Developing Public Transport Accessibility Model For Nashik City, Maharashtra, India

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Abstract—Theories of new urbanism and smart growth usually point at accessibility as one of their most significant principles. Researchers have called for a paradigm shift from auto mobility oriented planning towards accessibility oriented planning. In most of Indian cities accessibility criteria is neglected while preparing for transportation plans. Mobility is major factor within urban areas but mobility based approach create sprawls. This resulted into lot of time and money spend on basic travel needs such as shopping or commuting. Accessibility is function of both land use pattern and performance of transportation system. It is particularly appropriate criteria for evaluating service provided by transport system to different categories of users. Movement in cities mainly governs by various purposes like work, education, shopping etc. Among all these trips work are mandatory trips. Study focuses on to access the accessibility for public transportation systems within the Nashik city. To fulfil this aim, first concepts and definitions of accessibility understood along with case studies as a part of literature. After this secondary data is collected and analyzed. It is not possible to understand traffic scenario of Nashik city only by secondary survey. Firstly, gaps are identified and based on the data required questionnaire is design for primary survey. Then primary survey is conducted in Nashik city to understand present travel pattern of city along with issues faced during trip. After that for public transportation accessibility index is calculated and mapped for all zone by trip purposes. Public Transport Accessibility Model (PTAM) is used for evaluating level of accessibility by public transport. Values of PTAM can be used by policy makers for public transport improvement.

Index Terms—Geographic Information System (GIS), Public transport, Workplace accessibility, Public transport Accessibility Model (PTAM), Public Transport Accessibility Level (PTAL), Relative Accessibility Index (RAI), Traffic analysis Zones (TAZ)

1 INTRODUCTION

Accessibility is an estimation of the spatial dispersion of various activities around a point, balanced for the ability and the desire of individuals or firms to overcome spatial division [1]. Accessibility, an idea utilized as a part of various scientific fields, for example, transport planning, urban planning and geography, assumes an imperative part in policy making [7]. It can be characterized as the closeness of individuals, places, and services to the transportation system [5]. Accessibility refers to individuals’ capacity to reach services, goods and activities, which is a definitive objective of most transport activity [11]. The more accessible to various activity area in community lead to greater its development potential [1]. Accessibility is a crucial characteristic for metropolitan regions and is frequently reflected in transportation and land-use planning objectives [4]. Land-use and infrastructure policy plans are frequently assessed with accessibility measures which helpful to policy makers and researchers to solve the problems [7].

Public Transport Accessibility Levels: Ahmedabad study PTAL is calculated by four different methods out of which quintile method is finalized for the PTAL mapping of Ahmedabad City [16]. GIS for Multi-modal accessibility to Jobs for the Urban Poor: Ahmedabad study links the urban poor, jobs and public infrastructure with help of GIS modelling. This study shows that local planning effort should concentrate on public transport improvement, the NMT feeder function as well as integrated urban land use and transport development strategies, acknowledging the home and job locations of the urban poor [13]. Geographic accessibility analysis and evaluation of potential changes to the public transportation system: Milan, Italy study, potential changes to the surface public transportation system in the City of Milan are evaluated. Surface public transportation system can be considered unattractive because of its lack of efficiency. This case study also helpful for finding out the potential zones for the improvement of public transport system not only for citizens but also for business area within the city limit [14]. Measuring Local Accessibility by Public Transport: Krefeld, Germany study aims to enhancement of accessibility indicators to be used in public transport plans. In traditional public transport plans planners mainly examine the transport system itself and its own quality of development and connectivity. This study presented a proposal to use a travel time budget indicator for analyzing local accessibility by public transport. By using the developed GIS application, the method was exemplarily demonstrated for a planned project in the case study city Krefeld [8].

In various researches, workplace accessibility is also referred as job accessibility. Workplace accessibility measures might be influenced by transportation implies, transportation means, congestion, road network, and force of competition for employments among workers [6]. The study by Wang and Fahui (2003) reveals that job access is the spatial issue [6]. The poor workplace accessibility in inner city area has intense impacts in the residents [6]. The lack of employment level has severe impact on city ranging from criminal behavior, social disorder [3]. The reason behind it, might be socioeconomic factors including vehicle ownership [2].

Amsterdam Job Accessibility Measure study shows that, job accessibility can be measure and mapped in GIS environment. For this purpose, data related to transportation network and location activity is essential. This case study also gives an idea about diversity of job opportunity and its mapping. This information can be used for formulation of various Policies [12]. Public Transport Accessibility Level: London study PTAL is calculated in terms of number. This PTAL value is used in development plan to formulate policy like decision of housing density, Parking area location and Allocation [15]. The accessibility describes the how places are well connected to each other. If the public transport works efficiently then the level of accessibility improves. In this study the main focus is given on work trip because it is mandatory trip and no one can deny this trip. Primary survey conducted in Nashik city indicate that there are five major mode of transport which are bicycle, motor cycle, car, auto rickshaw, bus (public transport). To calculate Relative
Accessibility Index (RAI) of public transport these modes are considered. RAI is mapped on GIS environment using ArcMap. The objective behind this study is to give background to local authority for improve transport infrastructure of city. RAI mapping gives the picture of whole city which would help to decision makers and policy makers to decide the development pattern of city with respect to public transport.

The study proposes the method to assess public transport accessibility level at macroscopic level and the method can be called as Public Transport Accessibility Model (PTAM).

2. STUDY AREA: NASHIK CITY

The city is situated at the foothills of the Western Ghats Mountains on the banks of the river Godavari. Nashik was seventh largest city in 1947 in Maharashtra after Mumbai, Pune, Nagpur, Solapur, Ahmednagar and Amravati, all having industrial activities. Now it is the fourth largest. Two rivers, river Godavari and river Nasardi, flows through the center of the city in west-east direction. Nashik has the second highest working population in service sector (27%) next to Aurangabad (31%). Hence Nashik is listed in “Industrial cum service” category. This city is also known as Grape City or Wine City. Nashik has long been an important religious center, attracting millions of pilgrims, and every 12 years hosting one of the world’s largest gatherings, the Kumbhmela which is next estimated to bring 100 million visitors over the course of 55 days in August-September 2015 [17].

2.1 STUDY AREA ZONING:

A pilot study was conducted in Nashik city to study the travel pattern of Nashik city in core area with the help of questionnaire. This study shows, the working trip are from within city limits as well as from peripheral area of city also. The Military area is not considering for survey. To analyze the accessibility, it is needed to add this area in zoning. Therefore, totally six zones are classified as Traffic Analysis Zone (TAZ) for accessibility study purpose of work trips in Nashik City.

2.2 ANALYSIS OF WORK DENSITY PRESENT IN CITY:

1) Analysis of Work Density Based on total Area:

Figure 3 shows that Work density is maximum in core area and CIDCO area of city. Maximum Work density is 432 PPHa in ward number 11 which is in core area of city and also it is near to City centroid. Average population density of City is about 75.12 PPHa. Study also shows that Work density goes on decreasing exponentially as we go away from city centroid.

2.3 LOCATION ANALYSIS OF WORKPLACES:

The Wikimapia API and Google Earth is used to data retrieval and workplace location mapping is done as presented in Figure 4. This exercise shows that, the core has more working location which mainly includes restaurant, offices, industry, schools, hospitals etc. Figure 4 shows that work places are concentrated in core area of city – Nashik East. Apart from this Satpur and Ambad MIDC area also having number of industries. Nashik Road also showing some workplaces as it is near to Railway Station.
3. METHODOLOGY

To understand and give PTAM a primary survey was conducted in Nashik city. Primary data mainly includes the personal information, socioeconomic condition and work trip details. Total 645 sample size collected from different zone of Nashik city. Table 1 shows zone wise sample collected from all six zone.

TABLE 1
ZONE WISE SAMPLE COLLECTED

<table>
<thead>
<tr>
<th>Zone</th>
<th>Population</th>
<th>No of HH</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panchavati</td>
<td>310646</td>
<td>68632</td>
<td>130</td>
</tr>
<tr>
<td>Satpur</td>
<td>242702</td>
<td>56200</td>
<td>115</td>
</tr>
<tr>
<td>Nashik West</td>
<td>151046</td>
<td>34121</td>
<td>100</td>
</tr>
<tr>
<td>CIDCO</td>
<td>289758</td>
<td>68913</td>
<td>110</td>
</tr>
<tr>
<td>Nashik East</td>
<td>279296</td>
<td>61912</td>
<td>130</td>
</tr>
<tr>
<td>Nashik Road</td>
<td>212605</td>
<td>46555</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>1486053</td>
<td>336333</td>
<td>645</td>
</tr>
</tbody>
</table>

3.1 PUBLIC TRANSPORT ACCESSIBILITY MODEL (PTAL) DEVELOPMENT:

To develop PTAL following methodology is adopted to calculate RAI. The stepwise procedure is given below.

Step 1: Calculate the mode choice between the zone i to zone j based on the equation 1.

\[ P_{ij} = \frac{ec_{ij}}{\sum ec_{ij}} \]

(1)

Pij represents the probability of mode to be selected for trip from zone i to zone j.

cij is the parameter which is calculated by the vehicle travel time from i zone to j zone, walking time to stops, waiting time at stops, total cost travel from zone i to zone j. This all data is taken from primary survey.

Step 2: Calculate the RAI for each zone i. This can be calculated by comparing all values of Pij to every zone value of i for every mode of travel. It gives the RAI as shown in Figure 5. It represents mode choice between the one zone to other available zone independently. But it cannot give the overall accessibility level when compared with other and mode together. Therefore, in the third step it calculates the accessibility level by considering mode as well as zone together.

Step 3: Add the value RAI of each mode for single zone i which gives the PTAM value for each mode and for each zone as tabulated in Table 2.

Step 4: Do the mapping on GIS environment for a whole view of accessibility level of each zone with respect to other zone as presented in Figure 6.
Table 2

<table>
<thead>
<tr>
<th>Zone</th>
<th>AI for Bicycle</th>
<th>AI for Two wheeler</th>
<th>AI for Four Wheeler</th>
<th>AI for Auto</th>
<th>AI for Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.488</td>
<td>2.45</td>
<td>0.77</td>
<td>0.17</td>
<td>1.12</td>
</tr>
<tr>
<td>2</td>
<td>1.378</td>
<td>2.095</td>
<td>1.09</td>
<td>0.15</td>
<td>1.29</td>
</tr>
<tr>
<td>3</td>
<td>1.05</td>
<td>2.1</td>
<td>1.17</td>
<td>0.17</td>
<td>1.15</td>
</tr>
<tr>
<td>4</td>
<td>1.174</td>
<td>2.23</td>
<td>1.27</td>
<td>0.17</td>
<td>1.15</td>
</tr>
<tr>
<td>5</td>
<td>1.1</td>
<td>2.4</td>
<td>1.14</td>
<td>0.16</td>
<td>1.18</td>
</tr>
<tr>
<td>6</td>
<td>0.74</td>
<td>2.42</td>
<td>1.47</td>
<td>0.19</td>
<td>1.16</td>
</tr>
</tbody>
</table>

Then the accessibility mapping has been done for each zone with help of Arc GIS mapping which gives the better assessment of accessibility index by type of mode used.

4. FINDINGS

The PTAM is developed for assessing accessibility level of workplace location by public transport for Nashik city. From this study following finding can be drawn:

- For quantifying the accessibility it is needed to study travel pattern of working population and according to this for TAZ as presented in Figure 2.
- Figure 6 presented PTAM values which gives Accessibility Index for work trip is maximum in Nashik East and lowest in Satpur zone. It shows that travel time and travel cost required to reach workplace is maximum for zone Satpur and Nashik Road. It also shows that Nashik East and Nashik West have maximum proximity to the workplace compare to other zones. This issues can be solved by completing links between zones, improving public transport and other suitable action have to be taken like allocation of facilities in that zone etc.
- c) Level of accessibility by public transport towards workplace location is less for zones Panchavati, Nashik road and NE. This shows that these zones need increase in public transport infrastructure.
• d) Figure 5 gives the mode choice decision amongst each zone which would help for analysis of mode choice between zone and at individual level.

5. CONCLUSIONS
PTAM is developed and gives the values which can be used to compare the accessibility level at zone level. The mapping of PTAM values can be used at policy level. For example, the extent of development of public transport infrastructure can be decided by using mapping. As the accessibility level value is low then it indicates that remedial measure has to take at that location. PTAM can be used to analyze and improvement of public transport infrastructure by the transport strategy. The GIS mapping is used to visualize the accessibility of public transport. GIS mapping will help in future for periodic revision and updating of the old map. This study is not considered the micro level of modelling but it is useful to formulating zone wise proposals in development plan of city. Further study can be done on the ward level and considering activity based trips. This study is also possible by considering small unit instead of zone and considering activity based trips.

REFERENCES
[8] Zwacarze and Bjorn,” MEASURING LOCAL ACCESSIBILITY BY PUBLIC TRANSPORT, Research and Teaching Assistant, University of Dortmund, Faculty of Spatial Planning Chair of System Theory and Systems Engineering, Germany.August-2006.