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Four Step Travel Demand Modeling for Urban Transportation Planning

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ABSTRACT: Travel forecasting is crucial in the urban transportation planning phase. For projecting the future traffic scenario, various travel forecasting models are used. It is used to evaluate potential road capacity, improvements in transportation systems, and new land use patterns and policies. In terms of Travel Demand and Modelling, it includes the use of a mathematical model sequence to simulate human travel behaviour. We read a number of papers on traditional four step modelling and made a graph with the experimental conditions after analyzing the author's work. Each graph is given a rating from one to five. A higher rating is given to a paper with just a clear methodology and easy-to-understand terminology, while a lower rating is given to a paper with such a complicated methodology. The traditional four-step transportation modelling method is the focus of this paper. Most of those models are focused on data regarding the pattern and activity of the transportation system. You'll need a decent foundation with the most current data set to calibrate the models.

KEYWORDS: Urban transportation planning, four-step modeling, Travel demand forecasting, graphical and theoretical representation

I. INTRODUCTION

Transportation is the cornerstone of economic planning, and passenger transportation is critical to the city's operation. One of the most important factors is transit planning and the growth of infrastructure for the arrangement, particularly in major metropolitan area levels of and rapid urbanization [1]. To define and examine emerging traffic problems, it is essential to provide a thorough understanding of current travel trends. Precise forecasts of total passenger and freight demand, as well as competitive and complementary intermodal relationships, are required to schedule, build, analyze, and regulate transportation and supply chain networks.Graphs are developed by analysing the paper with particular focus on four-step modelling. Transportation planning and management's primary aim is to balance transportation availability with travel demand. The decision-making procedure for future road infrastructure upgrades in a region is used in transportation planning. Various programming software and manuals have been created to aid in the decision-making process. Two of the most important methods are [2].

1. Travel demand prediction models for the four-step planning process implementation.
2. Travel cost indicators to provide data on regional congestion and delays.

For the four-step urban planning method, these involve trip demand forecasting models. TRIP GENERATION, TRIP DISTRIBUTION, MODAL SPLIT, and TRIP ASSIGNMENT are the four steps in the trip planning process. This paper aims to learn more about the urban transportation modelling environment in order to better understand traffic behaviour. As a result, public transportation operators and logistics companies are keen to learn more about the creation and interpretation of accurate and effective demand forecasting models.

II. SCOPE OF THE STUDY

The demand for passenger and freight transportation in modern societies is increasing. People prefer personal transportation to public transportation as household income rises, according to a general trend. The obvious and convincing reason for this is that personal transportation maximizes individual freedom, choice, and versatility in ways that public transportation cannot. They are often used to estimate future traffic and are the foundation for determining the need for additional road capacity, changes in transit service, and changes in land-use policies and patterns.

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The current four-step model might best be viewed in two stages.

- In the first stage, various characteristics of the traveller and the land use-activity system are "evaluated, calibrated, and validated" to produce a non-equilibrated measure of travel demand (or trip tables).
- In the second stage, this demand is loaded onto the transportation network in a process that amounts to formal equilibration of route choice only, not of other choice dimensions.

The study's scope includes a literature review and logical design of different urban transit planning models. Travel demand management, employer-based trip reduction services, pedestrian and cycling programmers, and

land-use policies could not be managed well in the process, according to the study's limitations. All of the models are focused on travel trends and behaviour data. No matter how good the models are, if the data is out-of-date, incomplete, or incorrect, the results will be poor.

III. TRANSPORTATION PLANNING USING CONVENTIONAL FOUR STAGE MODELING

In 2012, the author Bayes Ahmed [2] describes the parameters of a transport modelling framework based on the simplified transport network of a simplified transport network at Dhaka City, Bangladesh. The author developed a series of mathematical models in step-by-step, taking travel requirements into account and human behaviour when travelling. The steps to generate, distribute, divide modes and allocate the journey [2] are those. So it works at the macro stage.

In 2016, the author P.N. Dadhich, Arun, Singh Shekhawat [14] published a paper "Travel Demand Modelling and Forecasting (A Case Study of Sitapura Industrial Area)". According to the author, the purpose of the study is to familiarise itself with the modelling of city transport and to better understand, on a zonal basis, the conduct of the state of traffic conditions in the Sitapura industry in the Jaipur area and to improve the network assignment. This research focuses on 4-stage modelling that includes a range of mathematical models that simulate human behaviour [14]. This is also the macro-level approach. To study Sitapur the technique of Bayes Ahmed was used by Rajasthan, P.N Dadhich and Arun Singh Shekhawat. The Bayes Ahmed technique is explained as follows:

Trip Generation: It forecasts the number of trips that originate in or end in a specific traffic analysis zone. To begin, calculate the 10-year growth rate. Then, for demand, measure the population and average zonal income after 10 years. Then, for attraction, estimate employment and land prices after ten years. After ten years, the calculated parameters for trip production and attraction are as follows: by using the following two regression equations.

For trip production $= a_0 + a_1 * (forecastedpopulation) + a_2 * (forecastedincome)$

For trip attraction-$= b_0 + b_1 * (forecastedemployement) + b_2 * (forecastedlandprice)$

Trip Distribution: For each of the 10 zones, the trip distribution phase is an origin-destination matrix. The trip attraction or destination must be similar to the product. Create an O-D matrix to represent the distribution of trips amongthevarious zone

Modal split: The Modeler will use mode choice analysis to decide which mode of transportation will be used.

The equation for calculating modal share is as follows: Modal Share for any Mode$= tripi-jXprobabilityi-j$

Trip Assignment: To determine facility needs and costs and benefits, we need to know the number of travellers on each route and the link of the network.

First, calculate generalized travel cost, $GTC = TC + \frac{a1}{a2} X\ TT$

Then, calculated generalized travel time, $GTT = \frac{a2}{a1} X\ TC + TT$

The difference in both articles is the one that is seen in a line graphic by P.N. Dadhich, Arun, Singh Shekhawat paper, and in a map that has been obtained by Bangladesh Corporation to show the network. The paper by Bayes Ahmed uses zoning and ward marking in the map. According to both documents [14], regulation of travel demand, employer-based travel reductions, cycling and pedestrian programmes, and land use policies may not be well managed[2]. These two papers use the 'ANOVA' package for the results calculation and the regression equation Microsoft C++ programme.

In 2011, the author Kevin B Modi [4] wrote a review paper on "Transportation planning models". The aim of this paper, according to the author, is to provide an overview of travel demand modelling for transportation planning. The trip generation, trip distribution, modal split, and trip assignment are the four stages of the model. Through their various approaches, this four-step modelling elaborates. The author briefly explains two approaches to trip generation. 1) Regression technique 2) categorization. The authors of the trip distribution model describe their three sub-models: growth factor models, synthetic models, and opportunity models. The author goes into great detail about the probit

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and Logit models in the modal split.The following sub models are widely used in the trip assignment model. 1) An all-or-nothing assignment model, and 2) An assignment model with multiple routes.
3) Capacity restriction multipath route assignment model, 4) Capacity restraint assignment model 5) Strategy model for diversion curves.
In 2007, Michael G. McNally [9] published a paper titled "The Four-Step Model". In this paper, it was learned that, in theory, travel is derived from the demand for activity participation, which has been modelled in practise using trip-based rather than activity-based approaches. There are two steps to remember. The first stage evaluates,

calibrates, and validates traveller and land use activity system characteristics to deliver non-equilibrated measures of travel demand. The second stage loads this demand onto the transportation network in a phase that amounts to formal equilibration of route preference only. To research FSM, data must be gathered through a household survey and traffic studies. This survey data is used to verify the sample's representativeness, establish and estimate travel generation, delivery, and mode preference models, and conduct travel time studies. The goals in both the papers mentioned below are the same [4] and [9].
Trip generation: The objective of this model is to define the magnitude of total daily travel within the model framework, at both the household and zone levels, for a variety of purposes.
Trip distribution: The purpose of this model is to recombine travel ends from one generation to the next, though these are more commonly referred to as production-attraction pairs than origin-destination pairs. The gravity model is widely used.
Mode choice: The step's goal is to determine which vehicle to use on each route from point A to point B. For the estimation of the mode option model, the Logit method is widely used.
Route choice: At this stage, routes are chosen based on a combination of demand and results. The traffic assignment technique includes the all-or-nothing assignment model.The traditional model of travel forecasting, generally referred to as the four-step model [9], was discussed at the conclusion of this chapter. The author is aware that computer programmers have developed ready-to-use software for resolving transportation planning issues [4].
In 2015, Theodore Tsekeris [8] published a paper on "Demand Forecasting in Transport: Overview and Modeling Advances". According to the author, planning, developing, analysing, and regulating transportation and supply chain systems requires accurate forecasting of total passenger and freight demand, as well as competitive and complementary relationships among modes of transportation. The author creates a new model called the combined transportation planning model. The methodology used is explained as below.
Trip generation: - The linear regression model of trip generation can be generally expressed as follows: $Y =$

k
$i=1$
$\beta i * xi$. The following set of equations can be regarded as typical example models.

Trip production rate of households of income group ($RinG$):- $Yik = HHi * RinG * fik$
Trip production rate of households with car ownership (RiC):- $YIK = HHi * Ric * fik$ Trip distribution: The result of this step is the construction of a complete origin-destination (O-D) table. The gravity model of trip distribution is as follows: $Y = \alpha i * \rho i * \beta j * Aj * f(dij)$
Mode choice:- The relation between private and public transportation is usually considered in this phase. A user's utility function U can be expressed in a general way as: $Uin = Vin + \in in$
Traffic assignment: The traffic assignment problem can be mathematically expressed as follows:$\sum a\ qa * ca$
In 2018, author Sandeep S. Udmale [10] published an article "Extended Four-Step Travel Demand Forecasting Model for Urban Planning". The purpose of this work is to develop a mathematical model for a new phase in the conventional travel demand forecasting model. The aim of this additional phase is to determine heavily loaded roadways between TAZs and recommend zones containing such heavily loaded links as the best zones for implementing a regional road transportation network. The methodology used in this paper is the same as above [2]. The extended step given by the author is to calculate the maximum shortest path from the trip assignment step called maximum path length denoted by 'h' [10]. Extension of four-step modeling is developed in both papers [8], [10]. The author, Theodore Tsekeris, studies the extension step involving the simultaneous estimation of two or more stages of the overall process to develop a combined transport travel model. The combined urban location and travel option models incorporate long-term location options, land prices, and housing rents dependent on improvements in accessibility, among other factors. Sandeep S. Udmale, the author of another paper, added a new step to the four-step model, with the goal of identifying heavily loaded roadways between TAZs and recommending zones with such loaded links as the best zones to implement a road transportation network from the overall area.

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IV. METHODOLOGY ADOPTED

A flow diagram is provided to show the approach used in the literature review. There are mainly two represent ations are shown. One is graphical and the other is theoretical. During the data collection process, collect various papers related to four step modelling and research each one in consideration for writing a review. In the result, learn that which paper is best for future reference.

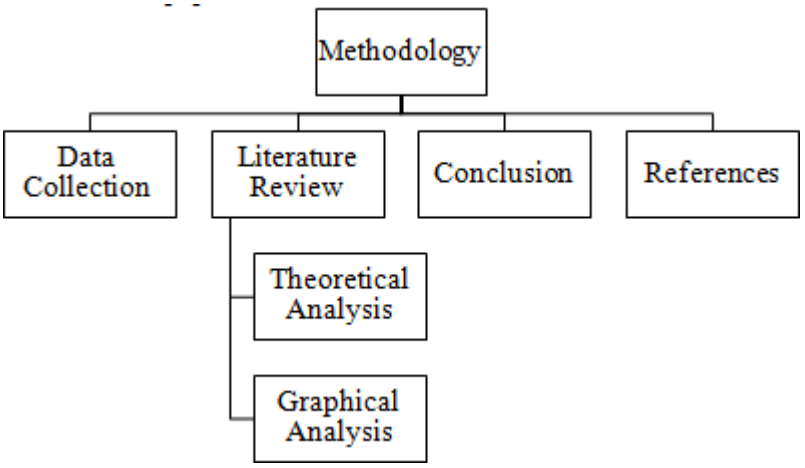
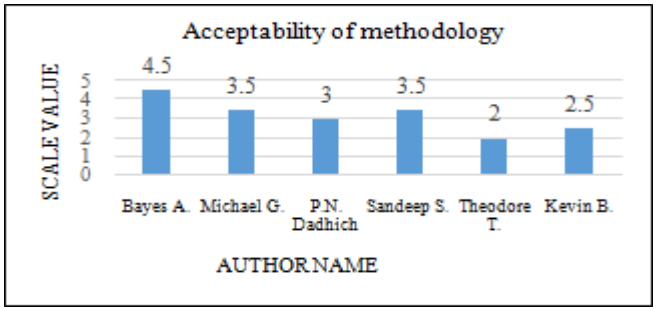


Figure: 1 Diagram for showing adopted methodology

Read a variety of articles to know about conventional four step modelling for urban transportation planning. After reading all of the articles, create a summary graph that identifies the main points. Each graph has the name of the author on X-axis and Y-axis rating based on important points they have written in each of the papers.

5. Graphical and Theoretical Analysis



Figure– 2 Graph on focus on four step modeling

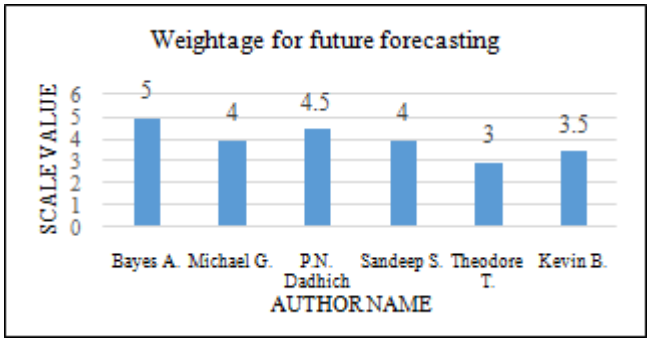


Figure- 3 Graph on suitability for transportation planning

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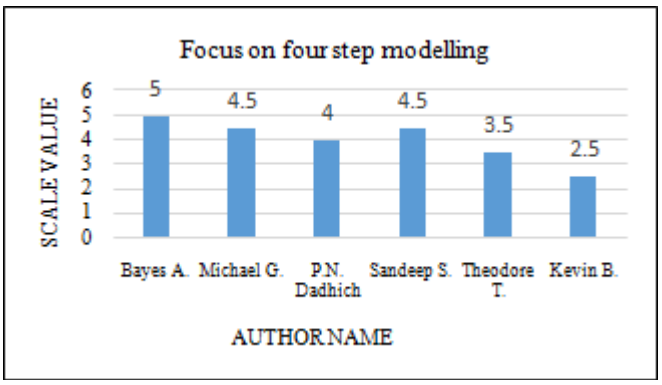

Figure – 4 Graph on simplicity of methodology

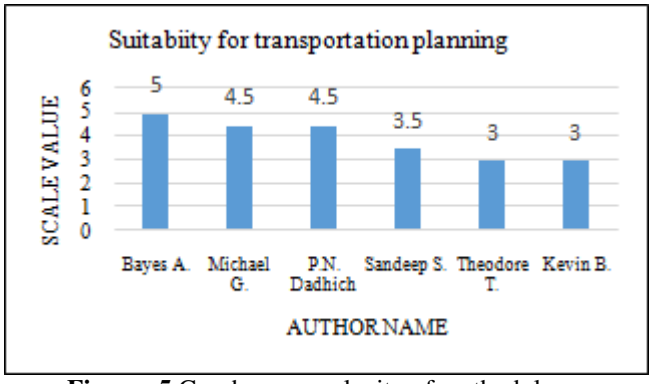

Figure- 5 Graph on complexity of methodology

After analysing all the articles, the simplicity of methodology is classified in fig. 2. The author, Bayes Ahmed, received a better score because it is easier to understand than the other papers. In addition, the authors P.N. Dadhich and Sandeep followed Bayes Ahmed's approach.

As shown in fig. 3, author Kevin B. has briefly explained all the methods available, so the articlegives 3.5 score. The methodology used by Theodore T. is complex to understand.

The procedure in all the papers is like acceptance. But look at the comparison graph and noticed that in fig. 4, author Bayes Ahmed's approach is similar to just accepting. Also, other researchers in the graph have adopted the methodology used by author Bayes Ahmed. But after studying, we found that author Kevin B. did not use any specific methodology.

Transportation needs to be planned for the future by studying the traditional four steps. The author has created such a graph (refer to fig. 5) after studying each paper. The graph gives a rating based on the future results of each author's study. The author, Bayes Ahmed, was given a 5 rating because the concepts are clear. Also, authors Kevin B. and Theodore T. have low ratings.

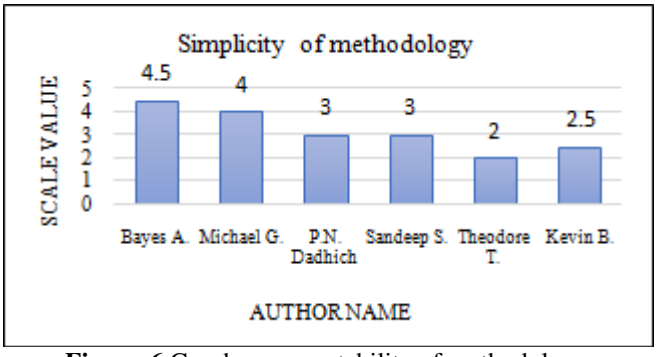

Figure-6 Graph on acceptability of methodology

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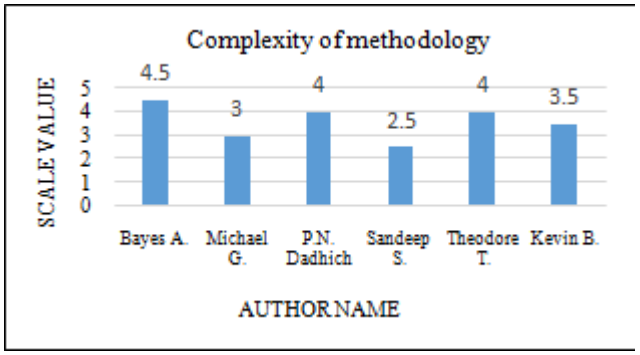

Figure-7 Graph on weightage for future forecasting

The author has given a rating to the paper in which focused on four-step modelling as shown in fig: 6. The author, Bayes Ahmed, has given 5 ratings because presented four-step modeling properly. Also, authors Sandip S. and Theodore T. have studied additional step in four step modeling, so the author have been given a lower rating than Bayes Ahmed's rating. As shown in this fig-7, the author has studied all the papers and compared the papers suitable for transportation planning with a different rating. The end result of the graph study is an article by author Bayes Ahmed, which is more suited to transport planning.

VI. CONCLUSION

Transport modeling was used to explore and resolve "real" problems – by combining theory and practice. For future planning, four conventional models will be produced. Trip generation provides an estimate of the total number of trips created to and attracted from various zones in the study area. The trip matrix can be used to describe the study area's trip pattern in trip distribution. The trip matrix is computed using the growth factor method and the gravity model.Mode selection determines the number of trips by people using a certain mode of transport. This approach uses the model Logit. Travellers will choose a path with the shortest route time and distance by measuring the results of their journey. Built a comparison chart by analyzing all of the author's papers. In this graph, look at the articles that are good and which are poor for transportation planning. Having sufficient data to calibrate the models and provide tests for their accuracy is one of the best ways to improve the model's value and accuracy. Until models can be used to predict future travel, they must first show that they have an accurate image of current travel. After examining all of the graphs, it was discovered that Bayes received the highest score. As a result, Bayes' paper will be useful in the future.This method does not actually cover travel demand management, employer-based trip reduction services, and pedestrian and cycling programmers, shifting population age structure, and land use policies. There are several critical points that should be considered and implemented into the conventional transportation modelling framework in order to make it more practical and realistic.

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