Alliance for an Energy Efficient Economy

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GREEN MOBILITY FOR RURAL E-COMMERCE

Feasibility of Electric Two-wheelers in Last-Mile Logistics

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Jointly prepared by: Alliance for an Energy Efficient Economy (AEEE) and Villgro Innovations Foundation.

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Acronyms

B2B	Business-To-Business
B2C	Business-To-Consumer
BMS	Battery Management Systems
BaaS	Battery-as-a-Service
COD	Cash on Delivery
E4W	Electric Four-Wheeler
E3W	Electric Three-Wheeler
E2W	Electric Two-Wheeler
EVs	Electric Vehicles
FAME	Faster Adoption and Manufacturing of Hybrid and Electric Vehicles
FDI	Foreign Direct Investment
GST	Goods and Services Tax
GeM	Government E-Marketplace
GP	Gram Panchayat
GDS	Gramin Dak Sevaks
ICE	Internal Combustion Engine
LSPs	Logistics Service Providers
NRLM	National Rural Livelihood Mission
NEMMP	National Electric Mobility Mission Program
NBFCs	Non-Banking Financial Companies
OCEN	Open Credit Enablement Network
OEMs	Original Equipment Manufacturers
PLI Scheme	Production Linked Incentive
PPP	Public-private partnership
QIS	Quick Interchange Stations
SEZ	Special Economic Zone
SPV	Special Purpose Vehicle
TCO	Total Cost of Ownership
UPI	Unified Payments Interface

Executive Summary

This report explores the transformative potential of electric two-wheelers (E2Ws) in last-mile e-commerce delivery across rural India, addressing both environmental challenges and socio-economic opportunities. The demand for efficient last-mile delivery systems in rural e-commerce has surged due to the rapid growth of e-commerce and changing consumer behaviors, particularly accelerated by the pandemic. E-bikes offer a viable solution to reduce emissions, with lower operational costs and reduced environmental impact, while also creating job opportunities and promoting gender inclusivity in logistics.

The feasibility of using E2Ws for rural last-mile delivery is assessed through a comprehensive analysis of market dynamics, consumer behavior, infrastructure challenges, and policy landscapes. The study combines secondary research (reviewing government documents, market analysis reports, and academic publications) with primary research (consultations with stakeholders such as OEMs, delivery partners, investment banks, e-commerce companies, and policymakers).

Rural areas are projected to account for

54%

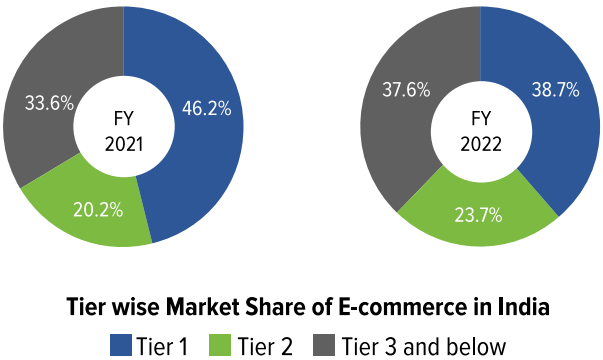
of online shoppers by 2030

The Indian e-commerce market is expected to deliver 40 billion parcels annually, leading to

8 million tonnes of CO_2 emissions

Market and Policy Assessment

- India's e-commerce growth rate is over three times the global average, driven by improved infrastructure, increased smartphone usage, and digital adoption, especially in tier II and tier III cities.
- Rural internet penetration has reached approximately 55%, surpassing the global rural average of 50%, fueled by the Digital India program and a 200% surge in rural internet subscriptions since 2015.
- Consumers in tier II and tier III cities are increasingly embracing online shopping, facilitated by payment options like Unified Payments Interface (UPI) and e-wallets.



Rural India accounts for **55%** of the two-wheeler sales in India with a **13%** year-on-year increase.

- Major e-commerce players, including Amazon India, Flipkart, and Myntra, are expanding into rural markets, with delivery personnel earning between INR 15,000 and INR 25,000 monthly.
- Female participation in the delivery workforce is rising due to gender diversity initiatives.
- Barriers to e-commerce adoption include security concerns, knowledge gaps, perceived costs, and shipment issues, which are being addressed by secure payment gateways and reliable delivery services.

E2Ws: Benefits and Strategic Opportunities

While E2Ws are gaining traction nationally, constituting **56% of the total EV sales** in FY 2023-24, deeper inroads into the rural market remains to be made.

- Two-wheelers dominate India's vehicle market, accounting for over 70% of total sales, with around 17.97 million (1.8 crore) units sold in FY 2023–24.
- The Indian government promotes E2Ws through initiatives like the PM E-DRIVE, FAME Scheme, state-level policies and infrastructure improvements such as charging and swapping stations.
- E2Ws are cost-effective, with lower operational costs, significant fuel savings, and reduced physical strain on delivery personnel, leading to faster and more reliable deliveries.

Introduction to the Pilot

A total of **20 E2Ws** were deployed across the two locations using a structured approach that accounted for driver experience, gender inclusion, and logistical feasibility.

- The pilot project was designed to assess the acceptability, feasibility, and viability of transitioning last-mile e-commerce deliveries to E2Ws in rural Telangana.
- It was implemented in Sangareddy and Warangal, selected based on the presence of pilot partners, regional e-commerce activity, and growing E2W penetration.
- The study followed a structured methodology comprising baseline assessments, continuous monitoring, and endline evaluations, integrating field observations, driver interviews, and weekly feedback to capture both operational challenges and benefits of E2W adoption.

Pilot Implementation

- The pilot was implemented through close coordination among Villgro, Hala Mobility, MOWO, and AEEE. Key activities included vehicle allocation, driver onboarding, training, and ongoing operational support.
- In Sangareddy, all participating drivers were experienced male delivery personnel, while in Warangal, the pilot focused on women drivers, many of whom were first-time drivers and new to formal employment.

Key Findings

Sangareddy

- Most drivers were familiar with E2Ws through prior exposure or test rides and recognised their potential for fuel and maintenance cost savings. However, range anxiety emerged as an initial concern due to daily travel distances of 40 to 60 km.
- Drivers consistently reported high comfort and ease of use. While most found a single full charge sufficient for a day's work, a few required mid-day charging. Charging practices varied between overnight home charging and partial charging during breaks.
- Endline interviews showed that monthly charging costs ranged between ₹100 and ₹500, significantly lower than previous fuel expenses of ₹1,500 to ₹3,500. Despite these savings, leasing costs remained a key barrier, with monthly lease rates of ₹3,500 to ₹5,000 viewed as unsustainable for long-term use.

Warangal

- Women drivers viewed E2Ws as a pathway to financial independence and stable income, particularly as many previously relied on informal work. However, affordability and lack of prior vehicle ownership posed challenges. Several participants initially struggled with confidence, especially in traffic conditions.
- The Warangal pilot required additional interventions, including an outreach programme, one month of structured training by MOWO instructors, support for obtaining driving licenses, and onboarding with Swiggy.
- All drivers highlighted the lack of nearby charging infrastructure, which caused delays and operational stress. A strong sense of community emerged, with women supporting each other through shared practice sessions and home-based charging access.

Business Model and TCO Insights

- The pilot adopted a monthly subscription model to enable drivers to use E2Ws without upfront ownership costs and to assess the viability of leasing for rural last-mile deliveries.
- In Sangareddy, the three-month pilot followed a progressive pricing approach. Vehicles were initially provided free of cost, followed by a phased willingness-to-pay assessment. While drivers accepted a reduced lease of ₹1,500 per month, most opted out at the market rate of ₹5,760 per month.

The 10-year TCO analysis shows that **owned E2Ws** have nearly **half the TCO** of owned ICE two-wheelers.

- A Total Cost of Ownership (TCO) analysis was conducted across multiple vehicle types and ownership scenarios, including new and second-hand ICE vehicles, owned and loan-financed low- and high-speed E2Ws, and leased E2Ws.
- EV ownership and loan-based purchases offer the strongest long-term value, while leased E2Ws are the least cost-effective, as recurring lease payments increase TCO over time.

Challenges and Recommendations

- **High Leasing Costs Without Ownership:** Leasing at ₹5,760 per month was unattractive, lease-to-own or EMI-based models aligned with ICE vehicle costs could significantly improve adoption.
- **Lack of Corporate Fleet Support**: Demand-based hiring by platforms like Flipkart and Swiggy discourages long-term leasing commitments. Aggregator-led or platform-owned fleet models could reduce individual risk and improve affordability.
- **Limited Charging Infrastructure**: Drivers without home charging access struggled due to limited public charging in rural areas. Dedicated charging hubs in high-delivery zones, supported through public private partnerships, are critical.
- **Women-Centric Ownership and Financing Models**: Shared ownership through SHGs or cooperative financing, along with corporate-backed fleets for women drivers, can lower entry barriers and support sustained participation.
- **Training and Work Flexibility:** Continued training, local servicing capacity, and flexible shift structures are essential. Fixed shifts such as 6 AM to 2 PM often conflict with women's household responsibilities and should be reconsidered.

The transition to electric two-wheelers for last-mile delivery in rural India presents an opportunity to address environmental challenges, improve logistical efficiency, and foster socio-economic growth. Leveraging government policies, technological advancements, and strategic partnerships, stakeholders can create a sustainable and inclusive e-commerce ecosystem. This report provides a roadmap with actionable insights for policymakers, businesses, and community leaders, paving the way for a cleaner, more efficient, and equitable future for India's rural e-commerce sector

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Introduction

1.1 Background

The significance of last-mile delivery in rural e-commerce cannot be overstated. In recent years, the demand for efficient delivery systems has surged, driven by the rapid growth of e-commerce and changing consumer behaviors. The pandemic played a pivotal role in this transformation, shifting demand from urban to rural areas as more people began ordering products online from their homes. This shift was particularly pronounced in tier II and tier III cities, where the e-commerce sector saw a significant uptick in activity (Indian Retailer, 2024).

The anticipated growth of e-commerce in rural areas is projected to have significant environmental implications. Rural areas are projected to account for 54% of online shoppers by 2030. The Indian e-commerce market is expected to deliver 40 billion parcels annually, producing 8 million tonnes of CO_2 emissions (World Economic Forum, 2022). This surge in emissions is primarily driven by the direct-to-consumer logistics model, which significantly contributes to carbon emissions due to transportation and packaging requirements.

As a response to this increasing demand, the logistics infrastructure in India has evolved. New players, including dedicated last-mile delivery companies and hyperlocal delivery services, have joined traditional logistics providers. These companies have adopted technology-centric approaches to enhance efficiency and reduce costs. Innovations such as AI-powered logistics platforms, autonomous delivery vehicles, and electric vehicles (EVs) are being integrated into last-mile delivery operations, reflecting a broader trend towards sustainability and technological advancement in the sector (World Economic Forum, 2022).

Electric vehicles, particularly Electric two-wheelers, are emerging as a viable solution for last-mile delivery in rural areas. They offer several advantages, including lower operational costs, reduced environmental impact, and the ability to navigate challenging rural terrains. Companies like Delhivery and Ecom Express are investing in EVs and underscoring the potential of E2Ws in transforming rural delivery networks (World Economic Forum, 2022)

Beyond environmental benefits, E2Ws have the potential to create significant job opportunities and promote gender inclusion in the mobility workforce. The shift towards E2Ws in delivery services can lead to the creation of new roles in vehicle maintenance, logistics management, and delivery operations. Additionally, the relatively lower physical demands of E2Ws compared

to traditional vehicles make them accessible to a broader demographic, including women (Honbike, 2024). This inclusivity can help bridge gender gaps in the traditionally male-dominated logistics sector, fostering a more diverse and equitable workforce .

In this context, the study assesses the feasibility of E2Ws for last-mile rural e-commerce delivery. By evaluating market dynamics, consumer behavior, infrastructure challenges, and policy landscapes, we seek to provide a comprehensive analysis that can inform strategic decisions and policy recommendations to support the integration of E2Ws into rural delivery systems.

1.2 Study Objectives and Components

Table 1: Objectives of the study

	Objectives
Market Assessment	Identify and analyze relevant stakeholders across the e-commerce supply chain, EVs, and rural female livelihoods, including government entities, OEMs, charging infrastructure providers, and rural logistics firms.
	Perform a demand assessment to understand the landscape of the EV market relevant to last-mile e-commerce, focusing on the supply and demand sides and the accompanying infrastructural needs and gaps.
	Analyze EV demand in logistics. Assess EV availability, affordability, and infrastructure readiness for charging and maintenance. Gender Inclusion: Examination of the uptake of Electric two-wheelers among women in rural India and the socio-economic benefits associated with increased female participation in the e-bike market
	Analyze the financial viability of existing business models for EV adoption and provide strategic insights into financial models and partnerships to support widespread E2W use.
Policy Assessment	Policy and regulation in India are boosting e-commerce. Analyze policies relevant to electric vehicle (EV) adoption and infrastructure development at the central and state levels. This includes incentives, subsidies, tax reductions, and regulatory frameworks that support EV deployment. Examine government initiatives aimed at urban and rural areas to support EV adoption, such as the creation of EV charging stations and support for electric two-wheelers. Assess the current policy environment's efficacy in supporting EV adoption, focusing on how well these policies meet the needs of Original Equipment Manufacturers (OEMs) and other stakeholders and make recommendations for improvement.
Pilot Study and Impact Assessment	Deploy E2Ws in selected rural areas to assess their feasibility and impact on rural last-mile e-commerce delivery.
	Assess the impact of E2Ws deployment on the rural e-commerce space and the lives of delivery partners. This includes evaluating changes in job opportunities, delivery times, and the overall efficiency of delivery operations.

1.3 Methodology

This study adopts a dual approach comprising secondary and primary research. The methodological framework is designed to ensure a comprehensive analysis of the feasibility and impact of integrating E2Ws into rural last-mile delivery for e-commerce.

This report focuses on the market and policy assessment, which will guide the pilot design for the project's next phase. Following the completion of the pilot, the study and impact assessment will be conducted.

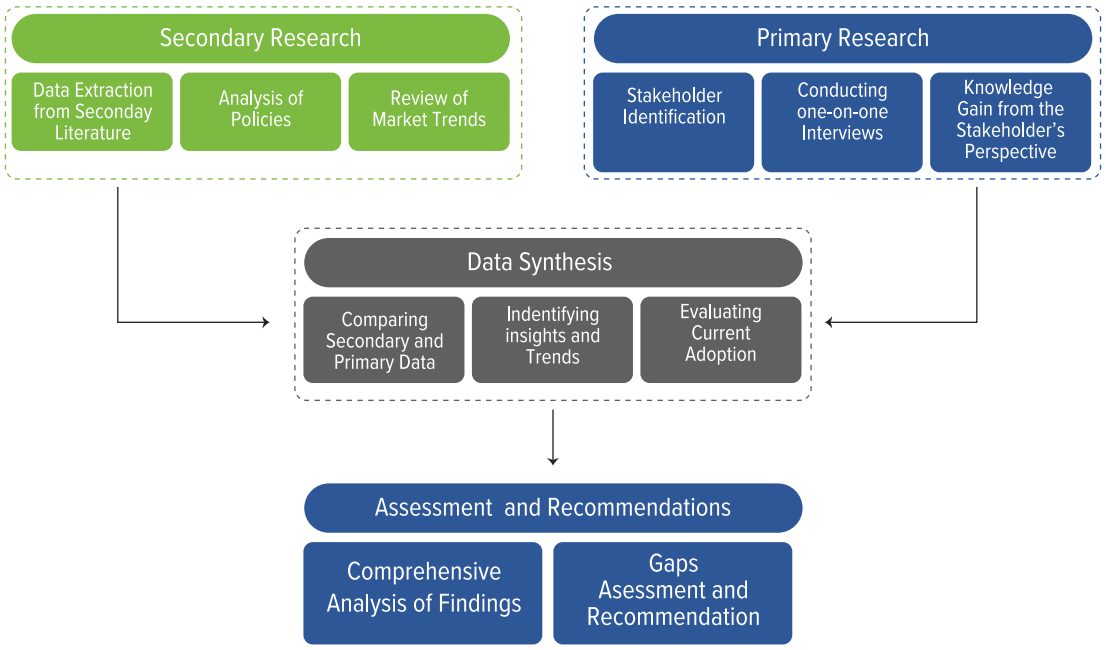

Figure 1: Methodological Framework

This methodological framework integrates secondary and primary research insights to ensure a robust and comprehensive analysis. It provides a solid foundation for developing effective strategies and recommendations for adopting E2Ws in rural last-mile delivery.

Secondary Research

Sources and Key Thematic Areas:

Government Reports and Policies: The key documents and policies, such as the PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) Scheme, FAME India Scheme Phase-II reports and NITI Aayog's guidelines on EV charging infrastructure implementation (NITI Ayog, 2024), were reviewed. These sources provided insights into the incentives, infrastructure developments, and regulatory frameworks supporting EV adoption in India.

Market Analysis Reports: We examined the reports and reputed media newsletters on the last-mile delivery market, focusing on trends, challenges, and opportunities specific to rural areas.

Academic and Industry Publications: Articles and studies from academic journals and industry publications were reviewed to understand the broader context and technological advancements in E2Ws adoption and last-mile logistics.

As part of the policy assessment, we conducted a detailed review of existing policies impacting the electrification of last-mile delivery services. This included analyzing central and state-level incentives for EV adoption. We evaluated financial incentives, subsidies, and tax reductions aimed at reducing the cost of E2Ws and enhancing their adoption, as well as regulatory frameworks concerning EV infrastructure, including charging stations and maintenance facilities.

Primary Research

Stakeholder Types and Consultations:

Our consultations involved a diverse range of stakeholders, including OEMs, delivery partners, investment banks, e-commerce companies, and policymakers. Each consultation featured semi-structured interviews that focused on the stakeholders' areas of expertise and their views on E2Ws adoption. All participants consented to recording interviews, and we maintained confidentiality in data collection and storage throughout the study.

The key areas of expertise and inquiry for each stakeholder group were as follows:

- **OEMs** provided insights into technological advancements, manufacturing challenges, and the market potential for E2Ws.
- **Financial Experts** evaluated the financial viability, investment opportunities, and economic impacts of E2Ws adoption.
- **E-commerce Companies** explored the integration of E2Ws into delivery networks and consumer acceptance.
- **Policymakers** focused on regulatory frameworks, incentives, and policy support for E2Ws adoption.
- **Logistics and Mobility Experts** examined optimizing delivery systems and incorporating E2Ws into logistics.
- **Gender Inclusion Organizations** assessed current female representation and possibilities for gender diversity in the mobility and logistics workforce. They also examined the impact of E2Ws adoption on equitable participation and opportunities in the mobility sector.

The consultations aimed to understand market dynamics by examining demand and supply patterns in rural e-commerce, assessing the availability and requirements for EV charging and maintenance infrastructure, and evaluating the existing policy landscape to identify gaps or areas for improvement.

Ethical Standards and Confidentiality: We adhered to strict ethical standards in conducting this research. Confidentiality was ensured through secure data storage and anonymization of participant information, and informed consent was obtained from all participants, including explicit permission to record the interviews.

1.4 Limitations

a. Data Constraints:

- Availability and reliability of information on E2Ws adoption in rural areas pose significant challenges.
- Lack of granular data specific to rural market dynamics and consumer behavior.

b. Geographical Variability:

- Rural areas in India differ widely in terms of infrastructure, economic conditions, and cultural factors.
- These differences affect the generalizability of findings across different regions.

c. External Factors:

- Changes in government policies, economic conditions, and technological advancements may influence the study's outcomes.
- These factors impact the feasibility and adoption rates of E2Ws in rural areas.

d. Stakeholder Participation:

- Limited to those available for consultations, potentially omitting critical perspectives.

e. Time Constraints:

- Impacted the depth and breadth of insights gathered.
- Scheduling conflicts and limited availability of stakeholders led to a condensed consultation process, potentially overlooking some nuanced perspectives.

02

Market Assessment for Last-mile E-commerce Delivery

2.1 E-commerce and Its Last Mile Market Dynamics in Rural India

Rising Rates of E-commerce Penetration in India

The Indian e-commerce sector has been experiencing rapid growth, with projections indicating significant expansion in the coming years. India's e-commerce market is expected to grow with a CAGR of 27%, reaching $163 billion by 2026 and $300 billion by 2030 (E-Commerce, 2024). According to a Deloitte India Report, The e-retail market alone is expected to surge to US$ 120-140 billion by FY26. With a growing online shopper base, which was the third-largest globally at 225 million in 2023, India's e-retail industry is projected to exceed 300-350 million shoppers in the next five years, driving the online Gross Merchandise Value (GMV) to US$ 100-120 billion by 2025 (Deloitte India, 2023).

Several factors on the supply side have contributed to the growth of Indian e-commerce. The logistics sector's recent designation as "infrastructure" has opened up better access to funding, enabling significant investments in infrastructure development. This has facilitated the national consolidation of warehousing and simplified distribution across states, thanks to a more transparent tax structure. The sector also benefits from 100% Foreign Direct Investment (FDI) in warehousing and logistics, providing a viable entry point for foreign investors keen to capitalize on India's e-commerce boom despite restrictions on FDI in e-marketplaces (India Retail and E-commerce Trends Report, 2022). Furthermore, the proposed National E-commerce Policy, which includes regulations on cross-border data flow and favorable FDI policies, is attracting key players to the market (E-Commerce, 2024). The growth of online shopping in India, fueled by increasing trust in e-commerce companies and expanding access to a diverse range of product categories, is a significant factor. This growth is particularly strong in tier II and below cities, driving most of the anticipated expansion in the next three to five years. The market has evolved from being heavily discount-driven to one where convenience is paramount, with consumers preferring the ease of ordering products online over visiting physical stores (Issuu, 2024).

A considerable portion of the growth in Indian e-commerce is expected to come from rural areas. While metro cities like Bengaluru, Mumbai, and Delhi have accounted for most online

shopping in absolute numbers, less densely populated regions have generated a larger proportion of online sales. E-commerce is experiencing remarkable growth in India's tier II and tier III cities, with the market share in tier III cities growing from 34.2% in 2021 to 41.5% in 2022. These regions are becoming significant contributors to the e-commerce market due to increasing internet penetration and the government's focus on digital inclusion. Companies like Amazon and Walmart actively invest in initiatives to reach these underserved areas, recognizing their potential (E-Commerce, 2024).

Understanding the dynamics of e-commerce growth in rural areas is crucial for contextualizing why projects targeting these regions are essential. These areas are witnessing a surge in digital adoption, driven by improved infrastructure and increased smartphone usage, making them the next frontier for e-commerce expansion. Businesses can tap into a vast, previously underutilized market by focusing on these regions, fostering economic development, and bridging the urban-rural divide in digital commerce. The supply side of e-commerce and its last-mile delivery in India, particularly in rural regions, is influenced by various factors that collectively drive growth and efficiency. A major driver is technology adoption, especially solutions that integrate payment systems with last-mile logistics. These innovations are essential in addressing the prevalent high return rates and the risks associated with cash on delivery. Companies that can harness technology to streamline these processes stand to gain significantly in the fragmented logistics market (India Retail and E-Commerce Trends Report,2022).

However, rural regions face unique challenges, such as poor logistics and delivery infrastructure and a lack of regional language support (Gupta & Singh, 2022). To overcome these, the rise of assisted e-commerce models has been instrumental. In these models, local retailers use internet-enabled devices to order products for customers, acting as both the cash collection point and the pickup location. This approach addresses the issues of low awareness and technological knowledge among rural customers and simplifies logistics for single orders to remote locations. The success of this model has attracted interest from both online and organized retailers, positioning it as a potential catalyst for the next wave of growth. Government initiatives like Digital India, which aim to increase internet penetration and digital literacy and reduce the prices of smartphones and data plans, have significantly boosted the adoption of e-commerce (E-Commerce, 2024).

Intense competition among e-commerce players has led to acquisitions, with top players acquiring smaller rivals to increase market share, often influenced by international investors (E-Commerce in India, 2022). This competitive landscape also drives companies to explore unrelated diversifications and invest in private labels across various categories, such as fashion, electronics, and home appliances. Strategies like omnichannel approaches, celebrity brand endorsements, and leveraging digital influencers are being employed with varying levels of success. Overall, the interplay of these factors—technological adoption, regulatory support, innovative business models, and competitive dynamics—is shaping the supply side of e-commerce and enhancing last-mile delivery capabilities in India's rural regions.

Digitization has paved the way for the E-commerce Sector

Globally, overall internet penetration is about 67-70%, with rural areas around 48-50% of rural populations using the internet. In India, as of 2022, about 48% of the total population uses the internet. Among those users, 52-53% are from rural areas. This shows rural India contributes a large share of India's online population. (India Retail and E-Commerce Trends Report, 2022) . This expansion has

driven digital literacy and economic opportunities in rural areas, with a notable shift towards mobile-based internet usage. States with historically low internet usage, such as Jharkhand and Bihar, are now experiencing above-average growth rates, indicating a broadening of digital access across the country (India Retail and E-Commerce Trends Report, 2022).

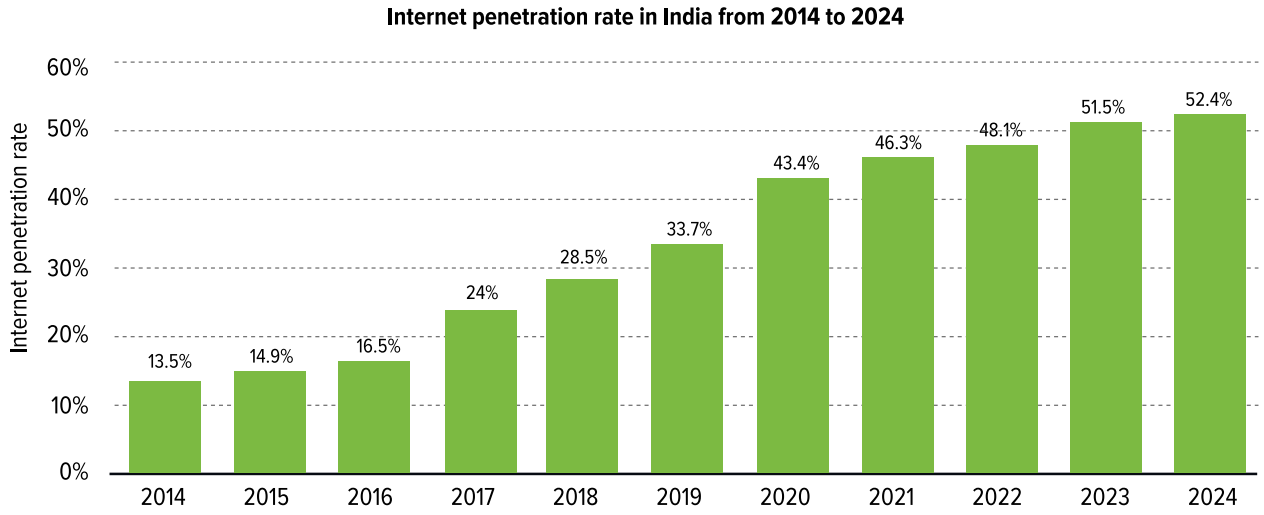

Figure 2: Internet penetration rate in India from 2014 to 2024

Recent digital shifts in India's retail sector, amplified by pandemic-related changes, have increased e-commerce adoption among consumers and businesses. Internet usage in India has grown tremendously, particularly in rural areas. As of 2023, India boasts approximately 820 million internet subscribers, a figure that is projected to increase to 900 million by 2025 (Internet in India, 2023). This surge in Internet connectivity has facilitated a significant increase in online retail penetration, which is expected to reach 10.7% by 2024, up from 4.7% in 2019 (Internet in India, 2023).

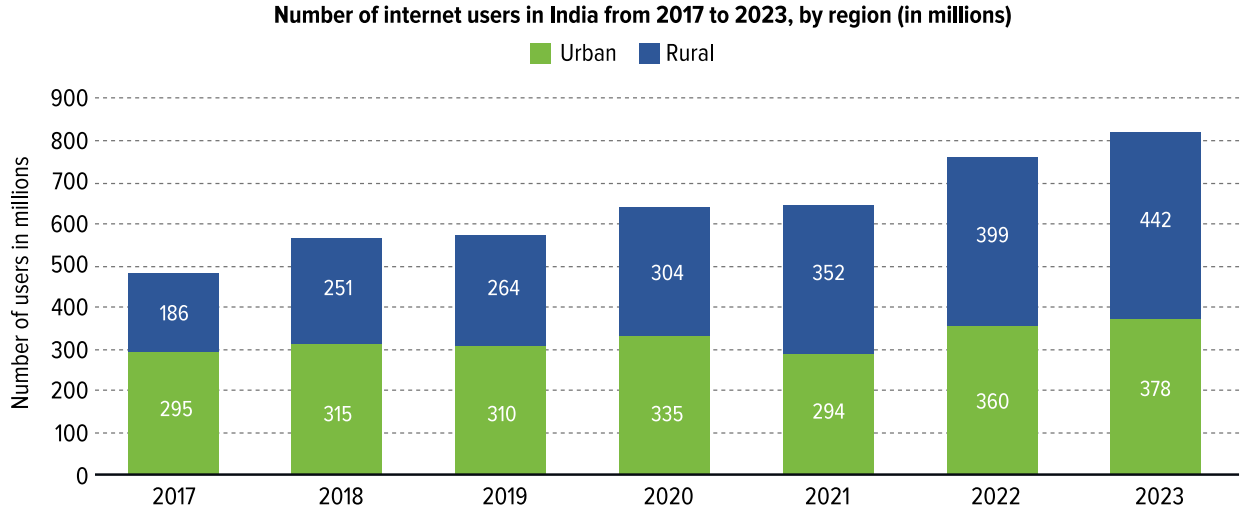

Figure 3: Number of internet users in India from 2017 to 2023, by region (in millions) (Internet in India, 2023)

Consumers in India's Tier II and Tier III cities increasingly embrace online shopping, driven by innovative payment options such as Unified Payments Interface (UPI) and enticing e-wallet offers (Redseer Strategy Consultants, 2024). The rise in smartphone usage has significantly contributed to this trend, with estimates indicating that one in three Indian consumers now shop online using their mobile devices. Amazon and Flipkart continue to dominate the e-commerce market, competing fiercely during festive seasons with massive sales events.

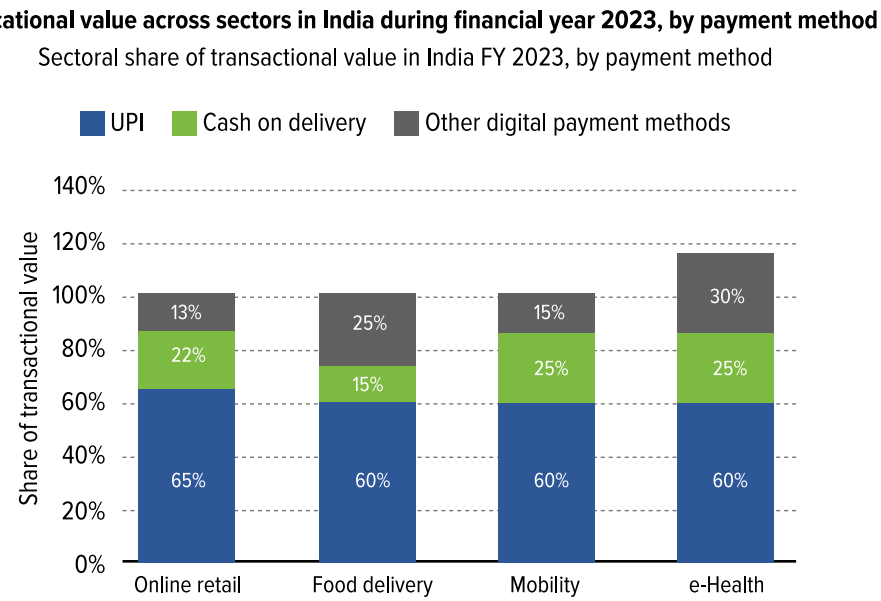

Figure 4: Transactional value across sectors in India during the financial year 2023 by payment method (Redseer Strategy Consultants, 2024)

2.2 Players in Indian E-commerce

Landscape overview of Indian E-commerce market players

Several key players, each catering to different market segments, dominate India's e-commerce landscape. Amazon and Flipkart continue to dominate the e-commerce market, competing fiercely during festive seasons with massive sales events. As of May 2023, looking at the competitive dynamics of the e-commerce sector in India, Amazon India leads significantly with 295.8 million visitors per month, underscoring its market dominance due to its extensive product range, efficient logistics, competitive pricing, and strong brand reputation (Webretailer, 2024). With 167.4 million visitors, Flipkart is the second most visited platform, bolstered by aggressive marketing strategies, a wide product range, and popular shopping events like the Big Billion Days sale (Webretailer, 2024).

Amazon and Flipkart lead India's e-commerce market while other platforms like Myntra, Snapdeal, and Meesho carve out specific niches, highlighting varied strategies and market focus within the Indian e-commerce landscape. Meesho, a newer entrant with 3 million visitors, has grown rapidly through its social commerce model, empowering small entrepreneurs and housewives, particularly in rural and semi-urban areas.

Other players, including Pepperfry, Paytm, and Limeroad, command a significantly smaller market share.

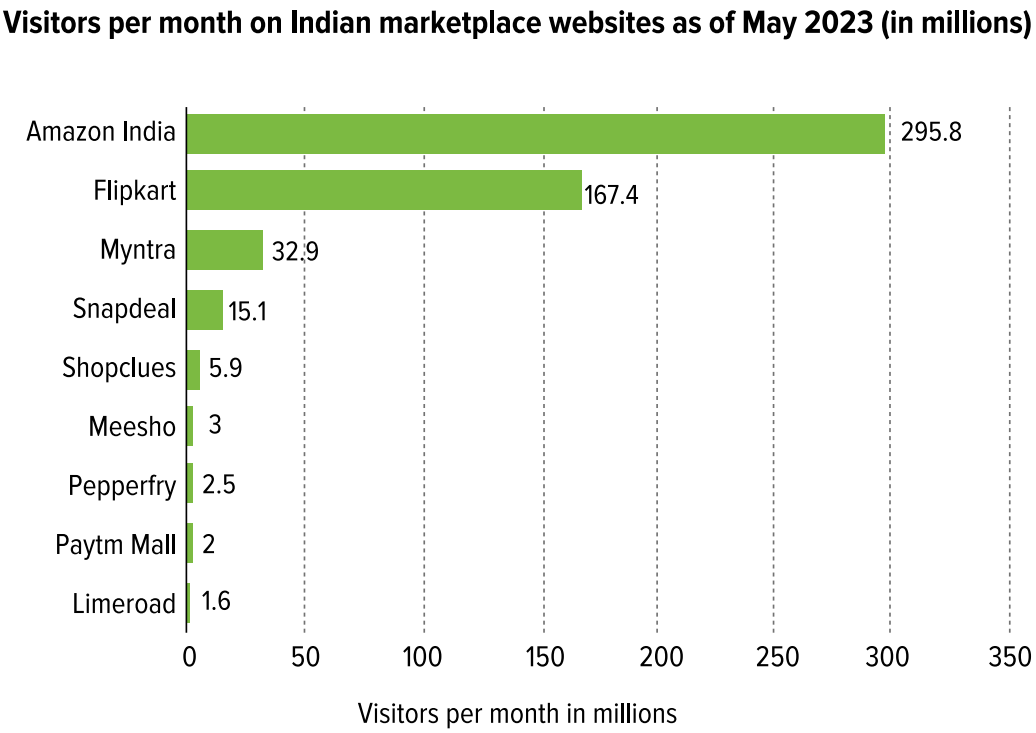

Figure 5: Visitors per month on Indian marketplace websites as of May 2023 (Webretailer, 2024)

Major e-commerce players such as Amazon and Flipkart have made substantial inroads into rural markets in India, recognizing the immense potential and growing demand.

Amazon has significantly expanded its network to include over 60 fulfillment centers across 15 states, enhancing its ability to serve rural consumers efficiently (Amazon India, 2024). The company has committed to investing $26 billion in India by 2030, focusing on initiatives to improve logistics, support small businesses, and enhance digital literacy. Programs like "I Have Space," which partners with local Kirana stores for last-mile delivery, and "Amazon Easy," which provides kiosks for easy access to online shopping, have been pivotal in reaching rural areas. Similarly, Flipkart has extended its grocery services to cover 1,800 cities, including many in rural areas, reflecting the growing importance of these markets in the overall e-commerce landscape (E-Commerce, 2024).

Flipkart has strategically added over 19 lakh square feet of space across several states, including Uttar Pradesh, Gujarat, Bihar, Punjab, Rajasthan, and Telangana, to strengthen its supply chain network in tier III cities and beyond (Flipkart Stories, 2024). Flipkart's collaboration with the National Rural Livelihood Mission (NRLM) in 2023 at Maharajganj empowers rural artisans by providing a platform to sell their products online (Hans India, 2023). Through workshops and training sessions, Flipkart equips these artisans with the necessary e-commerce skills, enhancing their market reach and socio-economic status.

Other significant players are also making strides in rural markets. Meesho, a social commerce platform, has gained popularity by enabling small businesses and individuals to sell products through social networks like WhatsApp, Facebook, and Instagram. This model allows rural entrepreneurs to start businesses with zero capital, making e-commerce accessible to people in remote areas. Snapdeal focuses on value-driven products and has a significant presence in tier II and tier III cities, tailoring its offerings to suit rural consumers' needs and investing in robust logistics to ensure delivery in remote areas.

These companies' expansion strategies underscore the potential of rural markets in India and their efforts to overcome the unique challenges these markets present, such as logistical hurdles, digital literacy, and trust issues among first-time internet users. The growth of internet penetration, coupled with the development of logistical infrastructure, is enabling these e-commerce giants to tap into the vast rural customer base, contributing to the overall growth of the Indian e-commerce sector

2.3 Stakeholders in the E-commerce Supply Chain

The e-commerce supply chain in India involves various stakeholders beyond the primary e-commerce companies.

1. **Logistics and Delivery Companies:** These companies handle the transportation and delivery of goods, ensuring that products reach consumers efficiently.

Last-mile delivery refers to the final step of the delivery process, where a product is transported from a distribution center or warehouse to the end consumer's location. In e-commerce, this stage is crucial as it directly affects customer satisfaction and delivery speed.

Traditionally, this operation has involved transporting parcels to industrial areas for B2B deliveries or residential areas for B2C and C2C deliveries. Historically, this segment of the logistics process has been low in efficiency and constitutes a significant portion of the overall parcel logistics costs. With growing volumes and improved optimization, shipment expenses have declined, though last-mile delivery still makes up the bulk of costs. Strengthening last-mile efficiency is crucial to further reducing expenses and improving customer satisfaction.

One evolving model is **customer pick-up**, where logistics companies and e-commerce retailers invest in near-door delivery points. These points can be manual or automated lockers where customers can conveniently collect their parcels. This model aims to reduce the dependency on home deliveries, mitigate the inefficiencies of failed delivery attempts, and provide a flexible solution for customers who might not be at home during delivery times (Issuu, 2024).

> *In rural areas, Kirana shop owners are well-acquainted with most villagers, making them ideal for delivering e-commerce orders or serving as collection hubs. This setup allowed shop owners to earn an additional Rs. 15,000 to Rs. 20,000 monthly, which could be used for home renovations, children's education, or purchasing a bike. The success of this model spread through word of mouth, facilitating its rapid expansion."*
>
> *– E-commerce expert*

Third-party logistics (3PL) is another prevalent model in which logistics companies outsource the last-mile delivery either partially or completely to specialized 3PL players. A 3PL provider offers outsourced logistics services, managing one or more aspects of procurement and fulfillment activities. This approach can enhance reach, especially in less accessible areas, and often results in better service levels due to the expertise and established networks of 3PL providers. By leveraging

the capabilities of 3PL companies, logistics providers can focus on their core operations while ensuring efficient last-mile delivery.

Delivery through retailers is a collaborative model where logistics companies partner with local retail stores to facilitate parcel deliveries to customers' residences. Retail stores act as intermediaries in this setup, holding parcels until customers collect them. This method benefits from the extensive presence of retail stores, providing customers with convenient pick-up locations close to their homes, thus enhancing the delivery network without significant infrastructure investment.

The e-commerce retail logistics sector in India comprises three main types of logistics service providers: traditional logistics service providers (LSPs), e-commerce retail-focused LSPs, and captive logistics arms. Each type plays a unique role in the ecosystem and exhibits varying relevance and functionality in rural markets (India's E-Commerce Logistics Industry, 2020).

- **Traditional logistics service providers** have historically been the backbone of logistics in India. With the rise of the e-retail sector, these providers have adapted by developing specialized logistics solutions for e-commerce. Their functioning relies heavily on their extensive, pre-existing networks and experience across India, which can be particularly advantageous in reaching rural areas. They have created separate B2B and B2C operations to stay relevant. However, their limited technological capabilities have been a constraint compared to newer entrants. Their well-established networks can be beneficial in rural markets, but the lack of advanced technological integration can hinder efficiency and reliability. Grameen Dak Sevak (GDS) is a prime example of traditional logistics service providers. GDS leverages the vast network of the Indian postal service, reaching even the most remote rural areas.
- **E-commerce retail-focused logistics service providers** are relatively new players that have emerged with a technology-centric approach tailored specifically to the needs of e-commerce. They use advanced technology to enhance efficiency, scalability, and cost-effectiveness, offering competitive pricing and high service levels by leveraging real-time data and analytics. These providers have been growing quickly, capturing about 28% of the market share and rapidly expanding their operations, reach, and capabilities. In rural markets, their tech-driven approach allows for better tracking, route optimization, and customer service, which are critical in areas where logistics can be complex. However, despite their rapid growth, their reach might still be limited in the most remote rural areas compared to traditional LSPs.
- **Captive logistics arms**, which are in-house logistics divisions of large e-retailers, handle most of their parent company's deliveries. These captive arms are assured of high volumes from their parent companies, which helps achieve economies of scale. They excel in managing complex and high-value shipments requiring special care, like jewelry and furniture. In rural markets, captive logistics arms invest heavily in expanding their facilities, reach, and manpower, including setting up fulfillment centers across India and rural areas. While they have significant resources, their primary focus remains on the parent company's needs, which might limit their external services in rural regions compared to independent LSPs.

In rural markets, the efficiency of logistics service providers is influenced by factors such as infrastructure quality, technological adoption, and local partnerships. Each type of logistics provider brings unique strengths to the table, and their relevance in rural markets depends on how well they can adapt their strategies to meet the specific challenges and demands of these areas.

In the financial year 2023, the e-commerce logistics market in India was dominated by the logistics wings of major e-commerce platforms Flipkart and Amazon, which collectively captured 50 percent of the market share. Delhivery emerged as the leading player with a 21.4 percent market share among third-party logistics providers. Other notable providers, including Xpressbees, Ecom Express, and Shadowfax, accounted for 29 percent of the market. This distribution highlights the significant reliance on major e-commerce platforms' in-house logistics capabilities while also showcasing the growing importance and competitive presence of specialized third-party logistics companies in the Indian e-commerce ecosystem. The substantial market share held by Delhivery and other third-party providers indicates a robust demand for specialized logistics services driven by the expanding e-commerce industry in India.

Leading courier companies based on market capitalization in India as of March 2024 (in billion Indian rupees)

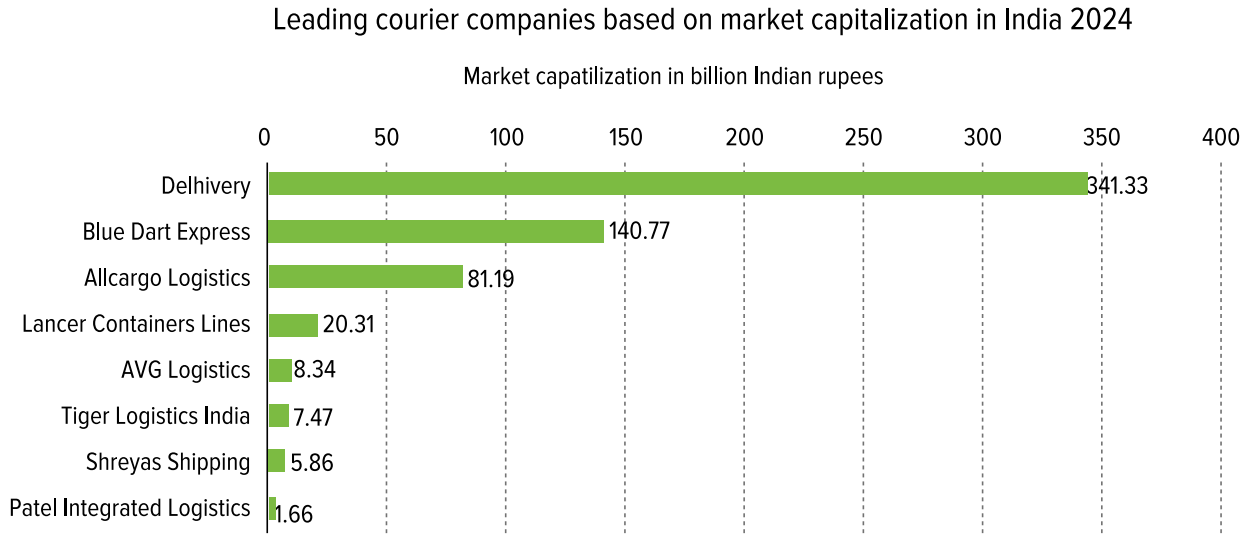

Figure 6: Leading courier companies in India (Moneycontrol, 2024)

These figures highlight the dominance of Delhivery and Blue Dart Express in the Indian courier and logistics market, reflecting their extensive network and service capabilities. The substantial market capitalizations of these companies suggest robust investor confidence and a significant market share. The presence of specialized logistics providers like Allcargo and Lancer Containers Lines further underscores the diversity and specialization within the sector. The relatively lower market capitalizations of smaller companies such as AVG Logistics and Patel Integrated Logistics indicate a competitive market environment with opportunities for growth and consolidation.

Table 3: Leading courier companies and their key services

Company Name	Services provided
BLUE DART	Leading logistics and courier service provider
DELHIVERY	Supply chain and logistics services
DHL	Domestic and international courier services
DTDC	Domestic and international courier services
allcargo GATI	Express distribution and supply chain solutions
TCIEXPRESS	Integrated supply chain and logistics solutions provider
SAFEXPRESS	Supply chain and logistics services
allcargo LOGISTICS	Multi-modal transport operations
VRL LOGISTICS LTD	Road transport services for cargo and passengers
First Flight	Courier and cargo services across domestic and international markets
Ecom Express	E-commerce logistics solutions, including last-mile delivery

2. **Drivers and delivery personnel** are the backbone of last-mile e-commerce delivery, which ensures packages reach their final destinations. These individuals navigate through traffic, weather conditions, and various challenges to deliver goods directly to consumers' doorsteps. Their responsibilities go beyond just transportation; they often manage customer interactions, handle delicate items with care, and ensure timely deliveries. Their efficiency and reliability significantly impact customer satisfaction and trust in the e-commerce platform. Moreover, they are essential in bridging the gap between digital orders and physical deliveries, making e-commerce feasible and successful.

Working in the last-mile delivery sector offers drivers and delivery personnel several benefits. The job provides a steady income, which is vital for supporting families. Many employers offer incentives, bonuses, and health insurance, enhancing the overall compensation package. The experience gained in logistics and customer service can also open up further career opportunities.

While delivery personnel faces several challenges too in their line of work. Navigating through busy urban areas, especially in cities like Mumbai, Delhi, and Bangalore, can lead to delays and increased

stress due to traffic congestion (Gigin, 2023). Weather conditions make deliveries more difficult and hazardous. Handling large or heavy packages requires physical strength and can lead to injuries if not done properly. Managing interactions with a diverse customer base, including language barriers and varying customer expectations, requires strong communication skills. Ensuring timely deliveries while efficiently managing multiple stops is crucial for customer satisfaction. These challenges highlight the demanding nature of the job and the resilience required by delivery personnel to ensure successful last-mile deliveries.

The income of last-mile delivery drivers in India can vary widely depending on location, employer, and type of employment (full-time, part-time, or gig work). On average, delivery personnel earn between INR 15,000 and INR 25,000 monthly (The Economic Times, 2024). In high-demand metropolitan areas, earnings can be higher due to additional incentives, bonuses, and tips. Gig economy platforms like Swiggy, Zomato, Dunzo, and Amazon Flex offer flexible earning opportunities, where drivers' income is influenced by the number of deliveries completed, peak delivery times, and customer tips (The Economic Times, 2024).

Most last-mile delivery jobs in India do not require advanced educational qualifications. A high school diploma or equivalent is generally sufficient. Key skills for these roles include a valid driver's license, basic literacy and numeracy skills, and familiarity with navigation tools and smartphones.

Historically, the last-mile delivery sector in India has been male-dominated. However, a growing trend of increasing female participation is driven by initiatives to promote gender diversity and inclusivity within the workforce. While men still make up the majority of delivery personnel, the number of women in these roles is steadily increasing, especially in urban areas. The growing trend of increasing female participation in the delivery workforce in India is driven by initiatives promoting gender diversity and inclusivity, flexible working conditions offered by the gig economy, and societal shifts towards gender equality. Companies are implementing policies to ensure safety and support for female employees, particularly in urban areas where better infrastructure and safety measures exist. Additionally, success stories of women excelling in these roles serve as inspiration, further encouraging female participation (Observer Research Foundation, 2024).

> *"Surprisingly it is not young women who are motivated to take driving-related jobs and they have access to many alternative job opportunities. It is older women between 25-50 who have children and who need supplementary income but have fewer job opportunities who are interested in driving skills and driving-related livelihood opportunities. Jobs in mobility also give women with kids the flexibility they desire compared to a 9-5 job."*
>
> *– Gender Inclusivity Expert*

- **Consumers:** Consumer satisfaction is heavily dependent on the reliability and efficiency of the last-mile delivery system. They expect timely and accurate delivery of their purchases, directly influencing their shopping experience. A seamless last-mile delivery process ensures that consumers receive their products in good condition and within the promised timeframe.

This reliability builds trust and loyalty, encouraging repeat purchases and positive word-of-mouth, which are essential for the sustained success of e-commerce platforms. Moreover, consumers increasingly demand transparency, real-time tracking, and flexible delivery options, further underscoring the importance of an efficient last-mile delivery system in meeting their expectations and enhancing their satisfaction.

2.4 Nature of Rising Demand for E-commerce in Rural India

India's e-commerce landscape is profoundly transforming as Tier II and Tier III cities emerge as the primary growth engines, significantly outpacing Tier I cities. With annual growth rates of 92.2% for Tier II and 85.2% for Tier III cities, compared to 47.2% for Tier I cities, these smaller cities are becoming the real growth levers of the industry (Jain et al., 2022). This trend is driven by the increasing digital penetration and the enhanced delivery and shopping experiences that e-commerce companies now offer in these regions (E-Commerce, 2024).

The rise in demand from these smaller cities has also led to significant infrastructural developments. Warehouses and fulfillment centers are now being established in smaller towns, and brands with strong offline presence are leveraging omnichannel technology to meet the increasing order volumes. This has resulted in the emergence of new online sellers from smaller business hubs such as Jaipur, Agra, Surat, Ahmedabad, and Ludhiana. Simultaneously, larger companies are setting up warehouses and dark stores in cities like Hyderabad, Ghaziabad, Coimbatore, and Pune to cater to the growing demand from nearby regions (Jain et al., 2022)

High-Frequency Purchases in Rural Areas

In rural India, consumer electronics and appliances are among the top products purchased online. This is driven by increasing electrification and rising disposable incomes. Fashion and apparel also see high demand, reflecting growing awareness and acceptance of online shopping. Additionally, essentials like groceries and fast-moving consumer goods (FMCG) are witnessing a surge in e-commerce sales (New Relic, 2024).

> *"Most common goods purchased through Flipkart in tier IV markets include clothes, gifts like pens, mobile accessories, electronics like mobile phones, women's cosmetics- mostly between Rs. 500- 1000. On the bigger side goods purchased in rural markets on e-commerce include fridges and TVs."*
>
> *– E-com expert*

Regional Breakdown

Different states in India exhibit varying levels of e-commerce adoption. For example, states like Maharashtra, Karnataka, and Tamil Nadu show higher online shopping activity than others. Due to several key factors, Maharashtra, Karnataka, and Tamil Nadu exhibit higher e-commerce activity. Firstly, these states have strong economic foundations with high levels of industrialization and a robust

IT sector, especially in cities like Bangalore, Mumbai, and Chennai. This economic strength translates into higher disposable incomes and greater internet penetration, both critical for e-commerce growth (Browntape, 2024).

Additionally, these states have better infrastructure, including logistics and supply chain networks, which facilitate efficient delivery services. Maharashtra, Karnataka, and Tamil Nadu are also home to several Special Economic Zones (SEZs) and IT parks, which attract significant investments and create a conducive environment for e-commerce businesses to thrive (Factly, 2024). Furthermore, these states lead in imports, indicating high consumption power and a larger market for e-commerce platforms. The purchasing power in these regions is boosted by a higher per capita income and a substantial urban population, which tends to engage more in online shopping (Mint, 2024).

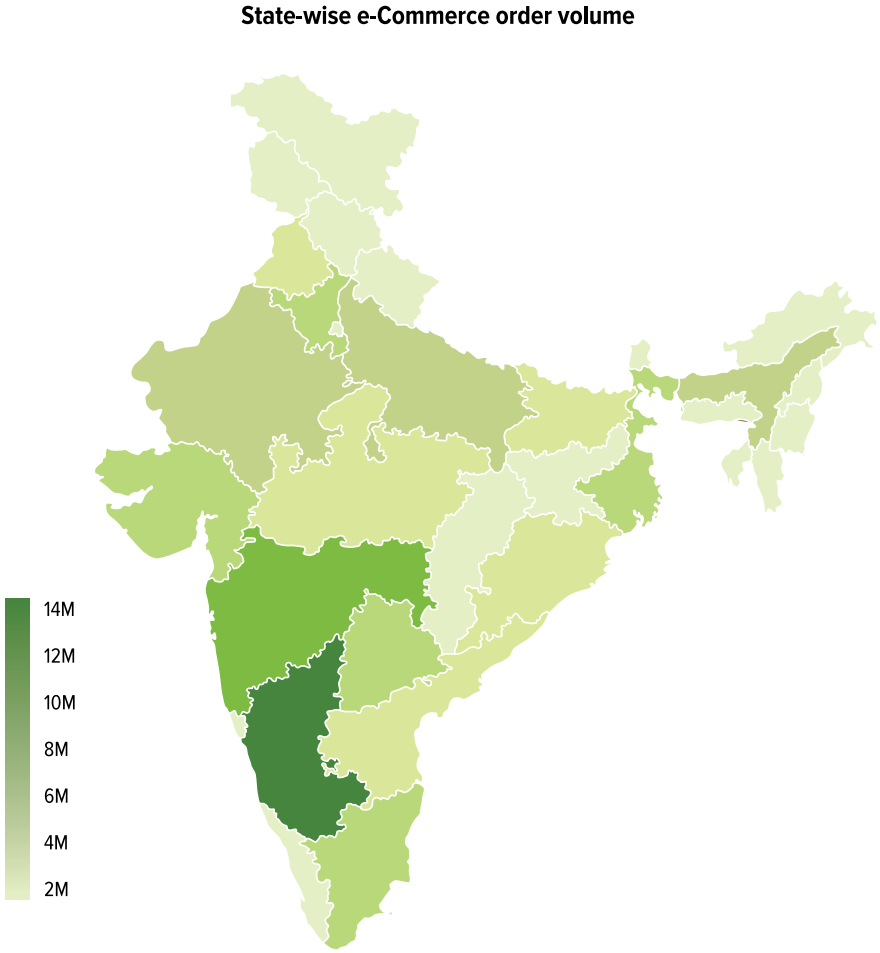

Figure 7: State-wise E-commerce order volume (India Retail and E-commerce Trends Report, 2022)

The market has extended beyond major metropolitan areas into tier II and tier III cities, which are now becoming vital growth engines. These smaller cities have shown faster adoption rates, especially for value segments, contributing to approximately 60% of all online orders and 50% of e-commerce shoppers (India Retail and E-commerce Trends Report, 2022). Rising income levels and consumer aspirations in these regions are driving this trend. E-commerce players recognize this market potential and are strengthening their fulfillment capabilities to cater to the growing demand (Kearney India Digital Commerce Index, 2024).

Below map shows top 20 cities that are expected to play a pivotal role in the next wave of e-commerce expansion in India (Kearney India Digital Commerce Index, 2024). The ongoing digital revolution, rising

consumer aspirations, and targeted efforts by e-commerce companies to improve accessibility and delivery services are set to transform these areas into significant contributors to India's e-commerce growth story.

Top 20 cities in the Kearney India Digital Commerce Index

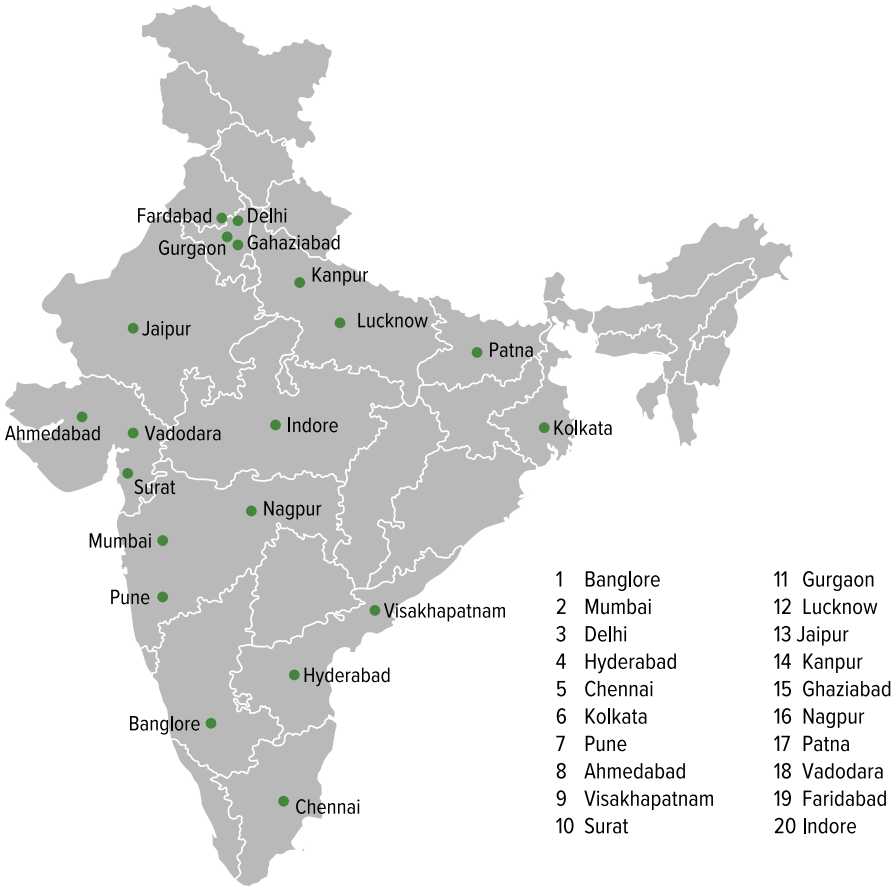

Figure 8: Top 20 cities in the KID commerce index (Kearney India Digital Commerce Index, 2024)

Overall, the geographic expansion of e-commerce in India is a combined outcome of macroeconomic factors and digital advancements. The rapid adoption in tier II and tier III cities, coupled with the rising digital consumer base in regions like the Northeast and Hindi Heartland, underscores the enormous untapped potential for future growth in these areas (Kearney India Digital Commerce Index, 2024).

2.5 Role of Gramin Dak Sevaks in Rural Deliveries

Gramin Dak Sevaks (GDS) plays a crucial role in the Indian postal system, especially in rural areas, by delivering mail, managing post office operations, and providing various postal services in remote locations. Their roles are multifaceted, including the sale of stamps and stationery, assisting in financial services like the India Post Payments Bank (IPPB), and ensuring the transmission and delivery of mail (Testbook, 2024)

Their role is especially significant in rural areas due to several reasons:

1. **Accessibility:** GDS ensures that even the most remote locations can access essential postal and financial services, bridging the gap between urban and rural areas.

2. **Financial Inclusion:** By assisting with services like IPPB, they help promote financial inclusion, offering banking services to people who might not have access to traditional banks.

3. **Reliability:** In areas where other means of communication and logistics may be unreliable, GDS provides a dependable service for delivering important documents and goods.

4. **Community Trust:** As locals, GDS deeply understands the community and is trusted by the residents, enhancing their service's effectiveness.

5. **Economic Impact:** By facilitating commerce through the postal system, they help stimulate local economies and support small businesses and entrepreneurs in rural areas.

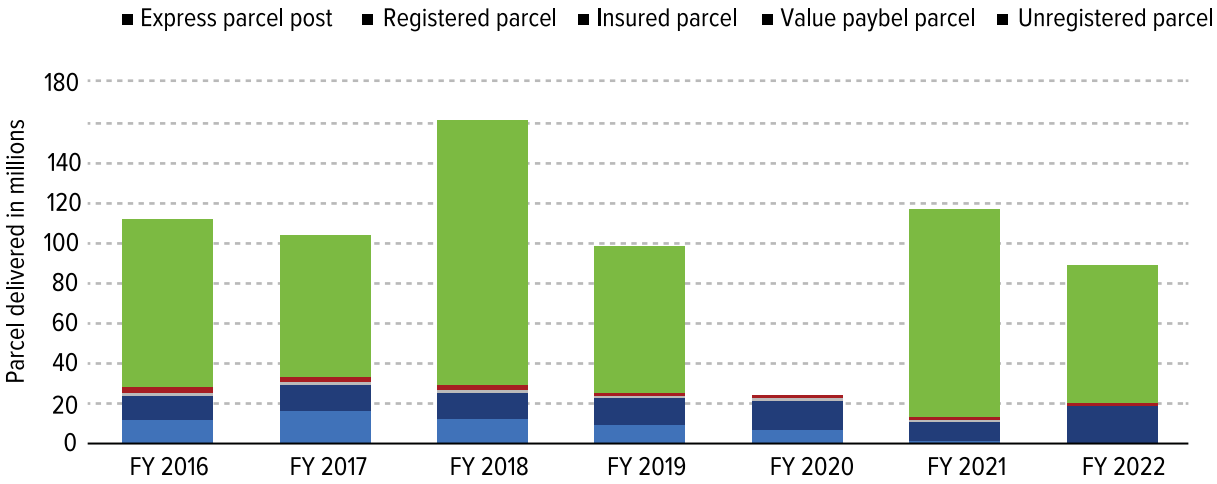

Figure 9: Number of parcels delivered by India Post (Department of Posts Ministry of Communication Government of India, 2022)

Express Parcel Post is designed for quick and efficient delivery, ideal for urgent items requiring faster transit times. Registered Parcels provide additional security and tracking, making them suitable for valuable items that need proof of dispatch and delivery. Insured Parcels offer insurance coverage for contents, allowing senders to declare the value and receive compensation for loss or damage, perfect for high-value shipments. Value Payable Parcels function similarly to cash on delivery (COD), enabling senders to collect payment upon delivery, commonly used by businesses to ensure payment before the recipient takes possession. Lastly, Unregistered Parcels represent the basic delivery service without tracking or security features, appropriate for non-valuable items where additional services are not required. The data shows the number of parcels delivered in each category, reflecting trends and volume changes over the years.

The data shows that India Post's parcel delivery volumes peaked in FY 2018, driven largely by a surge in unregistered parcels. This category consistently represents the highest portion of deliveries, underscoring the preference for cost-effective shipping solutions, which is particularly crucial in rural areas where affordability is a key concern. The reliance on unregistered parcels highlights the need for accessible and economical postal options to support rural e-commerce growth. The trends also show a noticeable dip in parcel volumes in FY 2019 and FY 2020, likely influenced by disruptions such as the COVID-19 pandemic, which significantly affected logistics and supply chains, especially in less infrastructurally developed rural regions. This dip was followed by a recovery in FY 2021, indicating resilience and a rebound in e-commerce activities as conditions improved (Department of Posts Ministry of Communication Government of India, 2022).

The express parcel post deliveries, alongside registered and insured parcel volumes, maintain an approximate average of around 20 million per year, suggesting a steady demand for reliable and trackable postal services. The express parcel post was discontinued by the India Post in 2021, and its share seems to be absorbed by the registered parcel. Rural businesses likely utilize these services for higher-value or time-sensitive shipments, emphasizing the importance of maintaining and expanding these options to support diverse e-commerce needs in rural areas. The insights from these trends highlight the need for strategic enhancements in India Post's services to support rural e-commerce better. Expanding access to registered and insured parcel services, investing in digital infrastructure, and addressing logistical challenges unique to rural areas—can significantly improve delivery efficiency and reliability. Understanding the underlying factors driving these trends is essential for planning future improvements and ensuring robust support for the evolving e-commerce landscape in rural India (Department of Posts Ministry of Communication Government of India, 2022).

GDS plays a pivotal role in managing a substantial volume of e-commerce parcels. During peak seasons, such as festivals and sales events, GDS handles thousands of parcels daily, emphasizing their critical importance. Each GDS manages about 20-50 parcels daily, significantly increasing during high-demand periods (Times of India, 2024). This extensive involvement underscores their integral role in the delivery ecosystem, ensuring that even the most remote areas receive timely and reliable services. Several prominent e-commerce companies have integrated GDS into their supply chains. Companies like Amazon, Flipkart, and Snapdeal have leveraged GDS's extensive reach and local knowledge to penetrate rural markets.

The primary reason for engaging GDS lies in their deep penetration nationwide. India Post operates through a network of over 150,000 post offices, with more than 130,000 in rural areas. This extensive reach ensures that GDS can deliver parcels to even the most remote villages, which would otherwise be challenging for private logistics providers (Post Office Network, 2024). The widespread presence of GDS helps e-commerce companies overcome logistical challenges posed by poor infrastructure and connectivity issues in rural regions.

2.6 Policies and Drivers Helping E-commerce in India

The e-commerce sector in India has experienced remarkable growth over the past decade, fueled by a combination of technological advancements, government initiatives, and policy reforms. These drivers have collectively created an ecosystem that supports the expansion of e-commerce. This chapter delves into the key policies and initiatives that have played a crucial role in propelling the e-commerce sector forward, focusing on their impact and significance in shaping the industry's landscape.

a. Open Network for Digital Commerce (ONDC):

Launched in 2022, the ONDC aims to democratize e-commerce by providing equal opportunities for micro, small, and medium enterprises (MSMEs). Currently available in 273 cities with 35,000 sellers, ONDC facilitates a more inclusive digital commerce ecosystem, ensuring that smaller businesses can compete with larger players. This initiative is designed to break down barriers in the e-commerce sector, making it easier for MSMEs to reach a wider customer base and participate in the digital economy. By providing a level playing field, ONDC enables MSMEs to showcase their products on a

national platform, increasing their visibility and market reach. This initiative also promotes competition, leading to better prices and services for consumers.

The penetration of ONDC into tier II, tier III, and tier IV cities significantly boost local economies by integrating small businesses into the digital marketplace. Overall, ONDC fosters economic inclusivity, drives innovation, and supports the growth and sustainability of MSMEs across India. (ONDC, 2024)

b. Digital Payments & Technology:

The Indian government's support for technologies like UPI, RuPay, DigiLocker, and electronic Know Your Customer (eKYC) has significantly promoted digital transactions and innovation. Introduced in 2016, UPI has revolutionized how people make payments by enabling instant money transfers between bank accounts through mobile devices. RuPay, launched in 2012, provides a domestic card payment network that competes with international systems like Visa and MasterCard, making digital payments more accessible and affordable. DigiLocker, introduced in 2015, offers a secure cloud-based platform for storing and sharing documents digitally, while eKYC simplifies the process of verifying identities online. In 2022, digital payments in India saw a remarkable growth of 76% in the number of transactions and 91% in value, reflecting the widespread adoption and trust in these technologies. Incentive scheme for low-value UPI transactions and encourage digital payments among small merchants continued in 2023-24, further bolstering the digital payment ecosystem.

The adoption of UPI and RuPay in rural areas has facilitated easier and faster transactions, boosting economic activities and enabling small businesses to thrive. Digital payments have also empowered women in rural regions by giving them more control over their finances and reducing the gender gap in financial inclusion. Additionally, the use of DigiLocker and eKYC has simplified the process of accessing various services, contributing to greater efficiency and transparency.

c. Goods and Services Tax (GST):

Implementing the Goods and Services Tax (GST) on July 1, 2017, replaced India's complex indirect taxation system, significantly benefiting the e-commerce sector. This unified tax structure has simplified tax compliance, reduced the overall tax burden on businesses, and streamlined the movement of goods across state borders.

One of the primary benefits of GST is the removal of interstate taxes, which has eased the movement of goods between states. This change has significantly reduced e-commerce companies' logistical challenges, as they no longer need to navigate the previously complex web of state-specific taxes. The simplified tax structure has also reduced the paperwork for logistics companies, making the entire process more efficient. Under the new tax regime, logistics companies must raise **E-way bills** to move goods between states. Government bodies monitor These E-way bills centrally, providing better visibility of the logistics sector across the country. This central monitoring system has helped reduce tax evasion and improve compliance, benefiting the e-commerce logistics industry. (India's E-Commerce Logistics Industry, 2020).

d. Open Credit Enablement Network (OCEN):

The Open Credit Enablement Network (OCEN), launched in July 2020, is critical in empowering B2B marketplaces by simplifying credit access, enhancing transparency, and increasing efficiency. OCEN provides a standardized framework that enables seamless integration between lenders

and marketplaces, simplifying businesses' access to credit by reducing the complexities and time involved in securing loans. This initiative is particularly beneficial for MSMEs, which often face significant challenges in obtaining financing.

The network ensures greater transparency in the lending process. Using a standardized credit protocol, lenders and borrowers understand the terms, conditions, and eligibility criteria. This transparency helps build trust between financial institutions and MSMEs, encouraging more businesses to seek formal credit. Additionally, OCEN increases the efficiency of credit distribution by automating various aspects of the lending process. Using digital tools and data-driven assessments reduces the need for manual intervention, speeding up the approval and disbursement of loans. This efficiency not only benefits businesses in need of quick financing but also allows lenders to manage and allocate resources more effectively (OCEN, 2024).

e. Trade Receivables Discounting System (TReDS):

The Trade Receivables Discounting System (TReDS), launched in 2014, is an electronic platform that facilitates the financing of trade receivables for MSMEs through multiple financiers. TReDS significantly improves MSMEs' access to working capital by converting trade receivables into liquid funds, addressing the common issue of delayed payments. This timely access to funds allows MSMEs to manage operational expenses efficiently and invest in growth opportunities

The platform enhances transparency and efficiency by recording and tracking all transactions centrally, reducing fraud risk. A competitive bidding process among financiers helps MSMEs secure the best financing rates, lowering their cost of capital. TReDS also promotes financial inclusion by providing access to a wide network of financiers, including banks and non-banking financial companies (NBFCs), expanding financing options.

Additionally, TReDS standardizes and simplifies the trade receivables financing process, reducing administrative burdens and speeding up the financing cycle. TReDS has significantly benefited MSMEs helping them grow and thrive in a competitive business environment (*E-COMMERCE*, 2024; *Make In India*, n.d.).

f. Digital India and Digital Infrastructure:

Digital India seeks to ensure that government services are made available to citizens electronically by improving online infrastructure and increasing Internet connectivity. This initiative has been a significant boon for the e-commerce market by promoting the digitalization of businesses, enhancing efficiency, and reducing operational costs. The widespread adoption of digital technologies has enabled businesses to innovate, reach new markets, and improve customer engagement. Additionally, Start-up India aims to nurture innovation and entrepreneurship by providing support through funding, mentorship, and incubation. (Digital India, 2024).

As of 2023, rural broadband penetration in India has significantly improved, with around 60% of rural households accessing broadband services. This advancement has been made possible through various government schemes and policies under the Digital India program, launched in July 2015. One of the most notable initiatives is BharatNet, approved by the Union Cabinet on October 2011, 2011. BharatNet aims to provide broadband connectivity to all 250,000 Gram Panchayats (GPs) across the country, implemented in phases by Bharat Broadband Network Limited (BBNL), a Special Purpose

Vehicle (SPV) incorporated on February, 2012. As of May, 2024, 212,778 GPs have been connected, and 686,963 km of Optical Fibre Cable (OFC) has been laid. Additionally, 1,022,018 Fibre-To-The-Home (FTTH) connections have been commissioned, and 104,574 Wi-Fi hotspots have been installed to ensure last-mile connectivity.

The benefits of enhancing digital infrastructure in rural areas are manifold. BharatNet's phased implementation has facilitated rural e-commerce by connecting remote areas with larger markets, allowing local businesses to reach a wider customer base. Increased broadband penetration enables access to digital education, healthcare, and financial services, significantly improving the quality of life in rural communities. It supports government initiatives like direct benefit transfers and digital governance, ensuring efficient delivery of services to the intended beneficiaries. Overall, the push for rural broadband under the Digital India program fosters economic growth, reduces the urban-rural divide, and promotes inclusive development across the country (BharatNet Project, 2024).

g. Make in India and One District One Product (ODOP):

Government initiatives such as Make in India (launched in September 2014) and the One District One Product (ODOP) program, launched in 2018, have been instrumental in driving the expansion of the e-commerce market in India. Make in India aims to transform India into a global manufacturing hub by encouraging both multinational and domestic companies to manufacture their products within the country. This initiative has created numerous opportunities for e-commerce businesses by boosting industrial growth, fostering innovation, and increasing investments in manufacturing. The focus on enhancing infrastructure, streamlining regulations, and providing incentives has made it easier for businesses to set up and expand their operations in India (Make in India, 2024)

The ODOP program, aims to select, brand, and promote one unique product from each district across India. This initiative is designed to foster holistic socio-economic growth by leveraging the unique strengths of each district's traditional industries. By focusing on a single product per district, ODOP seeks to enhance local production, support artisans and entrepreneurs, and create employment opportunities, thereby boosting the district's economy.

The benefits of the ODOP program are extensive. It promotes the preservation and development of local crafts and industries, encouraging traditional skills and knowledge. By providing a platform for these products to reach national and international markets, the program helps increase income for local producers and artisans. Additionally, ODOP enhances the branding and marketing of district-specific products, making them more competitive. This initiative also supports the government's broader goals of promoting Make in India and boosting exports, contributing to a more balanced regional development and reducing economic disparities across different parts of the country. Overall, ODOP plays a crucial role in driving sustainable economic growth and empowering local communities through targeted support and promotion of their unique products (One District One Product, 2024).

03

Electric Two-wheelers as a Sustainable Solution for E-commerce Deliveries

Introducing E2Ws offers a promising solution to many challenges faced by e-commerce in rural areas. E2Ws. They reduce physical strain, allowing delivery personnel to cover larger areas without fatigue, thus increasing productivity and reducing delivery times. E2Ws are also cost-effective, with lower operational costs and significant fuel savings. Equipped with GPS and tracking technologies, E2Ws improve route planning and real-time delivery monitoring, enhancing the accuracy and efficiency of postal services (Jain et al., 2022).

Environmentally, they reduce the carbon footprint, supporting sustainability efforts. Thus, efforts to mitigate fossil fuel issues should focus significantly on transitioning two-wheelers to more sustainable energy sources. Given their dominance in the market, promoting electric two-wheelers and improving the necessary infrastructure, such as charging stations, would be crucial steps towards achieving a greener transportation sector.

3.1 Growth of E2Ws in India

The Indian vehicle market predominantly comprises two-wheelers, accounting for over 70% of registered vehicles. Between 2001 and 2011, registered two-wheelers significantly increased from around 40 million to over 100 million (Alliance for an Energy Efficient Economy, 2023). This surge can be attributed to the liberalization of the Indian economy in the early 1990s, which led to the entry of foreign automobile companies and increased competition. Additionally, government policies promoting affordable and accessible transportation contributed to this growth. From 2011 to 2021, this trend continued, with two-wheeler registrations rising to approximately 220 million, driven by rising income levels, urbanization, and the need for efficient personal mobility solutions (NITI Ayog, 2024).

China is the largest producer and market for E2Ws globally. By 2021, China accounted for 53% of global two-wheeler sales, with approximately 70% of these being electric. The country has a well-established battery supply chain and extensive domestic manufacturing capabilities,

exporting significant quantities to surrounding regions. The high volume of production and early adoption of E2Ws give China a significant advantage in the global market.

India's EV sector is experiencing rapid growth fueled by government incentives, rising environmental concerns, and technological advancements. Initiatives like the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme aim to significantly increase EV adoption, revolutionizing the transportation landscape towards sustainability and innovation. India has set ambitious targets for 2030: 30% of private cars, 70% of commercial vehicles, 40% of buses, and 80% of two-wheelers and three-wheelers to be electric, translating to 80 million EVs on Indian roads (FAME India, 2022).

The market for E2Ws in India is expected to grow at a compound annual growth rate (CAGR) of 17.68%, reaching USD 60.93 million by 2029 (Mordor Intelligence,2024). The industry's growth trajectory looks promising, making it a key area for efforts to reduce fossil fuel dependency and promote sustainable transportation solutions.

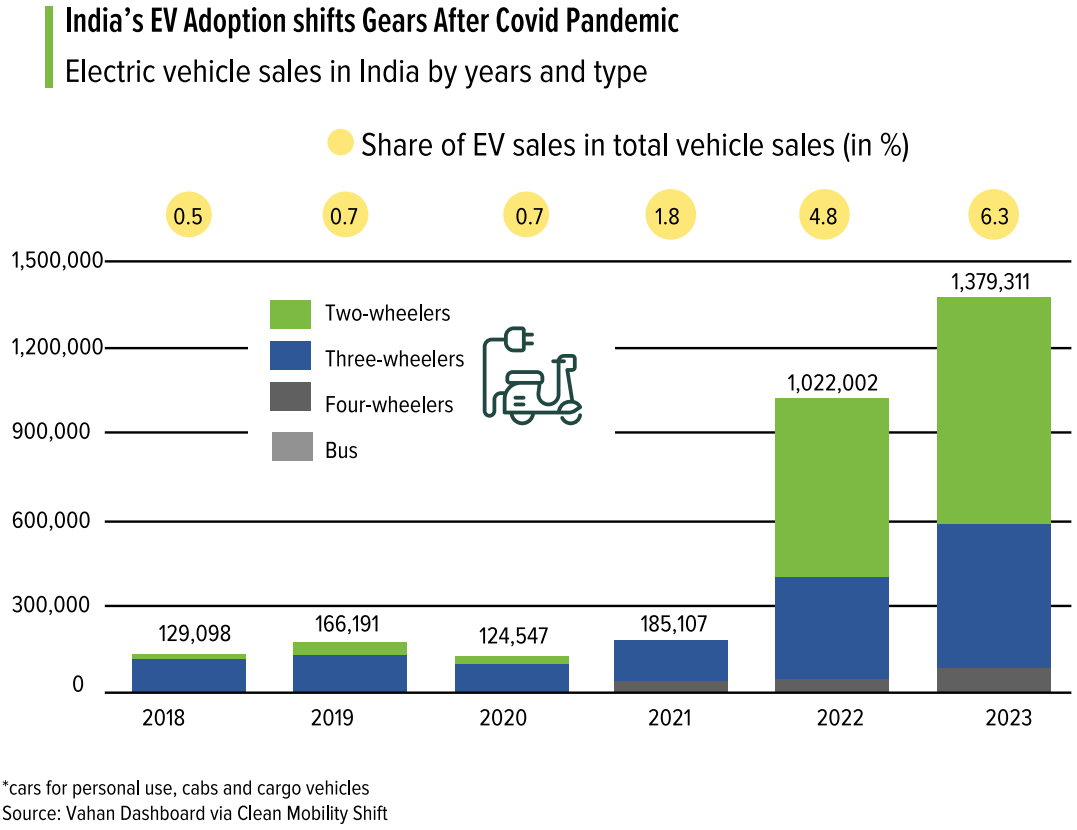

Figure 10: India's EV adoption (EV Vahan Dashboard - Clean Mobility Shift, 2023)

Several advancements in battery technology have also significantly contributed to the rise of electric two-wheelers. This includes:

- **Lithium-ion Batteries:** The development and widespread adoption of lithium-ion (Li-ion) batteries have been a game-changer for electric vehicles, including e-2Ws. Li-ion batteries offer higher energy density, longer life cycles, and better efficiency compared to traditional lead-acid batteries. This means electric two-wheelers can travel longer distances on a single charge, which is a crucial factor for consumer acceptance. Advancements in technology have resulted in a reduction in the price of lithium-ion batteries, thereby lowering the overall cost of electric vehicles.

- **Improved Battery Management Systems (BMS):** Modern battery management systems have enhanced the performance, safety, and longevity of EV batteries. BMS technology optimizes battery usage, ensures balanced charging and discharging, and provides protection against issues such as overcharging, overheating, and short-circuiting. This increases the reliability of E2Ws and boosts consumer confidence in them .
- **Swappable Battery Technology:** The introduction of swappable battery technology allows users to exchange depleted batteries for fully charged ones at designated stations. This innovation reduces downtime for charging and extends the usability of electric two-wheelers, making them more convenient for daily use.
- **Cost Reduction:** Advances in manufacturing processes and economies of scale have gradually reduced the cost of battery production. As battery prices drop, electric two-wheelers become more affordable for a broader range of consumers, accelerating market adoption.
- **Fast Charging Capabilities:** The development of fast-charging technologies has made it possible to charge batteries more quickly, reducing the time users need to wait to get their vehicles back on the road. (Nayak et al., 2023).

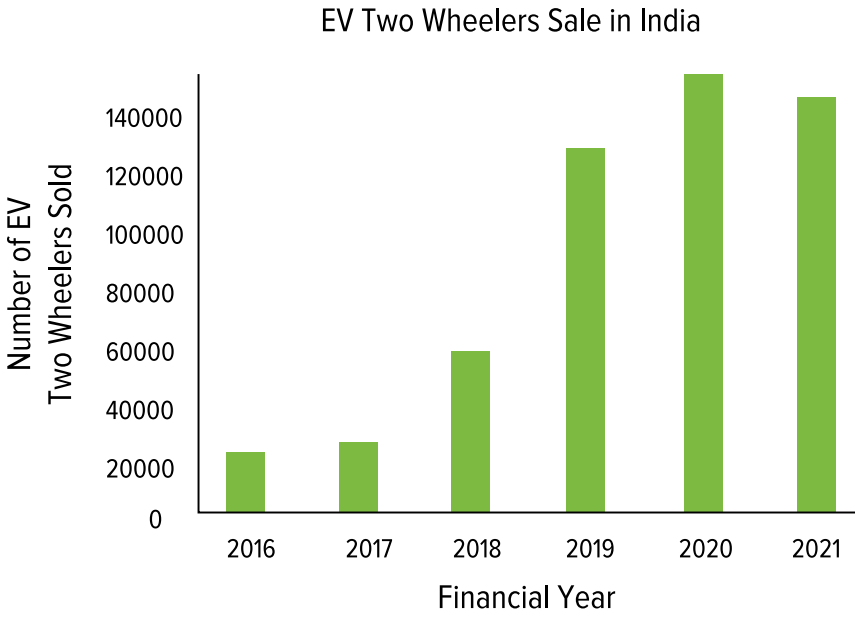

Figure 11: EV Two-wheelers Sale in India (NITI Ayog, 2024).

Despite the rising demand for electric two-wheelers, reducing vehicle manufacturing costs remains crucial, primarily influenced by battery prices. Batteries account for a substantial portion of an EV's cost, often between 30% and 40% (NITI Ayog, 2024). As such, any reduction in battery prices directly impacts the affordability of electric vehicles. Enhancing domestic manufacturing by decreasing reliance on imported components and expanding charging infrastructure will be key. Technological advancements in vehicle performance and battery cost reduction are essential for widespread EV adoption. Future regulatory measures and a supportive ecosystem could further accelerate this transition.

Comparing the growth rates, while ICE two-wheelers still dominate in absolute numbers, the electric two-wheeler segment is growing much faster. This shift highlights the increasing consumer preference for electric vehicles, driven by government incentives, rising fuel prices, and enhanced

environmental awareness. In FY 2023-24, 17.075 million two-wheelers were sold, marking a 9.12% increase from the 15.862 million units sold in FY 2022-23. Meanwhile, EV penetration in the two-wheeler segment reached about 5% of total vehicle sales between October 2022 and September 2023. The total EV sales in India for the 12 months ending November 2023 were approximately 14,92,620 units (Business Standard, 2024).

Projections indicate that electric two-wheelers could account for 60-70% of new sales by 2030 (Economic Diplomacy Division, 2023). This shift is driven by their affordability, accessibility, and consumer readiness to embrace electric mobility.

wnership preferences are also evolving, shifting from outright purchases to alternative models such as financing, leasing, and subscription services. However, this trend is progressing more slowly for electric two-wheelers due to their lower purchase costs than other electric vehicles.

3.2 Regional Market Penetration of E2Ws

E2Ws have a penetration rate of 5.10% in the Indian market for 2022-24, with total sales reaching 2.20 million units. This figure, while notable, is significantly lower compared to the 54.75% penetration seen in the electric three-wheeler (E3W) segment, which sold 1.58 million units. The relatively low penetration rate of E2Ws suggests that while growing interest and adoption, barriers such as cost, infrastructure, and consumer awareness must be addressed (EV Vahan Dashboard - Clean Mobility Shift, 2025). Overall, the E2W segment shows promise but needs accelerated efforts in policy support, infrastructure development, and consumer incentives to match the rapid adoption rates seen in E3Ws and achieve broader market penetration.

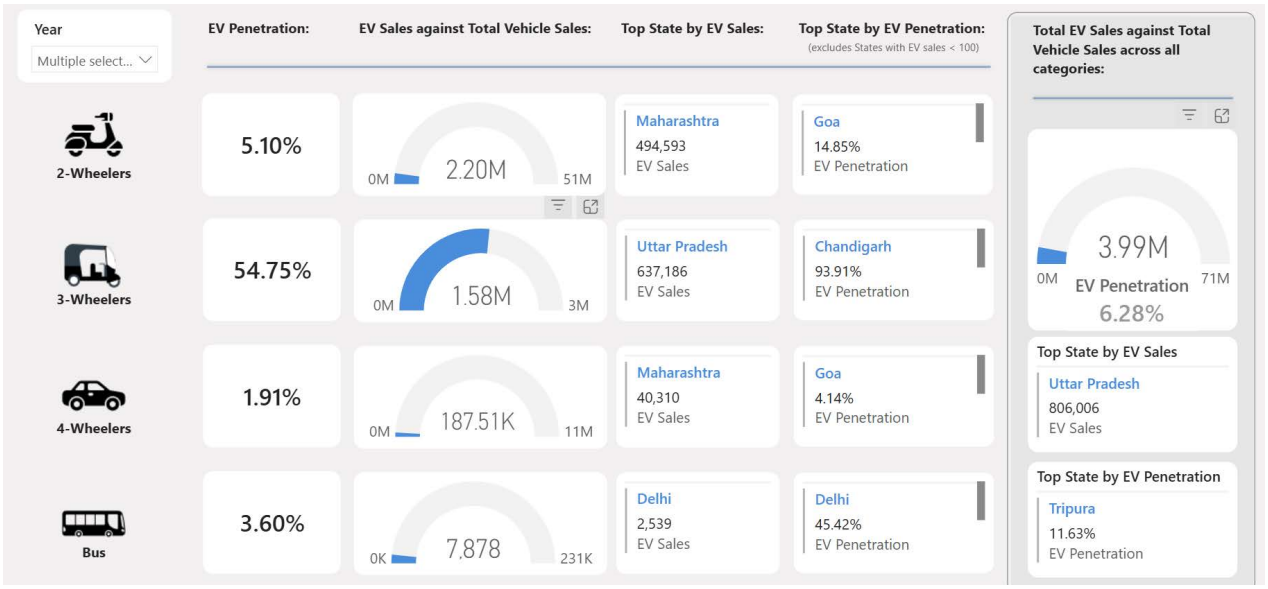

Figure 12: EV sales and Penetration 2020-24 (EV Vahan Dashboard - Clean Mobility Shift, 2024)

Maharashtra leads in E2W sales with 494,593 units, while Goa shows the highest penetration rate at 14.85%, indicating regional variances in adoption driven by state policies, infrastructure readiness, and market dynamics. The high penetration of EVs in Goa and Maharashtra results from supportive policies and infrastructure readiness. Goa offers substantial subsidies and tax waivers and has focused

on developing a robust charging infrastructure. Its small size and significant tourism industry, which favors eco-friendly transportation options, further boosts EV adoption.

E2Ws penetration varies significantly across states and demographics. States like Maharashtra, Karnataka, and Tamil Nadu show higher adoption rates due to better infrastructure and government policies. Maharashtra leads in E2W sales with 0.49 million units, followed by Karnataka with 0.37 million units and Tamil Nadu with 0.25 million units between 2022-24. All three states offer substantial subsidies on E2W purchases, and targeted incentives for charging station development, creating a favorable economic environment for buyers and investors. (EV Vahan Dashboard - Clean Mobility Shift, 2025).

3.3 Major Players in the E2Ws Market in India

Timeline of Market Entries

India's E2W market is highly competitive, with key OEMs such as Ola Electric, Hero Electric, TVS Motor, Ather Energy, Bajaj Auto, and Ampere Vehicles leading adoption across different states. These players are strategically capturing markets in regions like Maharashtra, Tamil Nadu, Karnataka, Kerala, Delhi NCR, Gujarat, Punjab, Uttar Pradesh, and Rajasthan. Their extensive product portfolios, ranging from affordable scooters for cost-conscious buyers to premium, high-performance models, cater to diverse consumer needs. Coupled with robust service and charging infrastructure, wide dealer networks, and strong after-sales support including easy access to service centers and spare parts, these factors have significantly enhanced customer confidence and satisfaction, thereby accelerating E2W adoption across urban and rural markets.

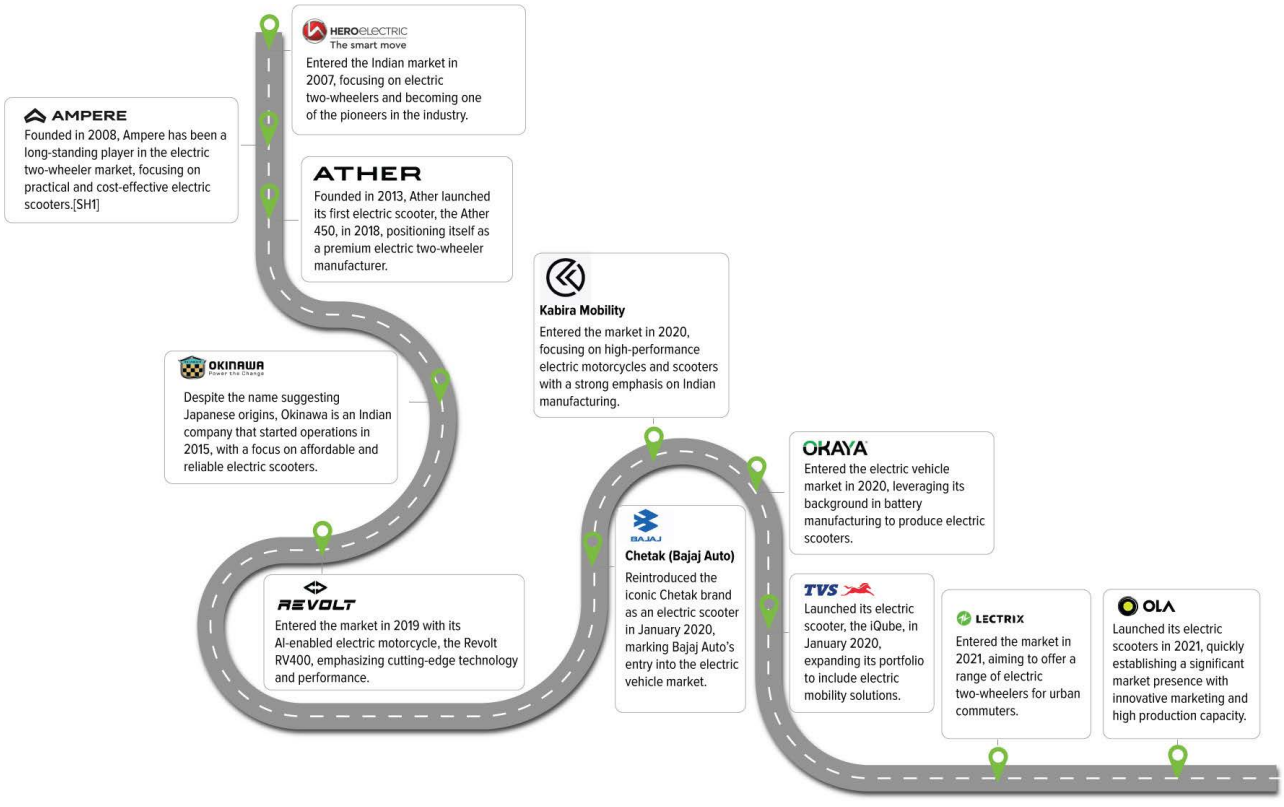

Figure 13: Timeline of entry of E2W OEMs in India

Hero Honda's "Har Gaon Har Aangan" initiative focuses on enhancing customer service in rural areas by providing door-to-door service through a network of specially customized bikes equipped for on-the-spot maintenance. This program involves recruiting rural support executives to regularly cover over 7,500 villages and attend to more than 70,000 customers each month, thereby strengthening Hero Honda's presence in the hinterlands and supporting the company's aim to significantly increase sales in rural markets.

The competitive capacities of these manufacturers indicate a robust infrastructure capable of supporting the increasing demand for electric vehicles, driven by both consumer preferences and supportive government policies. This production landscape positions India to potentially lead in the global electric two-wheeler market, promoting sustainable transportation solutions and reducing reliance on fossil fuels.

In March 2023, the Indian E2W market saw Ola Electric leading with a sales volume of 21,310 units, followed by TVS at 16,780 units, Ather at 12,080 units, Ampere at 9,340 units, and Hero at 6,650 units (Global Market Research & Consultancy, 2023).

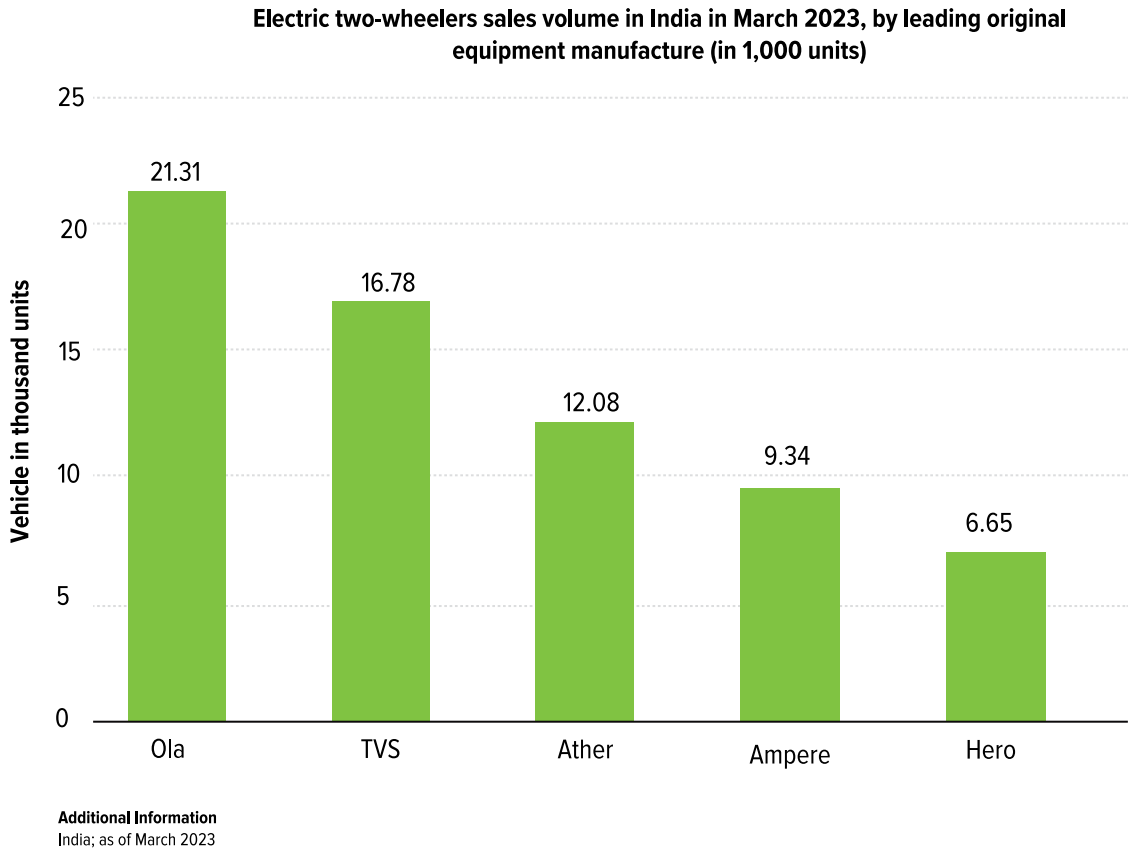

Figure 14: E2W sales volume in India in March 2023 - by leading OEMs (Global Market Research & Consultancy, 2023)

While these figures highlight the competitive landscape and the growing adoption of electric vehicles in urban areas, the penetration and market share in rural regions presents a different picture. Ola Electric has a significant presence in rural areas, leveraging its extensive sales and service network to cater to a broader audience. The company's strategy includes establishing experience centers and

digital platforms to enhance customer engagement and accessibility, which has helped increase its market share.

3.4 Integration into E-commerce Supply Chain in Rural Markets

Typically, e-commerce companies deploy a fleet of delivery vehicles ranging from a few dozen to several hundred per day, depending on the demand density and operational scale (Jain et al., 2022). Moreover, companies focusing on these smaller markets often have to deal with challenges such as lower average order values and cash-on-delivery preferences, which can influence the number and type of vehicles used. For instance, firms may use smaller bikes to optimize costs and improve delivery efficiency in these regions (Bain & Company, 2024).

In recent years, several major e-commerce and food delivery companies in India have made significant strides in deploying EVs for last-mile deliveries. Each company sets ambitious targets and partners with various EV manufacturers to achieve these goals.

Flipkart and Amazon have set the highest EV deployment targets. Amazon aims to have 10,000 electric vehicles in its fleet by 2025. As of now, they have deployed over 6,000 EVs across India. Amazon's fleet includes a variety of models from manufacturers like Mahindra Electric, Tata Motors, and Eicher Trucks and Buses (Amazon India, 2023). This initiative is part of Amazon's broader sustainability goals and its partnership with the Indian government's Shoonya campaign to promote zero-pollution mobility. Flipkart has set an even more ambitious target, planning to deploy over 25,000 EVs by 2030 (The Economic Times, 2021). Flipkart has partnered with Hero Electric, Mahindra Electric, and Piaggio, among others, to achieve this goal. The company has already deployed more than 450 EVs in cities like Delhi, Bengaluru, Hyderabad, and Kolkata (Business Standard, 2024).

Zomato has committed to converting its entire delivery fleet to electric by 2030. They have partnered with Zypp Electric to deploy 100,000 e-scooters by 2024 (The Economic Times, 2023). Additionally, Zomato's EV transition is part of the EV100 initiative by the Climate Group, which aims to accelerate the adoption of electric transport. Swiggy plans to cover 800,000 kilometers per day using EVs by 2025 (Business Standard, 2021). They have signed agreements with companies like Hero Lectro for cargo e-cycles and Reliance BP Mobility Limited for building an EV ecosystem and battery-swapping stations.

A major challenge for all these companies is establishing sufficient charging infrastructure. Flipkart is addressing this by installing charging stations near its 1,400 supply chain facilities (The Statesman, 2021). Additionally, as seen in Swiggy's collaboration with RBML, battery-swapping technology is being explored to reduce downtime and improve delivery efficiency (Business Standard, 2024) .

Companies often collaborate with multiple EV providers to meet sustainability goals and promote electric mobility in their delivery operations. E-commerce giants such as Flipkart and Amazon have partnered with Yulu to electrify their fleets in pursuit of zero-emission targets.

The EV solutions in rural areas differ from those in tier I/metropolitan areas primarily due to these infrastructure constraints. In cities like Bangalore, where low-cost EV solutions such as Yulu and Bounce Electric are popular among delivery drivers, the well-developed charging network supports their operation. These vehicles, with maximum speeds of 25-30 km/h, are ideal for urban environments

with shorter delivery distances and frequent stops. Heavier loads drain EV batteries faster, making it crucial to find vehicles with a 120-150 km range.

In contrast, rural EV deployments must contend with longer travel distances and the need for vehicles that can handle rougher terrain. This has led to the adoption of EVs, which can carry heavier loads and require less frequent charging. To mitigate these issues, such as the loss and theft of packages, some EV providers have introduced innovations like geofencing and GPS tracking features to mitigate these issues. These technologies help monitor vehicles' location and ensure delivery safety.

For rural e-commerce, various electric vehicles are being utilized by major e-commerce companies to ensure efficient and environmentally friendly last-mile delivery. Here are some of the commonly used models and companies:

1. Amazon

- **Models**: Mahindra Treo Zor
- **Details**: They primarily use Mahindra Treo Zor, a three-wheeler EV with an 8 kW motor and a 550 kg payload, suitable for multiple cities (Amazon India, 2023).
- **Introduction of EV in fleet**: October 2020.

2. Flipkart

- **Models**: Mahindra Treo Zor, Hero Electric models, Piaggio Ape E-City, Spero eBikes
- **Details**: Flipkart plans to deploy over 25,000 EVs by 2030 (Flipkart Stories, 2024).
- **Introduction of EV in fleet**: 2018

3. Meesho

- **Models:** Yulu DEX, Hero Electric models, Okinawa Dual
- **Details:** These models are chosen for their reliability and efficiency in short-range deliveries (Bike Advice, 2024).

4. Zomato

- **Models**: Zypp Electric e-scooters, TVS iQube e-scooters, Gogoro Smartscooters
- **Details**: Zomato has partnered with Zypp Electric to deploy 100,000 e-scooters by 2024. They also use TVS iQube and Gogoro Smart scooters for their delivery fleet (HT Auto, 2024).

5. Swiggy

- **Models**: Gogoro Smartscooters, Hero Lectro e-cycles, e-rickshaws
- **Details**: Swiggy is using Gogoro Smart scooters, Hero Lectro e-cycles, and e-rickshaws for deliveries in various cities. Innovative battery-swapping solutions and partnerships with e-cycle manufacturers like Hero Lectro offer flexibility and reduce downtime, boosting delivery efficiency.
- **Introduction of EV in fleet**: 2019

6. eSamudaay

- **Models:** Yulu DEX
- **Details:** Yulu DEX is used for last-mile deliveries of food, groceries, and other essentials. It offers a range of 60 km per charge and does not require a driving license, making it accessible to a wider range of delivery personnel (Bike Advice, 2024).

7. ShopG

- **Models:** BattRE Electric Mobility models (BattRE Electric LoEV, BattRE Electric One), Okinawa Dual
- **Details:** ShopG uses electric two-wheelers like BattRE Electric LoEV and Okinawa Dual, which are known for their durability and efficient performance in delivery operations. The focused use of specific models like BattRE Electric LoEV for targeted delivery operations highlights adaptability to niche requirements. (Bike Advice, 2024)

Here are the some electric scooters that are ideal for delivery purposes in India, focusing on range, performance, and features that cater to the needs of delivery professionals:

Table 4: E2W in India suitable for e-commerce deliveries

	**Simple One**	**Range:** 212 km **Top Speed:** 105 km/h	**Battery:** 5 kWh **Price:** ₹1,45,000	**Features:** Fast acceleration (0-40 km/h in 2.77 seconds)
	**Ola S1 Pro**	**Range:** 195 km **Top Speed:** 115 km/h	**Battery:** 3.9 kWh **Price:** ₹1,29,999	**Features:** Hyper-mode acceleration, large boot space, and advanced connectivity options
	**Vida V1 Pro**	**Range:** 165 km **Top Speed:** 80 km/h	**Battery:** Removable **Price:** ₹1,44,926	**Features:** Custom riding modes, configurable seating
	**Ather 450X**	**Range:** 150 km **Top Speed:** 80 km/h	**Battery:** 2.9 kWh **Price:** ₹1,18,000	**Features:** Warp mode, robust build quality, fast charging
	**Bajaj Chetak**	**Range:** 90 km **Top Speed:** 70 km/h	**Battery:** 3 kWh **Price:** ₹1,17,285	**Features:** Steel body, retro design, durable build
	**Hero Electric Optima CX**	**Range:** 140 km **Top Speed:** 45 km/h	**Battery:** 1.92 kWh **Price:** ₹1,06,763	**Features:** Lightweight, efficient for city commutes
	**TVS iQube**	**Range:** 100 km **Top Speed:** 78 km/h	**Battery:** 3.04 kWh **Price:** ₹1,55,600	**Features:** Quick acceleration, robust motor
	**Okaya Faast F4**	**Range:** 160 km **Top Speed:** 60 km/h	**Battery:** 4.4 kWh **Price:** ₹1,09,000	**Features:** High-speed capabilities, strong motor
	**Komaki XGT-KM**	**Range:** 85-95 km **Top Speed:** 55 km/h	**Battery:** 1.22 kWh **Price:** ₹56,890	**Features:** Affordable, efficient for short deliveries
	**Komaki X-One**	**Range:** 85-95 km **Top Speed:** 55 km/h	**Battery:** 1.22 kWh **Price:** ₹47,617	**Features:** Budget-friendly, suitable for small-scale deliveries
	**Kinetic Green – E-Luna X2**	**Range:** 110 km **Top Speed:** 50 km/h	**Battery:** 2 kWh **Price:** ₹79,990	**Features:** Large carrying space, Saree guard, USB charging point. Suitable for e-commerce delivery

Sources
https://www.bikeleague.in/motorcycle-articles/top-10-electric-scooters-with-highest-range-in-india/
https://www.drivespark.com/best-electric-scooters/
https://komaki.in/best-electric-scooter-for-delivery/

> *"There is a significant lack of awareness about EVs in rural areas, where people often perceive them as unsafe. For rural people, the adoption of new products requires first-hand observation and seeing it work well for their friends, neighbors, and those in their immediate proximity. Giving them an opportunity to observe EVs in use can help address their fears and hesitations around it."*
>
> *– EV Policy Experts*

3.5 Infrastructure and Logistical Challenges and Solutions

The landscape of rural last-mile delivery in India presents unique challenges that impact efficiency and reliability. Addressing these issues is crucial for improving e-commerce penetration and overall economic development in rural areas.

1. One of the most significant challenges in rural logistics is the **poor condition of roads.** Many rural areas lack well-maintained infrastructure, making transportation difficult, especially during the monsoon season when roads become impassable. This situation delays deliveries and increases wear and tear on delivery vehicles, raising operational costs.
2. **Connectivity** issues further complicate last-mile logistics. Many rural areas do not have reliable internet or mobile connectivity, which hampers GPS and real-time tracking technologies essential for efficient delivery operations. The lack of structured addresses in rural India exacerbates this problem. E-bikes offer several advantages in overcoming some of these logistical challenges. Due to their maneuverability and lower operational costs, they are well-suited for rural areas' narrow and often unpaved roads (Jain et al., 2022).

Example of Technological Upgrades: Pataa App

A digital addressing system that creates a short code for your long address and location

The Pataa app addresses key infrastructural and logistical challenges in last-mile rural delivery by providing unique digital addresses. These precise location services improve delivery accuracy and reduce fuel wastage, making it a valuable tool for e-commerce and EV delivery services. Pataa's advanced geotagging, voice directions, and additional location information ensure packages reach their destinations efficiently. By integrating this technology, companies can overcome traditional addressing issues, enhance delivery performance, and build consumer confidence, particularly in rural and semi-urban areas. Companies like ZedBlack, Indian Threads, Simplyy Organics, and Swiss Bosch have integrated Pataa's digital addressing system to solve last-mile delivery challenges.

Furthermore, by utilizing EVs equipped with route mapping and advanced digital technologies like AI and machine learning (ML), e-commerce companies can significantly improve their delivery operations in rural areas. AI and ML can optimize delivery routes and predict demand patterns, while IoT devices can provide real-time tracking and monitoring of deliveries. These technologies enhance

visibility and control over logistics operations, leading to better resource allocation and higher customer satisfaction. This enhances delivery efficiency and reduces the environmental impact by minimizing unnecessary travel and fuel consumption. Moreover, the adoption of EVs with built-in navigation systems helps drivers manage their routes better, avoiding the need for frequent charging stops and thus maintaining a high level of operational efficiency.

3. **Lack of charging infrastructure and battery swapping facilities is also a challenge for operating EVs in rural e-commerce.** The availability of charging infrastructure in rural areas is limited, making it difficult to maintain a fleet of e-bikes. Innovative solutions such as mobile charging units and solar-powered charging stations are being explored to address this issue. Meeting the demand for adequate servicing and maintenance of EVs is also a struggle in rural areas.

4. Rural consumers are often unaware of EVs' reduced total cost of ownership (TCO) compared to ICE vehicles. Instead, they focus on the higher upfront costs and perceive EVs as niche products. **Awareness around EVs** long-term savings on fuel, the environmental benefits, and the resale value of EVs compared to ICE vehicles is needed.

3.6 Charging Infrastructure Demand for Rural E-commerce

Existing Infrastructure

The existing infrastructure for charging e-bikes in rural areas is limited but growing. Current charging solutions primarily include home-based charging systems, which are convenient but slow. Public charging stations are still sparse in rural regions, which poses a challenge to the widespread adoption of e-bikes.

There is a pressing need for fast charging solutions, especially for fleets requiring frequent top-ups. These fleets need a charger that can provide a 50-60 km range in 30 minutes. Currently, OEMs offer up to 1 kW chargers, with most providing 500W, 700W, or 800W chargers (US Department of Transportation, 2024.

> *"In the two-wheeler and three-wheeler market, there's a significant lack of standardization for connectors, unlike cars where CCS2 is the norm. Currently, Type 6 and Type 7 connectors are prevalent, while a smaller share uses connectors like Chagori Anderson. This lack of standardization has made us cautious about developing a dedicated hardware product, as we want to avoid the risk of investing in a connector type that might become obsolete. However, we are working on a versatile solution compatible with both Type 6 and Type 7 connectors,"*
>
> *– Expert from a leading EV solutions company.*

Required Infrastructure for Charging and Maintenance

Establishing a reliable network of charging stations and maintenance facilities is necessary to support the adoption of e-bikes in rural areas. The Indian government, through its FAME II scheme, is promoting the development of public charging infrastructure, including battery-swapping stations

and fast chargers. These initiatives aim to reduce range anxiety and make e-bikes viable for rural delivery services.

Feasibility of Establishing Charging Stations

Establishing charging stations in rural areas hinges on several critical factors, including investment in infrastructure, technological advancements, and maintenance facilities. Government initiatives, such as the FAME II Scheme and PM E-DRIVE, have allocated funds to develop charging infrastructure, but these efforts often focus on urban and peri-urban areas. Significant capital is required to build a comprehensive network of charging stations in rural regions, with estimates suggesting costs between INR 1.5 lakh to INR 5 lakh per basic charging station (Sachan & Singh, 2022). A combination of public and private investments is essential to achieve extensive coverage. Public-private partnerships (PPPs) can mobilize the necessary funds and distribute the financial burden.

> *"Financial barriers to purchasing or leasing e-bikes include high upfront costs, limited access to affordable financing options, and the lack of tailored financial products that cater to the specific needs of rural entrepreneurs. These barriers can hinder the adoption of EVs in rural areas, where income levels are generally lower and financial literacy may be limited."*
>
> *– Finance Expert*

One of the primary reasons for the investment gap in rural areas is the high initial costs and lower immediate returns due to lower population density and perceived risks. Private investors often hesitate due to longer payback periods and higher perceived risks. Government incentives and subsidies can mitigate some of these risks, encouraging private sector participation. However, more targeted policies and financial instruments are needed to attract substantial investments. Advances in battery technology, such as faster charging and longer battery life, are crucial to reducing the frequency and duration of charging stops, making EVs practical for rural users. Mobile charging units and solar-powered charging stations are being explored as cost-effective and sustainable solutions, reducing reliance on grid infrastructure and leveraging abundant rural solar resources.

> *"Unlike the common strategy of waiting for vehicle sales to grow, our approach establishes charging infrastructure in multiple cities regardless of local EV sales figures. This unique peer-to-peer network involves over 30,000 hosts who purchase our hardware and receive network, technology, and support. These hosts can install and manage chargers, set pricing, and benefit from the revenue. For instance, hosts with parking spaces can dedicate spots to EV charging and adjust prices based on location. This model allows us to expand our network quickly and adapt to regional needs, supporting the growth of two-wheeler and three-wheeler EVs across numerous cities. The hosts play a key role in facilitating EV adoption and developing comprehensive charging infrastructure.,"*
>
> *- Expert from a leading EV solutions company.*

In non-metro cities, it's easier to convert hosts due to less densely populated charging networks. Vehicle owners can purchase a charger, use it privately, and switch to public mode when not in use, allowing others to charge their vehicles. In metro cities, despite high interest, dense populations and limited parking space pose challenges. Many potential hosts face barriers such as restrictive housing societies that don't permit outsider access. Conversely, smaller towns offer ample parking space, making it simpler to enable public charging and attract hosts.

While e-bike availability and affordability are improving, significant investment in charging and maintenance infrastructure is needed to support their adoption in rural last-mile delivery. By addressing these infrastructure challenges, e-bikes can become a sustainable and cost-effective solution for enhancing rural logistics and e-commerce deliveries.

Charging Solutions

Charging solutions for e-bikes in rural e-commerce aim to address the unique challenges faced in rural areas, such as limited infrastructure and the need for cost-effective, reliable power sources.

Home and Community Charging:

Many rural users rely on simple home charging setups using standard electrical outlets. This slow charging method is cost-effective and accessible, though it requires longer charging times. For e-commerce deliveries, home and community charging are currently underutilized. The main reason is the longer charging times, which may not align well with the high-frequency delivery schedules. Nevertheless, promoting this method could benefit smaller delivery fleets or during off-peak hours, reducing reliance on more expensive charging infrastructure. States like West Bengal and Odisha have seen higher adoption rates due to supportive policies and community initiatives.

Home and community charging setups typically use standard electrical outlets, which provide alternating current (AC) power at 220-240V and a current of 10-15A in India, as these batteries generally have a 1-2 kWh capacity. In contrast, fast charging stations, which provide direct current (DC) at higher power levels (such as 50 kW or more), can replenish an electric scooter battery in less than an hour.

Battery Swapping Stations:

Battery swapping is an emerging solution where depleted batteries can be exchanged for fully charged ones at designated swapping stations. This method is particularly advantageous in rural areas with sparse charging infrastructure. Currently, battery swapping is increasingly being adopted for e-commerce deliveries in rural areas due to its efficiency and ability to reduce vehicle idle time. However, its adoption is limited by the need for standardized battery types and sufficient infrastructure. Expanding battery swapping could significantly enhance delivery efficiency and reduce operational costs.

Battery swapping stations are a promising solution for rural areas where charging infrastructure is sparse. Currently, most of the battery swapping infrastructure is concentrated in urban and semi-urban areas, with rural penetration being low due to high initial setup costs and the need for standardized batteries.

Public Charging Stations:

Public charging stations are gradually being installed in rural areas scheme, which aims to expand EV infrastructure across India. These stations typically support both slow and fast charging options, catering to different needs. (EVreporter, 2024).

Public charging stations are gradually being installed in rural areas under the FAME-II scheme, which aims to expand EV infrastructure across India. As of 2022, 2,877 stations have been sanctioned, focusing on pan-India coverage, including rural locations (Fame II | Ministry of Heavy Industries). However, the actual deployment in rural areas remains limited. The top five states receiving allocations under FAME-II include Maharashtra, Tamil Nadu, Gujarat, Andhra Pradesh, and Madhya Pradesh. However, rural areas in these states still face significant challenges in access and reliability.

Myntra has integrated public charging stations into its EV logistics strategy, leveraging the growing public charging infrastructure network supported by initiatives like the FAME-II scheme. This ensures that Myntra's delivery EVs have access to reliable charging options during their routes. Similarly, Swiggy, following in the footsteps of Zomato, is incorporating public charging stations for its expanding fleet of electric two-wheelers. By partnering with companies like EVRE and Statiq.

In rural areas, a mix of battery swapping, home and community charging, and public charging stations is being utilized to support the growing demand for e-bikes in e-commerce deliveries.

Challenges in Setting Up Charging Stations in Rural Areas

Setting up charging stations in rural areas has faced several challenges:

- **Infrastructure:** The lack of reliable electrical infrastructure, including frequent power outages and voltage fluctuations, makes consistent charging difficult.
- **Standardization:** The absence of standardized connectors and protocols complicates the deployment of universal charging stations.
- **Financial Viability:** High initial setup costs and uncertain utilization rates make it challenging for operators to achieve a return on investment, deterring extensive rural deployment.
- **Awareness and Adoption:** Limited awareness and slower adoption rates of EVs in rural areas compared to urban centers slow down the demand for charging infrastructure.

Despite solar power's clear benefits in reducing operational costs and providing a sustainable energy source, its adoption in rural areas for EV charging is limited by high initial costs, space and maintenance requirements, the need for reliable energy storage solutions, and logistical challenges. Addressing these issues requires targeted government incentives, technological advancements, and infrastructure development to make solar power a more viable and widely used solution for rural EV charging needs (EVreporter, 2024).

Solar-Powered Charging Stations: Gram Oorja

Gram Oorja, an Indian company which provides sustainable and community driven energy solutions in remote regions to fulfill electricity, cooking fuel and water needs, has successfully implemented solar-powered charging stations in rural areas to support the use of electric vehicles, including e-bikes. One notable project is in the village of Darewadi, Maharashtra, where the company installed a solar microgrid system in July 2012. The project received sponsorships from GIZ, Bank of America, the Prayas Energy Group, Shakti Foundation, ICICI Bank, etc. This system not only provides electricity to households but also powers a charging station for e-bikes and other electric vehicles. The solar-powered charging station has significantly improved mobility for villagers, enabling them to use e-bikes for commuting and local transportation without worrying about the availability of charging infrastructure (Gramoorja).

Changing Battery Swapping Solution for EVs by Sun Mobility

Sun Mobility is advancing electric vehicle (EV) infrastructure with its battery swapping solutions, such as SwapX and S2.1, which facilitate quick battery exchanges to reduce charging times and address range anxiety. Their Quick Interchange Stations (QIS) can perform battery swaps in under two minutes, compared to the average EV charge time of ...., significantly enhancing the efficiency of EV refueling. In partnership with IndianOil, Sun Mobility aims to establish over 10,000 battery swapping stations across 40+ cities by 2030. This initiative supports over 25,000 electric vehicles across 20 cities in India, achieving over a million battery swaps per month (SUN Mobility).

3.7 Financial Viability and Business Models

The Indian government has implemented several incentives and subsidy schemes to promote the adoption of EVs, including E2Ws. The FAME II scheme provides subsidies that reduce the cost of e-bikes by up to 40%, making them more affordable for consumers and businesses. State-specific incentives further enhance affordability, with some states offering additional rebates on the purchase price of e-bikes (Mordor, 2024).

These financial incentives significantly lower the cost of E2Ws, making them more attractive for last-mile delivery services in rural areas. By reducing the initial investment required, these subsidies encourage small businesses and individual delivery agents to switch to e-bikes, thus promoting sustainable transportation solutions. The increased affordability is expected to drive higher adoption rates, supporting the government's goals of reducing carbon emissions and promoting green mobility.

Purchase and Leasing Options

Banks, NBFCs, and fintech startups have pitched in to offer low-interest financing options for electric two-wheeler buyers, reducing the high upfront cost burden. To promote green technologies, the focus is shifting towards EV leasing, which provides an affordable solution for consumers to transition to electric vehicles without actually owning one.

Consumers can either lease an E2W on a monthly basis or hire the vehicle on a pay-per-use basis. In the latter business model, consumers pay the vehicle providers a sum of money agreed in advance for every ride they take. Both these models offer a cheaper alternative to owning an EV, yet they help boost the popularity of the emerging technology.

Purchase Models

a. Outright Purchase:

Consumers can buy e-bikes by paying the full price upfront, immediately making them the vehicle owners. This model eliminates the need for recurring payments but requires a significant initial investment.

Benefits, and Challenges of Outright Purchase for E-Bikes

Benefits:

1. **Cost Savings:** Long-term savings as there are no recurring payments.
2. **Government Subsidies:** In India, subsidies on e-bikes like those from Hero Electric reduce the initial cost.
3. **Flexibility and Control:** Owners have full control over usage, maintenance, and customization.
4. **Asset Ownership:** E-bikes can be sold or traded in the future.

Challenges:

1. **High Initial Cost:** The significant upfront investment can be a barrier.
2. **Depreciation:** Owners bear the depreciation costs.
3. **Maintenance and Repairs:** The owner is responsible for all maintenance and repair costs.
4. **Technological Obsolescence:** Rapid advancements may make e-bikes outdated quickly.

b. Financed:

Banks, Non-Banking Financial Companies (NBFCs), and fintech startups offer loans to make e-bike purchases more affordable. These financing options allow consumers to spread the cost over time, reducing the initial financial burden. Examples include personal loans, bike loans, and EMIs (Equated Monthly Installments) tailored for e-bike purchases.

Example: RevFin and Bajaj Finserv: These companies provide digital loans for e-bike purchases in India, simplifying the financing process and making e-bikes more accessible.

Benefits, and Challenges of Financing Options for E-Bikes

Benefits:

1. **Affordability:** Makes e-bikes accessible by lowering the upfront cost.
2. **Flexible Payment Plans:** Options like personal loans, bike loans, and EMIs cater to different financial situations.
3. **Immediate Ownership:** Consumers can use the e-bike immediately.
4. **Improved Cash Flow:** Spreading costs maintain better cash flow.

Challenges:

1. **Interest and Fees:** Increase the overall cost.
2. **Creditworthiness Requirements:** Financing depends on credit scores.
3. **Risk of Default:** Missed payments can lead to penalties and repossession.
4. **Long-term Commitment:** Requires careful financial planning and discipline.

Leasing Options

Monthly Leasing:

Leasing allows consumers to use an E2W for a monthly fee without owning it. This model offers flexibility and reduces long-term commitment, making it easier for users to upgrade to newer models as technology evolves.

Pay-Per-Use:

In this model, consumers pay a predetermined fee for each ride they take. This is ideal for occasional users who do not need a vehicle full-time. It lowers the financial barrier to entry by aligning costs with actual usage.

Battery leasing Model - The battery leasing model for E2Ws in India is gaining traction as an effective solution to address high upfront costs and battery performance concerns. This model allows users to lease batteries instead of purchasing them outright, significantly lowering the initial investment required to own an E2W.

Benefits, and Challenges of Leasing

- **Benefits:** Leasing reduces the financial burden of upfront investment and ensures regular maintenance, which can extend the lifespan of the e-bike and improve operational efficiency.
- **Challenges:** The primary challenge with leasing is the total cost over time, which can be higher than outright purchase. Additionally, reliance on leasing companies for maintenance and battery swapping can be a limitation if service quality is inconsistent.

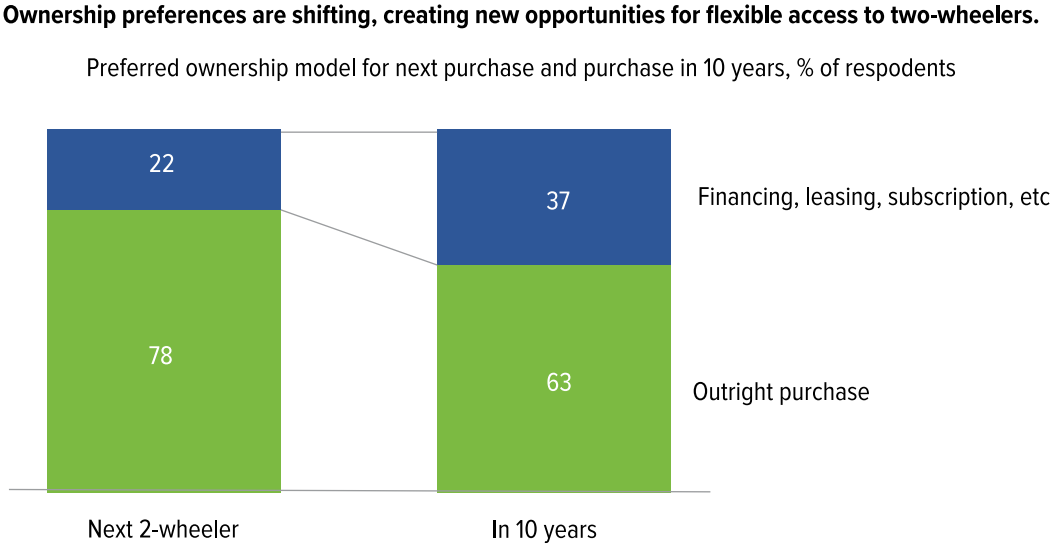

Figure 15: Preferred ownership model for E2W in India (McKinsey, 2022).

> *"Public-private partnerships (PPP) are crucial for expanding E2W infrastructure, especially for low-income groups and diverse communities. These partnerships help municipal corporations set up charging stations by addressing land and power challenges. Governments can offer surplus public land to private investors to charge infrastructure. Approx 70% of India's charging infrastructure operates under the PPP model, which has also been successful in bus operations, with the public sector providing land and support while private companies manage investment and maintenance."*
>
> *– EV Policy Expert*

3.8 Gender Inclusion

The adoption of E2Ws can create job opportunities in rural areas. The ease of use and lower physical strain associated with E2Ws can encourage more women to participate in the delivery workforce, promoting gender inclusion in the logistics sector. E2Ws operation is simplified, often requiring less gear shifting, which minimizes physical and cognitive effort. EVs also produce less vibration and noise, decreasing physical fatigue during extended use. Instant torque from a standstill means riders exert less effort to start moving, particularly in stop-and-go traffic. Additionally, many EVs are ergonomically designed with adjustable features to enhance comfort, and they are generally lighter than conventional ICE Vehicles, making them easier to handle.

Various e-commerce companies are actively working to increase female representation in their EV delivery fleets, especially in rural areas. Their initiatives include self-defense training and designated women-only delivery stations in some areas to encourage female participation. However, integrating women into delivery roles in other rural regions remains challenging due to social and cultural norms that view such jobs as unsuitable for women. To address these issues, Amazon and Zomato place a strong emphasis on safety measures, such as training and protective gear for women, which are crucial in overcoming barriers related to personal security. Cultural sensitivity is another key area where Flipkart and BigBasket excel, focusing on localized hiring and community engagement to address cultural challenges that restrict women's employment.

Additionally, government and NGO partnerships play a vital role in these initiatives. Flipkart and Amazon both leverage government schemes and NGO collaborations to attract and retain female employees, helping them reach out to women in rural and conservative areas. Continuous collaboration with local communities, government bodies, NGOs, and tailored safety and training programs are essential to furthering these initiatives and promoting greater inclusivity in the e-commerce delivery workforce.

Addressing the gender disparity in e-commerce delivery fleets requires tackling several significant barriers. Another significant barrier is the lack of facilities, such as female toilets at e-commerce hubs, and the perceived danger of traveling to remote areas. The physical demands of being a delivery agent, typically involving 150 deliveries in 8-9 hours, can be too taxing for women. Consequently, e-commerce companies often prioritize male employment in their delivery fleets. To address this, government policies should mandate around 25% female representation in e-commerce fleets. Women are more likely to be motivated to learn to drive if they are assured of a stable job with a fixed income for at least a year post-training.

"Gender considerations are seldom highlighted in mobility discussions, yet they are critically important, especially in rural areas where women have almost no access to vehicles. For many rural women, the mere idea of operating a vehicle is often unattainable. This lack of access to safe mobility significantly hinders their ability to participate in skill development programs, thereby confining them to traditional, home-bound roles such as cooking and salon services. In rural regions, job selection criteria differ markedly between men and women. Men typically pursue opportunities based on earning potential, whereas women must consider factors such as the proximity of the workplace, the feasibility of commuting, and the availability of work within their own villages. Inadequate access to mobility thus poses a significant socio-cultural barrier, preventing rural women from accessing livelihood and income-generating opportunities."

– Gender Inclusivity Expert

Language changes, such as referring to "delivery persons" rather than "delivery boys," are also important to create a more inclusive environment. Employment patterns for women vary across states; for instance, women in Tamil Nadu and Kerala are more likely to take up jobs in logistics and as e-commerce delivery agents than those in Rajasthan and Telangana. Women working in rural e-commerce can earn between Rs. 10,000-20,000 with a two-wheeler and up to Rs. 30,000 with a three-wheeler. This income potential can motivate women to pursue these roles, provided they have the necessary training and support.

To accommodate women's needs, it is essential to provide diverse income opportunities that allow them to work flexibly between their household and childcare responsibilities. Ride-hailing jobs, for example, may not be viable if peak hours coincide with key household responsibilities. However, rural women have shown a strong interest in learning to drive when given the opportunity, as evidenced by the 144 sign-ups for two-wheeler driving classes advertised by Moving Women (MOWO) in Narayanapet. MOWO is a platform dedicated to empowering women through mobility solutions, providing training and support to help them become independent and confident drivers, ultimately improving their access to economic opportunities and personal freedom.

Additionally, most rural women lack credit histories and are first-time credit users, facing high interest rates of around 24% on loans to purchase EVs. To make EV ownership feasible, they need access to loans at lower interest rates, around 9%, typically offered by institutions such as the NABARD and microfinance organizations like Grameen Bank. Addressing these multifaceted barriers can significantly enhance job creation and gender inclusion in rural mobility sectors. A notable case study is the Amma Two-wheeler scheme by the Government of Tamil Nadu, which provided women with discounts on two-wheeler purchases of up to a maximum of 50% or Rs.25,000, whichever is lower. The program significantly increased employment and mobility for working women, enhancing gender inclusion in the mobility sector.

04

EV Policy Landscape Assessment

4.1 Existing Policies Impacting Electrification

India's EV journey has evolved significantly over the past decade, driven by policy interventions, technological advancements, and changing consumer preferences. Early adoption was slow due to high costs and limited infrastructure, but recent years have witnessed a remarkable shift. The introduction of the Policies by Central and state governments provided financial incentives and charging infrastructure expansion, paving the way for increased EV adoption. Additionally, state-level policies, tax benefits, and a growing ecosystem of manufacturers have accelerated this transition.

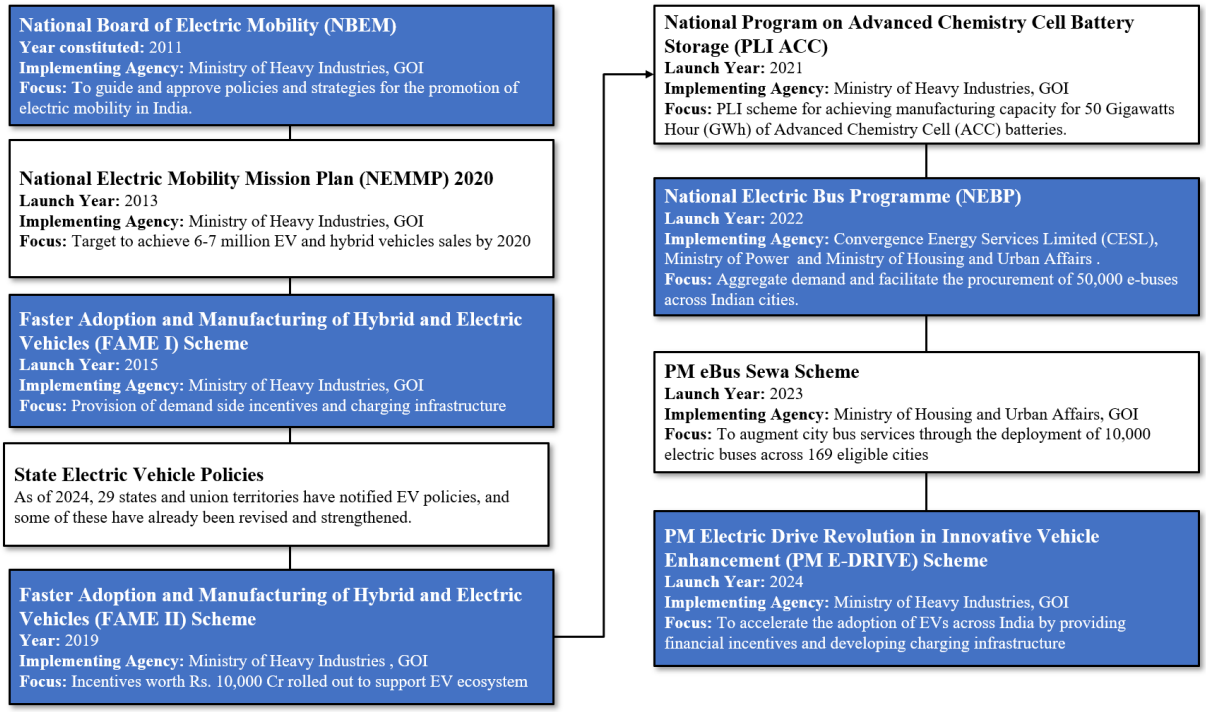

Figure 16: Major keystones in EV adoption in India (Source: Authors)

The Indian government began to prioritize the adoption of EVs in 2013, with the launch of the National Electric Mobility Mission Plan (NEMMP). The NEMMP aimed to provide a clean alternative to the conventional automotive industry and achieve national fuel security by promoting hybrid and electric vehicles. Government ambitions to promote EVs are further reflected in initiatives like the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme, first launched in 2015, which offers incentives for EV buyers and manufacturers. The government aims to have 30% of all vehicles on the road to be electric by 2030. Policies are increasingly focused on creating a robust infrastructure for EVs, including charging stations and battery-swapping facilities, to support this transition.

Several key motivations underpin the Indian government's push towards EVs. One of the primary reasons is energy security. India relies heavily on oil imports to meet its energy needs, making it vulnerable to global oil price fluctuations. By promoting EVs, the government aims to reduce this dependency, thereby enhancing national energy security. Another critical motivation is addressing environmental concerns. With rising pollution levels and significant greenhouse gas emissions, particularly from the transportation sector, the shift to EVs is crucial in combating climate change and improving air quality. Economic growth is another significant driver. The EV sector presents substantial economic opportunities, including job creation, technological advancements, and the development of new industries. The government aims to position India as a global EV manufacturing and innovation hub. Additionally, reducing vehicle emissions can significantly decrease health issues related to air pollution, such as respiratory and cardiovascular diseases, improving public health outcomes.

4.2 Central and State-Level Policies

Both central and state governments in India have implemented various policies to support the electrification of last-mile delivery services. These policies aim to provide financial incentives, create a supportive regulatory framework, and build the necessary infrastructure to facilitate the adoption of EVs.

Central Policies

The central government introduced several broader national initiatives like the FAME Scheme, PM E-Drive, that support electrification by promoting EV adoption and manufacturing across the country.

National Electric Mobility Mission Plan (NEMMP) 2020

- **Policy Year:** A Government of India initiative launched in 2013 to promote the adoption and manufacturing of electric and hybrid vehicles to enhance fuel security and environmental protection. The plan provides a roadmap and policies, including the FAME India scheme, to accelerate the shift towards electric vehicles in India.
- **Target:** There is an ambitious target to achieve 6-7 million sales of hybrid and electric vehicles year on year from year 2020 onwards.
- **Implications:** The NEMMP 2020 provided a comprehensive roadmap for the EV sector, laying the groundwork for subsequent policies and initiatives. With the support from the Government, the cumulative sale is expected to reach 15-16 million by year 2020. It is expected to save

9500 million litre of crude oil equivalent to saving INR 62000 Cr. It is envisaged that early market creation through demand incentive, in-house technology development and domestic production will help industry reach a self-sufficient economy of scale in the long run by year 2020.

FAME India Scheme (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles)

Phase I (2015-2019)

- Objective: The primary focus was on creating demand for hybrid/EVs through direct subsidies and supporting the development of charging infrastructure.
- **Key Initiatives:**
  - Subsidies: Financial incentives for purchasing electric two-wheelers, three-wheelers, four-wheelers, and buses. The subsidy amount varied depending on the battery capacity and other specifications of the two-wheeler. The incentives aimed to reduce the upfront purchase price, thus making E2Ws more affordable (India Today, 2024).
  - Infrastructure Support: Financial support for setting up public charging stations to enhance the accessibility and convenience of charging EVs.
  - Pilot Projects: Implementation of pilot projects in select cities to demonstrate the viability and benefits of EVs in urban transport (FAME, 2022).

The outcome of Phase I: Phase I successfully laid a strong foundation for the adoption of EVs, contributing to the initial growth of the EV market in India. During this phase, approximately 2.78 lakh electric vehicles were supported, with total demand incentives amounting to around ₹343 crores. Additionally, 465 electric buses were sanctioned to various cities and states, contributing to the growing awareness and adoption of clean mobility solutions. E2Ws received significant attention under Phase I, with subsidies designed to make them more affordable and attractive to consumers. The subsidies aimed to reduce the upfront purchase price, making E2Ws a viable option for a broader population segment. These incentives played a crucial role in increasing the adoption of E2Ws, which formed a substantial portion of the total EVs supported during this phase. (BEE, 2022).

Phase II (2019-2022)

- Expanded Scope: Phase II broadened the scope to include more vehicle categories and emphasized establishing comprehensive charging infrastructure.
- **Objectives:**
  - Accelerate the adoption of EVs across various segments.
  - Enhance the charging infrastructure network to support EV usage.
  - Encourage the development of a robust local manufacturing ecosystem for EVs and related components.
- **Target:**
  - E2Ws: Provide subsidies for 1 million units.

- Total Subsidy Amount: ₹5,790 crore as of January 2024 (PIB, 2024).
    - Initial Subsidy: Due to budget constraints, 40% of the ex-showroom price was reduced to 15% in June 2023. For example, if an electric two-wheeler had an ex-showroom price of ₹100,000, the initial subsidy was ₹40,000, which was reduced to ₹15,000 (Fame II, 2024).

The outcome of Phase II: As of January 2024, under Phase II, subsidies amounting to ₹5,790 crore were given to electric vehicle manufacturers for the sale of 13,41,459 electric vehicles. E2Ws grew substantially under Phase II, driven by high-demand incentives. The subsidies provided significant financial relief, making E2Ws more accessible to consumers.

Production Linked Incentive (PLI) Scheme (2020)

- Objective: To encourage domestic manufacturing of EVs and their components, thereby reducing import dependency and promoting a self-reliant EV ecosystem in India.
- Key Features:
    - Financial Incentives: Production-based incentives provided to manufacturers based on their output and scale. The PLI scheme provides financial incentives to manufacturers based on their output and scale.
    - Support for EV Components: Incentives for manufacturing key EV components such as batteries, motors, controllers, and other advanced automotive technologies.
    - Encouragement of Large-Scale Production: Focus on attracting large-scale investments and promoting the establishment of major manufacturing units. (PLI Scheme for Automobile and Auto Component Industry, 2024).
- **Successes:** The PLI scheme has significantly enhanced the manufacturing capacity of domestic companies. It has also attracted considerable foreign direct investment (FDI) and domestic investment, further strengthening the EV industry's financial foundation. Additionally, the scheme has encouraged the development of advanced EV technologies and components, positioning India as a hub for innovative EV solutions.
- **Challenges:** The high initial cost of setting up manufacturing units and producing advanced components remains a significant barrier for many companies. Moreover, gaps in infrastructure, especially the insufficient availability of charging stations and other supportive infrastructure, pose ongoing challenges. Ensuring consistent and effective policy implementation across different states is also critical to overcoming these obstacles and achieving the scheme's full potential.

PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) Scheme (2024)

- **Objective:** The scheme aims to incentivize the adoption of EVs and establish a robust EV manufacturing ecosystem in India.

Key Components:

- **Subsidies:** Demand incentives for e-2W, e-3W, e-ambulances, e-trucks & other new emerging EV categories;

- **Grants for creation of capital assets:** e-buses, establishment of network of charging stations & upgradation of testing agencies identified under this Scheme; and
- Administration of Scheme including IEC (Information, Education & Communication) activities and fee for project management agency (PMA).

Salient features of PM E-DRIVE scheme:

i. Introduction of E- Vouchers: - The Ministry of Heavy Industry (MHI) is introducing E-vouchers for Electric vehicle buyer to avail the demand incentive under the scheme.

ii. Introduction of new vehicle segments: - An allocation ₹500 crore each has been done for deployment of e-ambulances and e-trucks under the scheme. This is new initiative of MHI, Government of India to promote the use of e-ambulances for a comfortable patient transport. Similarly, e-trucks have also been introduced under the scheme since trucks are major contributors to air pollution. To avail subsidy on e-truck submission of a scrapping certificate from Ministry of Road Transport and Highways (MoRTH) approved vehicles scrapping centres (RVSF) has been made mandatory.

iii. Upgradation of testing agencies: Rs. 780 Crore has been earmarked for upgradation of vehicles testing agencies. The scheme has following three components: i. ii. iii. Subsidies: Demand incentives for e-2W, e-3W, e-ambulances, e-trucks & other new emerging EV categories; Grants for creation of capital assets: e-buses, establishment of network of charging stations & upgradation of testing agencies identified under this Scheme; and Administration of Scheme including IEC (Information, Education & Communication) activities and fee for project management agency (PMA).

Incentives for Charging Infrastructure in India

The Government of India's flagship EV demand promotion policy, the scheme, offered incentives for the development of charging infrastructure, among other support. The second phase of the scheme, FAME II, concluded in March 2024. The third iteration, PM E-DRIVE scheme, was announced in September 2024 (Ministry of Heavy Industries, 2024b). The scheme was launched on October 1, 2024 and will be in effect until March 31, 2026, with ₹2,000 crore in funding to be allocated for charging infrastructure development

FAME I had a budget outlay of ₹895 crore, of which ₹43 crore was earmarked for the development of 520 charging stations (Ministry of Heavy Industries, 2023b).1 FAME II was launched in April 2019 with an initial allocation of ₹10,000 crore for demand incentives, support for charging infrastructure, administrative expenditures, and committed expenditures of FAME I. According to the research by ICCT, FAME II utilized 75% of the ₹893 crore allocated for charging infrastructure development.

Guidelines for Installation and Operation of Electric Vehicle Charging Infrastructure (2024)

The Ministry of Power (MoP) issued the "Guidelines for Installation and Operation of Electric Vehicle Charging Infrastructure-2024" on September 17, 2024. These guidelines aim to establish a connected, interoperable, and standardized EV charging infrastructure network across India, ensuring seamless accessibility and reliability.

As per the Dec,2024 data from the Ministry of Power, 25,202 Public EV Charging Stations (EVPCS) have been installed nationwide.

Objectives of the Guidelines:

- **Enhancing EV Adoption –** Ensuring that EV charging stations are safe, reliable, and easily accessible to accelerate EV penetration.
- **Developing a Robust Charging Network –** Establishing a widespread and efficient EV charging ecosystem, prioritizing essential locations such as highways, urban centers, and commercial hubs.
- **Improving Viability and Affordability –** Facilitating public land at concessional rates, expediting electricity connections, and standardizing power tariffs to make charging stations financially sustainable.
- **Promoting Renewable Energy Utilization –** Encouraging EV charging during solar hours to integrate renewable energy sources into the charging infrastructure and reduce grid dependency.
- **Strengthening Grid Preparedness –** Enhancing the power grid's capacity to manage the increased electricity demand from EV charging, ensuring stability and efficiency.

Analysis of E2W Policies in Indian States

Indian states have launched various policies to promote the adoption of E2Ws, each with distinct features tailored to regional needs. Comparing these policies reveals both similarities and differences that highlight their strengths and weaknesses. Here is an overview of the different subsidies offered by several states:

Key State Initiatives

Karnataka: Karnataka was the first state to introduce a comprehensive EV policy in 2017, focusing on making Bengaluru the EV capital of India. The policy includes tax exemptions, grants for R&D, and support for charging infrastructure, positioning Karnataka as a leader in the EV sector.

Andhra Pradesh: Andhra Pradesh's Sustainable Electric Mobility Policy (4.0) 2024–29 sets ambitious goals to electrify transport, including registering 2 lakh E2Ws and fully electrifying the APSRTC fleet by 2029. It incentivizes EV purchases with up to 10% off the ex-showroom price and supports charging infrastructure through a 25% capital subsidy. Manufacturers, especially MSMEs and socially disadvantaged groups, benefit from investment subsidies, power tariff reimbursements, and SGST incentives. The policy also promotes e-mobility cities, R&D, and green corridors, backed by a ₹500 Cr fund and supportive industrial measures.

Bihar: Bihar's Electric Vehicle Policy, 2023 targets 15% EV adoption among new vehicle registrations by 2028. It offers purchase incentives up to ₹10,000 for E2Ws and ₹1.5 lakh for E4Ws, with enhanced benefits for SC/ST buyers. The policy supports charging infrastructure through subsidies of up to 75% on AC/DC charger equipment and installation costs. It also provides 30% power tariff subsidies for public charging and tax rebates for new EV units. Additional incentives include land conversion fee reimbursements and a forthcoming battery reuse policy to strengthen the recycling ecosystem.

Tamil Nadu: Tamil Nadu's Electric Vehicle Policy 2023 aims to transform the state into a leading EV manufacturing hub in South-East Asia while promoting rapid EV adoption. The policy offers purchase incentives of up to ₹30,000 for commercial E2Ws and full exemptions on road tax, registration, and permit fees for electric two-wheelers and other commercial EVs. To boost charging infrastructure, incentives of up to ₹10 lakh are provided for fast charging stations. The policy also supports battery recycling, renewable energy sourcing, R&D, skill development, and incentives for green industries.

Maharashtra: Maharashtra's Electric Vehicle Policy 2021 provides a substantial subsidy of ₹5,000 per kWh, up to a maximum of ₹10,000 per E2W for the first 100,000 vehicles. This is designed to make E2Ws more affordable for consumers and boost sales (Alliance for an Energy Efficient Economy, 2023). Additionally, the policy includes comprehensive tax exemptions, including waivers on road tax and registration fees, further reducing the total cost of ownership.

Table 2: Analysis of E2W Policies in Indian States

Sr. No	State / UT	Consumer Incentives - EV Adoption			Operational Incentives		Charging Infrastructure Incentives							Skill Development	R&D
		Purchase Incentive E2W	Road & Registration Tax Exemption	Access to Financing / Interest Subvention	Green Zones	Reserve Parking Slots	Capital Subsidy on Charging Equipment	Land Subsidies/ Provisions	Special EV Tariffs	Electricity Connection	Use of RE	Setting Up of Charging Stations	Battery Swapping Incentives		
1	Ladakh: Ladakh Electric Vehicle and Allied Infrastructure Policy, 2022	✔	✔			✔	✔		✔			✔	✔		✔
2	Meghalaya: Meghalaya Electric Vehicle Policy, 2021	✔	✔		✔	✔		✔	✔	✔		✔		✔	
3	Bihar: Bihar Electric Vehicle Policy 2023	✔	✔				✔	✔	✔	✔	✔	✔		✔	✔
4	West Bengal: West Bengal Electric Vehicle Policy, 2021				✔			✔		✔	✔	✔	✔	✔	✔
5	Odisha: Odisha Electric Vehicle Policy & Amendment of Odisha Electric Vehicle Policy, 2021	✔	✔	✔		✔	✔	✔	✔		✔	✔		✔	✔
6	Kerala: Kerala EV Policy 2019		✔		✔	✔	✔		✔			✔	✔	✔	✔
7	Rajasthan: Rajasthan EV Policy 2022						✔	✔	✔	✔	✔			✔	✔
8	Delhi: Delhi Electric Vehicle Policy 2020	✔	✔	✔			✔	✔	✔		✔	✔	✔	✔	✔
9	Karnataka:Karnataka EV Policy 2017		✔				✔		✔		✔	✔	✔	✔	✔
10	Gujarat: Gujarat Electric Vehicle Policy 2021	✔					✔		✔	✔		✔			
11 11	Andhra Pradesh Sustainable Electric Mobility Policy (4.0) 2024-29	✔	✔		✔		✔	✔	✔	✔	✔	✔	✔	✔	✔
12	Tamil Nadu:Tamil Nadu Electric Vehicle Policy 2023	✔	✔			✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
13	Tripura: Tripura EV Policy 2022		✔			✔			✔			✔	✔	✔	

Sr. No	State / UT	Consumer Incentives - EV Adoption			Operational Incentives		Charging Infrastructure Incentives							Skill Development	R&D
		Purchase Incentive E2W	Road & Registration Tax Exemption	Access to Financing / Interest Subvention	Green Zones	Reserve Parking Slots	Capital Subsidy on Charging Equipment	Land Subsidies/ Provisions	Special EV Tariffs	Electricity Connection	Use of RE	Setting Up of Charging Stations	Battery Swapping Incentives		
14	Maharashtra: Maharashtra Electric Vehicle Policy, 2021	✔	✔	✔	✔	✔	✔		✔					✔	✔
15	Chattisgarh: Chhattisgarh State EV Policy 2022	✔	✔			✔	✔	✔	✔		✔	✔			✔
16	Chandigarh: Chandigarh Electric Vehicle Policy 2022	✔	✔				✔		✔			✔	✔	✔	
17	Haryana:Haryana Electric Vehicle Policy 2022		✔	✔	✔		✔	✔	✔		✔	✔	✔	✔	✔
18	Assam: Electric Vehicle Policy Assam 2021	✔	✔			✔	✔		✔			✔			✔
19	Madhya Pradesh: Madhya Pradesh Electric Vehicle Policy 2019	✔	✔		✔	✔	✔	✔	✔		✔	✔	✔	✔	✔
20	Punjab: Punjab Electric Vehicle Policy 2022	✔	✔		✔	✔	✔		✔		✔			✔	✔
21	Telangana: Telangana Electric Vehicle Policy 2020	✔	✔	✔		✔			✔		✔				✔
22	Uttar Pradesh: Uttar Pradesh Electric Vehicle Manufacturing and Mobility Policy 2022	✔	✔		✔		✔	✔	✔	✔		✔	✔	✔	✔
23	Uttarakhand: Uttrakhand EV policy 2023	✔	✔			✔			✔			✔	✔	✔	✔
24	Jharkhand: Jharkhand Electric Vehicle Policy 2022	✔	✔	✔		✔		✔				✔			
25	Manipur: Manipur Electric Mobility Policy 2022	✔				✔	✔	✔	✔	✔				✔	✔
26	Arunachal Pradesh: Arunachal Pradesh Electric Vehicle Policy-2021	✔					✔		✔						
27	Goa: Goa Electric Mobility Promotion Policy-2021		✔				✔ ✔		✔		✔	✔	✔	✔	

Incentives on charging infrastructure offered by various state government

On the infrastructure front, Karnataka led with the largest public charging network (5,765 stations), accounting for 23% of the national total. Maharashtra (3,728) and Uttar Pradesh (1,989) followed, reflecting strong alignment between sales and infrastructure growth. Delhi and Tamil Nadu rounded out the top five in charging station installations. Together, the top 10 states drove over 70% of India's EV sales and hosted the majority of its public charging stations, showcasing the regional momentum behind the country's electric mobility push.

Table 3: State-wise charging infrastructure policies

State Govts	Capital Subsidy on Charging Equipment	Setting Up of Charging Stations
Karnataka	Incentives for the first 100 fast charging stations. 25% capital subsidy on equipment (max Rs. 10,00,000) for the first 100 fast charging stations for 2 and 3 wheelers.	Investment subsidy for the first 100 fast charging stations. Fast charging station/battery swapping infrastructure every 50 KM. Amendments to building bye-laws for EV charging infrastructure in high-rise buildings/ SEZs/apartments.
Maharashtra	Incentives for public and semi-public charging stations. Varying incentives based on charging station type.	
Meghalaya		Encourage investments in slow and fast charging networks. Set up stations at key locations, including government facilities and commercial buildings.
Uttar Pradesh	25% subsidy, max Rs 6 lakh per charging station.	20% subsidy, max Rs 10 lakh per unit for first 2000 charging stations.
Delhi	Encourage private charging points with a grant of 100% for equipment purchase. Capital subsidy for public charging stations for charger installation expenses.	100% grant for first 30,000 charging points.
Tamil Nadu	Capital subsidy for public charging stations. Tariff control.	Provisions in commercial buildings. Capital subsidy incentives.

05

Insights from Stakeholder Consultations

Our consultations engaged diverse stakeholders, including OEMs, delivery partners, investment banks, e-commerce companies, and policymakers. Semi-structured interviews explored technological advancements, manufacturing challenges, financial viability, and market potential. E-commerce companies discussed integrating e-bikes into delivery networks, while policymakers focused on regulatory frameworks and incentives. Urban logistics planners examined optimizing delivery systems and reducing congestion. Gender inclusion organizations assessed workforce diversity impacts. These consultations aimed to understand rural e-commerce demand and supply, evaluate EV infrastructure requirements, and identify policy gaps and areas for improvement.

Figure 17: Stakeholders interviewed

5.1 Evaluating Policy Frameworks: Stakeholder Perspectives

Current Policies and Their Impact

Central and state fiscal incentives have significantly reduced the upfront costs of EVs, a crucial factor for cost-sensitive markets like India. Key policies such as the FAME Scheme, PLI Scheme,

and PM E-Drive have profoundly impacted the EV sector, with government subsidies playing a pivotal role in vehicle sales., as evidenced by the dip for a few months in EV sales following subsidy reductions in June 2023. Effective policy implementation requires seamless collaboration between the government, industry stakeholders, and service providers. Despite supportive policies and initiatives, EV adoption in rural areas faces significant barriers, including economic constraints, lack of infrastructure, and limited capacity for policy implementation. The absence of a standardized connector for two-wheelers and three-wheelers further complicates the situation, underscoring the need for fast-charging solutions for fleets, which OEMs currently do not fully address.

Innovative models like peer-to-peer hosting mitigate dead investments and allow for flexible scaling based on utilization patterns, emphasizing the need for policies that support the rapid development of charging infrastructure and address power load availability. Collaboration with government bodies like NITI Aayog and SIDBI is crucial for influencing policies, fostering a deeper understanding and cooperation with manufacturers, and reducing specific challenges related to battery policies.

Support for Women's Participation

Gender has often been overlooked in mobility discussions, both in rural and urban contexts. Mobility policies need a gender-specific perspective, especially in rural areas, to support the inclusion of women in mobility sectors, including ride-hailing and logistics. Training programs that provide practical skills in sustainable transportation have shown positive results, particularly in rural regions, where local government support and infrastructure play a critical role in the success of such initiatives. Women face significant challenges in the logistics sector, such as high rates of undelivered packages, which affect their earnings. Supportive partnerships with companies ensure women drivers have safe, accessible facilities and adequate infrastructure. Advocacy campaigns and training programs tailored to build confidence and provide women with guaranteed monthly incomes and stable job opportunities are essential. These efforts are crucial for transforming the gender dynamics in the transportation sector and promoting greater gender inclusion in rural and urban mobility landscapes.

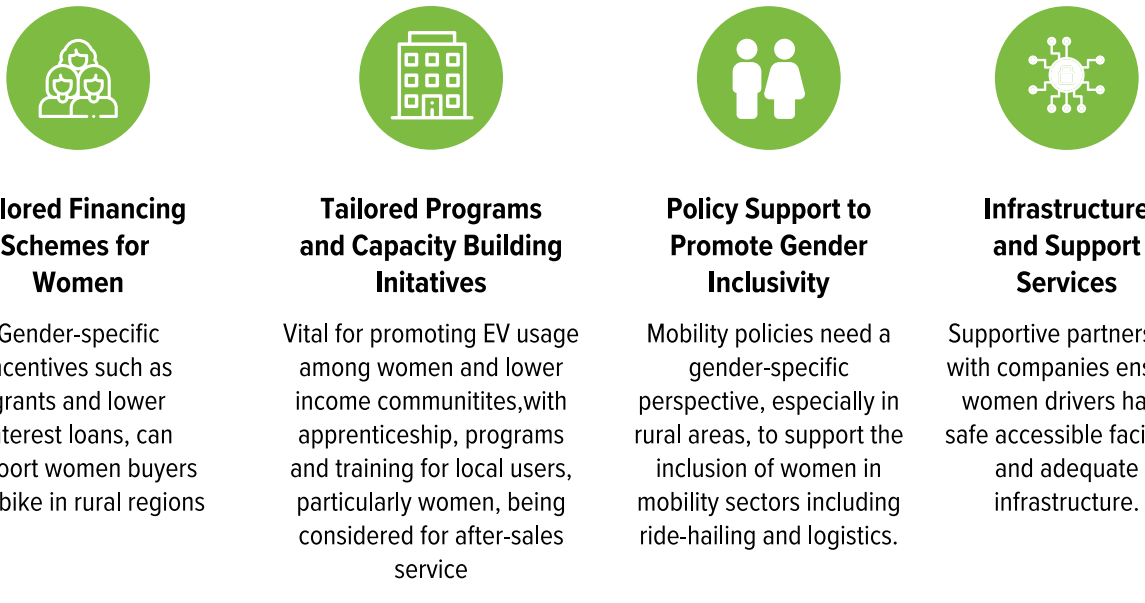

Figure 18: Recommendations to increase Women's participation in E2W, (author)

Tailored financing schemes for women, developed in collaboration with financial institutions, along with gender-specific incentives such as grants and lower-interest loans, can support women buyers of e-bikes in rural regions.

5.2 Market Dynamics and Trends: Insights from Industry Experts

Stakeholders and Financial Viability

The financial viability of existing business models for E2Ws adoption in rural logistics is pivotal, with concessional financing and subsidies being key enablers. The booming EV market, particularly in the two-wheeler segment, holds significant potential for commercial adoption, though economic challenges, bureaucracy, and limited infrastructure pose barriers in rural areas.

Peer-to-peer models for expanding charging infrastructure, where individuals and businesses purchase hardware and provide network technology and support, are becoming increasingly significant. These models allow hosts to set pricing for charging based on their location and business needs, supporting vehicle ownership over leasing. This approach helps consumers buy vehicles outright, earning an extra income once EMI payments end, supported by partnerships with retailers and e-rickshaw companies.

The primary drivers of the EV ecosystem in India are two-wheelers and three-wheelers, especially in the delivery and fleet sectors, underscoring the importance of comprehensive support and innovative financial models to overcome existing barriers and promote widespread adoption.

Demand and Supply

The demand for E2Ws in rural e-commerce is growing, highlighted by significant additional demands in pilot projects, emphasizing the need to focus on customer experience and selecting the right products for rural markets. Demand assessments reveal substantial potential for E2Ws adoption in rural e-commerce, yet infrastructure readiness and financial viability persist. State policies that support infrastructure development and increase awareness of sustainable transportation options are key enablers. The demand for EV charging infrastructure in rural areas is driven by vehicle penetration and the need for frequent charging by fleet operators, necessitating rapid deployment in areas with growing EV demand.

States like Tamil Nadu, Karnataka, and Maharashtra show strong markets for EVs, with rural areas demonstrating potential based on dealer strength.

Ultimately, the demand for e-bikes in rural e-commerce is influenced by the availability of financing options and infrastructure readiness, making comprehensive support and innovative solutions essential for widespread adoption.

5.3 Navigating Obstacles and Crafting Solutions

The major barriers to EV adoption in rural areas include financing challenges due to inadequate documentation, high upfront costs, limited access to affordable financing options, and a lack of tailored financial products for rural entrepreneurs. Economic constraints and funding issues are significant, compounded by limited infrastructure availability. Slow adoption rates often result from a lack of awareness and trust in new technologies, necessitating awareness programs to educate

people on the risks of DIY repairs and the benefits of demand aggregation for fleet services to reduce costs and build trust.

Technology and Infrastructure

Selecting EV models with fast charging capabilities and sufficient range for delivery services is essential while developing a robust recycling system for batteries and other EV components, which is necessary for sustainability. High-speed vehicles are preferred in rural areas to meet consumer expectations, and there is growing interest in funding solar-based charging infrastructure to support green mobility. Reliable, research-backed hardware from reputable brands ensures quality and sustainability, emphasizing avoiding unreliable OEMs.

Infrastructure challenges, such as power load availability, parking space, and compliance issues related to safety and fire hazards in older facilities, add to the complexity. Charging infrastructure challenges include finding suitable land and ensuring reliable electrical connections. Fast charging infrastructure is viable with sufficient vehicle concentration, while home and neighborhood chargers are also deployed. Supporting the development of charging infrastructure in these regions can help mitigate these challenges and promote widespread EV adoption.

Operational Challenges

Managing the higher upfront costs of EV rentals and ensuring an adequate supply to meet demand presents a significant challenge in the EV adoption landscape. Addressing safety and compliance issues related to charging infrastructure, particularly in older facilities, is crucial.

Fluctuations in payment capacity in rural areas necessitate timely EMI payments and financial literacy. Addressing challenges with leasing models and promoting vehicle ownership is important for sustainable adoption. Navigating government permissions and electrical infrastructure requirements can be complex, and ensuring profitability within a short timeframe, despite initial losses, is a common challenge. Infrastructure compliance issues, particularly safety and fire hazards, hinder expansion.

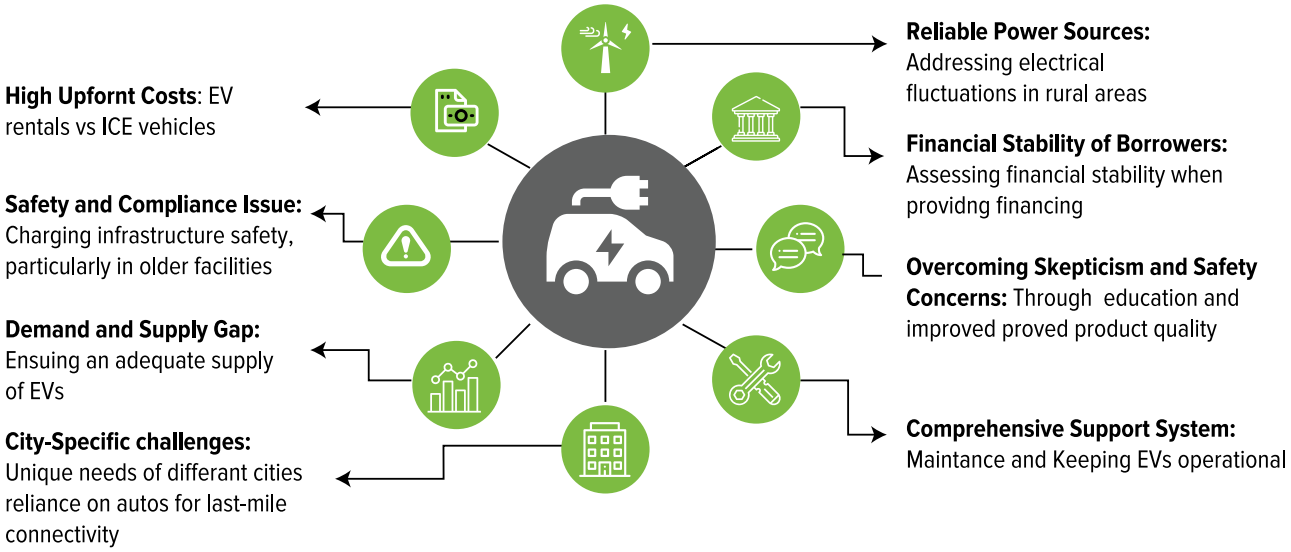

Figure 19 Barriers to EV adoption (author)

5.4 Strategic Directions for Future Growth

Economic Benefits

Significant economic benefits of e-bikes have been observed with substantial reductions in weekly fuel expenses highlighting their cost-effectiveness. Policies and incentives that lower the total cost of ownership are crucial for increasing EV adoption among rural communities. Delivery riders using EVs save significantly on operational costs compared to those using ICE vehicles. Additionally, hosts can earn extra income by installing charging points and setting competitive pricing based on location. Emphasizing financial education and flexible EMI payment concepts enhances productivity and financial inclusion, with incentives such as reduced EMI rates for vehicles driven by women further supporting adoption.

EVs offer lower maintenance costs and more stable operating expenses than ICE vehicles, making them financially beneficial in the long run. Campaigns and incentives, such as extended warranties and financing options, help promote EV adoption among gig workers. The cost savings provided by EVs create a significant difference for rural consumers, and shared EV models can increase farm productivity and offer rental income opportunities.

Financing terms for E2Ws purchases, including lower interest rates and flexible repayment schedules, make EVs more accessible, contributing to a more sustainable and inclusive economic landscape.

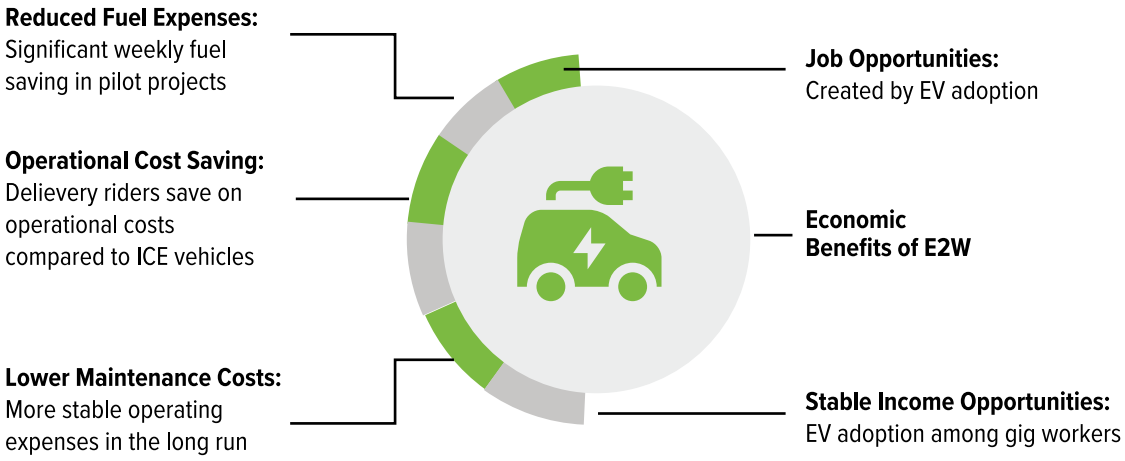

Figure 20: Economics benefits of E2W (author)

OEM Engagement

PPPs are vital for developing and maintaining E2Ws infrastructure, facilitating market entry, and addressing land and power availability challenges. Successful PPP models in developing charging infrastructure and operating buses highlight their importance. Collaboration with OEMs and utilities to bundle charging infrastructure with vehicles and partnerships with logistics companies to integrate charging solutions near hubs or dark stores is essential.

Partnering with two-wheeler manufacturers ensures quality and reliability, while logistics companies support drivers in onboarding and utilizing EVs for deliveries. Working with OEMs and EV partners ensures a reliable supply and maintenance of vehicles, and partnerships with OEMs create financing solutions to reduce the financial burden on gig workers.

Innovations in Charging Technology

Innovations in charging infrastructure are essential, that rural users can easily access. This includes the development of low-cost and easily deployable charging infrastructure. R&D investments are crucial for advancing charging technologies and infrastructure, with collaborations between technology companies and startups driving innovations in the EV sector. Interest in solar-based charging infrastructure for larger vehicles like e-rickshaws and cargo vehicles is growing, with collaborations with OEMs to develop fast-charging solutions and support swappable battery options being critical.

Technological advancements in EVs, such as improved dashboard features and better battery management systems, are necessary to enhance the user experience.

This approach ensures that EV infrastructure is accessible and efficient across different environments, facilitating widespread adoption and sustainable development.

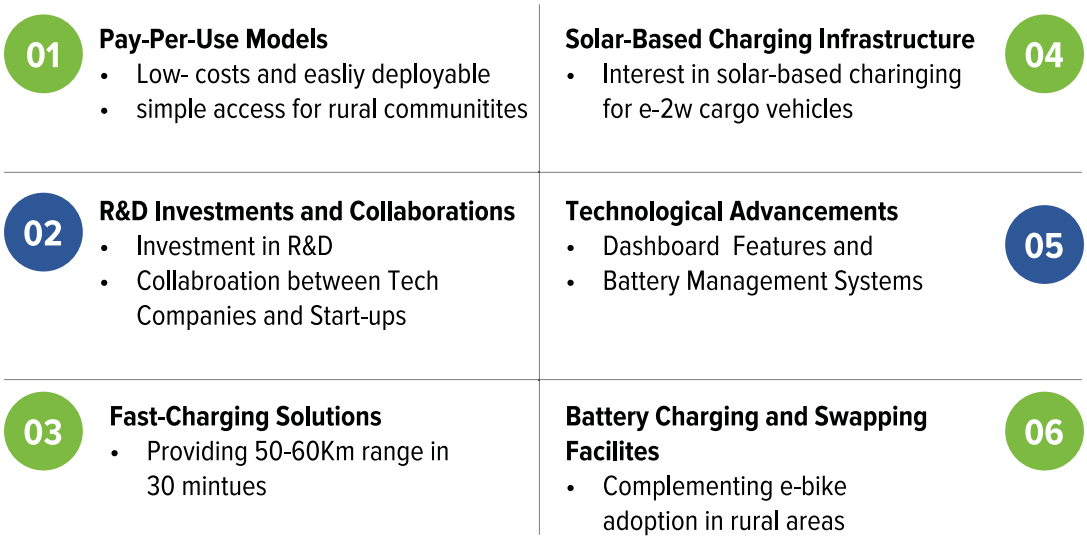

Figure 21: Innovations in Charging (author)

Future Opportunities

Developing a risk-sharing facility for EV financing can significantly enhance the scale of pilot projects, informing broader implementation and impact. Policies supporting recycling facilities and incentivizing companies to recycle batteries and products are crucial. Enhanced subsidies and incentives tailored for rural areas will promote the adoption of e-bikes and other EVs, expanding charging infrastructure and establishing maintenance and service centers in rural regions.

Developing scalable models for e-bike adoption in rural logistics and sharing insights to inform policymakers and engage stakeholders is vital. Innovative financing models, including microfinance, subsidies, grants, and leasing options, will support e-bike uptake in rural areas, creating a comprehensive approach to promoting sustainable EV adoption.

06

Introduction to Pilot

6.1 Background of the Pilot Project

The rapid growth of e-commerce in India has led to an increasing demand for efficient and sustainable last-mile delivery solutions, particularly in rural areas where logistical challenges persist. Recognizing the potential of E2Ws to address these challenges, this pilot project was initiated to assess the acceptability, feasibility, and viability of transitioning last-mile e-commerce deliveries to E2Ws in rural Telangana. It involves key investigations of financial and business models, vehicles and charging infrastructure required for the rural adoption of E2Ws. The project aims to evaluate operational efficiencies, cost and benefits, and environmental impacts of E2Ws while identifying key enablers and barriers to adoption for rural e-commerce deliveries and mechanisms for making it gender inclusive. The pilot is being conducted in **Sangareddy** and **Warangal**, selected based on factors such as the presence of pilot partners, regional e-commerce activity, and high E2W penetration.

Beyond assessing the operational feasibility of E2Ws, this pilot also aims to understand the socio-economic impact of electric mobility on delivery personnel and local businesses. Factors such as income generation, job satisfaction, and gender inclusion in last-mile delivery roles are being explored to evaluate how E2Ws can contribute to broader economic empowerment in rural areas and creating opportunities for green livelihoods. Moreover, the pilot will provide key policy insights regarding incentives, financing and business models, and infrastructure support required to scale E2W adoption. By documenting challenges, successes and lessons learned, this study will serve as a foundation for future interventions that promote sustainable and inclusive rural e-commerce logistics.

6.2 Pilot Design and Initiation

The design and initiation of the pilot were structured to ensure a systematic and efficient implementation of E2Ws in rural last-mile delivery. This phase involved identifying key partners, selecting suitable locations, defining stakeholder roles, and conducting initial consultations to align objectives and expectations. A critical aspect of this stage was understanding the local ecosystem, including the availability of e-commerce hubs, existing delivery networks, and infrastructure support for electric mobility. The pilot was launched with a collaborative approach, bringing together logistics providers, E2W deployment partners, training organizations, and

field teams to ensure a seamless transition for participating drivers. Through careful planning and structured engagement, this phase laid the foundation for effective execution, real-time learning, and data-driven insights that would shape the overall success and scalability of the initiative. The research and analysis and stakeholder consultations with industry experts from the Market and Policy Assessment also provided a landscape overview of E2Ws for rural e-commerce deliveries and provided a strong foundational understanding on which to develop the pilot study.

6.2.1 Identification of Potential Partners

A structured and multi-stage selection process was designed to identify suitable pilot partners capable of supporting the deployment of E2Ws for last-mile e-commerce deliveries in rural India. The objective was to onboard partners with strong operational capabilities, alignment with project goals, and readiness for rural deployment. The process involved an open call for applications, followed by multiple rounds of screening, including in-depth interviews, pilot strategy evaluations, and final assessments of feasibility. Potential partners were assessed based on criteria such as existing partnerships with e-commerce platforms, fleet capacity, financial viability, gender inclusivity, and operational readiness. This structured approach ensured that only the most suitable and capable organizations were selected to participate in the pilot.

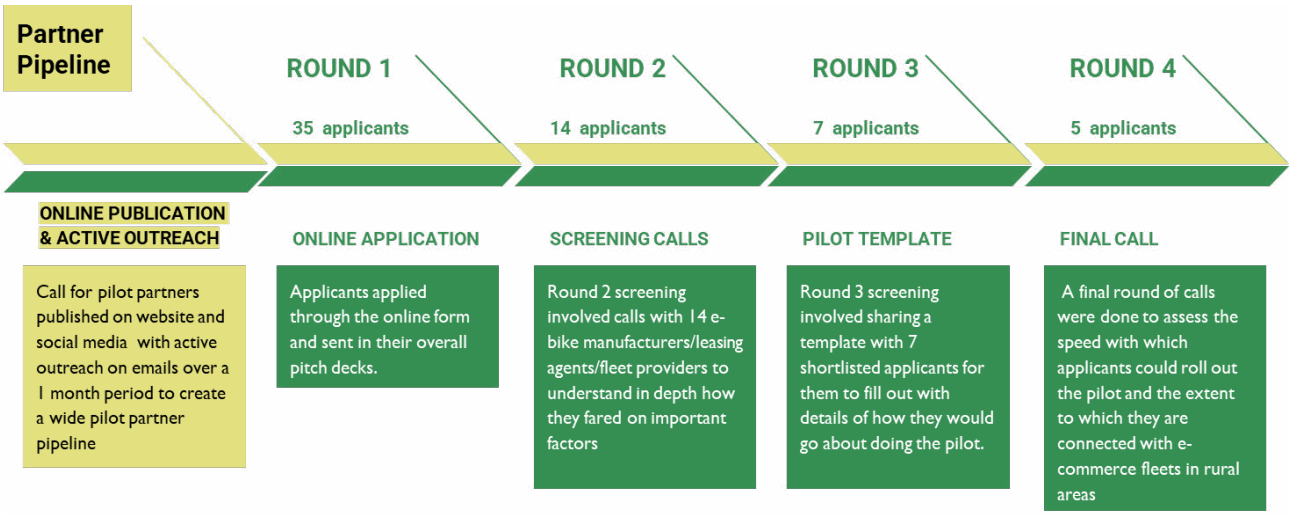

Figure 22: Overall Pilot Partner Selection Process

The partner selection process began with an open call for applications, which was publicized on the Villgro website and social media platforms. Additionally, targeted email outreach was conducted over a one-month period to ensure a diverse and competitive applicant pool. As a result, 35 applicants submitted online applications for participating in the pilot. These applicants included E2W leasing companies, fleet operators, EV manufacturers, and organizations focused on gender-inclusive mobility solutions. The first stage involved online applications, where applicants submitted their business models, fleet sizes, existing partnerships, and capacity to support rural last-mile deliveries. This stage helped shortlist organizations that demonstrated strong alignment with the pilot's objectives.

Following the initial application stage, a multi-round screening process was conducted to assess the shortlisted applicants in greater detail.

In Round 4, the final five shortlisted applicants underwent a last round of evaluation through detailed calls to assess their execution speed, logistical readiness, and existing connections with rural e-commerce delivery networks. The assessment also focused on financial feasibility, ensuring that the selected partners had sustainable business models that could support the long-term adoption of E2Ws in last-mile deliveries. Additionally, the ability of partners to address gender inclusivity in their operations was considered, with organizations like MOWO Social playing a key role in training and onboarding female drivers. By the end of this rigorous selection process, Hala Mobility was identified as the most suitable partner to lead the pilot due to its strong existing partnership with Flipkart, extensive E2W fleet, and collaboration with MOWO for gender-inclusive deployment.

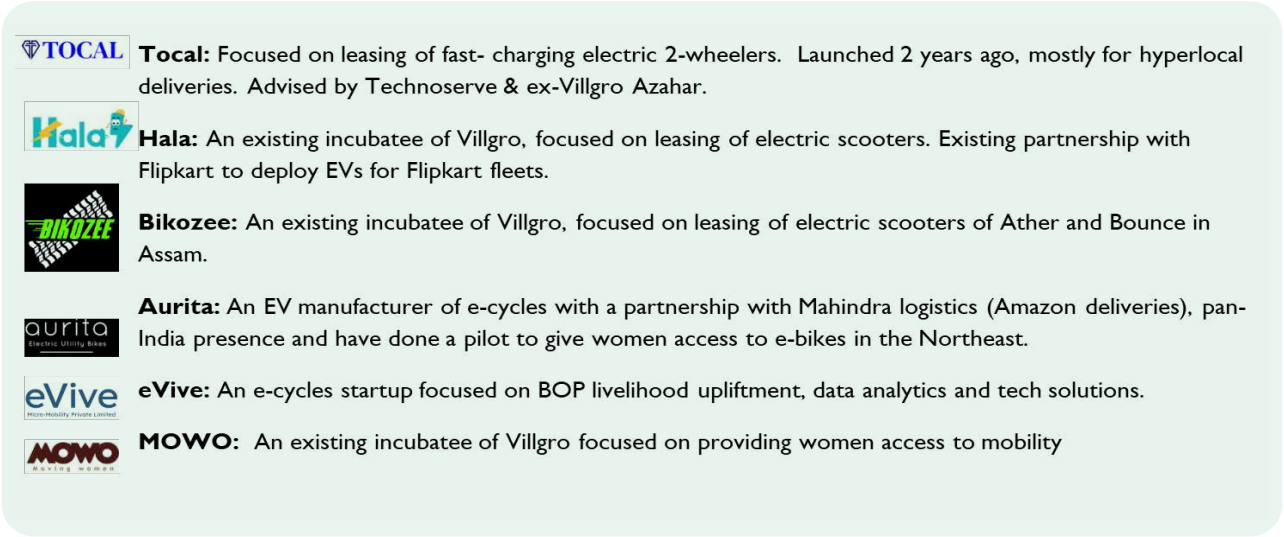

Figure 23: Top Applicants Overview

Hala Mobility is India's first multi-modal vehicle-sharing platform, offering E2Ws through app-based subscriptions to address last-mile connectivity issues; it operates in multiple cities across India. Their existing partnership with Flipkart ensured seamless integration with e-commerce logistics, reducing deployment risks. The feasibility of their proposed budget and their experience in rural markets further reinforced their suitability. In addition to Hala Mobility, the need also emerged to contract MOWO Social Initiatives Foundation as a gender inclusion partner. MOWO Social Initiatives Foundation is a not-for-profit social enterprise based in India that empowers women through motor training, aiming to create safe and reliable commute options 'For, and By Women'. The need to contract a gender inclusion partner was given the minimal representation of women in the existing e-commerce delivery workforce and additional barriers for women in rural areas to access these jobs added to the inability of e-bike and e-commerce companies to address the gender issue. MOWO was considered the best gender inclusion partner being the only organization in the country that trains women to drive electric vehicles and has trained 3,000 women over the last 4 years.

Given these factors, the pilot was designed to roll out in a staggered manner, starting with 20 vehicles across two rural locations, with half of them allocated to female drivers trained by MOWO and the other half to male delivery agents working in the Flipkart fleets that Hala Mobility is connected to. This structured approach ensured that the pilot was not only operationally viable but also contributed to long-term sustainability and inclusivity in rural last-mile delivery.

6.2.2 Roles and Responsibilities of Stakeholders

The successful execution of the pilot required collaboration among multiple stakeholders, each playing a crucial role in different aspects of the project. Villgro served as the project lead, overseeing and managing all components of the pilot to ensure its smooth implementation. Their responsibilities included onboarding partners, setting project timelines, organizing key events, and ensuring alignment between all stakeholders. Villgro also played a central role in strategic decision-making, ensuring that the project adhered to its goals of testing the viability and acceptability of E2Ws in rural last-mile logistics. By working closely with all partners, Villgro ensured that data collection, implementation, and feedback mechanisms were well-coordinated and effectively executed.

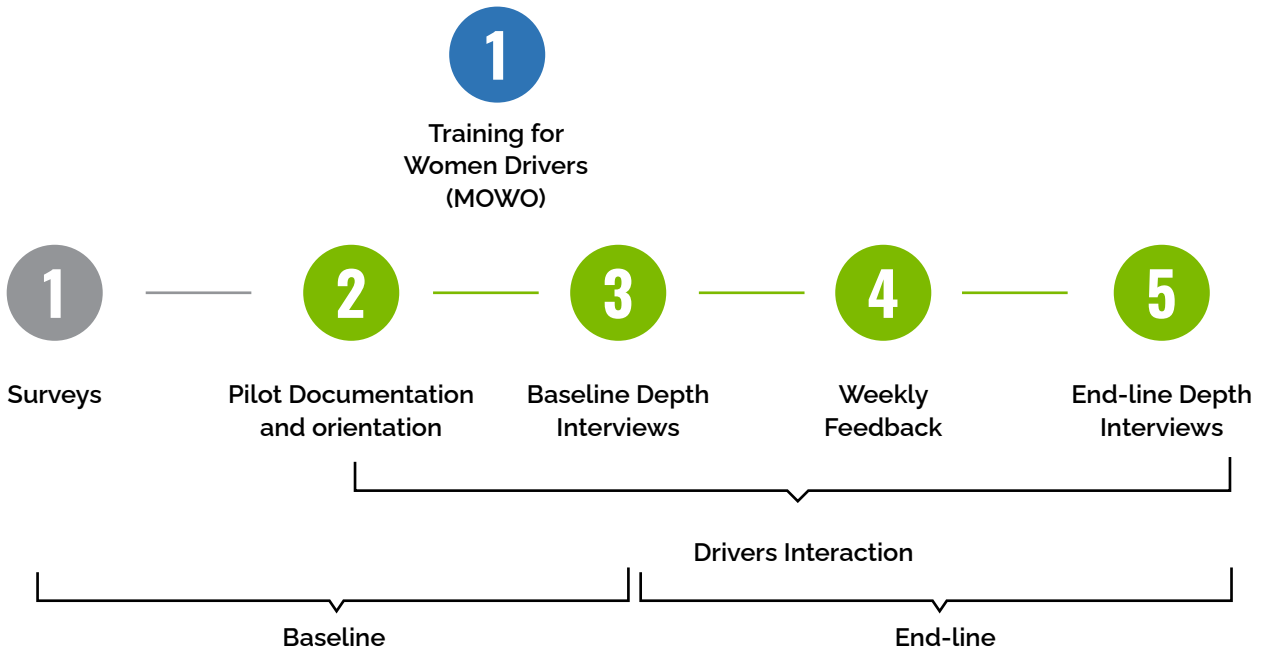

Figure 24: Overall Flow of the Pilot

Alliance for an Energy Efficient Economy (AEEE) served as the technical research partner, providing critical expertise in survey design, data collection, and policy analysis. AEEE was responsible for developing and implementing the data collection framework, ensuring that the pilot generated robust, evidence-based insights on the feasibility of E2Ws in rural last-mile delivery. Their role included conducting market and policy assessments, structuring baseline and endline interviews, and managing the data repository and refinement process. Additionally, AEEE led the impact assessment by analyzing the collected data to identify key trends, challenges, and success factors. Their findings were instrumental in shaping recommendations for scaling the project and informing future policy interventions to support rural electrification in logistics.

Hala Mobility was onboarded as the mobility partner, responsible for providing E2Ws to the drivers and ensuring their smooth operation throughout the pilot. Their role extended beyond just vehicle deployment—they were actively involved in vehicle maintenance, troubleshooting technical issues, and assisting drivers in resolving any operational challenges related to the E2Ws. Hala also played a crucial role in coordinating with Flipkart, ensuring that drivers were integrated into e-commerce delivery networks and had consistent delivery assignments. Additionally, they were the primary on-ground support for the drivers, maintaining direct communication with them, collecting weekly feedback, and facilitating online interviews.

MOWO was engaged as the training and gender inclusion partner, playing a key role in facilitating the participation of women drivers in Warangal. Their primary responsibility was to train female drivers in handling E2Ws, ensuring they were comfortable and confident in navigating last-mile delivery operations. MOWO's involvement extended beyond initial training—they maintained regular contact with the women drivers, providing ongoing mentorship, technical support, and troubleshooting assistance throughout the pilot. They were also responsible for training women for their driving tests and supporting them to obtain driving licenses. Additionally, they helped in collecting training-related data, capturing insights into the challenges faced by women during their transition into delivery roles, their adaptation process, and overall feedback on the experience. MOWO also contributed to the weekly and online feedback mechanisms, ensuring that gender-specific challenges and perspectives were well-documented and addressed. Their expertise in women's mobility and workforce integration made them a crucial stakeholder in ensuring that the pilot was not only operationally successful but also inclusive and empowering for female drivers.

6.3 Overall Data Collection Methodology

The pilot project employs a multi-faceted methodological approach to assess the viability of E2Ws in last-mile e-commerce deliveries across rural Telangana. A combination of qualitative and quantitative research methods has been utilized to capture diverse stakeholder perspectives, operational performance, and socio-economic impacts. The methodology is structured into key phases, including baseline assessments, continuous monitoring, and an endline evaluation, ensuring a comprehensive understanding of both the operational challenges and the benefits of E2W adoption. By integrating field observations, interview data, and weekly feedback interviews, the study provides actionable insights for scaling sustainable delivery solutions in rural markets.

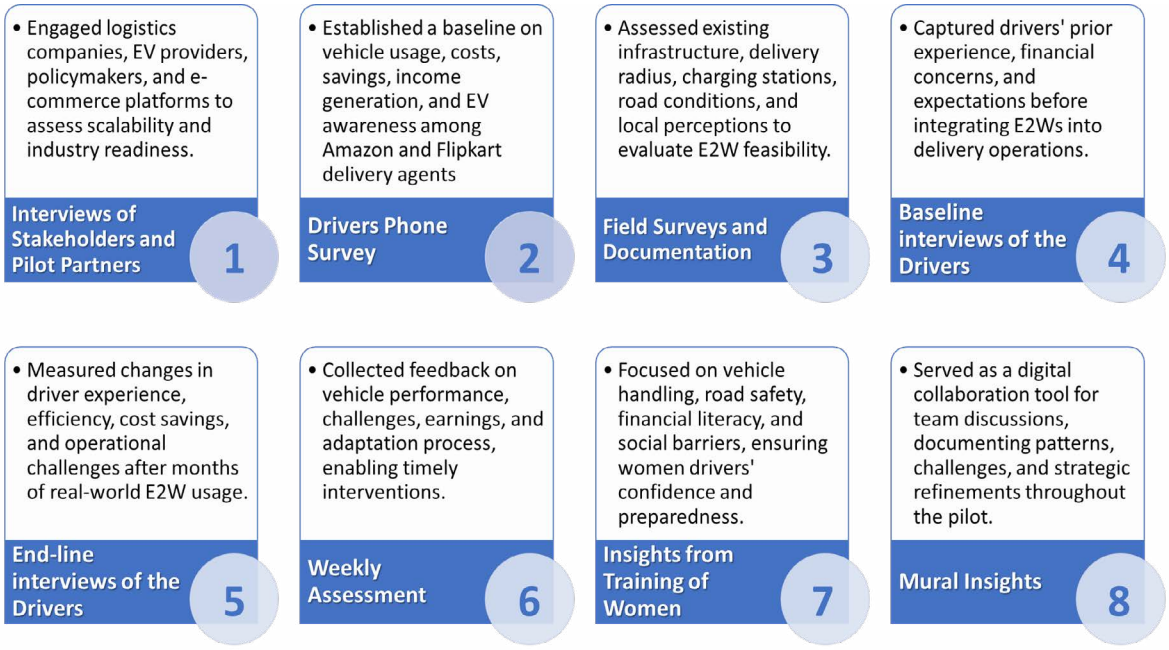

Figure 25: Data collection Tools used for the pilot

Interviews of Stakeholders and Pilot Partners

In addition to gathering insights from drivers, the pilot incorporated structured interviews with key stakeholders and partner organizations to understand their perspectives on the feasibility and scalability of E2Ws in last-mile logistics. These interviews included hub managers from Flipkart, who provided insights into operational efficiency, delivery performance, and logistical challenges faced when integrating E2Ws into existing supply chains. They also provided insights into recruitment requirements, process and career trajectories for e-commerce delivery jobs. Representatives from Hala Mobility, shared their experiences regarding vehicle performance, maintenance issues, charging infrastructure gaps, and driver feedback on usability. Similarly, trainers and representatives from MOWO, offered reflections on the impact of skill-building programs, social barriers faced by women drivers, and recommendations for improving the onboarding process for female delivery agents. These discussions were critical in identifying key enablers and challenges from the perspective of organizations responsible for execution and support.

Beyond direct implementation partners, interviews were also conducted with other logistics and e-commerce stakeholders, including representatives from Zepto, Instamart, and local delivery aggregators, to assess their willingness to onboard E2Ws into their fleets. Their feedback provided insights into operational expectations, delivery time efficiency, and cost considerations when compared to conventional ICE two-wheelers.

Drivers Phone Surveys

The driver survey form was designed to gather comprehensive data on vehicle usage, operational costs, income generation, and EV awareness among delivery agents working with Amazon and Flipkart, including those beyond the direct beneficiaries of the project. The survey aimed to establish a baseline understanding of how delivery partners manage fuel expenses, vehicle maintenance, and overall earnings, while also capturing their perceptions of E2Ws as a viable alternative. Structured with both quantitative and qualitative questions, the form included sections on current vehicle ownership, daily travel distances, fuel costs, and willingness to transition to EVs, ensuring a well-rounded analysis of existing challenges and opportunities in last-mile logistics.

Additionally, questions explored drivers' awareness of EV incentives, concerns around charging infrastructure, and financial feasibility of leasing or owning an E2W. By capturing data from a diverse set of delivery agents, the survey provided valuable insights into market readiness, behavioral trends, and necessary policy interventions to drive EV adoption in the sector.

Field Surveys and Documentation

Field interviews were conducted in both Sangareddy and Warangal to assess the existing infrastructure and viability of E2Ws for last-mile delivery operations. These interviews focused on mapping the delivery radius based on e-commerce hub locations to understand how far delivery agents typically traveled and whether E2Ws could efficiently cover these distances on a single charge. Additionally, the availability of charging infrastructure—including public and private charging stations, home charging feasibility, and the presence of backup charging options—was documented. Furthermore, the road conditions—such as the quality of paved roads, presence of potholes, and accessibility in different weather conditions—were evaluated to determine how they might impact the performance and durability of E2Ws in daily operations.

(a) *(b)*

Figure 26: Field surveys to understand the infrastructure around the Pilot locations (a) Parking of the bikes of delivery person, (b) condition of road infrastructure around the hub

Beyond infrastructure assessment, the field interviews also examined the cost and reliability of electricity supply in both locations, as uninterrupted access to affordable electricity is crucial for scaling E2W adoption. Factors such as power outages, voltage fluctuations, and the cost per unit of electricity were documented to evaluate the feasibility of regular charging. Additionally, the existing government subsidies in Telangana, such as free electricity up to 200 units, were considered to assess their potential impact on reducing charging costs for delivery agents using E2Ws. Another critical aspect was parking and storage facilities for E2Ws, particularly in areas where delivery agents might need safe and accessible locations to charge or park their vehicles between shifts. Delivery hubs were also reviewed to assess their existing electricity and charging infrastructure and potential for the installation of charging infrastructure required for E2Ws.

Lastly, local perceptions and acceptance of E2Ws were observed, including conversations with shop owners, logistics partners, Flipkart hub managers and end customers to gauge overall sentiment toward electric mobility. These insights helped create a more holistic understanding of the operational landscape and informed recommendations for infrastructure improvements necessary for wider E2W adoption in rural last-mile logistics.

Figure 27 (a): Flipkart hub, Sangareddy

Figure 28 (b): Flipkart hub, Warangal

Baseline Interviews of the Drivers

As part of the monitoring framework, baseline interviews were conducted with all drivers selected for the pilot to understand their mobility needs, experiences with and perceptions of their existing ICE vehicles, and expectations from the shift to electric mobility. Given the differences in demographic composition and employment background across the two pilot locations, the baseline assessments were tailored accordingly. In **Sangareddy**, all participating drivers were male and had prior experience working as delivery partners with Flipkart, with a minimum of four months on the job. In contrast, the **Warangal** cohort consisted entirely of female beneficiaries, most of whom had no previous experience in e-commerce deliveries and majority of whom were both new to driving and employment. Only one female beneficiary had worked in last-mile logistics before, necessitating additional training and onboarding support for the rest of the group.

The baseline interviews aimed to capture key insights into the drivers' initial perceptions, challenges, and expectations regarding E2Ws, as well as, their socio-economic contexts, aspirations, vehicle ownership and usage and technology usage and savviness. In Sangareddy, where male drivers were already accustomed to last-mile delivery, the focus was on understanding their prior experience with ICE two-wheelers and its associated operational costs and delivery efficiency, and anticipated impact on daily earnings. Questions also explored their employer and policy support and perspectives on gender inclusion in logistics deliveries. Meanwhile, in Warangal, the baseline interviews were designed to assess the women beneficiaries' occupational patterns and economic access, mobility needs and access and the challenges they faced in learning how to drive and adapting to delivery work. Given that most of them were new to this sector, the discussions also covered aspects of financial independence, safety concerns, and social acceptance of women in last-mile logistics. These interviews provided valuable qualitative insights that informed the training programs and support mechanisms tailored for each group.

	A	B
1		Sai Kiran
2	1. Background Information:	
3	• Personal Details:	
4	○ To start, could you tell me a bit about yourself?	
5	■ Could you tell me what your name is and how old you are? If you had to choose 1 vehicle to represent yourself, what would you choose and why?	Sai kiran 23 years Prefers scooters
6	■ Please can you share 2 adjectives for the following-	
7	• "How I see myself" … why do you see yourself like this?	
8	• "How my family sees me"…Moderator to probe…why does your family see you like this?	
9	• "How my friends see me"… …Moderator to probe… why do your friends see you like this?	
10	• "How my colleagues see me"… …Moderator to probe… why do your colleagues see you like this?	
11	■ Which village, district, and state do you belong to? Did you grow up here? What was your life like growing up? What jobs did your parents do?	Sangaredy, from narsapur, working in sangareddy Family is from farming background
12	■ Share a bit about your educational background… What class have you studied up to? What subjects did you study/ specialize in? In your childhood, what did you want to be when you grew up and why? Were you able to pursue this and why?	Completed school till 12th
13	■ What are the proudest achievements of your life and why? What have been the most difficult challenges you have had to overcome in your life and how did you overcome these?	
14	○ Let's talk about life now…	
15	■ Are you married? Do you have children?	No
16	■ Are there any other people living in your household? Who are they…tell me about them…If each member of your family was someone in a school- who would they be and why… who would be the principal, vice principal, teacher, students?	4 people, parents (only motherand sister
17	○ How about aspirations and concerns for the future-	
18	■ What personal goals do you have for yourself? And what about dreams for your children? What steps are you taking to	

Figure 29: Example of filled Baseline interview form

Endline Interviews of Drivers

The endline interviews were conducted at the conclusion of the pilot to evaluate the overall impact of E2Ws on last-mile delivery operations and conduct a comparative evaluation between E2Ws and ICE vehicles for the male participants as well as develop an understanding of their ability to provide socio-economic empowerment to female participants. These interviews aimed to capture key changes in driver experiences, operational efficiency, and perceptions toward electric mobility after months of real-world usage. Additionally, the endline assessments sought to identify any unforeseen operational constraints and policy recommendations that could support the broader adoption of E2Ws in similar contexts.

In Sangareddy, the interviews focused on comparing their operational efficiency and earnings and savings before and after using E2Ws. Key areas of assessment included vehicle performance, charging convenience, cost savings on fuel, and any technical or logistical challenges they faced during deliveries. In Warangal, where female participants were new to working in e-commerce deliveries, the interviews explored the socio-economic impact of learning how to drive, having access to an e-bike and jobs as e-commerce delivery agents on their lives and associated needs, enablers, barriers and gaps in the ecosystem to support them in these transitions. Additionally, responses from both locations helped assess whether the adoption of E2Ws influenced job satisfaction, and a long-term willingness to continue using electric vehicles in delivery operations.

Weekly Assessment

To track the evolving experiences of drivers using E2Ws for last-mile deliveries, a weekly assessment framework was implemented. Hala Mobility, conducted weekly customer service check-in calls with participants, which were used to fill out the assessment documents. Additionally, Hala Mobility carried out bi-monthly service visits, during which they photographed and documented reported problems while addressing vehicle-related concerns. These visits played a crucial role in tracking real-time issues, ensuring proactive servicing, and improving the overall user experience of E2Ws in rural last-mile logistics. The assessment also encouraged drivers to record any grievances, such as issues related to battery life, charging availability, vehicle handling, or breakdown incidents.

Date of entry- 30/11/24	Name of the drivers	Erra Sai Kiran	Nalla Aravind	Mohammed khadeer	Mohammed Khaja Pasha	Gade Madhu Madhu	A venkatesh
Main Question	Questions	7993119925	9951811947	8008629943	9676362604	7095153583 / 7981715514	8928165958
1 Overall comfort and ease of use with e-bikes/			it takes 5-10 per order.		HE TAKES 10-15 MIN PER ORD	TIME TAKEN BASED ON DISTA	Each order 20-25min t
a)	Rate from 1-5-	No responding to calls	4	No responding to calls	5	5	4
b)	Why this rating-		easy to use		Smooth RIDING	LOW OF COST	smooth ride
2 Number of times E-bikes are needed to be			1-TIME CHARGE IN ADAY		2 time a day	1-TIME IN ADAY	1-time charge
a)	Rate from 1-5-		5		5	5	4
b)	Why this rating-		low electricity consumption		fast charging and low power consur	TIME CHARGE GIVES FULLDAY	low maintenance
3 Do you fully charge your bike every time? if not			he fully charge vehicle everytime		he chargers full	YES , HE FULLY CHARGE	full charge at night
a)	Rate from 1-5-		4		5	5	5
b)	Why this rating-		it takes less time to charge		GOOD MILAGE	GOOD MILAGE	ss power consumptio
4 Problem/ challenges of e-bikes (in case of any			no issue		no issue	NO ISSUES	no issues
a)	Rate from 1-5-		5		5	5	5
b)	Why this rating-		free service		FREE SERVICE	FREE SERVICE	free service
5 Any addditional cost with e-bikes (Electricity,			he dont have anyidea of it		he didn't calculated the power comsu	The CM of Telangana has ann	no idea
a)	Rate from 1-5-						
b)	Why this rating-						

Figure 30: Sample of filled weekly feedback form

To ensure continuous improvement, this feedback was periodically reviewed by the project research team and pilot partners, enabling real-time interventions such as vehicle maintenance support, additional training, or infrastructure recommendations. The structured approach of weekly assessments ensured that ongoing challenges were promptly addressed while also generating valuable data for long-term feasibility analysis.

6.4 Selection Criteria for Locations

The selection of pilot locations was a critical step in ensuring the feasibility and success of integrating E2Ws into rural last-mile e-commerce delivery. The process was guided by a market and policy assessment of E2W adoption trends across India, as well as the presence of suitable pilot partners capable of executing the initiative effectively. The study aimed to focus on Tier-3 and Tier-4 towns, where there is both a high frequency of e-commerce deliveries and growing awareness and adoption of electric mobility. Based on secondary research and stakeholder consultations, key selection factors included the density of e-commerce traffic, regional infrastructure for EVs, and the penetration of E2Ws in the local transportation ecosystem. By prioritizing areas where digital commerce and sustainable mobility intersect, the pilot sought to assess the real-world viability of E2Ws in rural logistics while identifying opportunities for scaling this model in similar locations.

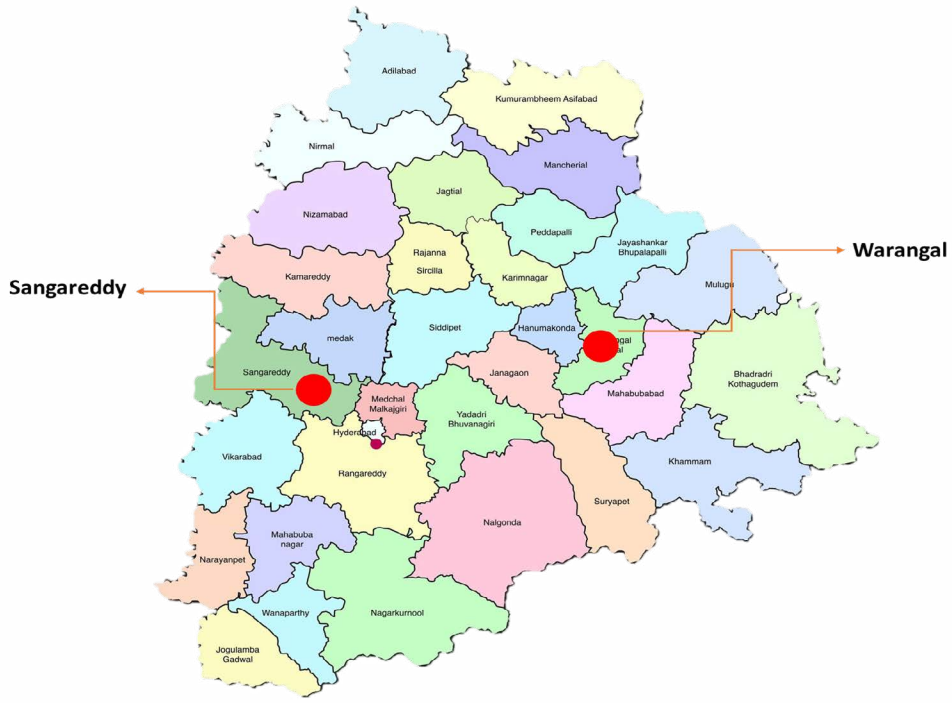

Figure 31: Selected Pilot Locations

While several states, including Maharashtra, Karnataka, Tamil Nadu, and the Northeast region, emerged as strong contenders for the pilot due to their high e-commerce activity and growing E2W penetration, Telangana was ultimately selected. The final decision was largely driven by the existing networks and operational experience of the selected pilot partners in the region. Hala Mobility, already had established operations in Telangana and a working relationship with Flipkart, ensuring a smooth integration of E2Ws into last-mile delivery networks. Additionally, MOWO, had prior experience working with women drivers in Telangana, making the state an ideal choice for implementing the gender-inclusive component of the pilot. By selecting a region where partners had local knowledge, logistical experience, and strong industry connections, the pilot could be executed more efficiently while ensuring greater stakeholder engagement.

Once Telangana was identified as the preferred state, the next step was to determine specific rural locations based on high consumer demand for e-commerce deliveries, as this directly influences

Flipkart's recruitment of delivery agents in different areas on a weekly basis. Sangareddy and Warangal were selected as pilot sites, ensuring that male delivery agents could be assigned to the project while also creating new job opportunities for female participants. Sangareddy, located near Hyderabad, had an existing Flipkart hub and a strong network of experienced male delivery drivers, making it an ideal testbed for assessing the transition from fuel-based two-wheelers to E2Ws. Meanwhile, Warangal was chosen for its potential in gender-inclusive mobility, with MOWO supporting the training and onboarding of female delivery agents, creating a pathway for women to enter last-mile logistics. These locations provided a diverse operational landscape, allowing the study to evaluate both experienced and new delivery personnel, while also assessing gender-specific challenges, infrastructural readiness, and the overall feasibility of E2W adoption in rural last-mile logistics.

07

Pilot Implementation

With the pilot design and partner selection finalized, the next phase focused on the on-ground execution of the initiative. The pilot implementation involved the deployment of E2Ws in Sangareddy and Warangal, onboarding and training delivery drivers, and establishing a structured framework for data collection and monitoring. This stage required close coordination between stakeholders, including Villgro, Hala Mobility, MOWO, and AEEE, to ensure seamless execution. Key aspects of the implementation included vehicle allocation, driver engagement, capacity-building initiatives, and troubleshooting operational challenges. Additionally, weekly feedback mechanisms and continuous monitoring were integrated into the process to capture real-time experiences and insights from both drivers and logistics partners. This phase was crucial in validating the feasibility of E2Ws in rural last-mile e-commerce delivery while identifying key learnings for future scalability.

7.1 E-bike Allocation and Target Group

A critical component of the pilot implementation was the allocation of E2Ws to the selected delivery drivers and defining the target group for the study. The deployment strategy was designed to ensure a balanced representation of drivers across different demographics and experience levels, allowing the study to capture varied operational insights. A total of 20 E2Ws were distributed across the two pilot locations—Sangareddy and Warangal—with a structured approach that considered driver experience, gender inclusivity, and logistical feasibility. In Sangareddy, all participating drivers were male and had prior experience in last-mile e-commerce deliveries, whereas in Warangal, the pilot focused on women drivers, many of whom were new to the delivery sector, driving and even formal employment.

Sangareddy

The male delivery drivers in Sangareddy come from diverse socio-economic backgrounds, with ages ranging from 21 to 27 years. Most of them are married, except for the youngest driver, and they belong to joint or nuclear family setups, with household sizes varying between four to six members. Their educational backgrounds vary, with some holding diplomas or vocational training (ITI), while others have college degrees or have dropped out due to financial constraints.

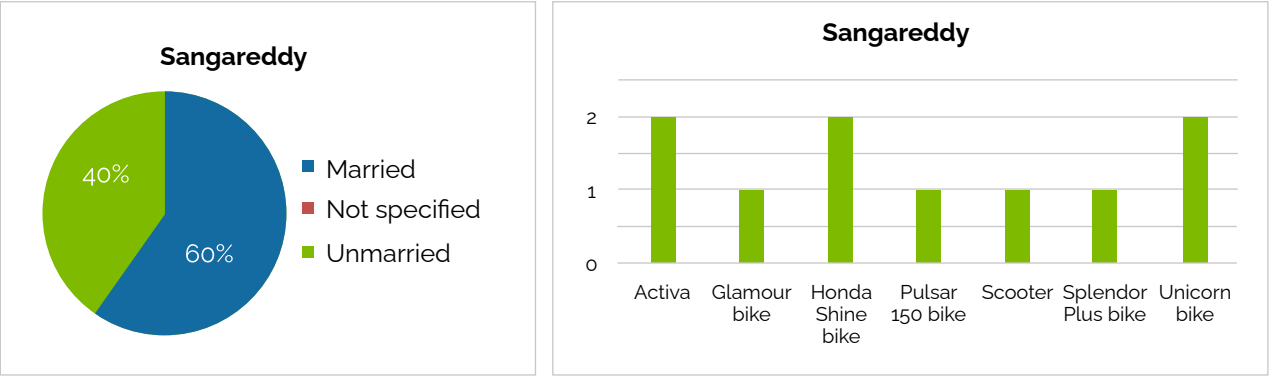

Figure 32: (a) Marital Status of drivers at Sangareddy, (b) Bike models used by the drivers

Their family income ranges from ₹50,000 to ₹1,00,000 per month, with the drivers contributing significantly to their households, and the majority of them being the primary income earners for their families. Some families have additional sources of income from agriculture, small businesses, or salaried employment. Despite financial stability in some cases, many drivers are responsible for supporting elderly parents, siblings, or extended family members, making income security a key concern.

Figure 33: E-bikes allocation at Sangareddy

Most drivers reside in nearby villages such as Nizampur, Kotharedipally, Chandapur, and Zahirabad, commuting daily for their work. Many have been in the delivery sector for several months to years, holding jobs at Flipkart. Their working hours are long, typically exceeding 10 hours per day, and they travel between 40-60 km daily for deliveries. In terms of financial commitments, some drivers are paying off loans or EMIs on their vehicles, while others rely on self-financed or second-hand bikes. Their monthly expenditure on fuel and maintenance ranges between ₹3,000 and ₹5,000, adding to their financial burden. While most drivers manage to balance work and family responsibilities, a few aspire to transition into different careers, such as government jobs or starting their own businesses.

Figure 34: E-bikes allocation at Warangal

Warangal

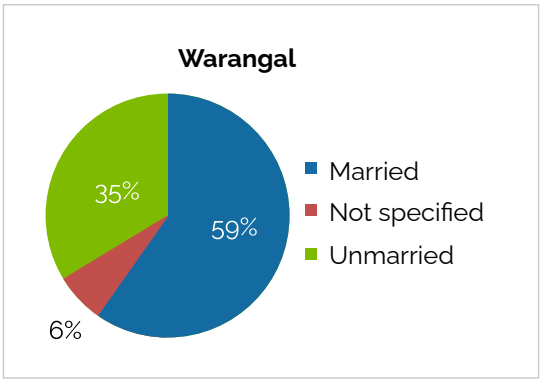

Figure 35: Marital Status

The women drivers participating in the Warangal pilot come from diverse age groups, ranging from 18 to 35 years old, and have varying marital statuses, with some being unmarried and others married for over a decade with children. Most of them come from lower to middle-income backgrounds, with family incomes ranging between ₹10,000 and ₹30,000 per month. Their household sizes vary from three to six members, and many have financial responsibilities, either supporting their families or contributing to household income. Several of them come from agricultural or daily wage labor backgrounds, while others have experience in part-time jobs, self-help groups, or teaching. Educational qualifications also differ, with some holding bachelor's degrees or diplomas, while others completed 10th or 12th grade but had to drop out due to financial constraints or marriage. Many of these women had not previously worked full-time outside their homes, making the delivery pilot their first exposure to structured employment.

Most of the women do not own personal vehicles and have relied on public transport or family-owned bikes for mobility. A few have experience riding two-wheelers, but many are first-time learners, requiring additional training in vehicle handling and navigation. Household responsibilities remain a significant part of their daily routines, with several women balancing caregiving, childcare, and domestic duties alongside their employment aspirations. Despite facing financial struggles, societal expectations, and limited previous work experience, many women in the program see this opportunity as a pathway to financial independence and empowerment. Support from family, particularly husbands and in-laws, varies—some families are encouraging, while others have concerns about safety and societal perceptions. Overall, these women represent a pioneering shift towards gender inclusion in rural last-mile e-commerce logistics, navigating both economic necessity and social change through their participation in the pilot.

The allocation of E2Ws and the selection of delivery agents in both Sangareddy and Warangal provided a unique opportunity to assess diverse user experiences in rural last-mile e-commerce logistics. While male drivers in Sangareddy brought prior industry experience and were able to quickly integrate E2Ws into their delivery routines, the women drivers in Warangal represented a new entrant segment, requiring additional training and support to navigate both technical and societal challenges.

Location	Warangal (General)	Sangareddy (Delivery Partners)
Median Age	29	24
Employment	Mixed (unemployed/low wage)	Stable delivery roles
EV Adoption	Moderate awareness	High openness but infrastructure gaps

7.2 Capacity Building and Training Conducted

In Warangal, where the pilot exclusively engaged female drivers, a structured training program was conducted in collaboration with MOWO Social Initiatives Foundation to equip women with the necessary skills for last-mile delivery operations. This initiative aimed to document the training process, capturing the challenges faced by women as they transitioned into a traditionally male-dominated sector.

The training covered essential aspects such as vehicle handling, road safety, navigation, and basic troubleshooting of E2Ws. The program followed a structured, step-by-step approach, beginning with basic riding skills, followed by progressive practice sessions to help women develop balance, control, and road awareness. Early sessions involved theoretical instruction through classroom-based learning on traffic regulations and road safety, ensuring that participants understood the rules and responsibilities of operating a vehicle. Trainers also emphasized the importance of safety gear, including helmets and gloves, to promote safe riding habits from the outset.

The training also highlighted infrastructure barriers, such as the availability of safe charging stations and designated rest areas for women drivers, which became key considerations for long-term policy recommendations.

(a) *(b)*

Figure 36: (a) Trainer explaining to the driver about balancing the vehicle, (b) Vehicle onboarding

Beyond riding skills, the training program focused on digital literacy and communication skills, essential for last-mile delivery operations. Many women, particularly those above 30 years of

age, had limited smartphone usage experience, as devices were often used by their husbands or children. To bridge this gap, they were trained on using Google Maps for navigation, handling delivery apps, and responding to customer messages via WhatsApp. Additionally, trainers emphasized the importance of maintaining a professional approach in customer interactions, helping participants develop confidence in handling deliveries independently.

(a) *(b)*

Figure 37: (a) Motivational session to the participants, (b) The hub manager clearing the doubts that women are having regarding job, timing, shifts

The final phase of training involved exposure visits and onboarding processes to integrate the women into actual delivery operations. A Flipkart hub visit was organized to familiarize trainees with the e-commerce delivery workflow, including package handling, shift schedules, and job expectations. Women had the opportunity to interact with hub managers, clarify doubts about their roles, and understand the logistics of order fulfillment. Following this, the Hala Mobility onboarding process took place, where participants received their electric two-wheelers, safety gear, and first-aid kits, ensuring they were fully equipped for their new roles. Sports shoes were also provided to enhance safety and comfort, ensuring a better grip and stability while riding the e-bikes. The onboarding also included KYC verification and registration with Swiggy Instamart, officially marking their entry into the workforce. Despite the initial struggles with confidence and mobility, the training program successfully transformed participants into independent delivery agents, providing them with the skills, knowledge, and motivation to navigate last-mile e-commerce logistics with electric mobility solutions.

08

Baseline, Weekly and Endline Assessment

8.1 Baseline Assessment

Subjective understanding and perception of users towards E-bikes

Sangareddy

The male delivery drivers in Sangareddy had prior experience in last-mile logistics, making their perception of electric E2Ws largely influenced by their existing knowledge of fuel-based vehicles and delivery operations. Most drivers were aware of E2Ws, having either seen, test-driven, or known people using them. They recognized potential cost savings associated with E2Ws, particularly in terms of lower fuel and maintenance expenses compared to conventional motorcycles. However, a key concern raised by many was range anxiety, as their daily travel distances ranged between 40 to 60 kmK. The drivers feared that charging constraints and the lack of adequate charging infrastructure could impact their delivery efficiency. Additionally, since they were accustomed to petrol bikes, which offer instant refueling, the idea of having to plan charging sessions was perceived as a major operational inconvenience.

(a) *(b)*

Figure 38: (a) and (b) Baseline interviews of Drivers at Sangareddy

Another significant concern among Sangareddy drivers was the financial feasibility of switching to E2Ws, particularly in relation to leasing costs and long-term profitability. While many acknowledged that E2Ws have lower operational expenses due to reduced fuel and maintenance costs, they were hesitant about the ₹5,000 monthly Hala E2Ws lease model, as it did not provide them with ownership of the vehicle. Several drivers expressed that they were comfortable paying up to ₹2,500 per month, but beyond that, they felt the lease fee cut too deeply into their earnings. This perspective was shaped by their previous experience with ICE vehicles, where they owned their motorcycles outright and primarily incurred costs for fuel and maintenance. Most drivers had been using motorcycles such as Honda Shine, Suzuki Access, and Hero Splendor, which they either purchased through EMI plans or owned outright after an initial down payment. Their average monthly expenditure on fuel and maintenance was approximately ₹3,500 per month, a cost they were comfortable managing because it was spread across fuel payments rather than a single fixed lease and because they had eventual ownership of the vehicle.

In contrast, the Hala E2Ws were leased scooters rather than motorcycles, and while they offered savings on fuel (charging costs between ₹100-₹500 per month) and free maintenance under the lease model, the high monthly rental cost of ₹3,500–₹5,000 without ownership made them financially less attractive to drivers in the long run. Drivers perceived that spending ₹3,500 or more on leasing an E2W with no ownership benefit did not justify the transition, especially when they could continue using their existing ICE vehicles at similar costs but with the advantage of ownership. Unlike in urban settings, where gig workers often take leased vehicles as a short-term arrangement, these rural drivers viewed vehicle ownership as a long-term asset, making them reluctant to continuously pay for a vehicle they would never own. Additionally, concerns about battery degradation over time and the cost of replacement further influenced their perception of E2Ws as a potentially risky financial commitment.

Beyond financial considerations, the performance of E2Ws for last-mile delivery logistics were key factors influencing drivers' perceptions. Many drivers were concerned about whether E2Ws could handle heavy parcel loads, as their current petrol bikes regularly carried packages weighing between 10 to 30 kg. They also questioned the durability of E2Ws on uneven rural roads, fearing that suspension and battery performance might deteriorate faster than conventional two-wheelers. Additionally, some drivers expressed skepticism about EV speed and acceleration, with a perception that E2Ws might not be able to keep up with their fast-paced delivery schedules. However, despite these concerns, a few drivers were open to switching to E2Ws if proper infrastructure and financial incentives were in place, such as affordable financing options, increased charging stations, and gradual lease-to-own models. This highlights that while operational challenges and financial hesitations exist, there is potential for adoption if structured support mechanisms are introduced.

Warangal

For female drivers in Warangal, the pilot aimed to assess whether access to an EV could provide better socio-economic opportunities, beyond just income gains. Many women had prior experience in agricultural labor, tailoring, domestic work, and retail, with earnings varying based on job stability and immediate cash flow needs. Some left the pilot early to return to agricultural work, as it provided quicker earnings, while e-commerce delivery required training before income stabilized. Beyond finances, social factors played a major role in job choices. Many faced family resistances due to safety concerns and societal perceptions of delivery work, while others found fixed shifts (e.g., 6

AM - 2 PM at Flipkart) incompatible with household duties. As a result, some preferred petrol pump jobs or police applications, seen as socially acceptable and stable. These insights highlight the need for gender-sensitive EV employment models, offering flexible schedules, financial incentives, and community awareness efforts to support women's participation in last-mile delivery.

Figure 39: (a) and (b) Onboarding and baseline interviews at Warangal

A major factor influencing the perception of E2Ws among Warangal's women drivers was their lack of prior experience with motorized vehicles, which led to initial apprehension about balancing, acceleration, and braking. Many participants struggled with basic vehicle control in the early days of training, requiring additional time and encouragement to gain confidence. Unlike their male counterparts, who were accustomed to fuel-based motorcycles, these women had to simultaneously learn how to ride and adapt to an electric vehicle. However, over time, they became more comfortable with the smooth acceleration and lighter build of E2Ws, with some even noting that E2Ws were easier to handle than conventional scooters. Despite these positive experiences, concerns remained regarding battery life, charging accessibility, and the potential difficulty of navigating longer routes.

A notable contrast emerged between the female beneficiaries of our pilot, who were new to driving, formal jobs, and e-commerce delivery, and Anitha, an experienced Flipkart delivery agent at the Hanamkonda hub. Unlike the pilot participants, who preferred scooters for ease of handling and prioritized work-life balance, Anitha favored motorcycles, specifically riding a Pulsar, prioritizing speed over comfort. While many new female drivers hesitated to navigate traffic and sought job flexibility, Anitha embraced efficiency, making her one of the top 10 delivery agents at her hub, completing

150 deliveries a day. Her experience highlights that with time and exposure, women can excel in last-mile delivery, even matching male counterparts in performance. However, the gap between her experience and that of the new female drivers suggests that structured training, mentorship, and job flexibility are crucial to support women in scaling from entry-level participation to high-performance roles in the e-commerce logistics sector.

Beyond technical concerns, the social and financial aspects of adopting E2Ws played a significant role in shaping the perceptions of Warangal's women drivers. Many women viewed E2Ws as a tool for financial independence, enabling them to earn consistent incomes without relying on family-owned vehicles. However, affordability remained a critical concern, as most drivers had never invested in a vehicle before, and the prospect of paying for an E2W lease post-pilot raised financial uncertainties. Additionally, societal acceptance of women in delivery roles was another barrier—several participants expressed fears about community judgment and skepticism from customers. Despite these challenges, the experience of using E2Ws boosted their confidence, and many drivers saw their ability to ride and work independently as a step toward breaking gender norms in the logistics sector.

8.2 Weekly Monitoring and Assessment

Key Questions and Responses Captured Weekly

Sangareddy

The weekly feedback from Sangareddy drivers provided valuable insights into their experience with E2Ws, highlighting both operational advantages and persistent challenges. One of the most consistently positive aspects reported was the overall comfort and ease of use of E2Ws. Drivers rated their experience between 4 and 5 on a scale of 5, citing smooth rides, low operational costs, and convenience in storing delivery bags as key benefits. Several drivers noted that E2Ws were easy to handle, and for short-distance deliveries, the performance was comparable to their traditional petrol two-wheelers. However, delivery times varied significantly based on distance, with some drivers reporting an average of 5–10 minutes per order, while others, particularly those traveling longer distances, took 15–25 minutes per order. This variance highlighted that while E2Ws were efficient for local deliveries, their range and speed might pose challenges for drivers covering larger territories.

One of the key operational concerns raised by drivers was related to battery performance and charging frequency. While most drivers found that one full charge was sufficient for a full day's deliveries, a few reported needing to charge their E2Ws twice a day, particularly when covering longer distances or carrying heavier loads. Drivers appreciated the low electricity consumption and fast charging times, but some expressed concerns about battery efficiency decreasing over time. Additionally, charging habits varied—while some drivers consistently charged their vehicles overnight at home, others preferred

Figure 40 Field visits in Sangareddy

partial charging during breaks to extend range throughout the day. These responses indicate that while E2Ws were largely effective for daily deliveries, range limitations and charging frequency remained a concern for those covering higher mileage routes, reinforcing the need for accessible charging infrastructure or battery-swapping solutions to improve operational efficiency.

Beyond performance and charging concerns, the financial impact of using E2Ws was a recurring theme in driver feedback. While many drivers initially appreciated the fuel cost savings, the increasing lease cost structure over time led to mixed perceptions about long-term viability. In the first month, when the E2Ws were provided for free, drivers were highly positive about the lower operational costs. However, as the lease amount increased to ₹3,000 in the third month, some drivers began questioning whether the savings justified the cost. Additionally, while most drivers reported no additional maintenance expenses due to free servicing, some noted minor costs related to increased electricity consumption at home. These responses suggest that for E2Ws to be a financially viable alternative in rural last-mile logistics, a more flexible lease model or partial ownership scheme may be necessary to encourage long-term adoption.

Warangal

The weekly feedback from Warangal drivers highlighted the challenges and progress of women adapting to E2Ws for last-mile deliveries. Many women initially struggled with confidence, particularly in handling the vehicle in traffic and navigating urban roads. Several drivers expressed that they were comfortable delivering within local areas but felt unsafe or hesitant driving in heavy traffic. This concern was reflected in confidence ratings, where drivers rated their comfort at 3 or 4 out of 5, indicating moderate apprehension. Additionally, some drivers reported issues with vehicle handling, particularly with older models, and requested better-maintained or newer vehicles for ease of use. Despite these initial hurdles, many drivers acknowledged that E2Ws provided a smoother ride compared to traditional scooters, making deliveries physically less exhausting over time.

Another key takeaway from the weekly feedback was the experience with battery performance and charging habits. Most drivers reported that one full charge was sufficient for an entire day's deliveries, though a few noted faster battery depletion when covering longer distances. Several women charged their vehicles at home overnight, while others asked some of the other drivers for help to charge their batteries. However, some drivers experienced battery drainage even when the vehicle was not in use, raising concerns about battery efficiency and possible maintenance issues. Additionally, while most drivers were proficient in using mobile apps, having successfully navigated Swiggy Instamart and Zepto platforms, completed KYC approvals, and independently secured alternative job opportunities, they faced challenges specifically with the ElectricPe app and the limited availability of chargers in the area. This suggests that their challenge was not general digital literacy, but rather a lack of public EV charging infrastructure. Unlike home or workplace charging, which they adapted to seamlessly, drivers required more structured training from Hala Mobility on how to identify, access, and efficiently use public charging points. Given that charging posed a significant operational hurdle, improving battery reliability and expanding access to external charging infrastructure would greatly enhance drivers' confidence and overall experience with E2Ws.

Beyond technical and operational factors, financial considerations and societal perceptions also played a significant role in shaping the drivers' experiences. Several women expressed uncertainty about their earnings, as many had only recently started making deliveries and were still adjusting to the workflow. Early earnings reports were low, with some drivers stating that they had only made around ₹300 in their first week, primarily due to limited delivery assignments and unfamiliarity with e-commerce logistics. Additionally, some participants faced resistance from community members, particularly regarding concerns about safety and the appropriateness of delivery work for women. Despite these challenges, several drivers remained motivated to continue, citing financial independence and the ability to contribute to household income as key incentives. The feedback suggested that long-term retention would require consistent earnings, community awareness efforts, better public charging infrastructure, and ongoing support to reinforce confidence in both driving and delivery logistics.

8.3 Endline Assessment

Key Themes and Responses Collected

Sangareddy

The endline interviews with Sangareddy drivers revealed several key insights regarding their overall experience with E2Ws, particularly in comparison to their previous ICE vehicles. One of the most consistent findings was the financial advantage of using E2Ws, as nearly all drivers reported significant fuel cost savings. Most drivers noted that charging an E2W cost them between ₹100-₹500 per month, which was considerably lower than their previous fuel expenses of ₹1,500-₹3,500 per month. Additionally, maintenance and servicing costs were significantly lower for E2Ws under Hala Mobility's leasing model, as most service requirements were covered for free. However, for larger repair issues, drivers sometimes had to wait for service technicians to arrive from Hyderabad or were asked to bring the vehicle to Hyderabad themselves, which was impractical. In such cases, many preferred paying for local servicing out of pocket rather than traveling to Hyderabad, highlighting the need for better local servicing infrastructure.

Despite these savings, leasing costs remained a major concern. While the initial rental price was manageable, the ₹3,500–₹5,000 monthly lease rate was seen as unsustainable for long-term use. Drivers compared this to their existing ICE vehicle expenses, where they were paying ₹3,500–₹5,000 per month but with the advantage of eventual ownership. Paying a similar or higher amount for leasing without ownership was viewed as financially unviable. Several drivers suggested that if the lease model allowed for partial ownership or was capped at ₹2,500 per month, they would be more inclined to continue using E2Ws, considering the benefit of zero upfront costs and lower fuel and maintenance expenses.

Beyond financial considerations, charging infrastructure and battery performance emerged as critical themes in the endline feedback. Most drivers reported that a full charge was sufficient for their daily deliveries, with charging times averaging 3-4 hours. However, home charging was not always a viable option, as some drivers faced restrictions from landlords or had concerns about electricity costs increasing, while some were able to charge at work locations for free, others relied solely on home charging, leading to varied experiences in charging convenience and range planning. Additionally, range anxiety was a persistent concern, especially for drivers covering longer routes exceeding 60

km per day. Some drivers also experienced battery efficiency issues over time, with a few reporting that their batteries drained faster as the pilot progressed, signaling a potential need for improved battery quality or maintenance support.

In addition to financial and operational concerns, vehicle performance and maintenance issues played a crucial role in shaping drivers' perceptions of E2Ws. While most drivers found E2Ws comfortable and easy to maneuver, some faced technical issues, including brake malfunctions, headlight focus problems, and display damages. Unlike ICE vehicles, where repair services were easily accessible, several drivers found that servicing and parts replacement for E2Ws took longer, sometimes requiring them to travel to Hyderabad for repairs. While Hala Mobility provided some maintenance support, delays in technician availability and spare part replacements made some drivers hesitant to continue using E2Ws. Additionally, a few drivers expressed concerns about top speed limitations, stating that E2Ws felt slightly slower than their previous petrol bikes, which could affect delivery efficiency over time. However, this perception largely depended on the type of ICE vehicle they were accustomed to using. Many drivers in Sangareddy had previously used motorcycles, which typically offer higher speeds and better acceleration compared to scooters. Since Hala's E2Ws were scooters rather than motorcycles, they naturally had lower top speeds, leading some drivers to feel that their delivery pace was slightly reduced. While the difference in speed was not a major operational challenge for shorter routes, it was more noticeable for drivers covering longer distances or requiring faster turnaround times for deliveries. This highlights the need to evaluate E2W models based on the specific delivery requirements of different geographies and rider preferences. Despite these challenges, many drivers acknowledged that if servicing networks improved and rental costs were adjusted, they would consider using E2Ws in the future.

Warangal

The endline interviews in Warangal provided several valuable insights into the driver's experience with E2Ws. The majority of them had no prior driving experience, and for those who did, they had been using their husband's or other family members' vehicles. This program marked the first time they owned and operated their own vehicles, which made the experience particularly empowering and transformative for them. Most women had no prior experience with E2Ws or delivery jobs.

The project in Warangal involved more extensive steps compared to Sangareddy. It began with an initial outreach event, where participants received detailed information about how the pilot program would operate. This was followed by one month of training led by one of the MOWO instructors, at the end of which they also obtained their driver's licenses. Finally, they were ready to be onboarded at Swiggy and start their work as delivery agents.

At various points throughout the pilot, several participants dropped out due to factors like physical limitations and the need for immediate income, which prevented them from continuing with the program. However, those who persisted in completing the training and entering the workforce as delivery agents often expressed a sense of pride in their newfound independence and ability to support their families.

One major challenge for the women in Warangal was the daily commute from their homes to the Swiggy hub, which was located about 30-60 km away. This meant that they had to travel approximately 60-120 km every day just for commuting, which would quickly drain their battery. This added a layer

of difficulty to their daily routines, as they not only had to ensure their vehicles were fully charged for the long commute but also faced the inconvenience of managing charging needs during their workday.

Since many of the women lived far from the hub, they were unable to take their vehicles home with them. As a result, they left their vehicles at the hub overnight. However, since there was no charging facility available at the hub, some of them paid the other drivers around ₹50 each day to charge their batteries for them. Since they leave their vehicles at the hub, they have to commute by auto which costs them ₹150 daily or by bus, which takes them 2 hours to reach the hub.

All of the drivers expressed a need for more charging stations and improved charging infrastructure near the hub. They highlighted that the current charging options were insufficient to meet the demands of their daily work, causing delays and added stress. Access to more reliable and conveniently located chargers would help them manage their work more efficiently and reduce downtime during deliveries.

Another challenge they faced was vehicle performance and maintenance issues. Some women reported problems with the battery display, which was faulty and made it impossible to gauge how much battery remained in the vehicle. This often led to the vehicles stopping unexpectedly during deliveries. Additionally, some women mentioned that the accelerator was too sensitive, making it difficult to control the vehicle, especially when navigating through busy areas. One driver shared that she did not receive enough assistance from the Hala team to address this issue, so she had to rely on another driver's husband to help her resolve it.

Most drivers, who charged at home, noted that charging an E2W cost them between ₹100-₹500 per month, while they earned around ₹60-₹300 per day. Some women expressed a preference for a job that provided stable income, while others appreciated the flexibility of being able to earn more by working longer hours. This mix of perspectives highlighted the varying needs and priorities among the drivers, with some valuing consistent pay and others preferring the potential to increase their earnings based on the amount of work they put in.

One of the most positive aspects of the program was the strong sense of community among the women drivers. Many women who were already familiar with driving took the time to help others practice and gain confidence. Additionally, some women allowed others to charge their vehicles at their homes, helping to address the charging infrastructure gap. This camaraderie fostered a supportive environment where the women could rely on each other to overcome challenges and succeed in their new roles.

09

E2Ws Business Models

9.1 Business Model Adopted for the Pilot

The leasing model was chosen as the primary business model for the pilot, allowing delivery drivers to use E2Ws without upfront ownership costs. This approach aimed to assess the financial viability of leasing E2Ws for rural last-mile logistics while ensuring that drivers had an opportunity to gradually adapt to the vehicles. In Sangareddy, the pilot ran for three months with a progressive pricing structure to evaluate drivers' willingness to pay. Initially, drivers were offered the E2Ws for free, reducing entry barriers and allowing them to experience cost savings compared to fuel-based vehicles. After one or two months, they were asked if they would be willing to pay half the standard lease amount ₹3,000. The majority declined, so an alternative rate of ₹1,500 per month was proposed, which they agreed to.

By the end of the pilot, most drivers chose not to continue leasing at the standard market rate of ₹5,760 per month. A key reason uncovered in the interviews was that they were already paying approximately ₹3,000 per month on leasing or EMI payments for their ICE vehicles, making them unwilling to spend extra for an EV lease. Additionally, many drivers voiced concerns about increasing electricity bills, with some reporting that their household electricity costs had risen by ₹300-₹500 per month due to regular vehicle charging. These findings suggest that for long-term adoption, leasing models would need to align more closely with drivers' financial expectations and provide clear cost benefits over ICE vehicles.

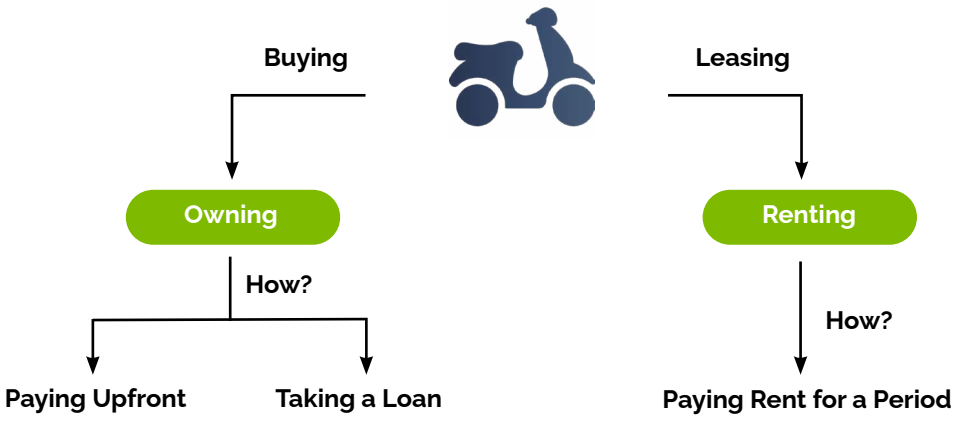

Figure 41: Leasing Model in a nutshell

In Warangal, the pilot followed a slightly different leasing structure due to the unique challenges faced by women drivers, particularly their lack of prior experience in last-mile delivery and financial constraints. Unlike in Sangareddy, where lease payments were gradually introduced, the entire two-month pilot period in Warangal was fully subsidized, allowing women to use the E2Ws for free. This approach aimed to remove financial barriers, ensuring that women had enough time to settle into their roles, gain confidence, and start earning a stable income before being required to pay for the vehicle. The initial assumption was that after two months, women drivers would have established consistent delivery routines and gained financial stability, enabling them to manage Hala Mobility's standard lease fee of ₹5,000 per month while maintaining a sustainable income. To facilitate this transition, Villgro provided financial support by supplementing leasing costs through retention incentives—a guaranteed salary of ₹10,000 in the first month, which was then reduced to ₹5,000 in the second month. This phased financial assistance was designed to ensure income security during the initial adaptation period, allowing women to sustain themselves even with lower delivery volumes. By providing a financial cushion, this approach enabled drivers to gradually adjust to the demands of e-commerce delivery work while building confidence and operational efficiency in their new roles.

The pilot revealed mixed responses to the leasing model, particularly in Sangareddy, where many drivers chose not to continue after the pilot ended. While they were comfortable paying up to ₹2,500 per month, they felt that ₹5,000 per month reduced their profit margins too much, especially in urban centers like Hyderabad, Hala Mobility's ₹5,000 monthly rental model has been more successful. A key reason for this is that many urban drivers view e-commerce delivery as a temporary or side income source, leasing vehicles while they search for stable jobs. A significant factor driving this trend is that numerous urban drivers perceive e-commerce delivery as a transient or supplementary income stream, opting to lease vehicles while pursuing more stable employment. This dynamic is further compounded by the economic disparity between urban and rural areas: urban residents generally earn higher wages, making vehicle leasing costs more financially feasible for them compared to those in rural regions, where lower incomes often limit affordability. This trend suggests that leasing models might need to be adapted for rural markets, possibly through lower rental costs, partial ownership options, or subsidy-based incentives to make E2W adoption more attractive and financially viable.

9.2 Comparative Assessment of Other Business Models

While the leasing model was adopted for the pilot, there are several other business models used in the E2W sector that offer alternative approaches to financing and deployment. One such model is the ownership model, where drivers purchase the vehicle outright either through one-time payments or financing options like EMIs (Equated Monthly Installments). This model is more appealing to drivers who prefer asset ownership, as it provides long-term cost savings compared to continuous lease payments. This was also found to be the most popular and preferred option they went with for their ICE vehicles.

However, the high upfront cost of E2Ws—even with financing—can be a major barrier for low-income delivery workers, making it less feasible in rural markets where financial liquidity is limited. Additionally, without proper maintenance support and guaranteed order volumes, individual ownership may place a higher operational risk on drivers, unlike leasing models where maintenance and support are often included. Individual ownership also carries heightened operational risks for drivers, such as lacking maintenance support and uncertain order volumes—unlike leasing models, which typically bundle

these safeguards. This risk dynamic is compounded by e-bike providers like Hala Mobility's broader reluctance to offer lease-to-purchase plans or direct sales with EMIs, especially in markets like rural areas or among women drivers. Such financing models are perceived as high-risk due to concerns over repayment consistency, including challenges in verifying stable bank balances for monthly installments. Leasing, however, mitigates exposure: if payments default, companies can reclaim vehicles, a flexibility that makes it preferable over riskier ownership structures in these contexts.

Another widely used model in the electric mobility sector is the pay-per-use or ride-sharing model, where drivers or logistics companies rent vehicles on a daily or per-trip basis instead of committing to long-term leases or ownership. This model has been successful in urban areas, especially for gig workers and part-time delivery personnel who do not require a full-time vehicle. Companies like Hala, Bounce and Yulu have implemented this approach, allowing riders to access E2Ws on demand. The primary advantage of this model is its flexibility, as drivers only pay for what they use, reducing financial risk. However, in rural last-mile logistics, this model may not be as effective due to inconsistent vehicle availability, lack of rental stations, and limited charging infrastructure. Without a stable supply of vehicles, drivers may face operational delays, making this model less suitable for dedicated e-commerce deliveries in non-urban areas.

A third model that has gained traction in electric mobility is the battery subscription or battery-swapping model, where drivers either lease batteries separately from the vehicle or swap depleted batteries at designated stations instead of waiting for charging. This model significantly reduces downtime, as drivers do not have to wait hours for charging and can instead swap their battery in minutes. It also lowers initial vehicle costs, as the most expensive component of an E2W—the battery—is leased separately. However, in rural areas, the lack of a widespread battery-swapping network makes this model less feasible unless significant infrastructure investment is made. Additionally, since battery performance and range remain key concerns, drivers may still prefer a model where charging can be done at home or at convenient locations rather than relying on swap stations that may be far apart in rural settings.

9.3 Total Cost of Ownership (TCO)

Introduction

Total Cost of Ownership (TCO) is a comprehensive measure that calculates the total expenses associated with owning and operating a vehicle over its entire lifespan, including purchase price, maintenance, fuel or electricity costs, insurance, and depreciation. It helps consumers and businesses assess the true financial impact of their vehicle choice, beyond just the initial purchase cost.

For the purpose of this study, this analysis focuses on comparing the TCO for ICE vehicles used by delivery personnel for last-mile e-commerce delivery at the selected site, Sangareddy, against E2Ws variants provided to them for the pilot study. The study evaluates both new and second-hand ICE vehicles, as well as low-speed and high-speed electric vehicles, considering different ownership and leasing models.

The following scenarios were generated based on vehicle types and ownership models to assess and compare their TCO:

Table 4: Different types of Scenarios considered

Type of 2-wheeler	Ownership Model	Vehicle considered
ICE	New Owned	Honda Shine
ICE	2nd hand	Honda Shine
ICE	New on loan	Honda Shine
EV: Low Speed (LS)	Owned	Astrid
EV: High Speed (HS)	Owned	Ryder
EV: Low Speed (LS)	Leased (Weekly)	Astrid
EV: High Speed (HS)	Leased (Weekly)	Ryder
EV: Low Speed (LS)	On Loan	Astrid
EV: High Speed (HS)	On Loan	Ryder

Parameters and Assumptions

This section outlines the key parameters used in the TCO model and highlights the assumptions made.

The following parameters have been used :

- Daily Distance Travelled
- Vehicle Holding period
- On- road price
- Financial incentive
- Annual Maintenance cost
- Battery Capacity
- Battery Replacement cost
- Mileage
- Fuel/ Electricity price
- Insurance cost
- Tariff growth rate
- Discount rate
- Resale rate
- Interest rate on loan

The Honda Shine was selected for the TCO analysis as the ICE vehicle, since it was the most common bike being used by the delivery partners. For the EVs, Astrid was considered as the low-speed electric vehicle, and Ryder as the high-speed electric vehicle since these are the vehicles being provided by Hala.

Table 5: EV Specifications

EVs	Model	Range	Top speed	Charge Time	Leasing cost
EV Slow	Ryder	50-100kms	25kms	6 hrs	₹ 1,699 weekly
EV Fast	Astrid	100kms	75kms	6 hrs	₹ 1,899 weekly

Table 6: Vehicle related costs

Parameter	ICE (Owned)	ICE (2nd Hand)	ICE (Loan)	LS EV (Owned)	HS EV (Owned)	LS EV (Leased)	HS EV (Leased)	LS EV (Loan)	HS EV (Loan)
Initial Purchase Cost	88,000	65,000	11,000 (Down payment)	85,000	1,00,000	-	-	11,000 (Down payment)	11,000 (Down payment)
Financial Incentive	-	-	-	10,000	10,000	-	-	10,000	10,000
Registration & Taxes	11,000	5,000	-	-	-	-	-	-	-
Annual Maintenance	7000	7,500	7,000	3750	3750	-	-	3750	3750
Insurance Cost	4,500	4,500	4,500	6,000	7,000	-	-	6,000	7,000
Lease payment	-	-	-	-	-	1,699 per week or 88,348 annually	1,899 per week or 98,748 annually	-	-

- **Daily Distance Travelled**: 75 km, leading to an annual distance of 27,375 km.
- **Vehicle Holding Period**: This refers to the number of years the vehicle is expected to be owned or operated before it is sold, replaced, or retired. For this analysis, the vehicle holding period is considered to be between 7 and 10 years, which is a typical range for the useful lifespan of a vehicle in delivery operations.
- **Fuel and Electricity Costs:** For this analysis, we have used the current rates of petrol and electricity in Telangana to calculate the fuel and energy expenses associated with operating the vehicles.

Table 7: The cost of petrol is ₹110 per litre, while the cost of electricity is ₹6 per kWh.

Parameter	Cost
Cost of Petrol:	₹110 per litre
Cost of Electricity	₹6 per kWh

Table 8: Battery related costs

Parameter	ICE (Owned)	ICE (2nd Hand)	ICE (Loan)	LS EV (Owned)	HS EV (Owned)	LS EV (Leased)	HS EV (Leased)	LS EV (Loan)	HS EV (Loan)
Battery Capacity	-	-	-	3 kWh	4kWh	3 kWh	4kWh	3 kWh	4kWh
Battery replacement cost	-	-	-	65,000	87,000	-	-	65,000	87,000
Mileage	50	40	50	33	50	33	50	33	50
Fuel/ Electricity Price (₹/L or ₹/ kWh)	110	110	110	6	6	6	6	6	6

Note: The **battery replacement cost** is considered to be zero if the vehicle holding period is less than 6 years. However, if the holding period exceeds 6 years, the battery replacement cost is spread across the entire duration of ownership. The **Diesel/Electricity Tariff Growth Rate** is assumed to be 5%, the **Discount Rate** is set at 10%, and the **Resale Rate** is estimated at 10%.

Table 9.1: Loan Details ICE Vehicle

Parameters	Values
Total cost	₹99,000
Down Payment	₹11,000
Interest rate	17%
Loan Period (Years)	3
Loan Period (Months)	36
Monthly Payment	₹ 2,839.51
Total Payment	₹ 1,13,222

Table 9.2: Loan Details for LS EV

Parameters	Values
Total cost	75,000
Down Payment	11,000
Interest rate	17%
Loan Period (Years)	3
Loan Period (Months)	36
Monthly Payment	₹ 2,281.77
Total Payment	93,144

Table 9.3: Loan Details for HS EV

Parameters	Values
Total cost	93,000
Down Payment	11,000
Interest rate	17%
Loan Period (Years)	3
Loan Period (Months)	36
Monthly Payment	₹ 2,923.52
Total Payment	1,16,247

Model Structure

To start the TCO calculation, we first calculate the **operational cost**, which includes various recurring expenses over the vehicle's ownership period. The operational cost is determined by considering the following components: annual maintenance, annual battery replacement cost for EVs, annual fuel cost, EMI (if applicable), annual lease (for leased vehicles), and insurance.

Next, we calculate the **Capital Recovery Factor (CRF)** using the discount rate factor and the vehicle holding period. Since the discount rate and vehicle holding period are the same for all cases, the CRF is consistently 0.16 across all scenarios. The CRF represents the proportion of the initial vehicle cost that needs to be recovered annually to cover the total cost of ownership, factoring in the time value of money.

We also calculate the **Present Value Factor (PVF)** using the resale rate and vehicle holding period. The PVF remains the same across all cases, coming out to be 0.39. The PVF represents the present value of the vehicle's estimated resale value at the end of the holding period, discounted to account for the time value of money.

Next, we calculate the **annual OPEX** for the subsequent **n** years, increasing it each year by the growth rate of 5%. Finally, we calculate the **annual TCO** by incorporating the PVF and CRF calculated earlier, along with the annual operational expenses.

Outputs and Results

Table 10: Yearly TCO

Yearly TCO	New	2nd hand	ICE: Loaned	LS-Owned	HS-Owned	LS-Leased	HS-Leased	LS-Loan	HS-Loan
1	6.37	6.01	5.51	3.28	3.66	3.58	3.91	2.86	3.14
2	4.73	4.83	5.65	2.01	2.21	3.67	4.01	2.90	3.30
3	4.24	4.50	5.82	1.60	1.74	3.76	4.11	2.97	3.43
4	4.03	4.38	5.22	1.41	1.51	3.86	4.22	2.44	2.79
5	3.94	4.35	4.90	1.30	1.38	3.96	4.33	2.13	2.41
6	3.90	4.36	4.71	1.31	1.41	4.06	4.44	2.01	2.28
7	3.90	4.40	4.60	1.32	1.43	4.16	4.55	1.93	2.18
8	3.93	4.46	4.54	1.34	1.45	4.27	4.67	1.88	2.12
9	3.97	4.53	4.52	1.36	1.48	4.39	4.79	1.84	2.07
10	4.03	4.62	4.52	1.37	1.50	4.50	4.92	1.81	2.04

Insights and Key Findings

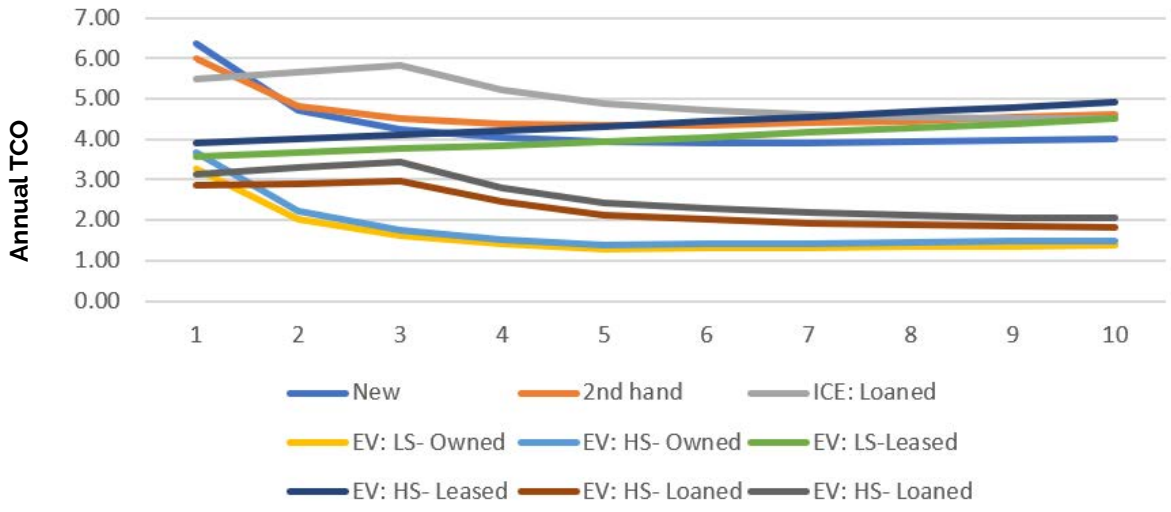

Figure 42: Annual TCO

- **New ICE vehicles** have the highest initial TCO but experience the largest reduction in cost over time.
- **Second-hand vehicles** offer lower initial TCO, compared to New ICE vehicles, but their cost reduction is slower, often due to increased maintenance and operational expenses.
- **ICE vehicles on loan** start with a lower TCO than outright purchased ICE vehicles due to the financing structure. However, the TCO increases in the initial years and then gradually decreases as the loan is repaid.
- **Low-speed electric vehicles (LS EVs)** are the most cost-effective option over a 10-year period, especially when owned outright, due to lower operational and maintenance costs.
- **High-speed electric vehicles (HS EVs)**, though more expensive initially, also provide significant TCO reduction, with ownership being significantly more economical than leasing.
- **Leasing** high-speed and low-speed EVs results in higher TCO over time due to consistent lease payments and rising operational costs.
- **Ownership of EVs** is the most financially beneficial, offering the best long-term value compared to ICE vehicles and leased EVs.
- **Leased EVs** are the only category where the TCO increases over time, instead of decreasing, because of the consistent lease payments throughout the vehicle's lifespan.
- **EVs on Loan** initially experience a rise in TCO due to loan repayments, but the total cost steadily decreases over time, ultimately offering long-term savings similar to owned EVs.

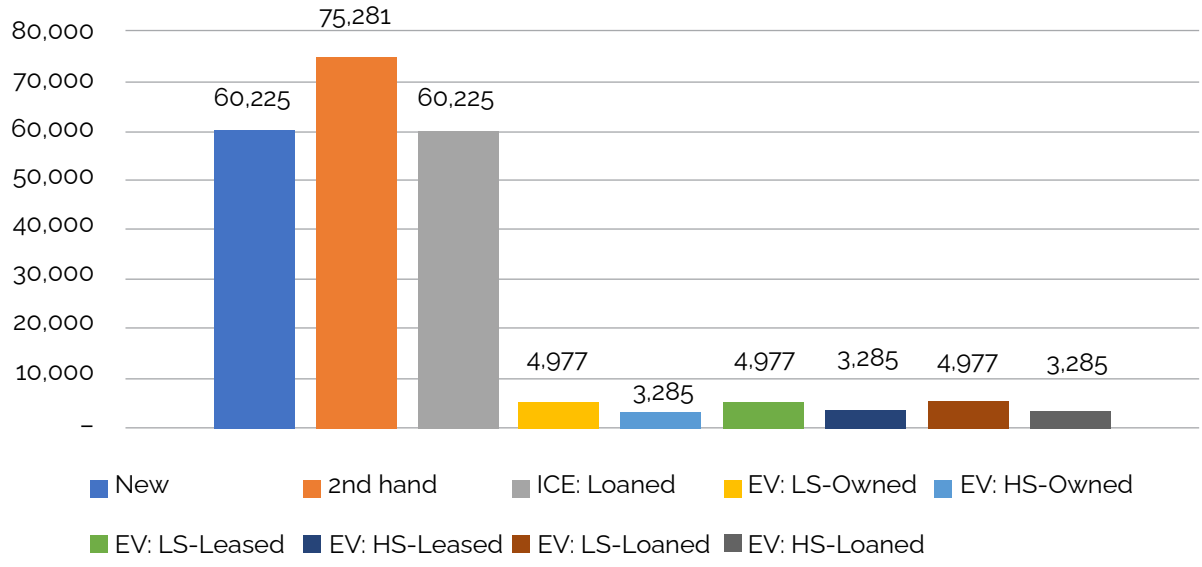

Figure 43: Annual Fuel Costs Across Vehicle Types and Ownership Scenarios (₹)" improve

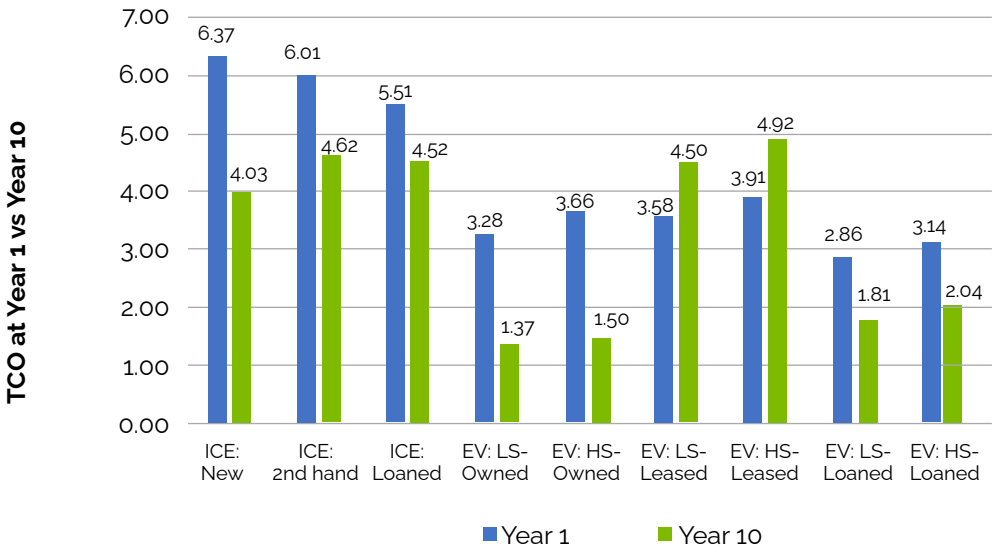

Figure 44: TCO at Year 1 vs Year 10

New loaned ICE vehicles have the highest initial TCO owing to the financing structure; however, the TCO increases in the early years and gradually decreases as the loan is repaid in contrast, second-hand ICE vehicles offer a higher initial TCO compared to new ones, but their cost reduction is slower, often due to higher maintenance and operational expenses. New ICE vehicles that are purchased outright begin with a lower TCO than loaned, since there is no interest.

Low-speed electric vehicles (LS EVs) are the most cost-effective option over a 10-year period, especially when owned outright, due to their lower operational and maintenance costs. High-speed electric vehicles (HS EVs), though more expensive initially, also provide significant reductions in TCO, with ownership proving far more economical than leasing. Leasing both high-speed and low-speed EVs leads to a higher TCO over time because of continuous lease payments and rising operational costs.

Table 11: Average 10-Year TCO Across Vehicle Types and Ownership Scenarios (₹/km)

Scenarios	ICE: New	ICE: 2nd hand	ICE: Loaned	EV: LS-Owned	EV: HS-Owned	EV: LS-Leased	EV: HS-Leased	EV: LS-Loaned	EV: HS-Loaned
Average TCO	4.30	4.64	5.00	1.63	1.78	4.02	4.40	2.28	2.58

Overall, owning EVs and buying EVs on loans offer the most financial benefit, providing the best long-term value when compared to ICE vehicles and leased EVs. Leased EVs are the only category where the TCO increases over time, rather than decreasing, due to the consistent lease payments throughout the vehicle's lifespan. This also aligns with insights from driver interviews, where the majority expressed a preference buying or loaning EVs.

10

Recommendations and Way Forward

The findings from the baseline, weekly, and endline assessments highlight both the potential and challenges of integrating E2Ws into rural last-mile e-commerce deliveries. While the cost savings on fuel and maintenance, ease of operation, and environmental benefits were widely recognized, concerns around leasing affordability, charging infrastructure, and vehicle servicing accessibility emerged as key barriers to long-term adoption. This section provides strategic recommendations aimed at enhancing the feasibility, financial sustainability, and operational efficiency of E2W-based delivery models. By addressing key financial, technical, and policy-related challenges, these recommendations seek to enable broader adoption, improve driver retention, and create an inclusive, scalable model for e-commerce logistics in rural India.

10.1 Key Pain Points and Problem Areas for Scaling E2Ws in Rural India

The pilot identified several challenges that must be addressed for scaling E2Ws in rural last-mile logistics.

Financial and Business Models

- **High Lease Costs Without Ownership** – Most drivers opted out of EV leasing at ₹5,760/month, as they were already paying around ₹3,000/month for ICE vehicles with ownership benefits. The lack of ownership made higher EV lease costs unattractive. For EV adoption to scale, leasing models must align with drivers' financial expectations and offer clear cost benefits over ICE vehicles. A lease-to-own option, with EMIs comparable to ICE vehicles, could improve acceptance by combining affordability with eventual ownership, making EVs a more viable long-term choice.
- **Cash Flow Issues for Women** – Women in the pilot preferred flexible, part-time work, making it difficult for them to afford fixed lease payments without upfront financial support or earnings stabilization mechanisms.
- **Lack of Corporate Fleet Leasing Support** – E-commerce platforms like Flipkart and Swiggy hire drivers weekly based on demand, making it difficult for drivers to commit to

long-term leases without employer-backed financial security.

Charging Infrastructure

- **Limited Public Charging Access –** Drivers, particularly those without home charging options (e.g., rental homes with restrictions), struggled to identify and access public charging stations**,** as existing infrastructure is focused on urban centers**.**
- **Unfamiliarity with Public Charging Apps –** While drivers were proficient in using e-commerce platforms**,** they were unfamiliar with EV charging apps like ElectricPe**.**
- **Range Anxiety for High-Distance Deliveries –** Drivers covering 60 km+ per day faced concerns over battery efficiency and charging downtime**,** with some reporting battery degradation over time**.**
- **Slow Servicing & Battery Replacement Delays –** Some drivers experienced long wait times for service technicians, with major repairs requiring trips to Hyderabad, making localized repair hubs essential.

Gender Inclusivity

- **Rigid Shift Timings in E-Commerce Delivery –** Platforms like Flipkart required fixed 6 AM – 2 PM shifts, conflicting with women's household responsibilities, such as childcare and meal preparation.
- **Family & Societal Resistance –** Several women dropped out due to family restrictions, with concerns around safety, community perception, and unfamiliarity with delivery jobs.
- **Preference for Alternative Jobs –** Women preferred government jobs (police, petrol pump work) over gig-based delivery roles, as these were seen as more stable and socially acceptable.
- **First-Time Vehicle Users Needed More Support –** Unlike male drivers, many women had never used two-wheelers before, requiring longer training durations to develop riding confidence.

Environmental Impact

- **Limited Awareness of Long-Term Benefits –** While most drivers recognized short-term cost savings, they were less aware of the broader environmental impact, such as reduced emissions and lower carbon footprints.
- **Battery Disposal & Recycling Concerns –** While battery degradation remains a concern, effective disposal and recycling practices can mitigate its impact. Hala is already implementing responsible battery recycling and disposal measures. However, as rural EV adoption scales, service providers must proactively address end-of-life battery management. Clear frameworks for recycling, second-life applications, and safe disposal will be essential to ensure sustainability. Following best practices can help mitigate environmental risks and build driver confidence in long-term EV viability.

10.2Policy Recommendations

To ensure scalability and broader adoption of E2Ws in rural logistics, government and private sector stakeholders must work together to develop a supportive policy ecosystem. Subsidies or incentives for rural E2W adoption—such as reduced leasing rates, free charging infrastructure, or battery replacement support—could help mitigate financial concerns and encourage drivers to transition from ICE vehicles. Additionally, dedicated public charging stations in high-delivery areas would address range anxiety and operational downtime, allowing drivers to complete more deliveries efficiently. This can be facilitated through public-private partnerships with logistics companies, EV manufacturers, and government agencies.

Figure 45: Recommendations for Enhancing the Feasibility of E-Bikes

10.3Feasibility and Scalability Recommendation

The pilot's findings indicate that while E2Ws have the potential to improve cost efficiency and sustainability in rural last-mile delivery, their long-term feasibility and scalability depend on a well-structured financial model. The leasing model tested in the pilot showed mixed results, with drivers in Sangareddy finding the ₹5,000 per month lease too high, while urban areas have successfully sustained this model due to different income patterns and employment structures. To make E2W adoption more feasible in rural areas, a hybrid model that combines subsidized leasing with eventual ownership options could be more attractive. For instance, a gradual rent-to-own model where monthly payments contribute toward vehicle ownership might incentivize more drivers to continue using E2Ws beyond the pilot phase. Additionally, government or

corporate-backed financing solutions, such as lower EMI options or subsidies, could further enhance adoption among delivery workers with limited financial flexibility.

For long-term scalability, the business model must also consider fleet aggregation and corporate-backed leasing structures to reduce financial burdens on individual drivers. Instead of requiring each driver to bear the full leasing cost, an aggregator-led model, where e-commerce companies or third-party logistics (3PL) providers lease fleets and distribute costs among multiple users, could enhance affordability and retention. Additionally, co-financing models, where government incentives or private sector subsidies reduce lease costs, can encourage wider E2W adoption. Another scalable approach is the asset-light model, where drivers lease vehicles only during peak demand periods, similar to urban gig-work trends. By diversifying financing options—through a mix of lower-cost leases, rental-to-ownership pathways, and aggregator-led fleet financing—E2Ws can become a sustainable and attractive choice for rural last-mile delivery, reducing financial risks while maximizing long-term viability.

Given the unique socio-economic challenges faced by rural women, business models need to be specifically tailored to ensure accessibility, affordability, and long-term sustainability for them. One potential approach is a shared-ownership model, where groups of women co-own E2Ws through SHGs or cooperative financing, allowing them to collectively manage costs while ensuring flexible usage. Another promising model is corporate-backed fleet financing, where e-commerce platforms or logistics aggregators invest in a dedicated fleet of E2Ws for women, removing financial entry barriers and mitigating risks of long-term leasing commitments. Additionally, a subsidized rent-to-own model, where women start with reduced lease payments that progressively transition into ownership, could enable them to build assets over time while maintaining job flexibility.

By focusing on these rural-specific recommendations, India can create a more inclusive and supportive ecosystem for electric mobility, ensuring that rural areas are not left behind in the transition to sustainable transportation. These measures will enhance the feasibility and adoption of e-bikes for e-commerce deliveries, promoting economic growth and environmental sustainability in rural regions.

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