

The Role of Battery Operated Auto-Rickshaw in the Transportation System of a City

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Abstract

The paper contains primary data based analysis on the role played by Battery Operated Auto-rickshaws in urban transportation system. Different aspects of battery operated auto-rickshaw, such as energy consumption rate, transport related emission attenuation rate, potentials of generating income and employment, trip characteristics, 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. Battery operated auto-rickshaw offers lower travel cost than rickshaw, greater travel comfort than other urban para-transits like auto tempo, nosimon and public transport like minibus, and therefore attracts passengers significantly from those modes. Around 88 % of people living in a city where battery operated auto-rickshaws are available, avail the mode now to meet their travel demand. Through attracting passengers from fuel operated vehicles, the mode has replaced them at great extent. A considerable percentage of daily electricity demand of local towns is being consumed by this mode which is creating pressure on local electricity supply in turn. However, considering the duration and period of load shedding caused due to recharging this mode, energy consumption by the mode can be negotiated as it is liable for only 1.53 hours of load shedding a day which takes place at off-peak period at night. The mode is economically beneficial in case of investment too as it involves an income-cost ratio of 1.85. From operator's point of view, driving of the mode as an occupation involves lower investment cost, greater earning, more comfort and occupational freedom than other occupations available in local towns for low income people.

Keywords

battery operated auto-rickshaw, energy consumption, employment generation, depressurization of migration, performance index

1. INTRODUCTION

Battery operated autorickshaw (locally called 'Easy-bike') is a newly added para-transit mode in urban transportation system of Bangladesh. From the very beginning of introducing, the mode has become a popular transport mode especially to the lower, lower-middle and even middle income people living in urban areas since the mode involves lower travel cost than other locally available transport modes as well as provides reasonable safety and comfort to the users during travel [The Daily Star, 2011].

The mode with limited speed and lightweight cannot produce fatal accidents [Mohan, 2007]. Battery-operated auto-rickshaw is faster than traditional cycle-rickshaw. In addition, a single mode can carry three to six passengers and thus can replace three rickshaws at the same time, which points to its potentials to resolve rickshaw-related traffic jams [The Daily Star, 2011]. Operators of the mode generally come from the poor

section of a city as it requires lower initial investment to own a battery operated auto-rickshaw privately [Dhakal, 2005]. The cost of a battery operated auto-rickshaw ranges from BDT 100,000 to 120,000 and one may get his money back in seven months [The Daily Star, 2011].

Typically in an urban area motor vehicle emission can make up over 70 percent of the total emissions of air pollutants [Bull and Zimmann, 2000]. Diesel and petroleum operated vehicles such as auto tempo could be substituted by plug-in hybrid electric vehicles (PHEV) which would result considerable reduction in emission [Mader, 2006].

However, Government of Bangladesh claims that battery operated auto-rickshaw consumes at least 300 megawatts of electricity every day due to recharge their batteries [The Daily Star, 2011]. In order to save the inadequate electricity supply in Bangladesh, government has recently taken decision to ban this mode from urban roads without carrying out any research on the fact [The New Age, 2011]. Before taking any decision regarding a crucial issue like battery operated auto-rickshaw, government should have carried out research on the mode's contribution in urban eco-

conomic development as well as transportation system of local urban areas where this mode has attained vast popularity now-a-days. In addition, whether the mode is a major threat to local or national electricity supply should have been explored.

From this perspective, the study has been undertaken to find out and analyze all possible aspects i.e. costs and benefits associated with the mode, which might help policy makers of a developing country like Bangladesh to take up decision whether and how to incorporate this type of energy consumptive mode in the local transportation system of urban areas.

2. OBJECTIVES OF THE STUDY

The aim of the research is to explore all possible aspects associated with battery operated auto-rickshaws in the context of local urban areas of Bangladesh. To satisfy the aim, three objectives are identified to carry out the research.

- To determine energy consumption rate of battery operated auto-rickshaws.
- To explore the role of battery-operated auto-rickshaws in urban income and employment generation.
- To determine the role of battery operated auto-rickshaws in urban transportation system.

3. METHODOLOGY OF THE STUDY

Methodology of the study is described briefly in this segment.

3.1 Study area selection

To carry out the research, two study areas are selected on the basis of two major criteria as following.

- Number of battery operated auto-rickshaws currently running within the urban area/town.
- Proximity of the urban 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. Among them, two are selected as study areas based upon the criteria mentioned above. Number of battery operated auto-rickshaws running within the town and physical distances (km) of those towns from Dhaka are presented in Table 1.

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 Data collection

Data required to fulfil the first objective are collected

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

Name of the town	Number of battery operated auto-rickshaws running within the town*	Distance of the town from Dhaka (km)**
Comilla	8,687	97
Kushtia	2,521	277
Jessore	1,800	274
Faridpur	1,200	145
Meherpur	1,250	286

Source: * Easy-bike Owner's Association, Kushtia & Faridpur, 2011; District Traffic Police, Comilla, 2011 & The Daily Prothom Alo, 2011

** Discovery Bangladesh, 2011

inclusively from user opinion survey, field survey and secondary sources. In addition, data regarding the physical and operational characteristics of battery operated auto-rickshaws are collected from the interview with owners of several battery operated auto-rickshaw recharging centers located both in Kushtia and Comilla town. Operator opinion and user opinion surveys are conducted extensively to collect data on selected variables to meet the second objective and third objective respectively. The sample size for both operator opinion and user opinion surveys are calculated adopting stratified sampling method at 95 percent confidence level and confidence interval of 5.

4. LITERATURE REVIEW

Momotaz (2009) showed fuel consumption rates of different vehicles available in local urban towns of Bangladesh as presented in Table 2.

Emission generation rates of these fuel operated vehicles in local urban areas of Bangladesh are shown in Table 3.

Hasan (2008) used the following formulae to calculate

Table 2 Fuel consumption rates of different vehicles in Bangladesh

Mode	Fuel type	Fuel consumption (liter/veh/km)
Human-hauler*	Diesel	0.1125
Auto-tempo	Gasoline/Diesel	0.04
Minibus	Diesel	0.52-0.87

Source: Momotaz, 2009

* Fuel consumption rate of nosimon (a local motorized and three-wheeled para-transit mode in Bangladesh) is assumed equal to human-hauler.

Table 3 Emission generation rates of different fuel operated vehicles in Bangladesh

Mode	Fuel type	CO (gm/veh/km)	NO _x (gm/veh/km)	SO _x (gm/veh/km)	HC (gm/veh/km)	SPM (gm/veh/km)
Human- hauler	Diesel	25.0	1.5	0.4	4.0	1.6
Auto- tempo	Gasoline	39.4	1.6	0.5	4.0	1.0
Minibus	Diesel	20.0	17.0	2.0	4.0	1.6

Source: [Momotaz, 2009] & [Hasan, 2008]

CO: Carbon Monoxide; NO_x: Oxides of Nitrogen; SO_x: Oxides of Sulpher; HC: Hydro Carbons; SPM: Suspended Particulate Matters.

the daily emission generation rate of a fuel operated vehicle: Daily Emission (ton/day) = [(Number of vehicles)*(daily length of operation of vehicle in km/day)* (emission generation rate of the vehicle in gm/veh/km)] / (1000)².

Occupancy rate of different types of vehicle available in local urban areas of Bangladesh are calculated in Upazilla Town Infrastructure Development Project (UTIDP) (2009) conducted by Local Government Engineering department (LGED) as presented in Table 4.

Table 4 Occupancy rate of different types of vehicles in urban areas of Bangladesh

Mode	Occupancy Rate
Human-hauler	8
Auto-tempos	8
Minibus	32

Source: UTIDP, 2009

As calculated from power generation data presented in Daily Electricity Generation Reports (2011) of Bangladesh Power Development Board (BPDB), 0.069 gallon diesel or furnace oil is required to produce 1 Kilowatt (KW) of electricity at 25 to 30 percent efficiency of plant.

Das (1998) tried to find operators' benefit and benefit-cost ratio associated with premium bus service in Dhaka City to assess its economic performance. The same procedure is adopted in this study to analyze the economic impacts of battery operated auto-rickshaws in urban Bangladesh.

Das (1998) used 'waiting time', 'travel time', 'travel speed', 'load factor', 'travel comfort', 'fare rate', 'cleanliness', 'crowd', 'safety', 'regularity of service' and 'crew behaviour' as several attributes to evaluate the performance of premium bus service in Dhaka City. Some of these factors that affect people's mode choice behaviour for para-transit modes have been used in the study to find out the role of battery operated auto-rickshaws in the transportation system of local towns of Bangladesh.

Chowdhury (1988) found that transportation system

in local urban areas of Bangladesh involves different types of public transport modes namely bus, minibus, CNG-autorickshaw, rickshaw and autotempu. Among all these modes, rickshaw is characterized by the slowest flow characteristics. As a service provider mode, rickshaw is much expensive mode of transport especially for the lower and lower-middle urban passengers because of its undefined and uncontrolled fare system. Also the presence of non-motorized vehicles especially rickshaw in the traffic stream affects vehicular performance and reduces the actual capacities of highway facilities. Rahman et al. (2003) studied that if the proportion of rickshaw in the mixed traffic stream is more than 50 % at signalized urban intersection, discharge rate of traffic reduces drastically as the proportion of rickshaws increases. CNG- autorickshaws are characterized by greater mobility than rickshaw, while these modes are very expensive and also considerably responsible for degrading urban environment through pollution. Minibus and bus are the popular mode of public transportation with least unit fare and these types of modes are highly appreciated for carrying passengers in the densely populated urban areas.

Rickshaw, on an average carries two passengers while at the same time a single battery operated auto-rickshaw can serve the transport demand of two or three times more passengers charging less fare compared to the manually-operated rickshaws [The Daily Star, 2011]. In maximum, a single battery operated auto-rickshaw can carry eight persons in a single trip where this figure is just four in case of rickshaw [The Daily Star, 2011].

Traffic of almost all the cities of Bangladesh involves a considerable percentage of rickshaw. However, Chowdhury (1988) stated that due to inferior flow characteristics within the traffic stream, rickshaw now has been identified as one of the major sources of traffic congestion in urban areas of Bangladesh.

According to Chowdhury (1988), the transport pattern of a city differs from country to country depending on its socio-economic conditions, technological advancements and local factors. The developed nations with higher economic prosperity and financial capability, and modern technological advancements have

invested heavily in more efficient transport system. Most of the cities in Bangladesh are characterized by higher population density. Majority of the city dwellers in a city are lower and lower-middle class people. This major portion of the city people demands low cost public transport which can be served by bus and minibus efficiently. However, Paulley (2004) found that bus and minibus both involve some crucial disadvantages like frequent stopping which may be required urgently in the densely populated city areas and this reduces their transport efficiency as well as increases energy consumption rate. These modes are also responsible for environment pollution. Moreover, they require huge parking areas at the destination and origin.

Mahmood (2011) found from his study that Bangladesh could save between \$200 million and \$800 million per year, about 0.7 to 3.0 % of its gross national product, if air pollution in the country’s four major cities was reduced. Around 6.5 million people in those cities suffer from air pollution related diseases each year. Vehicular air pollution is a major cause of respiratory distress in urban Bangladesh. Nearly seven million people in Bangladesh suffer from asthma, more than half of them are children. About 9 deaths in every 10 due to air pollution take place in the developing world, where about 80% of world populations live.

However, battery operated auto-rickshaws do not cause any air pollution. Mader (2006) examined that substituting the diesel and petroleum operated vehicles by plug-in hybrid electric vehicle (PHEV) results 35-50 % reduction in nitric oxide and reactive organic gases, 45-65 % reduction in petroleum usage and 30-45 % reduction in greenhouse gases in city areas. Dhakal (2005) mentioned in his study-“Role of Government, Private Sector and Civic Society in Promoting Battery Operated Electric Three-Wheelers In Kathmandu, Nepal” that just because the battery operated auto-rickshaw generates least pollution, diesel-operated three-wheelers (the so-called “tempo”) has

recently been relocated by the Government of Nepal out of the Kathmandu valley to encourage the use of battery-operated auto-rickshaws to curb air pollution.

5. RESULTS AND DISCUSSION

Results obtained from the analysis of data collected to meet the objectives are discussed in following sections.

5.1 Energy consumption by battery operated auto-rickshaws

Amount of electricity required to recharge a battery operated auto-rickshaw for a single time is on average 7.5 kilowatt as found from the study. Accordingly, total 2521 battery operated auto-rickshaws in Kush-tia Town consume around 5.9 percent (that is 18.9 Megawatt) of the total daily demand of electricity of that town every day to be recharged. In transposition, demand for electricity per day to recharge the mode in Comilla Town is 17.14 percent of the town’s total daily demand. Study shows that in 2011, total 11208 battery operated auto-rickshaws running within study areas altogether consume around 82.90 Megawatt of electricity per day due to be recharged.

In turn, the mode attracts passengers at considerable extent from other fuel operated vehicles as shown in Figure 1.

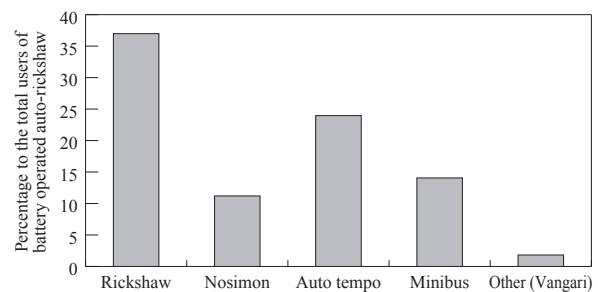


Fig. 1 Percentage of passengers attracted to battery operated auto-rickshaws from fuel operated vehicles

Table 5 Characteristics of trips made by fuel operated vehicles in study areas

Mode	Study area	Route distance (Avg.) in km	Trip frequency per day (Avg.)	Extent of distance to serve study area (Avg.) in km
Auto- tempo	Kushtia	11.75	6	10.00
	Comilla	5.64	12	4.07
Nosimon	Kushtia	4.67	8	4.67
	Comilla	0.00	0	0.00
Minibus	Kushtia	37.70	5	7.10
	Comilla	30.34	5	2.17

Source: Field Survey, 2011

Several characteristics of fuel operated vehicles e.g. average travel distance, number of trips made and the extent of distance to serve the study areas as collected from field survey are presented in Table 5.

Now, number of these fuel operated vehicles replaced by battery operated auto-rickshaws in 2011 is calculated adopting the procedure presented in Figure 2.

Study shows that battery operated auto-rickshaws replace the daily demand of 94 nosimons, 147 auto-tempos and 86 minibuses in 2011 in Kushtia Municipal Town and Comilla City Corporation area through attracting passengers from these modes. Thus, the mode saves consumption of around 3161.99 gallons of diesel and 106.08 gallons of gasoline per day in study areas in the year of 2011. The amount of diesel and gasoline fuel saved by the mode could produce daily 47.36 Megawatts of electricity at 25 to 30 % efficiency of plant. That means the mode consumes around 0.75 times greater amount of energy than the amount it saves. This indicates that fuel operated vehicles could serve urban passenger's travel demand in energy efficient way in local urban areas of Bangladesh if battery operated auto-rickshaws would not be introduced.

However, considering the duration and period of consumption, energy consumed by the mode could be made off-set. Data collected from Daily Reports (2011) on demand and supply of electricity from Power Grid Company of Bangladesh Limited, Bottail 132/33 KV Grid Substation, Kushtia, reveals that during summer season electricity demand rate is 14 MWH at off-peak period in the town. This indicates that during that season, deficit of 14 MW of electricity results load shedding of 1 hour at off-peak period. In transposition, load shedding for 1 hour takes place at off-peak period during winter season when there is deficit of 11 MW of electricity. If battery operated auto-rickshaw

could be banned from the town, 18.9 MW of electricity would be saved per day at night. That means, banning of the mode would reduce load shedding for 1.35 hours at night during summer and 1.72 hours during winter season. This points to that the mode is liable for only 1.53 hour of load shedding on average at off peak period of night (Note: The mode is recharged between 11:00 PM and 7:00 AM in local urban areas of Bangladesh as found from the study). It is worth mentioning that Kushtia town suffers from load shedding of 12.43 hours a day during summer and 8.54 hours a day during winter as reported in Daily Reports (2011). On average, the duration of load shedding in Kushtia Town is 10.48 hours a day as found from study. Data collected from Kushtia Municipal Office and Office of Generation, Power Grid Substation, Bottail, Kushtia reveals that there is no irrigation pump within the municipal area which generally gets priority for electricity supply during night in rural areas. That means, almost all amount of electricity demanded during off-peak period at night is for household consumption in the town. Therefore, load shedding of 1.53 hour during off-peak period at night occurred due to recharging battery operated auto-rickshaws can be compensated substantially by other benefits the mode involves.

In addition, battery operated auto-rickshaw plays significant role in attenuating urban transport related emissions through replacing fuel operated vehicles. The mode attenuates emission of 2505.0750 tons of Carbon Monoxide (CO), 773.2018 tons of Oxides of Nitrogen (NO_x), 273.5346 tons of Oxides of Sulphur (SO_x), 90.3335 tons of Hydro-carbon (HC) and 12.0560 tons of Suspended Particulate Matter (SPM) in 2011 in study areas. This aspect provides logical reasons to adopt the mode in the transportation system of rapidly flourishing local urban areas of Bangladesh in order to ensure environmentally sustainable growth

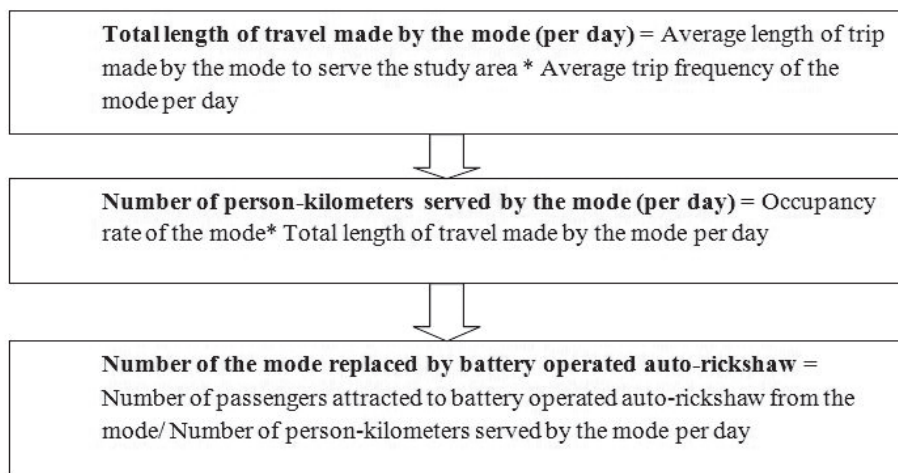


Fig. 2 Procedure of calculating number of vehicles replaced by battery operated auto-rickshaws

in there.

5.2 Role of battery operated auto-rickshaws in urban income and employment generation

Study shows that average purchasing cost of a single battery operated auto-rickshaw is BDT 114,447.39 in base year (i.e. 2011). In addition, average daily operating cost and monthly maintenance cost for the mode are BDT 58.03 and BDT 1261.63 respectively while the average daily income from the mode is BDT 532.32. Using these data, income-cost ratio for a single battery operated auto-rickshaw is calculated 1.85. The income-cost ratio indicates that as an occupation, purchasing and driving of the mode is highly economically beneficial. This high economic profitability associated with the mode gives logical reasoning for rapid growth of it in local urban areas of Bangladesh. Table 6 shows the number of battery operated auto-rickshaws in Kushtia and Comilla towns in different years starting from 2008.

Table 6 Number of battery operated auto-rickshaws in study areas in different years

Year	2008	2009	2010	2011
Kushtia	730	1,150	2,068	2,521
Comilla	3,045	4,332	7,158	8,687
Total	3,815	5,482	9,226	11,208

Source: Easy-bike Owner’s Association, Kushtia, 2011; District Traffic Police, Comilla, 2011 & The Daily Prothom Alo, 2011

As calculated from this data, the mode has grown at 43 percent average growth rate per annum between 2008 and 2011.

On average, income of individual operators from their previous occupations was BDT 251.75 per day. On the contrary, the current average income of individual operator earned from the driving of battery operated auto-rickshaw is BDT 532.32 per day. This indicates that as an occupation, driving of the mode increases individual operator’s income by BDT 280.61 in local cities of Bangladesh. Through this average net increase in individual operator’s income, 11,208 battery operated auto-rickshaws add BDT 113,22,27,677.00 increased income in the economy of study areas as a whole in 2011.

Previous occupations of operators as found from the study are presented in Figure 3.

Study shows that around 21.35 percent of the operators were unemployed before choosing the current occupation. All of the operators who were unemployed previously are aged between 15 to 29 years. Most of them are students who choose this occupation to earn

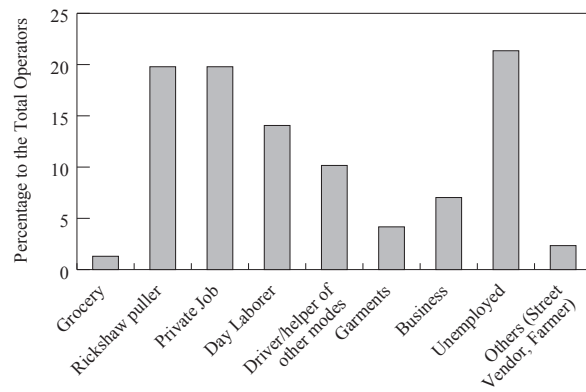


Fig. 3 Previous occupations of operators

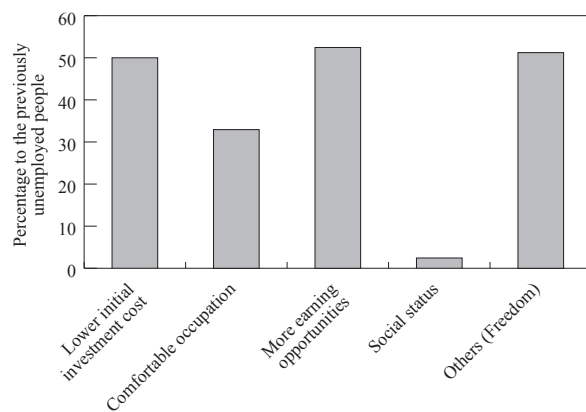


Fig. 4 Reasons for choosing battery operated auto-rickshaw driving as an occupation

a handsome income besides continuing their study. Figure 4 shows reasons for choosing battery operated auto-rickshaw as a medium of income by those who were unemployed previously.

More than 50 percent of operators who were unemployed before choose the occupation inclusively for more earning opportunities, occupational freedom and lower investment cost associated with it.

In contrast, around 38 percent of total operators were intended to migrate if the mode would not have been introduced in their towns. Furthermore, around 4 percent of operators were involved in garments work mostly in Dhaka who return back to their own town later on and avail the occupation as this occupation offers some clear benefits over their previous one. Therefore, it can be concluded that the occupation has much potentials to depressurize the migration as well. Driving of battery operated auto-rickshaw as an occupation offers some benefits over others, which instigate operators to avail the occupation leaving their previous one. As presented in Figure 5, major reason for changing occupation into the mode driving is greater earning opportunities the occupation involves than all others available within local town for them.

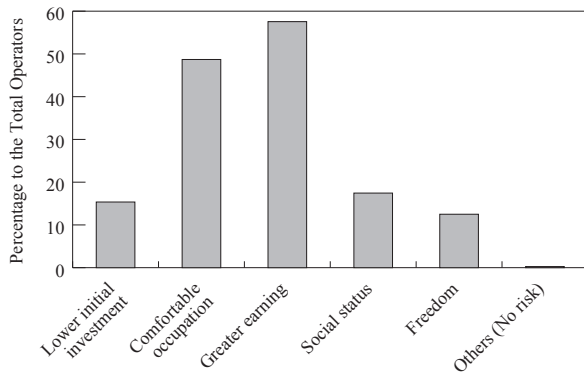


Fig. 5 Reasons for changing occupation into battery operated auto-rickshaw driving

Inclusively, the occupation involves greater comfort which comes out as the second major reason behind availing the current occupation.

Now, study regarding previous occupation-wise factors responsible to instigate operators to change their occupation into the current reveals that battery operated auto-rickshaw driving involves greater earning opportunities and more comfort than all other occupations operators had previously as illustrated in Figure 6.

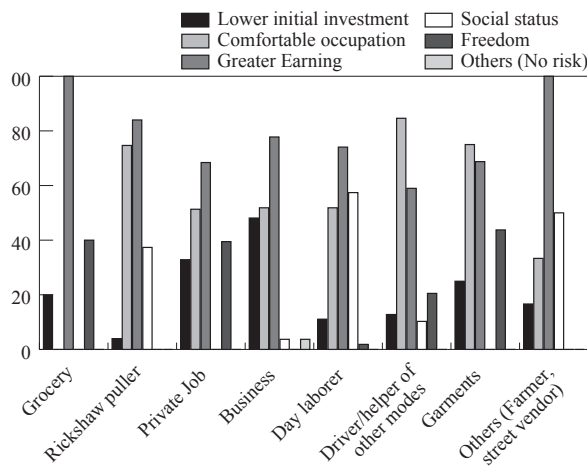


Fig. 6 Occupation wise factors responsible for changing occupation

More specifically, this occupation is better than grocery mainly in terms of earning opportunities and occupational freedom. It is beneficial over rickshaw pulling, day labour and ‘others’ in terms of earning opportunities, comfort in occupation and social status. The occupation involves greater earning, comfort and lower investment cost than business. Battery operated auto-rickshaw driving is beneficial over private job, driving/helping to other modes and garment’s work in terms of earning opportunities, comfort and occupational freedom.

5.3 Role of battery operated auto-rickshaw in urban transportation system

Around 85 percent of battery operated auto-rickshaws running within local towns of Bangladesh generate short trips of average 3.29 km length per trip as found from the study. The mode can make on average 16 trips per day of that length.

The average income generated by the mode is BDT 532.32 per day and BDT 33.27 per trip. As calculated from the income data, the mode requires average BDT 2.53 as fare per head at per kilometer operation. However, in real, the fare rate is found fluctuating between BDT 2.5 and BDT 5 per head at per kilometer of service.

Study shows that around 88 percent of people living in a city where battery operated auto-rickshaws are available, avail the mode to meet their travel demand. Users of the mode are mostly students and low income people. Generally the people with higher educational qualification and high income do not go for the mode as most of them have access to private transports.

Reasons for availing the mode are illustrated in Figure 7, which shows that around 94 percent of users of battery operated auto-rickshaw avail the mode as it involves lower travel cost than other locally available transport modes.

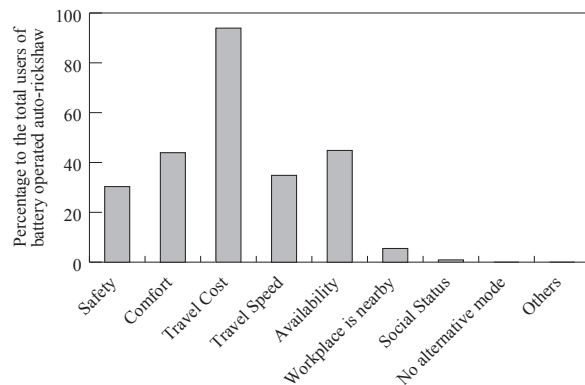


Fig. 7 Reasons for availing battery operated auto-rickshaws

In addition, large scale availability of the mode plays important role to attract passengers. Those who are regular user of other transport modes like auto-tempo, minibus etc. can make instant decision to take up battery operated auto-rickshaw because of its instant availability, when their intended modes cause them to wait. The mode involves greater travel comfort than auto tempo, minibus and nosimon which is another important reason to attract them.

Because of limited speed and light weight, battery operated auto-rickshaw does not create any fatal accidents as users opined. Due to this safety issue, a

considerable percentage of users choose the mode as found from the study.

However, driver’s lack of training, light weight of the mode and indiscriminate plying on heavy traffic carrying urban roads make the mode vulnerable to small scaled traffic accidents. Around 91% of people, who do not use battery operated auto-rickshaw, accuse this lack of safety issues for not using the mode as illustrated in Figure 8.

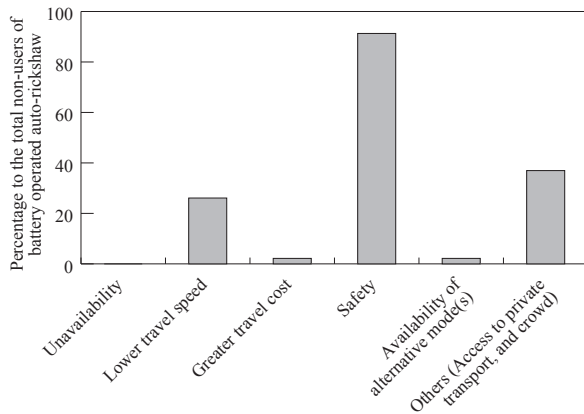


Fig. 8 Reasons for not-using battery operated auto-rickshaws

In addition, considerable percentages of non-users do not go for the mode since they have access to private transport like bi-cycle, motor-cycle, car etc, and/or for the crowding passengers associated with battery operated auto-rickshaw.

Around 86 percent of the users avail battery operated auto-rickshaw as primary mode. The mode makes trip of 3.29 km length on average aforementioned while users of the mode in towns demand travel for 1.31 km as found from study. This indicates that the mode can serve user’s travel demand as primary mode substantially. As primary mode, battery operated auto-rickshaw replaces mostly rickshaw as well as auto tempo and minibus at considerable extent.

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 the advent of battery operated auto-rickshaw in their town. Accordingly, 40 % of the users shift from auto-tempo, 28 % from nosimon and 24 % from minibus in inclusive manner as illustrated in Figure 9.

Figure 9 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 play vital role to at-

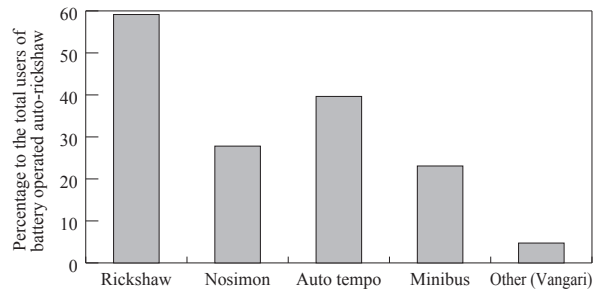


Fig. 9 User’s previous mode choice

tract passengers from the traditional cycle-rickshaw. Most of the passengers who availed auto-tempo, minibus and nosimon previously, changed their mode choice to battery operated auto-rickshaw for the sake of comfort in travel.

However, the mode involves several problems as found from the study. Figure 10 presents those problems associated with the mode from users’ point of view.

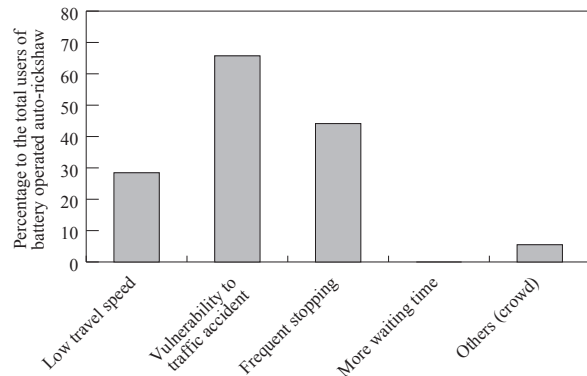


Fig. 10 Problems associated with battery operated auto-rickshaws

Users identify vulnerability of the mode to traffic accidents, and frequent stopping of the mode for haphazard loading-unloading of passengers as two major problems that battery operated auto-rickshaw involves.

Calculation of Performance Index of battery operated auto-rickshaws on its different attributes indicates that the fare rate of the mode holding an index value of 4.45 (in 0-5 scale, where 0 indicates the worst and 5 represents the excellent performance) is nearly excellent to its users. Performance index of the mode according to the respondent’s opinion are presented in Table 7.

Travel comfort, travel time, travel speed and crowding condition associated with the mode are satisfactory too as found from the study. However, regarding safety, users are not satisfied as the mode fails to ensure safety to passengers during travel.

Table 7 Performance index of battery operated auto-rickshaw based on opinions of 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 behaviour	0	3	82	238	61	0	2.93

Source: User Opinion Survey, 2011

Note: Figures presented in the table are frequencies of responses

6. CONCLUSION

Battery operated auto-rickshaw involves lower travel cost, greater comfort, and reasonable travel speed which make it popular transport mode to urban passengers. Driving of the mode as an occupation is a popular choice to urban low income people as well since the mode requires lower investment cost, generates greater income and involves more comfort and freedom than other occupations available for them in local towns. Therefore, local urban areas of Bangladesh have experienced rapid growth of the mode in recent years.

The increased number of battery operated auto-rickshaws creates pressure on the local electricity supply of urban areas as the mode consumes a considerable percentage of the daily demand of electricity of those towns. However, considering the duration and period of load shedding caused in urban areas due to the recharging of the mode, energy consumption by the mode can be made off-set. Moreover, battery operated auto-rickshaw plays significant role in attenuating urban transport related emission through replacing fuel operated vehicles, which could be seen as an advantage from environmental point of view.

From economic point of view, the mode increases daily income of operators and hence annual income of the city significantly. It also generates employment opportunities for low income people in local towns and reduces migration at considerable extent.

In addition to these, majority of urban passengers use the mode to meet their travel demand now for some specific benefits that the mode offers over other vehicles. Simultaneously, a large portion of urban poor people's livelihood is now associated with the mode. Therefore, banning of the mode might affect their living as well as bring negative impact in urban transportation system especially regarding passenger's modal

choice. Rather, addressing and repelling problems associated with the mode would be more knowledgeable.

7. RECOMMENDATIONS REGARDING BATTERY OPERATED AUTO-RICKSHAWS

- The rapid growth of battery operated auto-rickshaw should be controlled in urban areas to minimize energy consumption. The number of mode should be allowed within a town according to its energy provision capacity.
- The design of the mode could be altered with a view to minimizing energy consumption. Battery could be replaced by renewable energy capacitor such as solar panel. City authority should offer discount to operators of the mode in this regard as investment cost for this type of energy source is too high to be affordable to the low income operators.
- The mode should be controlled on national or regional highway which carries heavy traffics, to minimize the vulnerability of the mode to traffic accidents.
- Mostly the operators are unknown of traffic rules. This issue increases the mode's vulnerability to traffic accidents at great extent. Therefore, operators of the mode should be provided with training from city authority's own accord as most of them are from poor section of the city and hence reluctant to spend money on training or driving license purposes.

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