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Suitability of Existing Public Bus Routes

Aiswarya Dilip[1], Devika C A[2] ,Joyal K George[3] , Jeeva P.Winto[4] and Rahul R[5]
[1] *Department of Civil Engineering, ASIET, City, Kalady, India*
[2] *Department of Civil Engineering, ASIET, City, Kalady, India*
[3] *Department of Civil Engineering, ASIET, City, Kalady, India*
[4] *Department of Civil Engineering, ASIET, City, Kalady, India*
[5] *Department of Civil Engineering, ASIET, City, Kalady, India*

Abstract: *Transportation is very much related to the economy and growth of the nation. The public transportation in Kerala is undertaken by both government and private sectors. The distributions of bus routes of these service providers are unscheduled & non-scientific. This leads to higher fuel and labour wastage and loss of time of commuters. This study aims to assess the level of service of existing public sector buses in Kalady area and propose changes for better commuter satisfaction based on specific parameters and to chart most feasible bus routes depending on peak hour demand. In addition to this we aim to chart bus routes that are economically feasible at peak demand periods and to analyse the existing bus route service in a given area. The data collection is done through questionnaire survey to the bus users and service non bus users. The level of service will be evaluated by analysing the Likert scale and correlating it to performance index. The feasible routes can be evaluated by charting and analysing the routes*

Keywords: *Feasible, Questionnaire Survey*

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I. Introduction

Transport system plays a crucial role in the economic and sustainable growth of a country. Public transportation is a system of transport for passengers, a group travel systems available for the general public use, typically managed on a schedule, operated on established routes, and charge a posted fee for each trip. Bus systems provide a versatile form of public transportation with the flexibility to serve a variety of access needs throughout an urban area as well as rural and remote areas. Passenger transportation has an impact on all aspects of mobility and is an important part of overall economic development of the nation. Improving the performance of public transport undertakings is becoming more and more critical due to the paucity of public funds, increased demand on transport services and expanding social needs across developing country like India. Examples of public transport include city buses, trolley buses, trams and passenger trains and ferries. Most public transport systems run along fixed routes with set embarkation or disembarkation points to a prearranged timetable, with the most frequent services running to headway. In current scenario the use of personalized motor vehicles (PMV) are increasing day by day which results in decreasing the use of public modes. Studies have shown that in most of the metropolitan cities in India, the use of PMV has dominate over the public transport modes, in order to divert back the choice of society towards public modes we have to provide a good quality bus transit network which also contribute for the economy and infrastructure development of the nation.

Public transportation is a high-capacity and energy efficient alternative for urban passenger transportation, as compared with the private modes of transport. If planned, operated, and managed effectively, it can serve as an environmental safeguard for conserving energy, and helps in facilitating urban economic growth and development. In order for any public mass transit service to secure the appropriate number of users‟, it is requisite that the users‟ of the transit service can get to their destination faster, smoother and more comfortably. Public transportation facilities such as railways, etc. which have dedicated tracks can easily satisfy this requirement. However, with respect to buses, which travel on ordinary roads together with other motor vehicles, are forced to stop and start repeatedly by traffic congestion and under the restriction of travelling through traffic signals, resulting in worsening the smoothness of ride and comfortability of passengers and a large delay in travelling. Public transport faces severe problems in almost all countries of the developing world, although the situation varies from one country to another and even from one city to another.

The level of service (LOS)concept, as a tool for evaluating service quality, measures the effect of factors such as travel time, speed, cost, which in combination with other factors, determine the type of service that any given facility provides to the user under the stated conditions . There are the three major groups of factors:

• Performance elements affecting users
• Service quality
• Price or the fare rate that the user pays for the service.
and quality service are the top priority in bus services for the customers

For the design of good quality bus transit network certain considerations have to be taken into account. Customer satisfaction survey is one of the best methods to assess the bus quality service. Customer satisfaction surveys are an essential tool for listening to customers about their satisfaction levels and for developing strategies for improvement. Design aspects include balanced number of passengers, minimum distance, travel time, direct bus service, maximum comfort, etc.,. Passenger number should always be in a moderate value which means there should not be any overcrowded or empty no of passengers. The passenger has to travel through a shortest path to his desired destination with a saving in his travel time. For design, the currently available methods are Mathematical modelling, Graphical modelling, Statistical modelling etc.

1.1Need for Study

Indian cities are facing the problems of congestion, pollution, crashes and inefficiency to urban residents due to the rise in population and motor vehicles. Thus it becomes necessary to evaluate the urban transportation system of the city in terms of its performance by identifying certain Key Performance Indicators (KPIs). The performance of any system depends on a set of factors and thus, it is necessary to study all the parameters in detail and arrive at a set of indicators that are of prime importance. This work aims at identifying the performance indicators that influence the users‟ perception of urban transport facilities and to have a qualitative assessment of urban transport facilities based on the identified indicators. This would enable the Urban Local Bodies (ULBs) to have a clear idea of the infrastructure demand by time for their city. It will help in identifying performance gaps, ultimately resulting in better services to people. Hence, a performance measurement and evaluation of public transport facilities becomes essential, as it would aid in the management of existing transport plans and programmes and largely contribute to the identification and assessment of successful alternative programmes and projects. And can also be used to determine the best feasible route network.

1.2 Objectives

- To analyse the existing bus service quality in a selected area.
- To analyse LOS of the bus service in the region
- To chart the most feasible bus routes between the major origin and destinations of the selected area using QGIS software.
- To carry out data analysis of the bus users and non-bus users survey, using SPSS analytical software.

1.3 Issues For Performance Improvement Of Urban Bus System

Some of the important issues for inefficient performance of public transportation system in Indian cities as identified for this study are as follows:

1. Environmental Issues : Detrimental Effects of Urban Bus System on City Environment
2. Operational Issues :

- Inefficient Operation of Urban Bus System
- Overcrowding due to inadequate system
- Inefficient & uneconomic bus routes
- Irrational location of bus stop
- Frequency of service & schedule is not strictly adhered
- Inefficient design of buses
- Traffic congestion, frequent stopping & starting needs more fuel consumption, wear & tear of vehicle
- Higher fleet strength of buses
- Higher overall operational cost
- Public transport system is less attractive mainly due to unsafe and inconvenient vehicles etc.

II. Literature Review

Yu Bin, Kong Lu , Sun Yao , Yao Baozhen , Gao Ziyou (2015) In their paper proposes a bi- level programming model to solve the design problem for bus lane distribution in multi-modal transport networks. The upper level model aims at minimizing the average travel time of travellers, as well as minimizing the difference of passengers comfort among all the bus lines by optimizing bus frequencies. The lower model is a multi-model transport network equilibrium model for the joint model split/traffic assignment problem. The

column generation algorithm, the branch –and – bound algorithm and the method of successive averages are comprehensively applied in this paper for the solution of bi level model.

Hemant Kumar Suman , Nomesh B. Bolia , Geetam Tiwari(2016)Reported that people use public bus transport to commute to work in Delhi. The mode share of the bus trip has reduced from 60% in 2001 to 41% today. Only 3% of this population shifted to the Delhi metro (57% of metro users are cannibalized from buses); hence, it is clear that there is a drastic increase in the use of private vehicles in Delhi. If a high share of bus trips has to be retained in the future, specific policy interventions may be required based on the needs and perceptions of commuters. In this study, a survey of existing bus commuters is con- ducted, and their profile and perceptions are recorded. It is clear that vehicle ownership has a positive correlation with household income. Responses also reveal with a strong statistical significance that crowding is an attribute that inhibits people from using public buses, and buses are perceived to be relatively safer and more secure by male commuters than their female counterparts.

Mazloh Al-Enazi(2016) Jeddah city is the second largest city in Saudi Arabia. Jeddah city has witnessed a remarkably rapid urban growth rate during the past four decades. The aim of this paper is to use many GIS functions (network analyst, shortest path) in evaluating traffic congestions point during working day hours according to road directions. One of the useful GIS functions to be used for this purpose is known as shorts

Sanjeev Sinhaa, Shubhajit Sadhukhanb and Shiv Priyea(2017)Reported that the role of transit operation in developing countries is great, as it serves a larger number of people living in urban agglomeration in rapidly growing urban areas and thereby provides capacities to handle the requirements of urban transportation in these rapidly growing urban areas . In developing countries such as India, rapid urbanization has led to increased travel demand; however, lack of commensurate comprehensive transportation planning in urban areas has put tremendous pressure on the existing inadequate and out of date transportation infrastructure. This study justifies the need of improving 'qualitative' aspects of existing bus services. The findings of the study will provide the policy makers and bus operators in planning and implement the effective and sustainable public transport system in future for small and mid-sized cities of developing countries

David Lois, Andrés Monzón, Sara Hernández(2017)Based on the previous research this paper means to explore how attitudes towards several service factors can predict general satisfaction with a transport interchange. It also analyses how personal and trip characteristics affect the evaluation of some variables, examine the relationship between waiting time and perceived quality. A two-step methodology was applied to a representative sample of seven forty users. The model was tested with path analysis and showed a satisfactory statistical fit. The results also revealed a strong association between design and environmental quality although these factors do not affect general satisfaction directly, but through the perception of information and safety & security, which act as a mediator variables.

Amit Vashisth, Ravinder Kumar and Shashank Sharma(2018) Noted that public transportation is regularly confined as a key part of building practical urban areas. The motivation behind this examination was to distinguish the definition of sustainable transportation and to identify best practices related to major principles of sustainable transportation these includes Car free developments, Clean vehicles, Transit Oriented Developments (TODs), Promoting pedestrians and cyclists, Optimization of road network, Developing public spaces in city centre, Parking management for sustainable transportation, and Traffic calming. The main idea of these eight principles is proposed on the basis of eight major principles suggested by Institute for Transportation and Development Policy (ITDP) for sustainable transportation i.e. Walk, Cycle, Connect, Transit, Mix, Densify, Compact, and Shift. It is concluded that these eight principles proved to be the effective measures for developing sustainable cities with efficient public transport systems.

Aatmaj Janardanan,Deepa Rajendran,Varun Menon Nallur (2018)In their paper It is observed that many buses are plying in the roads without people. Nowadays the public transportation of Kerala that is the KSRTC is running under huge loss and to analyse the reason behind why such a loss is incurred. In order to find a solution, the aim was to properly model this system. In this study they considering buses from to different locations and study how well the present transportation schedule works. Here the aim is to model this with all the parameters involved and make the mathematical equation as real as possible. Optimization and verification is done using available software tools. In this paper the importance is mainly given on to transit networking problem, that is bus route problems where buses will carry people from one location to another via intermediate stops. If two depots are considered then there will be many route combinations possible and all of these routes will have varying demand and varying distance as well as traffic and time taken .All these parameters will change and vary in different time slots, Hence we can clearly justify the complexity of the problem.

Sarbast Moslem and Szabolcs Duleba(2019)In their paper aims to introduce a sustainable urban transport development problem in which citizens are involved to allow them to express their preferences for improving certain elements of the public bus system. To mitigate the uncertainty of the non-expert evaluations, a fuzzy-analytic hierarchy process (AHP) model has been created and applied. Since the objective of the

research is to provide a suitable framework for transport development tenders, only the criteria weights have to be determined; thus, an alternative level has not been applied. The model has been tested on the urban bus transport system of a large Turkish city: Mersin. Based on the application, citizen preference weights could be associated with certain elements of the supply. Thus, government development source allocation decisions could be supported.

Mazloh Al-Enazi(2016) Jeddah city is the second largest city in Saudi Arabia. Jeddah city has witnessed a remarkably rapid urban growth rate during the past four decades. The aim of this paper is to use many GIS functions (network analyst, shortest path) in evaluating traffic congestions point during working day hours according to road directions. One of the useful GIS functions to be used for this purpose is known as shorts.

III. Methodology

User directly influence and get influenced by the services and facilities that are offered by urban transport facilities. In order to evaluate the performance of existing urban transport facilities, the key performance indicators had to be identified. Performance indicators are specific measurable outcomes that were used to evaluate the progress towards established goals and objectives. Questionnaire had been developed incorporating these indicators in order to identify the preferences of users. The most preferred attributes were sorted out to obtain the most favoured ones. The preferred attributes were then used to draft the final questionnaire for rating survey. Using the data obtained the ranking of factors; SPSS analysis; LOS and the most feasible path were formulated.

3.1 Study Area Identification

Kalady or kaladi is a census town located in Angamaly east of the Periyar river, in the Ernakulam district of Kerala, India, not far from Cochin International Airport. It is notable as the birthplace of Shankara, commonly known as Adi shankaracharya, and is a popular destination for Hindu pilgrims. Kalady came to prominence only after its rediscovery in the late 19th century by the then Shankaracharya of Sringery and the subsequent consecration of an Adi Shankara temple in 1910.

Traffic was disrupted on Kalady – Thanipuzha stretch when a large crater developed on the Sree Sankara bridge at mc road, Kalady. The major routes through Kalady are Perumbavoor, Aluva, Angamaly, Malayatoor..Several factors need to considered for the selection of site. Some of the factors are:

- Number of routes,
- Route length and time of travel
- Number of bus stops,
- Demography of passengers,
- Considering number of schools, Government institution, shopping centers if any. Various sites are considered,taking it as origin, it includes

Table 3.1 Route details

Origin	Destintion	Route Length	No Of Educational Institutions	No Of Stops	No Of Hospital
Kalady	Angamaly	10 km	9	15	3
Kalady	Perumbavoor	10 km	9	14	4
Kalady	Kanjoor	10 km	9	19	2
Kalady	Malayatoor	10 km	1	20	1

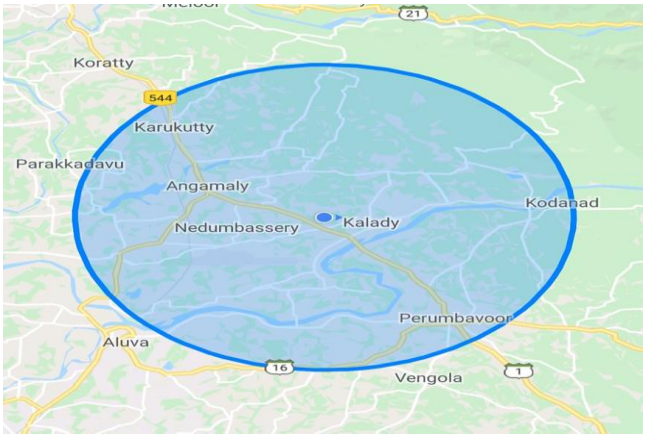

Figure 3.1: Study area around a stretch of 20 km (Source: Google map)

3. 2 Factors for Data Collection and Sorting

Several factors need to be considered for data collection, for that purpose several factors were chosen after conducting literature survey and about forty four factors were identified .From the total number of factors, the best suitable factors for collecting data were identified(most commonly used factors from journals) . Which are then grouped into factors for bus users and non-bus user's data collection and from those the best factors were chosen after conducting preference survey then followed by rating survey. And the factors collected include:

(1.) Travel cost
(2.) Total journey time
(3.) Waiting bus stops
(4.) Walking distance both at origin(home to bus stop)
(5.) Punctuality and reliability
(6.) Availability of seat
(7.) Space available for standing inside bus
(8.) Comfort level of seat
(9.) Easy of boarding
(10.) Ventilation inside the bus
(11.) Quality of bus stop
(12.) Safety and security inside bus
(13.) Bus driver , conductor and co passenger behaviour
(14.) Route information
(15.) Convenience and ticket purchasing
(16.) Condition in cleanliness of bus
(17.) Noise level
(18.) Jerking inside the running bus
(19.) Driver efficiency
(20.) Air conditioners
(21.) Comfortable music facility
(22.) Crowded conditions
(23.) Safety at night
(24.) Convenience for elderly or disabled and children
(25.) Reservation of seat
(26.) Continuous bus availability
(27.) Frequency of bus
(28.) Smoothness of bus
(29.) Pollution level
(30.) Easy to carry luggage
(31.) Bus information at bus stop(maps)
(32.) Relatively cheap fare
(33.) Safety of goods
(34.) Peak hour service
(35.) Late night service
(36.) Administration of complaints
(37.) Availability of information by phone and internet
(38.) Bus temperature
(39.) Transfer action in case of travel breakdown
(40.) Safety of opening and closing of the door
(41.) Fitness of the bus
(42.) Integration with other mode
(43.) Lighting facility
(44.) Ceiling height of bus

The above mentioned factors were chosen from various journals for conducting general survey. And the above mentioned factors are further classified as below:

Table 3.2: Factor classification for bus users and non-bus users survey

BUS USERS	NON BUS USERS
Bus Punctuality And Reliability	Pollution
Total journey time	Safety and security inside bus
Availability of seat	Over crowding
Space available for standing inside bus	Speed of bus
Comfort level of seat	Comfort of ride
Reservation of seat	Quality Of Bus Stop
Safety and security inside bus	Cleanliness Of Bus
Co Passengers Behaviour	Accessibility Of Bus Stop
Route Information	Waiting Time
Convenience In Ticket Purchasing	Availability Of Seat
Cleanliness Of Bus	Total Journey Time
Driver Efficiency	Based On Status
Crowded Condition	Bus Punctuality
Safety At Night	
Continuous Bus Service	
Peak Hour Service	
Luggage Space	
Bus Information At Bus Stop Late Night Service	
Action In Case Of Breakdown	
Availability Of Information By Phone Or Internet	
Lighting Facility	

3.3 Data Collection

The present study was carried out for the assessment of the quality of the buses operating in the Kalady region from users' point of view through a questionnaire survey. The questionnaire was composed of two parts; the first part for bus users and the second part for non-bus user's .A five-point Likert-type ordinal scale had been used for rating. A Likert scale is the most widely used approach to scaling responses in surveys, and format is such that responses are scored along a range.

The scale is as follows:

1. Highly Dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Highly Satisfied

The survey was carried out and responses were collected from bus users in Kalady bus stand and non-bus users from shops and houses. A total of twenty two attributes were identified for collecting bus user's responses and thirteen for non-bus users. Initially preference survey was carried out in order to short list the factors to top ten based on preference of the users. Preference survey, is a technique for obtaining public feedback. Which can be done in the form of questionnaire survey and the participants must score according to their preference. It was done by circulating google forms in campus and nearby area and 61 non bus users data and 93 bus users data were obtained ,i.e. total of 154 data was collected from both bus and non-bus users. From which the top ten factors where shortlisted by using the method of average.

Preference Survey Questionnaire:

I. Bus Users Survey

Bus User's Survey: Rate the following factors based on your preference as a person regularly using public bus for your daily commute. Preference can be rated on a scale of 1-5, where 5 denote the factor being " Highly Satisfied " and 1 denote the factor being " Highly Dissatisfied ".

1. Is punctuality of bus an important factor?
2. Is journey time of bus an important factor?
3. Is availability of seat in bus an important factor?
4. Is space inside for standing an important factor?
5. Is comfort level of seat an important factor?
6. Is reservation of Seat an important factor?
7. Is safety and security inside the a factor
8. Is employee and co passenger behaviour a factor?
9. Is route information an important factor?
10. Is ease in ticket purchase an important factor?

11. Is cleanliness of bus an important factor?
12. Is driver efficiency an important factor?
13. Is crowd inside the bus an important factor?
14. Is safety of bus stops at night an important factor?
15. Is continuous bus services an important factor?
16. Is luggage space an important factor?
17. Is bus information at stops an important factor?
18. Is peak hour service an important factor?
19. Is late night service an important factor?
20. Is action taken in case of breakdown a factor?
21. Is availability of information by digital media factor?
22. Is lighting facility inside the bus an important factor?

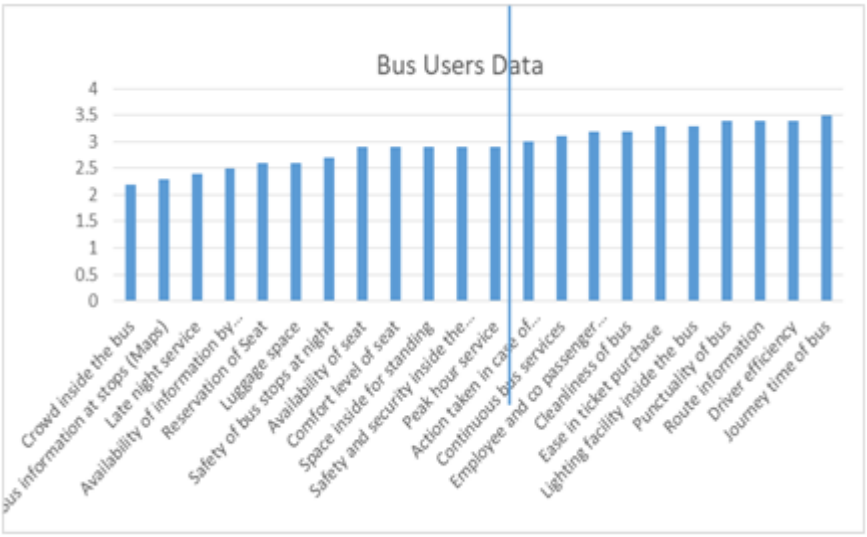

Figure 3.2: Data Extraction and Primary Analysis of Bus users

Ii. Non Bus Users Survey

Rate the following factors based on your preference as a person not using public bus for your daily commute. Preference can be rated on a scale of 1-5, where 5 denote the factor being " Highly Satisfied " and 1 denote the factor being " Highly Dissatisfied ".

1 Is pollution an important factor for not using the bus service?
2. Is safety and security inside the bus a reason an important factor for not using the bus service?
3. Is overcrowding a reason an important factor for not using the bus service?
4. Is over speed of the bus a reason an important factor for not using the bus service?
5. Is comfort of ride a reason an important factor for not using the bus service?
6. Is quality of bus stop an important factor for not using the bus service?
7. Is cleanliness of bus an important factor for not using the bus service?
8. Is accessibility to bus stop an important factor for not using the bus service?
9. Is waiting time an important factor for not using the bus service?
10. Is availability of seat an important factor for not using the bus service?
12. Is journey time an important factor for not using the bus service?
12. Is status an important factor for not using the bus service?
13. Is bus not being on time an important factor for not using the bus service?

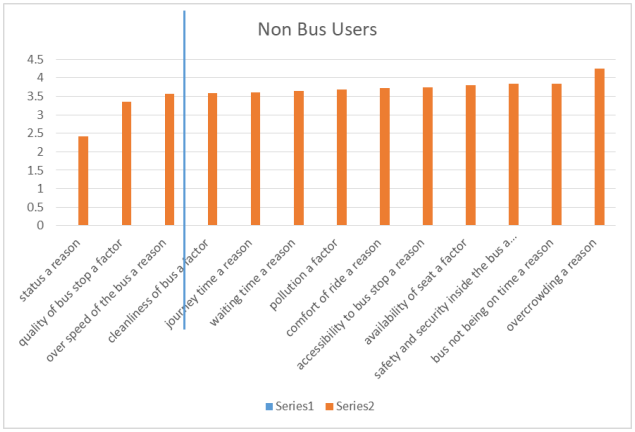

Figure 3.3: Data Extraction and Primary Analysis of Non Bus Users

After finding the top ten factors the rating survey was done ,it can be defined as closed ended survey question used to represent respondent feedback in a comparative form for specific particular features, services etc. one of the most establish question types for online and offline survey where survey respondent are expected to rate an attribute or feature. The field survey was carried on various days and a total of 489 bus user's response and 153 non bus user's response were obtained. The bus user's data was collected from the Kalady bus stand and a full day survey was carried on from 7am to 6pm. And non-bus user's data was collected from various shops in the locality .For rating the factors five-point Likert-type ordinal scale was used. And the factors were ranked using normalised method. In order for collecting the response ,response sheets were used.

3.4 Data Analysis

Data analysis of the bus users and non-bus user's survey was carried out by using SPSS analytical software. For that the data was categorized into three, they were Non-bus user's data, peak hour bus user's data and off peak hour bus user's data. The questionnaire survey brings out the data from 153 non bus users and 489 bus users data comprising of 230 data's from off peak bus users and 259 data's from peak hour bus users. The main objective of this data analysis was to find the weightage of each 10 factors of the three categories which is in turn used for ranking the factors. These ranked factors were necessary for finding the level of service index of the study area. Even though all the factors are of almost equal weightage slight variations may occur, on the basis of this variation these dependent factors were ranked. All the factors which were used in the questionnaire survey are dependent factors which varies with independent factors such as time, gender, age, type of transport etc…This should be taken into consideration while analysing the data.

SPSS statistics is a software package used for interactive, or batched, statistical analysis.it is a widely used program for statistical analysis in social science. In addition to statistical analysis, data management and data documentation are features of the base software. In order to achieve our objective ANOVA and mean comparison is used in SPSS software.

In statistics one-way analysis of variance is a technique that can be used to compare means of two or more sample. This technique can be used only for numerical response data, usually one variable. The ANOVA tests the null hypothesis, which states that samples in all groups are drawn from populations with the same mean values. The ANOVA produces F-statistics, the ratio of the variances calculated among the means to the variance within the samples. However, the one way ANOVA is used to tests for differences among at least three groups, since the two group case can be converted by t-test. When there are only two means to compare, the t –test and the F-test are equivalent; the relation between ANOVA and t is given by F=t^2. And the mean comparison method in SPSS is useful when we want to compare differences in descriptive statistics across one or more factors, or categorical variables.

3.5 Level of Service Concept

The quality of service is a user based perception of how well a transportation facility or service operates. Level of service (LOS) is a quantitative stratification of the quality of service into letter grades. LOS provides a general conceptual planning measure and can be used to assess the existing facility. It is a qualitative measure used to relate the quality of motor vehicle traffic service. LOS is used to analyse roadways and intersections by categorizing traffic flow and assigning quality level of traffic based on performance measure like vehicle speed, congestion etc. The need of this calculation is such that the performance index of the public transportation over an area can be identified and on the basis of the obtained results we can further improve the quality of the performance to a satisfied level for the future, if the performance index is unsatisfied. In this work,

the performance index value obtained for the three urban transport facilities were converted into four levels of service, „LOS S", „LOS A", „LOS B", „LOS C". For each of the urban transport facilities, the sum of weightage of all the variables used in preference survey is 100. For example, the upper limit for first LOS grade „S" is 100 (500/500×100) and the lower limit for LOS grade „S" is 80 (400/500×100).
The LOS grades are defined as follows;

- LOS S- Excellent
- LOS A- Good
- LOS B- Average
- LOS C- Poor

Table 3.3: Thresholds For Different Level of Service Overall

LOS S	100≤PI<80
LOS A	80≤PI<60
LOS B	60≤PI<40
LOS C	40≤PI<20

LOS is calculated using the numerical rating approach, it is Numerical rating approach is a simple conventional weighted average method used to calculate Level-of-Service (LOS).Level-of-Service-Index (LOSI) provided by a category of bus, which can be defined as the composite index calculated using the various service characteristics (attributes).Mathematically it is given as equation :

$$LOSI=\frac{\sum_{i=0}^{n} W_i * R_i}{\sum_{i=0}^{n} W_i}$$

Where,
N : No. of attributes that define the overall LOSI.
Wi : Weight associated with the ith service attribute
Ri : Value score for the ith service attribute for the category of bus service for the existing situation.
For a particular service characteristic, the LOSI provided by an urban bus service is expressed as shown in equation (2) below:
LOSI=Wi*Ri

Table 3.4: Relative Weightage Of Attribute of Bus Uses Data

Sl No	Attribute	Number of passengers putting weights on (preference survey)					Average weightage(X)	Relative weight
		5	4	3	2	1		
1	ACTION TAKEN IN CASE OF BREAKDOWN	13	31	32	14	3	3.39	.104
2	CLEANLINESS OF BUS	10	39	35	7	2	3.51	.107
3	CONTINUOUS BUS SERVICES	11	30	24	22	6	3.19	.097
4	DRIVER EFFCIENCY	23	23	22	16	9	3.38	.103
5	EASE IN TICKET PURCHASING	19	21	33	13	7	3.34	.102
6	EMPLOYEE & CO PASSENGER BEHAVIOUR	10	29	26	22	6	3.16	.096
7	JOURNEY TIME	12	33	33	9	6	3.38	.103
8	LIGHTING FACILITY	13	19	32	20	9	3.07	.094
9	PUNCTUALITY	15	28	30	13	7	3.33	.102
10	ROUTE INFORMATION	10	16	36	22	9	2.95	.09
Total							32.7	

Table 3.5: Service Quality of Attribute With Respect To Unity, Bus Users Data

Sl. No.	Attribute	Number of passengers putting weights on (rating survey)					Average weightage(X)	Service quality w.r. to unity
		5	4	3	2	1		
1	ACTION TAKEN IN CASE OF BREAKDOWN	121	163	104	75	26	3.57	0.714
2	CLEANLINESS OF BUS	68	153	152	81	35	3.28	0.656
3	CONTINUOUS BUS SERVICES	105	201	122	47	14	3.687	0.7374
4	DRIVER EFFCIENCY	149	177	90	48	25	3.77	0.754
5	EASE IN TICKET PURCHASING	62	112	121	127	67	2.94	0.588
6	EMPLOYEE & CO PASSENGER BEHAVIOUR	134	153	109	64	32	3.61	0.722
7	JOURNEY TIME	152	177	95	47	18	3.81	0.762
8	LIGHTING FACILITY	45	100	139	146	59	2.84	0.568
9	PUNCTUALITY	221	157	70	26	15	4.1	0.82
10	ROUTE INFORMATION	131	144	115	74	25	3.57	0.714

Table 3.6: Service Quality of Attribute With Respect To Unity of Non Bus Users Data

sl no	Attribute (Non Bus users)	Number of passengers putting weights on (rating survey)					Average weightage(X)	Service quality w.r. to unity
		5	4	3	2	1		
1	ACCESSIBILITY OF BUS STOP	20	52	43	23	15	3.25	0.651
2	AVAILABILITY OF SEAT	20	41	60	19	13	3.23	0.646
3	CLEANLINESS OF BUS	17	47	49	25	15	3.16	0.632
4	COMFORT OF RIDE	25	43	45	33	7	3.3	0.66
5	JOURNEY TIME	36	43	44	23	7	3.51	0.702
6	OVER CROWDING	36	52	48	15	2	3.67	0.774
7	OVERSPEED	26	38	52	28	9	3.29	0.658
8	POLLUTION	29	48	47	19	10	3.49	0.688
9	SAFETY & SECURITY INSIDE BUS	18	54	53	21	7	3.36	0.672
10	WAITING TIME	27	50	44	19	13	3.39	0.678

Table 3.7: Relative Weightage of Attribute Of Non Bus Users Data

sl no	Attribute (Non Bus users)	Number of passengers putting weights on (preference survey)					Average weightage(X)	Relative weight
		5	4	3	2	1		
1	ACCESSIBILITY OF BUS STOP	24	13	13	5	6	3.72	0.1
2	AVAILABILITY OF SEAT	27	11	12	4	7	3.77	0.101
3	CLEANLINESS OF BUS	21	12	16	4	8	3.56	0.095
4	COMFORT OF RIDE	21	15	17	5	3	3.75	0.1008
5	JOURNEY TIME	23	13	9	8	8	3.57	0.096
6	OVER CROWDING	32	16	10	1	2	4.23	0.113
7	OVERSPEED	20	16	9	8	8	3.52	0.095
8	POLLUTION	25	12	11	4	9	3.65	0.098
9	SAFETY & SECURITY INSIDE BUS	25	15	9	8	4	3.8	0.102
10	WAITING TIME	19	16	15	5	6	3.6	0.097

The performance index can also be calculated using the formula obtained from journal Chang 2009, Results of the rating survey together with the weightages obtained from preference survey were converted to performance index. The index of various facilities is calculated using the following formula,

$$PI=\frac{\sum_{i=1}^{1} AW_i * AS_i}{\sum_{i=1}^{1} AW_i * MS_i}$$

I = Number of indicators
AWi = Percentage of importance of weight for indicator
ASi = Average rating score for indicator „i"
MSi = Mean rating score for indicator „i"
PI = Performance index
The maximum value of the index is 100 and the minimum value is 0, higher values indicate better performance and lower values indicates poor performance

3.6 Feasible Route Mapping Using Software

The Feasible & best bus route is formulated on the basis of route length, number of bus stops, passenger capacity of the bus & overall passenger experience. Bus stops along all the major routes emanating from Kalady was analysed and all the parameters were studied. The major routes from Kalady were Perumbavoor, Angamaly, Malayatoor, Aluva, & Airport. The data was extracted from ticket count survey, Bus frequency on a selected route. The most feasible bus route found out had been plotted using GIS. QGIS was utilised for the same operation. The steps involved in analysing the routes were:

- Take world coordinate, zoom in on required area
- Acquire street characteristics from XYZ tiles,
- for each route create a new shape file layer , name layer, and select geometry type as line
- Select toggle edit tool and plot map for each route with different shades
- Alter layer characteristics in layer styling menu

IV. Result and Discussions

Generally level of service is a very important indicator in evaluating the performance of public transport. However it is difficult to measure as the service quality that a human mind perceives is affected by various qualitative and quantitative factors. For the study, the study area and the routes were chosen based on

factors identified which include accessibility, travel time, travel distance etc. The preference and rating survey were carried out to determine the level of service by using excel sheets & SPSS software.

4.1 Ranking of Factors

The factors were ranked using normalized method after conducting rating survey at peak and off peak hours. Figure 4.1 shows the ranking of non-bus users data , from the graph it is clear that the most important factor were overcrowding, journey time, pollution, waiting time, safety and security inside the bus are of great important , were as least ranked factors are comfort of ride, over speed , accessibility to bus stop, availability of seat , cleanliness. Figure 4.2 depicts the ranking of bus users survey conducted at peak hour's i.e. from 7am to 10am and 3pm to 6pm punctuality, journey time, continuous bus service , driver efficiency ,employee and co passenger behaviour are of great important were as least ranked factors are action taken in case of breakdown , route information, cleanliness, lighting facility , ease in ticket purchasing. Figure 4.3 shows the ranking of bus users survey conducted at off peak hour that from 11pm to 3pm punctuality, driver efficiency ,journey time, route information continuous bus service are of great important were as least ranked factors are employee and co passenger behaviour, action taken in case of breakdown , cleanliness, lighting facility , ease in ticket purchasing.

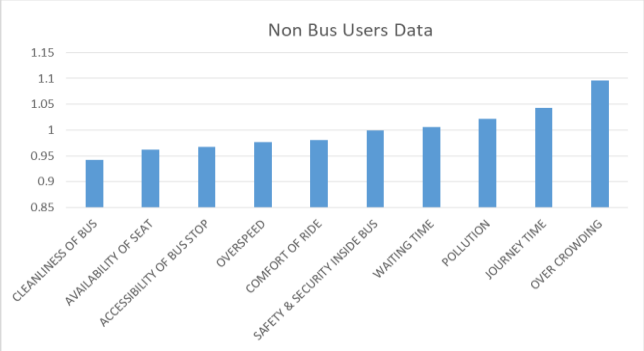

Figure 4.1: Ranking of Factors- Non Bus Users Data

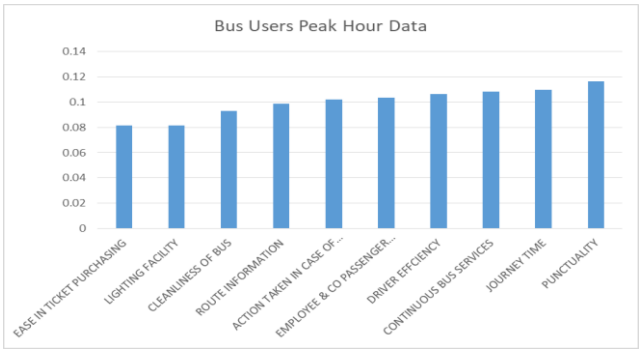

Figure 4.2: Ranking of Factors- Bus Users Peak Hour Data

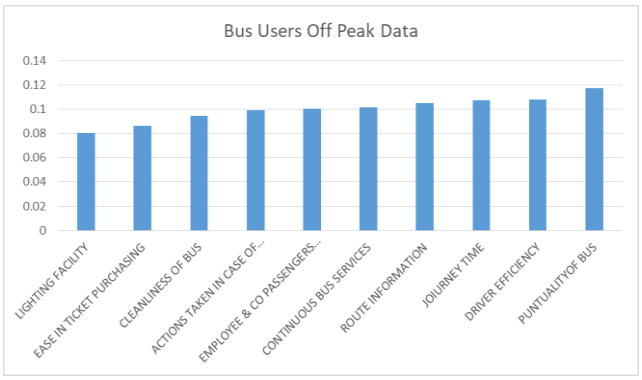

Figure 4.3: Ranking of Factors- Bus Users off Peak Hour Data

4.2 SPSS Data Analysis

Analysis of the data using SPSS software to determine, mean, standard deviation and to compare mean. In one way ANOVA analysis carried out for bus users data at off peak and peak hour and also non bus users data it is found that there is no difference between dependent and independent variable, the factors taken for data analysis are considered as dependent variable and here the independent variable chosen is gender, since the significant value lies above .05. Table 4.1, Table 4.2, Table 4.3 shows the result of one way ANOVA analysis and from it is clear that sig value lies above .05 except for lighting facility (.03) in peak hour analysis and ease of ticket purchasing (.025) in off peak hour analysis

Table 4.1: One Way ANOVA Results Of Non-Bus Users Data

FACTORS	F RATIO	Sig.
ACCESSIBILITY OF BUS STOP	.309	.579
AVAILABILITY OF SEAT	.852	.358
CLEANLINESS OF BUS	.943	.333
COMFORT OF RIDE	1.039	.310
JOURNEY TIME	.073	.788
OVER CROWDING	.139	.710
OVERSPEED	.095	.759
POLLUTION	5.292	.023
SAFETYANDSECURITYINSIDEBUS	.011	.917
WAITING TIME	.010	.921

Table 4.2: One Way ANOVA Results Bus Users off Peak Hour Data

FACTORS	F RATIO	Sig.
ACTIONS TAKEN IN CASE OF BREAKDOWN	.259	.611
CLEANLINESS OF BUS	.084	.772
CONTINUOUS BUS SERVICES	.040	.841
DRIVER EFFICIENCY	.055	.815
EASE IN TICKET PURCHASING	.783	.377
EMPLOYEE & CO PASSENGERS BEHAVIOUR	.054	.816
JOIURNEY TIME	1.032	.311
LIGHTING FACILITY	4.759	.030
PUNTUALITYOF BUS	1.929	.166
ROUTE INFORMATION	.621	.432

Table4.3: One Way ANOVA Results of Bus Users Peak Hour Data

FACTORS	F RATIO	Sig.
ACTION TAKEN IN CASE OF BREAKDOWN	.100	.905
CLEANLINESS OF BUS	.952	.387
CONTINUOUS BUS SERVICES	1.329	.266
DRIVER EFFCIENCY	2.118	.122
EASE IN TICKET PURCHASING	3.738	.025
EMPLOYEE & CO PASSENGER BEHAVIOUR	1.111	.331
JOURNEY TIME	1.814	.165
LIGHTING FACILITY	1.395	.250
PUNCTUALITY	1.641	.196
ROUTE INFORMATION	.191	.826

4.3 Level of Service Index

As per the objectives framed for this study, data analysis was done using conventional weighted average, the detailed calculations and results are shown in Tables 3.4,3.5,3.6,3.7 4.4, 4.5 . The results shown Table 3.3 and 3.7 represent a weighted average opinion on importance of service quality of the ten attributes for city buses on rating scale of 1-5, with 1 being 'not at all important' and 5 being 'extremely important'. It is evident from the results showing relative weights in Table 3.3 and 3.7 that relatively more importance was felt on the cleanliness of bus, overcrowding and safety and security aspect by the respondents. In the same manner, the results shown in column 8 of Table 3.5 and 3.6 represent a weighted average opinion on service quality of the ten attributes for city buses. In this category of service (Table 3. And 3.6), the service quality with respect to punctuality and overcrowding attains the maximum score (0.82 and .774), whereas lighting facility and cleanliness of buses receives less score (.568 and 0.632). The service level of the attributes and its deficiency from the acceptance level (0.6) as indicated by the negative sign as per numerical rating technique in Table

4.4 and 4.5. For example, in Table 4 .4the level of service of the attributes namely ,ease in ticket purchasing and lighting facility are having deficiency from acceptance level as they are shown with negative sign. The service levels of the remaining attributes considered were at acceptable level as they are indicated with positive sign, with respect to sufficiency/deficiency, which is shown in Table 4.4. Thus, from this analysis, it can be thought that the overall LOSI of buses on a particular route can be improved by improving the service quality of the attributes, which are below the acceptance level. The LOSI of the bus users were found to be .702 and the non-bus users were found to be .6756

Table 4.4: LOS of Bus Users Data Using Numerical Rating Method

sl no	Attribute (Bus users)	Relative weight	Service quality w.r. to unity	LOSI	Acceptance level (60% of scale)	Deficiency from acceptance level
1	ACTION TAKEN IN CASE OF BREAKDOWN	0.104	0.714	0.0742	0.0624	0.0118
2	CLEANLINESS OF BUS	0.107	0.656	0.0701	0.0642	0.0059
3	CONTINUOUS BUS SERVICES	0.097	0.7374	0.0715	0.0582	0.0133
4	DRIVER EFFCIENCY	0.103	0.754	0.0776	0.0618	0.0158
5	EASE IN TICKET PURCHASING	0.102	0.588	0.0599	0.0612	-0.0013
6	EMPLOYEE & CO PASSENGER BEHAVIOUR	0.096	0.722	0.0693	0.0576	0.0117
7	JOURNEY TIME	0.103	0.762	0.0784	0.0618	0.0166
8	LIGHTING FACILITY	0.094	0.568	0.0533	0.0564	-0.0031
9	PUNCTUALITY	0.102	0.82	0.0836	0.0612	0.0224
10	ROUTE INFORMATION	0.09	0.714	0.0642	0.054	0.0102
Total LOSI				0.7021		

Performance index=70.21

Table 4.5: LOS of Non Bus Users Data Using Numerical Rating Method

Sl No	Attribute (Non Bus users)	Relative weight	Service quality w.r. to unity	LOSI	Acceptance level (60% of scale)	Deficiency from acceptance level
1	ACCESSIBILITY OF BUS STOP	0.1	0.651	0.0651	0.06	0.005
2	AVAILABILITY OF SEAT	0.101	0.646	0.0652	0.061	0.0042
3	CLEANLINESS OF BUS	0.095	0.632	0.06	0.057	0.003
4	COMFORT OF RIDE	0.1008	0.66	0.0665	0.064	0.0025
5	JOURNEY TIME	0.096	0.702	0.0673	0.058	0.0093
6	OVER CROWDING	0.113	0.774	0.0874	0.068	0.0195
7	OVERSPEED	0.095	0.658	0.0625	0.057	0.0055
8	POLLUTION	0.098	0.688	0.0674	0.059	0.0084
9	SAFETY & SECURITY INSIDE BUS	0.102	0.672	0.0685	0.061	0.0075
10	WAITING TIME	0.097	0.678	0.0657	0.0582	0.0075
Total LOSI				0.6756		

Performance index = 67.56

Table 4.6: Los of Non Bus Users Using Chang Method

FACTORS	ASi	AWi	MSi	PI
POLLUTION	3.437908	0.102235	5	67.37803693
SAFETY & SECURITY INSIDE BUS	3.359477	0.099903	5	
OVER CROWDING	3.686275	0.109621	5	
COMFORT OF RIDE	3.300654	0.098154	5	
CLEANLINESS OF BUS	3.169935	0.094266	5	
ACCESSIBILITY OF BUS STOP	3.254902	0.096793	5	
WAITING TIME	3.385621	0.10068	5	
AVAILABILITY OF SEAT	3.235294	0.09621	5	
JOURNEY TIME	3.509804	0.104373	5	
OVERSPEED	3.287582	0.097765	5	

Table 4.7: LOS of Bus Users Using Chang Method

FACTORS	ASi	AWi	MSi	PI
PUNCTUALITY	4.11	0.116974	5	71.05156
JOURNEY TIME	3.81	0.108436	5	
EMPLOYEE & CO PASSENGER BEHAVIOUR	3.586	0.102061	5	
ROUTE INFORMATION	3.572	0.101662	5	
EASE IN TICKET PURCHASING	2.948	0.083903	5	
CLEANLINESS OF BUS	3.29	0.093636	5	
DRIVER EFFCIENCY	3.77	0.107297	5	
CONTINUOUS BUS SERVICES	3.68	0.104736	5	
ACTION TAKEN IN CASE OF BREAKDOWN	3.53	0.100467	5	
LIGHTING FACILITY	2.84	0.080829	5	

Performance index of the public transport determined using numerical rating method and using Chang formal found to be same which is clear from the table 4.4, 4.5, 4.6 and 4.7. Hence the performance index of the Kalady region for public transport (bus users) found to be LOS A, which indicates the public transport facility in Kalady is good.

4.4 Most Feasible Route Formulation – Using QGIS

The most feasible bus route among the ones taken from kalady was found out from passenger strength from each specified route. Passenger strength in each given route had taken from the rating survey & number of stops was determined. The most number of passengers had been recorded on Kalady-Angamaly route. Second most passenger mobility recorded was in Perumbavoor- Kalady route, the least passenger mobility was observed on Kalady- Airport route. The route had been plotted using QGIS software.

Figure 4.4: Feasible Route Network Using QGIS

4.5 Improvements Suggested

Performance index obtained for the three facilities in the two cities clearly indicates that improvements are required in order to enhance the satisfaction of users‟. In the Likert‟s scale, a moderately performing variable is given a scale of 3. Whenever the mode value of users‟ responses for any variable is observed lesser than 3, it will be recommended for improvement. Maximum score difference is observed when no response is given by the user for a variable and is 3. Importance of each facility obtained from preference survey is multiplied to the score difference to get the priority of improvement.

Improvement on below mentioned factors can also be done:

- Safety on road
- Safety from crime on bus
- Stopping of bus close to the bus stop for boarding and alighting of passengers
- Availability of service when you want
- Alternate arrangements made in case of breakdown

- Quality and age of vehicle
- Availability of fare chart
- Avoid humping

V. Conclusion

- Rating survey helped in assessing the existing condition of various facilities and formation of performance index. Priorities for improvement for each facility were obtained from the responses of rating survey and the weightage values obtained from preference survey. The factors analysed using preference and rating survey were ranked using normalized rating method in which ten factors for both bus users and non-bus users were ranked. The least ranked attributes need to be improved, there by quality of bus service can be improved.
- One way analysis of variance had been conducted to evaluate the null hypothesis that there is no difference between the factors ,and independent factor gender which include two groups (male, female), for both the cases, i.e. for non-bus users and bus users (peak and off peak hour) since the sig value lies above .05, there was no difference.
- Performance index for the Kalady region had found to be LOS A, indicating the performance of public transport facilities as good.
- The most feasible path in the study is identified using QGIS in which Kalady – Angamali was mound to the best one.

Scope for Future Work

This study considers only public transport facilities, public transport modes include city buses, trolley buses, trams (or light rail), passenger trains, rapid transit (metro/subways etc), ferries. This can be extended to any route length required, various modes of transport and various area identified by MOUD which include road safety, pollution level etc. This method can be applied to any geographical area of study.

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