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Original Article

Calibration of Trip Generation and Trip-End modal split model for city between Pandharpur to Solapur

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Abstract: *There is rapid increase in the urbanization of the metropolitan cities in India. Solapur is a city located in the south-western region of the Indian state of Maharashtra, close to its border with Karnataka. Solapur is the growing city in the Western Maharashtra region and attraction to the nearby region in terms of the employment opportunity. There are various people travel from Solapur to Pandharpur and vice versa. It is necessary to calculate the number of trips generated from Solapur to Pandharpur region for efficient and sustainable transportation. In this study, trip generation model is calibrated between Solapur to Pandharpur city. Data is collected at toll booths, railway station and ST stand. Data collection involves the socio-economic details, personal details and travel details of the individual. Trip generation equation is developed using SPSS software. Factors considered for trip generation are socio-economic details and travel details. Trip-end modal split model is developed between two cities. Total numbers of trips are calculated from Pandharpur to Solapur and appropriate strategy is implemented to make the transportation sustainable.*

Keywords: *Trip-End Modal, Split Model, Transportation Sustainable.*

Main Text:
The main text of the section is divided into various subsection which involves Introduction, Literature review, Methodology, Data collection, Model Development and Conclusion.

I. INTRODUCTION

There is great increment in the urbanisation in developing countries in India. Maharashtra is the important state in India from both commercial and industrial point of view. Solapur is one of the district in India and attraction hub for most of the region from both commercial and industrial point of view. Pandharpur is the developing town in Solapur district of Maharashtra. Various people travel from Solapur to Pandharpur and vice versa. Most of the people travel from Pandharpur to Solapur city and vice versa. It is therefore necessary to make the transportation from the Pandharpur city to Solapur city efficient and sustainable. Hence, in this research we have collected the data for the trip generation and modal split analysis and calibrated the trip generation and trip end modal split equation for the city between Pandharpur to Solapur. The results of the study is useful to apply certain strategies to make the transportation between Solapur and Pandharpur city more sustainable.

II. LITERATURE REVIEW

Oyedepo et al. 2009 (1) found that those with higher salaries and more access to cars travel more than people with lower incomes and fewer car options. In addition, home-based travel accounts for 52% of all travel in Ado Ekiti, followed by non-home-based travel (31%), and home-based employment (17%). Land use in the city

The planning of transportation is also influenced by patterns. Most of the land in India is used for a variety of purposes. Trip-based planning aids in simulating land use as a factor in transportation planning, although it has several drawbacks compared to activity-based planning. According to Pinjari and Bhat et al. (2010) (2), the trip-based strategy ignores the spatial and temporal diversity of excursions and only determines the number of trips generated. This is the difference between an activity-based method and a trip-based approach. As a result, the study project has changed from using a trip-based methodology to one that is activity-based. By developing a mathematical programming language that is used to compare and contrast traditional trip-based modelling with activity-based modelling, Recker (2001, p. 3) built a bridge between the two. A concurrent model of trip chain building and involvement in home activities was developed by Golob et al. in 1995 (4). The demand for the activities that lead to trip generation, trip demand, and travel time demand were all taken into account by the author. To estimate the demand for activity travel, the author considers both the Time budget

effect and the trip chaining behaviour. First-practice and operational studies on activity-based travel demand modelling have been synthesized by Davidson et al. in 2007(5). The authors discovered that activity-based models incorporate activity sequences and break down travel decisions by time of day, which is crucial for addressing important planning issues and policies like parking regulations, toll and congestion pricing plans, high-occupancy vehicle facilities, air quality analysis, and long-term scenarios with shorter workdays. One study has made an effort to present a thorough overview of several modelling methodologies in an effort to establish the optimum method for modelling travel demand and evaluating potential solutions. It is found that more research is required to develop travel demand models for educational excursions and to pinpoint several solutions to the issue of traffic congestion brought on by schools (6). In 2016, Rao et al. found a relationship between travel and activity and socio demographics. The construction of an innovative survey instrument called an activity-travel diary, its administration, and a study of activity-travel behaviour in the context of developing nations were the main topics of this research. Important information was supplied by the study regarding how to create a suitable survey instrument for gathering vast volumes of activity-oriented travel data in the cities of developing nations like India. In order to determine the utility of various mode selections, a simple multinomial Logit model was estimated by taking into account all the household and socioeconomic variables in addition to the mode-specific constants. (7). Using an activity-mobility simulator, Pendyala et al. (1998) were able to simulate how changes in the transportation system would affect people's activity and travel patterns. This algorithm models changes in activity and travel patterns as well as the effects of transportation policies (8). The association between socio demographic characteristics, activity involvement, and travel behaviour was developed by Xuedong et al. (1999). Socio demographic traits are the exogenous variables in this analysis, and the endogenous variables are descriptors of the person's activity involvement and travel behaviour. The quantity of time spent on each of a group of activity categories serves as a measure of activity involvement (9).

III. METHODOLOGY

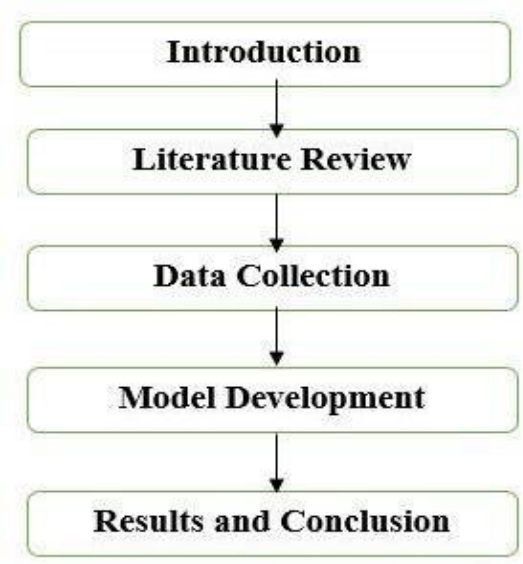

Figure 1: Methodology

A. Data Collection

Data is collected at Pandharpur and Solapur railway station, toll booths, S.T. stands and Private travels offices. Data collection involves the socio-economic & personal details of the household including age, gender, working status, number of vehicles and Income of the household. Data Collection also involves the trip details such as trip length, travel time and travel cost of the trip. Personal and Socio-economic details are used for the calibration of trip generation equation. Trip details and socio-economic data is used for the calibration of modal split equation.

B. Model Development

Model development section involves both trip generation model and modal split model. Trip generation model is calibrated by using SPSS software and modal split model is calibrated by using N-Logit software.

C. Trip Generation using Multiple Regression Model

Trip generation equation is calibrated using the concept of multiple regression technique with the help of SPSS software. Variables used for the trip generation are Age, Total Income, Number of vehicles and Number of Working members. Multilinear regression equation is calibrated using the concept of SPSS software.

$$Y= a_0+b_1Y_1+b_2Y_2+b_3Y_3+.....+b_nY_n$$

Where, Y is dependent variable and Y_1, Y_2, Y_3 ....Yn are independent variable. So, in this study, four independent variables are considered which are Y_1 (Age), Y_2 (Total Income), Y_3 (Number of Vehicles) and Y_4 (Number of Working Members). Multilinear regression is applied with dependent variables as Number of trips. Table 1 shows the calibration of trip generation equation using SPSS model. Model is calibrated with R2 value of 0.856.

Table 1: Calibration of Trip Generation Model

MODEL	UNSTANDERDIZED COEFFICIENT		STANDERDIZED COEFFICIENT	t	Sig.
	B	Std. Error	Beta		
Constant	-0.685	0.314		-1.185	0.011
Y1	2.12	0.085	0.139	9.235	0
Y2	0.315	0.003	0.212	4.256	0
Y3	0.065	0.185	0.185	0.855	0.421
Y4	0.114	0.085	0.26	8.561	0

D. Modal Split Analysis

Modal split analysis is carried out using N-Logit software. Various variables considered are Travel Time, Travel Cost, Age and Personal Income. Various modes available are 2W, 3W, CAR, BUS. Utility equations are developed for each mode of transport. Validation of MNL model is shown by Table 2.

$$U(2W) = a_0+a_1*(TT)+a_2*(TC)$$

$$U(3W)= b_0+ b_1*(TT)+ b_2*(TC)+ b_3* (Income)$$

$$U(CAR) = c_0+ c_1*(TT)+ c_2*(TC)+ c_3* (Income) + c_4* (Age)$$

$$U(BUS) = d_0+ d_1*(TT)+ d_2*(TC)+ d_3* (Income) + d_4* (Age)$$

Table 2: Validation of MNL Model

Variable	Coefficient	Probability [|Z|>z]
A0	-1.24	0.002
A1	-2.05	0.00056
A2	-301	0.00031
B0	-2.01	0.00048
B1	-3.14	0.00036
B2	-4.11	0.00041
B3	-1.11	0.00014
C0	-2.05	0.000036
C1	-4.11	0.00014
C2	-3.15	0.00064
C3	-4.12	0.000042
C4	4.13	0.000041
D0	-1.23	0.00031
D1	-2.11	0.00025
D2	-3.15	0.00041

D3	-1.34	0.000042
D4	2.66	0.00024

E. Policy Implementations

Various policies are implemented in order to make the transportation sustainable. Policies includes reduction in travel time of Bus by 20%, reduction in travel cost of Bus by 20 % , Increase in congestion pricing of 2W by 25%.

Do-Nothing Condition

The probabilities for various modes of transport are found to be given by Table 3 for Do- Nothing condition.

Table 3: Probability of Modes for Do-Nothing Conditions

Vehicle	Probability
2W	0.24
3W	0.45
Car	0.16
Bus	0.15

Reduction in travel time of Bus by 20 %

Travel time of bus is reduced by 20 % by providing dedicated lanes between Pandharpur to Solapur city. The revised probability for the same is shown by Table 4.

Table 4: Probability of Modes for Reduction in Travel Time by 20%

Vehicle	Probability
2W	0.19
3W	0.25
Car	0.22
Bus	0.34

Reduction in travel cost of Bus by 20 %.

Travel cost of bus is reduced by 20 % by providing dedicated lanes between Pandharpur to Solapur city. The revised probability for the same is shown by Table 5.

Table 5: Probability of Modes for Reduction in Travel Cost by 20%

Vehicle	Probability
2W	0.24
3W	0.21
Car	0.26
Bus	0.29

Reduction in congestion pricing of 2W by 20%

Congestion pricing of 2W is increased by 25 % with increase in the tolls on toll booths. Table 6 shows the probability of reduction in the congestion pricing of 2W by 25%.

Table 6: Probability of Modes for Reduction in Congestion Pricing by 25%

Vehicle	Probability
2W	0.11
3W	0.31
Car	0.25
Bus	0.33

IV. CONCLUSION

The following conclusions are made for made for the given study

- The four stage modelling can be applied to the regional transportation.
- Trip Generation equation is calibrated with good R-square value and can be influenced by socio-economic and personal characteristics of individual.

- Trip end modal split model is applied to the regional transportation and it is influenced by various variables such as travel time, travel cost, age and Income of the person.
- There is increase in number of trips by public transportation (bus) with increase in the different policies like reduction in travel cost, travel time of bus and increase in the congestion pricing of the bus.

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