SMEP

Sustainable Manufacturing and Environmental Pollution Programme

UNIFIED POLICIES, HEALTHIER JOURNEYS

Adressing the Used-Lead-Acid-Battery challenge in Bangladesh

April **2024**

UK International Development

Partnership | Progress | Prosperity

The report is prepared by Atiq Zaman and Tahmina Ahsan from Curtin University, Australia, in collaboration with Nusrat Zabeen Radia, Khoirom Kameshwar Singha, Mamun Hossain, and Kamrul Hasan from Consiglieri, Bangladesh. The authors thank Dr Mohammad Solaiman, Deputy Secretary, Ministry of Planning, Government of Bangladesh, for his feedback on the relevant policies. The report received comments and suggestions from Henrique Pacini and Glen Wilson from UNCTAD and Prof. Amrita Kundu from George Town University. Lia Tostes designed the report, and Lana Barcellos illustrated the cover art. This report is part of the Sustainable Manufacturing and Environmental Pollution (SMEP) Programme, funded by UK-FCDO and implemented in partnership with the United Nations Conference on Trade and Development.
Views expressed are those of the authors and do not reflect those of related institutions.

Contents

Abbreviations

ADB	Asian Development Bank
AIIB	Asian Infrastructure Investment Bank
ASEAN	Association of Southeast Asian Nations
BDT	Bangladeshi Taka
BELA	Bangladesh Environmental Lawyers Association
BRTA	Bangladesh Road Transport Authority
CAGR	Compound Annual Growth Rate
DoE	Department of Environment
ILA	International Lead Association
IPS	Instant Power Supply
IPT	Intermediate Public Transport
JICA	Japan International Cooperation Agency
LABs	Lead-Acid batteries
MDB	Multilateral Development Bank
MT	Metric Tons
MWh	Megawatt Hour
SMEP	Sustainable Manufacturing and Environmental Pollution
TTI	Total Tax Incidence
UN-FCDO	United Kingdom Foreign, Commonwealth and Development Office
ULABs	Used-Lead-Acid batteries

Executive Summary

E-rickshaws play significant roles in Bangladesh's society and economy, but there are major concerns about the health and environmental impacts related to the system in which they operate, in particular how their batteries are sourced and disposed of. This report reviews the current state of e-rickshaws and the recycling of Used-Lead Acid Batteries (ULABs) in Bangladesh, focusing on the regulatory landscape and policies ensuring sustainable practices, particularly in the context of e-mobility. Existing policies aim to address challenges associated with informal Used Lead-Acid batteries (ULABs) recycling, environmental pollution, and public health hazards. However, notable policy gaps and challenges persist, hindering the effective implementation of sustainable practices. The following sections present the key findings and recommendations of the study:

KEY FINDINGS

• **Policy Discrepancies** The regulatory framework lacks harmonisation and holistic integration, leading to discrepancies in managing ULABs effectively. E-rickshaws, essential for urban mobility among the marginalized poor, face unclear policies under the Road Transport Act 2018, while Hazardous Waste (e-waste) Management Rules 2021 only consider household lead batteries, excluding those from e-rickshaws.

• **Inadequate Integration** Regulations related to ULABs are spread across various policies and acts, including the Bangladesh Environment Conservation Act, 1995 (amended 2010), Hazardous Waste (e-waste) Management Rules, 2021, and Basel Convention (1993). Lack of integration creates loopholes, contributing to mismanagement.

• **Informal Sector Oversight** The significant role played by the informal sector in waste management is not acknowledged in regulatory roles. This gap needs to be addressed to integrate informal sectors into a formal waste management system effectively.

KEY RECOMMENDATIONS

• Establish a harmonised and integrated regulatory framework that encompasses all policies related to ULABs management and with regulations related to transportation, trade, energy and public health. This framework should foster better e-mobility for the marginalized poor while ensuring sustainable ULABs practices.

• Acknowledge the crucial role of e-rickshaws in the national e-mobility policy and provide clear guidance on addressing challenges such as energy theft and safety issues.

• Strengthen the enforcement and monitoring of the current relevant regulations, and execute penalties and set examples for non-compliant entities.

• Provide consistent messaging through digital platforms to all stakeholders regarding future plans for e-rickshaws, whether controlled, restricted, or banned. Clearly communicate ULABs management regulations, guidance, and penalties for both formal and informal sectors.

• Restrict and monitor the involvement of vulnerable individuals (including children under 18 and pregnant women), in the recycling of ULABs to ensure their safety and well-being.

• Foster business opportunities for both formal and informal ULABs recycling entities with appropriate support and incentives from government bodies.

CONCLUSION

A harmonized regulatory framework, recognition of e-rickshaws, clear communication, and measures to protect vulnerable individuals are crucial steps toward achieving a balance between economic importance and environmental responsibility in ULABs management to foster a more sustainable e-mobility system in Bangladesh.

1.

Introduction

Dhaka, Bangladesh, is known as the Rickshaw Capital of the World. Rickshaws have historically been and continue to be the primary mode of transportation for the local population in Bangladesh. A rickshaw is a three-wheeled, pedal-powered vehicle. However, with socio-economic development, the expansion of the electricity network, the increasing adoption of renewable solar power in rural areas and the adoption of new technologies, there has been a notable shift from pedal-powered to electricity-powered transportation. This transition is prominently observed in the widespread use of e-rickshaws, primarily powered by Lead-Acid batteries (LABs) in Bangladesh. Despite playing a significant role in transportation and employment creation in Bangladesh, electric rickshaws face controversies, bans, and exclusion from mainstream policies for electric vehicles, rather than being framed as a potential technology for "greening" public transport (Van der Straeten, 2022).

E-rickshaws work as intermediate public transport (IPT) or para-transit systems, which are often run by informal operators. As an IPT, e-rickshaws have gained popularity, and the global electric three-wheeler market is expected to grow from USD 1.55 - 2.71 billion in 2023 to USD 4.11 - 10.26 billion by 2030 (Coherent, 2024; FBI, 2023). The Asia Pacific region dominates the worldwide e-rickshaw market due to fast urbanization and population increase. Bangladesh, India, China, Nepal, Thailand, Indonesia and the Philippines are the primary markets for e-rickshaws (Saxena, 2019; Weinert et al., 2008). The global e-rickshaw market share is estimated to be more than 43% in 2023 in the Asia Pacific region (Coherent, 2024). Rapid urbanization, increasing pollution levels and large unexploited rural markets are driving the market growth in the Asia Pacific region. One of the primary benefits of rickshaws is their ability to navigate congested urban roadways, which is driving demand for the global e-rickshaw industry and providing last-mile connectivity. Emission standards applied on combustion engine technology are becoming more stringent globally to minimize pollution, a trend which further increases incentives for e-rickshaws. Moreover, e-rickshaws also offer longer travel distances than regular non-electric rickshaws, a key reason for their popularity among customers and continuous market growth (Maximize Market Research, 2023).

Facts

GLOBAL E-RICKSHAW MARKET SHARE

43%

▸ The global e-rickshaw market share is estimated to be more than 43% in 2023 in the Asia Pacific region.

With the market growth of e-rickshaws, the demand for batteries has also increased. These batteries are used as energy carriers to enable the vehicle to move. One e-rickshaw requires four to six dry Lead-Acid batteries with a voltage of at least 12 volts (V). Because of the way the batteries are set up, the combination provides 48 V to 72 V and between 140 ampere-hour (Ah) to 160 Ah rating. New batteries require about 8 hours to fully charge. After 8 to 12 months of use, the charging time increases to 10 to 12 hours (Nurunnahar et al., 2022). Lead and acid are the main materials used to make these batteries, at least 70% lead, which represents approximately 14 kg-21 kg per battery, depending on the battery size. Since imported lead is more expensive than domestically recycled lead, the battery industry relies primarily on unlicensed open pit smelting sites locally known as "bhattis". The number of bhattis increased from 50 in 2010 to 800 in 2023 due to a higher demand for used recycled lead in the local market. E-rickshaws are responsible for generating about 77% of total ULABs in Bangladesh. Additionally, according to a report by the United Nations Environment Programme, Bangladesh alone generates 90,000 tons of used lead batteries annually. This estimate is based on the 6-month life cycle of the battery (Rahman, 2023).

The global e-rickshaw battery market was worth approximately USD 1.3 billion in 2021 and is projected to rise to approximately USD 5.6 billion by 2030, with a Compound Annual Growth Rate (CAGR) of approximately 22% between 2022 and 2030 (Custom Market Insights, 2022). India has

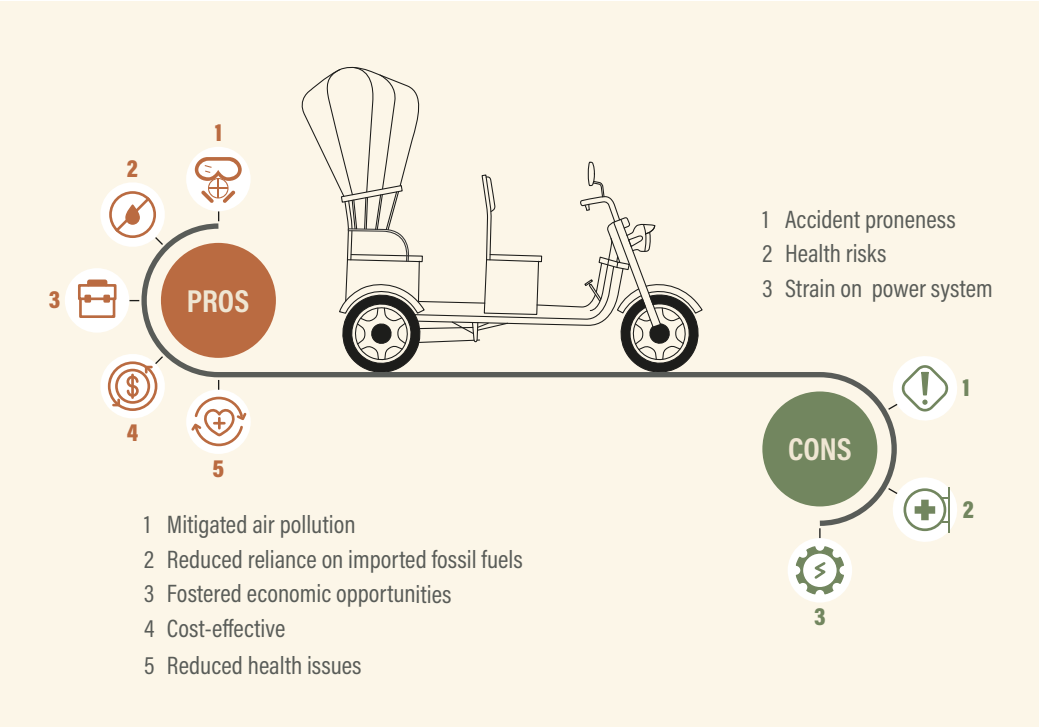
a significant market share as e-rickshaw manufacturing expands to meet the growing demand. China and the ASEAN countries are the second and third-largest markets for e-rickshaws, in terms of manufacturing and sales, after India. Furthermore, the Middle East and Africa region is likely to see moderate growth in the coming years. Sales of e-rickshaws are expected to increase steadily across Europe. Imports are limited due to high import tariffs applied on Lead-Acid batteries entering Bangladesh (total tax incidence over 80%), so domestic supply is primarily sought by operators.

Over the last few years, e-rickshaws have taken over the local transportation market in Bangladesh. The popularity can be attributed to the comfort for short- and medium-distance travel, the lack of crowding compared to buses and trains, affordability, availability, and relative safety of the e-rickshaws. The approximate number of e-rickshaws is difficult to determine since the sector is operated in an informal setting. The figure ranges from 1.5 to 4 million in Bangladesh (Rahman, 2023; The Daily Star, 2024), highlighting the inconsistencies. The industry gets around half of its lead supply from recycled Used Lead-Acid batteries (ULABs), which are produced in the open air by small, unofficial businesses and have negative effects on the environment and human health. Nationwide, there are more than a thousand locations for recycling and recharging batteries. According to the Battery-powered Easy Bike and Rickshaw Drivers Movement Council, which has branches in 50 districts, there are currently more than 3 million electric rickshaws in Bangladesh. The Lead-Acid batteries (LABs) industry holds the potential for substantial additional investment of USD 0.6-1.2 billion annually. However, without appropriate regulation and practice, the industry can pose significant risks to the environment.

The Government of Bangladesh decided to ban electric three-wheelers in 2021 on the major roads across the country, citing a rise in traffic accidents as the cause of the prohibition (TBS, 2021). The ban was adopted on December 15, 2021. However, in one of the parliamentary sessions in February 2024, the state minister of the Ministry of Power, Energy and Mineral Resources stated that the electric three-wheeler was the "Tesla of Bangla" (The Daily Star, 2024). He also stated that although there are concerns regarding electricity pressure on the grid system (around 700-800 MW of electricity per day is needed to charge 4 million three-wheelers) and electricity theft, the State Ministry of Power and Energy stated that battery-run three-wheelers "developed by our people" and thus should be encouraged. The ministry also stated that the electricity department has made a policy for setting up electric vehicle charging stations.

At the same time, the Bangladesh Road Transport Authority (BRTA) does not issue licenses to unauthorized vehicles, and the High Court noted that battery-powered three-wheelers lack both a license and an appropriate braking system for the back wheels. Police already seized many unauthorized electric motor-driven vans and rickshaws after the ban. The situation has reverted to the pre-ban scenario due to the lack of a clear stance from the government.

Bangladesh is facing a critical environmental and public health challenge due to the unregulated proliferation of e-rickshaws powered by Lead-Acid batteries. This report examines the escalating risks associated with the widespread use of recycled Lead-Acid batteries, their impact on public health and the environment, and proposes policy interventions to mitigate these pressing concerns. The focus of the report is to analyze gaps in policies regarding e-rickshaws and the use of Lead-Acid batteries in Bangladesh.



← Figure 1. Advantages and disadvantages of e-rickshaws in Bangladesh

2.

The Roles of E-mobility (e-rickshaws) in Bangladesh

In Bangladesh, e-rickshaws, as local light-duty vehicles in the transportation sector, play an important role. It has become a popular mode of transportation for distances ranging from 1 km to 7 km since it is less expensive, generally more pleasant than other modes of transit, time-saving and readily available. Depending on the vehicle size, they carry from 3 to 8 passengers at a time. The act of ride-sharing stands out as a key feature contributing to the popularity of this mode of transportation, as it effectively lowers the cost per passenger. Although it is difficult to find cost comparisons among various modes of transport, they are often determined by negotiations. A previous study showed that the ride cost of three-wheelers used in the local rideshare platform "Pathao" is one-third to half the price compared to other rideshare platforms available in Bangladesh, such as UberX and Toma Taxi Cab. For example, to travel 1 km, it would cost around USD 0.44 for Pathao, compared to USD 0.68 for UberX and USD 1.25 for Toma Taxi Cab for a 1 km ride with an initial fee (Ullah & Islam, 2017). This e-rickshaw has become a source of income for low and middle-income persons because it is relatively affordable (Al-Amin and Sahabuddin, 2023).

The adoption of e-rickshaws, which are electric vehicles emitting zero emissions during operation, contributes significantly to reducing emissions in transportation. Particularly in countries like Bangladesh, where air pollution is a pressing issue, the widespread use of e-rickshaws plays an important role in reducing emissions (around 90–95% lower over their lifetime compared to conventional diesel rickshaws) and enhancing air quality in urban areas (Medium, 2023).

THE KEY ROLES OF E-MOBILITY IN BANGLADESH

- **Reduced Dependence on Fossil Fuels:** By utilizing electric power, e-rickshaws contribute to reducing the country's dependence on fossil fuels. This not only helps in conserving non-renewable resources but also enhances energy security. However, it adds demand pressure on country's electricity generation from renewable sources.
- **Cost-Effective Mode of Transport:** E-rickshaws are generally more economical to operate compared to traditional fuel-powered vehicles. With lower operational costs, including maintenance and charging expenses, e-rickshaw drivers can potentially increase their earnings.
- **Employment Opportunities:** The adoption of e-rickshaws has created both formal and informal employment for drivers, mechanics, and other professionals involved in the electric vehicle industry. The growth of this sector contributes to economic development and job creation. Most importantly, e-rickshaws provide job and income opportunities for marginal and migrated communities affected by climate change in various parts of Bangladesh.
- **Reduced Noise Pollution:** Noise pollution in Bangladesh is one of the major issues, and electric vehicles operate quietly, leading to a reduction in noise pollution in crowded urban areas. This can have a positive impact on the overall well-being of residents and contribute to a more peaceful living environment.
- **Traffic Decongestion:** E-rickshaws, being smaller and more manoeuvrable than traditional vehicles, can navigate through congested traffic more easily. This helps in reducing traffic congestion and improving overall traffic flow in busy urban areas. Particularly for the secondary and tertiary arteries of the roads in congested parts of urban areas, e-rickshaws provide a better solution to combat congestion.
- **Rural Connectivity:** E-rickshaws play a role in improving connectivity not only in urban areas but also in rural areas where conventional transportation may be limited. They provide an affordable mode of transportation, particularly in regions with poor road infrastructure.
- **Technology Transfer and Innovation:** The adoption of e-rickshaws promotes technology transfer and innovation in the transportation sector, especially locally developed electric vehicle technologies. This can lead to the development of more advanced electric vehicles and related technologies, such as better battery technology adoption.
- **Global Environmental Commitments:** As one of the signatory countries of the Basel Convention, the Paris Agreement, and other international treaties, Bangladesh is obliged to align itself with global commitments to reduce greenhouse gas emissions and combat climate change. The adoption of electric vehicles and the fostering of e-rickshaws demonstrate a proactive approach to achieving that goal.

  Governments in Bangladesh may offer incentives and support for the adoption of electric vehicles, including e-rickshaws. This can include subsidies, tax breaks, and infrastructure development for charging stations, encouraging more people to switch to electric mobility.

3.

The Challenges and Opportunities of Recycling ULABs in Bangladesh

3.1. Overview of the Issue

In Bangladesh, as in many developing countries, Used-Lead-Acid Batteries (ULABs) recycling often occurs through informal channels, where safety and environmental regulations are not observed and weakly enforced. Improper disposal of ULABs has resulted in severe environmental pollution due to the release of toxic substances such as lead, sulfuric acid, and other hazardous chemicals in soil and water bodies. This waste stream is an increasing environmental and health risk for Bangladesh due to the lack of a regulatory framework for environmentally responsible management and recycling. Based on a Lead-Acid Batteries (LABs) inventory analysis of the International Lead Association (ILA) and the different life cycles of each category of ULABs and their respective applications, the annual generation is estimated at 118,000 metric tons (MT) (Lin et al., 2023). In spite of these negativities, the proper recycling method of ULABs offers opportunities for resource recovery, employment creation, environmental protection, technological adoption, and regulatory compliance

Historically, LABs were the primary electricity source in rural areas for television and other electronic gadgets to operate due to the lack of electricity infrastructure and grid connection in remote country areas. Most of the LABs were used in the transportation sector (buses and trucks or other vehicles to start the engine rather than use as fuel). Thus, only a handful of local manufacturers (formal and informal) were involved in the market. Rahimafrooz Batteries Ltd is Bangladesh's largest lead-acid battery manufacturer, producing 1,500,000 batteries per year and exporting to over 70 countries (Pure Earth 2020). In the Pure Earth report. Around 26 companies have been listed as notable LABs and ULABs manufacturers and recyclers; however, the number may vary since there is an influx of Chinese companies who operate both formally and informally in collaboration with local partners in Bangladesh. The presence of lead battery recyclers in Bangladesh can also be indirectly traced to China's ban on imports of 24 different recycling materials, including batteries, in 2018 to reduce environmental pollution and to protect the environment and human health (Lin, et al., 2023).

3.2. Recycling of ULABs in Bangladesh

There are over 1,100 informal and illegal ULABs recycling operations across the country, which employ more than 100,000 people (Pure Earth, 2020). Given high import tariffs on lead (over 30%) and on lead-acid batteries (over 80%) into Bangladesh, the informal battery shops account for 50% of the battery supply in the country (Batteiger & Rotter, 2018). The key reasons for informal battery shops are the availability of diversified services (repairing batteries and replacing the acid) at lower prices compared to formal business, trust, and taking care of end-of-life batteries with incentives (Brossmann, 2013).

In order to recycle ULABs sustainably, the reverse logistics supply chain or collection system needs to deliver the ULABs to the licensed and properly operated formal sector recyclers, and the less prominent route is the direct route from the user to the smelter, which is mainly used by institutional users, such as government vehicle pools, corporate offices, etc. The more prevalent route is via small buyers in the form of battery repair shops and auto and tire repair garages, as well as urban 'feriwallas' collecting old electronics via barter and trade. In most cases, these

secondhand battery shops sell new and used batteries for vehicles. The ULABs are transferred from the small buyers to the re-builder or 'vangari' shops, some of which are also smelters. The brokers have agreements with secondhand battery shop dealers and auto mechanics to buy old batteries. All these collected ULABs are sent to smelting facilities to recover lead, which is used to manufacture new batteries.

Regulators are unable to enforce other requirements pertaining to worker safety and environmental management since unlicensed ULAB recycling is carried out in secret, hidden from the perspective of law enforcement. Although the informal sector caused risky and unstable working circumstances, these activities also help to reduce poverty by engaging people in this sector (Lin, et al., 2023).

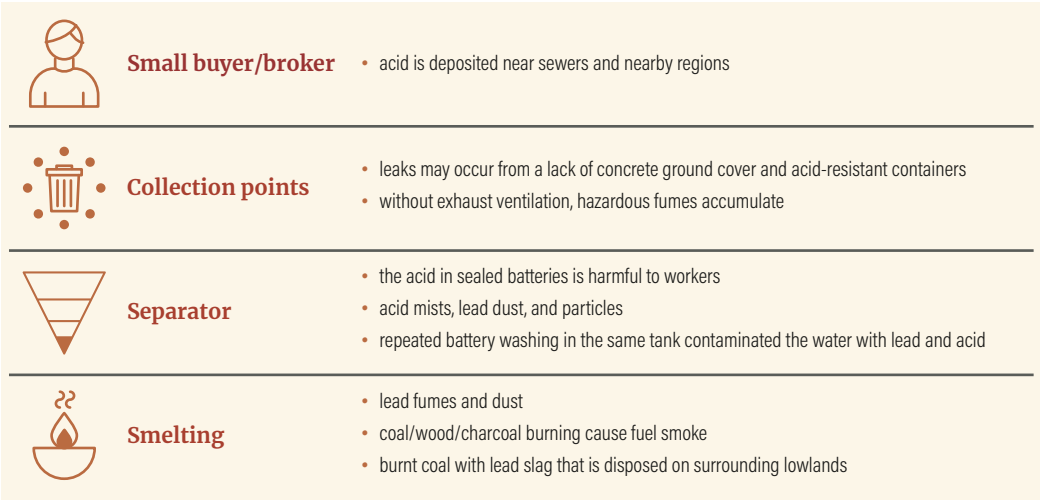
Table 1. Recycling process of ULAB in Bangladesh

Stages of Recycling	Formal	Informal
Collection	Some users, including mobile phone companies and government transportation authorities, invite tenders to sell their ULABs.	Users sell small customers their used batteries. The batteries are then given to the repairer/rebuilder either directly or via the broker. ULABs are occasionally sold to the smelter directly by the broker. Certain vendors or rebuilders gather ULABs by offering a new battery with a sales discount.
Separation	The manufacturers purchase lead in order to rebuild it or use it for different projects.	Re-builders and separators collect ULABs and separate their components, including plates (negative and positive), connectors, leads, electrolytes (sulfuric acid), containers, covers, separators, and other minor pieces.
Smelting	Formal smelting is done in a smelting factory using a sustainable technique known as pyrometallurgy.	Informal smelting is done in the open air with an unsustainable practice. This process is operated around riverbanks or highways (national or regional). These activities are spread throughout the country.

3.3. Environmental Implications

Bangladesh's government has banned leaded petrol to minimize ambient lead concentrations. However, anthropogenic sources and pollution hotspots may still provide a higher risk of exposure. Informal and inadequate recycling of ULABs is a major cause of lead pollution in Bangladesh. Informal ULABs recycling operations are frequently conducted in or close to residential communities where lead dust can collect in high-risk locations such as, playgrounds, sports fields, roads, pathways, homes, and other places where dust is likely to be stirred up and then swallowed or inhaled. Lead can leak into the water when lead-acid batteries are broken and associated waste is disposed of, but groundwater pollution with lead doesn't seem to be a prevalent problem because the lead produced during recycling is non-soluble. Lead dust from the site can spread to adjacent areas via workers' clothing, hair, shoes, vehicle tyres, stormwater runoff, wind, and off-site waste disposal.

During the melting process, lead dust and vapor are ejected into the air and often fall back to the earth within a few hundred meters due to its weight. The pollution has resulted in numerous animal deaths due to lead ash contamination of grass and other feeds. If local people protest against smelters after domestic cows and goats died near the recycling site, local leaders or police most often arrange arbitration to compensate them. However, sometimes the recyclers are unable to restart their practice, then they relocate to another site, to contaminate another region.



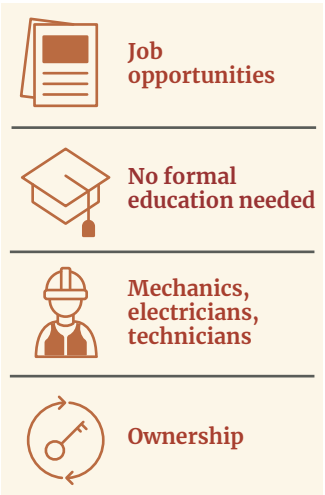
← Figure 2. Environment implications of informal ULAB recycling

Lead is a neurotoxin that harms children's neurological development, causing comas, hearing loss, convulsions, and even death. Even at lower levels of exposure, lead can permanently reduce a child's intelligence quotient (IQ), lower educational attainment, lower lifetime earnings, and increased violence. Early-life lead exposure in adults can cause kidney disease, heart disease, and even stroke (Lin et al., 2023).

3.4. Socio-Economic Impact

It's important to acknowledge the potential negative environmental impacts of e-rickshaws, but it is also essential to recognize the positive socio-economic aspects, particularly in terms of job creation and employment opportunities in Bangladesh. Job opportunities have been a significant challenge in Bangladesh, especially due to its large population and limited availability of formal employment prospects. But since e-rickshaws have been introduced, many people now have more work options across an enlarged urban radius, which has helped them to alleviate this problem.

The E-rickshaw sector has very low barriers to entry, thus creating income opportunities for people who don't need a formal education or specialized abilities to drive the vehicle. This has been especially helpful for lower-income families who have struggled to locate other career opportunities due to the lack of educational certifications. Additionally, the sector generates employment in associated industries, such as maintenance and charging infrastructure. Mechanics, electricians, and technicians are required to maintain and repair e-rickshaws, and people are also hired to operate and maintain charging stations. Besides this, individuals own e-rickshaws, which help them to start a business by purchasing or leasing them. They run their own e-rickshaw enterprises, generate work for themselves, and hire other drivers as their business grows. These job opportunities have reduced poverty rates and raised the standard of living of low-income families.



↑ Figure 3. Socio-economic impact of e-rickshaws

As unemployment and underemployment can lead to social unrest and instability, this work has decreased crime and encouraged safer communities by generating job opportunities. It has helped reduce stress, improve general well-being, and enable access to healthcare through stable employment, which, moreover, lowers healthcare costs and enhances productivity. Industry, in turn, fuels economic growth by creating a positive cycle of development. On the other hand, as this industry is unofficial and subject to government shutdown at any time, many people are reluctant to work in it. It would be a waste of their investment if that occurs. For those with limited incomes, it is significantly challenging.

Therefore, it's essential to acknowledge and support the positive socio-economic impacts that this industry has brought to Bangladesh. Also, it is imperative to address and mitigate the environmental challenges associated with e-rickshaws, particularly through the adoption of cleaner energy sources and sustainable practices.

3.5. Trade and Financing Mechanism

The current total tax incidence (TTI) for importing general lead waste and scrap (HS 78020000) in Bangladesh is around 31%, and the value-added tax (VAT) is 15%. However, for the specific waste lead-acid accumulator (HS 85491100), the TTI could be as high as 58.6%, of which 25% is Customs Duty (CD). The TTI of the lead-acid accumulators for sharing piston engines (HS 85071000) is 89.32%, of which around 25% is CD and 20% is Supplementary Duty (SD), along with 15% VAT. Surely, the high and inconsistent taxes can be a barrier to ensuring high-quality imported lead-acid batteries in Bangladesh. At the same time, for alternatives to lead-acid batteries, such as lithium-ion batteries, the taxes are not in a favourable range. For Lithium-ion (HS 85076000) the TTI increases to 58.6%. Since the ULABs are mainly dependent on locally sourced recycled lead, a higher tariff for Li would increase the cost of the LiB in the market. The current battery sector in Bangladesh is mainly driven by private local and international investors (formal and informal sector). The financial support from the public bank is nominal. For example, Bangladesh Bank has set up a Tk 400 million (USD 3.6 million) revolving fund for 68 green products with the aim of building a sustainable future for the country (Bangladesh Bank, 2022). Customers can access this refinance option through banks/financial institutions to raise funds at a lower cost and bring sustainability to their business.

The entitled major green products are:

- Any Solar Projects
- Biological/Bio-Chemical ETP
- Fire Safety Products
- Energy Efficient Technology
- Building/Industry
- Recycling Plant
- Renewable Energy Projects
- Waste Management Plant
- Different Recycling Plants (Plastic, Battery etc.)
- Different Agricultural Products

There are some specifications required for the service:

- The loan has to be long-term
- Debt: Equity ratio should be 80:20 (minimum)
- Interest Rate is mentioned in Table 2

Table 2. Interest Rate

Tenure	Current Rate
Less than 5 Years	5%
5 to less than 8 Years	5.5%
8 or more than 8 Years	6%

With a proper and innovative business proposition, the sector could attract finance from local finance institutes like Brac Bank and Grameen Bank. In relation to the regional and international financial bodies, there are opportunities to secure funding provisions for bankable business propositions through Multilateral Development Banks (MDB) like the Asian Development Bank (ADB), Asian Infrastructure Investment Bank (AIIB) and World Bank, as well as bilateral cooperation organizations such as Japan International Cooperation Agency (JICA).

3.6. The Dilemma of ULABs in Bangladesh

Despite E-rickshaws versatile roles in Bangladesh's socioeconomic and environmental sectors, there are some major concerns about e-rickshaws in the broader socio-technical system in Bangladesh.

A key concern relates to the national energy grid, as electricity demand and load shedding are serious problems in the country. Bangladesh grapples with severe load shedding during peak hours, primarily from 5 p.m. to 11 p.m., owing to a significant disparity between power demand and supply. The literature indicates that the approximately 500,000 autorickshaws operating daily across the country consume a substantial 4660 megawatt hours (MWh) of electricity per day from 6 p.m. to 6 a.m. (Al-Amin and Sahabuddin, 2023). The rising numbers of e-rickshaws each year pose a challenge to the national power system, raising concerns about macroeconomic implications and the sustainability of the electricity infrastructure (Al-Amin and Sahabuddin, 2023).

Rickshaws also have traffic safety concerns. The vulnerability of e-rickshaws to traffic accidents is a prominent concern among users. These vehicles lack an adequate stopping mechanism, as only their front wheels have brakes. Their uncontrollable speed often leads to mishaps while attempting to stop, resulting in numerous accidents and fatalities when colliding with other vehicles or pedestrians. Addressing these safety issues is important to ensure the well-being of both e-rickshaw users and other road users (Alamgir, 2022).

ULABs are also often subject to unsustainable recycling practices. To mitigate the adverse effects of battery recycling, there is a pressing need for the implementation of sustainable and regulated recycling practices. This includes the proper handling of lead-acid batteries and ensuring the safety of workers involved in recycling activities. The informal and inadequate recycling of lead-acid batteries in e-rickshaws poses a serious threat to public health, particularly affecting children in low- and middle-income countries like Bangladesh. The improper recycling practices involve breaking open battery cases, contaminating the environment with acid and lead dust, and smelting recovered lead in primitive outdoor furnaces that release poisonous fumes. A recent report stated that over 35 million children in Bangladesh have blood lead levels exceeding 5 micrograms per deciliter (µg/dL) and over 9.7 million surpassing 10 µg/dL, whereas the exposure should be near zero (UNICEF and Pure Earth, 2020). The same report claimed that Bangladesh has the world's fourth-highest rate of death due to lead exposure, with an average population blood lead level of 6.83 µg/dL.

Among the individuals exposed to ULAB recycling-related pollution, children are particularly susceptible to lead poisoning. The long-term health impacts include an increased risk of kidney damage and cardiovascular disorders. Additionally, lead exposure during childhood is associated with behavioural and mental health issues, contributing to a higher likelihood of social marginalization. Addressing this health crisis becomes imperative for the well-being of the younger population (Pure Earth and UNEP, 2020).

4.

Alternatives to Lead-Acid Batteries

In Bangladesh, exploring alternatives to Lead-Acid batteries for e-rickshaws offers a promising avenue for enhancing sustainability. Lithium-ion (Li-ion) batteries stand out as a viable option, providing higher energy density and a longer lifespan compared to lead-acid batteries. Despite concerns about environmental impact and recycling, Li-ion batteries offer cost-effectiveness over their lifetime. With efficiencies of at least 95%, faster charging capabilities, and better performance in harsh conditions, Li-ion batteries surpass lead-acid batteries in various aspects. While lead-acid batteries may be initially less expensive, the prolonged life cycle of Li-ion batteries makes them a more economically sound choice (Nair & Garimella, 2010; Li et al., 2010; Grey & Tarascon, 2017).

Table 3. Cost comparison between Lead-Acid Battery and Li-ion Battery

Characteristics	Lead-Acid Battery	Li-ion Battery
Nominal Voltage (Volt)	2	3.6
Energy Density (Wh/L)	35	118–250
Specific Energy (Wh/kg)	30–50	120–140
Specific Power (W/Kg)	180	200–430
Operating Temperature (C)	-15 to 50	-20 to 60
Life Cycle	1000	2000
Production Cost (USD/kWh)	60	150

Source: Habib et al, 2019; → Muzir et al., 2022

The state minister of the Ministry of Power, Energy and Mineral Resources, Bangladesh, showed his support for e-rickshaws and battery-driven three-wheels. In one of the parliamentary sessions, he mentioned a project where the ministry will "provide" lithium-ion batteries to replace LABs (The Daily Star, 2024).

Another noteworthy alternative is Nickel Cadmium (NiCd) batteries, which offer longer cycle life, higher energy densities, and lower maintenance requirements. Particularly suitable for applications requiring continuous or instantaneous power, NiCd batteries present a competitive replacement for lead-acid batteries, despite their larger size and inclusion of toxic metals. Additionally, Nickel Metal Hydride (NiMH) batteries, commonly used in hybrid vehicles, present an option with higher energy density and recyclability advantages over lead-acid batteries (Nair & Garimella, 2010; Van den Bossche et al., 2006).

Flow batteries, with liquid electrolytes stored in external tanks, prove highly scalable and suitable for grid-scale energy storage applications. Sodium-ion batteries, though still in early stages of development, emerge as a potential alternative due to the abundance and affordability of sodium (Skyllas-Kazacos et al., 2011; Soloveichik, 2015). Supercapacitors, known for high power density and rapid charging capabilities, are being explored for electric vehicles, offering a sustainable alternative to lead-acid batteries (Simon et al., 2014). Moreover, semi-natural/semi-synthetic substrates like paper show promise for rechargeable batteries, providing low-cost, lightweight, and eco-friendly options, although challenges such as cycling instabilities and limited capacities need to be addressed.

While these alternatives showcase the potential for eco-friendly and cost-effective solutions, barriers include concerns about environmental impact, recycling processes, and in some cases, toxicity. Collaborative efforts between the government, industry stakeholders, and research institutions are essential to overcome these challenges and facilitate the widespread adoption of alternative battery technologies, contributing to a more sustainable e-rickshaw ecosystem in Bangladesh.

5.

Analysis of Relevant Policies in Bangladesh

5.1. Stakeholders Involved in the ULABs Industry

ULABs directly and indirectly involve various stakeholders, including manufacturers, retailers, users/consumers, recyclers, regulatory bodies and funding agencies. Formal and informal sectors and systems are involved in the supply chain of ULABs in Bangladesh. Figure 4 shows the key relevant actors involved in the battery sector. In addition to the selected key stakeholders, local communities affected by the pollution of the LAB and relevant non-government organizations (NGOs) are also key actors in ULABs.

← Figure 4. The selected key relevant actors (direct, indirect, and potential) involved in the ULABs in Bangladesh

5.1.1. Manufacturers and Retailers

In the LAB market space, both formal and informal manufacturers and retailers co-exist and complete each other since they both offer unique services to their customers. Formal manufacturers and retailers like Rahimafrooz Batteries Ltd, Panna Battery Ltd and Khorshed Metal Industries (HAMKO Group) have a higher market penetration with high quality and a variety of battery options, which are often better compared to the batteries available in the local informal market. International manufacturers, particularly from China, have been establishing their manufacturing and recycling facilities in Bangladesh using both formal and informal systems (around 30 illegal Chinese companies were reported), which has led to recent price competition in the local market (Hasan, 2019). In addition, the Accumulator Battery Manufacturer and Exporter Association of Bangladesh (ABMEAB) needs to be taken into consideration while addressing the issues and finding solutions.

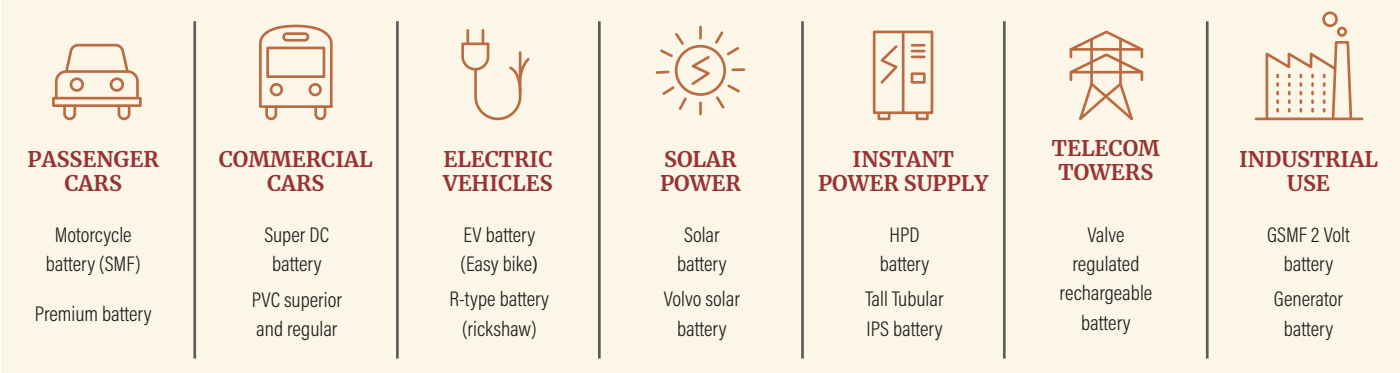
In addition, the informal manufacturers and retailers often offer additional services such as repairing and replacing acid within a reasonable price and in a shorter time, attracting the e-rickshaw owners/renters to use batteries offered by the informal manufacturers. A recent study claimed that around 70% of the local demand for LABs is met by informal manufacturers, including unregistered, non-compliant and clandestine battery factories (Babu, 2020).

5.1.2. ULABs Waste Generators

The automotive industry, particularly e-rickshaws (motorized three-wheelers with a capacity of two passengers) and easy bikes (motorized three-wheelers with a capacity of 3 or more passengers) stands as the primary consumers of Used Lead-Acid Batteries (ULABs) in Bangladesh. Furthermore, ULABs find applications in various sectors, such as the renewable energy sector, specifically in solar power systems, as well as in instant power supply (IPS), telecommunication systems, and industrial usage. Figure 5 visually illustrates the diverse areas where ULABs are utilized, showcasing their significance in supporting not only the automotive sector but also in powering renewable energy solutions and other critical applications across various industries in Bangladesh.

↓ Figure 5. Sectors use the ULABs in Bangladesh

Source: Pure Earth, 2020



5.1.3. Battery Recyclers and Smelters

Regarding ULAB waste in Bangladesh, the major contributors are easy bikes, constituting approximately 76% of the total ULABs waste generation (UNEP, 2020). This is followed by solar home systems (SHS), motorcycles, automotive cars, vans, taxis, telecom equipment, e-rickshaws, and buses (). The market is served by both formal recyclers, including local and international entities (such as Chinese and Korean firms), and informal recyclers and smelters. Adhering to local regulations, the recycling and smelting of Lead-Acid Batteries (LABs) necessitate high levels of safety and environmental compliance. However, informal recyclers currently operate in an environment lacking strict monitoring of existing regulatory policies. This dynamic highlights the need for enhanced regulatory oversight to ensure the safe and environmentally responsible recycling and smelting of LABs in the country.

5.1.4. Regulatory Bodies

The recycling of Lead-Acid Batteries (LABs) and ULABs involves a complex network of regulatory bodies crucial for ensuring environmental sustainability and compliance with local and international standards. These include the Department of Environment, overseeing aspects such as environmental clearance, pollution control, and waste management. The Ministry of Environment, Forest and Climate Change is pivotal in formulating international and local policies, including adherence to agreements like the Basel Convention. Other regulatory bodies contributing to the comprehensive oversight encompass the Ministry of Industry (managing export and import tariffs), the Ministry of Health and Family Welfare (addressing public health concerns), Local Governments- City Corporations and Municipalities, the Bangladesh Road Transport Authority (BRTA), the Ministry of Power, Energy and Mineral Resources (focused on the renewable energy sector), the Bangladesh Standards & Testing Institution (BSTI), the National Board of Revenue (NBR), and the Ministry of Commerce. Additionally, law enforcement organizations, such as the police, Rapid Action Battalion (RAB), and Mobile Courts (Mobile Court Act 2009) play integral roles in enforcing regulatory measures related to lead-acid battery recycling.

5.1.5. Funding Bodies

Funding bodies are important to facilitate the recycling of lead-acid batteries, encompassing a diverse range of entities. Public finance organizations, including public banks, alongside private institutions such as private banks, and non-governmental organizations engaged in microfinancing, are important agents in capital supply. Moreover, the sector involves various local private businesses and attracts investments from both local and international sources, such as Chinese investors. Notably, multilateral development banks (MDBs), including but not limited to the Asian Development Bank (ADB) and the Asian Infrastructure Investment Bank (AIIB), have loan instruments suitable for the ULAB sector. The ADB, for example, is a key source of external assistance for public sector loans, notably in the transport and energy sectors of Bangladesh, providing $2 billion on average every year since 2016 (ADB, 2022). The commitments from ADB under the co-financing model as loans, grants, guarantees, technical assistance (TA), and equity investments in various public sector projects.

5.1.6. Affected Communities and NGOs

Concerned communities and non-governmental organizations (NGOs) play a crucial role in addressing the environmental and social impacts associated with ULABs. As actors involved and affected by the disposal and recycling of these batteries, affected communities often bear the brunt of environmental pollution and health risks. NGOs actively engage in advocacy, awareness campaigns, and community empowerment initiatives to address the challenges posed by the improper handling of batteries. These organizations (e.g. Bangladesh Environmental Lawyers Association-BELA) work towards holding industry stakeholders accountable for sustainable and responsible disposal practices. By fostering community involvement, raising awareness about the dangers of lead exposure, and advocating for stricter regulations, concerned communities and NGOs contribute to mitigating the adverse effects of used lead-acid batteries on both the environment and public health.

5.2. Regulatory Landscape and Policies Related to ULABs

Bangladesh's regulatory landscape and relevant policies related to ULABs in Bangladesh follow the following judicial sources:

1. Laws/Acts
2. Rules
3. Guidelines
4. Government Orders/Circulation

In addition, there are international regulations (such as the Basel Convention) and local government practices that are relevant to the regulatory landscape of recycling ULABs in Bangladesh.

5.2.1. Relevant Regulatory Policies for ULABs

In Bangladesh, similar to many developing countries, the recycling of Used-Lead Acid Batteries (ULAB) often takes place through informal channels, where safety and environmental regulations are not effectively enforced. Improper disposal of ULABs has led to significant environmental pollution by releasing toxic substances like lead, sulfuric acid and other hazardous chemicals into soil and water bodies. To address these challenges, several policies have been implemented.

Table 4. Relevant Regulatory Policies in Recycling ULABs in Bangladesh

Types of regulations	Relevant regulatory policies	Scopes and notes
Laws/Acts	**Bangladesh Environment Conservation Act** 1995, amended in 2010	The Act is to provide for the conservation of the environment, improvement of environmental standards and control and mitigation of environmental pollution.
	Bangladesh Environment Court Law 2010	This Act allows the government to take necessary legal action against any parties who create environmental hazards/ damage to environmentally sensitive areas as well as human society.
	The Bangladesh Labour Act 2006 (Act No. XLII of 2006)	It covers health, safety, welfare and working conditions and the environment of workers and apprenticeship.
	Electricity Act 2018 (Law No. 7 of 2018)	It outlines the penalty for electricity theft, which is about 3 years of jail or double the payment of electricity price and/or 50,000tk for non-commercial and industrial use, and it could be about 3 years of jail or double the payment of electricity price and/or 5,00,000tk for industrial and commercial purposes.
	Bangladesh Public-Private Partnership Act 2015 (Act No. 18 of 2015)	An Act to provide for the legal framework for the creation of public-private partnerships by involving private sector participation along with public sector and attracting local and foreign investment upon connecting Bangladesh.

Types of regulations	Relevant regulatory policies	Scopes and notes
Rules	**Environment Conservation Rules,** 2023 (SRO No. 53)	This Rule aims to ensure sustainable development and prevent environmental degradation in Bangladesh by regulating activities that may adversely impact the environment and human health.
	Solid Waste Management Rules 2021	Specific sub-clauses have been added to the Solid Waste Management Rules 2021 to properly manage solid waste. Extended Producers Responsibility (EPR) has been included in the rules for the first time in Bangladesh.
	Hazardous Waste (e-waste) Management Rules 2021	The Rules set a goal of managing at least 50% of e-waste in 5 years and negotiating with the World Trade Organization (WTO) since the rule required the manufacturer and importer to collect and manage e-waste.
	Hazardous Waste and Ship-Breaking Waste Management Rules 2011	Which lists the hazardous waste, including Used Lead acid batteries whole or crushed (A1160) or any lead and lead compound.
Government Order Circulation	**The Lead-Acid Battery Preparation, Regeneration, Import, and Utilization Regulations Circulation** (S.R.O. No. 45-Law 2021)	The circulation put conditions for relevant stakeholders, actors to follow the regulations.
	Hazardous Waste (e-waste) Management Circulation 2021 (SRO 187, Act 2021)	The circulation put conditions for relevant stakeholders, actors to follow the regulations.
International Laws	**The Basel Convention** **The Rotterdam Convention**	Comply with the Basel and Rotterdam requirement and to prepare a coherent national strategy and action plan for the Environmentally Sound Management (ESM) of ULAB in Bangladesh. The Basel Convention Training Manual for the preparation of National Plans for the ESM of ULAB (including licensing, assessment of H&S, medical surveillance and site assessment.
Local Government	**DNCC/ DSCC/ City Councils/ Municipalities etc.**	The local governments' waste management practices and initiatives.
Others	**Integrated Energy and Power Master Plan 2023**	The Integrated Energy and Power Master Plan (IEPMP) 2023 (MPEMR, 2023) developed by the Ministry of Power, Energy and Mineral Resources, which outlines 50% of electric vehicles by 2050.
	Policy Regarding Special Tariff and Benefits	The Ministry of Industry, this policy aims to transition the majority of passenger cars, buses, trucks, and 3-wheeler auto rickshaws to Electric Vehicles (EVs) by 2030.
	BRTA Draft Policy (2021) to expedite the import and domestic manufacturing of EVs	However, e-rickshaws do not fall under the e-vehicle category due to their lack of safety measures.

A BRIEF DESCRIPTION OF THE RELEVANT POLICIES

Policy Regarding E-waste and Hazardous Waste

- In February 2021, the Ministry of Environment, Forest and Climate Change (MoEF) of Bangladesh issued an order (S.R.O No. 45-Act/2021) on battery recycling under the Bangladesh Environment Conservation Act, 1995. Key provisions of the act include that companies engaged in the production and recycling of lead-acid batteries shall designate agents and collection agents for used batteries. Additionally, companies must obtain a No Objection Certificate (NOC) from the Department of Environment (DoE) to obtain a license to import lead-acid batteries. The importer must also sign a contract with a battery recycling company.

- On June 10, 2021, Bangladesh's Department of Environment (DOE) published the Hazardous Waste (e-waste) Management Rules, 2021, under the Bangladesh Environmental Protection Act, 1995 (DoE, 2021). The Rules outline the role and responsibility of various stakeholders in the supply chain and management of e-waste, including manufacturers, retailers, buyers/sellers, exports, imports, stockpile, disposal, repair and recycling and transportation. (including lead-acid batteries from households)

- Environment officials in Bangladesh have enforced rules from 2011 related to "Hazardous waste and ship-breaking waste management" when dealing with battery recyclers. These rules classify residue (such as lead ash or particulates from flue gas) from secondary lead production as "Hazardous Waste." Following the Basel Convention guidelines from 1989, which identify lead as a hazardous chemical, these regulations mandate parties involved in battery recycling to adopt sustainable environmental practices and regularly disclose information about the recycling process, quantities recycled, and environmental impacts.

- The Department of Environment (DoE) published a gazette in July 2006 regarding battery recycling. This gazette provides guidelines for effective battery recycling activities, prohibiting the haphazard storage or breaking of lead-acid batteries without obtaining an Environmental Clearance Certificate. It also recommends that used batteries should only be sold or returned to DoE-approved battery buyers and dealers who follow DoE-approved recycling facilities.

Public Health and Environmental Exposure

Bangladesh Environmental Conservation Act, 1995 (Amendment, 2010)

It incorporates the protection of public health from hazardous materials into existing national legislation through amendments of the new regulation on ULABs recycling and lead phase-out as follows:

- Incorporation of the provision for keeping records of current stocks of lead in industries in the Hazardous Waste and Ship-breaking Waste Management Rules, 2011

- Include the products listed in the national inventory of lead-containing products.

Bangladesh Environment Court Law 2010

To foster the enforcement of the environmental laws in Bangladesh, this Act allows the government to take necessary legal action against any parties who create environmental hazards/ damage to environmentally sensitive areas as well as human society.

- Environmental Conservation Rules, 1997 (Amended 2011: Hazardous Waste and Ship-Breaking Waste Management Rules 2011)

It sets industry-specific gaseous emission standards for lead, including standards for Exhaust of automobiles, Ship Breaking sectors, Turmeric containing lead from soil, Lead containing product burning, Additives as pigments in Industrial Paints, Fertilizer, Pesticides and Biocides, Metal plating, finishing operations, Leaching from ULABs and Battery manufacturing, Lead/ULABs contaminated sites, waste from small and medium manufacturing facilities should be listed in SCHEDULE – 1, 10, 11 and 12.

Policy Regarding e-mobility in Bangladesh

- The policy of e-mobility focuses on establishing charging stations, defining tariffs for electricity consumption, establishing technical standards for charging stations, and streamlining the institutional arrangements for charging permissions.

- Formulated in accordance with section 124 of the Road Transport Act 2018, this policy allows the legal registration of motorised vehicles powered by electric motors in the country. This policy simplifies the EV registration process and provides registration for three-wheelers.

Energy and Power Master Plan

The Integrated Energy and Power Master Plan (IEPMP) 2023 (MPEMR, 2023) developed by the Ministry of Power, Energy and Mineral Resources outlines 50% of electric vehicles by 2050 (40% passenger vehicles and 10% buses and trucks) under the advanced technology scenario and around 100% of electric vehicle under the net zero scenario for Bangladesh. However, both scenarios in the Master Plans exclude the e-rickshaws.

Policy Regarding Special Tariff and Benefits

- Under the Ministry of Industry, the policy regarding special tariffs and benefits aims to transition the majority of passenger cars, buses, trucks, and 3-wheeler auto rickshaws to Electric Vehicles (EVs) by 2030. The proposals include Providing a tax holiday till 2040 for local EV assembly and manufacturing (TBS, 2024). Offering financial incentives, purchase subsidies, waivers of road tax and EV registration fees, and reductions in VAT/Import Duty. Encouraging the establishment of battery recycling industries and charging station networks. Establishing an EV Cell within the Bangladesh Road Transport Authority. Creating an "Energy-Efficient Vehicle Manufacturing Fund" funded by fines and taxes collected from environmentally harmful vehicles. In addition, there would be no tax if the EV power stations run on solar energy, and there would be a lower registration fee for the EVs (TBS, 2024).

- In July 2019, the Bangladeshi Government issued a Statutory Regulatory Order (SRO 176/2019/33) to promote the local assembly of affordable passenger vehicles and develop a new vehicle market. This SRO exempts VAT/supplementary duty on imported parts and materials for Completely Knocked Down (CKD) assembly of passenger vehicles below 1600cc, subject to meeting specific conditions such as local value addition, employment of local workers, and significant investment within a year.

Policy Regarding Labor

- The law and the Rules require the employer to ensure that waste is disposed of in a safe and orderly manner; provide safety equipment to the workers; require the employer to obtain a clearance certificate from the relevant authorities, and follow the Environmental Compliance Act 1995 (ECA 1995) for environmental management, including Hazard Exposures Mitigation, Training Sessions and Hazard Minimization Options.

- National Child Labor Elimination Policy 2010. This policy was introduced with the goal of eliminating risky child labour by 2021 and all other types of child labour by 2025 (LSE, 2023). In addition, the Ministry of Labour and Employment 2021 (Ministry of Labour and Employment, 2021) published the National Plan of Action to Eliminate Child Labour (2021-2025).

BRTA Draft Policy (2021)

• BTRA draft policy to expedite the import and domestic manufacturing of EVs. However, e-rickshaws do not fall under the e-vehicle category due to their lack of safety measures.

International- Basel Convention

• Used lead acid batteries contain lead, sulfuric acid and lead dioxide which are hazardous and fall under the Basel Convention. They are controlled by transboundary movements of waste destined for recovery operation or final disposal. Bangladesh became a signatory country to the Basel Convention on April 01, 1993.

5.2.2. Policy Gaps and Challenges

The policy gaps in e-mobility in Bangladesh are apparent, particularly in the administration and implementation of Lead-acid batteries (LABs) and Used Lead-Acid batteries (ULABs) rules. Loopholes in the Lead-acid Battery Recycling and Management Rules, 2006 create challenges, highlighting the need for a comprehensive regulatory framework. The government has the authority to address this gap under the Bangladesh Environment Conservation Act 1995 (BECA), Section 20(C), allowing the establishment of safe procedures for the use, storage, and transportation of hazardous substances. The BECA also outlines the penalty for violating the rules, which can cause imprisonment of a maximum of 10 years or fines up to 10 lac (USD[1] 9,113) or both or a lesser penalty depending on the violation. However, there are very few examples of executing these penalties for poor management and violation of the rules. While this provision sets certain standards for lead battery use, disposal, and retailing, there is a critical need for stricter monitoring and enforcement of the regulations to ensure proper administration and implementation.

Used Lead-Acid Batteries (ULABs) contain toxic ingredients such as lead and dilute sulfuric acid, which are essential for safe handling. However, the lack of proper regulation in Bangladesh poses a significant environmental and public health risk. Current recycling practices in the country are far from eco-friendly, with informal industries conducting dismantling operations in an unsafe and dangerous manner. This necessitates the development and enforcement of stringent regulations to ensure responsible and environmentally sustainable ULABs recycling practices.

The Statutory Regulatory Order (SRO) promulgated by the Ministry of Environment, Forest, and Climate Change in 2021 (SRO No 45-Act/2021) on the recycling of ULABs also appears to have limitations, as it does not specify the quality of the recycled ULABs and the methods for verifying the standard of the recycled ULABs by any competent authority. Consequently, raising or maintaining the standard of recycled ULABs could prove challenging.

Under the Hazardous Waste (e-waste) Management Rules, 2021, any person/company involved in e-waste management is required to be enlisted at the DoE, and the department will register all enlisted e-waste management companies and the relevant information electronically. DOE has the right to hold and withhold the registration and all relevant stakeholders need environmental clearance from the Department. A maximum of 180 days is allowed for a stockpile of e-waste. The Rules also set e-waste collection targets of 10% in the first year and a maximum of 50% in the fifth year (2026). The main discrepancy between the rules is this doesn't include e-waste from transportation or e-mobility like e-rickshaws but rather from households. Without a clear classification of e-waste (e.g. households, industrial -transport, etc.) the e-waste collection and target could provide misleading information. For example, batteries containing lead used in the household (IPS) may not return to the formal recycling channel and thus be excluded from the targets.

1 1 USD=110 BDT

The inadequacies extend to the management of laboratory tests and ULABs, where a lack of proper administration and implementation is observed. The majority of the informal recycled ULABs lack the expected level of efficiency. The inefficient batteries made by informal recyclers and manufacturers put extra pressure on the grid system, leading to energy losses and unnecessary economic burdens on direct stakeholders and on the country as a whole.

Additionally, the absence of an age limit for working in ULABs processing units raises concerns about the well-being of the workforce. The implementation of an age limit outlined by the National Child Labour Elimination Policy 2010 is crucial for ensuring the safety and health of workers in this hazardous industry. Furthermore, the absence of a defined public health and environmental exposure measurement procedure or safety clause underscores the need for a more unified regulatory framework to protect both the workforce and the environment.

The Bangladesh Road Transport Act 2018 does not define e-rickshaws as a mode of transport. Although electric vehicles (EVs) are defined at the beginning of the law in the definition segment, there is no specific definition for electric three-wheeler rickshaws. Bangladesh's Integrated Energy and Power Master Plan (IEPMP) 2023 outlines the targets of 50% EV by 2050, which excludes the e-rickshaws (MPEMR, 2023). Additionally, in alignment with this Act, the Ministry of Industry of Bangladesh has not yet acknowledged or formalized the manufacturing/assembling of e-rickshaws and its backward linkage industry. Furthermore, the Ministry of Industry has not officially recognized ULABs Recycling as a formal industry. Such recognition is crucial as it paves the way for the government to enact and enforce targeted policies and legislation.

The BRTA Draft Policy (2021), focusing on expediting the import and domestic manufacturing of Electric Vehicles (EVs), reveals a significant policy gap by excluding e-rickshaws from the electric vehicle category due to perceived safety concerns. This omission neglects the crucial role of e-rickshaws in sustainable urban transportation, hindering their contribution to reducing carbon emissions and traffic congestion, contrary to the country's eco-friendly transportation goals. To address this gap, there is a need for a more nuanced approach, defining specific safety measures rather than outright exclusion, fostering collaboration with manufacturers for safety enhancements, and recognizing e-rickshaws as integral to the broader electric vehicle ecosystem. Failure to include e-rickshaws in the electric vehicle framework may impede the growth of the electric mobility sector in Bangladesh, hindering the potential for comprehensive policies and incentives that could drive sustainable development in e-mobility across various modalities of vehicles.

Due to a lack of a clear standpoint from the government on e-rickshaws, confusion arises due to actions taken by different authorities. For instance, the BRTA and the Ministry of Power aim to curb e-rickshaws as they are considered unpermitted and illegal electricity users. Several enforcement activities have been undertaken to seize and discard e-rickshaws in Dhaka and other major cities. However, considering the limited employment opportunities for marginalized individuals, the High Court has permitted the use of e-rickshaws within city limits while prohibiting them only on highways. Despite the High Court's permission for city operations, the Road Transport Authority does not recognize them at all.

One of the fundamental challenges is the lack of commitment and funding, hindering the development of a National Chemical Profile- which provides information to assess the country's current situation in terms of effectively managing chemicals with a reference or baseline data and the fulfilment of the country's obligations under the Basel Convention. This not only reflects a gap in resource allocation but also highlights the need for a strong commitment from the government to address the environmental and health implications of e-mobility practices. Bridging these policy gaps requires a collaborative effort between government agencies, industry stakeholders, financial institutions and environmental organizations to establish and enforce regulations that prioritize sustainability, safety, battery quality, human health and environmental well-being in the growing field of e-mobility in Bangladesh.

6.

Conclusions and Recommendations

6.1. Summary of the Findings

The juxtaposition of e-mobility, particularly e-rickshaws, providing a crucial informal economy for the marginalized poor in Bangladesh, and the inadequate management and informal recycling of used lead-acid batteries (ULABs), pose a dual challenge. While millions depend on the lead-acid battery supply chain for their livelihoods, spanning manufacturing, use, recycling, and re-manufacturing, this reliance carries substantial risks to public health, particularly for vulnerable groups such as women and children.

The informal recycling sector, though integral to livelihoods, contributes significantly to environmental pollution due to improper practices and the use of low-quality lead. This inefficiency exacerbates the country's energy demand compared to the more structured formal and industrial-grade lead-acid battery sector. The ULAB sector's complexity is heightened by the involvement of diverse stakeholders, including manufacturers, retailers, consumers, recyclers, regulatory bodies, funding agencies, and local communities.

Operating under both formal and informal systems, with participation from local and international entities, the ULABs sector faces challenges in implementing sustainable practices in manufacturing and recycling. Despite implementing policies addressing ULABs-related issues, substantial gaps in administration and implementation persist, resulting in environmental degradation and health hazards. Balancing the economic importance of the ULABs sector with the imperative for sustainable and responsible practices remains a critical challenge for Bangladesh.

The lack of homogeneousness and holistic integration of the relevant regulatory policies is the key challenge when it comes to managing ULABs more effectively. The following are the key discrepancies in the regulatory policies:

i. The Road Transport Act 2018 doesn't include e-rickshaws as part of e-mobility. Thus, the e-rickshaw sector lacks clear policies in relation to fostering e-mobility in Bangladesh.

ii. Hazardous Waste (e-waste) Management Rules, 2021 only consider household lead batteries and thus, ULABs generated from e-rickshaws are not part of the hazardous waste management, while it is the same battery technology that is used in the household (e.g. IPS) and e-rickshaws

iii. The BRTA Draft Policy (2021) focuses on expediting the import and domestic manufacturing of Electric Vehicles (EVs); however, it excludes existing and important e-rickshaws as part of e-mobility solutions in Bangladesh.

iv. Sustainable management of lead-acid batteries falls under multiple regulations and rules such as the Bangladesh Environment Conservation Act, 1995 (amend 2010), Hazardous Waste (e-waste) Management Rules, 2021, Basel Convention (1993) and so on. Unfortunately, they lack homogeneousness and holistic integration of the relevant regulatory policies, and thus, they often create loopholes for mismanagement.

v. Lack of integration between national (Ministry, Department, etc.) and local government organisations (councils, city corporations, municipalities, etc.) and regulatory enforcement bodies (police, RAB, Mobile Court, etc.) while monitoring and enforcing the relevant regulations.

vi. Trade-related aspects play an important role in inducing domestic recycling of ULABs. The high total tax incidence to import lead metal into the country (31%), LABs (89%) and ULABs (58%) create a domestic market insulation in Bangladesh that makes it difficult for foreign high-quality battery producers to compete in the local market. The high import barriers also induce significant levels of domestic recycling, often employing unsustainable practices.

vii. Informal sectors play a significant role in the waste management sector in Bangladesh, and none of the regulatory roles acknowledge and propose any specific guidance on how to integrate them into a formal waste management system.

6.2. Key Recommendations

As Bangladesh lacks a well-developed regulatory system and national ULABs management guidelines, it is important to implement appropriate legislation on the handling, transporting, and end-life management of batteries. Some recommendations in this direction:

i. Establish a harmonised regulatory framework which is homogeneous and integrated with all regulatory policies related to the management of lead-acid batteries. These include the energy sector, transportation, and child labour, which are also indirectly related to the sector that needs to be integrated to foster the e-mobility of the poor with sustainable management of ULABs in Bangladesh.

ii. Recognise the role of e-rickshaws as part of the national e-mobility policy and provide clear guidance on how to overcome current challenges (e.g. energy theft, safety issues, etc.).

iii. Provide clear messaging and clear communication to all relevant stakeholders on the plan for the future of e-rickshaws (controlled/restricted/banned) and the management of ULABs (relevant regulations, guidance and penalties for both formal and informal sectors) through the digital available platforms.

iv. The recycling of ULABs should prohibit the involvement of children under the age of 18 and vulnerable women (e.g. pregnant women).

v. Foster business opportunities for both informal and formal recycling of ULABs with appropriate support and incentives for sustainable practices from governmental bodies, as well as measures to increase the availability and use of higher-quality and/or more modern batteries in Bangladesh's internal market.

References

Alamgir, H. (2022). Impact of ban on battery-run rickshaws in districts. The Financial Express. Retrieved from https://thefinancialexpress.com.bd/views/columns/impact-of-ban-on-battery-run-rickshaws-in-districts-1643812426

Al-Amin, M., & Sahabuddin, M. (2023). High penetration of electric autorickshaw on national power system and barriers against the adoption of solar energy: A case study in Bangladesh. ScienceDirect. Retrieved from https://www.sciencedirect.com/science/article/pii/S2666790823000423

Asian Development Bank-ADB. (2024). ADB's Work in Bangladesh. Retrieved from https://www.adb.org/

Babu, M. U. (2020). 70% local battery market in hands of clandestine factories. The Business Standard. Retrieved from https://tbsnews.net/interviews/70-local-batterymarket-hands-clandestine-factories-39291

Bangladesh Bank. (2022). Sustainable Finance Department. Retrieved from https://www.bb.org.bd/mediaroom/circulars/gbcrd/jul242022sfd04.pdf

Batteiger, A., & Rotter, V. S. (2018). Material implications of rural electrification—a methodological framework to assess in-use stocks of off-grid solar products and EEE in rural households in Bangladesh. Recycling, 3(1), 7. https://doi.org/10.3390/recycling3010007

Brossmann, M. (2013). Off-grid rural electrification and fighting poverty: A comparative impact assessment of solar home systems and small solar home systems in rural Bangladesh. Global Studies Working Papers of the Tübingen Institute of Geography, 19. Retrieved from http://hdl.handle.net/10900/50005

Coherent. (2024). E-rickshaw market size and share analysis - growth trends and forecasts (2023 - 2030). Retrieved from https://www.coherentmarketinsights.com/industry-reports/e-rickshaw-market

Custom Market Insights. (2022). Global Electric Rickshaw Battery Market 2023–2032. Retrieved from https://www.custommarketinsights.com/report/electric-rickshaw-battery-market/

DoE. (2021). Bangladesh Gadget on the Hazardous Waste (e-waste) Management Rules. Retrieved from https://resource.chemlinked.com.cn/617/%E5%AD%9F%E5%8A%A0%E6%8B%89.pdf

FBI. (2023). Electric three-wheeler market. Fortunate Business Insights. Retrieved from https://www.fortunebusinessinsights.com/electric-three-wheeler-market-105028

Grey, C. P., & Tarascon, J. M. (2017). Sustainability and in situ monitoring in battery development. Nature Materials, 16(1), 45-56.

Habib, A. K. M. A., Motakabber, S. M. A., & Ibrahimy, M. I. (2019). A comparative study of electrochemical battery for electric vehicles applications. In Proceedings of the 2019 IEEE International Conference on Power, Electrical, and Electronics and Industrial Applications (PEEIACON), Dhaka, Bangladesh, 29 November–1 December 2019 (pp. 43–47).

Hasan, M. (2019, September 12). Bangladeshi battery busting boundaries: 25 local companies now exporting to 70 countries. Dhaka Tribune. Retrieved from https://www.dhakatribune.com/business/187180/bangladeshi-battery-busting-boundaries-25-local

Hwang, J. Y., Myung, S. T., & Sun, Y. K. (2017). Sodium-ion batteries: Present and future. Chemical Society Reviews, 46(12), 3529-3614.

IDLC. (n.d.). Green Financing Scheme. Retrieved from https://web.idlc.com/uploads/downloadable_file/green-refinancing-scheme-635586.pdf

Irimia-Vladu, M. (2014). "Green" electronics: Biodegradable and biocompatible materials and devices for sustainable future. Chemical Society Reviews, 43(2), 588-610.

Janoschka, T., Hager, M. D., & Schubert, U. S. (2012). Powering up the future: Radical polymers for battery applications. Advanced Materials, 24(48), 6397-6409.

Li, L., Ge, J., Chen, R., Wu, F., Chen, S., & Zhang, X. (2010). Environmental friendly leaching reagent for cobalt and lithium recovery from spent lithium-ion batteries. Waste Management, 30(12), 2615-2621.

Lin, C., Paengsri, P., & Yang, Y. (2023). Impact of China's National Sword Policy on Waste Import: A difference-in-differences approach. Economic Analysis and Policy, 78, 887-903.

London School of Economics-LSE. (2023). Policies and plans for workers' protections in Bangladesh. Retrieved from https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2023/05/Annexe-1.-Policies-and-plans-for-workers-protections-in-Bangladesh.pdf

Maximize Market Research. (2023). E-Rickshaw Market: Global Industry Analysis and forecast (2023-2029). Retrieved from https://www.maximizemarketresearch.com/market-report/global-e-rickshaw-market/72844/

Medium. (2023, November 27). Reducing Air Pollution: How Best E-Rickshaws Can Benefit the Environment. Retrieved from https://anikaarickshaw.medium.com/reducing-air-pollution-how-best-e-rickshaws-can-benefit-the-environment-d0cf96642866

Ministry of Labour and Employment. (2021). National Plan of Action to Eliminate Child Labour (2021-2025). Retrieved from https://dife.portal.gov.bd/sites/default/files/files/dife.portal.gov.bd/publications/

Ministry of Power, Energy and Mineral Resources. (2023). Integrated Energy and Power Master Plan (IEPMP) 2023. Retrieved from https://powerdivision.portal.gov.bd/

Muzir, N. A. Q., Mojumder, M. R. H., Hasanuzzaman, M., & Selvaraj, J. (2022). Challenges of electric vehicles and their prospects in Malaysia: A comprehensive review. Sustainability, 14, 8320.

Nair, N. K. C., & Garimella, N. (2010). Battery energy storage systems: Assessment for small-scale renewable energy integration. Energy and Buildings, 42(11), 2124-2130.

Nurunnahar, S., Islam, M. S., & Rahman, M. (2022). Public Health Challenges, "Electric vehicles in Bangladesh: Impact on the environment, mobility, and the economy of an impending ban".

Pure Earth. (2020). Assessment of Informal Used Lead Acid Battery Recycling and Associated Impacts in Bangladesh.

Rahman, S. (2023). Vicious toxic lead cycle: Illegal lead battery factories, pollution, and unauthorized. The Business Standard. Retrieved from https://www.tbsnews.net/features/panorama/vicious-toxic-lead-cycle-illegal-lead-battery-factories-pollution-and-unauthorised

Saxena, S. N. (2019). Two- and three-wheeler electric vehicles in India—Outlook 2019. International Journal of Electrical Engineering and Technology, 9(13).

Simon, P., Gogotsi, Y., & Dunn, B. (2014). Where do batteries end and supercapacitors begin? Science, 343(6176), 1210-1211.Skyllas-Kazacos, M., Chakrabarti, M. H., Hajimolana, S. A., Mjalli, F. S., & Saleem, M. (2011). Progress in flow battery research and development. Journal of the electrochemical society, 158(8), R55.

Soloveichik, G. L. (2015). Flow batteries: Current status and trends. Chemical Reviews, 115(20), 11533-11558.

TBS. (2021, June 20). Govt to ban motorised rickshaw. TBS Report. Retrieved from https://www.tbsnews.net/bangladesh/govt-ban-motorised-rickshaw-263680

TBS. (2024, March 20). Duty cuts in plan to promote electric vehicles. Retrieved from https://www.tbsnews.net/bangladesh/transport/duty-cuts-plan-promote-electric-vehicles-811858

The Daily Star. (2024, February 8). 'Tesla of Bangla': Nasrul Hamid defends battery-run three-wheelers. Retrieved from https://www.thedailystar.net/environment/natural-resources/energy/news/tesla-bangla-nasrul-hamid-defends-battery-run-three-wheelers-3539466

Ullah, G. W., & Islam, A. (2017). A case study on Pathao: Technology-based solution to Dhaka's traffic congestion problem. Case Studies in Business and Management, 4(2), 100-108.

UNEP. (2020). Inventory of Lead Acid Batteries and Used Lead Acid Batteries in Bangladesh. Prepared by the International Lead Association for UNEP. Retrieved from https://www.unep.org/resources/assessment/inventory-lead-acid-batteries-and-used-lead-acid-batteries-bangladesh

UNICEF and Pure Earth. (2020). The Toxic Truth: Children's Exposure to Lead Pollution Undermines a Generation of Future Potential. UNICEF and Pure Earth. Retrieved from https://www.unicef.org/reports/toxic-truth-childrens-exposure-to-lead-pollution-2020

Van den Bossche, P., Vergels, F., Van Mierlo, J., Matheys, J., & Van Autenboer, W. (2006). SUBAT: An assessment of sustainable battery technology. Journal of Power Sources, 162(2), 913-919.

Van der Straeten, J. (2022). Sustainability's "Other". Historical Social Research/Historische Sozialforschung, 47(4), 139-167.

Weinert, J., Ogden, J., Sperling, D., & Burke, A. (2008). The future of electric two-wheelers and electric vehicles in China. Energy Policy, 36, 2544–2555.