-contained clusters are considered desirable from a
transport perspective. It is essential that the transport network guide the urban form, rather than the urban form guiding the transport system. Land use planning would, therefore, require that transport corridors be developed early so that new settlements come up around these corridors systematically.

The success of this strategy would, however, depend on the ease with which people can shift residences or employment. Unfortunately, neither of these is very easy. For instance, buying and selling of houses is complicated or job mobility is limited as employment is difficult to find and having once found a job, many people tend to stay on life-long. Again, in addition to travel demand, there is demand for employment, housing, power, water supply, schooling, healthcare and every other aspect of human existence that needs to be comprehensively viewed if the dream of self-contained clusters is to be successfully realized. The fructification would need complete cooperation from various interest groups and seamless coordination across government departments, which seems somewhat utopian at present.

Any transport planning process dealing with the management of transport demand would thus require focused attention to the problems while preparing basic data and information to be used in testing the solutions. It requires careful survey and analysis of trip generation, existing and future uses of urban land, trends in vehicle growth, the performance and conditions of existing infrastructure, and environmental conditions. It is important to estimate the dimensions of future demand because that is the measure of required performance of the solutions. It is also important that the planning should be financially realistic and economically sound. Furthermore, the planning should also include the traffic management of streets and highways, as well as related systems such as parking. To this end, this work tries to find out a simple yet effective way to the traffic planning process and employs a mixed-method approach to answer the research question presented in Section 1.6: Is it possible to formulate transportation plans with affordable information to suit the future growth and development of small cities and towns of Assam?

5.1: Transport plans with affordable information

The goal of this research is not to develop a new ITLUM tool, but to use an existing approach and apply it to the towns of Assam. For this purpose the present work mainly
resorts to the established work of the steering group and working group appointed by the Ministry of Transport, Her Majesty’s Stationary Office (HMSO), London, entitled ‘Traffic in Towns’. It is the pioneer study on the long-term problems of traffic in urban areas, published by HMSO in 1963.

This research finds the approach adopted by Buchanan as an example of a simpler modelling approach that could be used to support urban planning decision-making. However, necessary modification will be made according to the situation in Assam on one hand and the data availability and possibility to generate the required data or information on the other. For the small and medium sized towns of Assam, such an approach can be beneficial for two basic reasons – firstly, it involves the collection of a very modest data and secondly, it is operational. Furthermore, it can be achieved with reasonable resources, it takes less time and most importantly this scientific method is not based on any computer software. So, the small towns of Assam can easily use such an approach as a means for urban planning decision-making process. Here, question may arise as to whether the approach taken by Buchanan in 1960s may be considered as a modern approach or not? To answer this it is worth mentioning that in the towns of Assam, most of the variables for the traffic problems are almost same as they were in the 60s in London. So, though the number and magnitude of some of them may show some change, they can be treated as those affected the traffic of London in 1960s. In this connection, it is noteworthy that this research also tries to incorporate some ingredients of modern integrated land use transport policies to the Buchanan’s approach.

The main parameters (existing or assumed) and measures used by Buchanan for a small town are as mentioned below:

A. For assessing the present condition -

(i) Urban population - population of the town, population in the fringes dependent on it, expected population over a period of time

(ii) Occupation of the people – types and number of workers in each type, % of workers to the total population

B. For vehicular traffic -

(i) Identification of the busy routes of the network
(ii) Identification of the time of high traffic during the day

(iii) Determination of the peak hour of flows.

(iv) Counting of the number of cars entering the city during the peak hour on a working day and a non-working day to estimate roughly the position of the number of people using cars for the journey to work in the town.

(v) Counting of the volume of traffic in all the major entry points into the town from 6 am to 6pm (generally on a working day).

C. For assessing the environment -

(i) General observation on danger, noise and confusion, how close the vehicles are to the pedestrians and to each other.

(ii) The conflict between pedestrians and vehicles in terms of road causalities.

D. For the traffic and accessibility -

(i) Examination of the existing system of roads

(ii) Observation on stationary vehicles

E. Determination of the primary network

To workout the applicability of this Buchanan based approach for the towns of Assam, a case study on Tezpur town has been made. This represents how to use this simplified modelling approach. So, the methods for working on the Buchanan’s approach and modifying it as per the local conditions of Assam include practical case study and surveys. The following is a discussion of the chief methods applied for the purpose.

The first method is the case study approach, using the Tezpur town master plan area as the case study area. It is used in order to partially support the above mentioned research question. The second method is the field surveys, which are meant for working on the Buchanan’s approach. This research uses different survey methods to gather different field data relating to the working population, their work places, the income pattern etc. on one hand and the number of vehicles and traffic volume, supply and demand of parking space etc. on the other hand, for the case study town.

5.2 Case study method

This research uses a descriptive case study to illustrate the role that the adopted simpler traffic planning approach can play in the transportation planning process of the
towns of Assam. More specifically, the case study in this research will show how this modelling approach can be used as an additional strategy, besides the master plans, for certain town planning decision-making categories. While no two regions are exactly the same, the results of this case study could be used to generalize how to deploy a simpler transportation land use modeling tool. The nature of data available for the case study town is similar to that of other towns of Assam and many towns are facing similar challenges regarding transportation and land use policies.

The case study method has been described by some researchers as a weak research method within the realm of social science. Critics point to the insufficient precision of the results, lack of objectivity, lack of generalisability, and the limited academic rigor. Nonetheless, proponents point to recent evidence suggesting that it is a commonly used method that, if conducted properly, can mitigate concerns raised by critics. There are three key criteria that can be used to judge the quality of descriptive case studies (Yin, 2008). First is —construct validity or the establishment of the correct operational measures for the concepts being studied. In our case, the measures and parameters are just taken from the established work of Buchanan, which had proved their worth in the towns of England and in that sense, they are said to be operational. Second is —external validity or the ability to make generalizations from the case study’s findings. While every town in Assam is unique in some way, including the Tezpur town, this town is typical of many towns in the state in terms of data availability and transportation/land use policies being debated. Thus, the findings may said to be applicable to other towns of the state. Third is —reliability or the ability to repeat the operations of the study with the same results. To this end, it can be said that, an important component of developing this case study is documenting exactly where the data comes from and how the simpler modelling approach is created. So, any one can repeat the operations to obtain the results.

5.3 Survey method

Social scientists routinely use surveys of several types. Surveys can be useful when a researcher wants to collect data on phenomena that cannot be directly observed. As defined by Lavrakas, survey research is a systematic process using various methods to collect information that can be analyzed and used to generate insights (Lavrakas, 2008).
For this research, a random survey was taken during January to March, 2009, as means to collect village level data on economic condition of the residents, number of vehicles they have and the places of their work. As the population is very large, this survey covered only 2 to 3 per cent households of each village under study as per 2001 census (covering a total of 721 households). The survey schedule method was employed to gather the information.

Besides the above, 14 villages (out of 73 villages) and 2 of the municipality wards (out of 19 wards) were chosen randomly (Fig. 5.1) to collect detail information about the population of workers in different occupations, place of work and the route they use, number of vehicles, monthly income, number of daily trip and the purpose of journey, the mode they use etc. Importantly, for this random selection, first we have divided the villages within the master plan area and the municipality area into well defined population density zones as per 2001 Census. Then we have randomly taken 14 villages and the 2 wards from these density zones. In doing so, the proportion of representation from each of the density zones was maintained as far as possible.

Fig. 5.1: Surveyed villages within Tezpur master plan area
Information from these selected villages and wards are then collected during the months of March and April 2009, by means of a schedule (Appendix: A.1), covering 70 - 100% households in the case of the villages and at least 50% of the residential households for the wards. In both these surveys a total of 4,608 households from the 14 villages and 357 households from the two wards (Ward No. 9 and 4) were covered. As the total number of households in the master plan area is \[20585(\text{Village}) + 5336(\text{OG}) + 15345(\text{MB}) = 41266\] 41,266, the surveyed households contribute about 12%. Again, if we add to this, the households covered in the 2 – 3% survey (i.e. 721 households), the total surveyed households will cover about 14% of the total households of the master plan area. In terms of population, the survey covers about 13% of the total population of the master plan area.

The analysis of surveyed information on monthly family income was then used in delineating the zones, within the master plan area, having 40% or more of its families with monthly income above Rupees 10,000/-.

Further, on the basis of the information about the place of work and market, we have also estimated the expected villages, from where at least 80% of the people come to a particular node for work and shopping. Thus, we have obtained the basic catchment area of 6 major nodes in the master plan area, which are then used for further analysis.

**Road inventory**

One of the fundamental measures of traffic on a road system is the volume of traffic using the road in a given interval of time. It is also termed as flow and it is expressed in vehicles per hour or vehicles per day. The knowledge of the vehicular volume that uses a particular road network is important for understanding the efficiency at which the system works at present and the general quality it offered to the road users. Again, by knowing the flow characteristics, one can easily determine the peak hour flow or flow per hour and compare it with the standard road capacity to see whether a particular section of the road is handling traffic much above or below its capacity. For example, if the traffic is heavy, the road suffers from congestion with consequent loss in journey speed.

We have counted the traffic volume at all the 8 major entry points into the town (Fig. 5.2). It was done manually by counting and classifying traffic flowing past the selected fixed lines on the road on Monday, the 10th Sept., 2007 from 6.00 AM to 4.30 PM.
we have taken the field data sheet and the daily summary sheet for traffic census in similar manner as prescribed in table 4.3 and 4.4 by L.R. Kadiyali in his book *Traffic Engineering and Transport Planning*. From this survey, we have found that the majority of the journey to and from the municipal area of the town takes place during the period from 9.00 AM to 10.00 AM denoting it as the peak hour. Having thus obtained the peak hour, we have conducted another two road side counts from 9.00 AM to 10.00 AM i.e. on Tuesday, the 18th May and Sunday, the 23rd May, 2010. Here, one working day and one non-working day were selected for the survey for obtaining the peak hour volume difference between a working day and a non-working day. The locations for these counts were the same as the previous count.

Fig. 5.2: Traffic volume count points in and around Tezpur municipal area

To know the hourly pattern of traffic volume in the central area of the town (and also the pedestrian movement), we have also counted the traffic on the roads in the central area of the town on Tuesday, the 18th May, 2010. The traffic volume survey was done at 10 selected points (Fig. 5.3, count points from 1 to 10) from 9.00 AM to 4.00 PM.

As the traffic is composed of a number of types of vehicles, for further analysis, by following the normal practice, we have also converted the flows found on the above mentioned traffic counts into equivalent passenger car unit (PCUs). It is to be noted that the
PCU has been defined by Transportation and Road Research Laboratory (TRRL), London in 1965 as "on any particular section of road under particular traffic condition, if the addition of one vehicle of a particular type per hour will reduce the average speed of the remaining vehicles by the same amount as the addition of, say x cars of average size per hour, then one vehicle of this type is equivalent to x PCU". Again, for the purpose, we have taken the PCU equivalents as recommended in the ‘Guidelines on Capacity of Roads in Rural Areas’, I.R.C., 1990 (Kadiyali, 2004).

To compare the traffic volume at the peak hour with the standard capacity, we have taken the practical capacities recommended by the UK standards for urban roads as given in the Roads in Urban Areas, Ministry of Transport, H.M.S.O., London in 1966 (Kadiyali, 2004). In our case this standard will be 300 to 500 PCUs per hour for a two lane
carriageway with effective width of 6.00 metre, 450 to 600 PCUs per hour for a two lane
carriageway with effective width of 6.75 metre and 600 to 750 PCUs per hour for a two lane
carriageway with effective width of 7.30 metre.

Survey on road condition and width

The carriageway widths as well as the shoulder widths of roads within the master
plan area were measured manually during February, 2011, at 104 cross sections on different
roads (Fig. 5.4). While taking the measurement, the condition of the road was also observed
and recorded. The conditions were evaluated on the basis of black topped, graveled or kutcha
road and the physical condition of the road. In taking the cross sections, utmost care was
taken to cover as many roads in the area as possible.

Measurement of road length

The lengths of different roads are measured with the help of a Rotametre. For this
purpose, we have taken the road map of the master plan area. Roads were then classified
into black topped, graveled and earthen (kutcha) on the basis of their physical nature, and
measured their lengths accordingly. On the basis of service and status, roads were also
considered as Major distributors and Local distributors.
Parking survey

In order to gather an understanding of the existing parking situation in the town, a parking survey was undertaken. The survey was carried out from 9.00 AM to 4.00 PM on Friday, the 2\textsuperscript{nd} April, 2010. Mention should be made that a decision was taken to include only the adopted section of the main road (approximately 100 metre on both the sides from Chowk Bazar) in the parking survey. The survey established the following:

(a) The existing volume of acceptable parking space and the parked vehicles in the area; and

(b) The existing volume of unacceptable parking.

For the purpose of the parking supply survey, it was assumed that one car covers a space of 2.5 metre x 4.7 metre (when parked at 30° angle) and that of a motorcycle or cycle needs a space of about 0.8 metre x 2 metre parking space. Again, for the acceptable parking space, the areas deemed to be ‘acceptable’ was the areas specified for parking lots along the roadsides. The field survey included the measurement of each parking lot, record of the registration numbers and counting of all vehicles parked within the survey area and classification of the vehicles either legally or illegally parked. The survey was done by the ‘walked petrol’ method, where a frequency of half an hour was taken for recording the on-street parking.

Pedestrian counts and environmental quality survey

Pedestrian counts were taken to determine the movement of pedestrians within the central area of Tezpur. For this purpose, 13 different points were selected. Ten of the pedestrian count points were the same, taken for the traffic volume count in the town centre (Fig. 5.3). The other three pedestrian volume count points are - in front of the Ananta Complex, in front of Parek Hardware store and in front of the Fish Market (Fig. 5.3). The pedestrian counts were taken on hourly basis.

For the assessment of environmental quality also, the same locations as for the pedestrian counts were used. Here, a ‘Quantitative’ rather than ‘Qualitative’ system was used so as to compare different sites. For this an Environmental Index (Appendix: A.3), was used. It is to be noted that the areas of survey were approximately 20 metres around the Pedestrian Count points in all directions.
**Land use survey**

One of the simplest methods for determining urban land use over a large area is to use a system of grid squares. This allows a rapid assessment of land use. So, for the purpose of land use survey of the central part of the town, done during October to December, 2009, the base map taken was divided into four zones and then grids. The fieldwork uses examples of area and point data collection. It has also of course used transects to collect the information. The investigation on land use was done by assessing what is the ‘Dominant’ land use within each grid square, and recording of this information on the map. The land use key used for the purpose is given in Appendix: A.2. The survey involves the use of a large number of maps. The base grid map used for the survey is as follows (Fig. 5.5).

![Sample base map for the land use survey](image)

**Fig. 5.5:** Sample base map for the land use survey (the original map was of A4 size having scale 1 cm to 40 m)
Collection of accident data

Accident data were generated from the secondary source, i.e. from the police records of Tezpur Sadar Thana during October, 2009. For this we have opted for the period from 2004 to 2008. We have gone through month wise total number of accidents, place of having maximum number of casualties, hour of the day having maximum number of accidents and the days of the week having maximum case of accidents. An accident, here, means a collision, overturning or slipping, which occurred on a road resulting either injury or loss of life, or damage to property, in which at least one moving vehicle was involved.

5.4 Examination of functional zoning in Tezpur and land use patterns

After collecting the land use data, by using the colour code, different zones within the town centre were identified. While doing so, care was taken in the selection of colour. For instance, to colour the recreational areas in green rather than bright red or for the public and semi-public lands the red etc. The map thus produced was examined to determine any patterns that exist. A few questions, for this, are: What is in the central area? How do residential areas change away from the centre? Where are the industrial developments? Where is transport functions located? Is there any evidence of physical restrictions on development? Is there any evidence of ‘Out of Centre’ retail developments?

5.5 Examination of environmental quality

To examine whether the Environmental quality varies with distance from the town centre, following correlations were calculated:

(i) Between Shopping Quality and distance from the centre;
(ii) Between Environmental Quality and distance from the centre;
(iii) Between Environmental Quality and Shopping Quality (which might be the independent variable here?);
(iv) Between the Numbers of Pedestrians and Shopping Quality; and
(v) Between Numbers of Pedestrians and Environmental Quality.

5.6 Examination of settlement pattern

Depending upon the variation of intra-ward settlement, the total number of houses of a particular ward, the concentration of urban settlement in any ward can be specified. The formula devised by J.A. Bernard (Khan, 1998) has been used here to evaluate the degree of
concentration of the settlements in the town. The village level concentration indices are computed by using the relation –

\[ Ci = \frac{HA}{S^2} \]

Where, \( Ci \) = Concentration Index, \( H \) = Total number of houses, \( A \) = Area and \( S \) = Number of settlements in the ward/village.

5.7 Examination of service distribution in Tezpur

To see the distribution of different services in the town, at first we have plotted the location of the services on a base map. For this, we have used a colour key to get clearest result. Then, to investigate the extent to which the services are clustered, the method of Nearest Neighbour Analysis was used. The Nearest Neighbour Analysis (NNA) provides a test of random distribution and gives a statistical meaning to the terms clustered, dispersed and random. In this method, the Nearest Neighbour index gives a value between 0 and 2.15. The value of 0 means that points are completely clustered; 1 means random distribution and 2.15 means uniform distribution.

The formula to calculate the NNI (usually referred to as R) is:

\[ R = 2D \sqrt[n]{\frac{n}{A}} \]

Where, \( D \) = mean observed nearest neighbour distance, \( n \) = total number of points in survey and \( A \) = The study area.

While defining the boundary of the study area, we have taken the portion of the map that comes on an A4 size paper. Here, we did not convert the scale of the map because; an A4 piece of paper has an area of approximately 624cm² and the calculation can be done on that basis.

5.8 Structure of the road network

A representation of the structure and geometry of transportation within the study area would include nodes or vertices and edges or links. Here, a node represents an intersection or a confluence, while an edge or the segment represents the road link between two nodes (Fig. 5.6).

By assuming that the level of development of transportation is measurable through the surrogate variable of transportation structure indices, the four empirical and measurable structure indices are used in the present investigation. They are – (i) Cyclomatic number \( (\mu) \), (ii) Alpha index \( (\alpha) \), (iii) Beta index \( (\beta) \) and Gamma index \( (\gamma) \). All these four indices belong to planner graphs and hence the planner graph formulas have been used in their
computation. They provide a measure of the quantum of connectivity between nodes and thus, their levels of accessibility.

For computation of these indices, this work uses the number of edges and vertices at different population density zone level, which have been identified for the analysis of different aspects of the study town. The edges and vertices were taken from the road map of the Master Plan.

Fig. 5.6: Map showing nodes and edges of the existing roads within the Tezpur Master Plan area

It may be pointed out that, the higher the value of the cyclomatic number ($\mu$), the more connected will be the transportation network. In the case of Beta index, it is logically true that where beta is equal to zero, the network system is absent. In the areas where the values are greater than zero but less than unity, there are some routes along which goods can flow. Lastly a network with a beta index of connectivity equal to unity can be described as a simple connected graph, for all vertices are connected by the maximum number of edges required for complete network connection. Beta indices of greater than unity, therefore, indicate higher degree of interconnections (Yeates, 1968). The Alpha index is
actually an adjustable form of the cyclomatic number, hence, strengthens the interpretation of the role of the latter. The Gamma index, which is again a useful index of the connectivity of networks, provides a still more sensitive measure. Higher the gamma index higher will be the connectivity.

Though each of the structure indices contributes towards knowing the efficiency of the transportation network, individually any of the structure indices may not be expressive of the entire capacity of the transportation network. Thus we have computed the aggregate road network structure of different density zones within the town by summing up the values of the contributions of the above four indices. For this, the concept of Aggregate Transportation Scores (ATS) has been taken and calculated from the technical paper on 'Indian Roads Congress' (May, 1973 issue) by A. B. Mukerji entitled 'Road Transport Network Structure and the Levels of Urbanisation in Rajasthan' (Mukerji, 1973). The ATS of different zones within the study town have been computed in the following manner:

(a) Each of the structure indices values have been arrayed in ascending or descending order.

(b) The arrayed series are broken into three segments on the basis of the average of all the zones and termed as high, medium and low classes.

(c) These classes are allotted scores according to the following chart; where the scores are allotted in such a way that the values of ATS for high, medium and low categories are 100, 60 and 40, and the ratios between any two consecutive figures, either in the vertical or horizontal column, remain almost the same.

<table>
<thead>
<tr>
<th>Classes/ Indices</th>
<th>α</th>
<th>β</th>
<th>μ</th>
<th>γ</th>
<th>ATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>29</td>
<td>27</td>
<td>25</td>
<td>19</td>
<td>100</td>
</tr>
<tr>
<td>Medium</td>
<td>17</td>
<td>16</td>
<td>15</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>Low</td>
<td>13</td>
<td>11</td>
<td>9</td>
<td>7</td>
<td>40</td>
</tr>
</tbody>
</table>

(d) The values of structure indices are then given scores appropriate to the classes to which they belong in the preceding chart.

For example, the aggregate transportation score of population density zone number 1 in Table No. 6.6 has been calculated as follows:
(i) The $\alpha$ value of 15.21 belongs to the low class as per the average value of the master plan area. Hence, its score is 13 in the above table.

(ii) The $\beta$ value of 1.29 belongs to the low class; hence, its score in the table is 11.

(iii) The cyclomatic number is 75, which places the zone in the high class and the score is 25 in the table.

(iv) The $\gamma$ value of 0.43 belongs again to low class, and its score in the table is 7.

Thus by adding the scores of $\alpha$, $\beta$, $\mu$ and $\gamma$ indices ($25 + 13 + 11 + 7$), we got the ATS as 56.

5.9 The horizon year

The growth of an urban centre is a continuous process. However, any development plan requires a time frame for its implementation. Accordingly, by taking a period of 15 years, the horizon year for our projections and other future requirements is made as 2025. But, it equally important to realise that urban dynamism will carryon beyond this horizon year and thus any plan proposals cannot be entirely based on the requirements of the horizon year. The town has to function efficiently beyond it.

5.10 Projection of population and traffic

There are various methods of projecting population (mathematical, economic and component methods). Some are very sophisticated and rigorous while others are simple and less sophisticated. Normally, population in future is governed by the following equation:

\[ P_n = P_0 + \text{Number of Births (B)} - \text{Number of Deaths (D)} + \text{Net Migration (N_m)} \]

If we want to use this equation for projecting the population in 2025 ($P_n$), the base year population ($P_0$) in 2001, the number of births and deaths between 2001 and 2025 and net migration is required. Now, though population in the base year (2001) is available, number of births, deaths and migration in future needs to be projected which is not an easy task.

Another method that is considered to be suitable for projecting district and even village level population is the component method of population projection. It requires detailed age-structure of population in the base year along with estimation of a variety of demographic indicators. For instance, distribution of population in 2001 in different age
groups such as, 0-4, 5-9, 10-14 etc. is required. But, in our case, the data required by the
component method was not available at the village level. Further, use of the method
requires expertise in demography for understanding the demographic structure of the
population at village level. Therefore, we have taken the following simple and easy-to-
handle methods of population projections:

(i) The growth rate method: For computing the annual rate of growth (simple), the
following formula can be applied to the information at any two points of time.

The formula:

\[ r = \frac{100(P_n - P_0)}{n(P_0)} \times 100, \]

Where, \( r \) = annual rate of growth,
\( P_n \) = population in the current year, \( P_0 \) = population in the base year and \( n \) = number of
intermediary years.

For instance, the population of the master plan area of Tezpur as per 1991 (\( P_0 \))
Census was 1,57,783 persons as against 2,02,384 persons in the 2001 (\( P_n \)) Census. So, the
‘\( r \)’ would be 28.27% and it gives the decadal rate of growth which has taken place between
the two given years, 1991 to 2001. The annual rate of growth can be simply obtained by
dividing the decadal rate of growth by 10; thus 2.83% is the annual rate of increase. By
assuming that this rate of growth would continue in the future, population figures can be
obtained in any given year.

(ii) The compound rate of growth method: It is a slightly improved method, where
the geometric rate of change is based on the assumption that the rate of change over 10
years be equally divided across each of the 10 years and that the population will continue to
grow at the same rate as it has in the past. The formula for it is as follows:

\[ R = \left[ \left( \frac{P_n}{P_0} \right)^\frac{1}{n} - 1 \right] \times 100 \]

And by the formula, given below, population in any requisite year can be projected.

\[ P_n = P_0 \left( 1 + \frac{R}{100} \right)^n \]

For instance, if we want to project the population of Tezpur master plan area for the
year 2011 with the known 1991 and 2001 populations of 1,57,783 and 2,02,384
respectively, we have the following:
Thus, during the period 1991 to 2001, population increased at the rate of 2.52 per cent per annum.

The above rate can now be applied to know the population figures in any given year. For the year 2011, this would be,

\[ P_{2011} = P_{2001} \times (1 + \frac{R}{100})^n \]

\[ = 202384 \times (1 + .0252)^{10} = 259575 \text{ persons.} \]

The same method can also be used for projecting other variables like the number of vehicles. One of the limitations of this method is that while computing the rate of growth, it considers information at only two points of time.

(iii) The arithmetic projection: For the purpose of projecting the population of different density zones (as has been selected within Tezpur Master Plan Area), the following arithmetic projection method has been used. The simple reason is that it is easy to calculate. Further, we took the arithmetic projection due to unavailability of reliable data on population parameters at the village level. While using this formula it was assumed that there exists a straight-line pattern i.e. increments or decrements from the population are equal throughout the projection period, year by year.

The Formula:

\[ P_n = P_0 + n(P_0 - P_m)/m \]

Where, \( P_n \) = Projected population in \( n \) year later from the year, \( P_0 \) = Present population and \( P_m \) = Population at a date \( m \) years earlier from the present.

Turning to the number of vehicles, the numbers of vehicles at present (2011) as well as at the horizon year are projected with the same formula as has been used for arithmetic projection of the population. Similarly, with the help of the per capita trip generation, as obtained from the household survey of the aforementioned 14 villages and wards, we have also estimated the number of daily trips. The daily trips by different modes as well as purpose have been estimated for the population density zones, income group wise zones and catchment areas of six major nodes for comparison.
By comparing the number of vehicles in the town, as apparent in Table 6.19 and the road side vehicle count at 4 major entry points into the town (Table 6.10), the number of motorized vehicles seeking to enter the municipality area daily was also estimated.

5.11 Data base for the study and tools

To address the specific need of the research, the study was started with the study of literature on transport and traffic planning, city planning and land use – transport integration. The study of literature is not only done to create a thorough knowledge about the problem, but also is used in theoretical evaluation of the problem.

Due to lack of reliable statistics, the observations are a vital part in the investigation. The necessary secondary data was collected from PWD, DTO, Municipal office, Office of the Town and Country Planning, Census office, Thana etc. To know the planning procedure, the Town and Country Planning Officer and two of the engineers were interviewed.