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Assessment of Socio-economic and Environmental Aspects of E-rickshaws on Urban Scenario: Case of Butwal, Nepal

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Abstract
When compared to auto rickshaws and human-pulled rickshaws, E-rickshaws are a better option due to less human effort and lower fuel costs. E-rickshaws emit far less pollution and provide last-mile connectivity, which means they give door-to-door service. It is a popular means of transportation in Nepal since it is both comfortable and cost-effective. E-rickshaws, one of these para-transit modes, have grown in popularity among urban people in developing countries as a quick and economical method of transportation. The case area Butwal has seen a rapid development of the E-rickshaw service in a relatively short period. Apart from mainstream public transportation, para-transit today plays an important role in the movement of people and products in cities all over the world. Electric rickshaws have both positive and negative consequences. The rapid rise of e-rickshaws has become a burden on the current transportation sphere due to unplanned development, unregulated population development, and a shortage of road space. Even though it is an environmentally beneficial, noiseless, and sustainable method of transportation, it contributes to the town's growing traffic congestion problem.
The main objective of this study was to examine the socio-economic and environmental aspects of E-rickshaws in an urban setting. The research paradigm was Post - Positivism, and Constructivism and mixed methodology (Qualitative and Quantitative Research methodology) was used. Questionnaire survey of e-rickshaw driver and passengers was conducted and results were analyzed using SPSS. From the results it was concluded that e-rickshaw is socially sustainable but for achieving economic sustainability there are few areas of improvements. Environmentally it is sustainable means of transportation which requires some strict regulations in battery disposal and safe recycling of batteries and spare parts. Based on the conclusions recommendations were made.

Keywords
Sustainable transportation, E-vehicles, E-rickshaws, Para-transit System, Butwal, Socio-economic aspects, Environmental aspects

1. Introduction

An electric vehicle is one that is propelled by one or more electric motors or traction motors (EV). An electric vehicle can be self-contained by converting gasoline to energy using a battery, solar panels, fuel cells, or an electric generator, or it can be powered by electricity from off-vehicle sources through a collector system. Electric vehicles (EVs) are energy efficient and frequently advertised as a zero-emission mode of transportation to aid in the transportation sector's long-term de-carbonization goals [1].

Rickshaws, which are small three-wheeled vehicles that are the most common para-transit mode of passenger transportation in developing countries, may be seen on nearly every city street. Liquid petroleum gas (LPG) or diesel-fueled auto-rickshaws, mechanized van-rickshaws, battery-operated electric rickshaws or e-rickshaws, van-rickshaws, and cycle-rickshaws are all part of the public transportation industry. E-rickshaws are also commended for their environmental friendliness and ability to reduce carbon emissions [2].

When India placed a trade ban on Nepal in 2015, effectively blocking gasoline supply, traffic in all major cities throughout the country came to a halt. Motor cars were removed from the roads, forcing people to walk on foot. However, thanks to

e-rickshaws, a few places were unaffected by the gasoline scarcity. Since then, the use of electric three-wheelers has increased dramatically. E-rickshaws have emerged as a viable option for low-income people who are particularly affected by a shortage of transportation. Furthermore, promoting e-rickshaws, particularly in the terai region where they can run smoothly and create little pollution, can help Nepal lessen its growing reliance on imported petroleum goods[3].

In Butwal, E-rickshaws provide services similar to that of shared taxis. They don't follow any specific route. They provide door-to-door personalized service and the cost varies from 25 to 50 depending on the travel distance. Because of their accessibility and low cost they have gained huge popularity in Butwal in the last few years.

2. Research Objectives

2.1 General Objective

The main objective of this study is the assessment of socio-economic and environmental aspects of E-rickshaws in Butwal.

2.2 Specific Objectives

The specific objectives of this study are listed below:

- Assessment of socio-economic aspects of e-rickshaws
- Assessment of environmental impacts of e-rickshaws
- Review of policies formulated for the regulation of e-rickshaws

3. Goals

The main goals of this study are listed below:

- The study will generate results that will be relevant to Academicians, Transportation Infrastructure planners, and policymakers.
- The result will show the positive and negative impact (pros & cons) of e-rickshaws in urban scenarios.
- Based on results, recommendations can be made for proper regulations of e-rickshaws.

4. Literature Review

4.1 History of E-vehicles

The design and construction of electric-powered vehicles are not a new concept. During the early 1970s, unilateral control of oil production and price set up by OPEC (Organization of the Petroleum Exporting Countries) led to the energy crisis which resulted in active research and development in EVs. Electric Vehicles were the top choice of automobile industries among all the non-gasoline-powered vehicles. Then the second wave of the strong interest in producing EVs occurred during the late 1980s due to the worsened air quality in major cities [4].

4.2 Types of E-vehicles

Internal combustion engines (ICEs) in conventional cars (CVs) burn petroleum, are inefficient, and release a considerable quantity of greenhouse gases. Vehicles designed to run on at least one alternative to petroleum and diesel, such as electric vehicles, biofuel vehicles, fuel cell vehicles, compressed natural gas vehicles, and so on, are known as Alternative Fuel Vehicles (AFVs). EVs, or electric drive vehicles, are cars that rely on electricity for part or all of their propulsion. EVs come in several varieties [1].

Table 1: Classification of EVs

Vehicle Type	Description	Benefits
HEV	Electric vehicles that use an internal combustion engine in addition to an electric motor.	Better fuel economy, less expensive to run and lower emissions than similar conventional vehicles
PHEV	Electric vehicles with smaller internal combustion engine and more powerful electric batteries that can be recharged.	Better fuel economy, less expensive to run and lower emissions than similar HEVs and conventional vehicles. Offers flexibility of fuel source
BEV	Electric vehicles that derive motive power exclusively from onboard electrical battery packs that can be charged with a plug through an electric outlet.	No liquid fuels and zero emissions at tailpipe. Less expensive to run than similar HEVs and conventional vehicles.

4.3 Contribution of EVs for Sustainable Development

Sustainable development policies have identified the importance of preserving the environment and avoiding activities that affect the environment. One of these sustainable development policies is the reduction of carbon emission from vehicles operating on fossil fuel by adopting the less polluting and more efficient alternative mode of transportation [5].

Carbon is one of the most polluting agents in the ecosystem and one of the major reasons responsible for it is the dependency of humans on carbon-emitting

fossil fuel-based vehicles for so long. Electric vehicles are now adopted all over the world with the target of reducing carbon emission and pollution. However, in developing countries replacing motor vehicles with E-vehicles is perceived as a huge challenge because of its high initial investment cost. The process of replacing fuel-based vehicles with electric vehicles has been in motion for many years. In the public transportation sector, replacing auto-rickshaws and other fuel-based vehicles with e-rickshaws is studied in many Asian countries. Studies have shown that e-rickshaws are more energy-efficient than other motorized public road transport vehicles and it has the potential to address the environmental pollution issues but the improper implementation of e-rickshaws is a major drawback [2].

4.4 Paratransit

Paratransit is a type of demand-responsive and flexible transportation service that has different definitions in developed and developing countries. Paratransit is characterized as the whole range of demand-responsive services in developed countries, including subsidized, general public dial-a-ride, and human service transportation. Paratransit refers to demand-responsive systems such as shared-ride taxis, dial-a-ride, and subscription buses. These privately run, small-scale services are referred to as ”low-cost transportation,” ”intermediate technologies,” and ”third world transportation” in developing countries, among other terms. A service that isn't quite full-fledged public transportation, but uses smaller cars, and can be lawful or illegal depending on local rules and regulations. Paratransit options play a vital role in developing countries' urban transportation sectors by offering transportation services to a large number of people. Paratransit modes are frequently regarded as an important component of urban transportation in developing countries cities due to distinguishing characteristics such as low carrying capacity, low speed, low energy requirements, higher labor intensity, greater dependability, and a small area of coverage [6].

4.5 Environmental Consequences of E-Rickshaw

E-rickshaws, which run entirely on electricity, are widely regarded as one of the cleanest modes of transportation available today, and they are successfully addressing the issue of 'last-minute connection.' They run on either a lead-acid or a lithium-ion battery. Because lead is a highly toxic metal that, if left unchecked, can be harmful to organic life, it is critical to ensure proper collection and eco-friendly recycling when a lead battery becomes inoperative. Smelting is the process of recycling spent lead so that it can be utilized in a new battery. Many local smelters, on the other hand, use non-ecological smelting procedures. To reduce lead pollution, it is urgent to discover a technique to collect old batteries and recycle them in an environmentally responsible manner. Solar batteries made of lithium-ion are becoming more popular as a replacement for lead-acid batteries. These batteries are 1/3 the weight of lead batteries and have a 5000-fold longer life cycle. Even at low temperatures, they are 100 percent efficient in charge and discharge, and the voltage is maintained throughout the discharge [7].

5. Methodology

5.1 Research methodology

For this research following research methodology will be adopted: Paradigm: Post - Positivism, and Constructivism Methodology: Qualitative and Quantitative Research methodology Research Design: Exploratory and Descriptive Research Strategy: Correlation, Phenomenology Research Approach: The abduction approach Methods: Direct observations, Structured and open-ended questionnaires, Interview, Google forms, SPSS analysis, Photographs, etc.

5.2 Research Framework

One of the key literatures reviewed during this study was an article named “A study of Battery Operated E-rickshaws in the State of Delhi” by Shashank Singh. The general objective of this article was “To study the socio-economic impact of the battery operated e-rickshaws in the state of Delhi.” which was similar to the main objective of our study. So, the socio-economic parameters for our study were drawn in reference to this article.

Table 2: Parameters of socio economic study [8]

General Objective	Section	Variables
To study the socio-economic impact of the battery operated e-rickshaws in the state of Delhi.	Non-Rental Rickshaws (Owned by the drivers)	Initial Investment; Daily Cost; Daily Income; Net Daily Profit; Battery Replacement Cost; Breakeven Time Period.
	Rental Rickshaws (Owned and driven by separate individuals)	Daily Earnings; Daily Rental; Net Daily Profit;
	Social Parameters	Previous Occupation; Migrant Percentage; Professional Advantage; Job Security and Independence; Change in Social Status, Living Conditions; Education of the drivers; (In the Questionnaire)

Based on the literature review the socio-economic and environmental parameters were determined which are listed down below.

SOCIAL

Social parameters for drivers:

- Employment Opportunity
- Improved Living Status
- Job Satisfaction
- Safety
- Increased Income

Social parameters for passengers:

- Safety
- Comfort
- Accessibility
- Affordability

Social parameters for policy makers:

- Existing policies for the regulation of e-rickshaws
- Quality control of drivers and e-rickshaws
- Allocation of minimum and maximum tariff
- Subsidies

Economic parameters:

- Initial Investment
- Maintenance Cost
- Battery Replacement Cost

Environmental parameters:

- Type of Battery Used
- Battery life
- Disposal of Battery
- Recycling

5.3 Operationalization

The questionnaire survey of drivers was carried out using "kobo toolbox" application at the main junctions of Butwal. The questionnaire survey of passengers was done directly in filed as well as by sending Google forms via. social media. A statistical tool; SPSS software was used to do the further analysis of the data collected.

For qualitative data in depth interview of few Key stakeholders and site observation was done. Some of the drivers, passengers and other road users were also asked few open ended questions of get qualitative data.

6. Results and Discussion

6.1 Results from questionnaire survey with drivers

280 drivers were interviewed among which 263 were male and 17 were female. Age group of majority of drivers was in range of 39 to 58 years and education level of most them was SLC. The previous occupation of most of the drivers was foreign employment.

Results of questions reflecting the social aspects of drivers:

Table 3: Average mean of social variables

	N	Mean	Std. Deviation
Feeling Safe While Driving	280	.18	.384
Improved Social Life	280	.75	.434
Never Faced Offensive Behavior	280	.35	.479
Willingness to Continue	280	.92	.270
Valid N (list wise)	280		
Average Mean		0.55	

Where, Coded as 0=No & 1= Yes The average mean of social variables is 0.55, indicates the inclination of response towards yes.

Results of questions reflecting the economic aspects of drivers:

Table 4: Average mean of economic variables

	N	Mean
Rickshaw Ownership	280	.99
Main source of income	280	.64
Satisfied with present fare	280	.00
More Earning	280	.26
Valid N (list wise)	280	
Average mean		0.475

The average mean of economic variables main source of income, earning increased, rickshaw ownership and satisfied with present fare is 0.4725, indicates the inclination of response towards No.

Calculation of net income of e-rickshaw drivers:

Table 5: Calculation of mean of economic variables

	N	Mean
Initial Investment	280	1.60
Daily Income	280	2.42
Annual Maintenance	280	3.20
Battery Replacement Cost per Cell	280	2.12
Valid N (list wise)	280	

The mean of initial investment is 1.6, indicates the inclination of response towards initial invest is 3-5 lakhs. Similarly, mean of daily income is 2.42, indicates the inclination of response towards daily income is Rs.500-1000. Also the mean of annual maintenance is 3.2, indicates the inclination of response towards annual maintenance is Rs.20000-30000. Mean of battery replacement cost per cell is 2.12, indicates the inclination of response towards battery replacement cost per cell is Rs.10000-20000.

In addition to above mentioned variables other economic variables were initial investment, daily income, annual maintenance and battery replacement cost. Using the results of questionnaire survey based on these variables and considering 5 Years life span & 6.5 % inflation rate the net income of E-rickshaw drivers was calculated as Rs.15500 approx. per month.

Environmental aspects:

The specific energy consumption of e-rickshaw is lowest (53.76 KJ/passenger-km) when compared to private bus, ac bus and auto rickshaw [2].

In electric vehicle such as e-rickshaw there is no tailpipe emission so CO_2 emission is calculated based on upstream emission i.e. emission during production of electricity that is used for charging EVs. CO_2 emission from E-rickshaw is lowest as compared to auto rickshaw and mechanized van rickshaw[2].

From results of questionnaire survey it was found that on average battery last 1-2 yrs and majority of drivers exchange those batteries and get new ones from dealers.

6.2 Results from questionnaire survey with passengers

Results of questions reflecting the social aspects of passengers

Table 6: Average mean of social variables

	N	Mean
Safe	311	1.29
Preference Over Others	311	1.11
Comfortable	311	1.49
Never Offensive Behavior	311	1.87
Never Faced Accident	311	1.75
Accessibility	311	1.00
Valid N (list wise)	311	
Average Mean		1.41

Where, Coded as 1= Yes & 2=No The average mean of social variables is 1.41 which indicates the inclination of response towards yes.

Results of questions reflecting the economic aspects of passengers:

Table 7: Average mean of economic variables

	N	Mean
Never paid more than Fixed Tariff	311	1.54
Affordable	311	1.21
Valid N (list wise)	311	
Average Mean		1.375

The average mean of economic variables is 1.375 which indicates the inclination of response towards yes.

All the respondents were aware about environmental benefits of E-rickshaw.

6.3 Opinion of different stake holders

The e-rickshaw drivers as well as passengers were asked about the positive and negative aspects of e-rickshaws in their opinion. These were the common answers:

Opinion of e-rickshaw drivers

According to drivers the positive aspects of being an e-rickshaw driver are:

- They are able to spend quality time with family.
- There is no time boundary.
- They are self-employed.
- All the transactions are in cash is a very strong point.

Meanwhile negative aspects in their opinion are:

- Less respect
- Held responsible for traffic congestions and accidents
- Low tariff
- Unsafe due to road condition
- High registration and maintenance cost
- High Competition
- Decline in number of passengers since outburst of Covid.

Opinion of Passengers

According to passengers the positive aspects of e-rickshaw are:

- They are affordable means of transportation.
- They provide door to door service.
- They are easily accessible at any time and place.
- They are environment friendly

According to passengers the negative aspects of e-rickshaw are:

- Harsh driving of e-rickshaw drivers mainly in feeder roads where there are no traffic police.
- They are charged more than the fixed fare especially during night.
- It is unsafe to share ride in this Covid situation.
- Unsafe to travel with children as there are no door and handles are too high

Opinion of other road users

The positive aspects of E-rickshaw according to the road users other than E-rickshaw drivers and passengers are:

- It is the easiest option for people who don't own private vehicles to commute between areas not connect via highway
- Direct employment to many drivers and indirect employment to many repair workshop owners.
- It is environmental friendly means of transportation.

And, in their opinion negative aspects of E-rickshaw are:

- Increasing number of e-rickshaws has caused traffic jam during peak hours
- E-rickshaws running back and forth on high speed on streets has made it unsafe for bicycle riders as there are no separate bicycle lane
- It is unsafe to let children play outside.
- Harsh driving of e-rickshaw drivers has caused trouble to other road users too.

Interview with manual rickshaw driver:

A manual rickshaw driver named Ravi Chandel was interviewed during field survey. He is involved in this occupation since 15-16yrs.

When asked about his daily income he said that he earns Rs.400-500 per day which is almost half of what he used to earn before introduction of E-rickshaws. Now as the passengers have option to choose between manual and e-rickshaws they prefer e-rickshaws as they are cheaper and take less time. So, there are rarely any passengers and the main source of earning is carrying goods.

Many manual rickshaw drivers have switched to e-rickshaw however there are many others like Ravi who are not able to switch to E-rickshaw because they don't have a driving license and they are not able to afford e-rickshaw because of it's high initial investment cost.

6.4 Policy Review

For the operation, management and regulation of E-rickshaws inside Butwal Sub-metropolitan City ”Procedure for Operation, Management and Regulation of Electric Rickshaw, 2076” was formulated. Some of the highlights of this policy are listed down:

- Total number of e-rickshaw that will be permitted to run within Butwal Sub-metropolitan city will be limited to 1018
- E-rickshaws can run on all roads that are at least 20feet wide (except highway , earthen roads and hilly areas within municipality)
- Registration and renewal for route permit is compulsory
- Drivers should carry driving license and route permit paper while driving
- Third party insurance is compulsory
- If e-rickshaw registered in other municipalities are only allowed to carry people to or from the hospital.
- E-rickshaw fare will be revised every 2 yrs as per market inflation.
- Color coding of E-rickshaws registered in this municipality
- Provision of relief fund from which Rs. 25000 can be provided to e-rickshaw driver or owner in case of accident or severe illness.
- If operated without registration, route permit then they have to pay 500(first time), 750(second time), 1000(third time) and cancelation of registration and route permit if found guilty for more than 3 times.
- Life of e-rickshaw is 5 yrs. and registration of e-rickshaws older than that will be cancelled.

Shortcomings:

- No provision for subsidies
- Lack of policies for proper disposal of batteries and recycling of e-rickshaw after its useful life is over.

Field Observations:

- Color coding of registered e-rickshaws is not in practice. Lack of filtration between registered and not registered e-rickshaws.
- Fare of e-rickshaw is not revised even once.

7. Conclusion

The main objective of this research was assessment of socio-economic and environmental aspects of E-rickshaws in Butwal.

The results of average mean of social variables in case of both drivers and passengers showed inclination towards positive response (Yes) so it can be concluded that E-rickshaw is socially sustainable in transportation realm of Butwal.

However, the results of average mean of economic variables showed inclination towards negative response (No). Also, the calculation of net monthly income based on the data from questionnaire survey showed that net monthly income of an E-rickshaw driver is Rs.15500 per month which is less than average earning of many Nepalese and also less then what they could have earned from foreign employment. There is not subsidy for buying e-rickshaw and all the drivers feel that the present e-rickshaw fare in not enough. It is mentioned in policy that there will be revision in e-rickshaw fare every 2 years but it has not change even once since it came in operation. So, it can be concluded that there are few area of improvement in economic dimension which needs to be addressed to ensure economic sustainability of E-rickshaw in Butwal.

From environmental perspective E-rickshaw is an environmental friendly transport medium that runs on clean energy source like hydroelectricity. The specific energy consumption as well as CO_2 emission of E-rickshaw is much less than other vehicles. However only issue in environmental dimension is battery disposal. The average battery life according to questionnaire survey is 18month and after the battery is completely or partially damaged and drivers sell them at dealers who then further sell these batteries to scrap holders. Scrap holders get rid of the acid of the batteries by throwing it directly in water source or land and the lead part is illegally exported to India. There is lack of policy to regulate and monitor the safe disposal of batteries. So, it has caused damage of soil and water resources. Also, in the policy by Butwal Sub-metropolitan it is said that the life of a rickshaw is only 5years but it is not mentioned what will most sustainable way to recycle e-rickshaw.

8. Recommendation

- From demographic data of drivers it is seen that women participation is very low. So, training programs and subsidies prioritizing women will be helpful to encourage them.
- Many drivers have said that bad road condition is one of the reasons for high maintenance cost and it has made it unsafe for them to drive. So municipality should work on maintaining and repairing all the feeder roads and streets.
- Regular inspection by traffic police in feeder roads and streets will be helpful in preventing reckless driving of e-rickshaw and will make it safer for the passengers as well as other road users.
- Color coding of e-rickshaws registered in this municipality will be helpful in filtration of e-rickshaw with and without route permit.
- The fare of e-rickshaw should be revised regularly considering market inflation as well as opinion of drivers and passengers so that there will be uniformity in fare. This will help to economically upgrade situation of drivers and will also prevent situational overcharging of fare by drivers.
- Strict regulations should be formulated for proper and safe disposal of lead acid batteries.
- The production company of e-rickshaws should also take responsibility in recycling of it's spare parts as well as batteries after it's useful life is over.
- The results can be taken reference for analyzing socio-economic and environmental aspects of e-rickshaws in others cities of Nepal as well.

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