Clean Mobility Adoption in Urban Freight Sector, Bihar

Clean Mobility Adoption in the Urban Freight Sector of Bihar

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This report on ‘Clean Mobility Adoption in Urban Freight Sector, Bihar is a part of an important activity that supplements the ongoing strategic interventions in the public and private mobility segment.

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MESSAGE

The adoption of clean mobility in Bihar's urban freight sector is crucial for reducing emissions and promoting sustainable transportation. Freight vehicles, although only 2% of on-road vehicles, contribute to nearly 40% of emissions, highlighting the need for a transition to electric vehicles (EVs). The Bihar Electric Vehicle Policy 2023 aims to achieve 30% e-mobility by 2030 by providing financial incentives and infrastructure support. However, commercial freight vehicles still rely heavily on diesel, mainly due to the lack of research on potential policy interventions to facilitate EV adoption. Addressing this gap is essential to curb emissions and improve air quality while ensuring efficient freight movement.

To accelerate the transition, Bihar needs targeted policies that support commercial EV adoption, expand charging infrastructure, and offer financial incentives for businesses to invest in clean mobility. Lessons from other Indian states and global practices, such as tax rebates, subsidies, and manufacturer incentives, can help drive change.. It is vital to evaluate the policy outcomes in terms of user perceptions, willingness to pay, and development methodologies to estimate expected market shares and intended benefits. By implementing measures that are supported by data-driven and cutting-edge research, Bihar can lead the way in clean urban freight mobility, fostering economic growth while achieving environmental sustainability.

This report summarizes the research project taken up by the Centre for Studies on Environment and Climate (CSEC) at the Asian Development Research Institute (ADRI) Patna in collaboration with the Indian Institute of Technology (IIT), Delhi. The project assessed the user perceptions of freight carriers and fleet managers on current operations and government policies and evaluated the drivers and barriers to adopting cleaner vehicle technologies. The findings, results, and mathematical models assist in strengthening the potential strategies for electrification of urban freight using an integrated approach to transit to zero-emission fuels for vehicles in the transport sector of Bihar. In addition, improving urban logistics efficiency requires predominant investments in research in demand-side interventions with an emphasis on rising e-commerce and on-demand deliveries, e.g., consolidation programs, smart parking management, and spatiotemporal staggering of freight deliveries to mitigate traffic congestion and pollution.

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1 Background

Urban freight plays an important role in propelling a state's economic development which also affects the urban environment and communities. With an increase in the urban population and growing e-commerce activities, the demand for freight movement in cities has increased rapidly. India possesses more than 2.8 million registered commercial vehicles that log over 100 billion kilometers per year. These vehicles make up a share of only about 2% of on-road vehicles but are responsible for about 40% of emissions and 33% of the fuel consumption recorded by road transport[1]. A NITI Aayog study reveals that 70% of goods and services are made available in India by utilizing roads and only 17.5% are done so through Railways[2].

The average annual registration trend in Bihar shows a decline of 4% in passenger vehicles, an increase of 14% in private vehicles, and a decline of 6% in commercial vehicles. These figures are for newly registered vehicles during the period of 2017-2022. In the category of all registered freight vehicles (Three-wheelers, Light Commercial Vehicles, Medium Commercial Vehicles, and Heavy Commercial Vehicles) between 2017 and 2022, 82% ran on diesel, 14% were electric, and 4% consumed CNG[3]. This indicates that most freight vehicles in Bihar run on diesel and are very old, which results in superfluous fuel consumption and alarmingly high tail-pipe emissions. The Bihar government has taken the lead for improving environment quality by reducing air pollution emanating from the transport sector.

In November of 2019, the government of Bihar floated the Bihar Clean Fuel Scheme to encourage the operation of CNG and battery-powered three-wheelers so as to rein in the pollution being generated by diesel vehicles in towns like Patna, Danapur, Khagaul and Phulwarisharif. Under the scheme, the government allocated a sum of Rs. 5 Crores in 2020-21 for incentivizing three-wheeler owners to retrofit three-wheelers with either CNG kits or battery packs. This resulted in a growth in the registration of battery-operated three-wheelers, which went from 3,576 in 2017 to 11,653 in 2019 and ultimately to 45,666 in 2022[4].

In December of 2023, the government of Bihar announced the Bihar Electric Vehicle (EV) Policy. The objective of this policy is to develop a manufacturing eco-system for e-vehicles in Bihar along with a support center in order to achieve the goal of 30% e-mobility by 2030. This Bihar EV Policy of 2023 seeks to ensure that 15% of new vehicles which are going to be purchased and registered by 2028 should be electric vehicles. A major focus has been on getting private four-wheeler and two-wheeler vehicles to go electric. The purchase incentive for buying four-wheeler electric vehicles is a maximum of Rs. 1.25 lakhs as well as a 75% rebate on Motor Vehicle Tax for the first 1000 vehicles. Furthermore, light electric

[1] Where are India's Electric Truck, ICCT https://theicct.org/ev-india-electric-trucks-may22/

[2] Fast Tracking Freight in India, NITI Aayog, 2021

[3] VAHAN SEWA Dashboard

[4] Vahan Dashboard

vehicles for carrying goods have been provided with a 50% rebate on Motor Vehicle Tax and exemption of permit fees during the policy period of five years. Additionally, the policy offers 75% purchase incentive for installing charging infrastructure consisting of slow, moderate, and fast charging points in public and semi-public spaces. The policy aims to install as many as 277 charging infrastructure (136 in the first three years and 141 in the next two) by different government institutions all over Bihar. The Bihar government is also executing a central government scheme titled “Faster Adoption and Manufacturing of Hybrid & Electric Vehicle, Phase-II (FAME-II)”. A total of 5,725 e-vehicles were added under Fame-II using incentives, out of which 5,250 were electric two-wheelers and e-rickshaws, while the remaining were public transport buses[5].

A number of other policy incentives by the Bihar government are also assisting the state to shift towards clean mobility. Along with policies, measures like leap-frogging from BS-IV norms to BS-VI norms are being marshalled to cut down pollutants emitted from vehicles. The state government promulgated its Ethanol Production Promotion Policy, 2021 to promote sustainable and alternative fuels and reduce fossil fuel dependency. This policy was launched to support the central government’s National Bio-Fuel Policy, 2018. The state government has approved the provision of either a capital subsidy of 15% of the cost of the plant or Rs. 5 crore, whichever is lower to the owner for setting up an ethanol plant.[6]

With these policies, Bihar is on a path which is shifting the state towards cleaner mobility, but this is not good enough to achieve the targets of Net Zero Carbon emission by 2040 and 30% e-mobility by 2030. Existing national policies like FAME I and II, tax rebates, and state-level policies are showing results by accelerating the pace of EV adoption amongst private vehicles. By leveraging successful policies on the subject of commercial vehicles and with more targeted interventions, Bihar can thrive by creating a shift towards clean mobility in the coming decades.

2 Introduction

Bihar has seen a significant growth of urban population in the past two decades by adding 199 new towns. It is also projected that Bihar will attain a 34% growth in urbanization by 2031[7], resulting in increased commercial activities and a more frequent movement of goods and services. The number of establishments in Bihar, including urban and rural, has grown from 3,94,043 in 2005 to 11,79,739 in 2022[8]. The growth of the urban population and establishments will lead to increased demand for transportation of goods and services. A transition to clean fuel in the urban freight sector holds the potential to reduce overall emissions from the transport sector by as much as 14% [9].

[5] National Automotive Board, 2021
[6] Ethanol Production Policy, 2021
[7] Bihar Economic Survey 2021-22, Finance Department, Govt. of Bihar.
[8] Directorate of Economics and Statistics, Govt. of Bihar
[9] Shakti Sustainable Energy Foundation, 2020

Bihar's transportation sector, which has a contribution of 10% in Bihar's GDP[10] presently, was also the second highest contributor of CO_2 emissions with a share of 12% (6.76 Mt of CO_2) in 2018[11]. The key factors pressurizing Bihar's transition towards cleaner alternatives include high oil prices, rising pollution levels due to vehicular emissions, overcrowded roads, high vehicle density, and commitment to achieve Net Zero Carbon Emission by 2040.

This study focuses on the transition of freight transportation from Internal Combustion Engine (ICE) vehicles to Electric Vehicles (EVs), delving into the underlying motivations, its current status, challenges, and potential advantages. By the means of a comprehensive analysis of case studies, existing research and baseline data, this report presents a well-rounded view of the advancements in the adoption of EVs. By pinpointing strategies to accelerate adoption and proposing solutions to tackle obstacles, the aim is to develop a comprehensive understanding of the characteristics of urban freight and the barriers to widespread adoption.

Although there are several bottlenecks to urban freight vehicles progressing from the ICE approach to EVs, the benefits include reduced air emissions, lower noise levels, greater driving comfort for drivers, and lower energy consumption and maintenance costs, thereby leading to an overall reduction in operating costs[12]. But the electrification of freight vehicles is also challenging due to the complex nature of the sector, which is characterized by informal operations, small vehicle fleets, and the presence of multiple stakeholders. Also, the public sector inhibits the decision-making process for transition of freight vehicles to EVs, thereby constraining the adoption rate.

Understanding and being able to forecast electric vehicle adoption patterns in the freight sector is critical to planning for future transportation issues in terms of capacity, vehicle operations, safety and security, energy, and investment needs. Many adoption forecasting models and data sources are actually more appropriate for passenger transport rather than for freight movements and understanding freight transport behavior. Creating baseline data and models is imperative for enabling policy makers to predict adoption rates and design better policies. The objective of the present study has been conceptualized with this backdrop in mind and presented in the next section.

[10] Bihar Economic Survey 2022-23
[11] Trend Analysis of GHG emission of Bihar, GHG Platform India
[12] Factors Influencing Electrification of Urban Freight Vehicles, H. M. Shivanand Swamy

3 Objectives

As this study supplements the ongoing strategic interventions in the public and private mobility segment, it has been envisaged that the transition possibilities in the commercial transportation sector be investigated further in order to achieve the following objectives: -

- To investigate the characteristics of commercial sector transportation in emerging economic hubs for the exchange of priority goods and services within the confines of and in between the cities of Bihar;
- To evaluate policy, technological, and infrastructural reforms required for transition in commercial sector transportation which will eventually engender overall ambient air quality at the city level or complement the research requirements of a pathway for transiting to low carbon in the state.

4 Literature Review

4.1 Role of the Transportation Sector in Economic Development

Bihar's Gross State Domestic Produce (GSDP) grew by 2.5% in 2020-21 and 10.98% in 2021-22. However, India's GSDP shrank by -7.25% in 2020-21 and grew by 8.68% in 2021-22. The per capita income of Bihar was Rs. 46,300 in 2020-21, which has grown to be Rs. 54,400 in 2021-22. The rapid rise of motorized mobility during the last two decades can be primarily attributed to rise in urbanization, improvement in road transport (including infrastructure), increasingly smoother exchange of goods and services from rural to urban areas and vice-versa in Bihar. The growth rate of the tertiary sector in Bihar recorded a decline of 6.7% during 2020-21 but increased to 13.3% in 2021-22. The primary sector saw a decrease of 4.8% in the growth rate in 2020-21, but this increased to 9.6% in 2021-22. Also, the secondary sector has shown a growth rate trend of being minus 4.9% in 2020-21 to 3.8% in 2021-22[13]. The structural composition of Bihar's economy is as follows: -

- Primary Sector: The agricultural sector had a growth rate of 8.4% in 2020-21, which went up to 9.6% in 2021-22. The mining sector has also shown an increasing trend in growth rate, going from -81.4% in 2020-21 to 7.5% in 2021-22.
- Secondary Sector: The manufacturing sector growth rate increased from minus 6.0% in 2020-21 to 1.2% in 2021-22. The construction sector increased from minus 7.0% in 2020-21 to 6.3% in 2021-22.

[13] Finance Department, G. o. (2022). Bihar Economic Survey 2021-22. Govt. of Bihar.

- Tertiary Sector: The trade sector increased from a minus 15.7% growth rate in 2020-21 to a 21.4% growth rate in 2021-22. The transport sector increased from a minus 13.4% growth rate to a 20.4% growth rate from 2020-21 to 2021-22.

The average annual growth rate of the agriculture and allied sector is 5% over the five-year period of 2017-18 to 2021-22. It has a contributed a 20% share in the Gross State Value Addition. Livestock and fisheries are the most important growth-driving sectors, growing at 10% and 7% respectively from 2018-22. The annual growth rate of individual industrial sectors like mining and quarrying, manufacturing, and construction has been fluctuating. Sugar and dairy industries are two major industrial sectors among agro-based industries as these industries produce many by-products. Handloom and power looms are a large non-agro based industry scattered over 14 locations in Bihar. The three major industries that the Bihar government treats as high priority are the ethanol, food-processing, renewable energy, and cement industries.

As Bihar's economic growth accelerates, its demand for energy will also grow, and emissions from transportation, especially from the commercial sector, are expected to grow even further. Upon considering the case of Bihar, it is observed that the consumption of petroleum products like petrol, diesel and LPG in 2021-22 was 7.4, 16.5, and 13.1 Metric Tons per thousand persons respectively. Urbanization of Bihar has progressed rapidly in the past ten years. According to the Bihar Economic Survey of 2022, the total number of commercial establishments in Bihar was 11,79,739. Crop-based and animal husbandry establishments numbered 8,06,872; fishing and aqua-culture amounted to 1,23,703 units, and food products-manufacturing units totaled 62,294 establishments[14]. Consequently, there has been an increase in demand for trade and e-commerce in the services sector.

Figure 1 shows the district-wise growth of per capita District Domestic Product (DDP) for the year 2015-20. Patna has the highest per capita DDP of Rs.1,31,064, with a growth rate of 33%. This is followed by other districts with a per capita DDP (2019-20) of more than Rs. 30,000 and a more than 30% growth rate. Rohtas, Gaya, Aurangabad, Muzaffarpur, Vaishali, and Bhagalpur districts have the highest recorded per capita DDP with more than 30% growth. West Champaran, Begusarai, and Jamui are the districts with the lowest growth rate in terms of per capita DDP.

[14] Directorate of Economics and Statistics, Govt. of Bihar. 2008.

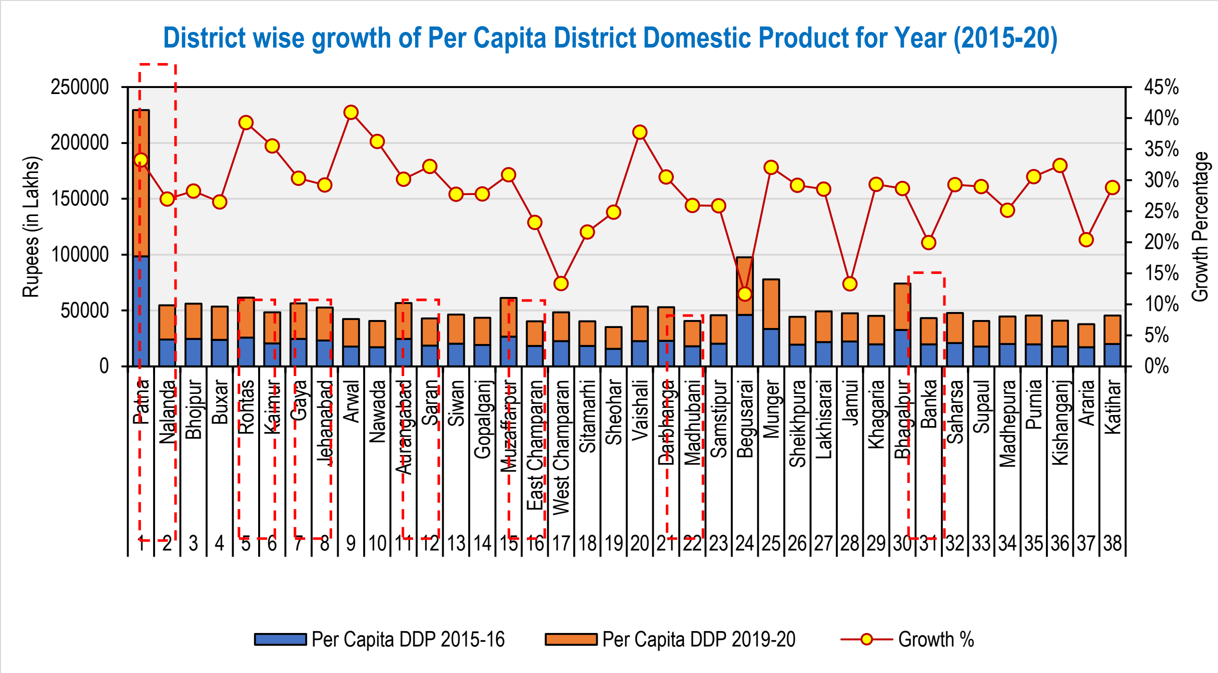


Figure 1: District-wise growth of Per Capita District Domestic Product in Bihar

Source: Bihar Economic Survey 2021-22

Figure 2 show the trends for the sector-wise Gross State Domestic Product (GSDP) of Bihar from 2011 to 2021. The agriculture, forestry, and fishing sectors have made a high contribution of 19% in the total GSDP and they also grew at a rate of 19% from 2011 to 2021. Other sectors, such as trade and transport, have made contributions of 15% and 11% respectively; mining has contributed the least when compared to all the sectors. Road transport is the fastest-growing sector of all, with a growth rate of 182% from 2011 to 2021. This shows a rising trend in urban freight demand from the districts of Bihar. Transportation plays a crucial role in achieving an equitable distribution of goods and services for different local bodies. Urban freight depends majorly on road transport vehicles.

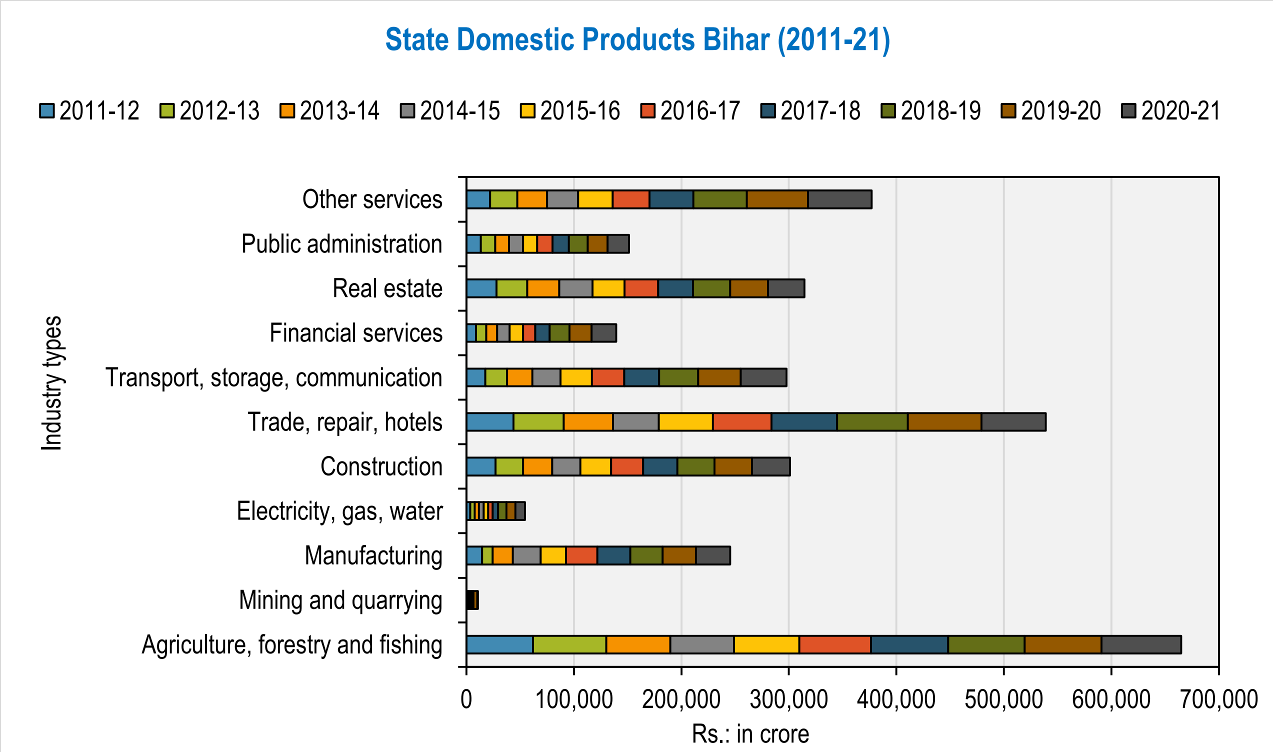


Figure 2: Sector-wise Gross State Domestic Product (GSDP) at Current Prices for 2011-21

Source: Dept. of Planning and Development, Govt. of Bihar

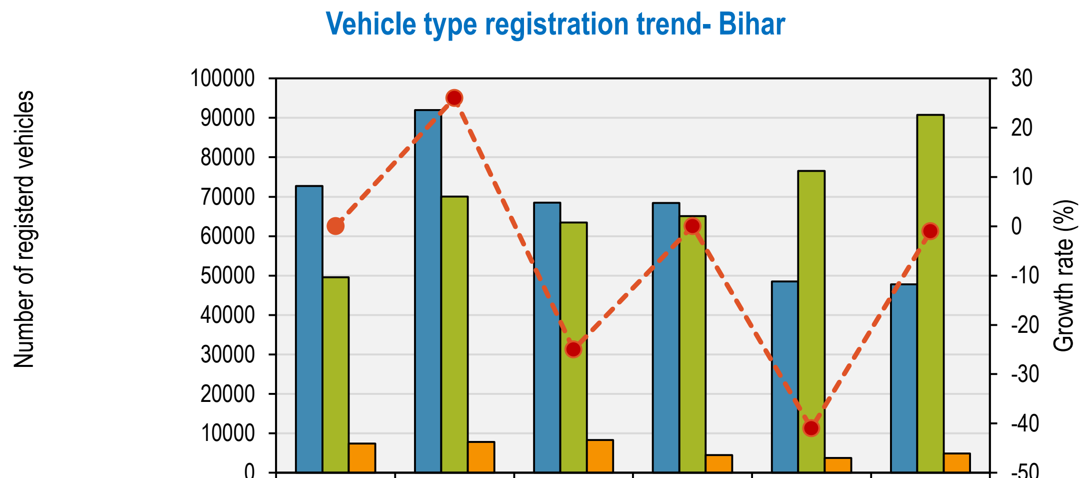
4.2 Transportation scenario

The Ministry of Road Transport and Highways of India (MoRTH) classifies vehicles into transport and non-transport types. Transport vehicles generally mean those which are primarily used for commercial purposes such as freight and public transport. Freight vehicles can be further disaggregated into the vehicle categories of Light Goods Vehicles (N1), Medium Goods Vehicles (N2), and Heavy Goods Vehicles (N3). The vehicles' gross weight does not exceed 3.5 tonnes, 12 tonnes, and is more than 12 tonnes respectively[15].

Figure 3 shows the total number of vehicles registered between 2017 and 2022 by vehicle type. On observing the trends, one finds that the registration numbers for commercial vehicles have declined, whereas the registration of private vehicles has increased. Bihar has 34.46 Lakh Micro, Small and Medium Enterprises (MSMEs), which amounts to a 5% share in the total number of MSMEs of India[16]. This has created a substantial demand for four-wheeler and three-wheeler goods vehicles in the market. These vehicles play a major role in connecting farmers producing raw materials to industries producing finished products and then going on to distribution centers and local shops. Although most three-wheeler and four-wheeler goods vehicles are used for the first-mile and last-mile connectivity, the type of vehicle

[15] Central Motor Vehicle Rule, 1989 (CMVR)
[16] GOI, MSME. 2021. "Annual Report 2020-21.

used varies with different commodities. For instance, tractors and trailers are used by construction industries.



	2017	2018	2019	2020	2021	2022
COMMERCIAL VEHICLE	72702	92016	68465	68447	48491	47791
PRIVATE VEHICLE	49545	70025	63468	65104	76569	90771
PUBLIC VEHICLE	7359	7841	8300	4456	3711	4908
COMMERCIAL VEHICLE GROWTH RATE	0	26	-25	0	-41	-1

Figure 3: Total vehicle type registered in between Year 2017-22

Source: Transport Department, Govt. of Bihar

The annual domestic sales of freight vehicles grew from 37,837 units in 2017-18 to 53,798 units in 2019-20 and 37,507 units in 2021-22. The decline in 2021 was a result of the post-COVID aftermath. Figure 4 shows the sales pattern of all four vehicle segments over five years. Light goods vehicles and two-wheeler transport vehicles show a 43% and 47% increase in sales respectively during 2017-22, while M/HCVs sales have declined. Light goods vehicles and two-wheeler commercial vehicles have majorly contributed to sales. Patna, Gaya, Muzaffarpur, and Bhagalpur districts have the highest number of vehicles registered in all vehicle categories.

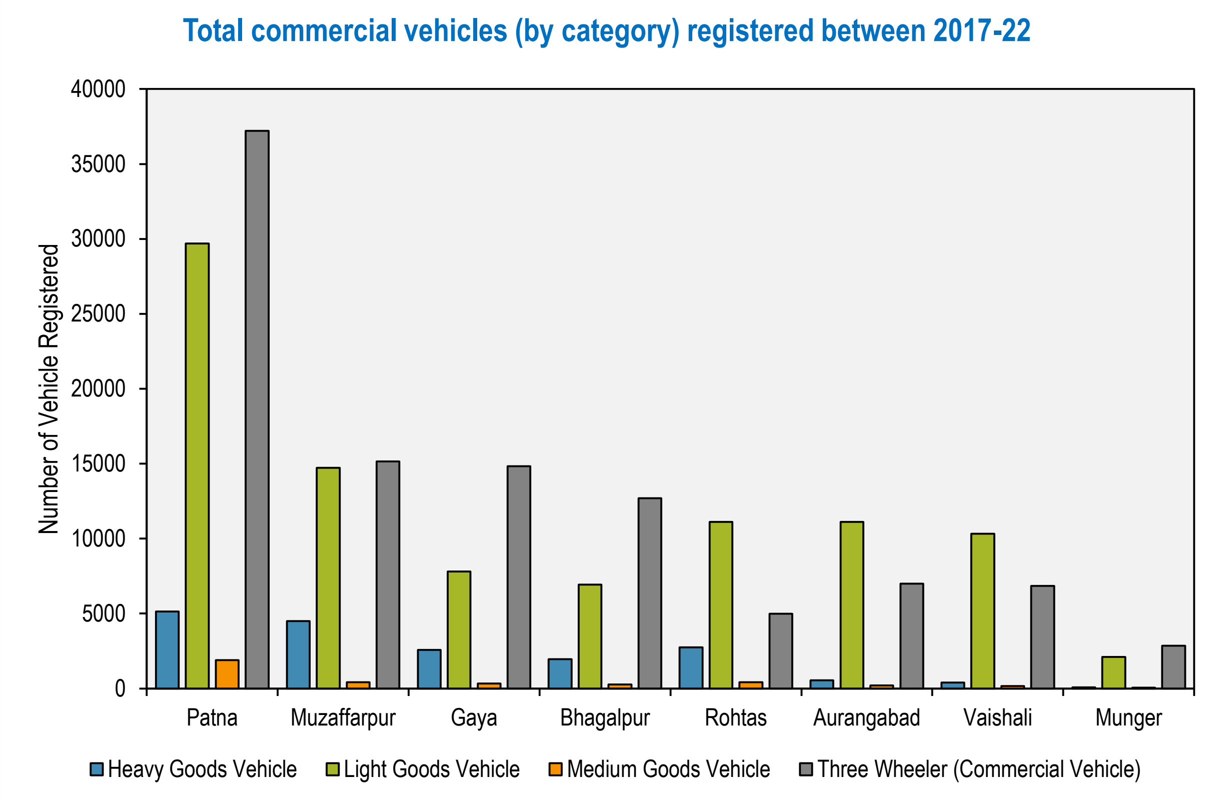


Figure 4: Total commercial vehicles (by category) registered between 2017 and 2022

Source: Transport Department, Govt. of Bihar

Figure 5 shows that among all registered commercial vehicles (LCV, MCV, HCV & 3-W) used between 2017 and 2022, 82% ran on diesel, 14% were electric and 4% were CNG-based. The high share of fossil fuel sources indicates high energy consumption and vehicular emissions emanating from the urban freight sector. However, on observing the average annual growth trend, diesel-based freight vehicles have decreased by 11%, whereas CNG and electric freight vehicles show an increase of 282% and 53% respectively. This is a positive sign. It shows that a transition to clean fuel use in commercial vehicles is being achieved.

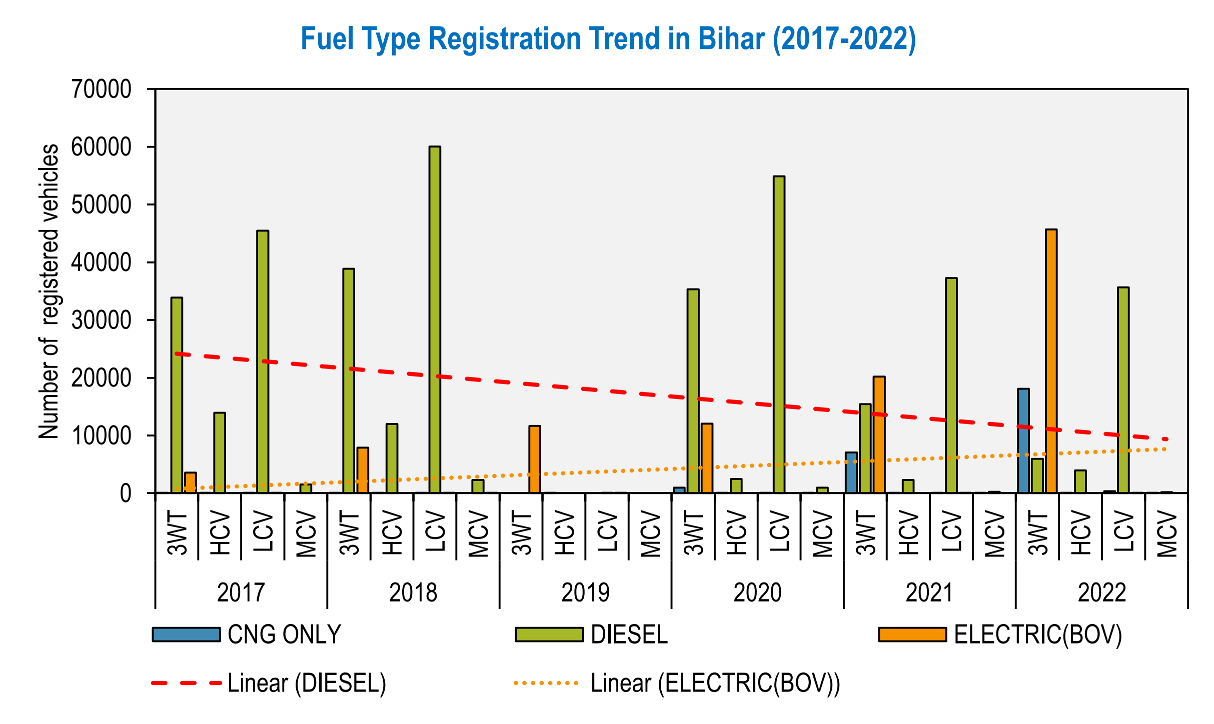


Figure 5: Trend of goods vehicle (LCV, MCV, HCV & 3-W) registered as per fuel use (2017-22)

Source: Transport Department, Govt. of Bihar

5 Materials and Methods

5.1 Survey procedure

As per the study literature mentioned in the section above, the following assumptions and steps have been taken in order to select study areas for the subject of urban freight transition in Bihar: -

- Districts with higher per capita DDP will have higher number of commercial establishments, resulting in higher number of trips generated for carrying freight in urban areas. The districts with more than 30% growth rate in per capita DDP from 2015-16 to 2019-20 were the subjects for the study area, i.e. Patna, Gaya, Muzaffarpur, Bhagalpur, Rohtas, Aurangabad, Vaishali, and Munger.
- Districts showing a higher number of commercial vehicle registration were taken as the criterion. Patna, Gaya, Muzaffarpur, Bhagalpur and Rohtas had the maximum number of commercial vehicles registered between 2017-22.
- Types of industry play an important role in attempting to understand the freight distribution pattern in the state. Agriculture and its allied sectors are the primary productive industries in Bihar. The horticultural produce of fruits and vegetables along with crops accounts for 75% share of the state's production. The industry type was selected after basing it on a priority list made by Bihar Industrial Area Development Authority.

- Districts having a particular type of industry along with producing it significantly were selected in order to identify locations for the survey of different industry types as mentioned in Table 1.

Table 1: Priority Industries in Bihar and Major Producing Districts

S. No.	Industrial Sector	District Name
	High Priority Industry	
1	Food Processing/ FMCGs	
1.1	• Rice	Rohtas, Aurangabad
1.2	• Wheat	Rohtas, Muzaffarpur
1.3	• Maize	Katihar, Purnia
1.4	• Pulses	Patna, Nalanda
1.5	• Sugar	Harinagar Sugar Mill, West Champaran, Narkatia Ganj Sugarmill, Narkatiaganj
1.6	• Fruits & Vegetables	Muzaffarpur, Nalanda, Patna
1.7	• Livestock	Begusarai, Muzaffarpur
1.8	• Chura/ Poha	Bhagalpur, West Champaran
1.9	• Soyabean Bari	Begusarai, Muzaffarpur
1.10	• Snacks & Biscuits	Vaishali, Gaya
1.11	• Soft Drinks	Gaya, Saran, Patna
2	Textiles	Bhagalpur, Banka, Gaya
3	Leather	Muzaffarpur, Vaishali
4	Dairy	Dr. Rajendra Prasad Milk Union, Barauni, Vaishali Patliputra Milk Union, Patna
5	TSC&S (Transport, Storage, Communication and Services)	Begusarai (Storage), Darbhanga (freight), Araria (Transportation services)
	Medium Priority	
6	Plastic & Rubber	Patna, Muzaffarpur, Gaya
7	Small Machine Manufacturing	Muzaffarpur, Patna
8	Health Care	Patna, Vaishali
9	Renewable Energy	
10	Metal Fabrication	Gaya, Muzaffarpur, Patna
11	General Manufacturing	Bhagalpur, Aurangabad
	Low Priority	
12	Bricks	Bhagalpur, Gaya
13	Cement	Patna, Bhojpur
14	Sand	Kishanganj, Patna
15	Hot Mix Plant	Rohtas, East Champaran

Source: Bihar Industrial Area Development Authority

The survey was conducted in Patna, Gaya, Muzaffarpur, Bhagalpur, and Rohtas from 13th March, 2023 to 31st July, 2023. Existing land-use maps of selected urban areas were used to identify the major commercial and industrial hubs for the survey's locations. These survey locations were focused on wholesale markets, Mandis, FCI godowns, rail yards, and industrial areas. The survey locations are as mentioned in Table 2.

Table 2: Survey Locations in Districts of Bihar

S. No.	Districts	Survey Location
1	Patna	Bazar Samiti, Dhanki More, Transport Nagar, Mithapur Sabji Mandi, Sudha Dairy Phulwari, Sarari Gumti Danapur, Danapur Cement Yard, Saguna More, Marufganj Grain Market, Khaitan Market, Jagdeo Path.
2	Gaya	Kiryawa, Gaya Bypass Road, Delha, Bodhgaya, Basandhi, Patwatoli, Dugeshwari Mandir, Kedarnath, Bakraur, Sudha Dairy, FCI Godown, Gere, Purani Godown
3	Muzaffarpur	Bazar Samiti, Gola Road, Sudha Dairy, Sata Patti Textile Market, Bariya Golambar, Jagdamba Nagar, Akharaghat Road, Muzaffarpur Industrial Area
4	Bhagalpur	Sabji Mandi Ultapul, Tikani Jagdishpur Railway Yard, Patal Babu Road, Sujaganj, Tilkamanjhi, Zero Mile Bhagalpur, Jawaripur, Gurhatta Chowk, Sabour, Baluachak Haat, Nathnagar
5	Rohtas	Dehri-on-Sone Railway Station, Sudha Dairy, Dalmia Nagar, Rice Mandi, Sasaram Railyard, Madaini Bridge, GT Road, Nooranganj, Banliya Chowk, Shobhaganj, Takiya Bazar.

The survey was conducted from 8 am to 7 pm. Interviews for the survey were conducted with truck drivers. The entire interview took 20 minutes per vehicle. Freight vehicle data was obtained from randomly-chosen trucks at the survey locations of the five selected cities. The surveyor noted down the registration number and the type of the vehicle surveyed. Questions were asked about the vehicle's fuel usage, annual distance covered, and average payload carried by each truck. Travel diaries of the freight vehicles have been collected so as to obtain information about the trip details generated by the freight vehicles. This information consists of the origin and destination of the trips, start and end times, and loads carried by the vehicle and has been collected using travel diaries. The average daily distance covered by each vehicle can also be estimated from the trip dairy. Please refer to Appendix I for taking a look at the questionnaire used. This survey questionnaire was prepared based on vehicle characteristics, trip characteristics, awareness of electric vehicles and intention to purchase electric vehicles among the respondents. A detailed description of the variables involved is mentioned in Table 3.

Table 3: Description of Variables Included in Quantitative Survey Questionnaire

Characteristics	Variable	Type of Variable	Description
Vehicle	Vehicle Type	Independent	Freight vehicle classification was done by grouping the freight vehicles into 8 classes. They are three-wheeler goods carriers, E-Rickshaws, mini-trucks, pick-up trucks, six-wheeler trucks, tractors, Jugaad, and two-wheelers
	Make Year	Independent	Year of purchasing

	Commodity Type	Independent	The type of goods carried was classified into 17 categories as per NIC classification. They were Crops, Fruits, Vegetables, Livestock, Diary, Packed Food, Textiles, Plastics & Rubber, Fabricated metallic items, Sugar, Bricks, Stone Chips, Logistics, Cement, Oil and Gas.
	Odometer Reading	Independent	The last odometer reading of the vehicle
	Ownership	Independent	Ownership was categorized into three categories. Personal, Leased & Third-Party Ownership
	Fuel	Independent	Fuel type used for freight vehicles were Petrol, Diesel, CNG, and Electric
	Mileage	Independent	Average No. of Km traveled by vehicle for every 1 liter of fuel/charge
	Origin	Independent	The beginning point of the trip
	Destination	Independent	The final end point of the trip
Trip	Movement Type	Independent	The movement type of vehicle was classified into fixed and flexible movement types.
	Trips per day	Independent	Number of trips made by each vehicle per day. This classification was divided into 6 types: 1-2, 3-6, 7-10, 11-20, 21-50, and >50 trips
	Commodity Weight	Independent	Weight of commodity carried by vehicle irrespective of passing load by a different vehicle
	Time Taken per trip	Independent	Time taken to reach the final endpoint of the trip. They were grouped into 1-2 Hrs, 3-4 Hrs, 5-10 Hrs, 11-15 Hrs, 16-24 Hrs, 2 days, and 3 days
	Average Distance per day	Independent	Distance traveled by vehicle in one day adding up all the trips. This distance ranged from 1-2 Km, 3-5 Km, 6-10 Km, 11-30 Km, 31-50 Km, 51-80 Km, 81-120 Km, 121-200 Km, 201-300 Km, 301-500 Km, and >500 Km
	Parking Location	Independent	Location where the vehicle is parked in the middle of the day or night. It has been categorized into three categories, i.e. Roadside, Private Parking, Common Parking
	Parking Time	Independent	The total time clocked when vehicles are parked and not doing any activity. The range is 0-1 Hr, 2-3 Hr, 4-5 Hr, 6-8 Hr, 9-12 Hr, and >12 Hr
Awareness	Subsidy Awareness	Dependent	Are vehicle drivers aware of government subsidies for electric vehicles? Yes or No
	Retrofitting Awareness	Dependent	Are vehicle drivers aware that their vehicles can be retrofitted into CNG/ Electric? Yes or No
Intention to shift to electric vehicle	Subsidy from Govt.	Dependent	Rank the eagerness to buy another vehicle if the government is providing subsidy; Rank 1- Lowest and Rank 5- Highest
	Financing by Bank	Dependent	Rank the eagerness to buy another vehicle if banks are financing vehicles at a lower interest rate. Rank 1- Lowest and Rank 5- Highest
	Operation & Maintenanc e	Dependent	Rank the eagerness to buy another vehicle if the electric vehicle has operational characteristics similar to ICE vehicles. Rank 1- Lowest and Rank 5- Highest
	Similar Range	Dependent	Rank the eagerness to buy another vehicle if the electric vehicle has a travel range similar to ICE vehicles. Rank 1- Lowest and Rank 5- Highest

	Similar Speed	Dependent	Rank the eagerness to buy another vehicle if an electric vehicle can travel at speeds similar to ICE vehicles. Rank 1- Lowest and Rank 5- Highest
	Similar Payload	Dependent	Rank the eagerness to buy another vehicle if an electric vehicle has a carrying capacity similar to ICE vehicles. Rank 1- Lowest and Rank 5- Highest
	Higher Refueling Time	Dependent	Rank the eagerness to buy another vehicle if an electric vehicle has a longer refueling time compared to ICE vehicles. Rank 1- Lowest and Rank 5- Highest

5.2 Calculation of sample size

To investigate the degree of correlation between a set of 23 independent variables and 7 dependent variables, we used Cramer's V as the main measure. Since most of the variables in our data were categorical, Cramer's V was the most appropriate statistic to use because it showed the strength and significance of the correlations between our variables. Since Cramer's V values close to 1 indicate a significant correlation and values near 0 suggest a negligible relationship, this approach is especially helpful in differentiating substantial relationships from weaker ones. Our analysis showed that only nine out of the twenty-three independent variables and five out of the seven dependent variables showed significant relationships that called for additional research after applying the Cramer's V method to each pair of variables as shown in Table 4. The process of selection played a crucial role in focusing our attention on the most significant variables, strengthening our resources and exertions to a maximum for subsequent phases of this research.

A response surface methodology called Box-Behnken Design (BBD) is used in experimental design to reliably examine the effects of interaction and maximize the responses of many factors. The BBD 9 configuration, which includes nine independent variables, was especially selected for our study in order to sort out the following stages of our survey and experimental investigations in a way that would be more methodical and informative. We will be able to carry out a systematic survey and experimentation approach that optimizes the amount of information gathered from a minimal number of experimental runs by employing BBD 9. When working with many variables, this design is very helpful since it reduces complexity by concentrating on just second-order interactions, thereby eliminating the need for a complete factorial design. By avoiding combinations of extreme values for all elements, the BBD reduces the possibility of running into situations that can produce dodgy results in real-world applications.

To guarantee that every experimental run yields the most valuable information possible about the major effects and interactions, we must strategically arrange the variables and their levels in such a way so as to integrate BBD 9 in our survey process. For example, using this strategy in our research enables us to collect data on how various combinations of the chosen nine independent factors affect the five dependent variables that are being studied. By using this approach, we can be certain that we are effectively investigating the dependencies and possible outcomes while simultaneously avoiding needless redundancy.

The effectiveness of BBD 9 in our survey procedure improves the accuracy and applicability of the data while also saving time and money. We will be in a position to anticipate more precisely how our system will behave in different scenarios by carefully planning the tests to encompass the variable space's most instructive points. Having a thorough knowledge of the study's findings is essential to creating plans and solutions that work.

Table 4: Cramer's V Correlation Between Independent and Dependent Variables.

	Dependent Variable	If electric vehicles have less operational & maintenance costs	If an electric vehicle has the same range as the current vehicle	If an electric vehicle has the same speed as a Petrol/Diesel vehicle	If an electric vehicle has the same payload capacity as a Petrol/ Diesel vehicle	If the vehicle has a higher refueling time/ charging time]
Independent Variable	CODE	27OP_MA	28SA_RA	29SA_SP	30SA_PA	31RE_TI
Odometer Reading	9ODO	0.92	0.83	0.94	0.88	0.82
Drop Point	14 DR_PO	0.71	0.71	0.84	0.79	0.71
Point-to-Point deliveries	17PTP_DE	0.41	0.49	0.43	0.42	0.74
Mileage	12MIL	0.28	0.32	0.26	0.48	0.39
Pick-up-point	13PU_PO	0.47	0.4	0.4	0.38	0.44
Payload Capacity	20PA	0.3	0.42	0.28	0.27	0.25
Ownership of Vehicle	10OWN	0.24	0.33	0.23	0.22	0.28
Movement Type	18MO_TY	0.31	0.2	0.2	0.2	0.17
Type of Commodity	8COMM	0.2	0.16	0.17	0.16	0.19

Table 5: Maximum Cramer's V Correlation between Independent and Dependent Variable

Independent Variable	Code	Max		Dependent Variable
Odometer Reading	9ODO	0.94	29SA_SP	If an electric vehicle has the same speed as a Petrol/ Diesel vehicle
Drop Point	14 DR_PO	0.84	29SA_SP	If the electric vehicle has the same speed as Petrol/ Diesel vehicle
Point-to-Point deliveries	17PTP_DE	0.74	31RE_TI	If vehicles have higher refueling time/ charging time]
Mileage	12MIL	0.48	30SA_PA	If the electric vehicle has the same payload capacity as a Petrol/ Diesel vehicle
Pick-up-point	13PU_PO	0.47	27OP_MA	If electric vehicles have less operational & maintenance costs
Payload Capacity	20PA	0.42	28SA_RA	If the electric vehicle has the same range as the current vehicle
Ownership of Vehicle	10OWN	0.33	28SA_RA	If the electric vehicle has the same range as the current vehicle
Movement Type	18MO_TY	0.31	27OP_MA	If electric vehicles have less operational & maintenance costs
Type of Commodity	8COMM	0.2	27OP_MA	If electric vehicles have less operational & maintenance costs

6 General statistics of collected data

A total of 2047 samples were collected from the selected locations of cities in Bihar, as shown in Table 6. This collected data plays an important role in assessing the contribution of freight vehicles in carbon emissions and local pollution. The data also analyses some crucial characteristics of freight trips undertaken in Bihar, such as vehicle age distribution, vehicle ownership, essential commodities carried, trip frequencies, and parking characteristics. Furthermore, the survey also provides insights with respect to the perspective of freight drivers and owners regarding the adoption of electric vehicles. This aids the development of policies and incentives aimed at fostering cleaner and more sustainable freight transport in Bihar.

Table 6: Survey Sample Collected from Study Area

S. No.	Place Name	No. of samples collected
1	Patna	514
2	Gaya	398
3	Muzaffarpur	494
4	Bhagalpur	417
5	Rohtas	224
	Total no. of samples collected	**2047**
	Data Error	**32**
	Effective data set	**2015**

The samples collected were later digitized using the Geographic Informatics System for understanding the distribution and intensity of freight within the study area as shown in Figure 6.

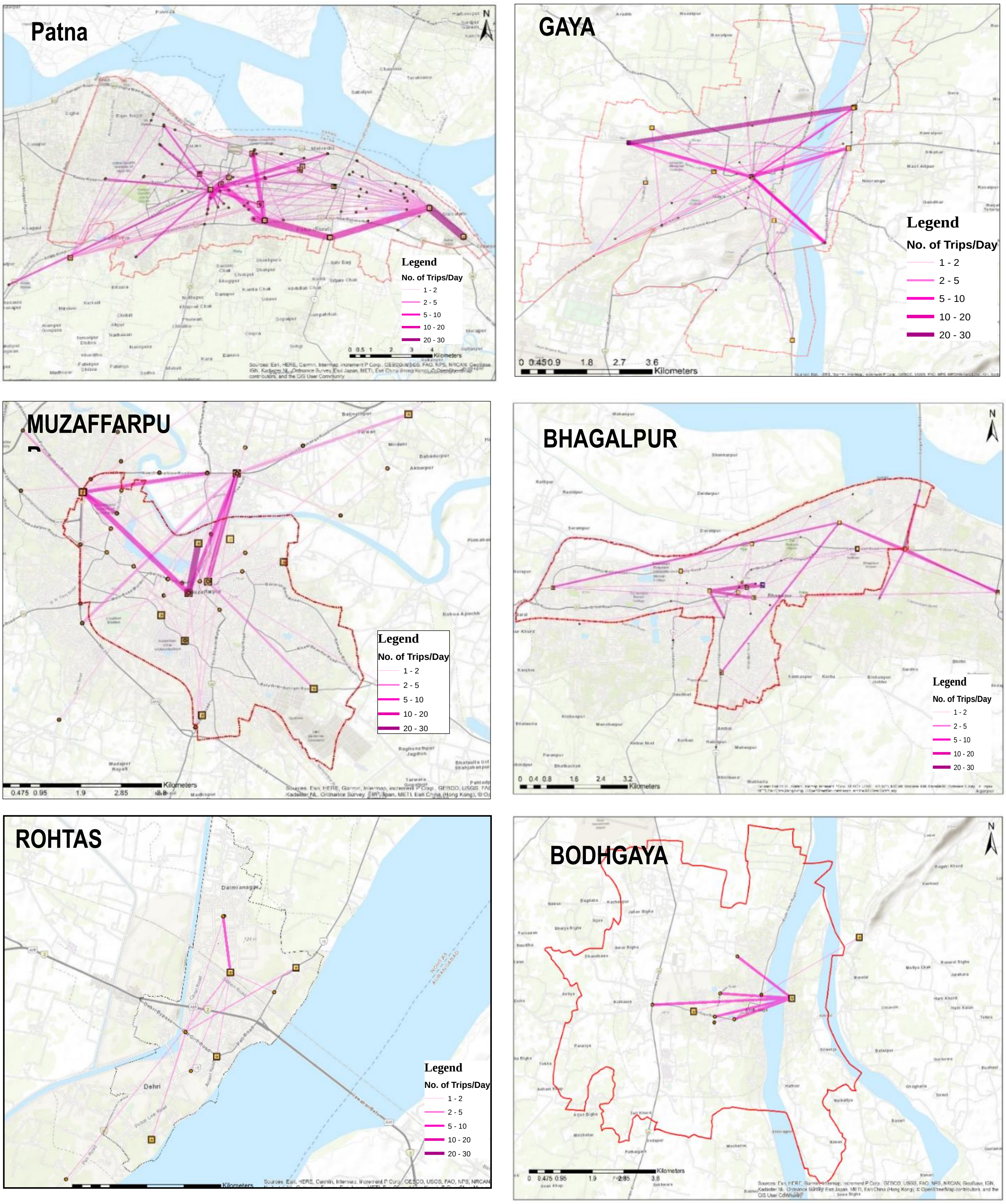


Figure 6: Origin-destination map of freight activities in districts studied

7 Results and discussion

7.1 Age distribution

Figure 7 represents the share of the freight vehicle type in the total surveyed sample in Bihar. The most prevalent type of freight vehicle is the Three-wheeler Goods Carrier, accounting for 29% of the total surveyed vehicles. This is followed closely by pick-up trucks and six-wheeler trucks and they reflect a 19% and 18% share respectively. Tractors also show a substantial contribution at 17% of the total surveyed sample. Mini-trucks and E-Rickshaws represent smaller but statistically significant proportions nevertheless at 7% and 5% respectively. Jugaads, on the other hand, constitute a modest 4% of the surveyed vehicles. Lastly, Two-Wheelers make up a miniscule category with a mere 1% portion of the surveyed fleet. This distribution portrays the diverse array of freight vehicles traversing the roads of Bihar, with small and medium-sized commercial vehicles like Three-Wheeler Goods Carriers and Six-Wheeler Trucks dominating the landscape, and even smaller vehicles playing a supporting role. The percentage share of freight vehicles in surveyed cities is being presented below.

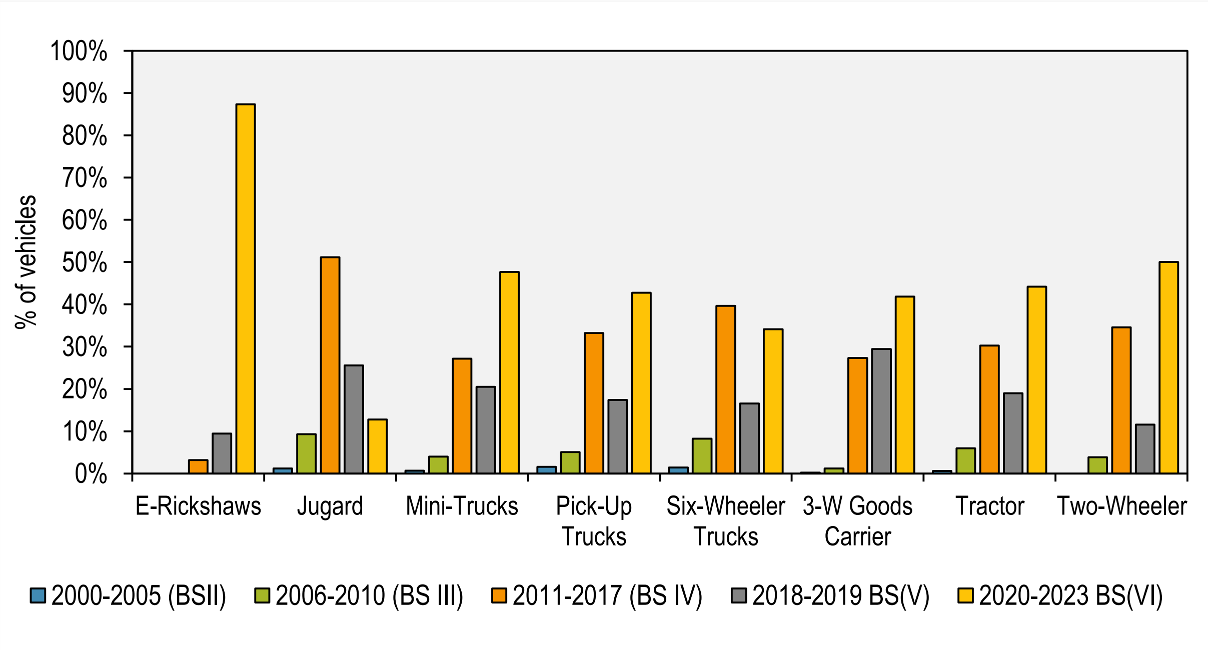


Figure 7: Percentage share of freight vehicles in surveyed cities

Figure 8 shows the percentage distribution of vehicle age (except E-Rickshaws) along with the BS emission standards of vehicles from 2000 to 2023. Jugaad vehicles log a 51% share of BS-IV engines; mini-trucks, pick-up trucks, six-wheelers, and 3-W goods vehicles make up a considerable share of BS-VI engines. They also dominate the figures for BS-IV and BS-V engine usage. The percentage share of BS-VI engine usage remains below 50% in each vehicle category except for E-Rickshaws. This data suggests that there is a pent-up demand for more environmentally-friendly and fuel-efficient vehicles. It shows that regulatory efforts to reduce emissions and improve air quality are bearing fruit.

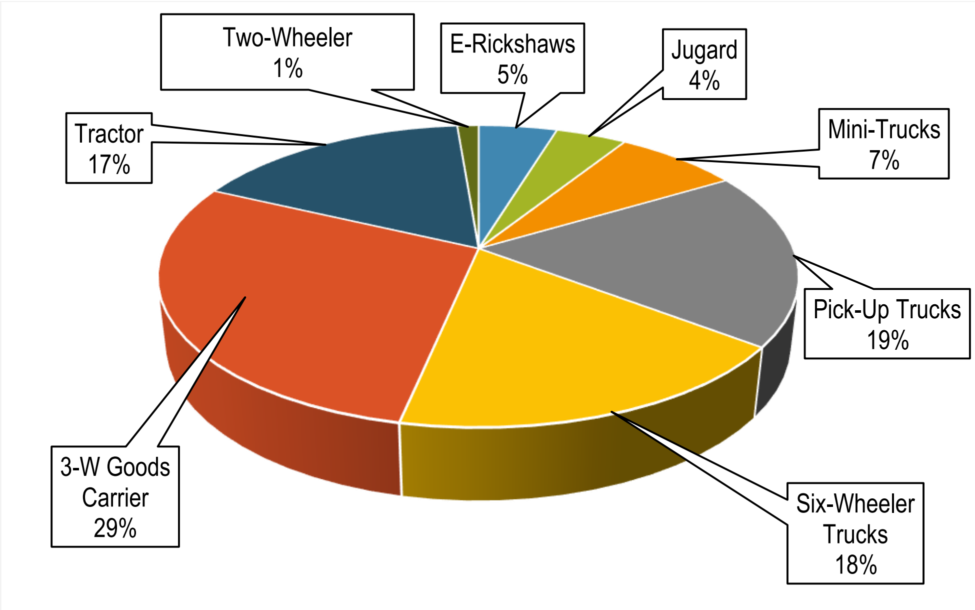


Figure 8: Age distribution and BS standards of freight vehicles in surveyed districts

7.2 Characteristics of Commodity Transportation by Freight Vehicles

Figure 9 shows the percentage of each commodity transported by freight vehicles. Crops (16%), fruits (11%), vegetables (11%), and textiles (11%) are among the most transported commodities in Bihar along with dairy products and packed food items logging in a share of 8% each. Figure 10 shows the percentage distribution of vehicles carrying various types of commodities. E-rickshaws are primarily used for transporting fruits (32%), vegetables (39%), and packed food (11%), indicating their important role in urban delivery services. Jugaad vehicles transport diverse commodities, with a significant share being that of crops, fruits, and textiles. Mini-trucks are mainly involved in transporting crops (21%), fruits (13%), and dairy products (19%), suggesting that they are a part of the agricultural and dairy supply chains. Pick-up trucks transport crops (21%), fruits (20%), and stone chips (15%). This proves that they are very versatile in carrying various goods. Six-wheeler trucks haul crops (19%), livestock (9%), and stone chips (6%), making them a participant in heavy-duty transportation. 3-W goods carriers primarily transport crops (19%), textiles (27%), and packed food (11%). They contribute significantly to urban logistics. Tractors are mainly involved in moving construction materials like stone chips (18%), cement (34%), and bricks. Two-wheelers haul vegetables, textiles, and fruits. Fruits (16%), vegetables (11%), and crops (11%)

constitute the largest proportion of transported commodities. Livestock, sand, and stone chips make up around 3-6% of all the shipped goods, and other commodities such as dairy products, textiles, bricks, and cement collectively contribute a smaller share ranging from 4-11%.

Understanding the nature of distribution of these commodities by vehicle type can help in making informed decisions related to logistics planning, resource allocation, and infrastructure development. Efficient transportation networks are essential for supporting agricultural activities, urban logistics, and industrial supply chains. Policy interventions and investment strategies should take into consideration the diverse needs for transporting different commodities and sectors to ensure effective and sustainable transportation systems.

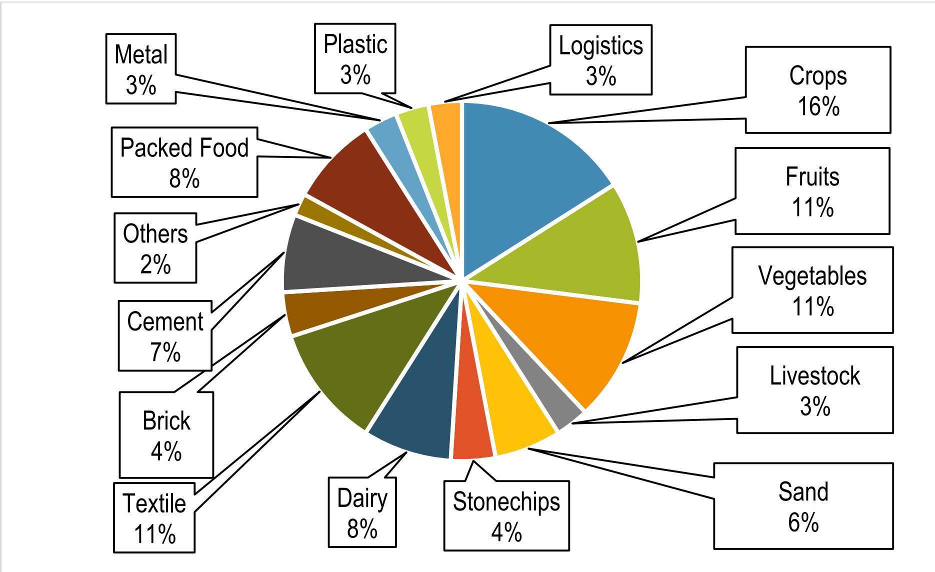


Figure 9: Percentage of each commodity transported by freight vehicles .

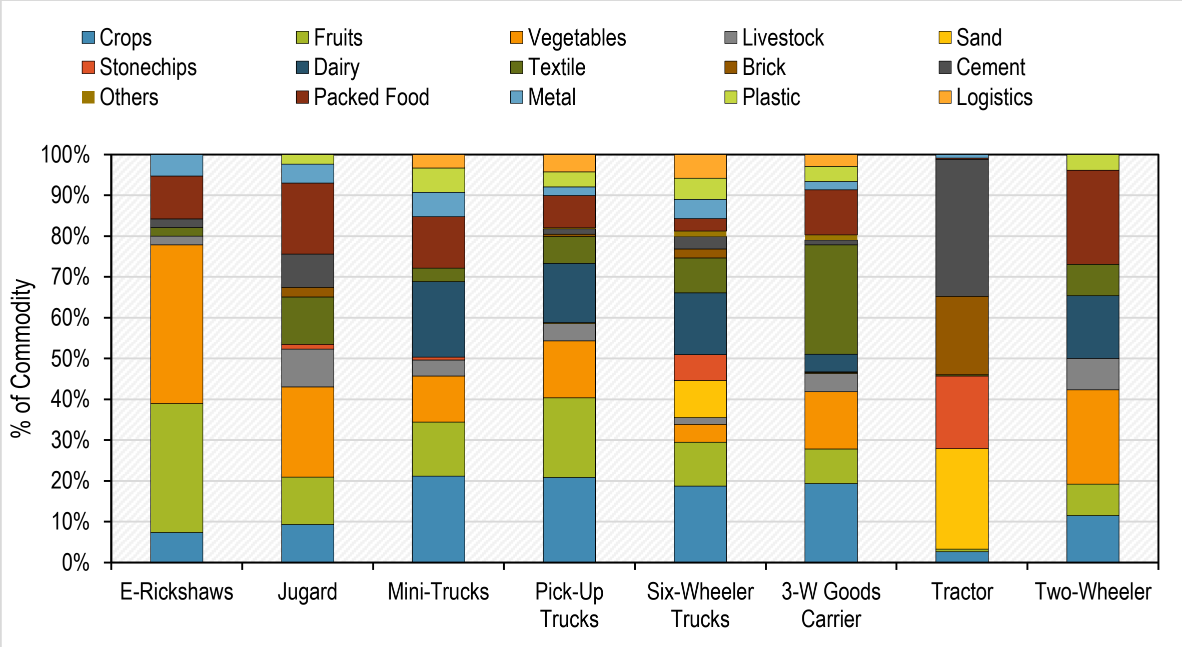


Figure 10: Percentage of freight vehicles hauling different commodities

7.3 Vehicle Ownership Distribution

Figure 11 lays out the ownership distribution pattern of surveyed freight vehicles in Bihar revealing varying degrees of third-party ownership, lease agreements, and personal ownership. E-Rickshaws predominantly report personal ownership, constituting 82% of the total fleet, with a bare 1% under lease and 17% under third-party ownership. Jugaads belong exclusively to individuals, with 100% of them being under personal ownership. Mini-trucks and Pick-up trucks exhibit a similar pattern, with significant proportions having been leased out (42% each) and a majority (58% and 55% respectively) being owned personally. Meanwhile, six-wheeler trucks have a notable presence in numbers for both leased (27%) and personal (68%) ownership. It has a small fraction (5%) that is owned by a third-party. Three-wheeler goods carriers also report a significant portion as being under personal ownership (70%), with leases accounting for 28% and third-party ownership for 1%. Tractors display a trend similar to six-wheeler trucks, with a substantial portion being owned personally (62%) and notable percentages are under lease (36%) and third-party ownership (2%). Two-wheelers are overwhelmingly personally-owned (96%), with a minority (4%) tied in personal lease agreements. This kind of distribution reveals the diverse ownership arrangements existing in Bihar's freight vehicle landscape. It reflects a medley of individual ownership, leasing arrangements, and third-party ownership affecting different vehicle types.

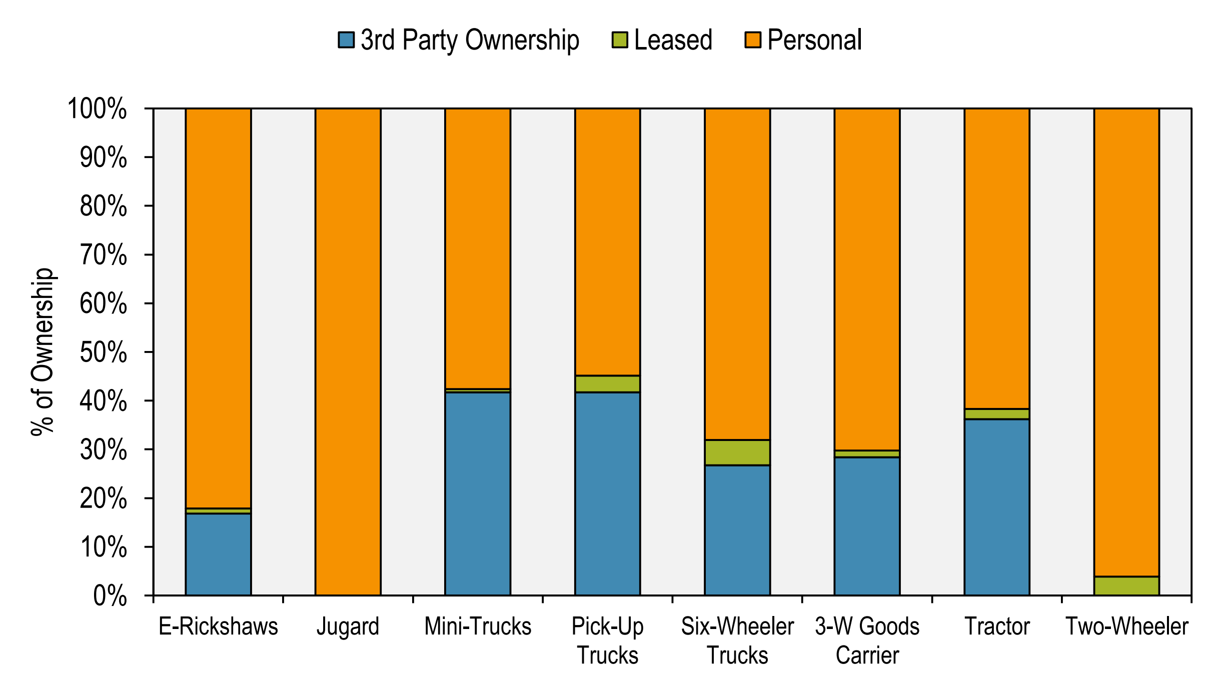


Figure 11: Vehicle Ownership Pattern of Freight Vehicles.

7.4 Fuel Efficiency

The categories of average mileage and average distance traveled per day for various surveyed freight vehicles point towards a significant variation in fuel efficiency and distances traveled daily. E-rickshaws lead the pack in terms of mileage, averaging 101 km/charge while covering an average distance of 55.7 km per day. In stark contrast to this are the six-wheeler trucks, which log the lowest mileage of 5.5 km/L and traverse the highest average distance per day of 226.3 km. Jugaads record an average mileage of 23 km/L, covering 40 km per day. Mini-trucks and pick-up trucks boast similar average mileages of 16 km/L and 14.2 km/L respectively. Also, the average distances they travel daily are 85.3 km and 135.2 km respectively. Three-wheeler goods carriers report a relatively high average mileage of 24 km/L, and cover an average daily distance of 63.3 km. Tractors have an average mileage of 6.6 km/L, with the average daily distance traveled being 67.6 km. Finally, two-wheelers log in a good average mileage of 54.6 km/L after covering an average distance of 31.2 km per day. Thus, these figures underscore the variegated travel patterns and fuel efficiencies present in each of the freight vehicle categories in Bihar. The operational demands and usage scenarios keep changing with change in the type of freight vehicle.

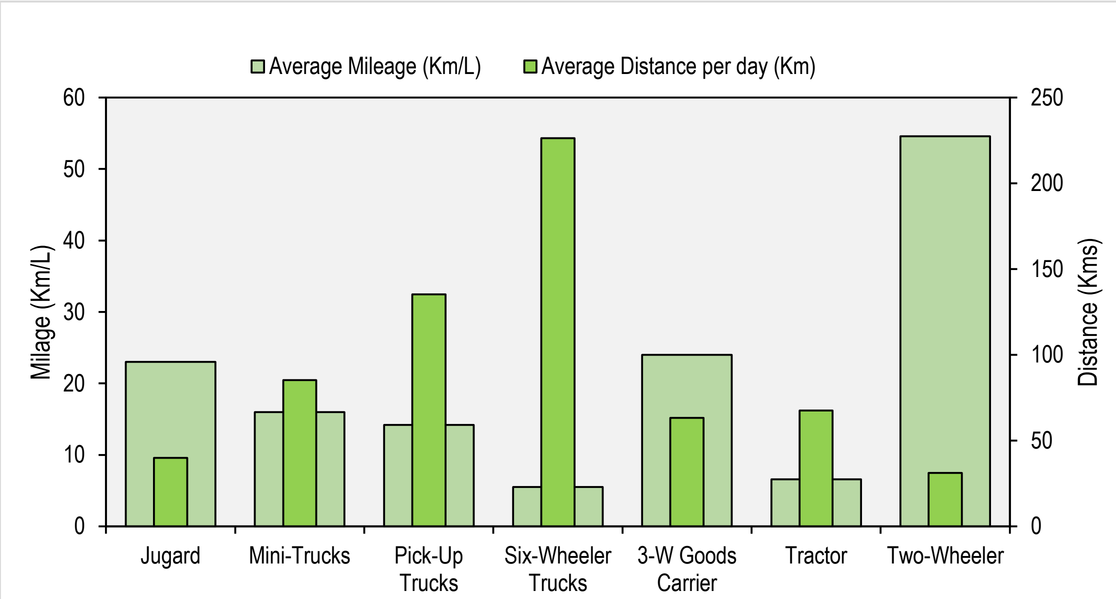


Figure 12: Freight vehicle mileage (Km/l & Km/charge) and distance covered (km)

Vehicles with lower average mileage are likely to consume more fuel per unit distance traveled, which results in higher emissions. Vehicles with heavier payloads, such as pick-up trucks, mini-trucks, six-wheeler trucks, and three-wheeler goods carriers often have old BS engines and use diesel majorly. This characteristic typically produces more pollutants like various nitrogen oxide (NOx) gases and particulate matter (PM).

7.5 Frequency of Trips

Figure 13 shows the trip length distribution of freight vehicles. Most of these trips are short-distance trips (1-10 Km), indicating that these trips are for local commuting or short-distance transportation needs. Trip frequency lessens as distance covered in the trip increases, with the highest trip frequency observed for short-distance trips of 1-2 Km and a much lower trip frequency is seen for longer-distance trips (>500 Km). The majority of trips within the 11-20 trips frequency range is short-distance (1-2 Km) in nature, suggesting the existence of repetitive short-distance commutes.

A good understanding reached after analyzing trip distribution by distance range and trip frequency can help inform making decisions for urban planning, transportation infrastructure development, and policy interventions. Short-distance trips constitute a major chunk of these trips. It only serves to emphasize the importance of efficient and sustainable urban transportation systems.

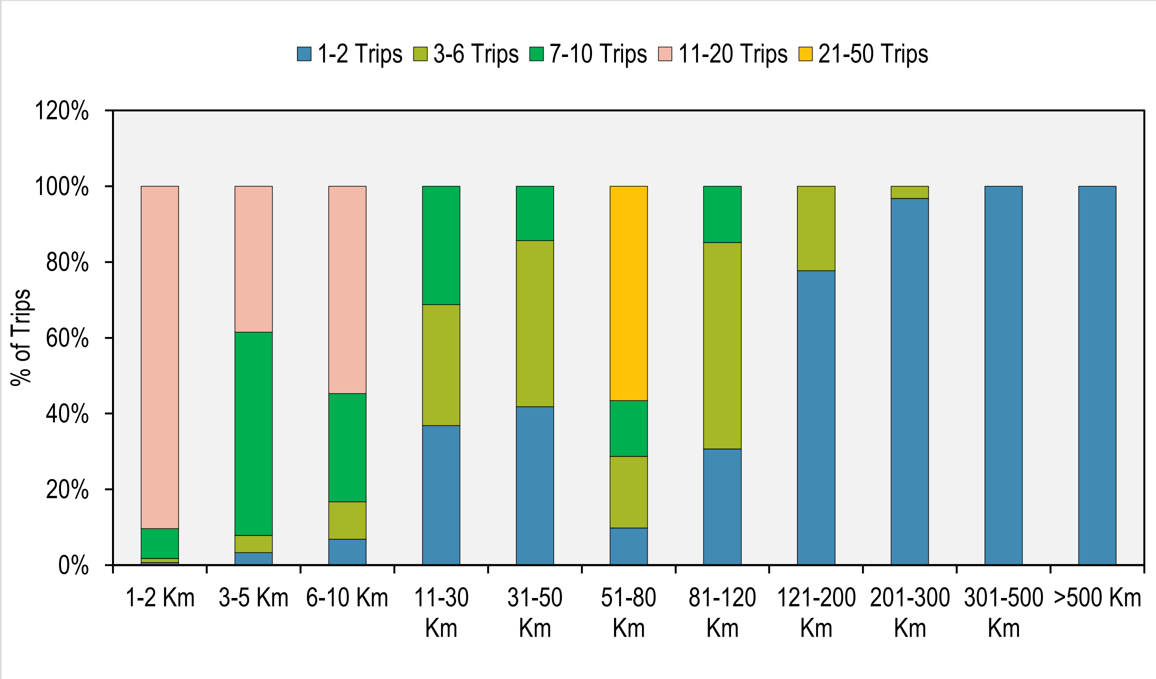


Figure 13: Distribution of Trip Frequency and Distance Travelled by Freight Vehicles

7.6 Payload Carried

Figure 14 shows the weight of commodities carried in tonnes by various freight vehicles over the distance covered in kilometers. The distribution of these payloads varies across different distance ranges. It describes which payload category is suitable for how much distance the commodity has to be hauled for transportation needs. Short-distance transportation (1-50 Km) primarily involves payloads in the lower tonnage categories (0-1 Tonnes, 1-2 Tonnes, and 2-5 Tonnes). Longer-distance haulage (>50 Km) predominantly involves payloads which are in tonnage categories higher than 5.1 Tonnes. This is particularly true for distances exceeding 300 Km. The greater than 10 Tonnes payload category is primarily used for long-distance transfers that exceed 200 Kms, indicating its suitability for heavy-duty freight transport.

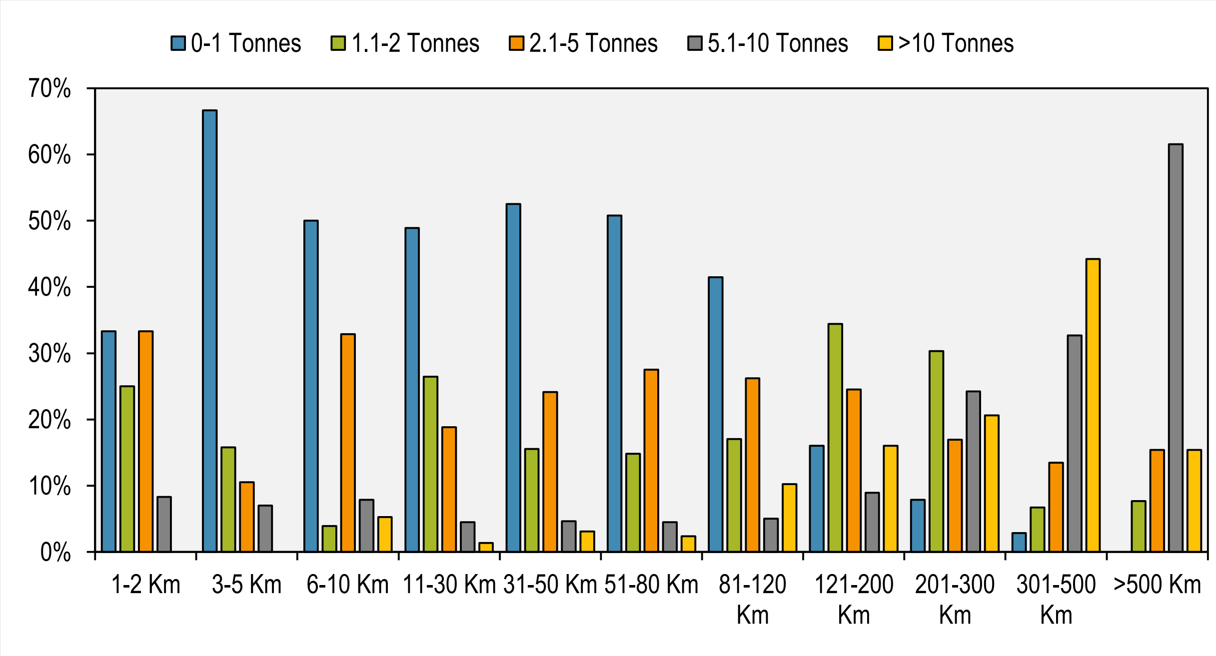


Figure 14: Carrying capacity per vehicle and distance travelled per day by freight vehicles

Getting a good grasp of the payload and distance distribution of commodities in freight transport can help the taking of wise decisions with respect to logistics planning, fleet management, and infrastructure development. Creation of efficient transportation networks must fulfill the many payload requirements of hauling different commodities over ever-changing distances. This will also help run industries. Policy interventions and investment strategies should prioritize the development of infrastructure and logistics solutions tailored to meet the needs of multiple tonnage categories and haulage distances.

7.7 Parking Characteristics

Figure 15 presents the parking characteristics of freight vehicles. Most of these vehicles have been found to be idly parked for either 0-1 Hrs or 9-12 Hrs. per day. Parking for long durations has been mostly observed to be made at homes or on the roadside and shorter-duration parking has been seen in common parking spaces. Roadside parking is the most prevalent type of parking, suggesting a heavy reliance on roadside spaces for extended stops and overnight stays.

Comprehension of the inferences that can be drawn from these parking duration variations can help design parking facilities tailored to cater to specific needs and optimize space utilization. This brings to our attention the necessity of infrastructural assets such as charging stations and battery swapping stations to be located in the common parking spaces of commercial zones and local markets of towns and villages.

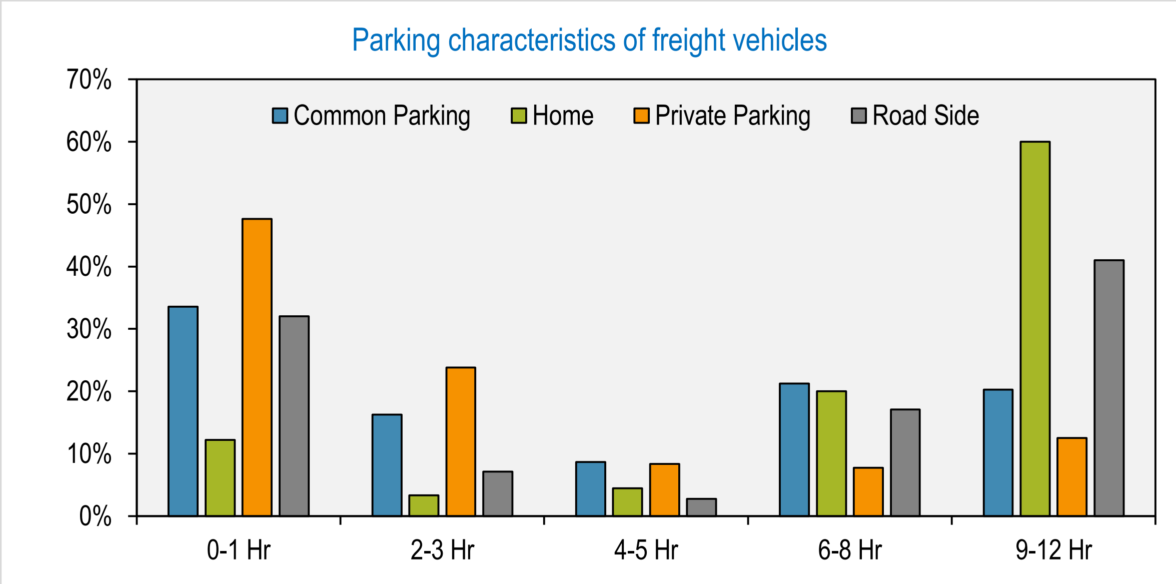


Figure 15: Parking characteristics of freight vehicles

8 A Descriptive Analysis of Baseline Data on the Freight Sector

The questionnaire-based survey conducted in the districts of Patna, Gaya, Muzaffarpur, Bhagalpur, and Rohtas provides valuable insights about the characteristics and operational patterns of freight vehicles. The data collected is essential for analyzing the effect of operating freight vehicles on carbon emissions and pollution. Additionally, the survey sheds light on the perceptions and readiness of owners of freight vehicles to switch over to electric ones. This could help formulate policies and incentives to promote cleaner and more sustainable freight transportation in Bihar. This study has analyzed seven dependent variables.

Figure 16 shows the perception of freight owners/drivers to shift from ICE vehicles to electric vehicles based on different dependent variables. Government subsidies and favorable loan conditions can significantly promote the adoption of electric vehicles, but there is uncertainty among respondents with a significant portion not providing any answer. Lower maintenance cost is a significant factor influencing the decision to purchase an electric vehicle, with a considerable portion of respondents finding it very plausible to influence their decision to buy. The majority of respondents find it very unlikely to purchase an electric vehicle if the charging time is higher than that taken to refuel ICE vehicles. This brings to the fore the importance and urgency of developing fast and easy-to-use charging infrastructure to address anxiety about the range of travel that EVs can provide. and enhance the appeal of electric vehicles.

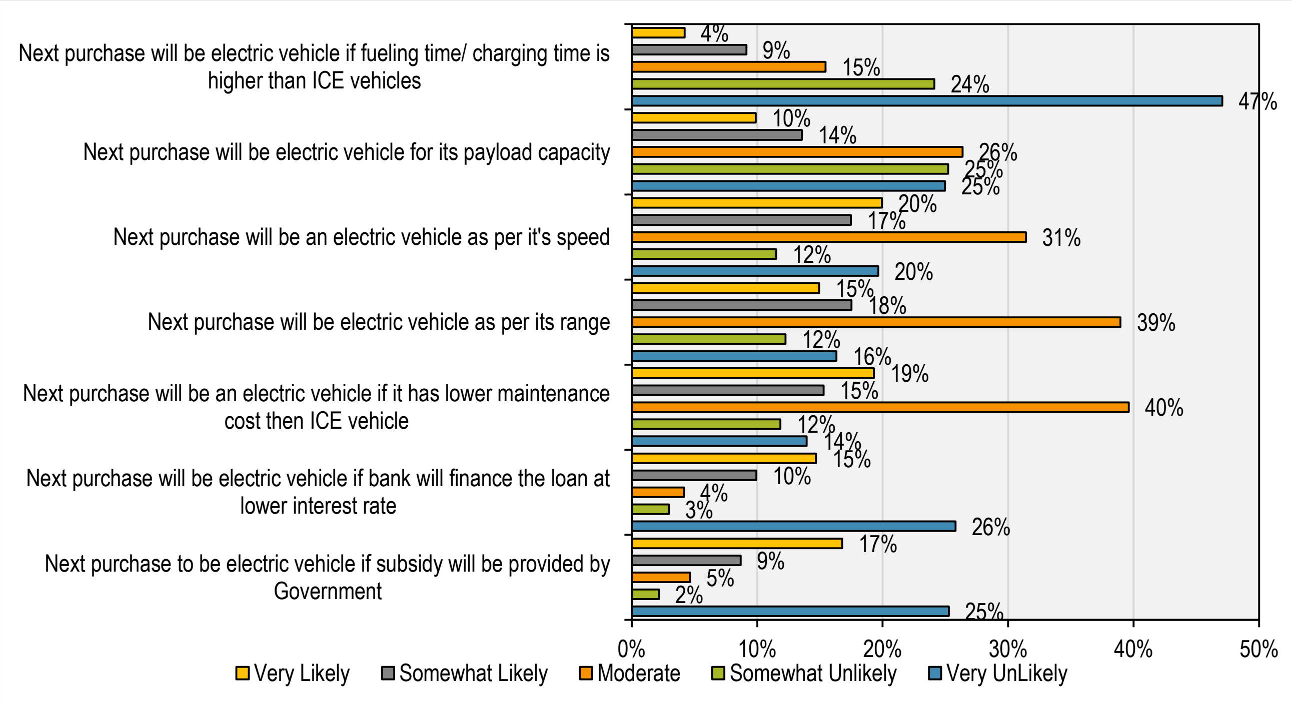


Figure 16: Intention of freight drivers to shift from ICE vehicles to electric vehicles

8.1 Descriptive Analysis of Likelihood of the Next Purchase Being an Electric Vehicle if Government Subsidy is provided

This analysis provides insights into the potential effect of government subsidies on the likelihood of purchasing electric vehicles across different variables. Areas of interest and potential barriers to adoption will be brought up.

Owners of three-wheeler goods carriers evinced considerable interest, with 31% of them very likely and 14% somewhat likely to consider buying EVs if there is a subsidy. However, 48% remain very unlikely to make the switch. Mini-truck and pick-up truck owners also show moderate interest, with 27% and 22% of them very likely or somewhat likely to consider shifting to EVs respectively if there is a subsidy.

Vehicle owners carrying commodities like sugar, fruits, and leather show significant interest in purchasing electric vehicles if there is provision of a government subsidy. 75%, 13%, and 50% of these owners are very likely to do so respectively. Carriers of other commodities display varying levels of interest, with some showing moderate interest and others showing no interest, even with a subsidy.

Personal ownership is characterized by the highest likelihood of considering a shift to electric vehicles with a subsidy; 41% personal owners are very likely to do so. However, 23% remain very unlikely to make the switch. Leased and third-party ownership exhibit varying levels of interest, with 36% and 95% remaining very unlikely to shift respectively.

Both fixed and flexible movement types show interest in purchasing electric vehicles with a subsidy, with 39% and 17%, respectively, very likely. However, 77% of flexible movement type respondents remain very unlikely to shift. Respondents who make 1-2 trips per day signaled an interest in purchasing electric vehicles in presence of a subsidy, with 33% being very likely. However, 35% of those with 3-6 trips made per day remain very unlikely to shift.

Possessors of vehicles which make trips lasting a short duration of 0-2 hours show interest in buying electric vehicles with a subsidy; 29% of them are very likely. Similarly, respondents covering short average distances per day show more interest in purchasing electric vehicles with a subsidy, with 55% being very likely to do so for distances of 1-2 km. However, 62% of owners traveling distances of 51-80 km every day remain very unlikely to shift. Respondents who park at home show the highest interest in purchasing subsidized electric vehicles, with 68% being very enthusiastic. However, those who park on the roadside (28%) and in common parking (20%) also show interest. The owners of vehicles with shorter parking times are more keen about buying subsidized electric vehicles. 49% of owners with a parking duration of 0-1 hours are very likely to do so. However, longer parking duration drivers show varying levels of interest. Vehicles registering lower odometer readings have their owners showing more interest in purchasing electric vehicles with a subsidy, where 43% of lower reading groups being very likely. However, carrier owners displaying higher readings show varying levels of interest.

Inference: Three-wheeler goods carrier owners show the most interest in purchasing electric vehicles with a government subsidy. Parties involved in the transfer of commodities like sugar, fruits, and leather show significant interest in buying subsidized electric vehicles. Personal ownership is characterized by the highest likelihood of considering the purchase of electric vehicles with a subsidy. Subsidized electric vehicles show promise as an alternative fuel option, especially for trips with short distance transfers. For further details of descriptive statistics about the likelihood of the next purchase being an electric vehicle with the provision of a government subsidy, please refer to Annexure II.

8.2 Descriptive Analysis of Likelihood of Next Purchase Being an Electric Vehicle if Banks Provide Loans

This analysis delves into the specific factors influencing the likelihood of freight drivers considering the purchase of electric vehicles (EVs) at lower interest rates when financed by banks. Among the different vehicle types, two-wheelers emerge as the most amenable to EV adoption, with a striking 60% of respondents expressing a “Very Likely” intent to purchase electric variants. Pick-up trucks and six-wheeler trucks also exhibit a notable interest in transitioning to electric models, with 21% and 28% expressing a “Very Likely” intent respectively.

Fruits, logistics, and packed-food sectors stand out as prime candidates for EV adoption, with a substantial percentage of respondents expressing a “Very Likely” intent. Respondents hauling commodities like livestock and Oil & Gas present challenges for widespread EV integration, with no respondents indicating a “Very Likely” inclination. Personally-owned vehicles emerge as the frontrunners for EV adoption as 35% of respondents indicate a strong inclination towards electric models.

Fixed movement types and higher trip frequencies by carriers correlate positively with a propensity for possessing electric vehicles as a notable percentage signal a “Very Likely” intent. Fewer trips along with short durations and distances also result in a heightened interest in EVs, reflecting practical considerations in operational efficiency. While factors like vehicle age, odometer readings, and commodity weight provide valuable context with respect to the existing fleet and operational dynamics, they do not directly influence the likelihood of EV adoption under favourable financing terms.

Inference: The analysis done above brings out the presence of a tangible interest among freight drivers in embracing electric vehicles, especially when it is coupled with favourable financing options. However, the successful adoption of EVs by the freight industry hinges on addressing multi-faceted considerations like infrastructure development, operational feasibility, and regulatory support. By taking up these specific challenges, stake-holders will be able to accelerate the transition towards sustainable transportation and capitalize on the growing interest in electric vehicles among freight drivers. For more details of descriptive statistics on the likelihood of the next purchase being an electric vehicle if banks provide loans, please refer to Annexure-III.

8.3 Descriptive Analysis of Likelihood of Next Purchase Being an Electric Vehicle with Lower Maintenance Costs

This analysis investigates the likelihood of freight drivers considering the purchase of electric vehicles (EVs) under the condition of lower maintenance costs when compared to internal combustion engine (ICE) vehicles. The dataset for this study encompasses parameters such as vehicle type, ownership structure, fuel preference, operational patterns, and vehicle characteristics while excluding E-rickshaws from the analysis.

Excluding E-rickshaws, drivers/owners of all other vehicle types exhibit a notable interest in potential EV adoption. Owners of three-wheeler goods carriers, mini-trucks and pick-up trucks show moderate to a “somewhat likely” inclination towards electric variants, with percentages ranging from 16% to 19%. This indicates a positive response of “Very Likely”. Personally-owned vehicles are in the ‘highest likelihood’ category of transitioning to electric models, with 25% of the owners expressing a “Very Likely” intent.

The adoption of electric vehicles ignites significant interest across the entire spectrum of fuel preferences, with 49% of respondents indicating a “Very Likely” inclination towards EVs. Both fixed and flexible movement types show notable interest in electric vehicles, with approximately 20% of respondents in each category indicating a “Very Likely” likelihood. The drivers/owners who make 1-2 trips per day and cover distances of 1-2 km every day continue to be those who exhibit the highest interest in electric vehicle adoption, with 19% and 42% indicating a “Very Likely” viewpoint respectively. People parking their carriers at home and those who park for a time ranging from 0-1 hour still show the most interest in electric vehicles with a 74% and 28% share respectively, thereby indicating a “Very Likely” possibility of going electric.

Inference: The analysis done above highlights the existence of a notable interest among freight drivers in transitioning to electric vehicles, even when E-Rickshaws are excluded. Three-wheeler goods carriers, mini-trucks, and pick-up trucks emerge as potential candidates for EV adoption. Persons owning freight vehicles continue to present the highest likelihood of transiting to electric. While lower maintenance costs serve as a significant motivator, the actual adoption of EVs within the freight industry will depend on a multitude of factors, like infrastructure development, operational feasibility, and regulatory support. Thus, targeted interventions addressing these multi-faceted concerns will be essential in facilitating the widespread adoption of electric vehicles among freight drivers. For more detailed descriptive statistics on the likelihood of the next purchase being an electric vehicle with lower maintenance costs, please refer to Annexure-IV.

8.4 Descriptive Analysis of Likelihood of Next Purchase Being an Electric Vehicle if it has a Range Similar to an ICE Vehicle

This report tries to examine the likelihood of individuals opting for electric vehicles (EVs) over internal combustion engine (ICE) vehicles by focusing on factors such as vehicle range.

Among the vehicle types considered, mini-truck owners show a moderate inclination towards EV adoption, with 12% of respondents indicating a high likelihood of purchasing an EV if it matches ICE vehicles’ range. Tractor owners/drivers also display a moderate preference, with 12% expressing a strong inclination towards EVs. Conversely, three-wheeler goods carriers and pick-up trucks exhibit lower levels of interest, with only 17% and 9% being very likely to choose EVs respectively.

Preference for EVs varies among carriers hauling different commodity types. Livestock transportation and packed-food delivery sectors are characterized by a relatively high likelihood of adopting EVs, with

23% and 17% indicating a strong inclination respectively. Conversely, industries like oil & gas and leather have no preference for EVs, with 0% indicating a likelihood of adoption. Personal vehicle owners report the highest inclination towards EV adoption, with 20% indicating a strong likelihood of choosing EVs. Diesel vehicle owners also show moderate interest, with 14% being very likely to opt for EVs. However, individuals who lease out vehicles display a lower likelihood, with only 16% indicating a strong inclination towards switching to EVs.

Factors such as flexible movement types and shorter trip durations correlate with a higher likelihood of EV adoption. Respondents with flexible movement types and those undertaking shorter trips of 1-2 hours exhibit higher levels of interest in EVs compared to their counterparts. Additionally, individuals parking their vehicles at home demonstrate a significantly higher likelihood (18%) of choosing EVs over those parking on the roadside (14%).

Inference: Understanding consumer preferences with regard to EV adoption is crucial for manufacturers and policy-makers seeking to find and promote sustainable transportation solutions. By examining factors such as vehicle type, commodity type, ownership and fuel type, stake-holders can tailor strategies to encourage greater EV adoption and support the transition towards a greener transportation eco-system. For more comprehensive descriptive statistics on the likelihood of the next purchase being an electric vehicle with a range similar to ICE vehicles, please refer to Annexure-V.

8.5 Descriptive Analysis of Likelihood of Next Purchase Being an Electric Vehicle if its speed is similar to ICE vehicles

The ensuing analysis aims to uncover the propensity for consumers to opt for electric vehicles (EVs) as their next purchase, particularly if the EVs offer a speed performance similar to that of internal combustion engine (ICE) vehicles. E-rickshaws and two-wheelers emerge as the most receptive segments when it comes to considering EVs, with significant percentages indicating a likelihood of purchase, both somewhat likely and very likely. The tractor and mini-truck sections also show moderate interest, suggesting possibilities of a potential shift towards electrification in these sectors.

The logistics sector stands out as one with high interest in EV adoption, particularly for transportation purposes. Conversely, the captains of industries such as sugar, oil & gas, and leather exhibit minimal interest in transitioning to electric vehicles. Personal vehicle ownership demonstrates the highest inclination towards EV adoption, followed by third-party ownership arrangements. This indicates the presence of a consumer-driven demand for cleaner and sustainable transportation options. While CNG vehicles display the highest interest in EV alternatives, diesel vehicles also show significant receptivity.

This suggests a growing awareness and acceptance of EVs across various fuel-dependent vehicle categories. Vehicles with higher trip frequencies and shorter trip durations display a stronger inclination towards EV adoption, highlighting the suitability of EVs for urban commuting and short-distance travel. Vehicles whose owners mostly park them at home exhibit the highest interest in EVs. This proves the fact that the role of residential charging infrastructure in promoting EV adoption is decisive.

While these factors provide insights into the current vehicle landscape, they do not directly influence the likelihood of EV adoption but do contribute to understanding the existing vehicle fleets' characteristics.

Inference: The analysis done above reveals a marked interest in EV adoption across diverse segments, indicating a shift towards cleaner and more sustainable transportation solutions. The findings underscore the need and importance of continued investment in EV infrastructure, technological advancements, and policy support to accelerate the transition to electric mobility and mitigate environmental challenges posed by traditional ICE vehicles. For more insights into descriptive statistics about the likelihood of the next purchase being an electric vehicle if the speed is similar to ICE vehicles, please refer to Annexure-VI.

8.6 Descriptive Analysis of Likelihood of Next Purchase Being an Electric Vehicle if its payload capacity is similar to ICE vehicles

Apart from E-rickshaws, two-wheelers, with a combined interest of 57% (19% somewhat likely and 38% very likely) emerge as the most interested segment in electric vehicle adoption. Also, mini-trucks and tractors display moderate interest in electric vehicles, registering figures of 43% and 25% respectively, thereby indicating some level of interest. However, three-wheeler goods carriers and pick-up trucks show lower interest levels when compared to other vehicle types.

Commodities such as crops, packed food and those related to logistics and transportation feature a relatively higher interest in electric vehicles. Conversely, sectors like oil & gas, and livestock express minimal interest, with 75% of respondents in the oil & gas sector indicating that they are very unlikely to consider an electric vehicle for their next purchase. Personal vehicle ownership is characterized by the highest interest in buying electric vehicles, with 33% somewhat likely and 33% very likely to consider an EV. Leased vehicles and third-party ownership arrangements are marked by lower interest levels compared to personal ownership. Among vehicles which exclude E-rickshaws, CNG vehicle owners show the highest interest in switching to electric vehicles, with 58% indicating at least some level of interest. Diesel vehicle pliers also display notable interest, with 43% somewhat likely or very likely to consider an EV for their next purchase.

Vehicles with high trip frequencies tend to show greater interest in electric vehicles, with 36% of these vehicles making 11-20 trips per day expressing a "very likely" interest in EVs. Furthermore, vehicles with shorter trip durations (0-2 hours) exhibit higher interest in EV adoption compared to those recording longer trip durations. Owners/drivers of vehicles which park mostly at home exhibit the highest interest in electric vehicles, with 59% indicating they are somewhat likely or very likely to consider an EV for their next purchase. This highlights the importance of providing residential charging infrastructure in promoting EV adoption. While these factors provide insights into the characteristics of the surveyed vehicles, they do not directly influence the likelihood of electric vehicle adoption. However, it's worth noting that vehicles with higher odometer readings and cargo weights generally show a slightly lower interest in switching to EVs.

Inference: Apart from E-rickshaws, the data reveals varied levels of interest in electric vehicle adoption across different vehicle types, sectors of commodity being transported, ownership models, and usage patterns. Understanding these nuances can help inform the creation of targeted strategies to promote electric mobility adoption like incentives, infrastructure development, and awareness campaigns tailored to specific segments of the market. For more insights into descriptive statistics on the likelihood of the next purchase being an electric vehicle if the payload capacity is similar to ICE vehicles, please refer to Annexure-VII.

8.7 Descriptive Analysis of Likelihood of Next Purchase Being an Electric Vehicle if it has Longer Fueling/Charging Time than an ICE Vehicle

This detailed analysis provides specific insights into the preferences and tendencies with regard to the adoption of electric vehicles in comparison to ICE vehicles based on variations in fueling/charging time of these two categories of automobiles.

Three-wheeler goods carriers and mini-trucks also show considerable interest, with 13% and 24% of them being very likely or somewhat likely respectively. Nevertheless, 44% and 25% of these same two types respectively are very unlikely to shift to electric models. Pick-up trucks and tractors display lower interest, with only 6% and 5% opining to be very likely or somewhat likely respectively. However, the majority (57% and 50% respectively) are very unlikely to shift to EVs.

Sectors of commodities getting hauled such as livestock, packed food, and logistics demonstrate a higher propensity to consider electric vehicles, with 18%, 9%, and 5% very likely respectively to do so. Yet, 35%, 37%, and 49% respectively are very unlikely to transit. Moreover, captains of industries like sugar and oil & gas show absolutely no interest in adopting electric vehicles, with 0% in the "very likely" category. Personal ownership among the carriers has the feature of the highest likelihood of considering electric vehicles, with 13% very likely and 6% somewhat likely to make the transition. Also, 41% still remain very unlikely to shift. Leased and third-party ownerships show even lower interest, with only 2% and 1% very likely respectively to adopt EVs. The majority (62% and 59% respectively) are very unlikely to shift. Electric vehicles are favored over traditional fuel types of Petrol, Diesel, and CNG by 12% being very likely and 12% being somewhat likely in this consideration. However, 28%, 48%, and 51% respectively are very unlikely to shift. Vehicle age analysis indicates that those possessing older vehicles are less likely to consider switching to electric vehicles. For instance, vehicles with a mean age of 5.05 years show varying levels of likelihood to shift, but the majority are very unlikely to transit. Higher odometer readings on average are associated with a lower likelihood of considering electric vehicles. Vehicles with higher usage tend to be very unlikely to shift to electric. Vehicles transporting relatively heavy commodities are generally less likely to consider electric vehicles, with the majority remaining very unlikely to shift.

Inference: E-rickshaws, three-wheeler goods carriers, and mini-trucks are more inclined to make the transition to electric vehicles due to longer refueling and short charging times, although a significant proportion remains very unlikely to shift. Sectors like livestock, packed food and logistics are more receptive to electric vehicles, while industries such as Sugar and Oil & Gas show negligible interest, with a majority remaining very unlikely to shift. Personal ownership, lower trip frequency, longer trip durations, and shorter travel distances are factors associated with a higher likelihood of considering electric vehicles, although a substantial portion of respondents across various factors remains very unlikely to shift. Vehicle age, odometer reading, and cargo weight are additional factors influencing the likelihood of transitioning to electric vehicles, with older vehicles, higher usage, and heavier loads showing lower inclination. For more insights into descriptive statistics on the likelihood of the next purchase being electric with longer fueling/charging time than an ICE vehicle, please refer to Annexure-VIII.

9 Implications

9.1 Factors affecting the likelihood of the next purchase of vehicle being an electric vehicle

- Government Subsidy and financing by banks are the most influential factors for promoting the shift from ICE vehicles to electric vehicles, whereas high refueling time is the lest influential factor.
- Three-wheelers and mini-trucks are very likely to shift toward electric vehicles if they are provided with government subsidies and financing by banks. Also, this is very likely if the EVs can attain speeds similar to ICE vehicles.
- Vehicles carrying livestock, plastic and rubber are very much likely to shift towards electric vehicles followed by textiles, sugar and bricks. Apart from government subsidies and bank financing, the major factor supporting such a transition is the quality of EVs having the same range and speed.

- A personally-owned vehicle is very much likely to switch to an electric vehicle if the vehicle's maintenance cost is low as compared to ICE vehicles.
- Vehicles making trips which log between 7 to 20 per day and travel ≤50 kms per day are very much likely to switch to electric vehicle technology.
- Vehicles carrying a cargo weight of 2-3 tonnes (for three-wheelers and Jugaad vehicles) are mainly influenced by the EVs having comparable speeds and payload capacities. The vehicles which carry a cargo weight of 3-5 tonnes (mini-truck, pick-up trucks) are mainly influenced by promises of government subsidies and financing by banks. The vehicles which carry more than 4 tonnes of cargo are influenced chiefly by low maintenance costs and comparable range. During the survey, it has been observed that ICE vehicles tend to carry a cargo weight which is 1.5 times their maximum loading capacity. This helps save vehicles owners some extra trips and time.
- Vehicles which have travelled 54,000 Km or more on an average and are of an average age of 4-5 years are more likely to shift towards electric vehicles.

Table 7 reveals the factors influencing the chances of vehicle owners and drivers to shift from ICE vehicles to electric vehicles. The table identifies the policy requirements that need to be focused on in the short and long term in order to achieve electric vehicle transition in the freight sector of Bihar.

Table 7: Factors influencing the likeliness to shift from ICE vehicles to Electric vehicles on a scale of high to low

	Govt. Subsidy	Bank Finance	Low Maintenance Cost	Same range	Same Speed	Same Payload Capacity	High Refuelling Time
Vehicle Type							
Three-Wheeler Goods Carriers	22%	21%	18%	17%	24%	13%	7%
E-Rickshaw	22%	23%	28%	25%	27%	19%	12%
Mini-Trucks	22%	22%	17%	14%	20%	12%	4%
Pick-Up-Trucks	18%	19%	12%	10%	14%	8%	3%
Six-Wheeler Trucks	26%	22%	18%	19%	13%	11%	6%
Tractors	23%	22%	18%	17%	17%	12%	9%
Jugaad	17%	18%	16%	15%	13%	10%	10%
Two-Wheelers	38%	38%	37%	37%	33%	27%	12%
Commodity Type							
Crops	20%	19%	16%	14%	13%	7%	3%
Fruits	9%	9%	12%	9%	15%	4%	3%
Vegetables	15%	16%	17%	16%	21%	13%	10%
Livestock	29%	27%	22%	21%	27%	22%	14%

Diary	17%	19%	18%	16%	14%	10%	7%
Packed Food	21%	21%	17%	17%	28%	14%	5%
Textiles	32%	31%	19%	21%	22%	14%	7%
Plastic & Rubber	30%	30%	23%	22%	29%	23%	6%
Metal Fabrications	25%	22%	16%	12%	19%	12%	4%
Sugar	50%	7%	29%	21%	29%	21%	0%
Brick	31%	18%	21%	23%	22%	16%	16%
Stone-Chips	24%	23%	22%	22%	18%	16%	10%
Logistics	22%	19%	12%	10%	17%	12%	3%
Cement	27%	28%	16%	16%	18%	12%	6%
Oil & Gas	0%	0%	0%	0%	0%	0%	0%
Sand	25%	17%	21%	18%	16%	13%	11%
Leather	25%	25%	0%	25%	0%	0%	25%
Vehicle Ownership							
Personal	31%	30%	23%	22%	22%	17%	10%
Leased	32%	34%	26%	24%	10%	5%	1%
3rd Party Ownership	2%	1%	4%	3%	13%	1%	1%
Trips per Day							
1-2 trips	25%	25%	19%	18%	18%	13%	7%
3-6 trips	15%	14%	13%	12%	19%	9%	7%
7-10 trips	38%	33%	28%	20%	22%	20%	11%
11-20 trips	50%	50%	50%	50%	38%	38%	13%
21-50 trips	0%	0%	50%	50%	0%	0%	0%
>50 trips	0%	0%	0%	0%	0%	0%	0%
Distance travelled per day							
1-2 Km	36%	36%	38%	29%	25%	25%	0%
3-5 Km	45%	39%	35%	32%	31%	26%	9%
6-10 Km	39%	38%	28%	20%	20%	16%	11%
11-30 Km	33%	34%	26%	27%	21%	20%	9%
31-50 Km	30%	28%	21%	18%	17%	13%	6%
51-80 Km	14%	15%	18%	17%	25%	14%	9%
81-120 Km	10%	10%	12%	12%	18%	8%	5%
121-200 Km	17%	17%	11%	12%	12%	6%	5%
201-300 Km	14%	13%	11%	8%	13%	5%	2%
301-500 Km	19%	20%	17%	16%	12%	10%	5%
>500 Km	50%	31%	12%	15%	8%	4%	0%
Parking Location							
Roadside	21%	21%	16%	15%	18%	10%	5%
Private Parking	32%	30%	21%	20%	21%	17%	7%
Common Parking	15%	15%	14%	15%	14%	9%	5%
Home	42%	32%	43%	39%	38%	34%	34%
Parking Time							

0-1 Hr	36%	36%	28%	26%	19%	18%	7%
2-3 Hr	32%	33%	24%	20%	14%	12%	4%
4-5 Hr	34%	34%	21%	28%	23%	21%	16%
6-8 Hr	12%	10%	10%	9%	18%	6%	5%
9-12 Hr	5%	5%	9%	9%	19%	8%	7%
>12 Hr	0%	0%	0%	0%	0%	0%	0%
Commodity Weight (Tonnes)							
Mean	3.55	3.68	4.2	4.54	2.57	2.99	4.47
Odometer Reading (Kilometers)							
Mean	42392	47246	51367	49192	96879	40599	55020
Vehicle Age (Years)							
Mean	4.8	5.0	4.4	4.2	4.4	4.1	4.9
Colour Scheme	High Influence (>20%)		Moderate Influence (10-19%)		Low Influence (<10%)		

9.2 Drivers and Barriers to Adoption

The study results also identify the obstacles that are affecting the adoption of electric vehicles and the "unlikely to shift towards electric vehicles" category is in a higher proportion than the likely to shift one. On an average, 30% of the respondents are very much unlikely to shift, which shows how little the trust is among vehicle owners and drivers on electric vehicle technologies as compared to ICE vehicles. The challenges that are being faced in electric vehicle adoption are discussed below.

- Although government subsidies and financing by banks are important influential factors to shift towards electric vehicles, it is not sufficient as 45% of respondents are very unlikely to shift even if they are provided with government subsidies.
- Most of the respondents believe that they will be able to shift towards electric vehicles if provided with superior range, payload capacity, speed, and low maintenance cost.
- The comparative matrix of ICE and electric vehicles in Table 8 shows the performance and service levels of ICE and electric vehicles. The operational costs of electric vehicles are much less then diesel vehicles. However, the lesser range of electric vehicles is still a challenge to be surmounted.
- Lower range of electric vehicles affects freight delivery systems and income of the vehicle owners and drivers. They are compelled to either reduce their operational time or increase their current schedule of operations by one or two hours
- Unavailability of financial options is another major barrier in the adoption of electric vehicles. This is in contrast to ICE freight vehicles that get easily financed with flexible EMI options provided by different banks and non-banking financial companies. There are very limited financing options available for electric vehicles.

- The nature of the commercial vehicle loan given for ICE and electric vehicles is different. For instance, the loan payback period of electric goods vehicles is 36 months whereas it's 60 months for ICE vehicles. This discourages owners from shifting towards electric vehicles, thereby causing an increase in the EMI amount for purchasing EVs.

Table 8: Comparison matrix between electric and conventional diesel vehicles

Key Parameters	Three-wheeler Goods Vehicle (Diesel)	Three-wheeler Goods Vehicle (Electric)	Mini-Truck (Diesel)	Mini-Truck (Electric)
Range (in Km)	160-250 Km (Fuel tank: 8-10 L)	80-150 Km in single charge	660 Km (Fuel tank: 30L)	154 Km in single charge
Speed (in Kmph)	50-60	45-55	65-80	60 max
Payload Capacity (Kg)	500-510	480-500	750-900	600-650
Fuel Consumption	25-33 km/L	6.4-8.6 kWh/100 km	22-25 km/L	13-20 kWh/100 km
Refuelling time / Charging time	5 minutes	4-5 hours	5 minutes	1.5-2 hours
Gradability (in percentage)	17-18	16-20	20-27	20-22
Capital Cost (Rs)	300000 (approx.)	380000 (approx.)	550000 (approx.)	900000 (approx.)
Operational Cost	3-3.5 per Km	0.4-0.6 per km	4.5-5.5 per Km	1 per Km
Availability of Finance	Easy finance- almost all banks and NBFCs provide commercial vehicle loan	Finance difficult- limited institutions provide EV finance	Easy finance- almost all banks and NBFCs provide commercial vehicle loan	Finance difficult- limited institutions provide EV finance

10 Opportunities and Recommendations

Understanding freight movement patterns is critical to projecting future transition possibilities to electric vehicles. Creating baseline data and freight models is essential to enable the correct prediction of freight transportation behavior and design data-informed policies. The present study has been conceptualized to study urban freight and the perspective of users with respect to shifting from ICE vehicles to electric vehicles. This is an opportunity present in Bihar as it is in an early stage of the stated aim to move to a low carbon economy when the Low Carbon Development Pathway Report for Bihar was released. The study discusses the potential and strategies for electrification of urban freight using an integrated approach to transit to zero-emission fuels for vehicles in the transport sector. With strategic interventions and appropriate support, it is possible to catalyze this transition process. To accelerate the electric vehicle adoption, it is necessary to consider the following recommendations: -

Short-Term Strategies: Demand incentives in form of government subsidies on the purchase of electric vehicles and better financing opportunities from banks will help develop a strong market base for electric vehicles. Bihar has already decided to forego 50% of the Motor Vehicle Tax and permit fees for goods carriage vehicles for a policy period of five years, as stated in the Bihar EV Policy, 2023. This may be further strengthened by introducing various incentivizing programmes.

- Incentive of Scrapping: As per the Registered Vehicles Scrapping Facility of the Ministry of Road Transport and Highways, Govt. of India, there are a total of three scrapping centers in Bihar. Deregistration of older vehicles is equally important when compared to newer clean fuel vehicles. The Bihar government has already issued a notification for exemption of 15% road tax on the purchase of a new commercial vehicle accompanied by a scrapping certificate. More scrapping centers and proper awareness among people can encourage people to scrap out their old vehicles.
- Purchase Incentive: During the early stage, the government can provide purchase incentives for electric three-wheeler and four-wheeler goods vehicles. Most of the freight vehicle owners are ready to purchase brand new vehicles in the coming 2-3 years and such purchase incentives will boost the adoption of electric vehicles.

Long-Term Strategies: Continuous upgradation in vehicle technology is required to get out of the dependency on ICE vehicles and adopt electric vehicles. As the study suggests, freight vehicle owners are very anxious about shifting towards electric vehicle. This is because ICE vehicles have been over-performing as per the specifications set by automobile manufactures. Though some automobile manufactures producing electric vehicles claim ranges similar to ICE vehicles, it is much less in a real world scenario. Additionally, the range (as certified by manufacturers) keeps on decreasing with degradation of the EV batteries over time.

- Research and Development: The state government should support research projects on developing electric vehicle technologies to improve performance, efficiency and reliability. Designing innovative modules as per the market needs can improve manufacturing practices and will accelerate commercialization of EVs. This will also help the state government to set up a regulatory and monitoring framework in order to upgrade the quality of vehicles.

- Electric Three-wheeler Eco-system: Based on the study's findings, it was observed that three-wheeler vehicles are majorly used for freight activities in Bihar. On an average, a three-wheeler vehicle travels 50-60 km per day, which is perfectly within the range that an electric three-wheeler can attain. Lack of charging facilities is one of the major obstacles for three-wheeler electrification. Commercial hubs in the state should have dedicated parking facilities along with charging infrastructures.

Ease of Doing Business: The study finds that more than 50% of the freight trips are made without carrying any load. The freight delivery pattern is such that when goods are loaded at point A and delivered to multiple points within the city or to other places, the carrier vehicle usually comes back empty of any load. This results in superfluous consumption of fossil fuel. The Ministry of Commerce and Industry, Government of India has notified the National Logistics Policy in 2022 in order to improve logistics efficiency and develop integrated infrastructure by network planning. The state government must focus on developing a freight management plan for sustainable haulage of urban freight. There should be a continuation of the present study to develop comprehensive data and insight with regard to all aspects of freight logistics in Bihar.

Battery Swapping: Electric vehicle manufacturers need to strike a balance between the high price and low range of electric vehicles to make their costs competitive with ICE vehicles. Increasing the range of vehicles will lead to increase in battery size, thereby resulting in a higher purchase cost of vehicles. 40-50% of the entire cost of an EV is contributed by battery cost. Larger batteries also reduce the payload capacity of the vehicle. Taking this scenario into consideration, battery swapping can be a feasible alternative solution for problems arising due to cost and range. Although the battery swapping procedure in large vehicles like four-wheeler trucks is still very challenging, it is much more doable for smaller freight vehicles like three-wheelers.

Clean Mobility Transition in the Urban Freight Sector in the Eastern Regions

Survey Questionnaire

Surveyor Name: ____________________	**Survey Location:** _______________________
Insert the geo-location of survey location	**Longitude:** _____________________ **Latitude:** _______________________
Driver's Survey: *This survey is to understand the type of commercial vehicle used to deliver certain types of commodities at inter and intra city level. This survey will include interviewing drivers of commercial vehicles based on a predefined questionnaire. The aim of this survey is to understand the travel pattern of targeted commercial vehicles, in order to understand the flux of vehicle in specific routes.*	
Date and Time: __________________	**Name of Driver:** ________________________
Registration Number: _____________	**Make (Year) and Model:** _______________________

Type of Vehicle					
3W Goods Vehicle		E-Rickshaw	Mini-Trucks	Pick-up Trucks	
					
Six Wheeler Goods Vehicle		Two Wheeler Goods Vehicle		Jugard	
					
Number of Axles: 2 | 3 | 4 | 6		If vehicle is other than above vehicle class, please describe the vehicle type: ______________________________			

Code	**Type of Commodity loaded**	**Code**	**Type of Commodity loaded**	**Odometer reading of Vehicle (in KMs)**		
A111	Crops	C221	Plastic & Rubber	**Ownership of Vehicle**		
A112	Fruits	C251	Metal Fabrication	Personal	Leased	3rd Party Ownership
A113	Vegetables	C106	Sugar Mill	**Fuel type of Vehicle**		
A114	Livestock	B081	Sand	1. Diesel		3. CNG
C105	Dairy	C239	Brick	2. Petrol		4. Electric
C107	Food Processing	B089	Stone Chips			
C131	Textiles	H521	Warehouse/ Storage	If Others, specify the commodity by name		
C151	Leather	H522	Logistic Hub			

Trip Characteristics: To understand the pattern of transferring commodities from one place to another and to understand the flux of vehicle plying on each route.			
Specify the pick-up location of commodity	Place	District	State
Specify the drop location of commodity	Place	District	State

Which of the following driving condition suites the best for driver	Pick from point A, drop to point B & return empty vehicle to point A	
	Pick from point A, drop to point B & return loaded vehicle to point A	
	Pick at point A and drop at multiple points	
	If Other, please mention	
If Multi-stop delivery, where are the places you are going to deliver today (mention at least 5 names)?		
If Point-to-Point delivery, where are the places you generally deliver throughout the year (mention at least 5 names)?		

Please specify if the vehicle from specific point leaves loaded or unloaded with kind of commodity?

Point Name	Loaded/ Unloaded	Crops	Fruits	Vegeta bles	Livestoc k	Dairy	Food Processing	Textiles	Leathe r

Point Name	Loaded/ Unloaded	Plastic & Rubber	Metal Fabric ation	Sugar Mill	Sand	Brick	Stone Chips	Wareho use/ Storage	Logisti c Hub

<table>
<tr><th>Type of Movement</th><th>No. of Trips</th><th>Average Weight per trip</th><th>Time takes to deliver commodity</th><th>Total Km Covered per day (Kms)</th><th colspan="2">Is the trip route repeated on a daily basis (Yes/No/Maybe)</th></tr>
<tr><td rowspan="3">1. Fixed Route
2. Flexible Route</td><td rowspan="3">1. ≤ 2
2. ≤ 6
3. ≤10
4. ≤20
5. ≤50
6. ≥ 50
7. If More, please specify in No.</td><td rowspan="3">In Kg (Ex. 150-200kg)</td><td rowspan="3">1. 1- 2 Hrs
2. 2- 3 Hrs
3. 3- 5 Hrs
4. 5-10 Hrs
5. 10-15 Hrs
6. 15-24 Hrs
7. 1 day
8. 2 days
9. If more, please specify</td><td rowspan="3">1. 1-2 Km
2. 2-5 Km
3. 5-10 Km
4. 10-30 Km
5. 30-50 Km
6. 50-80 Km
7. 80-120 Km
8. 120-200 Km
9. Specify if above 200 Km</td><td colspan="2">Parking location
1. Roadside
2. Private Parking / in the shop
3.Comm. Parking
4. Home</td></tr>
<tr><td colspan="2">What is the average wait/ parking time of vehicle</td></tr>
<tr><td>1. 0-1 Hrs.
2. 1-3 Hrs.
4. 3-5 Hrs.
5. 5-8 Hrs.</td><td>6. 8-12 Hrs.
7. ≥ 12 Hrs.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

User Perception: To understand the anxiety levels in using the electric/CNG vehicle as compared to petrol/ diesel vehicle. Willingness to adopt CNG/electric vehicle for regular operations.

Q.1 Are you aware of any subsidy by government to procure electric vehicle? ◯ Yes ◯ No

Q.2 Are you aware, your current vehicle can be retrofitted with CNG kit? ◯ Yes ◯ No

Q.3 On the rank of 1-5 please rank the factors most helpful in buying electric vehicle, where 1 is least and 5 is max?

Factors	1	2	3	4	5
You get a subsidy from government					
You are financed by banks with a lower interest rate					
Operation & maintenance cost of electric vehicle less than your current vehicle					
Have a better or the same range than current vehcile					
Have the same speed as Petrol/ Diesel vehicle					
Have the same payload capacity as Petrol/ Diesel vehicle					
Have a higher refueling time/ charging time					

Truck Operators/ Logistic Hub Interview: *This interview is to understand the type of infrastructural/ technological needs required to plan an operation and what are the current challenges prevailing. These challenges can help to identify the transition pathway focused on specific sector. To also understand the financial challenges occurs in acquisition of electric/CNG vehicle.*

Vehicle Information and Operation									
Name of operator	Garaging Address	Vehicle Ownership Detail		Vehicle type and number of vehicles owned					
		State Permit		Three Wheeler		Four Wheeler	Six Wheeler	Two Wheeler	
		National Permit							
Total loading capacity combined all vehicle									
No. of workers (Drivers and Others)									
Type of loading or commodity				Crops	Fruits	Vegetables	Livestock	Dairy	Food Processing
				Textiles	Leather	Plastic & Rubber	Metal Fabrication	Sugar Mill	Sand
				Brick	Stone Chips	Warehouse/ Storage	Logistic Hub		
Tons of each commodity									
Frequency of trips				1. Daily	2. Alternate Days	3. Weekly	4. Monthly	5. Quarterly	

Revenue and Costs						
Total Earning per month	**Service charges per vehicle**	**Monthly / Annual Cost of Operation**				
Per Month *(In Rs.)*	(Including all other expenses) Per Km *(In Rs.)*	Monthly Rent / EMI *(In Rs.)*	Cost of Fuel /Charging per Month *(In Rs.)*	Monthly Maintenance Cost *(In Rs.)*	Monthly Parking / Other charges (permit, license, road tax etc.) *(In Rs.)*	Annual Insurance *(In Rs.)*

Q.4 What is the current fleet size operational right now?

1	2	3	4	5
Not more than 10%	10-20 %	20-50 %	50-80 %	80-100 %

Q.5 Are you planning to replace your current vehicle or add a new vehicle to your fleet?

1	2	3	4	5
< 1 Year	1 to 3 years	4 to 5 years	6 to 10 years	Not at all soon > 10 years

Q.6 Did you require any financial aid to purchase old fleet vehicle? ◯ Yes ◯ No

Q.7 What are the major serviceable areas of your fleet vehicles?

1	2	3	4	5
Within 50 Km of radius (local	Within cities in Bihar	Within only Eastern region like Jharkhand, West Bengal,	All states of India	Depends on orderly basis

level)		Odisha, Assam		

Q.8 Do you have knowledge of subsidies and benefits offered by central and state governments on buying and operating electric goods vehicles in Bihar. ◯ **Yes** ◯ **No**

Q.9 Do you know of any people who have purchased electric Vehicle?

1	2	3	4	5
None	Very few	Half of the people I know	Most of them have	Everyone I know has

Q.10 Are you aware of any owners who have availed any electric vehicle related government benefits / schemes?

1	2	3	4	5
None got it	Very few got it	About half of people who bought got it	Most of them got it	All got it

Please mention (if any) the challenges/difficulties faced by the current electric vehicle owners.

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Q.11 Which one of these facilities/services will positively contribute to meeting your operational requirements towards electrification? Please rank in the order of preference (1 to 5)

Lower Financing - Interest Rate	Cheaper Electricity Charges - lower than Rs 5/KW/h	Availability of more options of vehicle models	Parking & Charging infrastructure	Maintenance / Service Facility
Other -				

Qualitative Survey – Truck Operators/ Logistic Hub

Q.1 How do you plan your route? How do you ensure you vehicle and driver safety on the road?
Q.2 What are the challenges you face in day to day life related to operations?
Q.3 What infrastructure requirement you need, when planning to add new fleet vehicle in your operations?
Q.4 Do you think, electric commercial vehicle will prove more efficient then present ICE vehicles in future?
Q.5 What are day to day challenges you face during your fleet operations?

Variable	Variable Factor	Nature of Variable Factor
V1	Type of Vehicle	Controlled Factor
V2	Number of Axel	Controlled Factor
V3	Make year of vehicle	Un-Controlled Factor
V4	Type of commodity	Controlled Factor
V5	Odometer reading	Un-Controlled Factor
V6	Vehicle Ownership	Un-Controlled Factor
V7	Fuel Type	Controlled Factor
V8	Pick-up location	Un-Controlled Factor
V9	Drop-off location	Un-Controlled Factor
V10	Driving Condition	Controlled Factor
V11	Delivery Points	Un-Controlled Factor
V12	Type of Movement	Un-Controlled Factor
V13	No. of Trips	Un-Controlled Factor
V14	Payload weight	Un-Controlled Factor
V15	Time taken to deliver commodity	Un-Controlled Factor
V16	Total Km travelled per day	Un-Controlled Factor
V17	Parking location	Un-Controlled Factor
V18	Parking Time	Un-Controlled Factor