Sustainable Solutions for Urban Public Transportation: A Case Study

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Abstract Urban areas are significant components for any developing and developed countries. Urban areas provide livelihood for majority of the country's population. Various service and manufacturing sectors concentrate in and around the urban areas. Numerous markets operate within the urban areas. Urban areas require efficient and sustainable transportation systems to enable the people to move for their needs and also to connect markets for transportation of goods. The public transportation in urban areas is mainly run by state governments and is meant to cater for majority of the general public. It is seen from various studies that for an urban area to have sustainable transportation system, emphasis has to be given to public transportation while limiting the use of private transportation. The present study investigates into the problems affecting public transportation in an urban area and finds solutions for improvement and also sets the direction for moving towards sustainable transportation system. Pune city is taken up as a case for studying urban transportation problems. A questionnaire survey was carried out among various commuters in Pune city. The survey was aimed to find the problems faced by the general public and which factors influence them to choose private transportation over public transportation. A total of 1180 responses were collected from residents of Pune city. The responses were subjected to descriptive analysis and reliability and validity tests. An exploratory factor analysis on the response data revealed nine key factors in choosing between public transportation and private transportation. The factors were (1) service between home and work, (2) Flexibility in travel, (3) Doorstep availability, (4) Minimal stops or delay, (5) Clear fare structure, (6) Easy to arrange transport, (7) Maintenance or quality, (8) Safety in travel and (9) Social status. Some of these factors can be addressed and resolved to improve the sustainability of public transportation. Whilst

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some factors such as doorstep availability and flexibility in travel are distant possibilities of the future. Thus, this study finds key factors for the government departments to focus on improving urban public transportation and providing sustainability for the future.

Keywords Urban transportation · Sustainability · Factor analysis · Public transportation

1 Introduction

India as a country has many hurdles to overcome in its journey towards transforming from a developing country into a developed country. For one sector to flourish it is equally important for its supporting sectors to improve as well. The Indian transportation sector being large and diverse has been growing enormously catering needs of more than 1.3 billion people. Along with the movement of goods from one place to another, the urban transportation in India also plays a role in reduction of poverty by improving access to labour markets. Services and manufacturing sectors particularly concentrate around urban areas thus they require efficient and low cost transport systems to enable the workers to move and to connect them.

Urban public transportation includes the buses and metros run by the state government for conveyance of general public and private transportation include buses, taxis and autos run and administrated by private companies or individuals running their two wheelers and cars. There are various factors which might influence how an individual chooses whether to go for public or private transportation. It is by far considered by many experts and leading researchers that for transportation system to be sustainable there should be full emphasis on public transportation while discouraging the use of private transportation. Keeping this in mind, this research focuses on which influences the general public in choosing private transportation over public transportation. Also, to understand the expectations of the general public from public transportation thereby enabling arrival at solutions to reverse the choice of private transportation over public transportation.

2 Literature Review

Many peer reviewed research articles, newspaper articles, government publications and standards released by authoritative bodies were referred to understand the state of the art in public transportation.

Ranganathan (2003) in his report points out that urban transport is an important sector in the sustainable development of urban areas. Inadequate urban transport leads to a number of problems. First is congestion and delays, second problem is

accidents, third problem he has stated is that of pollution in cities and fourth problem is resources consumption like use of land, energy and capital etc.

Chopra (2003) points out that there has been a massive induction of personalized vehicles in all 23 urban areas in the country. As a result of this, the congestion on roads is increasing. He also mentions that a large scale of parking vehicles on road has not only reduced traffic capacity of existing roads but also has created safety problems as well. The author also mentions in his article that privatization of urban transportation would not release the pressure on the Government to allocate the capital resources for state run buses. He also recommends that public transport should attract car users and other personalized and hired mode of transport, by giving amenities in the form of bus terminals, queue shelters and suitable information system like display of route maps, time table etc.

Singh (1997) points out that the traffic in big cities is in a mess; the bigger a city, the greater the mess. According to the author following are some traffic congestion causes are private autos, Modern business and living styles, vast amounts of goods are needed to service a relatively high consumption urban population, Faulty city planning, Bad or inconsiderate driving and unsatisfactory or inadequate public transport.

Tripta (2003) presents a comparative study of assessment of the quality of service provided by private and public bus transport in Delhi. The study revealed that private buses are better than public buses in respect of service accessibility and reliability. Also, public buses have been rated better than private buses on safety service, information, comfort, convenience and journey time. The author has also stated that it is necessary to conduct periodical surveys to study the bus transport system in order to get the feedback from public for further improvement of the services.

Nandogopal and Chinnaiyan (2003) explained the-benefits of mini bus to commuters and owners. It was found that mini bus scheme is the solution to cover unserved area. Many of rural commuters can be benefited by mini bus scheme. And on the downside mini bus operators were not satisfied on the point of profit. Poor road condition higher fuel consumption and high maintenance cost were the major problems expressed by the owners.

3 Methodology

The methodology of this study is mainly focussed to acquire and analyze data from the regular commuters of Pune city, regarding the problems they face in public transportation and reasons behind increased preference towards private mode of transportation. A questionnaire survey was designed to collect information from the commuters of Pune city. A portion of the city, the Aundh-Baner-Balewadi (ABB) region was chosen as the sampling site for carrying out the survey. The sample size was found using Eq. (1). A total of 1180 responses were required for the survey, distributed uniformly across the survey area.

$$\text{Sample Size} = N = \frac{\left[Z^2 * P * (1 - p)\right]}{e^2} \quad (1)$$

wherein, 'e' is the desired level of precision (i.e. the margin of error),

'p' is the (estimated) proportion of the population which has the attribute in question.

The survey questionnaire was designed to capture information regarding following themes:

1. What will be the percentage of commuters using private mode of transportation and public transportation?
2. What are the reasons for opting to a particular mode of transportation?
3. Are there any problems faced while using public transportation?
4. What are parameters which commuters prefer while travelling?

The responses were analysed for completeness and completed responses were initially subjected to descriptive statistics. Exploratory factor analysis was then carried out on the responses. The Kaiser-Mayer-Olkin (KMO) test was administered for measure of sampling adequacy. This test provides for minimum standard to proceed for Factor analysis. Bartlett's test of sphericity provides for the validity of Factor analysis. Factor analysis looks for variables that correlate highly with a group of other variables, but correlate very badly with variables outside that group. This will find the underlying factors in commuter behaviour for choosing private transportation over public transportation.

4 Analysis of Data and Findings

A total of 1180 responses were collected from commuters in the Pune city. Among these responses, 101 were rejected because of errors in the response and remaining 1079 responses were considered for further analysis. Descriptive statistical analysis were carried out on the responses. The following sections summarize the results.

4.1 Descriptive Statistics

Table 1 shows the distribution of age of respondents. It is found that commuters in the age group of 15–45 make up for 77.6% of the total sample of commuters. This mostly includes college students and working professionals who rely on public transportation for their travel needs.

Table 2 shows the marital status of the respondents. The table shows that there is nearly equal distribution of single and married respondents among the sample.

Table 3 shows the working status of respondents. While students make up for

Table 1 Age group distribution of respondents

Age group	Frequency	Percent	Cumulative percent
15–25	344	31.9	31.9
25–35	276	25.6	57.5
35–45	217	20.1	77.6
45–55	176	16.3	93.9
55–65	49	4.5	98.4
>65	17	1.6	100
Total	1079	100	100

Table 2 Marital status of respondents

Marital status	No. of respondents	Percent	Cumulative percent
Single	473	43.8	43.8
Married	606	56.2	100.0
Total	1079	100.0	100.0

Table 3 Working status of respondents

Working status	No. of respondents	Percent	Cumulative percent
Student	397	36.8	36.8
Housewife	178	16.5	53.3
Employed	255	23.6	76.9
Others	249	23.1	100.0
Total	1079	100.0	100.0

36.8% of commuters, there is also 23.6% of employed professionals and 16.5% of house wives or homemakers. There is another 23.1% of commuters who are traveling for purposes such as businesses or contract works or for going out of station.

Table 4 shows the income range of the respondents. Nearly half of the respondents declined to disclose their income range, 40.2% of respondents were in the range of 1–7 lakh. There is very small percentage of respondents in the higher income category using public transportation for their travel needs.

Table 4 Annual income of respondents

Income range	Frequency	Percent	Cumulative percent
Undisclosed	511	47.4	47.4
1–5 lac	179	16.6	63.9
5–7 lac	255	23.6	87.6
>7 lac	134	12.4	100.0
Total	1079	100.0	100.0

Table 5 Primary mode of transportation

Transportation mode	No. of respondents	Percent	Cumulative percent
Public transport	386	35.8	35.8
Private vehicle/taxi	451	41.8	77.6
Other modes	242	22.4	100.0
Total	1079	100.0	100.0

Table 6 Frequency of travel in public transport

Travel frequency	No. of respondents	Percent	Cumulative percent
Daily	265	24.6	24.6
Weekly	223	20.7	45.2
Monthly	155	14.4	59.6
Occasionally	202	18.7	78.3
Rarely	234	21.7	100.0
Total	1079	100.0	100.0

Table 5 shows the primary mode of transport chosen by the respondents. The table shows that only 35.8% of respondents use bus as their primary mode of transport while the remaining respondents have the option to choose either bus or any other private mode of transport for their travel needs.

Table 6 shows the frequency of travel by the respondents. Nearly half of the respondents are occasionally using public transport for travel needs.

Table 7 shows the frequency of bus service in the selected area. Table shows that the bus service in the area is not as expected by the public. There are some parts, mainly in the outskirts which are not fully connected and serviced by the public transport. This reduces the frequency of bus service to these areas and can have negative consequences.

Table 7 Frequency of bus service

Frequency of bus service	No. of respondents	Percent	Cumulative percent
High	445	41.2	41.2
Low	634	58.8	100.0
Total	1079	100.0	100.0

4.2 Relative Importance Index (RII)

RII was used to rank the key service parameters (KSP's) influencing private and public transportation. The Rank of each parameter was found using Eq. (2), wherein W is the weight assigned by each respondent on a scale of 1–5, A is the highest weight and N is the total number of sample. The parameters are then arranged according to their rank as shown in Tables 8 and 9.

$$RII = \sum \frac{W}{A * N} \tag{2}$$

Table 8 shows the ranking of key service parameters rated for the public transportation system. The responses state that most of the service parameters are held important by the respondents. Similar observations can be made from Table 9 showing

Table 8 Rating of key service parameters for public transportation

Factors	No. of respondents					Mean of scores	RII
	1	2	3	4	5		
Safety during travel	8	44	257	406	364	3.99	0.80
Clear fare structure	11	68	279	475	246	3.81	0.76
Easy to arrange	12	71	274	497	225	3.79	0.76
Maintenance of system	29	89	270	434	257	3.74	0.75
Flexibility of travel	11	65	370	478	195	3.65	0.74
Service from work to home	31	78	357	388	225	3.64	0.73
Door step availability	15	79	382	414	189	3.63	0.73
Number of stops	17	91	355	441	175	3.61	0.72
Social status of system	101	102	275	341	260	3.52	0.70

Table 9 Rating of key service parameters for private transportation

Factors	No. of respondents					Mean of scores	RII
	1	2	3	4	5		
Safety	6	26	149	388	510	4.26	0.85
Clear fare structure	13	49	168	433	416	4.1	0.82
Very few stops	7	43	199	424	406	4.09	0.82
Maintenance	10	44	199	411	415	4.09	0.82
Easy to arrange	10	49	189	420	411	4.09	0.82
Social status	50	55	164	328	482	4.05	0.81
Service from work to home	12	47	234	457	329	3.97	0.79
Flexibility	11	43	233	504	288	3.94	0.79
Door step availability	9	28	2106	443	383	4.08	0.68

Table 10 Rating of bus services and bus stations

Factors	No. of respondents					Mean of scores	RII
	1	2	3	4	5		
Friendly customer service	112	280	393	240	54	2.86	0.57
Clear and helpful communication	102	310	394	240	33	2.81	0.56
Timely service	93	342	390	227	27	2.77	0.55
Ease in booking service	116	336	396	189	42	2.73	0.55
Error free time table	136	367	376	161	39	2.63	0.53
Arrival on time	127	399	361	157	35	2.61	0.52
Never breaking down of bus	134	388	376	142	39	2.6	0.52
Adequate resources	158	419	351	111	40	2.5	0.50
Attractive bus stop	123	507	302	125	22	2.46	0.49
Equipped with modern technology	155	496	304	93	31	2.4	0.48

ranking of key service parameters for the private transportation. This only indicates that satisfying one or two parameters is not sufficient to increase occupancy in public transportation. All the factors have more or less equal importance and the authorities should give importance to all the service parameters.

Table 10 shows the rating of existing bus service and bus stations by the respondents. It can be seen from the table that almost all of the service parameters have been given very low rating by the respondents. This indicates general low level of quality and dissatisfaction experienced by the commuters in public transportation systems.

4.3 Exploratory Factor Analysis

Table 11 shows the grouping of responses into six factors. These six factors explain a total variance of 59.68% for the preference of public towards private transportation. The Eigen values of these six factors are greater than one. Kaiser-Mayer-Olkin (KMO) test result was 0.841 indicating the sample was adequate for factor analysis. The Bartlett's test of sphericity value as shown in table proves the validity of factor analysis.

The six factors are named as stated below.

Factor 1: Hassle free travel
Factor 2: Punctuality
Factor 3: User specific services
Factor 4: Social status and safety

Table 11 Results of exploratory factor analysis (N = 1079)

Parameters	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Easy to arrange	0.792					
Safety	0.771					
Very few stop	0.759					
Clear fare	0.757					
Maintenance	0.722					
Never break down		0.839				
Bus always arrive on time		0.759				
Error free timetable		0.702				
Marital status			0.872			
Working status			0.856			
Age group			0.849			
Annual income			0.774			
Safety				0.747		
Social status				0.636		
Communication clear and helpful					0.903	
Willing to help					0.837	
Service from work to home						0.936
Flexibility						0.807
% Variance Explained	**20.00**	**14.61**	**8.28**	**6.49**	**5.72**	**4.58**
Cumulative Variance Explained	**20.00**	**34.61**	**42.89**	**49.38**	**55.1**	**59.68**
Eigen Values	**7.00**	**5.11**	**2.90**	**2.27**	**2.00**	**1.61**
KMO = 0.841, Bartlett's Test of Sphericity $\chi^2 = 20{,}430.02$, $p < 0.001$						
Extraction Method Principal Component Analysis						

Factor 5: Friendly customer service
Factor 6: Flexibility in Travel.

5 Conclusions

The study finds six factors namely, Hassle free travel, Punctuality, User specific services, Social status and safety; Friendly customer service and Flexibility in Travel influence the choice of commuters towards private mode of transportation. These factors are very well covered and addressed by taxi operators such as uber and ola and probably is the reason for their increase in market share in transportation.

State transport authorities will now have to upgrade their systems to have customised travel arrangements for different regions of the city. There is need to improve the cleanliness and safety in bus travel. There is general need to upgrade the

social status and image of buses and the authorities will have to introduce multiple grade of buses to satisfy the commuter expectations.

It is reasonable to understand that in spite of several improvements in public transportation, some areas such as door step availability and flexibility of travel timing cannot be improved to compete with private mode of transportation and as such requires more changes in policies and attitude of people towards public transportation.

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