

## ANALYSING THE SUSTAINABILITY OF E-RICKSHAWS IN INDIAN CITIES

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### **ABSTRACT**

In India, Auto Rickshaws as well as E-Rickshaws play an integral part in urban public transportation. In India, E-Rickshaws, have just appeared in the public transportation industry. These vehicles have grown in popularity due to the comfortability, environmentally friendly, cost-effectiveness and the public transit experience they give to their fellow commuters. E-Rickshaws are becoming increasingly popular in various Indian cities. Furthermore, in the coming years, it will become a very dependable form of communication, as well as a profitable career option for individuals living in rural India or cities with low-income families. The current paper aims to study the sustainable parameters of the E-Rickshaws such as Social, Economic and Environmental aspects as compared to the Auto Rickshaws and analyse the people's acceptance and perception in adoption of E-vehicles.

**Keywords:** E-Rickshaw, Auto Rickshaw, Sustainable Parameters, Three, Social, Economic, Environmental.

### **I. INTRODUCTION**

The fast development of India's urban population has put great strain on urban transportation networks. It is increasing the travel demand in urban areas, particularly in mega and metropolitan areas. An efficient transportation infrastructure is a crucial component for the social and economic development of metropolitan regions. To meet these expectations, the Indian government has planned many such transportation networks in each major city. The booming population and the need for sustainable fuel alternatives to combat pollution have shifted our focus to the usage of more sustainable substitutes, such as electric automobiles. However, cities are unable to meet demand owing to a shortage of efficient public transportation systems, creating the necessity for a para transit system.

Auto Rickshaws are small, three-wheeled vehicles, and the most important intermediate para-transit mode of passenger transportation, commonly operated on most of the urban streets in developing countries [1]. This sector consists of three-wheeler vehicles operating on various fuels, such as Compressed Natural Gas (CNG) fueled or Diesel fueled Auto Rickshaws, Battery-Operated Electric Rickshaws or E-rickshaws, Vehicle-for-Hires and the public bus services [2]. The absence of appropriate last-mile connectivity options prevents private mode customers from switching to public transport services. Unsafe and unpleasant last-mile circumstances force transit users to seek private modes of transportation for last-mile connectivity, resulting in a significant parking demand in metropolitan areas. Auto Rickshaws and, more recently, E-Rickshaws are examples of intermediate para-transit (IPT) vehicles that can offer first-to-last mile connectivity.

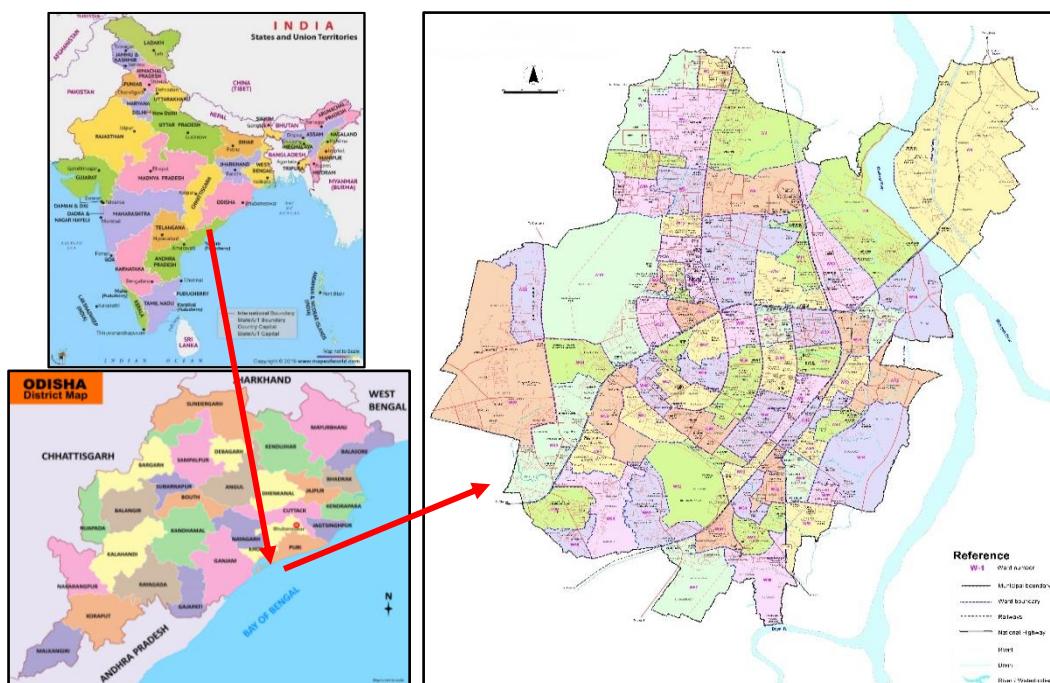
The continuous urbanization of India driven by the expansion of urban sprawls and consistent growth in demand for travel, leads to congestion, high fuel consumption, and inequality while accessing the transport facilities [3]. As, such Auto Rickshaws play an important means of transport contributing to the huge percentage in public transportation. Due to the need of motorized system of transportation the rickshaw has evolved from hand pulled Rickshaws to Electric Rickshaw. E-Rickshaws in a short span of time has been able to multiply its number thanks to its frequency, cost effectiveness and its mobility range. They currently comprise 83% (eighty-three percent) of the Indian electric vehicle market till 2020 [4]. Despite this, the Indian market lacks a clear guideline for the deployment of E-Rickshaws and their administration and maintenance, which has deterred many potential E-Rickshaw owners from owning one and contributing to a cleaner and more inexpensive means of public transportation.

Auto-rickshaws, or three-wheeled passenger vehicles, are synonymous with India's mass mobility. Millions of Indians depend on auto-rickshaws as the most convenient, cost-effective, and time-efficient transportation method. Auto-rickshaws are the backbone of India's mass mobility demands, and they are a preferred mode of transportation in urban, semi-urban, and rural areas. In terms of both sales and manufacturing value, India is the world's largest market for three-wheeler vehicles. Despite having a 3 percent (three percent) market share in the Indian automotive industry, three-wheelers have enjoyed tremendous success in mobility during the last couple decades [5]. Recent advancements and legislation in e-vehicles have contributed to a rise in e-rickshaw sales. Since their legalization in 2015, the number of e-rickshaws on the road has been rapidly increasing since they are typically less expensive than their internal combustion engine counterparts.

## II. LITERATURE REVIEW

After private automobiles, auto rickshaws are the most popular transportation method among residents. Thus, Auto Rickshaws in Bhubaneswar account for 24% of all journeys in the city, which is higher than the needed threshold of 5% for a city of Bhubaneswar's size [6]. The use of E-Rickshaws on the road is predicted to skyrocket with the adoption of the Odisha Electric Vehicle Policy, 2021. This, together with competent operating, maintenance, and management guidelines, could unlock the real potential of E-Rickshaws. As the state capital, Bhubaneswar is rapidly urbanizing and undergoing multiple transformations as a result of urban planning and development schemes, and has emerged as one of the state's fastest growing administrative, tourist, institutional, and commercial hubs, necessitating the need for a public transportation system, that is swift, efficient, cost effective, safe, and environmentally friendly.

Bhubaneswar and Rourkela are the two Smart Cities selected by the state of Odisha in the Smart Cities Mission. As a result, the basic prerequisites for deploying E-Rickshaws in the city are more both socially and economically feasible than in other cities in the state. The Smart City Proposal's essential transit development initiatives explain the goal to accomplish "Encouragement to non-motorized transport" through projects such as E-Rickshaws and Public Bicycle Sharing [6]. This research focuses on a comparison between battery-powered E-Rickshaws and their fossil-fuel-powered Internal Combustion Engine Auto-Rickshaw equivalents. Three-wheeled vehicles perform the most essential role in ferrying passengers among private and para-transit modes of passenger transportation. This method of transportation has been an important sub-sector in the transportation scenario, but it has received insufficient attention. The majority of public transit activities in India take place in cities, suburbs, and townships. These Three-wheeled vehicles perform the most integral part in this transportation system as public, private, and para-transit modes of transportation [2].



**Figure 1: Map of Bhubaneswar City**

### III. EXISTING SCENARION OF PUBLIC TRANSPORTATION IN BHUBANESWAR

In Bhubaneswar, there are three types of public transportation: Rickshaws, Vehicle-for-Hires, and intra city bus service known as the Mo Bus. The three-wheeled Auto Rickshaws for mass transportation in Bhubaneswar may be classified into three distinct categories based on the fuel used: CNG fueled, Diesel fueled, and Battery-Operated Electric Rickshaws or E-rickshaws. Currently, over 27,000 Auto Rickshaws are registered with the city's two Regional Transport Offices, however approximately 10,000 unregistered Auto Rickshaws from the city outskirts come to the city daily to do business [7].

#### a. Auto Rickshaws (Diesel Based)

These vehicles often operate in neighborhoods and are powered by high-speed diesel engines. These Rickshaws are a vital part of the community of major metropolitan regions, townships, and suburbs of Bhubaneswar. Auto Rickshaws in Bhubaneswar, as everywhere in India, transport people in both communal and reserved modes. The union organizations and the region's Regional Transport Authority (RTA) have approved specific routes for these Rickshaws. They could transport a maximum of five passengers at once.

#### b. Auto Rickshaws (CNG Based)

These vehicles are same as their diesel-based counterparts, and can have a carrying capacity of 4 people at max, excluding the Auto Rickshaw operator. The only difference is the cleaner fuel.

#### c. Electric Rickshaws (Electric Based)

In the last two years, E-Rickshaws have entered the public transportation industry in Bhubaneswar. Brushless DC motors propel these vehicles, which are fueled by conventional batteries. E-Rickshaws are eco-friendly and have the capability of reducing the carbon footprint associated with passenger transportation activities. E-Rickshaws have become one of the favored modes of transport for short distances and are now available in major metropolitan, suburban, and township locales. E-rickshaws can assist to improve the city's air quality while aiding to lower the reliance on fossil fuels. It aids in the generation of job opportunities in the informal sector and assists in enhancing the common public's lifestyle and finances.

#### Public Transit and Auto-Rickshaw Challenges

Due to the worldwide population trend, India will soon become the most populated nation in the world, and traffic and congestion on the roadways will most certainly be a daily annoyance. The growing number of automobiles has been a sign of an expanding middle class, but the issue of frequent road congestion and air pollution will necessitate some structured mobility planning, stricter policy enforcement, and government attention, particularly when it pertains to sustainability.

With rapid population growth in Indian cities and a boost in private car ownership, it is critical to reconsider the role of auto-rickshaws in the urban transportation landscape, not only from the perspective of providing an integrated and affordable public transportation system, but also from the socio-economic imperative of encouraging Auto Rickshaws as a means of livelihood for low-income, uneducated, or migrant populations.

### IV. METHODOLOGY

The study's primary goal was to study the sustainable parameters of E-rickshaws and understand the people's (both the passengers and operators) acceptance and perspective in utilizing the E-vehicles in Bhubaneswar City. The study compares the perspectives of the operators (Auto Rickshaws and E-Rickshaws) and the beneficiaries (passengers who use Auto Rickshaw and E-Rickshaw). In June 2022, data were collected from twenty Rickshaw drivers and fifty passengers in Bhubaneswar. A standardized personal interview was conducted in addition to the primary surveys with formatted questionnaires was utilized to gather data after obtaining verbal informed consent from research participants. The average interview time was 10-15 minutes. The study's objective was to understand their perspective and views on E-Rickshaw, its advantages, disadvantages, and feasibility in the context of the urban transport system and its policy implications.

The three-wheeled vehicles, as mentioned earlier, have an important role in public transport sector in Bhubaneswar. In this study the performance of e-rickshaws was studied and compared to other forms of three-wheeled public transport vehicles to check the merits. This study, once again, evaluated the sustainable

parameters of three-wheeled E-vehicles and compared these to the Auto Rickshaw for a comparative analysis. Because of the usage of hydrocarbons fuels in other types of vehicles, the issue of the environmental effect from public transportation remained. The majority of the electricity provided to the grids in Odisha (the state where Bhubaneswar is located) has been generated by coal-fired thermal and river-based hydropower projects. Thus, charging the battery for e-rickshaws requires pollution emissions at power plants.

The study population was selected randomly from all the major Rickshaw stands present in the city of Bhubaneswar. For analysis, a general “constant comparative analysis” [8] approach was used. The data collected through interviews from the Auto Rickshaws and E-Rickshaws and users were compared to develop conceptualizations of the possible relations between various data pieces. The purpose of the analysis was to generate knowledge about sustainable parameters of the E-Rickshaws and opinions within the passengers' experience and operators of E -Rickshaws and Auto Rickshaws.

## **V. ANALYSIS OF SUSTAINABLE PARAMETERS**

Sustainable development is a global phenomenon that has piqued the interest of policymakers, practitioners, and researchers in the environmental sciences, social sciences, and political sciences who are truly concerned about the growth of the economy, the environment, and the social community [9]. As a result, the sustainable development components used to determine the sustainability aptitude of E-Rickshaws are split into three distinctive parts of society. This analysis takes into account the elements and their sub-aspects in order to devise a comparative analysis of Auto Rickshaws and E-Rickshaws.

### **A. Social Analysis**

The social analysis parameter comprises of two sub-categories.

#### **a. Service User Group or Beneficiaries**

To provide a detailed analysis about the travelling pattern of the passengers, a user perception survey was conducted at major auto stands. A total of 50 responses from various age groups and professions were collected and analysed for better understanding the persuading parameters for passengers to avail Auto Rickshaw and their willingness to use E-Rickshaw. There are presently four modes of public transport available in Bhubaneswar city - shared Rickshaws, E-Rickshaws, Vehicle-For-Hires (Ola and Uber etc.) and city Mo bus services. The bus services are limited in number and do not ply on all routes. Fifteen passengers reported that they preferred Rickshaws because of their faster delivery rate and cost effectiveness. E-rickshaw charges INR 10 (US\$ 0.13) per passenger per trip, whereas Auto Rickshaws rates are two to two-fifth times higher than E-Rickshaws and vary depending upon the mode of mobility. Furthermore, the E-Rickshaw ride is not only smooth and comfortable for passengers; it is also quick and readily available. The Passengers believe that E-Rickshaws are safer and generate less pollution than Auto Rickshaws. Five passengers reported that they prefer Auto Rickshaws when three people travel together, allowing more privacy for generic discussion. Thirty-three passengers said that they use Rickshaws on a daily basis, and that they are the ideal mode of transportation in neighborhoods where one wishes to go to the main roadways. Currently, Auto Rickshaws and E-Rickshaws are primarily plying on all major roads; however, unlike Auto Rickshaws, the sphere of influence of E-Rickshaws is restricted, thus they are limited to specific zones; yet, some passengers feel that they should ply on all roads. This corresponds to the normal perspective of 45 passengers. According to the respondents, E-Rickshaws are more feasible and better ways of public transport services since they are affordable and clean, and more people are ready to utilize this mode provided their worries about E-Rickshaw handling are addressed.

#### **b. Service Provider Group or Rickshaw Operators**

E-rickshaws and Auto Rickshaws both ply on the main road in Bhubaneswar city from morning till night. Many Auto Rickshaw operators feel it will pose a problem when the number of Auto Rickshaws would increase on the streets. They also want that there should not be any restriction on routes as currently not all routes are specified inside the city. Many E-Rickshaws are not registered, which is a major concern, but with the enactment of the new Odisha Electric Vehicle Policy, 2021, that problem will be resolved. A survey was done among 20 Rickshaw drivers driving three different types of Rickshaws, namely: Diesel fueled Rickshaw, CNG fueled Rickshaw, and Electric Rickshaw, in order to analyze the socioeconomic circumstances of Auto Rickshaw drivers in the city of Bhubaneswar. Eighteen of the twenty Rickshaw operators drive diesel-powered Auto

Rickshaws, one drives CNG-powered Auto Rickshaw, and one drives a battery-powered E-Rickshaw. Ten Rickshaw drivers do not own their own Rickshaws and must rent one to support their daily expenses. The majority of Rickshaw drivers work in the informal sector and mostly hail from the same socio-economic background. Fifteen operators say that the maintenance expenses of E-Rickshaws are expensive, notably the battery replacement, repair, and maintenance costs. Sixteen Rickshaw operators admitted that they have their own Rickshaws for deployment, while the rest had to rent them on a daily basis. E-Rickshaw owners usually charge INR 350-450 (US\$ 4.42-5.68) per day for renting purposes, whereas Auto Rickshaw owners demand INR 400-550 (US\$ 5.05-6.94) per day as rental fee. The majority of E-Rickshaw drivers have sought for registration and a driver's license, but only seventeen of them have one. E-Rickshaw prices range from INR 90,000/- to INR 1,80,000/- (US\$ 1135 - 2273) depending on the dealer. The charge on the E-Rickshaw battery typically lasts 6-8 hours, depending on factors such as journey length, distance travelled, and road conditions. While only five Rickshaw operators agreed to be well aware about the government's various schemes and subsidies for encouraging adoption of E-Vehicles, the rest were unaware of any of it. Ten Auto Rickshaw operators stated that they wish to purchase an E-Rickshaw because they anticipate this would boost their profits and net earnings. Auto Rickshaw pullers also think that owning an e-rickshaw will improve their social status from low socio-economic groups and poor people.

### **B. Environmental Analysis**

The environmental analysis parameter comprises of two sub-categories.

#### **a. Carbon Emission**

For the analysis of environmental impact, the vehicle kilometer travelled was calculated by the formula as described below:

Vehicle Kilometer Travel = Total No. of Rickshaws X Average Daily Kilometer travelled.

No. of registered traditional Auto Rickshaw: 27,000 [7].

Average daily kilometer travelled by Auto Rickshaw: 70 kms.

Total Vehicle Kilometer Travelled (in kms): 18,90,000 kilometers daily.

The Vehicle kilometer travelled in the study area was observed to be 18,90,000 kilometers for 27,000 Auto rickshaws having a daily average kilometer travelled set at 70 kilometers.

According to the results of a public perception survey, E-Rickshaws are a more ecologically friendly means of transportation than Auto Rickshaws. Users and drivers agree that it is more ecologically friendly because it runs on batteries, which helps to reduce pollution in the city.

Currently, there are only two identified environmental impact of the E-Rickshaws:

1. Indirect CO<sub>2</sub> emissions from energy production, which might be avoided by generating energy from renewable sources.

2. Disposal of the Rechargeable Battery which can also be solved through stricter policy intervention.

From the data collected through the survey it was revealed that the charging option for the E-Rickshaw owners remained within their household socket. Therefore, these E-Rickshaws could not be considered zero emission vehicle as the charging process produces CO<sub>2</sub> emission at the thermal power stations. But, the overall emission of CO<sub>2</sub> and other pollutants are less than that of an Auto Rickshaw. Thus, the specific CO<sub>2</sub> emission of the E-Rickshaw and Auto Rickshaw are calculated and shown in the table below. The results show that the E-Rickshaw has been more efficient in decreasing CO<sub>2</sub> emissions than an Auto Rickshaw [2][10].

**Table 1:** Specific Emission Rate for Rickshaws in Indian Cities

VEHICLE	AUTO RICKSHAW	ELECTRIC RICKSHAW
<b>Engine Type</b>	<b>Internal Combustion</b>	<b>Battery Operated DC Motor</b>
<b>Max. Speed</b>	<b>60 – 65</b>	<b>50 - 55</b>
<b>Max. Distance per refuel/ recharge (km)</b>	<b>230 – 250 kms.</b>	<b>80 – 100 kms.</b>
<b>Specific CO<sub>2</sub> Emission (gm/ passenger-km)</b>	<b>23.55</b>	<b>19.12</b>

### **b. Noise and Air Pollution**

With increasing population, construction activity and transport, the pollution control board in Orissa has reported that levels of suspended particulate matter are well above the standard even in the summer months. The ambient PM2.5 concentrations were computed and found to be greater than 3500 tonnes per year, while the PM10 concentrations were estimated to reach over 3650 tonnes in 2021. Aside from the air pollution caused by the combustion of fossil fuels, Auto Rickshaws contribute to noise pollution through honking and engine noise. In the long run, these sounds have significant health implications. Thus, the E-Rickshaws are more environmentally friendly and healthy for the commuters as compared to the Auto Rickshaws.

### **C. Economic Analysis**

The economic analysis parameter comprises of two sub-categories.

#### **a. Investment Cost**

As per the survey, it was found that long distance routes have a higher average fee than short distance routes due to the lack of a meter system and a fixed rate charge set by the Auto Association that applies regardless of travel distance. The cost per kilometer for routes inside the research region is determined to be between INR 10 and INR 15 (US\$ 0.13 – 0.19) per km for Auto Rickshaws while it was INR 07 and INR 10 (US\$ 0.08 – 0.13) per km. Depending upon the vendor, E-Rickshaw pricing range varies from INR 90,000/- to INR 1,80,000/- (US\$ 1135 - 2273).

#### **b. Operation and Maintenance Cost**

From the survey data, it was concluded that, the annual operational cost of an Auto Rickshaw was calculated to be between INR 37,800/- and INR 40,000/- (US\$ 478 - 505), while that of an E-Rickshaw was calculated to be between INR 10,000/- and INR 15,000/- (US\$ 126 - 190), and the annual maintenance cost of an E-Rickshaw was calculated to be between INR 40,000/- and INR 45,000/- (US\$ 505 - 568) and that of Auto Rickshaws were calculated to be INR 63,000/- and INR 66,000/- (US\$ 795 - 833).

## **VI. RESULTS AND DISCUSSION**

The research examines the perspectives of Auto Rickshaw operators, E-Rickshaw operators, and passengers. Many Rickshaw drivers are owners, and they are satisfied with their work. However, they believe that the increased number of Rickshaws on the streets of Bhubaneswar would exacerbate traffic congestion, a shortage of parking facilities, and air pollution. They also demand that there be no restrictions on routes except for the eco-sensitive and cultural heritage areas. The availability of maintenance and replacement parts, public charging infrastructure facilities, and improved battery technology are major concerns in the mainstream ownership and deployment of E-Rickshaws. The majority of passengers agree that E-Rickshaws are superior since they are less expensive, greener, and consume less time.

**Table 2:** Comparative Analysis of Sustainable Parameters of E-Rickshaw

<b>SN.</b>	<b>Parameters</b>	<b>Perception of Auto Rickshaw</b>	<b>Perception of E-Rickshaw</b>
<b>1</b>	<b>Social Parameters</b>		
<b>2</b>	<b>Beneficiaries</b>	Positive	Positive
<b>3</b>	<b>Rickshaw Operators</b>	Positive	Negative
<b>4</b>	<b>Environmental Parameters</b>		
<b>5</b>	<b>Carbon Emissions</b>	Negative	Positive
<b>6</b>	<b>Air &amp; Noise Pollution</b>	Negative	Positive
<b>7</b>	<b>Social Parameters</b>		
<b>8</b>	<b>Investment</b>	Negative	Positive
<b>9</b>	<b>Operation &amp; Maintenance</b>	Negative	Positive

Passengers believe that Bhubaneswar, as a smart city, should focus on reducing traffic congestion as Bhubaneswar's public transportation system is constantly expanding. The Auto Rickshaws and E-Rickshaws provide a feasible last-mile connectivity option for the ordinary population. Some Rickshaw operators think that Auto Rickshaw is a better alternative because it has less burden as incase of any emergency all the services and facilities are already built and the refueling is also quicker as compared to E-Rickshaws. On the other hand, economic cost of renting and operating a E-Rickshaw is lower than that of an Auto Rickshaw's high rental cost, coupled with high charges associated with the regular changing of engine oil and refueling expenses. From the analysis, it is clear that with further policy intervention, vehicular upgradation as per the safety standards and the scientific disposal of the batteries and dilapidated Auto Rickshaws this new means of transportation will be a blessing to Bhubaneswar.

## VII. CONCLUSION

For city dwellers, transportation is essential since it makes daily living more bearable. We can't disregard Rickshaws' massive contribution to our everyday lives because so many people utilize them as a form of transportation and others as a source of livelihood. According to the study, E-Rickshaws are more environmentally friendly and energy efficient than other modes of public transportation. Proper E-Rickshaw deployment has the ability to alleviate the challenges of environmental and noise pollution caused by transportation. However, important problems such as maintenance and replacement components, public charging infrastructure facilities, and improved battery technology must be resolved before these E-Rickshaws can be widely deployed. The existing E-Rickshaw technology must be modified to be compatible with modern traffic. The main reason for the dissatisfaction of using E-Rickshaws among the Auto-Rickshaw drivers is due to the non-availability of proper charging infrastructure and the time taken to charge the battery.

The registration process is another example of a deployment challenge. The majority of Auto Rickshaw drivers are uninformed of the subsidy programmes for the purchase of E-Rickshaws, and as a result, they either don't buy them or, if they do, many are left unregistered; while the drivers themselves have legal licenses, the vehicles are not officially registered. For the E-Rickshaw market to flourish in a sustainable manner, a combination of policy and regulatory interventions are considered necessary, such as vehicle design with strict adherence to E-Rickshaw safety standards for both the operators and passengers and requiring proper inspection of these vehicles by the competent authorities, localization of efficient battery production, research and development of hybrid E-Rickshaw designs and scientific disposal of the E-Rickshaw wastes. E-rickshaws have the potential to minimize passenger transportation fuel oil use, which might result in both economic and environmental advantages.

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