

Exploring operational Characteristics of Battery operated Auto-Rickshaws in Urban Transportation System

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Abstract: The paper contains primary data based analysis on the role played by Battery Operated Auto-rickshaw in urban transportation system. As a transport mode, different aspects of battery operated auto-rickshaw like trip characteristics, travel speed, travel fare, type of use, problems associated etc have been explored with a view to providing a generalized idea on the mode. The paper would provide guidelines to the policy makers of a country regarding whether and how to incorporate the mode in the local town's transportation system. Moreover, the paper with scientific outcomes might assist transport planners in modeling for efficient transportation in the mixed traffic condition where battery operated auto-rickshaw co-exists as well.

Keywords: Battery operated auto-rickshaw, Trip characteristics, Frequency of trips, Home- bus/tempo stand-work place network, Travel distance, Traffic safety, Performance index.

I. INTRODUCTION

Battery operated auto-rickshaw (locally called 'Easy-bike') is a newly added para-transit mode in urban transportation system of Bangladesh . The mode, being introduced in 2008 in Bangladesh attains much popularity among urban passengers since it involves lower travel cost than other locally available transport modes as well as provides reasonable safety and comfort to the users during travel [1]. This popularity, in turn results rapid growth of the mode in urban areas of Bangladesh. Now, the mode has become inseparable part of urban people's mobility network, especially in small-compact towns [2]. Therefore, it requires careful attention in incorporating the mode in local urban traffic-mix. To serve the purpose, the study is made to explore and analyze different attributes associated with the mode both from operators' and users' point of view.

II. OBJECTIVE OF THE STUDY

The objective of the research is to explore operational characteristics of battery operated auto-rickshaws in local urban transportation system.

III. METHODOLOGY OF THE STUDY

3.1 Study Area Selection

Two study areas are selected for carrying out the study on the basis of two major criteria as following-

- i. Number of battery operated auto-rickshaws running within the town.
- ii. Proximity of the area (town) to Dhaka.

Initially several urban areas of Bangladesh are considered on the basis of availability of data regarding the number of battery operated auto-rickshaws running within the town. Among them, two are selected as study areas finally based upon the aforementioned criteria. Numbers of battery operated auto-rickshaws running within the urban centers as well as physical distances (road/travel distances) of these areas from Dhaka are presented in Table-1.

Table-1: Number of battery operated auto-rickshaws and physical distances of towns from Dhaka

From	To	Number of Battery Operated Auto-rickshaws Running within the Town*	Distance (km) of the Town from Dhaka**
Dhaka	Comilla	8,687	97
Dhaka	Kushtia	2,521	277
Dhaka	Jessore	1,800	274
Dhaka	Faridpur	1,200	145
Dhaka	Meherpur	1,250	286

*Source: Easy-bike⁴ Owner's Association, Kushtia & Faridpur, 2011 [3]; District Traffic Police, Comilla, 2011 [4]; The Daily Prothom Alo, January 3, 2011 [5]

** Source: Discovery Bangladesh, Travel Info: Distance City to City, 2011 [6]

According to the stated criteria and imposing priority on the first one to ensure data quality, Comilla City Corporation Area and Kushtia Municipal Town are selected as study areas.

3.2 Variable Selection and Data Collection

Variables selected to fulfill the objective are presented in Table-2.

Table-2: List of variables

Objective	Parameters	Variables
To explore operational characteristics of battery operated auto-rickshaw in local urban transportation system	Travel/trip related issues	Travel speed, Travel cost, Travel length, Travel time, Types of trips, Trip frequency, Trip length
	Modal issues/ attributes	Costs/benefits over other modes, Type of use, Change in mode choice, Travel safety, Fare Rate, Travel Time, Travel Comfort, Travel Speed, Crowd, Operator's Behavior, Quality of Service

Operator opinion and user opinion surveys are conducted extensively to collect data on selected variables. The sample size for each type of survey is calculated 384 at 95% confidence level and confidence interval of 5.

IV. RESULTS AND DISCUSSION

4.1 Trip Characteristics

General characteristics of trips made by battery operated auto-rickshaws in urban areas of Bangladesh are discussed in following segments.

4.1.1 Type and Length of Trips

The trip of length less than 5 kilometers is characterized as 'short' trip, between 5 and 10 kilometers as 'medium' and greater than 10 kilometers as 'long' trips. The study shows that most of the operators of battery operated auto-rickshaw tend to make short trips within the town as presented in Table-3.

Table-3: Type of trips made by battery operated auto-rickshaws

Types of trips	Percentage
Short (< 5 km)	85.15
Medium (>= 5 km and <= 10 km)	11.46
Long (> 10 km)	3.38

Source: Operator Opinion Survey, 2011

Short and medium trips generally serve passengers' travel demand within the town while long trips serve their inter-town travel demand as found from the study. Around 85% of battery operated auto-rickshaws make short trips as shown in Table-3. The mode generates medium trips at considerable percentage. Very few operators go for long trips to meet inter-town travel demand of passengers. However, average length of trips made by the mode is 3.29 km as shown in Table-4.

Table-4: Length of trips made by battery operated auto-rickshaws

Types of Trips		Trip Length (km)
Short (< 5 km)	Maximum	4
	Minimum	1
	Average	2.51
Medium (>= 5 km and <= 10 km)	Maximum	10
	Minimum	5
	Average	6.52
Long (> 10 km)	Maximum	13
	Minimum	11
	Average	11.65
Average		3.29

Source: Operator Opinion Survey, 2011

4.1.2 Frequency of Trips

Number of trips made by the mode per day is presented in Table-5 in accordance to types of trip.

Table-5: Frequency of trips made by battery operated auto-rickshaws

Types of Trips		Trip Frequency per Day
Short (< 5 km)	Maximum	32
	Minimum	8
	Average	19
Medium (>= 5 km and <= 10 km)	Maximum	20
	Minimum	6
	Average	10
Long (> 10 km)	Maximum	8
	Minimum	4
	Average	6
Average		16

Source: Operator Opinion Survey, 2011

Table-5 shows that battery operated auto-rickshaw can make average 16 trips of 3.29 km average length per day in local urban areas of Bangladesh.

4.1.3 Fare Rate

The average income generated by battery operated auto-rickshaw per day is BDT 532.32 as found from operator opinion survey. This indicates that the mode with average 16 trip frequencies per day is capable to generate income of BDT 33.27 per trip. Since the average length of trip made by the mode is 3.29 km as mentioned before, it generates income of BDT 10.11 at per kilometer operation. Therefore, the mode with average occupancy of 4 passengers [7] should require BDT 2.53 as fare per head at per kilometer travel. However, the actual fare rate moves between BDT 2.00 to BDT 5.00 as found from user opinion survey.

4.2 Characteristics of Battery Operated Auto-rickshaws from Users' Point of View

Characteristics of battery operated auto-rickshaws are also identified and analyzed from user's point of view as following.

4.2.1 Users of Battery Operated Auto-rickshaws

Around 88% of total population living in a town where battery operated auto-rickshaw is available, use the mode now-a-days to meet their travel demand as presented in Table-6.

Table-6: User of battery operated auto-rickshaws

Users	Percentage to the Total Population
Use Battery Operated Auto-rickshaw	88.02
Do Not Use Battery Operated Auto-rickshaw	11.98

Source: User Opinion Survey, 2011

4.2.2 Information on Users of Battery Operated Auto-rickshaws

The information regarding age group, sex, educational qualification and occupation of urban passengers who avail battery operated auto-rickshaw to meet travel demand are presented in Table-7.

Table-7: Information on users of battery operated auto-rickshaws

Information on		Percentage to the Users
Age Group (years)	0-14	3.85
	15-29	58.88
	30-44	14.50
	45-60	22.19
	60+	0.59
Sex	Male	72.78
	Female	27.22
Educational Qualification	Illiterate	15.09
	Primary	4.73
	Secondary	34.91
	Higher Secondary	37.57
	Degree/Pass course	2.66
	Technical/ Vocational	1.77
	Honors/ University	3.25
Occupation	Govt. Service	9.76
	Private service	27.22
	Business	21.30
	Student	30.77
	Laborer	4.14
	Unemployed	3.85
	Housewife	4.14
	Others	0.00

Source: User Opinion Survey, 2011

Table-7 shows that most of the users of battery operated auto-rickshaws are aged between 15 and 29 years. This mode is popular especially to students as found from the study. In addition, the people doing small scaled business and low paid private job avail the mode considerably.

However, around 12% of the populations living in towns are found not using the mode at all. Information on those non-users is presented in Table-8.

Table-8: Information on people not using battery operated auto-rickshaw

Information on		Percentage to the Non-users
Age Group (years)	0-14	0.00
	15-29	30.43
	30-44	43.48
	45-60	26.09
	60+	0.00
Sex	Male	82.61
	Female	17.39
Educational level	Illiterate	0.00
	Primary	8.70
	Secondary	6.52
	Higher secondary	19.57
	Degree/ Pass course	15.22
	Technical	0.00
	Honors/ University	50.00
Occupation	Govt. Service	21.74
	Private service	26.09
	Business	26.09
	Student	19.57
	Laborer	0.00
	Unemployed	0.00
	Housewife	8.70
	Others	0.00

Source: User Opinion Survey, 2011

Table-8 shows that mostly the people aged between 30 and 44 years, having higher educational qualification and doing well paid private job, government job and medium or large scaled business do not use the mode. In addition, most of them own a private transport like bi-cycle, motor-cycle or private car as found from the study.

4.2.3 Reasons for Using Battery Operated Auto-rickshaw

Battery operated auto-rickshaw offers series of benefits over other locally available transport modes, which attract urban passengers to avail it. Study shows that around 94% of total users of the mode avail it inclusively for lower travel cost the mode involves as illustrated in Figure-1.

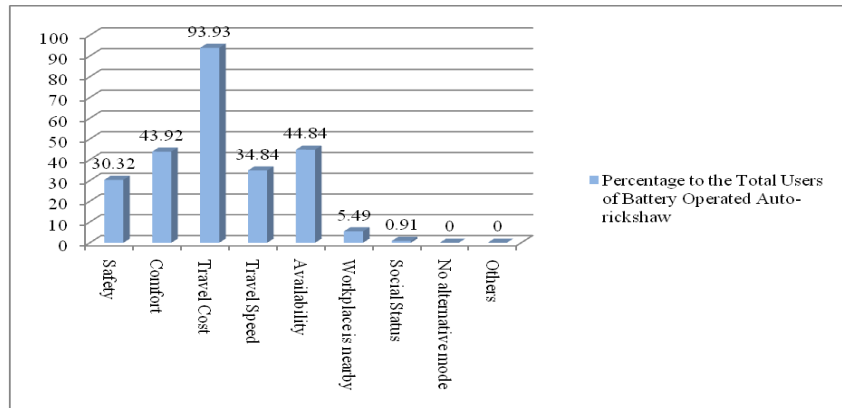


Figure-1: Graphical representation of reasons for availing battery operated auto-rickshaws

In addition, it offers greater travel comfort than others which affect urban dweller’s choice for the mode considerably. Furthermore, large number of battery operated auto-rickshaws in local towns of Bangladesh makes the mode easily available throughout the town. This aspect associated with the mode plays important role as well to make it a popular transport mode among passengers since availability of the mode reduces their waiting time. Because of limited speed and light weight the mode does not create any fatal accidents as users opined. Due to this safety issue, also a considerable percentage of users avail the mode as found from the study.

4.2.4 Reasons for Not Using Battery Operated Auto-rickshaw

Around 91% of people who do not avail battery operated auto-rickshaw accuse the lack of safety issues that the mode involves, for not using the mode. The mode doesn’t cause fatal traffic accident though. However, light weight of the mode, driver’s lack of skill and training, and indiscriminate plying of the mode on the heavy traffic carrying urban roads make it vulnerable sometimes to small scaled traffic accidents. Considerable percentages of non-users do not go for the mode since they have access to private transport like bicycle, motor-cycle or car, and/or for the crowding passengers associated with battery operated auto-rickshaw as presented in Figure-2.

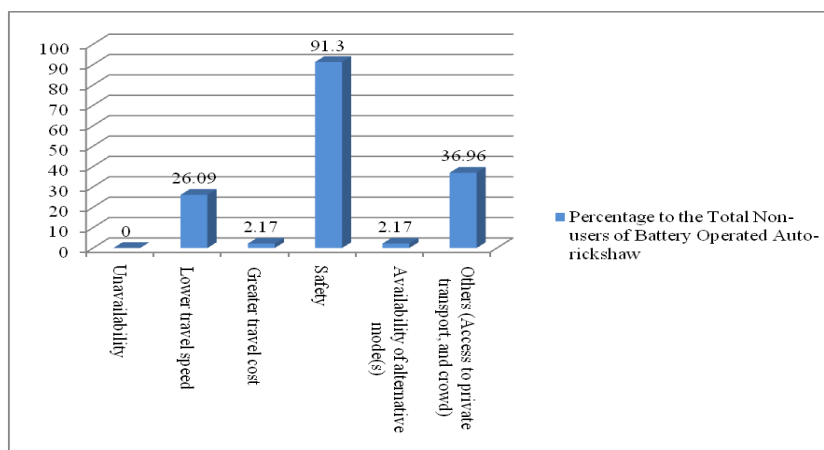


Figure-2: Graphical representation of reasons for not using battery operated auto-rickshaws From the above discussions it can be concluded that battery operated auto-rickshaw plays important role to meet the travel demand of low income urban dwellers seeking for low cost travel mode in local urban areas of Bangladesh. The mode provides comfort during travel along with reasonable safety and travel speed to low income people while higher income people do not use the mode for the lack of safety and comfort, and lower travel speed the mode associates. This is because definition of comfort and travel speed varies with people’s income level. From

neutral point of view, battery operated auto-rickshaw involves lower travel cost and hence it is easily accessible to all income group people. The mode provides service to majority of people of a city with considerable comfort and travel speed. In case of safety, it is drivers/operators with lack of skills and training who are responsible more for causing traffic accidents than the mode.

4.3 Type of Use

Around 86% of users of battery operated auto-rickshaws use it as primary mode in local urban areas as showed in Table-9.

Table-9: Type of use of battery operated auto-rickshaws

Type of Use	Percentage to the Total Users of Battery Operated Auto-rickshaw
As primary mode	86.09
As secondary mode	13.91

Source: User Opinion Survey, 2011

Users who avail local minibus or auto-tempo as primary mode generally avail battery operated auto-rickshaw as secondary mode within the ‘home- bus/tempo stand- work place’ network as illustrated in Figure-3.

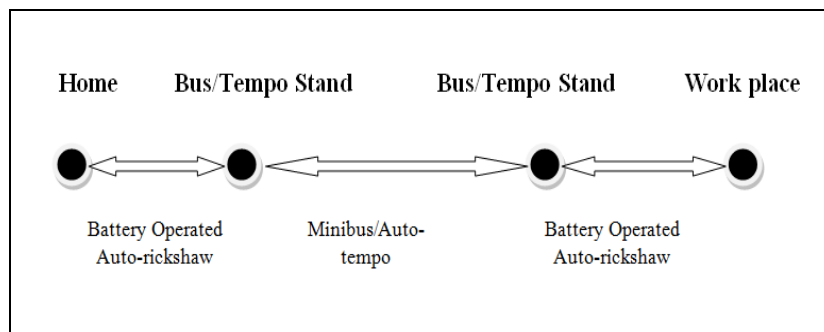


Figure-3: The ‘home- bus/tempo stand- work place’ network

Average length of a trip made by battery operated auto-rickshaws in local towns is 3.29 km as mentioned above. In transposition, average travel distance of users is found 1.31 km as calculated from the survey data presented in Table-10.

Table-10: User’s travel distance

Travel Distance	Percentage to the Total Users of Battery Operated Auto-rickshaw
< 1/2 km	4.44
1/2 to 1 km	11.24
1 to 1.5 km	60.65
1.5 to 2 km	20.71
2 to 3 km	1.78
3 to 4 km	0.00
4 to 5 km	1.18
> 5 km	0.00

Source: User Opinion Survey, 2011

Since battery operated auto-rickshaw makes trip of 3.29 km length on average and users of the mode in towns demand for travel for average 1.31 km distance, the mode can serve user’s travel demand as primary mode substantially. Therefore, most of the users of battery operated auto-rickshaws tend to use it as primary mode in local towns of Bangladesh.

Prior to the advent of battery operated auto-ricksaws in local urban areas of Bangladesh, passengers used to avail rickshaw, minibus, auto-tempo and nosimon (a locally developed, 8-12 hp diesel engine operated and three-wheeled para-transit mode) as primary mode as found from the study. After battery operated auto-ricksaw becomes available it mostly replaces rickshaw as primary mode as presented in Figure-4.

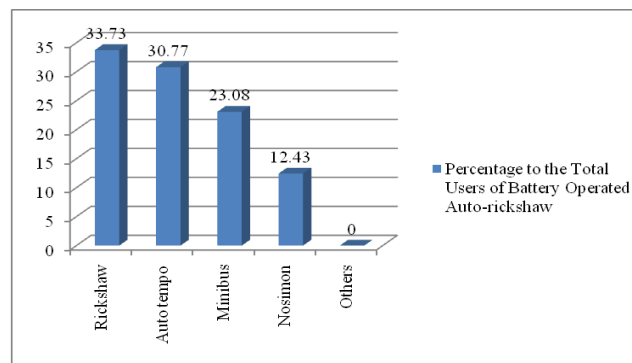


Figure-4: Graphical representation of primary mode choice of users in previous.

Figure-4 also shows that battery operated auto-rickshaw as primary mode replaces auto tempo and minibus considerably as well. As secondary mode, battery operated auto-rickshaw mostly replaces rickshaws and vangari (flat-bed rickshaw) as illustrated in Figure-5.

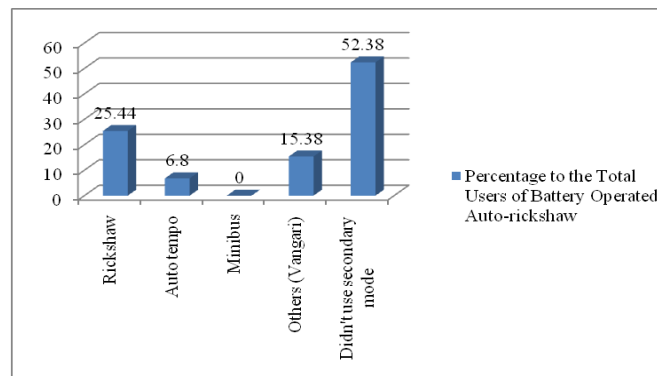


Figure-5: Graphical representation of secondary mode choice of users of battery operated auto-rickshaw in previous

4.4 Travel Speed

During user opinion survey, users of battery operated auto-rickshaws are asked to mention how much time the mode takes to serve up to their travel distance. Accordingly, it is calculated that the average travel speed at which battery operated auto-rickshaws serve urban passenger's travel demand in local towns of Bangladesh is 9.95 kilometer/hour.

4.5 Changes in Mode Choice

Battery operated auto-rickshaw attracts urban passengers from other transport modes for series of reasons discussed above. Around 59% of users of the mode inclusively used rickshaw before battery operated auto-rickshaw get introduced in their town. Accordingly, 40% of the users shift from auto-tempo, 28% from nosimon and 24% from minibus in inclusive manner as shown in Figure-6.

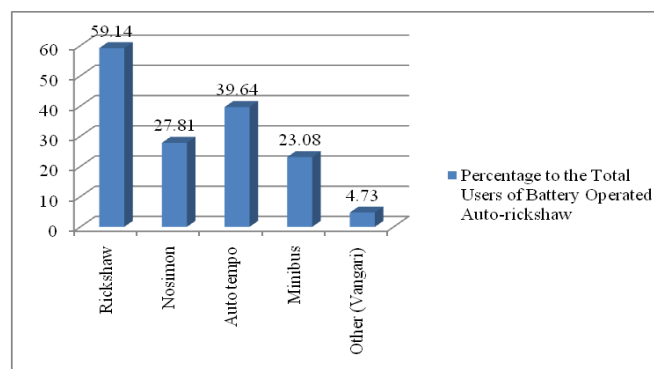


Figure-6: Graphical representation of user's mode choice in previous

Figure-6 shows that most of the users of battery operated auto-rickshaw shifts from rickshaws. In addition to this, the mode attracts passengers from auto-tempo, nosimon and minibus considerably. Study reveals that lower travel cost and better travel speed that battery operated auto-rickshaw involves have played vital role to attract passengers from rickshaw. Most of the passengers who availed auto-tempo, minibus and nosimon previously change their mode choice to battery operated auto-rickshaw for the sake of comfort mainly.

4.6 Frequency of Using Battery Operated Auto-rickshaws in A Week

During user opinion survey, users of battery operated auto-rickshaw are asked to mention how frequently they avail the mode in a week. Around 86% of the users of battery operated auto-rickshaws avail the mode daily as presented in Figure-7.

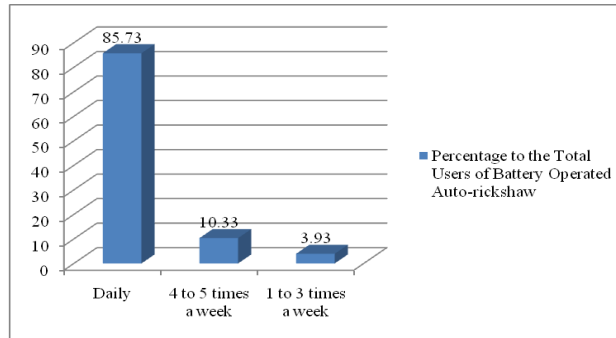


Figure-7: Graphical representation of frequency of using battery operated auto-rickshaw throughout a week

Figure-7 illustrates that most of the users of battery operated auto-rickshaws in local towns of Bangladesh use the mode on daily basis. Some of the users avail the mode irregularly and mostly of them use it as instant alternative to other modes like auto-tempo or rickshaws. Large scale availability of battery operated auto-rickshaws affects user’s instant mode choice decision. From the study it is found that passengers who are not regular user of battery operated auto-rickshaw generally use the mode as an alternative to their regular mode in case of its unavailability.

4.7 Problems Associated with Battery Operated Auto-rickshaws

Most of the users of battery operated auto-rickshaw identify its vulnerability to traffic accident as a major problem. In addition to this, frequent stopping of the mode to load and unload passengers is another problem as found from the study. A considerable percentage of users also accuse low travel speed that the mode involves as a problem as shown in Figure-8.

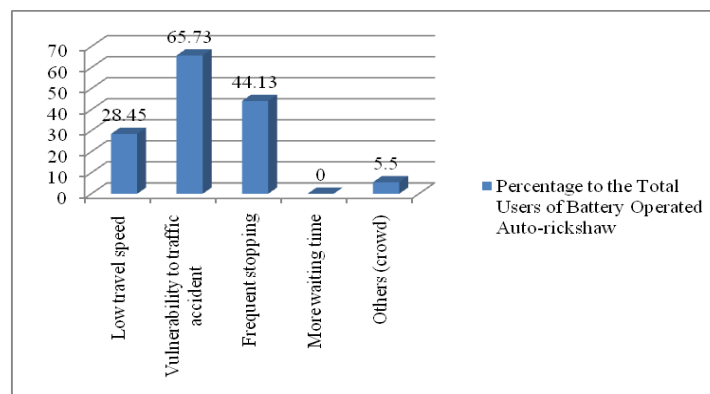


Figure-8: Graphical representation of problems associated with battery operated auto-rickshaws

4.8 Performance Index (PI) of Battery Operated Auto-rickshaws on Its Attributes

During user opinion survey respondents are asked to give their opinion on different attributes of battery operated auto-rickshaw over a 5 point scale (0-5), where 0 indicates the worst performance and 5 the excellent. The scale is constructed as shown in Figure-9. The higher the scale value the better is the performance. For instance, the scale value between 4 and 5 indicates nearly excellent performance.

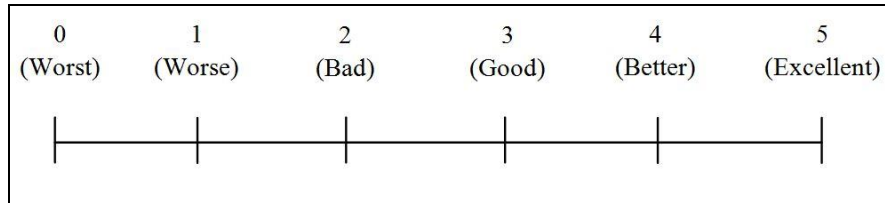


Figure-9: Performance Index scales

Respondent’s opinions are taken on the attributes- ‘fare rate’, ‘travel time’, ‘travel comfort’, ‘safety’, ‘travel speed’, ‘crowd’, ‘operator’s behavior’ and ‘quality of service’ associated with battery operated auto-rickshaws. Performance Index of the mode is calculated both from user of the mode and non-user of the mode’s point of view. The study results obtained from opinions of users of battery operated auto-rickshaw on attributes of the mode are presented in Table-11.

Table-11: Performance of battery operated auto-rickshaw based on opinion of users of the mode

Attributes	Scales					
	0	1	2	3	4	5
Fare Rate	0	0	3	23	104	208
Travel Time	0	0	27	115	172	24
Travel Comfort	0	0	30	21	136	151
Safety	15	27	109	92	77	18
Travel Speed	0	3	42	136	136	21
Crowd	0	9	17	208	104	0
Operator's Behavior	0	3	54	222	59	0
Quality of Service	0	0	27	103	172	36

Source: User Opinion Survey, 2011

Note: Figures presented in the table are frequencies of responses

Out of 384 sampled respondents, 338 respondents (88.02% of the total) use battery operated auto-rickshaw to meet their travel demand as found from the study. According to opinions of these users, calculation of performance index for battery operated auto-rickshaw for a single attribute (e.g. Fare rate) is demonstrated hereafter.

$$\text{Performance Index of Battery Operated Auto-rickshaw on Its Fare rate} = \frac{(0 \times 0 + 1 \times 0 + 2 \times 3 + 3 \times 23 + 4 \times 104 + 5 \times 208)}{338}$$

$$= 4.53$$

Accordingly, performance index of other attributes of the mode based on opinion of users are calculated and presented in Table-12.

Table-12: Performance index of battery operated auto-rickshaw on its attributes

Attributes	Performance Index
Fare Rate	4.53
Travel Time	3.57
Travel Comfort	4.21
Safety	2.72
Travel Speed	3.38
Crowd	3.20
Operator's Behavior	3.00
Quality of Service	3.64

Average fare that battery operated auto-rickshaw requires per head at per kilometer operation is BDT 2.53 as mentioned above. From Table-12, it is seen that the fare rate of the mode is nearly excellent to the users. In addition, the mode includes satisfactory performance on travel comfort issue. Regarding quality of service, travel time, travel speed, crowd and operator’s behavior with passengers, the mode holds good performance in meeting travel demand of users. However, regarding safety, the mode associates bad performance.

Respondents who are found not using the mode are asked also to give their opinions on attributes of battery operated auto-rickshaws. Performance index of the mode on its different attributes according to those non-users are presented in Table-13.

Table-13: Performance index of battery operated auto-rickshaws based on opinions of non-users of the mode

Attributes	Scales						Performance Index
	0	1	2	3	4	5	
Fare Rate	0	0	0	11	35	0	3.76
Travel Time	0	4	15	23	4	0	2.59
Travel Comfort	8	23	15	0	0	0	1.15
Safety	27	19	0	0	0	0	0.41
Travel Speed	0	11	12	23	0	0	2.26
Crowd	0	0	27	19	0	0	2.41
Operator's Behavior	0	0	35	11	0	0	2.24
Quality of Service	0	0	4	42	0	0	2.91

Source: User Opinion Survey, 2011

Note: Figures presented in the table are frequencies of responses

Table-13 shows that safety issue associated with battery operated auto-rickshaw has a performance index value of 0.41. This indicates that the mode cannot ensure safety to its users at all. In addition, travel comfort offered by the mode is hardly satisfactory. However, fare rate is satisfactory even to the non-users of the mode. Now, performance index of battery operated auto-rickshaws calculated from total respondent's opinion is presented in Table-14.

Table-14: Performance index of battery operated auto-rickshaws according to the opinions of total respondents

Attributes	Scales						Performance Index
	0	1	2	3	4	5	
Fare Rate	0	0	3	34	134	213	4.45
Travel Time	0	3	40	137	180	24	3.47
Travel Comfort	6	18	43	21	140	156	3.92
Safety	37	43	113	94	79	18	2.49
Travel Speed	0	12	52	159	140	21	3.28
Crowd	0	9	40	228	107	0	3.13
Operator's Behavior	0	3	82	238	61	0	2.93
Quality of Service	0	0	30	140	177	37	3.58

Source: User Opinion Survey, 2011

Note: Figures presented in the table are frequencies of responses

Table-14 presents that battery operated auto-rickshaws with nearly excellent fare structures involves highly satisfactory travel comfort, travel time, and overall quality of service. Crowd and travel speed that the mode associates with are satisfactory as well. However, operator's behavior, and safety associated with the mode are not satisfactory to urban passengers.

V. CONCLUSION

Battery operated auto-rickshaw with average trip length of 3.29 km compatible to urban passenger's average travel distance of 1.31 km, have become popular mode of travel to them. Around 88% of urban passengers are availing this mode now to meet their travel demand. The mode attracts urban passengers mostly from rickshaw and also considerably from nosimon, auto-tempo and minibus through offering a set of benefits over those modes, such as, lower travel cost than rickshaw, greater comfort than minibus, nosimon or auto-tempo, limited but acceptable travel speed and satisfactory quality of service.

Battery operated auto-rickshaws are mostly used as primary mode in urban areas since people living in local towns tend to generate short trips frequently, which can be better served by this mode. However, the mode involves lack of travel safety as operators/drivers of the mode are not well trained, the mode is light weighted and it plies on heavy traffic carrying urban road frequently, which increase its vulnerability to traffic accident.

VI. RECOMMENDATIONS TO IMPROVE SERVICES OFFERED BY BATTERY OPERATED AUTO-RICKSHAWS

Route Fixation:

The indiscriminate plying of the mode on national or regional highways which carry heavy traffics should be controlled by direct intervention of town's authority. This might minimize the mode's chance of getting engaged to traffic accidents.

Driving License:

Mostly the operators of battery operated auto-rickshaws are unknown of traffic rules. This issue has increased the mode's vulnerability to traffic accidents at great extent. Therefore, operators should be required with driving license to ensure all of them are well trained. They should be provided with training on town authority's own accord in this regard as most of them are from poor section of the town and hence reluctant to spend money on training or driving license purposes.

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