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Convergence Energy Services Limited

Impact Assessment

Sustainable Transport for Rural Entrepreneurs through Electric Bicycles (STREE)

Consolidated Report | March 2026

Bihar | Madhya Pradesh | Andhra Pradesh | Kerala

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Creating Innovative Solutions for a Sustainable Future

SHAKTI SUSTAINABLE ENERGY FOUNDATION

pci INDIA

Beneficiary from Madhya Pradesh

Impact Assessment

Sustainable Transport for Rural Entrepreneurs through Electric Bicycles (STREE)

Bihar | Madhya Pradesh | Andhra Pradesh | Kerala

Consolidated Report | March 2026

Report prepared by: Indian Institute of Technology Bombay.

Disclaimer: The views expressed in this report are those of the authors and do not reflect the views and policies of the Indian Institute of Technology Bombay, Energy Efficiency Services Limited, and Convergence Energy Services Limited.

Organisations:

Indian Institute of Technology Bombay (IIT Bombay) is one of India's premier institutions for higher education and research, known for its excellence in engineering, science, and interdisciplinary studies. The Institute adopts a research-driven and problem-solving approach to address complex societal challenges through collaborations with government, industry, and civil society. At IIT Bombay, the Department of Energy Science and Engineering (DESE) and the Centre for Technology Alternatives for Rural Areas (CTARA) both focus on contributing to developing scalable, impact-oriented solutions within the broad areas of clean energy, sustainable livelihoods, and development.

Efficiency Services Limited (EESL) is a Super Energy Service Company (ESCO), which enables consumers, industries, and governments to effectively manage their energy needs through energy-efficient technologies. EESL is implementing the world's largest energy efficiency portfolio across sectors like lighting, buildings, industry, electric mobility, smart metering, agriculture, etc., at an enormous scale. EESL's energy efficiency solutions have saved India over 47 billion kWh of energy annually while reducing 36.5 million tonnes of carbon emissions. Founded in 2009, EESL is promoted by the Ministry of Power, Government of India, as a Joint Venture of four reputed public- sector undertakings NTPC Limited, Power Finance Corporation Limited, REC Limited, and POWERGRID Corporation of India Limited. EESL focuses on solution-driven innovation without taking support from any subsidy from the Government

Convergence Energy Services Limited (CESL) is a green energy-focused venture of the EESL Group owned by central public sector undertakings under the Ministry of Power, New and Renewable Energy. It offers interventions that solve multiple gap areas in the energy ecosystem by amalgamating seemingly independent sectors such as electricity, transport, home appliances, and introducing models for adaptation at scale through government partnerships and innovative financing such as carbon markets.

Executive Summary

The **Sustainable Transport for Rural Entrepreneurs through Electric Bicycles (STREE)** project was designed by EESL & CESL to address a critical barrier to rural and peri-urban women's economic participation: **limited and unreliable mobility**. In many rural and peri-urban areas, women engaged in agriculture, small businesses, Self-Help Group (SHG)-linked work, and service activities face high travel time and costs, physical strain, and dependence on others. The project was implemented across four states - **Bihar, Madhya Pradesh, Andhra Pradesh** and **Kerala**, covering **1,800 selected beneficiaries**, with the e-bicycles distributed in a phased manner between January and July 2025.

The impact assessment followed a mixed-method approach, combining quantitative surveys and qualitative insights, with baseline data collected prior to distribution and endline data collected around six months after the women received the e-bicycles. A total of **1,214** beneficiaries were **surveyed at both baseline and endline**. Across the four states, **78%** (i.e. 947 of the surveyed beneficiaries) **reported using the e-bicycle**, indicating substantial adoption within a relatively short period. Findings presented here are based on this group of **947 users** of the e-bicycle.

The shift to e-bicycles **reduced dependence on conventional modes of transport** and **improved travel efficiency**, resulting in **significant time savings**, a major strength of the intervention. Overall, **72%** of the users **reported saving time** after shifting to e-bicycle travel. These savings were used for a mix of productive and household purposes, including income-generating work, family care, household responsibilities, and rest.

The findings also point to significant **livelihood and economic gains**. The e-bicycle mainly helped women **strengthen and expand existing livelihood activities** by enabling more frequent travel, easier access to markets and customers, and improved work efficiency. Across the four states, around **48% of the users reported an increase in monthly income** after receiving the e-bicycle. In addition, **60% of the users reported savings in travel costs**, with an **average monthly saving of ₹1,356**. In Bihar, **35% of the users reported zero monthly travel expenditure at endline**, indicating a significant shift away from paid transport for many users. Further**, 73% of the users experienced an average rise in income of ₹3,517**, while **23% reported a higher average increase of ₹8,064**. These savings & income increase were used for household expenses, children's education, health needs, future savings, or reinvestment into livelihoods.

Access to e-bicycles has led to clear improvements in beneficiaries' travel experience and well-being across states. Across the sample, the share of users reporting **comfortable or very comfortable** travel increased substantially (reaching **about 65–85%** at endline across states), while reports of discomfort declined sharply. **Physical stress** from travel also **reduced significantly**, with the share of users reporting no physical stress rising to **60%-99% across locations**, compared to very low levels at baseline. Similarly, those reporting no emotional stress increased to around 84%-93%, indicating a strong decline in travel-related anxiety after access to the e-bicycle.

Alongside these, most users report high confidence in riding independently, and cumulatively **42%** reported that their use of e-bicycles has generated **curiosity** or interest **within the community**, suggesting growing social acceptance and visibility of this mobility solution.

The use of e-bicycles also has clear **environmental benefits**. Across the **1,389 tracked e-bicycles**, the beneficiaries collectively travelled over **13 lakh kilometres** during the study period. This resulted in an estimated **45 tonnes of carbon dioxide (CO_2) emissions avoided** compared to equivalent travel by petrol scooters. This is equivalent to the annual carbon sequestration potential of about **2,143 mature trees**.

Taken together, the findings show that the STREE project has demonstrated the value of cargo e-bicycles as a **practical, low-cost, and gender-responsive mobility solution** for rural and peri-urban women. The strongest effects are visible in improved mobility, reduced travel expenditure, better time management, expanded livelihood efficiency, and enhanced confidence.

Looking ahead, the findings suggest that cargo e-bicycles can serve as an **effective mobility enabler** for women engaged in livelihood activities, particularly when embedded within the existing SHG ecosystems. Strengthening future interventions will require building on this institutional foundation by expanding beyond the SHG networks into diverse livelihood segments based on mobility needs, along with improved user orientation and refresher training. This pilot study has proven the potential of e-bicycles in various capacity and have a high potential for scale using programmatic approach.

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March 13, 2026

FOREWORD

Advancing inclusive and sustainable rural development remains a central priority of the **Ministry of Rural Development**, Government of India. Over the past decade, the Ministry's programmes have focused on strengthening livelihoods, building resilient community institutions and expanding economic opportunities across rural India, with women's empowerment at the centre of this transformation.

Through the **Deendayal Antyodaya Yojana – National Rural Livelihoods Mission**, millions of women organized in Self-Help Groups are today driving enterprise, strengthening household incomes and contributing meaningfully to local economic systems. Enabling these women entrepreneurs with reliable and affordable mobility can significantly enhance their productivity, expand their market access and unlock new livelihood opportunities.

The **STREE:** ***"Sustainable Transport for Rural Entrepreneurs through Electric bicycles"*** initiative provides encouraging evidence of how **innovative mobility solutions** can complement **rural livelihood programmes**. By enabling improved access, reducing travel constraints and supporting **productive economic activities**, the initiative has demonstrated the transformative potential of clean micromobility solutions in strengthening **women-led livelihoods** and **local enterprise ecosystems**.

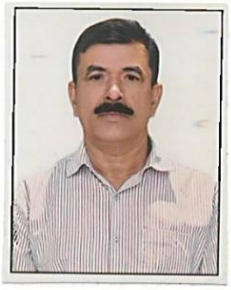
At the same time, the relatively high upfront cost of electric micromobility solutions remains a significant barrier to wider adoption, particularly for women-led self-help groups and rural entrepreneurs. Addressing this challenge will require coordinated efforts across concerned ministries, financial institutions and market stakeholders to lower acquisition costs and strengthen the supporting ecosystem. Such **convergence** will be critical in unlocking the full potential of electric micromobility and accelerating its adoption in rural and peri-urban India.

The insights presented in this report offer valuable guidance for **integrating innovative mobility solutions** within **rural development programmes**. As India advances its journey towards inclusive growth, initiatives such as **STREE** demonstrate how practical, locally relevant innovations can contribute meaningfully to strengthening rural livelihoods and expanding economic participation.

[Shailesh Kumar Singh]

एनर्जी एफिशिएंसी सर्विसेज़ लिमिटेड
विद्युत मंत्रालय के सार्वजनिक क्षेत्र के उपक्रमों की संयुक्त उद्यम कंपनी
ENERGY EFFICIENCY SERVICES LIMITED
A JV of PSUs under the Ministry of Power

FOREWORD



India's transition towards sustainable and energy-efficient mobility is gaining strong momentum as the country advances its commitments on climate action and inclusive development. While large-scale electrification of transport remains central to this transition, **electric micromobility solutions such as e-bicycles offer an important opportunity to address everyday mobility challenges in rural and peri-urban areas,** where reliable and affordable last-mile transport remains limited.

At **Convergence Energy Services Limited (CESL),** we are committed to advancing clean mobility through **demand aggregation, cost-effective technology deployment and ecosystem development.** The **STREE initiative**—***Sustainable Transport for Rural Entrepreneurs through Electric Bicycles***—reflects this approach by exploring the potential of **electric micromobility as a practical, scalable & livelihood-linked** mobility solution **for rural communities.**

Implemented in collaboration with the **Ministry of Rural Development,** the STREE pilot has demonstrated how **electric cargo bicycles can function not merely as a mobility solution, but as a productive economic asset** for women associated with Self-Help Groups. By improving access to markets and services, reducing travel time and physical drudgery, and lowering mobility costs, the intervention has enabled women to enhance productivity, expand livelihood opportunities and participate more actively in local economic systems.

This impact assessment report captures key learnings from the pilot and highlights the potential of electric micromobility to support **women-led livelihoods, strengthen last-mile connectivity and advance clean mobility in rural India.** As India continues to expand its clean mobility ecosystem, initiatives such as **STREE** demonstrate that **the future of sustainable transport must extend beyond urban centres and reach the everyday mobility needs of rural India.** By integrating clean mobility with livelihood generation and inclusive development, electric micromobility solutions have the potential to unlock a new paradigm of **innovative, people-centric, climate-aligned mobility solutions.** It will also help women becoming self-reliant in rural areas.

(Akhilesh Kumar Dixit)
CEO EESL & CESL

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Acknowledgement

Meaningful development in any sector is made possible through the collective efforts of institutions, implementing partners, and communities working together toward a shared goal. The Sustainable Transport for Rural Entrepreneurs through Electric Bicycles (STREE) initiative, led by EESL and CESL, reflects such a partnership-driven effort to enhance rural women's mobility and enable greater access to livelihood opportunities through cargo e-bicycles.

This report is the result of a collaborative effort undertaken by IIT Bombay, with the support and guidance of the teams at EESL and CESL. We sincerely appreciate their continued cooperation, valuable insights, and commitment to strengthening the initiative. We are also grateful to the Shakti Sustainable Energy Foundation for its facilitative role in coordinating stakeholders and supporting the smooth execution of the study.

We acknowledge the technical support of Motovolt Mobility Pvt. Ltd. in providing electric bicycles suited to the needs of rural women. Our thanks also extend to the implementation partners and community-based institutions, Bihar Rural Livelihoods Promotion Society (JEEVKA) in Bihar, Madhya Pradesh State Rural Livelihood Mission (MPSRLM) in Madhya Pradesh, Kuppam Area Development Authority (KADA) in Andhra Pradesh, and Kudumbashree and the Energy Management Centre (EMC) in Kerala. We further thank Project Concern International (PCI) for their field support in Bihar and The Energy and Resources Institute (TERI) for conducting the impact assessment in the state.

Finally, we express our sincere gratitude to the SHG women who participated in the study and shared their experiences, as well as to the field coordinators and enumerators whose dedicated efforts made this study possible.

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Credits: The photos included in the report were specifically taken by the members of the project team with the consent of the beneficiaries. The illustrations were made by Ms. Ketaki Jadhav (@littlemisschashmish).


STREE

Beneficiary from Kerala

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Abbreviations

ASHA	Accredited Social Health Activist
APL	Above Poverty Line
BPL	Below Poverty Line
CEEW	Council on Energy, Environment and Water
CESL	Convergence Energy Services Limited
CLF	Cluster Level Federation
CRP	Community Resource Person
DPIIT	Department for Promotion of Industry and Internal Trade
EESL	Energy Efficiency Services Limited
EMC	Energy Management Centre
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of Electric Vehicles
FGD	Focus Group Discussions
HH	Households
IITB	Indian Institute of Technology Bombay
IMT	Intermediate Means of Transport
MoRD	Ministry of Rural Development
NRDC	Natural Resources Defense Council
NRLM	National Rural Livelihood Mission
RuTAG	Rural Technology Action Group
SHG	Self-Help Group
STREE	Sustainable Transport for Rural Entrepreneurs through Electric Bicycles
TERI	The Energy and Resources Institute

Beneficiary from Andhra Pradesh

Introduction

Mobility plays a crucial role in enabling economic participation, particularly for rural women engaged in small-scale trade, services, and home-based enterprises. However, in many rural parts of India, access to affordable and reliable transport remains limited. Women often face mobility constraints due to inadequate transport infrastructure, safety concerns, household responsibilities, and dependence on other family members for travel. These challenges restrict access to markets, financial services, and livelihood opportunities while increasing the time and physical effort required for daily travel. Addressing these constraints is therefore essential for strengthening rural livelihoods and enhancing women's economic participation, highlighting the need for affordable solutions that meet short-distance mobility needs in rural and semi-urban areas while supporting cleaner transport transitions.

1.1 Background

A pre-feasibility assessment was undertaken by Convergence Energy Services Limited (CESL) between March and June 2023 to examine the potential of electric bicycles as a mobility solution for short-distance travel in rural and semi-urban areas. Field visits were conducted in Raipur (Chhattisgarh), Lucknow (Uttar Pradesh), Nalanda (Bihar), and Thiruvananthapuram (Kerala) to understand travel patterns, trip duration, transport expenditure, and mobility constraints among potential users such as Anganwadi workers, Accredited Social Health Activist (ASHA) workers, and women associated with Self-Help Groups (SHGs). This was followed by a detailed survey and demonstration exercise conducted by CESL, in collaboration with the Council on Energy, Environment and Water (CEEW) and the Energy Management Centre (EMC) of Kerala at Manikkal Gram Panchayat. Three models of e-cycles were tested by women workers to assess their suitability for daily work-related travel.

Pre-feasibility surveys indicated potential beneficiaries travelled 5–15 km daily for work, facing limited and costly public transport options.

The assessment found that many women travelled **5–15 km daily for work**, often relying on limited or costly transport options. Around **70–75% of participants reported that e-bicycles could reduce fatigue and improve work efficiency**, indicating strong acceptance of the technology. The study also showed that e-bicycles and low-speed e-mopeds could be **56–70% cheaper than conventional motorised alternatives** in terms of total cost of ownership, although the upfront purchase cost remained a barrier. The findings highlighted significant potential demand for e-bicycles among women workers and SHG members and indicated that cargo e-bicycles could be particularly suitable for livelihood-related mobility. These insights formed the basis for designing the **Sustainable Transport for Rural Entrepreneurs through Electric Bicycles (STREE)** initiative (Ghosh et al., 2024).

1.2 STREE Project Overview

The **Sustainable Transport for Rural Entrepreneurs through Electric Bicycles (STREE)** project was launched as a pilot initiative to examine how access to cargo e-bicycles could improve mobility and livelihood outcomes for Entrepreneurs in rural and peri-urban India.

SHG women were specifically chosen as the target group for the STREE pilot as they represent one of the most powerful and deeply embedded grassroots institutions created under the National Rural Livelihoods Mission, with an unparalleled ability to reach the last mile. Beyond being financial collectives, SHGs function as vibrant social and economic networks that enable women to engage in livelihood activities, access credit, and participate in community-level decision-making.

Their structured ecosystem—comprising community cadres, federations, and well-established institutional linkages—provides a ready platform for introducing transformative interventions at scale. In the context of the STREE initiative, SHG women are uniquely positioned to leverage electric bicycles not just as a mobility solution, but as an income-enhancing asset that expands their access to markets, services, and livelihood opportunities.

Their existing engagement in activities such as agriculture, livestock management, financial services, and micro-enterprises makes mobility a critical enabler of productivity and income growth. Furthermore, the collective nature of SHGs supports peer learning, adoption, and risk-sharing, which significantly enhances the scalability and sustainability of such interventions. This makes SHGs not only ideal target group but also effective agents of change for driving the adoption of clean, livelihood-linked mobility solutions across rural India.

1.2.1 Vision & Objective

The STREE project envisions empowering the rural economy, especially the rural women, by enabling access to clean and affordable mobility through electric bicycles, thereby expanding livelihood opportunities, enhancing independence, and contributing to low-carbon last-mile mobility.

The project was designed with the following objectives:

- **Enhancing Women's Mobility:** To improve access to reliable and affordable mobility solutions for rural women engaged in livelihood activities.
- **Strengthening Livelihood Opportunities:** To enable women to access markets, services, and institutions more efficiently by reducing travel time and transport costs.
- **Promoting Clean and Inclusive Mobility:** To encourage the adoption of environmentally sustainable mobility solutions while strengthening women's economic participation and independence.

The STREE project directly advances six Sustainable Development Goals, linking clean mobility to rural economic empowerment.

The initiative aligns with several **Sustainable Development Goals (SDGs)**, particularly those related to poverty reduction, gender equality, decent work and economic growth, clean energy, and climate action.

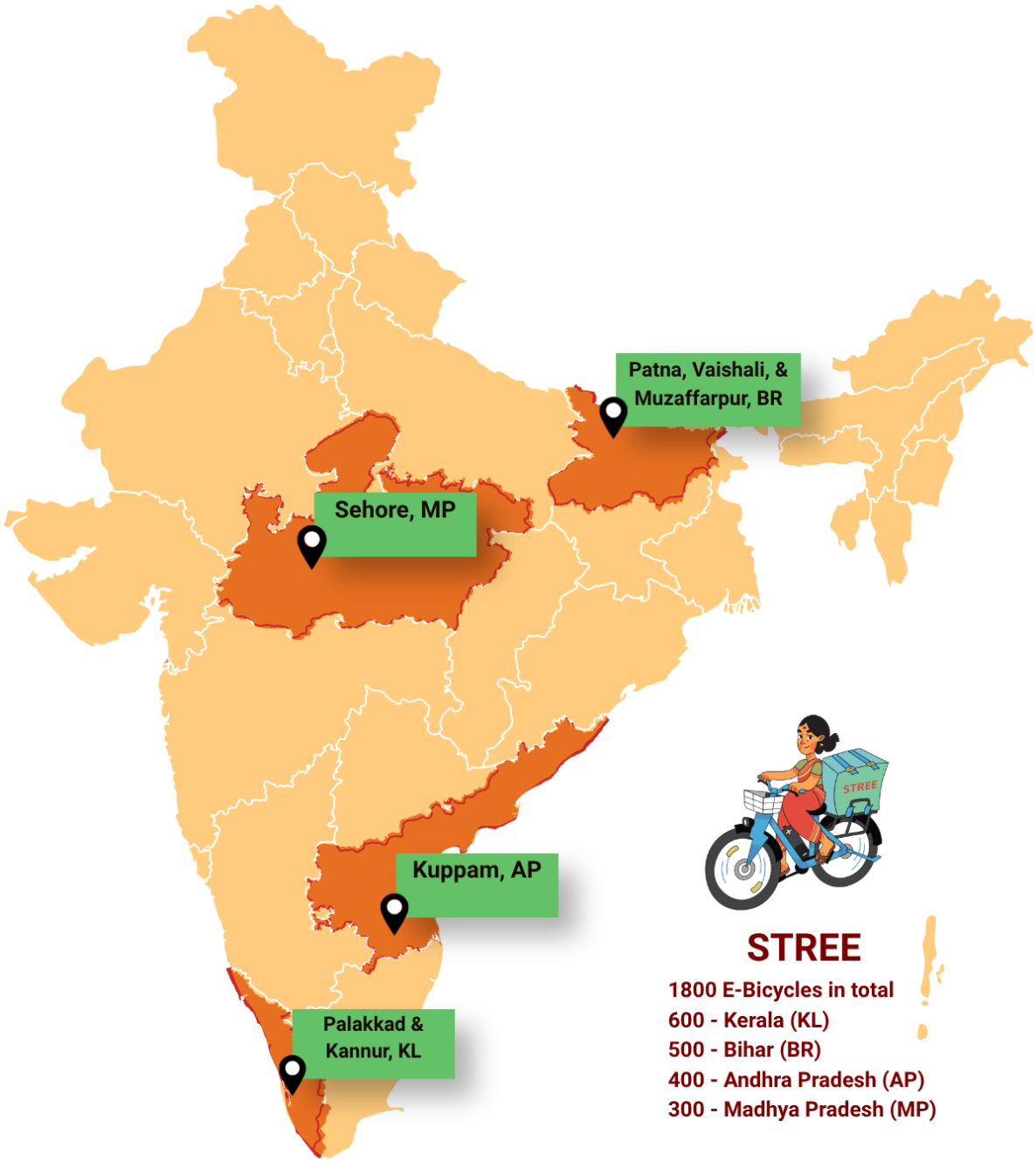
1.2.2 Scope

The STREE project was implemented across four states – **Bihar, Madhya Pradesh, Andhra Pradesh, Kerala,** focusing on selected districts within each state as shown in Figure 1. In Bihar, the intervention covered the districts of Patna Sadar, Muzaffarpur, and Vaishali. In Andhra Pradesh, implementation was carried out in the Kuppam constituency, while in Madhya Pradesh the project was concentrated in Sehore district. In Kerala, beneficiaries were distributed across all blocks in the districts of Palakkad and Kannur.

In all the four states, beneficiaries were selected by the respective state implementing agencies based on defined eligibility criteria. These included being an **active member of a SHG, below the age of 40, engaged in a livelihood activity, and capable of riding a bicycle**. Beneficiaries were also required to possess valid identification documents and a functional bank account to facilitate programme participation.

The distribution of cargo e-bicycles was carried out in a phased manner between January and July 2025. Alongside this process, beneficiaries were supported through training sessions and provided with instructional manuals and videos, enabling them to adopt and effectively use the e-bicycles.

Figure 1: Geographical coverage of STREE project



1.3 Methodology for Impact Assessment

The impact assessment of the STREE project was undertaken at the state level to evaluate outcomes associated with the sustained use of cargo e-bicycles among SHG women. The study was conducted in three phases: **baseline** (before distribution), **midline** (three months after distribution), and **endline** (six months after distribution). The impact assessment was undertaken to evaluate outcomes associated with sustained use of cargo e-bicycles among SHG women.

The impact assessment tracked 1,214 beneficiaries for a period of six months to evaluate changes in mobility, livelihood engagement, and well-being.

This phased approach enabled documentation of the pre-intervention scenario and the measurement of short-term changes in women's mobility, livelihoods, and related outcomes following access to e-bicycles.

The study focused on the following objectives:

1. Examine changes in mobility patterns and travel mode after access to e-bicycles.
2. Analyse impacts on livelihoods, income, and travel-related expenditure.
3. Understand changes in well-being, mobility confidence, and social perceptions.

The study adopted a **mixed-method approach**, combining quantitative surveys with qualitative insights to capture both measurable outcomes and lived experiences of beneficiaries. Table 1 summarises the number of beneficiaries surveyed for impact assessment of the project across the four states.

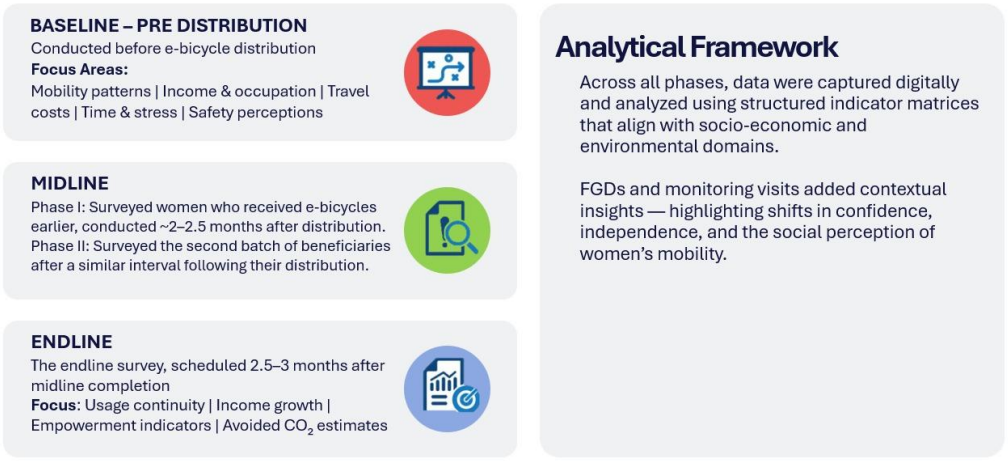
Table 1: Beneficiary coverage for impact assessment phases

State	Number of Beneficiaries	Distribution Phasing	Beneficiaries Surveyed at both Baseline and Endline
Bihar	500	Phase 1: 50 Phase 2: 450	212
Madhya Pradesh	300	Phase 1: 200 Phase 2: 100	249
Andhra Pradesh	400	Phase 1: 300 Phase 2: 100	327
Kerala	600	Phase 1: 250 Phase 2: 350	426
Total	**1,800**	**1,800**	**1,214**

To ensure structured and comparable analysis across states, an impact indicator matrix was developed to track key dimensions of change associated

with e-bicycle adoption. The matrix draws on data from the baseline, midline, and endline phases and includes indicators related to mobility access, travel patterns, livelihood engagement, financial savings, and social outcomes. This analytical framework, illustrated in Figure 2, enables consistent interpretation of programme effects across different implementation contexts while also allowing state-level variations to be examined. The detailed indicator matrix used for the assessment is provided in Annexure I.

Figure 2: Schematic overview of the Impact Assessment Framework



The subsequent sections of the report present insights from the impact assessment of the STREE project. The next section reviews relevant literature on gendered mobility barriers, e-bicycle adoption, and the role of SHG ecosystems in enabling mobility-based empowerment. This is followed by an analysis of quantitative findings and case studies from the project states, culminating in a discussion of key insights and recommendations for future scaling.

E-Bicycle Experience – Global and Indian

2.1 Gendered Barriers to Mobility and Livelihood Access

Gender-inclusive development must address not only disparities in income, health, and education but also **structural barriers** that constrain women's spatial access to opportunities. Mobility functions as a critical enabling condition for economic participation, time autonomy, and decision-making power. In many rural and low-income contexts, women's mobility is shaped by transport infrastructure, safety concerns, household responsibilities, and gender norms that regulate women's presence in public space (Uteng, 2011).

Mobility is not just about movement, it determines women's access to work, markets, and economic independence.

Empirical evidence demonstrates that improved connectivity has **a disproportionate positive effect on women's economic participation**. Lei, Desai, & Vanneman (2019) show that access to roads and frequent bus services significantly increases non-agricultural employment, with stronger impacts for women than men. However, the benefits of physical infrastructure are amplified only in contexts where gender norms are supportive. This underscores that mobility is not purely an infrastructural issue; it is embedded within social and cultural systems.

Similar patterns are documented in Sub-Saharan Africa. Bamberger & Davis (2001) show that women disproportionately shoulder transport-intensive tasks such as carrying agricultural produce, water, and fuelwood, yet often **face limited access to Intermediate Means of Transport (IMTs)**. The authors note that even when transport assets are introduced through development interventions, intra-household power dynamics may result in men assuming control over them. This underscores that transport programs without explicit gender safeguards risk reproducing existing inequalities rather than alleviating them.

Across contexts, mobility constraints restrict women to informal, low-return, or home-based work, thereby reinforcing economic dependency and limiting upward mobility. Addressing mobility, therefore, is not merely about reducing travel time; it is about expanding economic capability and spatial freedom

Previous rural EV pilots demonstrate that providing electric two-wheelers to women entrepreneurs reduces fuel costs that previously consumed 20%-40% of household income.

2.2 Mobility Independence and Women's Empowerment

While large-scale infrastructure investments are essential, emerging literature suggests that **individual mobility solutions**, such as women-specific transport programs, can directly address gendered barriers of **affordability, autonomy, and safety**.

The 1993 Pudukottai cycling initiative in Tamil Nadu demonstrated how collective cycling training reconfigured women's relationship with public space. Although framed as a literacy campaign, its transformative effect lay in normalising women's independent mobility and challenging spatial restrictions (Ahmed, 2024). Importantly, the intervention revealed that mobility is socio-political, it shifts power relations within households and communities.

Bihar's Mukhyamantri Balika Cycle Yojana further illustrates the structural impact of mobility tools. The program **increased grade 9 enrolment by 30–32%** and **reduced the gender gap by 40%**, particularly in villages located more than 3 km from secondary schools (Prakash & Muralidharan, 2013; Singh, 2023). Beyond education, the scheme shifted gender norms by legitimising girls' independent movement.

Evidence from Zambia shows similar outcomes. A randomised controlled trial found that providing bicycles **reduced commute time by 35%, lowered absenteeism by 27%, and increased girls' self-efficacy and aspirations** (Fiala, Garcia-Hernandez, Narula, & Prakash, 2022). These findings reinforce that even low-cost mobility tools can catalyse durable behavioural change when paired with supportive infrastructure.

Electric mobility pilots are beginning to extend this logic to livelihood contexts. The SEWA-NRDC-SIDBI rural EV pilot in Gujarat and Rajasthan provided electric two-wheelers to women entrepreneurs, many of whom previously spent 20–40% of household income on fuel. Participants reported improved efficiency, greater carrying capacity, and enhanced self-esteem (NRDC, 2024). Similarly, Mobility for Africa's solar-powered tricycle initiative in Zimbabwe improved women's access to markets, healthcare, and water while reducing unpaid labour burdens (Rodriguez, 2020). In Uganda, the AFricroozE initiative demonstrated how electrified bicycles, paired with decentralised solar charging infrastructure, can challenge gendered transport hierarchies (Katesi, 2022).

These experiences demonstrate that individual mobility solutions can play an important role in addressing gendered mobility constraints and supporting women's economic participation. However, international evidence also suggests that **the success of e-bicycle initiatives** depends on several enabling conditions related **to infrastructure, policy environment, affordability, and social acceptance**. The key factors influencing e-bicycle adoption identified in global literature are summarised in Table 2.

Table 2: Factors influencing success in e-bicycle adoption globally

Adoption Factor	Evidence from International Literature	References
Infrastructure Support	Countries with strong cycling ecosystems such as the Netherlands and Germany demonstrate that safe cycling lanes, traffic integration, and supportive infrastructure play a critical role in enabling widespread e-cycle adoption.	(Fishman & Cherry, 2016)
Regulatory and Urban Compatibility	In China, rapid adoption of e-bicycles has been attributed to favourable regulatory treatment, affordability, and compatibility with dense urban travel patterns where short-distance mobility is common.	(Weinert, Ma, & Cherry, 2007)
Affordability and Financing Mechanisms	Fiscal incentives and supportive policy frameworks in European markets have accelerated the adoption of electric mobility technologies by reducing purchase barriers and encouraging uptake across income groups.	(IEA, 2023; Fishman & Cherry, 2016)
Cultural Acceptance of Cycling	In contexts where cycling is socially normalised, e-cycles are viewed as legitimate mobility tools rather than inferior substitutes for motor vehicles, facilitating smoother adoption.	(Fishman & Cherry, 2016)
Policy Alignment with Climate Goals	Alignment of electric mobility policies with broader climate and sustainable transport strategies strengthens market signals and supports wider adoption of e-mobility technologies.	(IEA, 2023)
User-Centric Design and Ease of Use	Survey evidence from North America indicates that e-bicycles expand cycling participation among women and older adults and those who may find conventional cycling physically demanding, highlighting the importance of ease of use and reduced physical strain.	(MacArthur, Dill, & Person, 2018)

2.3 India Context: Adoption and Limitations of E-Bicycles

India's transition toward electric mobility has been shaped by several national policy frameworks aimed at promoting cleaner transport technologies. The National Electric Mobility Mission Plan established the long-term vision for electric mobility adoption while strengthening domestic manufacturing

capabilities (NEMMP, 2020). This was followed by the FAME (Faster Adoption and Manufacturing of Electric Vehicles) scheme, which provides demand-side incentives to promote electric two-wheelers, three-wheelers, buses, and charging infrastructure (FAME Phase-II Scheme, 2025). More recently, the PM E-DRIVE scheme (2024) has been introduced to accelerate electric vehicle deployment and expand charging infrastructure while further supporting domestic manufacturing (PM E-DRIVE, 2024).

While these initiatives have played an important role in promoting electric mobility, they largely focus on motorised electric vehicles. **Low-speed electric bicycles**, particularly **cargo e-bicycles** suited for short-distance mobility, remain **largely outside the direct scope** of these incentive programmes.

Individual mobility tools function as economic multipliers when their design, affordability, and support systems align with women's lived realities.

Academic research on e-bicycle adoption in India is still emerging but indicates growing interest in the technology. Studies suggest that adoption intentions are influenced by perceived usefulness, environmental awareness, and the reduced physical effort required compared to conventional bicycles (Zabiulla, Sahu, & Majumdar, 2025). These characteristics make e-bicycles particularly suitable for short-distance travel where conventional cycling may be physically demanding.

At the same time, several **barriers to adoption** have been identified**. Limited awareness of e-bicycle technology and uncertainty regarding performance and reliability** can slow uptake among potential users (Arning, Silva, & Kaths, 2023). Safety concerns in mixed traffic conditions and the absence of dedicated cycling infrastructure further discourage regular use option (Fishman & Cherry, 2016).

Social and behavioural factors further shape adoption patterns. Studies examining behavioural intentions toward e-bike use note that social influence and perceptions of technology usefulness play an important role in shaping willingness to adopt new mobility technologies (Gumasing, 2025). In addition, research examining social and cultural influences on e-bicycle adoption highlights that environmental attitudes and perceptions of sustainability benefits can encourage interest in e-bicycles as a mobility alternative (Abbas, Iftikhar, & Liu, 2025).

2.4 Leveraging SHG Ecosystems for Mobility-Based Empowerment

India's SHG ecosystem represents one of the largest platforms for **rural women's collectivisation**. SHGs extend beyond microfinance; they foster leadership, social capital, and market integration. Rout & Mishra (2025) show that SHG participation in Odisha enhances women's economic and symbolic mobility by expanding market engagement and confidence. Similarly, Kumar et al., (2021) emphasise the importance of "linking social capital", trust and

tangible support from implementing agencies, in sustaining women's engagement.

However, participation barriers persist for women **facing time poverty, caregiving burdens, or low literacy**. SHGs expand agency but do not automatically resolve spatial constraints. Mobility thus emerges as a complementary enabling factor: without reliable transport, training, market linkages, and financial inclusion cannot translate into sustained livelihood expansion.

This positions SHGs as natural institutional anchors for mobility-based interventions. When mobility assets are embedded within **collective ecosystems,** they can benefit **from peer support, accountability, and shared learning.**

2.5 Conceptual Positioning

Across global and Indian contexts, the literature demonstrates that mobility interventions succeed when infrastructural support, affordability, institutional embedding, and social acceptance align. Mobility, particularly for rural women, is not merely physical movement; it represents **capability expansion** (Uteng, 2011). Three interlinked propositions emerge from existing research. First, physical connectivity alone is insufficient without parallel shifts in gender norms and intra-household power relations. Second, individual mobility tools such as bicycles and **e-bicycles can generate measurable gains in time efficiency, market access, and confidence** when appropriately designed and supported. Third, institutional ecosystems, such as SHGs, play a crucial role in sustaining adoption, normalising women's mobility, and preventing asset capture within households.

Within this framework, e-cycles are not simply transport devices. They operate at the intersection **of gender equity, livelihood diversification, climate transition**, and **rural economic restructuring**. When supported by reliable service systems, inclusive financing, and gender-sensitive planning, e-cycles can transform spatial access into sustained economic participation. This conceptual foundation positions the **STREE intervention** as a mobility-enabled livelihood strategy rather than a standalone asset distribution programme.

Simple, Affordable, Low-maintenance

Insights from Quantitative Analysis

This chapter presents consolidated quantitative insights on the adoption and usage of e-bicycles, changes in mobility and travel behaviour, livelihood expansion, and economic outcomes across states. The quantitative analysis in this chapter is based on beneficiaries with comparable information at both baseline and endline stages.

3.1 Socio-demographic Profile of the Beneficiaries

The intervention reached women primarily in their livelihood-active years across the four participating states. Across states, most of the beneficiaries fall within the 26–40 years' age range, with limited representation among younger (18–25 years) cohorts. This indicates strong engagement with economically active women at a stage of high work and family responsibility.

Educational attainment across the four states is centred around secondary schooling (Class 9–12), which forms the largest share. Bihar and Andhra Pradesh also have notable representation across primary and higher education levels; Madhya Pradesh is more concentrated in secondary schooling; while Kerala has a relatively higher share of women with higher education.

Taken together, the programme has reached predominantly working-age women, most of whom have completed secondary education. This profile situates the intervention among economically active women where livelihood support can generate tangible household-level impact.

3.2 Adoption of E-bicycle

Adoption of e-bicycles by women in their day-to-day activities was assessed to evaluate the extent of programme uptake and integration into routine mobility. Survey-based questions were administered to beneficiaries, beginning with whether they use the e-bicycle, followed by indicators to gauge the level of adoption, including frequency of use, purpose of use, and identification of the primary user. Further to this, direct observations were conducted during monitoring visits. The detailed analysis is presented in the subsequent sections.

3.2.1 Usage of E-bicycle

The e-bicycle was introduced as an asset to strengthen women's mobility and livelihood access. Adoption is defined here as the use of the e-bicycle by the

beneficiaries, and varies across states, as seen in Table 3. In **Bihar, 79%** of the surveyed beneficiaries reported using the e-bicycle, while adoption is **87% in Madhya Pradesh**, **58% in Andhra Pradesh**, and **88% in Kerala** amongst the surveyed beneficiaries. Across the four states, **78% of the surveyed beneficiaries reported using the e-bicycle**, indicating widespread adoption.

Table 3: Adoption of e-bicycles

State	Beneficiaries Surveyed at both Baseline and Endline	Users*	Adoption Percentage
Bihar	212	167	79%
Madhya Pradesh	249	216	87%
Andhra Pradesh	327	191	58%
Kerala	426	373	88%
Total	**1,214**	**947**	**78%**

** A user is any beneficiary who herself uses the e-bicycle, regardless of whether it is shared within the household. The remaining who do not use the e-bicycle themselves are classified as non-users, even if the e-bicycle is used by other household members.*

Subsequent analysis of the impact of the e-bicycle is based exclusively on data from these users (n = 947).

Beyond direct use by women, the e-bicycle functions as a shared household asset, generating broader mobility benefits across all states.

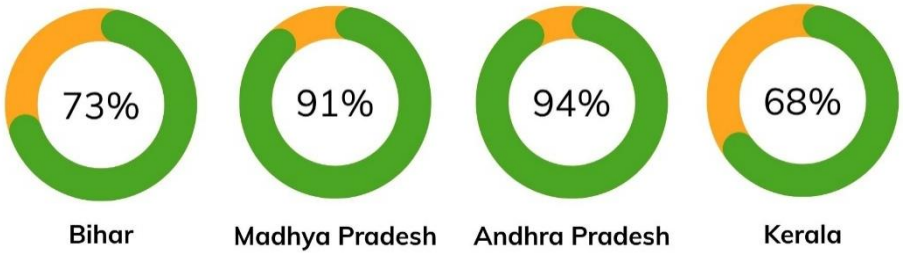
Among those who used the e-bicycle, patterns differ in terms of who uses it most frequently within the household. For this assessment, the **primary user refers to the household member who uses the e-bicycle most frequently for regular travel**. In **Madhya Pradesh, 80%** of the beneficiaries identified themselves as the primary user. In **Andhra Pradesh**, while only **39%** reported being the primary user, the remaining beneficiaries still used the e-bicycle, though other household members such as children or spouses used it more frequently. In **Kerala, 71%** of beneficiaries identified themselves as the primary user**,** indicating strong individual control over the asset. In **Bihar**, primary-user data was not directly captured. These findings suggest that while the asset is primarily intended for women's mobility, in many households it also contributes to broader household mobility needs.

3.2.2 Frequency and Primary Purpose of E-bicycle Usage

Patterns of e-bicycle usage vary across states, reflecting differences in mobility needs, distances travelled, and integration into daily routines. In Bihar, Andhra Pradesh and Madhya Pradesh, usage is frequent and routine, with a large majority of beneficiaries reporting use more than three days a week, indicating

strong adoption among active users (79% in Bihar, 86% in Madhya Pradesh, and 90% in Andhra Pradesh). Kerala shows a moderate usage (49%) for more than three days a week. Taken together, across the four states, **71% of beneficiaries** reported using the e-bicycle for **more than three days a week**, indicating regular usage. Of the total users, **82%** reported that they primarily used the e-bicycle for travelling to work or attending SHG meetings; state-wise percentages of the same are presented in Figure 3.

Figure 3: State-wise percentage of women using the e-bicycle primarily for traveling to work or attending SHG meetings



The e-bicycle is used by 82% of the beneficiaries for travelling to work or for attending SHG meetings.

Apart from work-related travel, beneficiaries also use the e-bicycle for a range of everyday mobility needs such as household errands, visits to local markets, taking children to school, travelling to nearby religious places and health related visits. These patterns indicate that the e-bicycle is integrated into routine daily activities beyond livelihood purposes.

3.3 Impact on Travel Patterns

After the adoption of e-bicycles, the analysis now examines how sustained use has translated into changes in mobility patterns. This section examines the impact on women beneficiaries' travel patterns across two dimensions — work-specific mobility and broader, general travel behaviour.

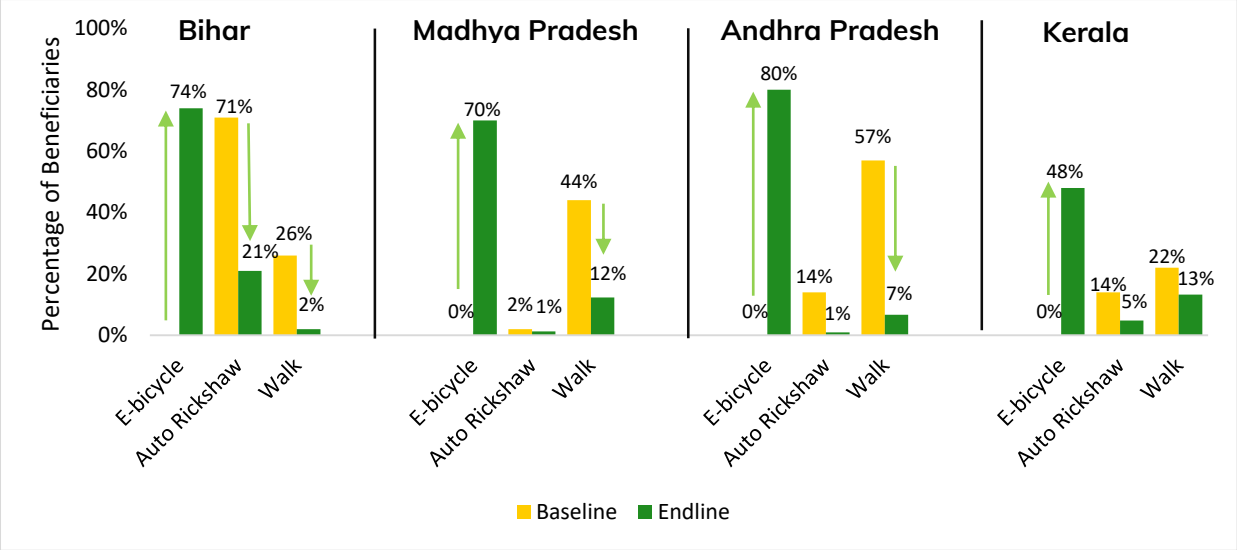
3.3.1 Shift in Primary Mode of Travel for Work

A comparison of baseline and endline data shows a shift in modes of travel for work following the introduction of the e-bicycle across states. Note that at baseline, beneficiaries may have relied on multiple modes of transport; therefore, they could be represented across more than one category in Figure 4 where state-wise patterns of the transition are shown.

In **Bihar**, dependence on auto-rickshaws drops sharply from **71% at baseline to 21% at endline**, as 74% of the beneficiaries report using e-bicycles for work travel. In **Madhya Pradesh**, reliance on **walking declines from 44% to 12%,** with **70% of beneficiaries using e-bicycles** for work travel at endline. In **Andhra Pradesh**, **walking** for work travel **reduces** substantially from **57% at baseline to 7% at endline**, as **80% of beneficiaries use e-bicycles** for work travel. In **Kerala**, the shift is more moderate, with **walking declining from 22% to 13%** and **auto-rickshaw use from 14% to 5%,** while **48%** of beneficiaries use e-

bicycles for work travel at endline, possibly due to a relatively well-established public transport system.

Figure 4: Modes of transport for work at baseline and endline



Overall, a **strong shift is observed from conventional modes of transport toward e-bicycles** across the four states, with the extent of the shift depending upon the existing transport infrastructure and the baseline mobility patterns.

3.3.2 Change in Travel Patterns for Beyond Work

Beyond work-related travel, beneficiaries also use the e-bicycle for a range of everyday mobility needs. **Local market visits** emerge as the most prominent non-work use, accounting for **60% of such trips in Bihar, 44% in Madhya Pradesh, 40% in Andhra Pradesh, and 64% in Kerala**. The e-bicycle is also used for visits to institutions such as banks, post offices, and government offices. Additionally, women also reported using the e-bicycle for taking children to school, visiting religious or cultural places, and occasional health-related travel.

Thus, the findings indicate that the e-bicycle extends women's mobility beyond livelihoods by supporting routine errands and access to essential services within their local areas.

3.3.3 Time Savings and Use of Saved Time

Use of the e-bicycle results in noticeable time savings across states, though the magnitude and use of saved time vary depending on travel distances and livelihood contexts. As women shifted from walking or relying on shared transport to using the e-bicycle, travel for routine activities became faster and more predictable. Having access to their own means of mobility allows beneficiaries to travel directly to destinations and better manage their daily schedules.

Out of the total users, a majority of the beneficiaries reported saving travel time, with **76% in Bihar, 85% in Madhya Pradesh, 97% in Andhra Pradesh, and 50% in Kerala**. Figure 5 presents the distribution of time saved among beneficiaries who reported time savings.

Figure 5: Time saved after using e-bicycle for daily travel

Beneficiaries reported using the time saved from faster travel in a variety of ways, depending on livelihood priorities and household responsibilities. In **Bihar**, the most prominent use is **spending more time with children or family (84%)**. In **Madhya Pradesh**, beneficiaries most frequently report **spending more time with children or family (42%)**. In **Andhra Pradesh (85%)**, and **Kerala (46%)**, the largest share reported **spending more time on work and income-related activities**. In addition to these dominant uses, beneficiaries across states also report allocating saved time to activities such as household errands, visiting family members, attending community meetings, and pursuing income-generating activities.

Overall, 72% of beneficiaries report saving up to 60 minutes per day that is used for income-generating activities and spending more time with their families.

Overall, **72% of beneficiaries reported saving travel time** after shifting to e-bicycle travel. Beneficiaries commonly use this saved time for **income-generating activities and spending more time with their families**. These findings indicate that while the e-bicycle improves travel efficiency across contexts, the benefits extend beyond reduced travel time, enabling different forms of livelihood intensification, well-being, and social participation depending on local realities.

3.4 Impact on Livelihoods

Across states, women beneficiaries manage diverse small enterprises rooted in local demand and SHG-linked livelihood ecosystems.

This section examines key aspects of beneficiaries' livelihood and work patterns, with a focus on the nature of occupations, engagement in income-generating activities, and selected indicators related to work routines based on self-reported information.

3.4.1 Occupational Profile

The occupational profile of beneficiaries at the time of the endline reflected variations in livelihood engagement across the intervention states, as shown in Table 4. In **Bihar**, **all beneficiaries were SHG members** and were also engaged in **small business activities**, with some also involved in private employment. In

Andhra Pradesh, women were **largely engaged in agriculture** alongside small business activities. In Kerala and Madhya Pradesh, livelihoods were strongly linked to participation in SHGs, often combined with **small businesses** or other income-generating work. Overall, the profiles indicated that many beneficiaries managed multiple livelihood activities alongside their participation in SHGs, providing the context within which the e-bicycle supported expansion of work activities.

The enterprise profile of the beneficiaries engaged in business activities provides insight into the types of income-generating work undertaken across states. Table 4 illustrates the diversity of enterprises pursued by the beneficiaries.

In Bihar, enterprise engagement is highly diverse, with beneficiaries involved in a range of small-scale livelihood activities such as food processing, packaging, retail trade, mushroom cultivation and sales, service provision, and other home-based micro-enterprises. Women are also engaged in Jeevika initiatives such as *Didi ki Rasoi* and *Didi ka Adhikar Kendra*, reflecting the variety of community-linked and individual livelihood activities undertaken by SHG members. In Madhya Pradesh, women are primarily engaged in retail and service-based enterprises such as grocery stores, tailoring, and beauty parlours. In Andhra Pradesh, enterprises are largely linked to local demand and agricultural ecosystems, with activities such as milk collection and delivery, grocery / kirana stores, and sewing or tailoring being prominent. In Kerala, enterprises are more service and processing oriented, with food-related businesses and tailoring forming a substantial share alongside grocery stores.

Table 4: Various businesses that are run by women beneficiaries

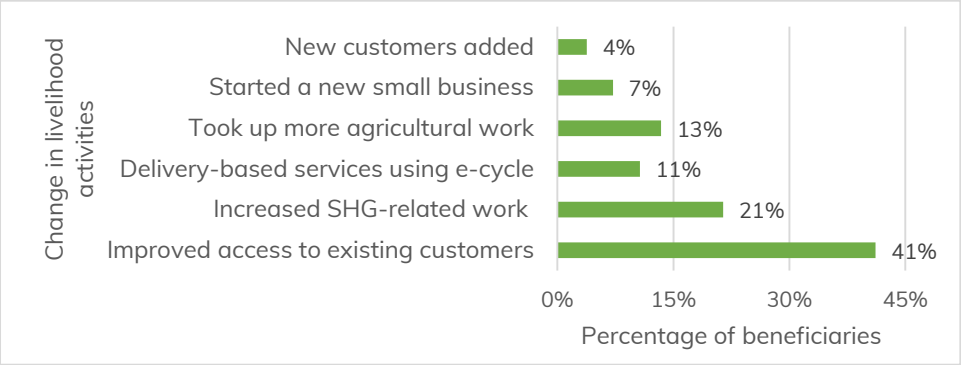
Small Enterprises	Bihar	Madhya Pradesh	Andhra Pradesh	Kerala
Sewing and Tailoring	38%	28%	13%	25%
General/ Grocery/ Kirana Store	17%	33%	20%	15%
Fruit / Vegetable seller	14%	6%	2%	1%
Fancy Store/ Clothing Store	8%	17%	7%	5%
Cosmetic and beauty parlour	6%	22%	0%	4%
Food serivces / Bakery	7%	6%	5%	37%
Milk Collection and Delivery	5%	14%	27%	1%
Flower Selling		0%	5%	0%
Other	6%	8%	2%	13%

Across states, the enterprise profiles reflect varied livelihood contexts rather than a single business model. Retail and tailoring activities appear across all four states, while other enterprises such as milk collection, bakery units, beauty services, or fresh produce vending vary depending on local opportunities and market conditions.

3.4.2 Change in Work and Livelihood Activities Since Using the E-Bicycle

This section examines changes in the nature of work reported by women beneficiaries six months after receiving the e-bicycle, highlighting how improved mobility influenced their engagement with livelihood activities. In **Bihar**, changes are mainly linked to **expansion of existing businesses (33%)** and improved access to markets and customers (9%). In **Madhya Pradesh**, multiple livelihood changes are reported, particularly **increased SHG-related work (54%),** along with smaller shares reporting new businesses (13%) and delivery-based work (12%). In **Andhra Pradesh**, the most prominent change is increased engagement in **agricultural work (61%),** while 17% of beneficiaries report starting small businesses such as tailoring or grocery shops. In **Kerala**, changes are concentrated in **SHG-related activities (23%) and delivery-based services using the e-bicycle (20%).** Figure 6 gives the consolidated values for all four states for the changes in livelihood activities since receiving the e-bicycle.

Figure 6: Change in the livelihood activities since receiving the e-bicycle



These findings demonstrate that the e-bicycle has primarily enabled the **expansion and strengthening of existing livelihood activities in all four states**. Improved mobility allows women to travel more frequently for work, access markets and customers with greater ease, and operate their enterprises more efficiently.

This suggests that **the e-bicycle has functioned primarily as an enabling asset that supports women's ongoing work, and with more time, it has the potential to act as an important catalyst for occupational shifts among more beneficiaries.**

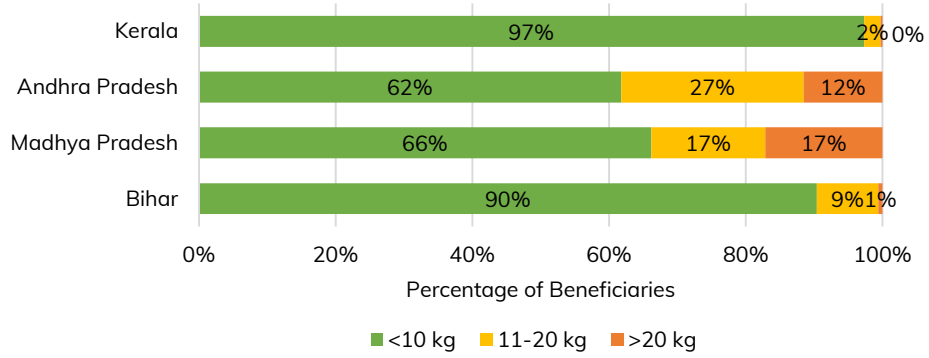
3.4.3 Load Carried at Work

As the intervention provided cargo e-bicycles designed to carry goods, beneficiaries were asked about the typical weight transported during work-related travel to understand how the asset supports livelihood activities.

Across all the four states, the majority of beneficiaries reported carrying **up to 10 kg,** including everyday items such as handbags, registers, or small quantities of products for sale or delivery, as seen in Figure 7. **The goods transported typically included cosmetics, plant saplings, vegetables, dairy cans, spices, and other household items.** This pattern is visible across states, with 90% of beneficiaries in Bihar, 66% in Madhya Pradesh, 62% in Andhra Pradesh, and 98% in Kerala carrying loads up to 10 kg.

Andhra Pradesh also shows a notable share **(27%) carrying 11–20 kg** is mostly linked to agricultural and allied activities related needs. A smaller proportion of beneficiaries reported carrying loads **above 20 kg,** particularly in **Madhya Pradesh (17%)** and **Andhra Pradesh (12%),** suggesting that in some contexts the e-bicycle supports livelihood activities that involve transporting relatively larger quantities of goods.

Figure 7: Load carried during travel on e-bicycle



Across the four states, **82% of beneficiaries reported carrying loads of up to 10 kg**, while **12% carried between 11 and 20 kg**, and **6% reported carrying loads above 20 kg**. These findings indicate that the cargo e-bicycle primarily facilitates **transport of small to moderate quantities associated with everyday livelihood activities**, with heavier usage varying depending on local work patterns.

3.5 Economic Outcomes

This section presents findings related to individual income of women, travel-related expenditure, and savings on travel and fuel as reported by beneficiaries six months after receiving the e-bicycle. It also examines patterns in household spending on travel, providing an overview of economic aspects linked to mobility and work-related activities.

3.5.1 Change in Individual Income

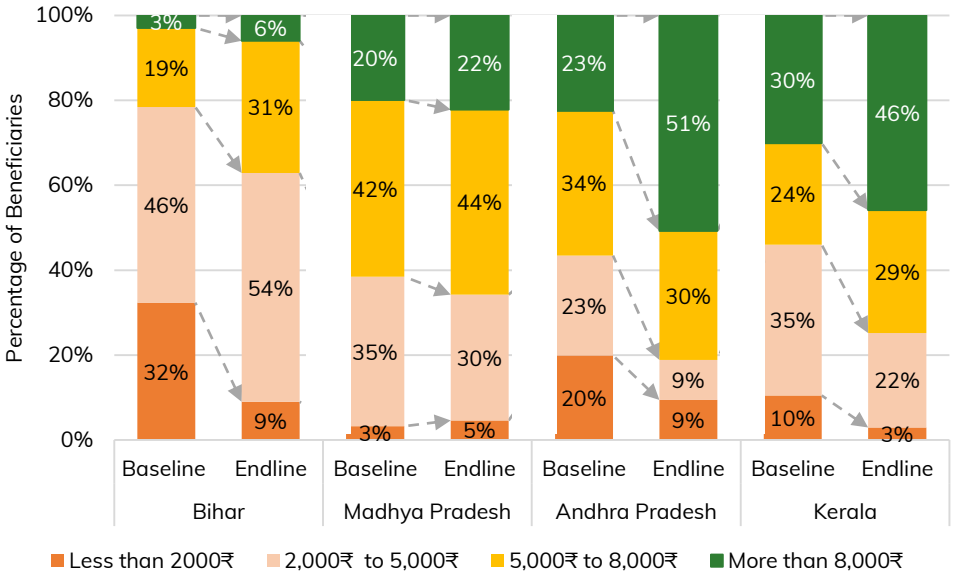
Six months after receiving the e-bicycle, beneficiaries report noticeable changes in their income levels. The distribution of monthly income across states shows an upward shift six months after beneficiaries received the e-bicycle.

48% of women reported an increase in their monthly income, of which around 73% experienced an average increase of ₹3,517.

In **Bihar**, the share of beneficiaries in higher income brackets increases, with those earning **₹5,000–₹8,000 rising from 19% at baseline to 31%** at endline, and those earning more than ₹8,000 increasing from 3% to 6%. A **sharp decline in the lowest income** (32% at baseline to 9% at endline for income up to ₹2000) category is also observed, indicating movement to higher categories. In Madhya Pradesh, there is a slight shift toward the ₹5,000–₹8,000 income bracket (from 42% to 44%), indicating modest income growth.

In **Andhra Pradesh and Kerala**, the share of beneficiaries earning more than **₹8,000 per month increases substantially** (Andhra Pradesh: 23% to 51%; Kerala: 30% to 46%), alongside a decline in the lowest income categories. These shifts in income levels, as shown in Figure 8, correspond with the expansion of livelihood activities enabled by improved mobility through the e-bicycle.

Figure 8: Individual-level income change between baseline and endline



Overall, across the four states, **48% of women reported an increase in their monthly income**, indicating improved earning opportunities associated with better mobility. Among those reporting an increase, **73% experienced an average rise of ₹3,517**, while **23% reported a higher average increase of ₹8,064**.

The overall upward shift in income distribution suggests a positive income trajectory, with enhanced mobility through the e-bicycle contributing to expanded earning opportunities.

35% of beneficiaries in Bihar reduced their monthly travel expenditure to zero after receiving the e-bicycle.

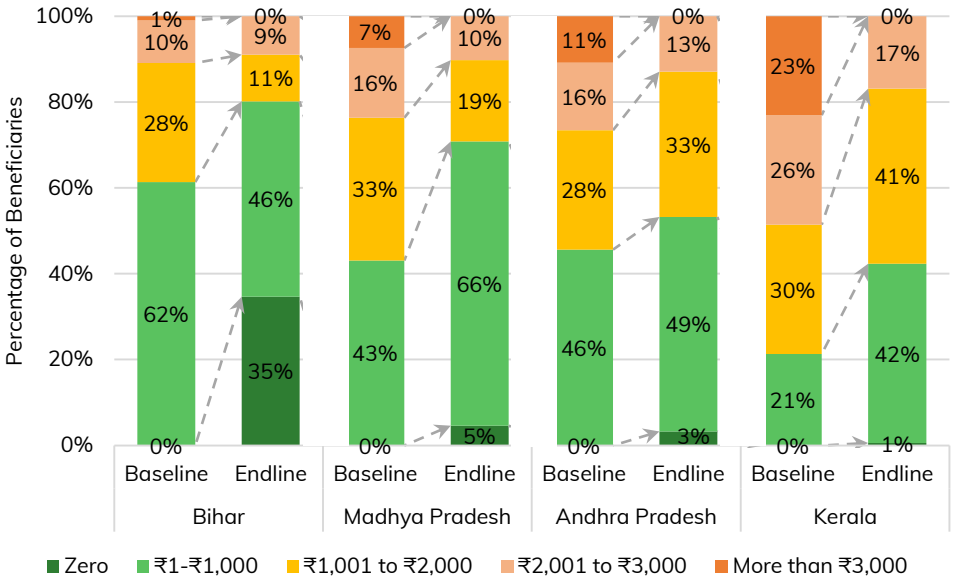
3.5.2 Change in Travel Expenditure

The distribution of monthly travel expenditure shows notable shifts between baseline and endline, with many beneficiaries reporting reduced spending after receiving the e-bicycle (see Figure 9). In Bihar, the share of beneficiaries reporting zero travel expenditure increased from 0% at the baseline to 35% at

the endline, as they were no longer dependent on paid transport since using the e-bicycle. In Madhya Pradesh, the most prominent change is the decrease in beneficiaries spending above **₹2000 per month (23% at baseline to 10% at endline),** indicating a shift from higher expenditure brackets to lower travel costs.

In Andhra Pradesh also the largest movement is the decline in the decrease in beneficiaries spending above **₹2000 per month (27% at baseline to 13% at endline),** reflecting reduced travel expenditure among a substantial share of beneficiaries. In **Kerala**, the most significant change is the sharp reduction in the **highest expenditure category** (more than ₹3,000), which falls from **23% at baseline to none at endline**, indicating a clear decline in high travel cost.

Figure 9: Individual-level travel expenditure change



The results indicate a clear net reduction in travel expenses at the individual level, with a substantially larger proportion of beneficiaries moving toward lower expenditure than toward higher expenditure over the intervention period.

Monthly Savings in Travel Expenditure

The use of e-bicycles has resulted in notable savings in travel expenditure across all four states. The bar chart in Figure 10 presents the monthly individual travel savings among beneficiaries whose travel expenditure decreased between baseline and endline. These savings are calculated using the midpoint estimation method, wherein each travel expense slab was assigned a representative midpoint value, and the difference between estimated baseline and endline expenditure was computed at the individual level.

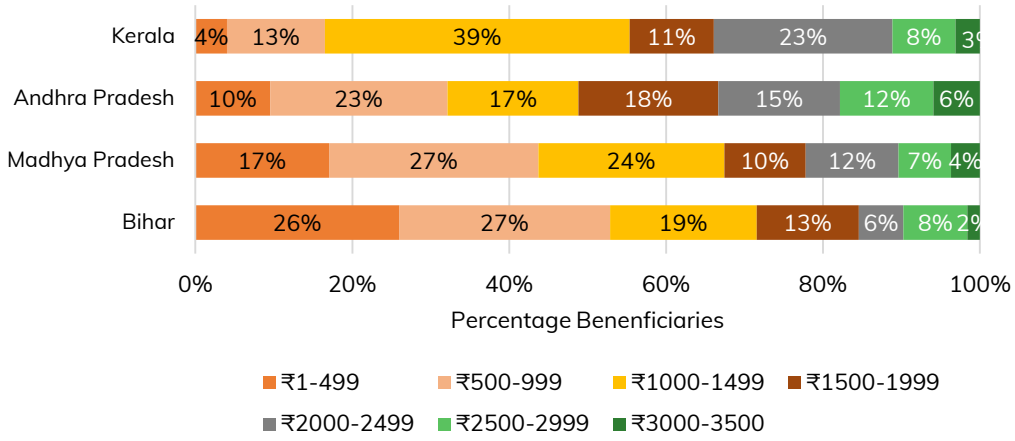
In Bihar, a substantial share of women in **Bihar (74%)** reported reduced travel expenditure after receiving the e-bicycle with an average monthly saving of ₹1,093 per person. In **Madhya Pradesh, 63%** of beneficiaries reported reduced

On an average, 60% of beneficiaries reported savings in travel costs, with an average monthly saving of ₹1,356 per person.

travel expenditure, averaging ₹1,282 per month per person. In **Andhra Pradesh, 41%** of beneficiaries reported reduced travel expenditure, with an average saving of ₹1,527 per month, while in **Kerala, 60%** of beneficiaries reported reduced travel expenditure, averaging ₹1,482 per month per person.

The state-wise distribution of travel savings is illustrated in Figure 10, showing the percentage of beneficiaries reporting savings across different expenditure slabs. These percentages in the figure are calculated **only among those beneficiaries who reported savings in travel expenditure.** Overall, **60%** beneficiaries reported savings in travel expenditure of **₹1,356** on an average across the four states.

Figure 10: Monthly individual savings on travel expenses



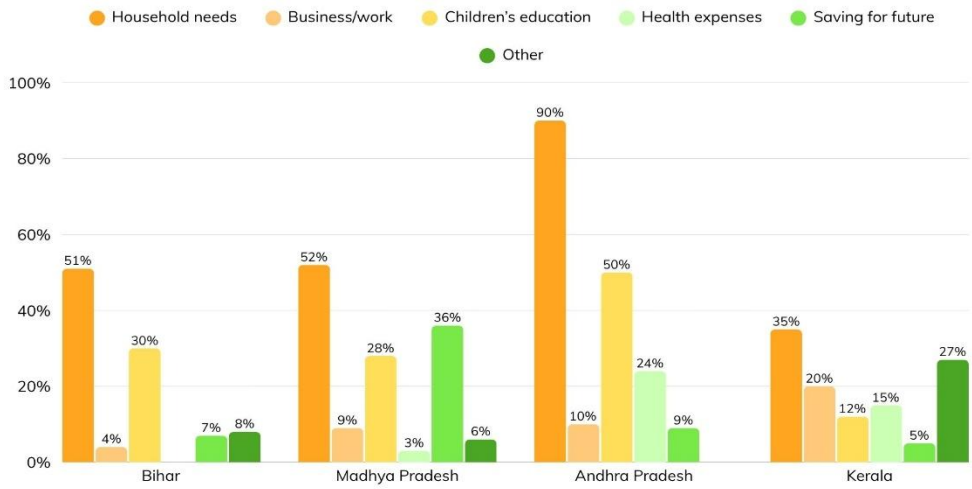
Use of Savings from Travel Expenses

The reported uses of travel savings among beneficiaries who experienced a reduction in travel expenditure are presented in Figure 11. Beneficiaries report using savings from reduced travel costs for a range of household and livelihood-related needs. Across states, the most common use is for **household expenses**, reported by **51% in Bihar, 52% in Madhya Pradesh, 90% of beneficiaries in Andhra Pradesh and 35% in Kerala**.

A substantial share also allocates savings toward children's education and health expenses. Savings are also used for household needs, business or work activities, and other purposes. Some beneficiaries report setting aside savings for the future or for e-bicycle care and maintenance.

Travel savings are being directly reinvested into core welfare, with up to 90% of beneficiaries prioritizing daily household needs.

Figure 11: Utilization of money saved from travel expenses



The above patterns indicate that savings generated through reduced travel costs are largely reinvested in household well-being and livelihood-related priorities.

3.6 Impact on Wellbeing indicators

This section examines changes in beneficiaries' well-being and social experiences associated with improved e-mobility. It focuses on travel-related comfort, stress, confidence, and time pressure, along with family and community responses to women's use of the e-bicycle.

The analysis draws on beneficiary-reported responses to capture both individual-level well-being outcomes and shifts in social perception following sustained use of the e-bicycles.

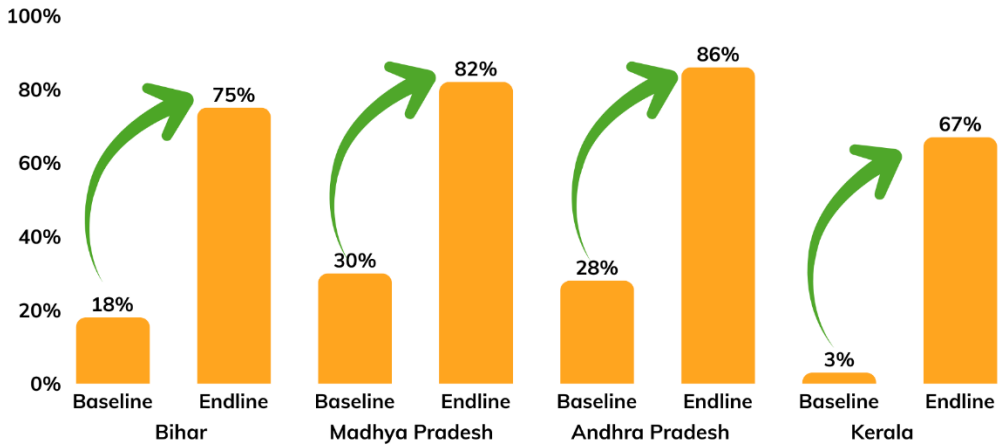
3.6.1 Comfort Levels

Beneficiaries report substantial improvements in travel comfort after receiving e-bicycles across all states as seen in Figure 12. In Bihar, share of beneficiaries reporting '**comfortable'** travel increased from **18% to 75%.** In Madhya Pradesh, the proportion reporting 'comfortable' travel rose from **30% to 82%**.

In Andhra Pradesh, the share reporting 'comfortable' travel increased from **28% at baseline to 86% at endline.** Kerala shows a similar shift, with beneficiaries reporting 'comfortable' or 'very comfortable' travel **increasing from 3% to 67%** alongside a sharp reduction in discomfort.

In Bihar, travel comfort ratings skyrocketed from 18% at baseline to 75% following e-bicycle adoption.

Figure 12: Increase in comfort levels due to e-bicycles



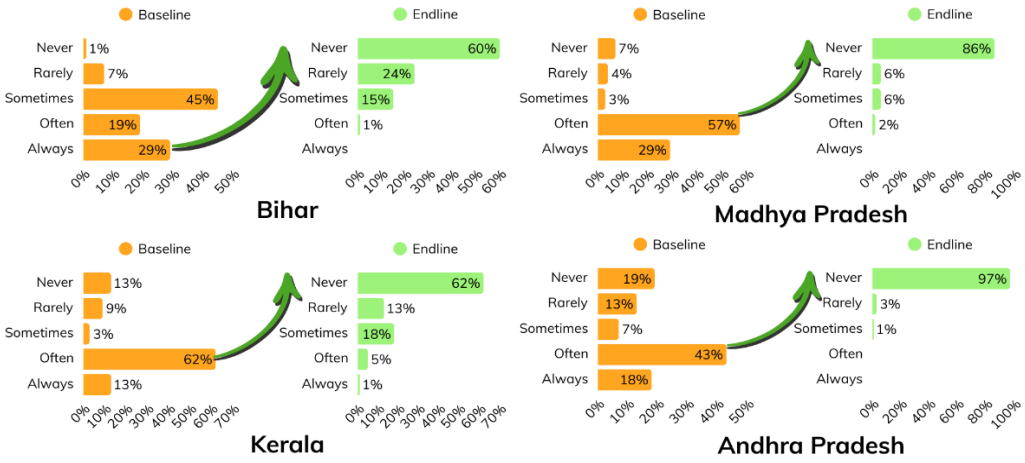
These patterns indicate a consistent improvement in beneficiaries' travel experience following access to e-bicycles.

3.6.2 Physical Stress

Physical strain associated with daily travel shows a clear decline across states after the introduction of the e-bicycle as seen in Figure 13. In **Bihar**, the share of beneficiaries reporting no physical stress increases from **1% at baseline to 60% at** endline, while those experiencing stress often or always decline sharply from 48% to 1%. In **Madhya Pradesh**, the share of beneficiaries reporting no physical stress rise from **7% to 86%,** accompanied by a steep reduction in frequent stress. In **Andhra Pradesh**, improvements are even more pronounced, with the share reporting never experiencing physical stress increasing from **19% to 97%. Kerala** also shows a positive shift, with the share reporting no physical stress rising from **13% to 62%,** alongside a substantial decline in frequent stress.

Beneficiaries in Andhra Pradesh reporting they "never" experience travel-related physical stress surged from 19% at baseline to 97% at endline.

Figure 13: Physical stress caused from travel at baseline vs endline



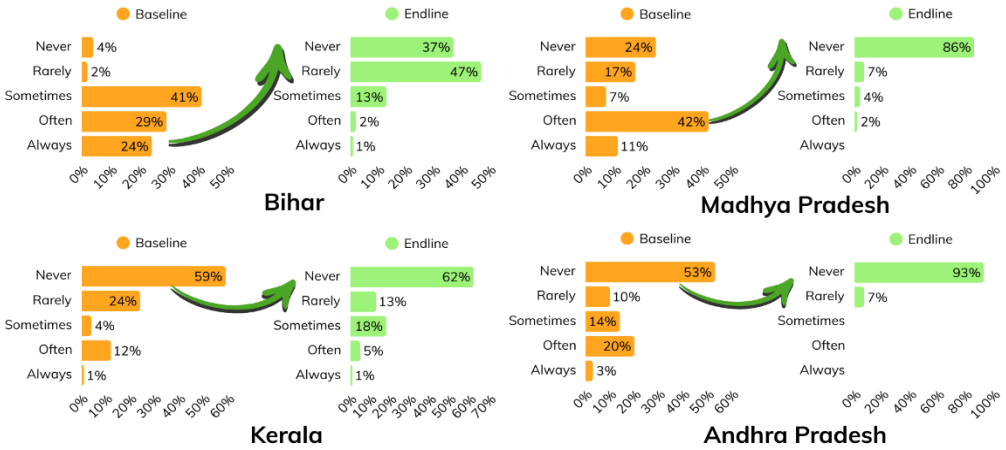
This **reduction in physical stress** is likely **associated with the shift away from earlier travel patterns that involved walking long distances, travelling in crowded buses or shared autos, changing vehicles during trips, or waiting for transport.**

The availability of a self-operated e-bicycle **has made daily travel less physically demanding and more convenient for many beneficiaries**.

3.6.3 Emotional Stress

Improved mobility through the e-bicycle has significantly reduced travel-related emotional stress among beneficiaries across states as seen in Figure 14. In Bihar, emotional stress related to travel shows a substantial improvement, with beneficiaries reporting **never** experiencing stress increasing from **4% at baseline to 37%** at endline, while those reporting **stress often or always decline sharply from 53% to 3%.** In Madhya Pradesh, the improvement is even more pronounced, with the share reporting **never** experiencing stress rising from **24% to 86%,** alongside a sharp reduction in frequent stress. In Andhra Pradesh, beneficiaries reporting **never** experiencing stress increase **from 53% to 93%,** indicating a strong shift toward more comfortable travel experiences. Kerala also shows a positive change, with the share reporting **no emotional stress** rising from **59% to 83%,** accompanied by a decline in frequent stress.

Figure 14: Emotional stress caused from travel at baseline vs endline



The above trends indicate that there is a clear **reduction in travel-related emotional stress** across all states following the introduction of e-bicycles. This shift is likely ***driven by increased independence in mobility, reduced reliance on external transport, and greater predictability in travel time.***

3.6.4 Enhanced Confidence and Social Perception through E-Mobility

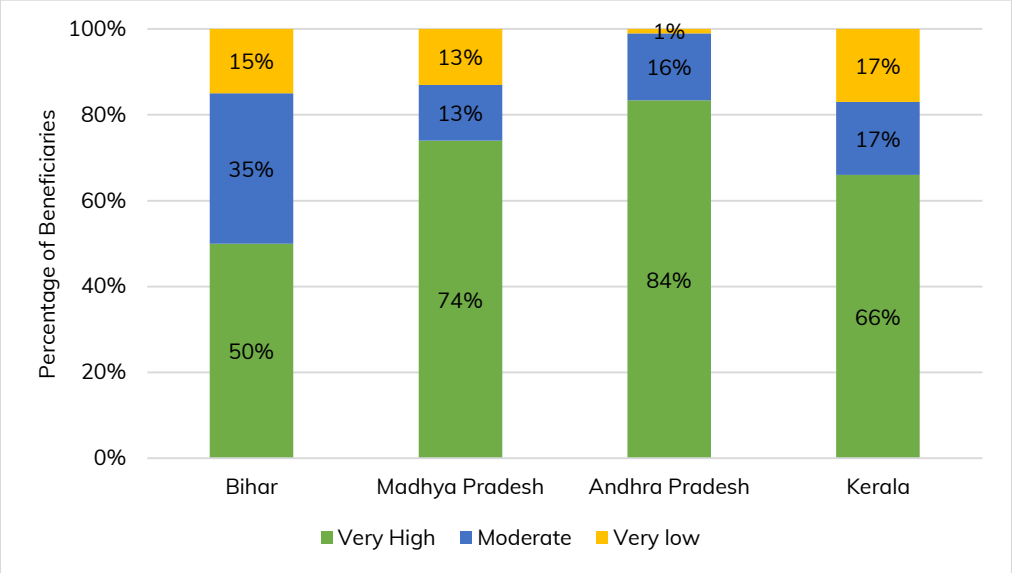
This sub-section reports the changes in the beneficiaries' confidence in travelling independently and the nature of family and community responses to their use of the e-bicycle.

Everyday Empowerment Through Mobility

For many beneficiaries, learning to ride and regularly using the e-bicycle marked an important personal milestone. What began as a mobility intervention gradually translated into greater confidence in travelling independently, managing daily responsibilities, and participating more actively in work and community life.

As seen in Figure 15, i**n Bihar, 50% of the beneficiaries reported very high confidence** and another 35% reported moderate confidence, indicating that most beneficiaries have become confident using the e-bicycle for their daily travel. In **Madhya Pradesh**, confidence levels were particularly strong, with **74%** beneficiaries who reported **very high confidence** in riding. Similarly, in **Andhra Pradesh** a large majority **(84%)** reported **very high confidence** and almost none indicating very low confidence. In **Kerala** as well, more than half the beneficiaries **(66%)** reported **very high confidence** in riding the e-bicycle.

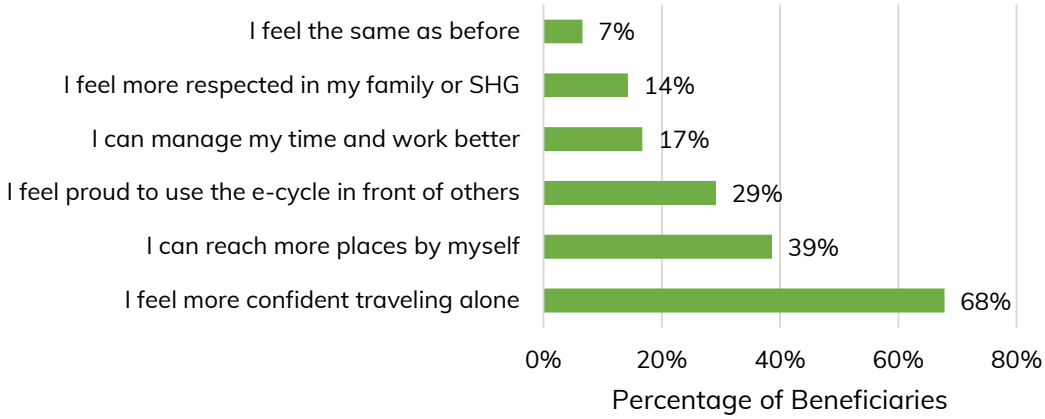
Figure 15: Confidence in riding the e-bicycle



Overall, across states, most beneficiaries reported high levels of confidence in riding the e-bicycle. Beyond riding confidence, beneficiaries also report several personal changes after using the e-bicycle as shown in Figure 16. As this was a multiple-response question, beneficiaries could choose more than one option, and the percentages reflect how many reported each change.

Many beneficiaries reported feeling **more confident travelling alone**, being **able to reach more places independently, and managing their time more efficiently**. Some beneficiaries also mention **feeling proud while using the e-bicycle in public, reflecting a sense of personal achievement and visibility within the community**.

Figure 16: Self-reported changes after receiving e-bicycle across the four states



Looking across the states, the pattern suggests that **the most immediate effects of access to e-bicycles are related to confidence, independent mobility, and everyday convenience, while social recognition and perceived respect emerge for some groups**. The differences in emphasis across locations reflect how local conditions and social contexts shape the ways in which mobility improvements are experienced.

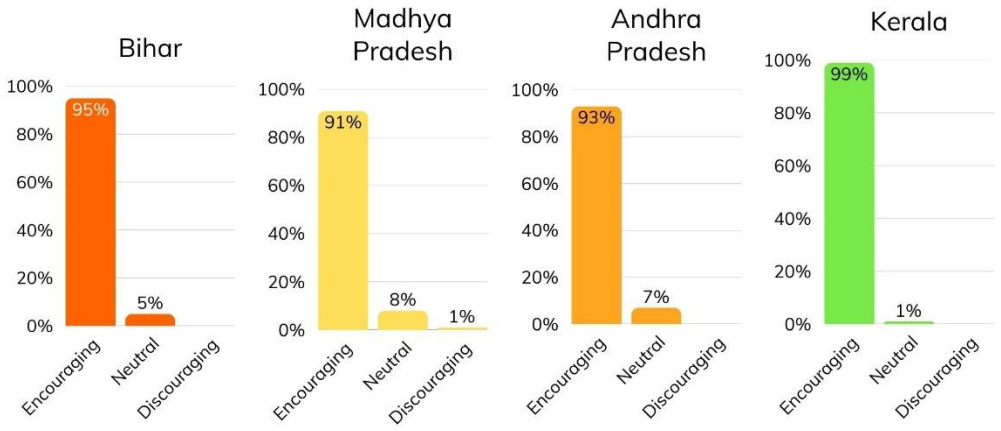
Family and community responses to e-bicycle usage

Family and community responses to women's use of e-bicycles are largely positive across states, **indicating a supportive environment for women's mobility** as seen in Figure 17 and Figure 18. In Bihar, beneficiaries reported encouraging responses from family and community members, while a few others describe neutral responses, suggesting that women travelling independently for daily activities is increasingly being accepted within households and communities.

In Madhya Pradesh, family and community responses were predominantly supportive, with several beneficiaries noting curiosity from others about the e-bicycle. In Andhra Pradesh, encouraging responses are particularly strong, reflecting widespread acceptance of women using e-bicycles for work and daily travel. Kerala also shows high levels of support, alongside visible curiosity and interest from family and community members.

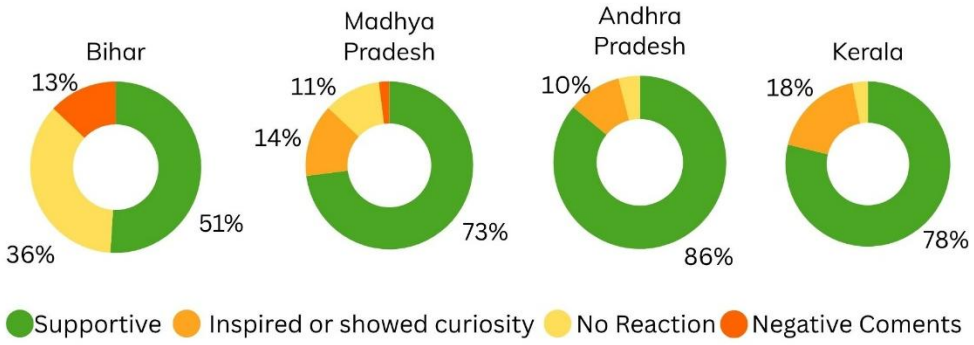
Family and community responses to women using e-bicycles were largely supportive, with 42% of beneficiaries reporting curiosity and questions from others.

Figure 17: Family response to use of e-bicycle



These responses point to a **meaningful shift in local social norms**. In several cases, women reported that mobility outside the home had earlier been restricted or dependent on other family members. The e-bicycle has enabled many of them to travel independently for work and daily needs, and in some households the same cycle is now being used by other family members as well. This indicates **growing recognition of women's mobility as both useful and legitimate within the household**.

Figure 18: Community response to use of e-bicycle



Importantly, across the four states, a substantial proportion of beneficiaries reported that people around them expressed curiosity or interest in the e-bicycle. Cumulatively, about 42% of beneficiaries noted that others were curious about the cycle or asked questions about it. This suggests that **women's visible use of e-bicycles is not only being accepted, but is also generating interest and signalling potential demand for similar mobility solutions within the communities**.

3.7 Environmental Impact

The data of total distance travelled using the e-bicycle was compiled for the beneficiaries with available readings, resulting in a total sample of **1,389 e-**

bicycles. This exceeds the core analytical sample as it includes extensive GPS-based records covering nearly all e-bicycles in Bihar, along with display-based readings, wherever available, from both users and non-users in the remaining three states.

Based on this dataset, the beneficiaries across the four states travelled a total of **13,05,540 km**, with a **mean of 938 km** and a **median of 542 km**. State-wise distribution (Table 5) shows that **Bihar records the highest usage**, with some beneficiaries exceeding **6,000 km**, indicating extensive use. **Madhya Pradesh** also records relatively high usage. In contrast, **Andhra Pradesh and Kerala** show more concentrated distributions at lower kilometre ranges, as reflected in their mean and median values. In Kerala, usage may have been influenced by monsoon conditions and terrain constraints, particularly in parts of Kannur district. These variations reflect differences in travel needs, livelihood activities, and local conditions across states.

The use of e-bicycles avoided 45 tonnes of CO_2 emissions, which is equivalent to the carbon sequestration potential of 2,143 mature trees.

The recorded distance travelled provides the basis for estimating the **environmental impact** associated with the shift from fossil fuel-based transport to electric bicycles. Emissions were calculated by applying standard emission factors to the recorded distances and comparing them with emissions from equivalent travel by petrol scooters (refer Annexure II for methodology and emission factors). State-wise figures on avoided emissions and their equivalent carbon sequestration potential, in terms of number of trees, are presented in Table 5.

Table 5: State-wise avoided emission estimates based on e-bicycles use

State	Sample Size	Kilometres Travelled			Avoided Emissions*	Trees Equivalent
		Total	Mean	Median		
Bihar	490	7,89,749	1,612	1,345	5.0	238
Madhya Pradesh	242	2,39,800	991	701	8.3	394
Andhra Pradesh	255	1,44,544	567	366	4.5	213
Kerala	402	1,29,447	322	206	27.3	1,298
Total	**1,389**	**13,03,540**	**938**	**542**	**45.0**	**2,143**

**In tonnes of CO_2.*

Across the four states, cumulatively, the recorded e-bicycle travel resulted in approximately **12.8 tonnes of CO_2 emissions**, while equivalent travel by petrol scooters would have generated about **57.7 tonnes of CO_2.** This corresponds to an **estimated avoidance of 45 tonnes of CO_2 emissions** during the study period, equivalent to the annual carbon sequestration potential of approximately **2,143 mature trees**.

Insights from Case Studies

The findings from the quantitative analysis demonstrated the changes due to the introduction of the e-bicycle at the programme level and the scale of those changes. To understand **how** these changes occurred in practice, the following section focuses on qualitative aspect by highlighting **individual case studies**. These narratives complement the quantitative results by showing how women used the e-bicycle in their everyday work, how delivery practices and decision-making evolved, and how similar constraints led to different livelihood outcomes. Together, the case studies provide a grounded view of the mechanisms through which the e-bicycle translated aggregate gains into lived improvements.

4.1 Bihar: Independent Door-to-Door Delivery and Income Strengthening

Sunita Devi – Muzaffarpur, Bihar

Sunita Devi, a 35-year-old Community Mobiliser with Jeevika Mission, regularly travels within her cluster to conduct SHG meetings and visit banks and CLF offices. Alongside her community work, she manages a small floriculture enterprise, cultivating marigold flowers for local markets. Earlier, travelling to fields and work locations depended on auto-rickshaws or the availability of her husband's motorcycle, which often limited her ability to manage cultivation in plots located farther from home

After receiving the e-bicycle, Sunita began using it for both her SHG responsibilities and farm-related travel. The improved mobility enabled her to lease additional farmland located at a greater distance, allowing her to expand the area under marigold cultivation and manage her fields more independently. She shared that with the expanded cultivation she is now targeting seasonal earnings of around **₹1 lakh from her flower harvest,** something she associates directly with the improved mobility provided by the e-bicycle. The e-bicycle has become an important asset in supporting her livelihood activities while strengthening her confidence in travelling and working on her own.

> ***"80% credit of my livelihood expansion goes to e-bicycle. With e-bicycle I have a sense of ownership as this is the first asset in my name."***

4.2 Madhya Pradesh: Reduced Dependency and Household Mobility Support

Sarita – Seku Kheda, Sehore, Madhya Pradesh

Sarita works as a Lakhpati Community Resource Person and along with it she runs a small Maniyari (cosmetic and bangles) shop. Earlier, she depended largely on her husband to procure shop supplies from Jawar a small town near her village. If he was unavailable, she had to arrange alternative transport, often waiting one to two hours to find a vehicle. Travel expenses ranged between ₹300–400 per month, including bus fares and fuel contributions when using others' bikes.

After receiving the e-bicycle, Sarita began independently travelling to Jawar to purchase shop inventory and attend meetings. The need to coordinate with others for mobility reduced significantly. The e-bicycle is now shared within the household, to drop children for school, and by her father-in-law when required, reducing overall fuel expenditure. She has travelled 1,676 km on the e-bicycle in six months.

> *"My husband used to get things for me. And now I go there (to the market) myself. Earlier, he had to tell me to get things for the shop. If he didn't have time, then I had to wait for him. But now I get things myself."*

The most notable shift in Sarita's case is the reduction in dependency. She no longer waits for her husband's availability and can manage shop procurement herself. Community perception has also shifted, with others observing her independence and expressing interest in similar cycles. Transport savings are being directed toward future plans, including house construction and children's education.

> *"The e-bicycle is very helpful, my husband uses the cycle whenever he has some work, children also take the cycle to school. And whenever I have work, I'll take the cycle and go for the work. I'll take the cycle to buy items for shop and to also attend the meetings."*

4.3 Andhra Pradesh: Reducing Physical Strain and Improving Business Continuity

Neelamma – Chinnakurubulapalle, Andhra Pradesh

Neelamma runs a small grocery (kirana) store and is also engaged in goat farming. Prior to receiving the e-bicycle, she travelled to the market by walking and auto. A single market trip took 3–3.5 hours including travel and procurement. Auto fares cost approximately ₹300 per round trip, amounting to nearly ₹2,000 per month. On days when she could not get autos or any other transport modes, she carried goods on her head while walking back, making daily travel physically exhausting.

After receiving the e-bicycle, her total market trip time reduced to under two hours. Travel has become less physically demanding and assured. She now uses the e-bicycle to procure shop inventory, visit town, attend hospital visits, and provide emergency home deliveries.

While customer numbers and sales volume have remained largely stable, the e-bicycle has improved operational efficiency. She saves approximately ₹1,000 per month in travel expenses, which she reinvests into shop inventory to improve stock rotation.

> *"Before I got the cycle, the hard part was going walking, and after that, doing household errands. I had to run faster to complete my works. After receiving the cycle, I feel free, now I can go faster to complete work and come back faster, I don't feel any difficulty, it feels easy and comfortable. I deliver the (shop) items to houses when it's an emergency using the e-bicycle."*

4.4 Kerala: Increased Sales through Product Visibility

Aiswarya – Palakkad, Kerala

Aiswarya is a small entrepreneur who earlier combined SHG-related work with sale of handmade products. Before receiving the e-bicycle, her mobility depended on buses, auto-rickshaws, or walking. Reaching the bus stop itself required time and effort, and missed buses often meant cancelled trips. As a result, sales and deliveries were planned around transport availability rather than opportunity.

After receiving the e-bicycle, Aiswarya began using it as her primary mode of mobility. Over six months, she has travelled 2,001 km on the e-bicycle. Her monthly travel expenses reduced from 'above ₹3,000' to about '₹500–1,000', saving her around ₹2,000 per month. This shift reduced dependence on public transport and gave her greater control over commute.

The most significant change, however, was how movement itself became a source of sales. Carrying products visibly on the e-bicycle turned routine travel into an opportunity for interaction and unplanned purchases.

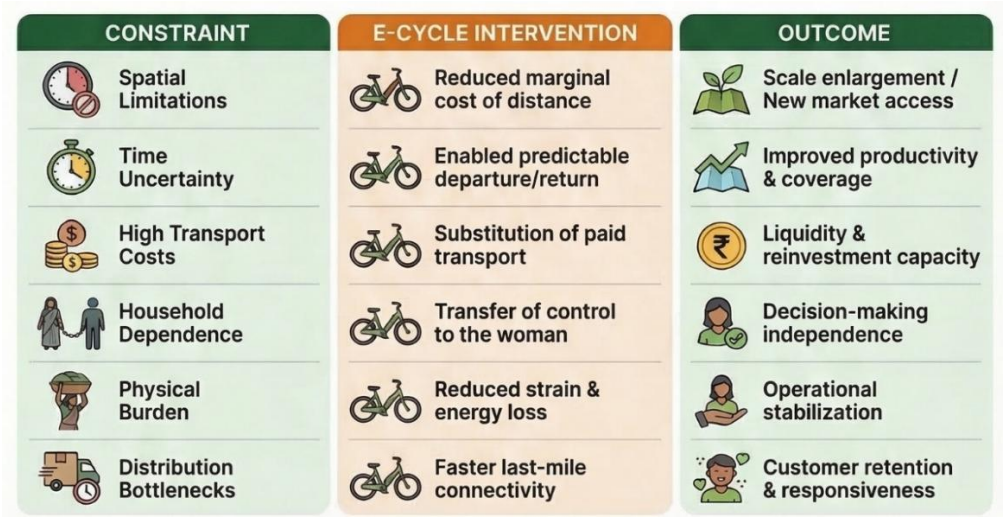
> *"Earlier, we used to walk and carry goods in a bag to deliver them. But now, when I go to the Panchayat office on the cycle, I put the items in the basket, and when people see it, they ask me what the goods are, what the product is, and then they buy it from me. When we carry it, people on the way, including acquaintances, ask about it when they see it. So, they ask and buy it like that. So, there has been a change in the business."*

Alongside this increased visibility, the e-bicycle also gave Aiswarya control over the timing of her work. She no longer had to plan trips around bus schedules and could respond immediately to customer's demand.

4.5 Summarising the Case Studies

The case narratives reveal recurring patterns in the types of mobility constraints women faced and the ways in which improved access to transport altered their daily work and decision-making. Figure 19 summarises these cross-case patterns, outlining the systemic pre-intervention constraints, the mechanisms through which the e-bicycle intervened, and the nature of outcomes that followed.

Figure 19: Summary of case studies



Har ghar mein ek electric bicycle ...

Summary and Way Forward

This chapter discusses the findings from the impact analysis to develop an integrated understanding of the outcomes of the intervention. It concludes by outlining key considerations and recommendations for strengthening programme implementation and guiding the future scale-up of such mobility interventions.

5.1 Discussion

This section reflects on the key patterns emerging from the study findings and examines their implications for mobility, livelihoods, economic outcomes, and well-being across the four states.

Mobility as an Enabling Input

Quantitative findings show that the e-bicycle has become part of daily mobility across states, though adoption patterns differ. **Bihar records the highest cumulative distance travelled**, indicating intensive use among a segment of beneficiaries. **Madhya Pradesh shows high adoption and frequent use**, with many reporting daily or near-daily travel. In **Andhra Pradesh**, overall adoption is lower, though active users report frequent work-related travel. **Kerala shows more moderate usage**, influenced by public transport availability, monsoons, terrain, and the shorter time gap since distribution.

Qualitative narratives show how the e-bicycle reshaped everyday mobility. Beneficiaries reported reduced waiting time, less dependence on buses or hired autos, and greater predictability in travel. The e-bicycle gave users more control over travel timing and routes. In **Bihar**, it often replaced hired auto-rickshaws. In **Madhya Pradesh and Andhra Pradesh**, it substituted walking or shared transport. In **Kerala**, it largely complemented existing transport options.

Livelihood Intensification Rather than Occupational Shift

Improved mobility enabled beneficiaries to travel more frequently for work and reach markets, customers, and suppliers more easily. As a result, many women were able to operate their enterprises more actively and increase the visibility of their products and services within local markets. In **Bihar**, women engaged in food processing, retail shops, and Jeevika initiatives such as *Didi ki Rasoi* and *Didi ka Adhikar Kendra* reported improved access to markets and customers. In **Madhya Pradesh**, women running grocery shops, tailoring units, and beauty services used the cycle for procurement, deliveries, and SHG-related work. In **Andhra Pradesh**, improved mobility supported agricultural activities as well as services such as milk collection and local deliveries. In **Kerala**, beneficiaries used the e-bicycle to strengthen SHG-linked enterprises, food businesses, and delivery-based services.

Overall, improved mobility enabled beneficiaries to **extend delivery areas, increase work-related travel, and connect with new customers**, thereby expanding the scale and efficiency of their existing livelihood activities. The e-bicycle therefore functions as a **livelihood-enabling asset**, strengthening market access and supporting the growth of small enterprises.

Economic Effects: Cost Compression and Income Variation

Across states, the introduction of e-bicycles led to noticeable reductions in travel expenditure. **Bihar shows the most visible reduction**, with many beneficiaries reporting zero transport expenditure after shifting away from hired autos. **Madhya Pradesh**, **Andhra Pradesh**, and **Kerala** also show a clear shift from higher travel costs to lower expenditure brackets, with very few beneficiaries remaining in the highest travel cost categories.

Income changes are also visible across states, driven by improved market access, greater work participation, and expanded customer reach enabled by the e-bicycle. **Bihar shows movement out of the lowest income categories**, while **Madhya Pradesh** reflects gradual improvements within middle income bands. **Andhra Pradesh and Kerala** show stronger growth in higher income brackets among some beneficiaries.

Economic gains emerged through two main pathways:

1. **Reduced travel costs**, which improved household cash flow.
2. **Increased income opportunities**, as better mobility enabled more frequent work and access to customers and markets.

Time Reallocation and Work–Life Balance

Time savings are reported across all states, though patterns differ. **Bihar and Madhya Pradesh** show **moderate** but consistent reductions in daily travel time. Andhra Pradesh and Kerala show larger shares of beneficiaries reporting savings of up to thirty minutes per day.

The use of saved time varies by context. In Bihar, time savings are often absorbed into caregiving and family responsibilities. In Madhya Pradesh, time is distributed between family responsibilities and SHG activities. In Andhra Pradesh, most beneficiaries reinvest saved time in work and income-generating activities. In Kerala, a notable share reported using the saved time for rest or recovery. Qualitative narratives suggest that predictability of travel, rather than time reduction alone, played a critical role in improving productivity.

Well-Being and Confidence Gains

Across all four states, access to the e-bicycle has led to significant improvements in women's well-being. Beneficiaries report greater travel comfort, reduced physical strain, lower emotional stress, and higher confidence in riding independently as they transitioned from walking or relying on hired transport to a self-operated mode of mobility.

A particularly notable change is the growth in women's confidence and independence. For many beneficiaries, regularly using the e-bicycle represents an important personal milestone. Women described feeling more capable of travelling alone, managing their time better, and reaching work, markets, and institutions without depending on others.

The e-bicycle acts as a mobility-enabling input that reduces cost, saves time, and increases operational flexibility.

The intervention has also contributed to gradual shifts in social norms. As women began travelling independently for work and community engagements, their presence in public spaces became more visible and accepted. Many beneficiaries reported curiosity and positive reactions from others, signalling growing recognition of women's mobility as both practical and legitimate.

Together, these changes show that the e-bicycle functions not only as a mobility asset, but also as a catalyst for **greater confidence, autonomy, and active participation in economic and community life**.

Household-Level Asset Dynamics

Usage patterns vary across households. In Bihar, the e-bicycle is often shared among household members. In Madhya Pradesh and Kerala, beneficiaries more commonly retain primary control over the asset. In Andhra Pradesh, usage patterns are mixed, with beneficiaries using the e-bicycle for work while other family members may also use it occasionally. Even when shared, the e-bicycle often reduces household transport costs and strengthens women's mobility within the household.

Environmental Impact

Distance data compiled from beneficiaries across the four states indicate substantial use of e-bicycles, with variations in usage patterns across regions. Bihar and Madhya Pradesh reflect relatively higher and more intensive use, while Andhra Pradesh and Kerala show more concentrated usage at lower distance ranges, shaped by differences in travel needs, livelihood activities, and local conditions such as terrain and weather. Based on these travel patterns, emissions from e-bicycle use are lower than those from equivalent travel by petrol-based modes, resulting in avoided CO_2 emissions over the study period. These avoided emissions are equivalent to the carbon sequestration capacity of a large number of mature trees, underscoring the environmental benefits of such interventions.

5.2 Summary of the Findings

The findings across **Bihar, Madhya Pradesh, Andhra Pradesh, and Kerala** show that access to cargo e-bicycles can generate meaningful improvements in mobility, livelihoods, and well-being within a relatively short period. By providing a reliable and self-operated mode of transport, the intervention addresses a critical constraint faced by many workers and service providers in rural and semi-urban areas, namely limited and inefficient mobility for short-distance travel.

Across the four states, the e-bicycle enabled beneficiaries to travel more frequently for work, reach markets and customers more easily, and operate their livelihood activities with greater efficiency. Reductions in travel time and transport expenditure also improved household financial flexibility and allowed beneficiaries to allocate time more effectively between work and personal responsibilities.

The intervention demonstrates several interlinked outcomes:

- **Improved mobility and time efficiency**, enabling more predictable and flexible travel for work and daily activities
- **Strengthened livelihoods**, through expanded customer reach, improved product visibility, and greater efficiency in agriculture, delivery services, retail, and SHG-linked enterprises
- **Greater confidence and independence**, as beneficiaries are able to travel and manage work activities more autonomously
- **Household-level economic benefits**, through recurring savings in transport expenditure and improved access to income opportunities
- **Environmental benefits**, through reduced reliance on fossil fuel-based transport for short-distance mobility

E-bicycles increased family savings by cutting travel costs and grew business income by allowing women to reach more customers.

Taken together, the findings suggest that e-bicycles can serve as an effective micro-mobility solution for a wide range of livelihood and service-related activities in rural and semi-urban contexts. These outcomes highlight the potential for e-micro-mobility solutions to be integrated more systematically into livelihood and service delivery ecosystems. The following section therefore outlines key considerations and recommendations for strengthening programme implementation and enabling responsible scale-up.

5.3 Way Forward

Field observations, along with quantitative and qualitative findings, indicate that the programme has delivered significant impact within a short period. At the same time, achieving large-scale transformative impact will require stronger financial structuring, institutional integration, and a supportive product and market ecosystem. This includes improving affordability for end users, strengthening manufacturing ecosystems, and ensuring product

standardisation. The recommendations below are structured at and policy and programmatic levels.

5.3.1 Scaling and Institutional Ecosystem for Mobility Interventions

Integrating E-bicycles with SHGs and Livelihood Missions

The intervention has demonstrated the value of linking e-bicycle access with SHG and rural livelihood platforms, which can serve as strong local institutional anchors for mobility initiatives. This presents a significant opportunity for scaling, given the presence of **over 10 crore women across nearly 90 lakh SHGs** under the **National Rural Livelihoods Mission (NRLM),** as per the Ministry of Rural Development (PIB, 2025), along with large frontline networks such as **over 10 lakh ASHA workers** (DoHFW, 2025) **and over 13 lakh Anganwadi workers**, as per the Ministry of Women and Child Development (PIB, 2024)**.** A similar intervention may be considered for postal service and last mile delivery. Even if demand emerges from just **1% of these networks**, the potential user base would still represent a substantial number of beneficiaries creating huge impact on inclusive development, economy and environment.

Financing Models and Risk Perception

Field insights suggest that many low-income users can afford repayments of around ₹9,000–₹10,000, comparable to conventional cycle costs, but may find it difficult to make the full upfront payment. This indicates the need for financing mechanisms that align with their repayment capacity. From a financial institution's perspective, financing mobility assets for low-income users may involve perceived risks related to repayment capacity, asset misuse, or maintenance uncertainty. Addressing both affordability constraints and institutional concerns requires structured financing models rather than one-time asset distribution.

Potential approaches include:

Credit-linked procurement: Beneficiaries contribute a small down payment while the remaining cost is financed through low-interest or zero-interest loans facilitated by livelihood missions or partner banks or relevant similar institutions.

Subsidy-plus-loan structures: Partial government subsidy combined with institutional credit to reduce upfront costs while ensuring user ownership.

SHG-based financing: Collective repayment through SHG networks to reduce perceived credit risk and improve repayment discipline.

Pay-as-you-use or lease models: Monthly instalments aligned with livelihood income streams to improve affordability.

CSR–government partnerships: Blended financing where public subsidy is complemented by philanthropy or CSR contributions aligning to activities 3 and 10 of schedule VII, section 135 of the Companies Act, 2013 to lower the effective cost for users.

Multi-Agency Coordination for Scaling up

Scaling mobility interventions requires coordinated engagement across multiple actors, including Government programs and missions under various ministries, financial institutions, and private sector players such as manufacturers. At the national level, the **Ministry of Rural Development (MoRD)** can serve as a key anchor, given that largest set of target beneficiaries fall under rural area. **State Rural Livelihood Missions (SRLMs)** can facilitate beneficiary identification, training, and monitoring through their networks. The **Ministry of Power, Ministry of Road Transport and Highways, and the Ministry of Environment**, **Forest and Climate Change** can support linkages with clean energy and e-mobility initiatives.

The **Department for Promotion of Industry and Internal Trade (DPIIT) under the Ministry of Commerce and Industry** can enable production-linked incentives (PLI), support domestic manufacturing ecosystems, strengthen local supply chains, and facilitate startup and innovation linkages in the e-mobility value chain. This will help in reducing costs over time and ensure reliable availability of e-bicycles at scale.

Initiatives such as the **Rural Technology Action Group (RuTAG)** can play a critical role in testing, validation, and contextual adaptation of technologies for rural conditions. Financial institutions can develop suitable credit products, while manufacturers and service providers can ensure reliable after-sales support. Such coordinated action can help move mobility interventions beyond pilots toward structured flagship programmes.

5.3.2 Programme Implementation and Delivery Strengthening

Strengthening Beneficiary Targeting and Accountability

The effectiveness of the intervention depends heavily on whether the e-bicycle reaches women with demonstrable mobility constraints that the asset can realistically address. Selection processes should therefore move beyond basic eligibility criteria and incorporate verification of work-related travel frequency, distance patterns, and route suitability. It is also necessary to assess terrain conditions, road quality, basic user comfort (including overall compatibility and cycling familiarity), and willingness of user to transition to e-mobility alternatives. Cluster-based deployment should also be prioritised by allocating e-bicycles to multiple women within the same village or SHG cluster simultaneously can reduce the “first mover” problem and normalise women’s riding in public spaces encouraging women to overcome social barrier.

Gender-Sensitive Product Design

Feedback across states suggests scope for further design refinements to enhance women's comfort and support greater adoption and sustained use of e-bicycles. While the current design considers several gender-related constraints, improvements such as lower seat height, wider seating, saree-friendly frame design, chain covers, footrests for longer rides, reduced weight, and better horn audibility could further improve rider comfort and confidence in traffic environment.

As adoption expands, there is also a need for standardisation of e-bicycle specifications with minimum required certification, ensuring that product quality, safety, and durability are maintained while keeping the product affordable for end users.

Stabilising Usage through Service Reliability

As part of the pilot design, the e-bicycle was offered with a three-year warranty along with periodic service camps conducted by the manufacturer. Despite these provisions, unresolved technical issues were frequently cited as a reason for reduced usage. These challenges appear to stem from multiple factors including lack of awareness about service camp due to communication gaps, limited accessibility to the single service location, and the lack of technical knowledge and repair skills among local cycle repair shops which are quickly accessible to beneficiaries. Strengthening the local service ecosystem will therefore be essential to sustain user confidence and support wider adoption of the intervention. Operational improvements could include:

Establish clearly communicated escalation pathways in simple local-language formats to enable users to seek timely support.

Strengthen local repair ecosystems by improving access to maintenance services and training local cycle repair vendors, including SHG women, to service e-bicycles.

Establishing reliable spare-part supply chains and authorised repair points will further strengthen confidence in the technology.

Expanding Capacity Building and User Familiarity

Evidence from Bihar highlights the value of structured capacity-building. In the state, 50 *Energy Champions* received an intensive four-day hands-on training in small groups. These trained champions mobilised demand, facilitated aggregation, and encouraged active use of e-bicycles, resulting in noticeably higher usage intensity compared to other states where training programmes were less rigorous.

User orientation should be strengthened through refresher sessions covering pedal-assist modes, realistic battery expectations, basic troubleshooting (battery, charger, display), and safety practices for mixed traffic and uneven

terrain. Training should extend beyond early adopters to include all registered beneficiaries, particularly low-usage or hesitant riders, with hands-on support where needed.

5.4 Concluding Remarks

Taken together, the evidence from this study points to a simple but powerful insight: **when mobility constraints are reduced, a wide range of economic, social, and personal outcomes begin to shift simultaneously**.

The e-bicycle, in this context, is not merely a transport asset, but an enabling infrastructure that connects livelihoods, time use, and agency. The challenge ahead is no longer to demonstrate value, but to design systems that can deliver it consistently, affordably, and at scale. Addressing this will require moving beyond pilot-based approaches toward integrated models that combine financing, institutional convergence, product reliability, and local capacity.

As India advances its priorities around inclusive growth and clean energy transitions, embedding such mobility solutions within existing programmes and market ecosystems offers a clear and actionable pathway for scale.

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Beneficiary from Madhya Pradesh

Annexure I

Indicator Matrix for Impact Assessment

Domain	Indicator	Parameters	Measurement Description
Mobility & Transport	Change in travel time for daily work	Minutes of travel time	Reported minutes (onward + return)
	Change in monthly expenditure on travel	Monthly travel expenditure (₹)	Ranges compared pre- vs post-intervention
	% women with change in mode of transport	Reported mode of travel	Direct question + distance covered by each mode
Livelihood & Income	% women with changed individual monthly income bracket	Income bracket movement	Converted to INR estimates; baseline vs later
	% beneficiaries reporting new/expanded businesses	Business expansion, new activity	Binary + qualitative description
	% beneficiaries reporting increased customer access	Customer access reported	Binary response (improved/same/decreased)
E-bicycle Usage	% beneficiaries using e-bicycle with varying frequency	Frequency of use	Direct question (daily, weekly, occasional, never)
	% women with change in usage purpose	Usage categories	Multiple-choice (work, SHG, errands, social, health)
Comfort & Safety	% reporting increased confidence in travel	Confidence in riding	5-point Likert (very low → very high)

Domain	Indicator	Parameters	Measurement Description
	% reporting improved comfort in work travel	Comfort rating	5-point Likert (very uncomfortable → very comfortable)
	% reporting reduced stress (physical, emotional, time, traffic)	Stress type and frequency	Reported frequency (Never → Always); baseline vs later
Environmental Impact	CO_2 emissions ($kgCO_2$) avoided	Total km travelled	Survey distance × emission factor
Social & Community Perception	% women with supportive family	Family support perception	Survey (supportive/neutral/negative) + qualitative insights
	% reporting about community perception	Community support perception	Supportive/inspired/negative
	% reporting empowerment outcomes	Autonomy, respect, confidence	Multiple-choice (confidence, reach, time, respect)

Annexure II

Methodology to Estimate Avoided CO_2 Emissions

The aim of this exercise is to determine the *well-to-wheel operational emissions* (in $kgCO_2eq$ per km of distance travelled) by an e-bicycle and a petrol scooter. The system boundary for the study includes the mining and transportation of the source fuel, conversion of the source fuel into useful products such as electricity or petrol, transportation of the useful product to the end user, and finally the use of this product in the vehicle. The scope of this study includes quantifying only the *operational emissions* during the entire process, and not the embodied emissions for the vehicles or the vehicle related logistics.

E-bicycles

The well-to-wheel operational emissions associated with the use of an e-bicycle (F_{km}) can be determined in $kgCO_2eq$ per km using Equation (1):

$$F_{\mathrm{km}} = \frac{\left(\frac{F_{\mathrm{c,ex}}}{e_{\mathrm{c}}} + F_{\mathrm{kWh,t}}\right) \cdot f_{\mathrm{c,gen}} + \left(\frac{F_{\mathrm{g,pt}}}{e_{\mathrm{g}}}\right) \cdot f_{\mathrm{g,gen}} + F_{\mathrm{kWh,gen}}}{(1 - f_{\mathrm{AT\&C}}) \cdot M \cdot \eta_{\mathrm{b,rt}}} \quad (1)$$

where $F_{\mathrm{c,ex}}$ is the emission factor for the mining (extraction) of coal (in $kgCO_2eq$ per kg of coal), e_{c} is the kWh of electricity generated per kg of coal, $F_{\mathrm{kWh,t}}$ is the emission factor associated with the transportation of coal (in $kgCO_2eq$ per kWh of generated electricity), $f_{\mathrm{c,gen}}$ is the share of electricity generated by coal out of the total generated electricity (in kWh of electricity generated by coal per kWh of total generated electricity), $F_{\mathrm{g,pt}}$ is the emission factor associated with the production and transportation of gas (in $kgCO_2eq$ per m^3 of gas), e_{g} is the kWh of electricity generated per m^3 of gas, $f_{\mathrm{g,gen}}$ is the share of electricity generated by gas out of the total generated electricity (in kWh of electricity generated by gas per kWh of total generated electricity), $F_{\mathrm{kWh,gen}}$ is the emission factor associated with the power generation part for the Indian grid (in $kgCO_2eq$ per kWh of generated electricity), $f_{\mathrm{AT\&C}}$ is the percentage of the aggregate technical and commercial loss for the Indian grid, M is the e-bicycle fuel economy at full discharge (in km/kWh), and $\eta_{\mathrm{b,rt}}$ is the round-trip efficiency of the e-bicycle battery. Table 6 lists the values of the various parameters used in estimating the operational emissions for the e-bicycle.

Table 6: Parameter values used in determining F_{km} for the e-bicycle

S. No.	Parameter	Value	Reference
1.	$F_{\mathrm{c,ex}}$	0.04595 $kgCO_2eq$ per kg of coal	CIL (2024)
2.	e_{c}	1.441 kWh per kg of coal	MOSPI (2025)
3.	$F_{\mathrm{kWh,t}}$	0.00766 $kgCO_2eq$ per kWh	NTPC (2024)

S. No.	Parameter	Value	Reference
4.	$f_{c,gen}$	0.7466	MOSPI (2025)
5.	$F_{g,pt}$	0.1209 kgCO_2eq per m^3 of gas	GAIL (2024)
6.	e_g	4.219 kWh per m^3 of gas	CEA (2024)
7.	$f_{g,gen}$	0.0180	MOSPI (2025)
8.	$F_{kWh,gen}$	0.727 kgCO_2eq per kWh	CEA (2024)
9.	$f_{AT\&C}$	0.1708	MOSPI (2025)
10.	M	104 km per kWh	Motovolt (2025)
11.	$\eta_{b,rt}$	0.90	Bai et al. (2024)

This gives F_{km} to be 9.8 gCO_2eq per km for the e-bicycle.

Petrol scooter

The well-to-wheel operational emissions associated with the use of a petrol scooter (F_{km}) can be determined in kgCO_2eq per km using Equation (2):

$$F_{km} = \frac{(F_{p,ptd} \cdot \rho_p) + F_{p,use}}{M} \quad (2)$$

where $F_{p,ptd}$ is the emission factor associated with the production, transportation, and distribution of petrol (in kgCO_2eq per kg of petrol) – i.e. for the well-to-tank part, ρ_p is the density of petrol (in kg/L), $F_{p,use}$ is the emission factor associated with the use of petrol in the scooter(in kgCO_2eq per L of petrol) – i.e. for the tailpipe emission part, and M is the fuel economy of the vehicle (in km/L). Table 7 lists the values of the various parameters used in estimating the operational emissions for the petrol scooter.

Table 7: Parameter values used in determining F_{km} for the petrol scooter

S. No.	Parameter	Value	Reference
1.	$F_{p,ptd}$	0.5043 kgCO_2eq per kg of petrol	HPCL (2024), BPCL (2024), IOCL (2024)
2.	ρ_p	0.750 kg per L	Typical
3.	$F_{p,use}$	2.2559 kgCO_2eq per L of petrol	Estimated for E10 petrol
4.	M	59.5 km per L	Activa (2026)

This gives F_{km} to be 44.3 gCO_2eq per km for the petrol scooter.

For contextual interpretation, the estimated avoided emissions were also expressed in terms of **tree-equivalent carbon sequestration**. According to the **United States Department of Agriculture (USDA)**, a mature tree can absorb

approximately **0.021 tonnes of carbon dioxide per year** under typical growing conditions.

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Notes

THE STREE E-BICYCLE

Parts- • Battery Lock • Adjustable Handlebar • Front Basket • Steel Frame • Pedal • Battery • Flip Type Saddle • Front Suspension • Rear Disc Break • Front Disc Break

Beneficiary from Bihar