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Assessment of Satisfaction Level for Existing Public Transport Systems using Machine Learning: A Case of Bhopal (India)

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Abstract

Most people are now highly dependent on private motorize travel because of the low Satisfaction level of public transit modes. This leads to poor public transit share in most of the cities in India. This study is intended to identifying the influencing parameters; those affect the satisfaction level of a PT mode, and also develop a model for assessing the Satisfaction Level of these public transport modes in Bhopal, India. A Machine Learning-based approach is used to analyze 1189 responses from the user. It classifies data in various dimensions that shape customers satisfaction among each mode of public transport (i.e. BRTS, Mini-Buses and Magic-Van service) and develops a model for evaluating the overall satisfaction of these PT modes in Bhopal. An On-board opinion surveys were done for identifying the parameters which influence the Satisfaction of these PT modes and also develop a model for evaluating the Satisfaction of these modes. Based on the literature, Delphi survey and opinion survey, eight parameters have been identified that influence the satisfaction level of these modes in Bhopal. Further by correlation matrix, most influencing parameters (key parameters) were considered amongst them for evaluating the satisfaction level for these modes. To determine the coefficient values acting from each of the respective elementary scores, we used a trained linear regression, multilinear regression, considering the classification of customers who assessed the performance of their satisfaction. This model will help to increase the Satisfaction of these PT Modes which result to increase the transit ridership in Bhopal. Adopted methodology in this study can help decision-makers to improve public transport services so that transit ridership can be improved.

*Keyword***:** Satisfaction Level; Public Transport system; Demand Assessment; User Satisfaction; Service Quality; Bhopal; Machine Learning

1. Introduction

Public transportation (PT) plays a key role in fulling the transport needs, reducing traffic volume and solving traffic congestion problems in urban areas (Bachok, 2014). PT has multiple benefits, i.e. environmental, social and economic, amongst all other available land transport alternatives (Le-Klahn et al., 2014). All over the world PT systems have been identified as a sustainable solution for all major transport problems (Cyril et al., 2019). Public transportation is an important service that people patronize to fulfil their travel needs worldwide; the most critical issue for this service is the user's satisfaction (Christopher et al., 2017). Transit service quality has a crucial impact on ridership. The quality improvement of the PT system is an essential strategy to increase ridership and also the attractiveness of these modes (Santos and Lima, 2021).

User satisfaction is a standard tool to evaluate transit service quality from the rider's perspective of and is also an essential key to the success of any PT system in developing countries (Chen Z et al., 2017). Poor satisfaction with PT is a significant cause of low ridership in Indian cities (Jaiswal and Sharma, 2012). The User's Satisfaction is defined as the customer's perception (in terms of comfort and convenience) of facilities provided by public transport. It is a judgment of service feature and service itself, which provides a pleasant level of consumption (Budiono, 2009). Due to enhancement in social status and paying capacity, most people are willing to buy a car and other personalized modes for their travel requirements. Therefore, these commuters compare the comfort and convenience of public transport with the car and other private modes (Jiancheng, 2018). This imposes more pressure on service providers and concerned agencies to provide better comfort and convenience in existing PT systems..

Public transportation is undoubtedly considered an essential solution for traffic congestion, air pollution and traffic fatalities. As per the Ministry of Urban Transport (MoUD) report, the modal share of PT is declining day by day in Indian cities particularly in category-IV cities (WSA, 2008). According to the Indian Road Congress (IRC), category-IV cities are those cities having a population between 2 to 4 million. Inefficiency and poor Satisfaction level of the PT system are the primary cause of decreasing transit ridership in this category of cities, especially in India (Pucher and Korattywaroopam, 2005). For increasing the Satisfaction level of the PT modes, the satisfaction of each service quality has to be improved as user's satisfaction of PT system depends on the service quality (Barabino et al., 2012).

In developing nations like India, the PT systems run at a lower capacity and face predominant ridership issues. A desirable modal share of PT will be 60-70% of all motorized trips to reduce energy needs (Working Group on Urban transport 2012). In the last few decades, the PT systems in Indian cities have not been able to fulfil the supply for a substantial increase in travel demand (Singh et al., 2012). Poor satisfaction may cause of the underutilization of public transport in Indian cities. An efficient PT system generally depends on the level of satisfaction, provided by the mode to the user. In order to attract more passengers, public transport must have a high satisfaction level for steady users and also to attract new users. To improve the user satisfaction, the service provider has to improve the service quality of these transit systems. For identifying the service qualities and facilities which might be improved to increase the user satisfaction, the public transport service provider must quantify the existing and desire value of user Satisfaction towards these PT modes, which is associated with the satisfaction of service quality of a particular transit system.

This study attempts to evaluate the satisfaction level of transit systems pertaining to the service quality so that the service provider can judge which service needs to improve for increasing satisfaction in PT systems. It allows all researchers and service providers to adopt this methodology for assessing and enhancing the Satisfaction level of transit users so that more people can be attracted to public transport; therefore, the transit ridership can be increased. To assess and estimate the overall satisfaction level of existing PT systems, three MLR model were developed for each PT transport. First the factors (parameters) are identified that influence the user satisfaction. Further, a relationship is developed between the satisfaction of these factors and the overall user's satifaction of PT to calculate the overall satisfaction of these PT modes.

The remaining of the paper is organized as follows; In section-2, associated literature is reviewed in which Importance and need satisfaction level of PT is discussed and also

stated how service quality and user satisfaction level effect the transit ridership. In section-3, different types of PT systems their characteristics are discussed in Bhopal. In Section-4, various parameters are discussed which influence the user's satisfaction In section-5 detailed methodology is described for developing the model to estimate the satisfaction level of various PT modes along with the process of collecting data. In section-6 final model of each mode is discussed. In section-7 model is validated with surveyed data set. In section-8, conclusions and research perspectives are discussed.

2. Literature Review

Barabino & Deiana (2012) highlighted the characteristic of transport services; it clarified the need of a new perspective on PT management in urban areas with the help of two methods, namely the modified SERVQUAL method and the Multiple Linear Regression (MLR) model. In the case study, a modified SERVQUAL analysis was done to understand the attributes affecting the use of public transportation in the Cagliari urban bus transport system by considering the five quality dimensions: tangibility, reliability, responsiveness, assurance and empathy. A total of eighteen attributes were considered to understand the relation between bus frequencies and customer satisfaction concerning the Quality Perception (P) and Expectations (E) of each attribute. Berabino et al (2020) suggested a total 26 KQI to monitoring the quality in transit service using Monte Carlo simulation method. Ladhari (2009) discussed four distinctive features of services, i.e. inseparability, perishability, intangibility, and heterogeneity, which have been recognized as significant in developing a construct of service quality. Too & Earl (2010) use a SERVQUAL framework to measure PT services within a master-planned community in Australia. In this study, survey results find a massive gap between the service quality and the community expectations for PT services.

In many similar studies, the SERVQUAL method has been used to investigate the service quality of the public transportation system (Too L and Earl G, 2010, Barabino et al., 2012, Ladhari, 2009). The SERVQUAL model features in many services marketing studies, usually when discussing customer satisfaction and service quality. With the help of this framework, shortcomings in the service can be exposed and addressed by 'GAP Analysis'.

Passengers always prefer a well-coordinated, safe and reliable environment in public transport (Le-Klahn et al., 2014). To fulfil the expectations of passengers, a strategy is required to analyze the performance and improve the service quality of PT (Putra et al., 2014). The performance of the PT system is mostly analyzed in terms of user's satisfaction which is actually the perception of the PT users towards the services delivered. Services refer to the elements needed to make the journey easy and more pleasant, like ease to pay fares, traveller's information, journey time and bus stop facilities, etc. The perception of passengers about the services and facilities provided by PT agencies is expressed with the help of experimental surveys known as "Customer Satisfaction Surveys" (Eboli et al., 2009). These Satisfaction surveys combine the science of measurement of importance and satisfaction of selected parameters. These parameters are primarily the services provided by PT modes like comfort, safety, reliability, etc.

Kaparias et al. (2011) said that safety is a significant issues in transport planning, as every day, many people are involved in road accidents. Another important parameter is customer-service which refers to the elements that are needed to make the journey easier and more pleasant like the easiness of purchasing tickets, paying fare, ticket integration, bus stop facilities, traveler's information, usage of ITS etc. Jaiswal and Sharma (2012)

said that Public transport demands responses are most sensitive to travel time, travel cost, accessibility, comfort, and convenience for Indian cities. Authors stated that to attract more ridership, travel time must be reduced and also the enhancement of accessibility is required. Chee et al. (2013) identified that comfort and flexibility are perceived an important factors by the majority of private vehicle users; those are willing to use PT. Comfort is an essential aspect of enhancing ridership of PT, emphasizing two types of comforts, i.e. inside comfort and outside comfort. Inside comfort implies availability of seats, cleanliness and sitting comfort (spacing between seats) inside the bus whereas outside comfort means designing waiting areas, parking areas, informative services, cleanliness, etc at bus stops (Jaiswal et al., 2012).

Le-Klahn et al. (2014) identified four service dimensions, i.e. travelling comfort, service quality, accessibility, and additional features the understanding tourist satisfaction with public transport. It is found that commuters are most satisfied with punctuality, reliability, network connection and frequency. Reliability of service is defined as 'the ability of the transit system to adhere to a schedule or maintain regular headways and a consistent travel time (Budiono, 2009).

Juan d O et al. (2016) state that the Service quality of any PT system is an important factor in influencing travellers' behavior, as it encourages PT users to select transport modes. Putra et al. (2014) concluded that accessibility, integration of different modes, capacity, on-time and comfort are the main priority expectations of public transport users. Budiono (2009) said that frequency, price, punctuality and travel time are the crucial factors responsible for higher satisfaction levels. Frequency can be defined as the number of service runs per unit time, i.e. per hour or day (Eboli, 2009). Studies also show that fare is the deciding factor for mode choice in most of Indian cities (jaiswal et al. 2012). Barabino et.al (2011) discusses the degree of perceived quality of public transportation in Cagliari's metropolitan area managed. The study focuses on the implementation of an Impact Score methodology to assess the degree of perceived quality considering ten core attributes of the public transport.

In the following table, we have discussed various noteworthy studies on the Satisfaction level of transit systems and the dependent parameters.

Table 1: Overview of Former Literature on Satisfaction of PT System

Author	Parameters Selected
Racca and Ratledge (2004)	Travel time, fare, income, captive user, parking availability and costs, age, accessibility, frequency, trip distance and service
Eboli and Mazulla (2009)	Frequency, reliability, information, Bus stop availability, bus stop furniture, bus overcrowding, cleanliness, safety, personal security, environmental protection etc
Tiwari (2007)	Accessibility, mobility and socio-economic well-being.
Budiono (2009)	Travel time, punctuality price, information, cleanliness, staff behavior, seat availability, bus stop security, safe from accident, information in bus stop and frequency.
Kaparias and Bell (2011)	Mobility, Reliability, Operational Efficiency, Safety, Accessibility, Total service area, No of Motor vehicle and electric vehicle.
Jaiswal and Sharma (2012)	frequency, headway, Comfort level, accessibility, feeder service, fare and travel time
Shah (2012);	Affordability and accessibility, mobility, operational efficiency, environmental and resource conservation
Chee and Fernandez (2013)	Age, sex, income, regular access to private vehicle, comfort, availability of parking facility and essentiality of flexibility

Ibrahim and Karim (2013)	Fare, travel time, waiting facilities, accessibility, routes suitability, trip schedule, waiting time, drivers attitude, safety, comfort, passengers' discipline and electronic ticketing system.
Putra et al. (2014)	Accessibility, integrated, capacity, regular, fast and quick, easy, reliability, comfort , fare, orderly, safety, low pollution and efficient
Klähn (2014)	Punctuality, reliability, network connection, frequency, convenience, accessibility, safety on board, ease-of-use, information, cleanliness and space on vehicle, comfort, fare and overall satisfaction in general.
Christopher et al. (2017)	Accessibility , service reliability, security and comfort
Jiancheng et al. (2018)	Timeliness, safety, convenience, comfort, reliability and economy
Cyril et al (2019)	Inadequate frequency, travel time, poor service quality and overcrowding
Obsie et al. (2020)	Safety and security, travel information, frequency, cleanliness, , ticketing system crowdedness, and comfort
Barabino B et al. (2020)	Travel time, travel cost, comfort level, frequency, egress and access distance, Availability, custermer satisfaction, headway, income, parking availability, convenience, waiting time, safety, driving behavior, fare collection, flexibility, bus stop facilites, punctuality, safety on boarding and alighting, cleaniness, informations, sitting capacity, crowdedness. service reliability.

In most of these studies, mentioned in the literature review, opinion surveys were conducted to assess the Satisfaction level and focus on only the causes of the inefficiency of PT systems. A few seem to deal with to identify the influencing parameters and also the gap analysis by Cluster technique and SERVQUAL method. Limited studies are attempted to convert survey data into a model to assess the Satisfaction Level of PT modes. Also, most of these studies have been conducted outside India where they have discussed the issue of the Satisfaction level (Table-1). Few studies have been conducted for Bhopal, but they were limited to identifying the causes for the reluctance to use public transport only and not even discussing the issue of Satisfaction level and any model to assess it.

In this research most influencing parameters were identified specifically in context of Indian cities and models are developed for estimating the Satisfaction level of available public transport modes using correlation & regression processes. Since disaggregated data are required for such studies, a revealed preference (RP) survey was conducted for all three PT modes. A separate relationship has been established for the Satisfaction level of available PT modes and their influencing factors (parameters). This study is also attempted to find out individual Satisfaction levels, a comparison of satisfaction levels for all three PT modes, the reason for low Satisfaction Levels and the determination of critical parameters which affect the Satisfaction level of public transport modes.

3. Public Transport in Bhopal

Bhopal is the capital of the Indian state of Madhya Pradesh and is also known as the lake city of India. Bhopal city was planned on a ring radial pattern with a hierarchical road network (Figure 1). Although this form and pattern do not support public transportation networks effectively, still there is a scope of an efficient public transport system to make the city sustainable.

Figure 1: Road Network and Public Transport Coverage in Bhopal
Source: CMP, 2012

There are mainly three modes of public transport system available in Bhopal city (Figure 2) namely, standard bus services, known as Bus Rapid Transit System (BRTS), Mini-bus services and Magic-Van services. Bhopal BRT system (standard bus) was funded by the government of India under the Jawaharlal Nehru National Urban Renewal Mission scheme(JNNURM). Bhopal BRTS is operated by Bhopal City Link Limited (BCLL) and has an average capacity of 45 persons per bus. Most of the operational BRT systems in India primarily aim to connect sub-urban parts of the city. This low-floor bus service is available on sixteen routes only with 251 buses with an estimated ridership of about 160,000 passengers per day.

Figure 2. Types of Public Transport Modes in Bhopal

Mini-bus stands second in the hierarchy system, with an average mode capacity of 25 persons per vehicle, and provides services on various routes based on demand. Mini-buses are run by private operators with assigned routes by Regional Transport Office (RTO), Bhopal. For many BRTS routes, mini-buses are good feeder alternatives. This mini-bus system has a total of nineteen routes with 450 mini-buses with an estimated ridership of 200,000 passengers per day. Van services (Magic), with an average capacity of eight persons, are an essential PT system for catering to smaller routes and shorter trips. Magic services are also run by private operators and act as a feeder service for BRTS and other standard buses in Bhopal. They have 43 routes in total with 488 Magic with an estimated ridership of 100,000 passengers per day (RTO and Bhopal Municipal Corporation, 2018).

A total of 78 routes of all public transport are available in Bhopal. The percentage of trips covered by public transit mode is less in the city, i.e. 49%. Figure 3 presents the current trend of ridership (for 2018) of Bhopal (ESCAP, 2019). According to Indian Road Congress (IRC), for category-IV cities (population between 2.0 million to 4.0 million) like Bhopal, the desirable public transit ridership must be 60% to 70% for an efficient transportation system for any city (WSA, 2008).

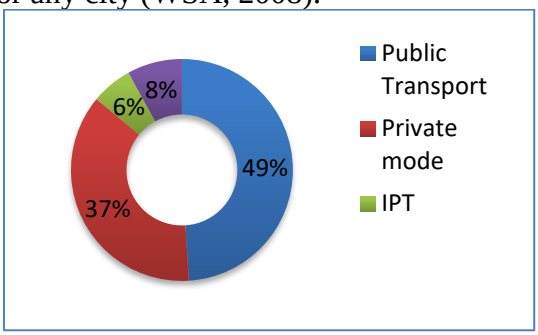

Figure 3 . Ridership (2018) of Public Transport
Source: ESCAP 2019

It shows that public transport systems can not satisfy people's needs in Bhopal. IPT and non-motorized mode have shared about 6% and 8%, respectively (Figure 4). There is an urgent need for a modal shift from private vehicles to public transit to achieve desired modal split as given by IRC (i.e. 60-70%) for smooth manoeuvre of traffic on urban roads. It is only possible when PT mode provides good service quality and achieve high Satisfaction Level. To improve the service quality of the PT system, the service provider requires an assessment of Satisfactionlevel of a particular transit system.

4. Selection and defining of Parameters

The parameters for the user's satisfaction of any public transport in developing countries may vary from developed countries. The parameters for developed countries have varying impacts on travel patterns, travel behavior and travel characteristics as compared to the Indian scenario. The previous related studies show that cleanliness, safety, reliability, travel time, comfort, fare, frequency and customer satisfaction are the critical factors for good service quality parameters in PT system (Jain & Dhiman, 2021). In developed countries where priorities are travel time and comfort, other aspects like travel cost, convenience and accessibility find lesser prominence (Table-1). A separate opinion survey was conducted to identify the parameters which influence the satisfaction of the PT system in Bhopal. Based on the literature and opinion survey, twenty four parameters were identified that influence the user's satisfaction in Bhopal. A nationwide Delphi survey was conducted from the experts in the said domain to shortlist the relevant parameters, especially in context of category-IV cities.

This led to selecting the eight most impacting parameters out of the twenty four parameters based on the Delphi survey. The shortlisted eight influencing parameters were accessibility, comfort, reliability, travel time, fare, safety, customer services, and frequency. further a revealed preference survey was conducted for all three PT modes and information regarding satisfaction of these eight parameters were asked by the user's along with overall Satisfaction levels. For the ease of developing the model and simplifying calculations, we have selected five critical parameters out of eight influencing parameters, having high correlation, based on the correlation matrix, in modal

development for all three modes. These five parameters may be differ for each PT mode among identified eight parameters.

Accessibility attribute represents characteristics of the route of the bus line in terms of path, area coverage, the number of bus stops, the distance between bus stops, and stop location. In other words, accessibility means the distance of the bus stop from the origin and destination of the trip (access and egress distance). Frequency attributes represent the number of buses for a route and time difference between two buses. The frequency has the most distinctive aspect in mode choice amongst these service attributes. Service reliability is mostly related to schedule adherence and is defined as the ability of the transit system to adhere to a schedule or maintain regular headways and consistent travel time (Budiono, 2009). Comfort means availability of seat, cleanliness, spacing between seats, air-conditioning etc. Safety includes two parameters: one is road accidents, and another is security against crime, especially for women. Safety is a psychological parameter and an important factor for the Satisfaction level of any PT system. Fare is the cost of travel and also an important factor for mode choice in many Indian cities. Travel time indicates the total journey time from origin to the destination, including access and egress time. Longer travel time in PT modes can lead to loosing working trips ridership. The mode choice between public transport alternatives or a car would somewhat depend on the relative time between PT and the personalized vehicle (Racca et al., 2004). Customer service attributes include all facilities necessary to make the journey easier, faster and convenient.

5. Methodology and Data collection

The study is conducted in threefold; first to identify the critical parameters which affect the user's satisfaction, second to develop a model to assess and estimate the user's Satisfaction Level considering these parameters, third to provide suggestive measures for improving the user's satisfaction so that the ridership of existing PT Systems can be increased in Bhopal. The entire methodology can be divided into five steps; we have achieved the specific objective from each step. The conceptual approach of proposed methodology is given in Figure 4**.**

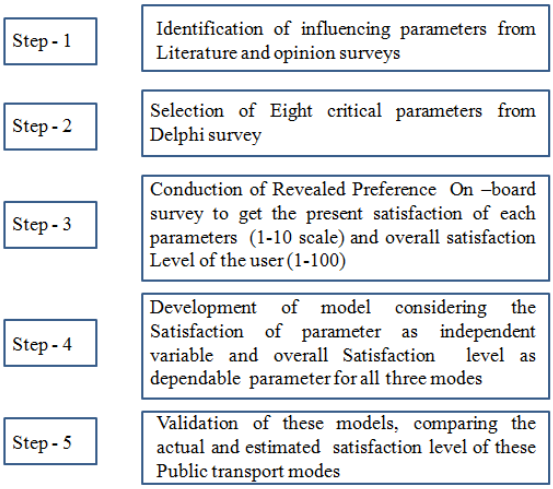

Figure 4. Conceptual approach of proposed methodology

In the first step of the study, we identified all influencing parameters (a total of twenty-four) from various literature and opinion survey on the major bus stops. In the second

step of the study, we have shortlisted eight influencing parameters by the Delphi method, among the identified parameters from opinion surveys and various literature.

In the third stage, for evaluating the Satisfaction Level of PT modes, we required information on the present user's satisfaction of all eight parameters (on 1-10 scale) as well as the overall Satisfaction of the respective PT mode on a 1-100 scale from all surveyed users. Questionnaires are the most common tools to investigate a similar aim (Budiono, 2009). To get this information and consider that the user had a discrete choice for selection of PT mode, an on-board revealed-preference survey on different routes was conducted. This revealed preference survey was mainly designed to examine the travel characteristics of the users, satisfaction of respective parameters and the overall Satisfaction Level. These on-board surveys were conducted inside the buses and at the bus stops (as per convenience) for all three PT modes i.e. Standard bus, Mini-bus, and Magic-van along the major routes. These surveys were carried out during morning and evening peak times and on the busiest routes for all three modes in Bhopal. In this survey, users were asked to provide present satisfaction of each respective parameter on a scale of **1 to 10** and the overall Satisfaction level on the scale of **1-100** for each PT mode. These surveys were conducted separately on major routes and a total of 1230 samples were filled, out of which 1189 were found satisfactory for further analysis.

In the fourth step, we have developed the models for evaluating the Satisfaction level for all three modes. To be consistent with the general form of models, as depicted in the various literatures, multiple linear regression models were widely used in similar studies. Since the data is distributed linearly, developing a multiple linear regression modal is more suitable in this context. Finally, three separate multiple linear regression models are developed to evaluate the Satisfaction level for all three modes considering only five parameters (having max correlation) amongst identified eight parameters. To avoid modal complexity, we have considered only five critical parameters based on the correlation matrix. Google Colab is used for data input, analysis and model development. To summarize and rearrange the data, several interrelated procedures were performed during the data analysis stage. The general form of relationship between Satisfaction Level (Y) as a dependent variable and satisfaction of each parameter as the independent variable (S) is shown below. Only five independent variables were taken for ease of model development, which has a maximum correlation with overall satisfaction level (Y). S_1, S_2, ….S_n is the user's satisfaction of corresponding parameters.

$$\mathbf{Y = C_1*S_1 + C_2*S_2 + \ldots\ldots\ldots\ldots\ldots + C_5*S_5 + U}$$

where, Y= Overall Satisfaction (1- 100 scale), C_1= Coefficient of parameter 1, S_1= Satisfaction of parameter 1(1-10 scale, max five parameters) and U= Intercept

In the fifth step, we have validated these models, as we have compared the actual and estimated Satisfaction Level of these public transit modes from the samples which are not used for the model development process (approximately 5%) and found the average difference in the observed and calculated value of the Satisfaction Level. In the sixth step, we have suggested measures for improving the Satisfaction Level of all three modes of public transport in Bhopal.

5.1 Demographic Analysis of Survey

After conducting the opinion survey, a revealed-preference survey was conducted at bus stops and inside the buses to collect the data from the PT users. The samples were collected at different times of the day during weekdays and also at all major routes of PT

modes to obtain reliable information. There is no specific framework to compute the exact sample size for any survey. However, the sample size selection will be according to the size of the study population (EMBARQ India). The survey adopted the stratified random sampling survey method. Many studies in India have considered the sample size of less than 1% for the opinion surveys and even up to 0.1%. Due to the limitation of time and resources, we have taken only a 0.2% sample of total transit demand.

A total of 1230 samples were collected, out of these, 1189 samples were found satisfactory for further analysis. The sample size for Standard Buses, Mini-Buses and Magic-Van services were 406, 385 and 398 respondents respectively. The respondents comprised of 69.5 % males and 30.5% females (as per the actual split of PT user). Similarly, the age groups of respondents were divided into three categories. The first category of age group is respondents less than 24 years (45% samples), the second category of age group is between 25-60 years (32%), and the third category of age group is people more than 60 years (23%). Out of these samples, 42% of respondents were students, 17.2% of respondents were working employees in different private and government firms, and 37.14% of respondents were for recreational, shopping and other social activities. Most of the users (71.8%) were captive users as they did not have any alternative mode option.

5.2 Method Specification for Calculating the Coefficients.

The primary idea behind a regression model is to divide data into sub-regions since a model tree can reach optimal accuracy via computing the linear regression with tiny sets of predictors for each sub-region individually. A machine learning model can be used to make data-related predictions. AI research is divided into two categories. The first examines how to effectively convey and draw logical inferences from human knowledge (supervised learning). The second is an investigation of how machines understand and do tasks independently from vast amounts of information (Unsupervised learning). The impact of each variable is calculated using the formulae below. Multiple linear regression analysis implies a linear relationship between different independent factors (X1, X2,..., Xn) and dependent variables (Y). Weighting coefficients can be calculated of each satisfaction parameter reported using regression models based on scores throughout our research.

5.3 Regression Algorithms.

Machine learning is a subset of AI technology that models cognitive processes and allows robots to execute processing operations and gather information from enormous sets of actual data. Many professions, including engineering, planning, health, and weather, now using machine learning. We applied regression or classification techniques based on the model output's consistency or discretion. The outcome in our example specifies a score on a scale of 100, with all available accurate estimations. As a result, regression techniques were utilized (Muller et al., 2021). Regression is a method for modelling a variable (named the target) using predictive factors (called features), with the algorithm attempting to uncover occurrence correlation between variables. We can identify much linear regression among some of the multi-regression algorithms (Chauhan et al., 2021).

Multiple regression, often known as multiple linear regression, is a statistical technique that predicts several factors. Its goal is to simulate a linear relationship between the independent covariates and the relying dependent variables. MLR is effectively a multivariable least squares regression that involves more than one parameter. Many recent researches have used MLR's power to develop dependable and conclusive models, primarily in the transport industry.

5.4 Model Specification and Data Study

We propose to determine the coefficient of their influence on the overall score, dependent on the group of clients, by taking into consideration the eight fundamental indicators that are scored by the customer (accessibility, comfort, reliability, travel time, fare, safety, customer services, and frequency) and which can be given with the data collected.
Multi Linear Regression (MLR) is the suggested method for assessing the quality of service. The major steps in MLR are as follows:

Steps 1: # Import necessary libraries/Surveys
Read the data
Features are separated into input and output categories.
Step 2: # Sort the information in ascending order.
Step 3: # The minimum and maximum thresholds are assessed.
Each parameter is compared to the minimal threshold for each model.
Each parameter is compared to the maximum threshold for each model.
Step 4: # Outliers are assessed using the Inter-Quartile Range.
Determine the Q1, Q2, Q3, and IQR.
Calculate Q1 – 1.5 IQR and Q3 + 1.5 IQR as the lower and upper bounds,
Step 6: # Outliers are data points that are higher than or less than the upper or lower limits.
Step 5: # Features are separated into input and output categories.
Convert X to a Pandas Data Frame for ease of use.
Create models
Divide the data into test and training sets
Separate the other characteristics from the predicting attribute
Divide the predicting attribute into Y for model training
Splitting the data
Creating multiple models, fitting them, and checking them
Importing train test split from sklearn
Evaluate Coefficients, Intercept, Mean Squared Error (MSE), and Coefficient of Determination (R2)
Create and test a number of models

Multiple Linear Regression (MLR) regression algorithm is used to estimate the coefficients operating on each indicator and, as a result, establish the degree of influence these have on the overall score. To describe the proper model with each type of parameters, the algorithm is trained in five rounds. The training data are the same ones used in the division section. The five critical parameters recorded by the users for the individual are also the inputs to our models, and the outcome is overall satisfaction.

6. Development of Model for Satisfaction Level

Revealed preference opinion surveys were conducted to get the present satisfaction of these parameters (on 1-10 scale) and the overall Satisfaction level (on 1-100 scale) of all three PT modes. Initially, total eight parameters were identified and examined (using Delphi Survey). After the correlation matrix, five critical parameters (having a maximum

correlation with the overall Satisfaction Level) were selected based on set criteria for each mode (Table 2). In other words, a separate matrix is prepared to select five parameters (having maximum influence) from the identified eight parameters. These critical parameters are used to develop a model to assess the Satisfaction Level of existing PT modes using a Machine Learning tool (Google Colab).

Table 2: Correlation between Satisfaction-level and identified parameters (Mode wise)

	Identified Parameters							
Mode	A	C	R	F	TT	S	CS	FRE
BRTS	0.576798	**0.74563**	**0.706185**	**0.732988**	0.682409	**0.743763**	**0.74099**	0.494243
Mini- Bus	0.358015	**0.72344**	**0.577835**	0.245823	**0.664448**	**0.736714**	**0.63089**	0.348511
Magicvan	0.598889	**0.77645**	**0.742118**	**0.734161**	0.698752	**0.770824**	**0.79894**	0.440232

Where A is the satisfaction of Accessibility, C is the satisfaction of Comfort; R is the satisfaction of Reliability, F is the satisfaction of Fare, TT is the satisfaction of Travel Time, S is the satisfaction of Safety, CS is the satisfaction of Customer Services, FRE is the satisfaction of Frequency. The dataset was separated into training and test data, with 80% and 20% of the data in each model. The data is chosen for training and testing at random. Using the R^2 score, we can acquire the accuracies (Table- 3) after training our model. For each of the three categories tested, the algorithm shows somewhat similar accuracies.

Table-3: Accuracy of MLR algorithm

PT Mode	Multi Linear Regression
BRTS	0.93
Mini Bus	0.90
Magic-Van	0.93

The coefficients derived using the MLR algorithm for the chosen client categories (Table 4). We also calculated the average of these factors because we believe they will be beneficial in further interpretations.

Table 4: Coefficients acting on the satisfaction indicators using the algorithms MLR

	BRTS	Magic-Van	Mini Bus	Mean
Comfort	0.98	0.59	0.86	0.81
Reliability	1.14	1.51	1.08	1.24
Fair	2.61	1.61	1.41	1.88
Safety	2.01	1.53	1.41	1.65
Customer Service	1.43	1.34	1.73	1.50

Multicollinearity test was also performed in all data set for each mode, to check the multicollinearity in all dependent variables. No multicollinearity was observed which proves that parameters are independent of each other.

6.1 Model for Standard Bus service (BRTS).

Five parameters were selected to develope model for Standard Bus (Table-2) i.e. Comfort (C), Reliability (R), Fare (F), Safety (S) and Customer service (CS). Using the Multi Linear Regression analysis, the following model was obtained for Standards Bus.

$$\mathbf{Y_{Standard\ Bus} = 0.98 * C + 1.14 * R + 2.61 * F + 2.01 * S + 1.43 * CS + 13.14}$$

In the above model C, R, F, S, and CS represent the satisfaction of selected parameters for standard buses. It shows the correlation coefficient R^2, for equation, was 0.93 (Table-5). The t-test and significance level statistics indicated that the variables had good significance.

Table-5: Evaluation metrics for BRTS

BRTS					
	Coefficients	Intercept	MSE	Coeff. of det (R^2)	p-value
Comfort	0.98380342				4.98E-05
Reliability	1.14069351				1.36E-11
Fare	2.61272092	13.14	16.42	0.93	4.11E-20
Safety	2.01085058				3.63E-14
Customer Service	1.43620905				0.000136

6.2 Model for Minibus service

Five parameters were selected to develope model for Mini Bus services (Table-2) i.e. Comfort (C), Reliability (R), Travel Time (TT), Safety (S) and Customer Services (CS). Using the multiple linear regression analysis, the following model was obtained for Minibus.

$$\mathbf{Y_{Minibus} = 1.85 * C + 1.34 * R + 1.01 * TT + 1.42 * S + 1.22 * CS + 28.08}$$

In the above model C, R, TT, S and CS represent satisfaction of selected parameter for Mini Bus services. Here it shows the correlation coefficient R^2, for equation, was 0.90 (Table-6). The t-test and significance level statistics indicated that the variables had good significance.

Table-6: Evaluation metrics for Mini Bus

Mini-Buses					
	Coefficients	Intercept	(MSE)	Coefficient of det (R^2)	p-value
Comfort	1.85860971				1.8E-18
Reliability	1.33940252				2.82E-13
Travel Time	1.01688434	28.08	6.07	0.90	4.88E-15
Safety	1.41988204				3.78E-12
Customer Service	1.22437702				5.5E-12

6.3 Model for Magic-van service

Five parameters were selected to develope model for Magic services (Table-2) i.e. Comfort (C), Reliability (R), Fare (F), Safety (S) and Customer Services (CS). Using the multi-linear regression analysis, the following model was obtained for Magic services.

$$\mathbf{Y_{Magic} = 0.59 * C + 1.51 * R + 1.61 * F + 1.53 * S + 1.34 * CS + 7.79}$$

In the above model C, R, TT, S, and CS represent the satisfaction of selected parameters for Magic-services. It shows the correlation coefficient R^2, for the equation, was 0.93 (Table-7). The t-test and significance level statistics indicated that the variables had good significance.

Table-7: Evaluation metrics for Magic-Van Services

Magic-Van Services					
	Coefficients	Intercept	Mean squared error (MSE)	Coefficient of det (R^2)	p-value
Comfort	0.59262467				1.50841E-07
Reliability	1.50991673				3.7863E-21
Fare	1.61051084	7.79	7.35	0.93	4.06002E-28
Safety	1.52626364				3.82061E-23
Customer Service	1.34043554				1.19863E-13

7. Validation of Model

Based on the above models, we can calculate the existing Satisfaction Level of Standard Buses, Minibuses and Magic services from the collected samples. This Satisfaction Level was compared with the observed (surveyed) Satisfaction Level of the same mode during the Onboard survey (Table-8). The following formula is used to find the average difference in the observed and calculated value of the Satisfaction Level.

$$\boldsymbol{Difference}\ \% = \frac{\boldsymbol{Y\ observed - Y\ calculated}}{\boldsymbol{Y\ Observed}}$$

Table-8: Summary of observed and calculated Satisfaction level.

Public Transport Mode	**Difference % ($Y_{Observed}$- $Y_{Calculated}$) /$Y_{Observed}$**	**Number of Sample**	**% of Data**	**Average Difference**
Standard Bus	0-5%	235	58%	**5.30%**
	5%-10%	116	28%	
	10% - 15%	40	9.8%	
	15% and above	15	3.5%	
Minibus	0-5%	246	63.9%	**4.46%**
	5%-10%	107	27.8%	
	10% - 15%	27	7%	
	15% and above	5	1.3%	
Magic	0-5%	224	56.3%	**5.91%**
	5%-10%	116	29.1%	
	10% - 15%	42	10.5%	
	15% and above	16	4%	

From Table-6**,** it is observed that only 3.5% of samples of Standard buses have more than 15% variation from the observed value of Satisfaction Level, for Minibus this difference is ceased to only 1.3% and for Magic services it is only 4%. Table-3 also shows that the maximum average-difference of Satisfaction Level from observed and calculated values is 5.91 % for all three public transport modes.

7.1 Identification of PT mode having maximum Satisfaction Level in Bhopal

To identify the best public transport system (having maximum Satisfaction Level) for Bhopal, the average value of satisfaction for all parameters (based on survey) is calculated and considered as an input for the proposed models (Table-9).

Table-9:- Average value of satisfaction of each Parameter on scale of 0-10.

Parameters	Average satisfaction of parameters		
	Standard Bus	Minibus	Magic
Accessibility	7.4	6.8	6.8
Comfort	7.5	4.0	5.8
Reliability	7	3.5	5.6
Fare	5.2	7.7	5.9
Travel Time	6.6	4.4	6.4
Safety	7.5	3.6	5.8
Customer Service	7.2	4.1	5.7
Frequency	4.9	7.3	6.2

source: Author

From the above values (Table-9), we have calculated the overall Satisfaction Level of each PT mode using the proposed model. The computed value for the present Satisfaction Level for Standard bus, Minibus and Magic is 68%, 59%, and 61%, respectively. The commuters have also responded their willingness to accept these PT modes as a primary mode if they have a Satisfaction Level of more than 80%. The success of any transit system depends on the ability to attract more non-captive users. For attracting these non-captive users, the Satisfaction level of these modes must be increased.

8. Conclusion

An increase in the population of the city is generating high travel demands for PT systems. Bhopal has lower ridership (i.e. 49%) as compared to IRC recommendation of a minimum of 70% for an efficient transport scenario for a city like Bhopal. The basic reason for this poor transit ridership is low user satisfaction. Therefore, there is a need for enhancing the satisfaction level of these public PT systems for minimizing the usage of private vehicles. In this study three model were developed to evaluate the Satisfaction Level of existing PT systems in Bhopal. Eight influencing parameters were identified for the preparation of these models, which influence the user's satisfaction, from the literature review and Delphi survey. Finally, only five critical parameters were selected with the help of the correlation matrix (for ease of models). Then linear regression was performed using machine learning by considering the overall Satisfaction Level as a dependent variable and satisfaction of critical parameters as the independent variable. These models will help to assess the user satisfaction of all three PT modes in Bhopal, further suggest to service provider to increase the service quality so that transit ridership can be improved.

From these derived models, we have calculated the Satisfaction Level for all existing PT mode, i.e. Standard bus (68%), Minibus (61%) and magic (59%). These results show the inefficiency of the existing PT System in Bhopal, as the desire Satisfaction Level is a minimum of 80% (as found in opinion survey). To validate our model, we have calculated the existing Satisfaction Level of these modes and compared it with the observed (surveyed) Satisfaction Level of the same mode during the Onboard survey.

Results of the study show that comfort, reliability, fare, safety, and customer service are the essential parameters for Standard buses. Existing standard bus service is plagued by higher cost, low frequency, high waiting time and safety issues. Women safety is also an important factor and vastly required to improve it in these buses. In the case of Minibus and Magic-van services, comfort, safety, reliability, travel time and customer service are the critical factors for the reluctance to use these modes. Existing Mini bus service has less reliability due to delays and poor coordination among the service providers.

This study is conducted with limited parameters and data. For similar future studies, it is recommended to use other parameters and more detailed information for assessing the Satisfaction Level of public transit systems so that the study can have scope beyond Bhopal. A similar methodology can also be adopted to evaluate the Satisfaction Level of public transport systems in other cities.

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