Impact Assessment of Tata Capital's - Green Switch Programme

Insights and Recommendations
Sattva Consulting

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Contents

Summary Findings

The Green Switch programme provides reliable and effective grid electricity while also indirectly impacting health, education and livelihood for a sustained period of time : Key Insights

100% electrification with **81%** receiving 24-hour supply and **96%** experiencing minimal outages.

63% report improved access to care and facility, **84%** HH reported **improved overall household health** and **76%** of households reported r**educed night-time stress and anxiety.**

94% households perceive **electricity as affordable. 100% HH believe paying bills is important.**

93% of households report **increased study hours** post electrification, 84% of them reported **1-3 hour** increase in daily study time. **66% have dedicated lighting for studies**.

From 89% to 1% i.e near-elimination of kerosene drives immediate health gains for locals; 68% report reduced symptoms & exposure.

Electrification is shifting households from passive support to active involvement with **88% reporting improved parental involvement in studies.**

92% household have invested and brought 1030 electric appliances post electrification indicating willingness to invest to utilize electricity and improve HH assets.

Electrification drives **productivity gains, 44% higher yields** with 27% of households reporting increased income.

Villagers reported that **electrification reduced migration for ~30% households**, while strengthening local livelihoods within seasonal economic contexts.

96% of women report **increased leisure time** and **57% complete tasks earlier;** indicating significant gains in efficiency and control over daily routines.

From over **90% feeling restricted mobility to 83% participating in evening activities,** electrification transforms night-time into a space of safety and social engagement

The Green Switch Programme: Growing Usage, Sustained Satisfaction, and Improved Affordability

(Key finding of impact assessment from 2022 and 2026)

The indicators below are drawn from two independent study rounds: 2022 and 2026, conducted across different sample sizes. As the studies do not track the same cohort, figures reflect overall programme averages at each point in time. When looked at together they offer a directional assessment of how key outcomes have shifted over time, providing a credible basis for understanding the programme's incremental impact and sustained impact across communities.

Indicators	2022	2026	Observations
Electrification meets basic needs of the HH	95%	98%	Near universal households feel that electricity sufficiently meets basic needs lighting, home appliances, and safety. A 3-point rise over four years reflects deepening confidence in the grid's reliability.
Satisfied with electricity supply	96%	100%	Satisfaction has reached 100% in 2026, improvement from an already high baseline. This indicates consistent and reliable supply, sustained VEC management, and growing community trust in the solar grid model.
Affordability of grid electricity	79%	94%	A 15% improvement in affordability is a strong signal. As households increase usage and experience tangible benefits.
Average monthly HH electricity usage	4.3kWh	37 kWh	Average consumption has grown nearly 9 times from 4.3 kWh to 37 kWh. This reflects a fundamental shift from minimal lighting use to productive and diversified electricity adoption across appliances, agriculture, and livelihoods.
Importance of paying bills	98%	99%	Already high at 98% in 2022, the near-universal 99% in 2026 reflects strong internalisation of the collaborative model. Communities understand that timely payment is directly linked to grid continuity and sustainability.

The Green Switch Programme: Improvement in health , sense of safety, improved educational environment at home (Key finding of impact assessment from 2022 and 2026)

The indicators below are drawn from two independent study rounds: 2022 and 2026, conducted across different sample sizes. As the studies do not track the same cohort, figures reflect overall programme averages at each point in time. When looked at together they offer a directional assessment of how key outcomes have shifted over time, providing a credible basis for understanding the programme's incremental impact and sustained impact across communities.

Indicators	2022	2026	Observations
Improved health post grid electricity	40%	84%	Health shows a significant shift with 44% increase from 40% to 84%. Reduced dependence on kerosene and fuel wood, improved night-time safety, and better access to healthcare facilities are key contributing factors.
Feel safe due to electricity	98%	100%	Safety perception was already near-universal in 2022 and has reached 100% in 2026. Night-time lighting has eliminated a key vulnerability and safety from wildlife for communities.
Improvement in agri cultivation and output	5% (increase in cultivation land)	44% (increase in yield)	5% of households reported improved cultivation in 2022. In 2026, 44% report improved yields. Electricity-facilitated access to irrigation and mechanisation has been the primary driver of this shift, enabling farmers to produce higher yields.
Increase in study time	47%	93%	Electrification has significantly improved learning at home. Households reporting daily study time have surged from 47% to 93% with children 83% now averaging 1– 3 hours of study daily.
Improvement in women's leisure time	42%	96%	Women reporting improved leisure time has increased from 46% in 2022 to 96% in 2026. Reliable electricity is reducing the time burden of household tasks, returning time to women for rest, social engagement, and improved mobility.

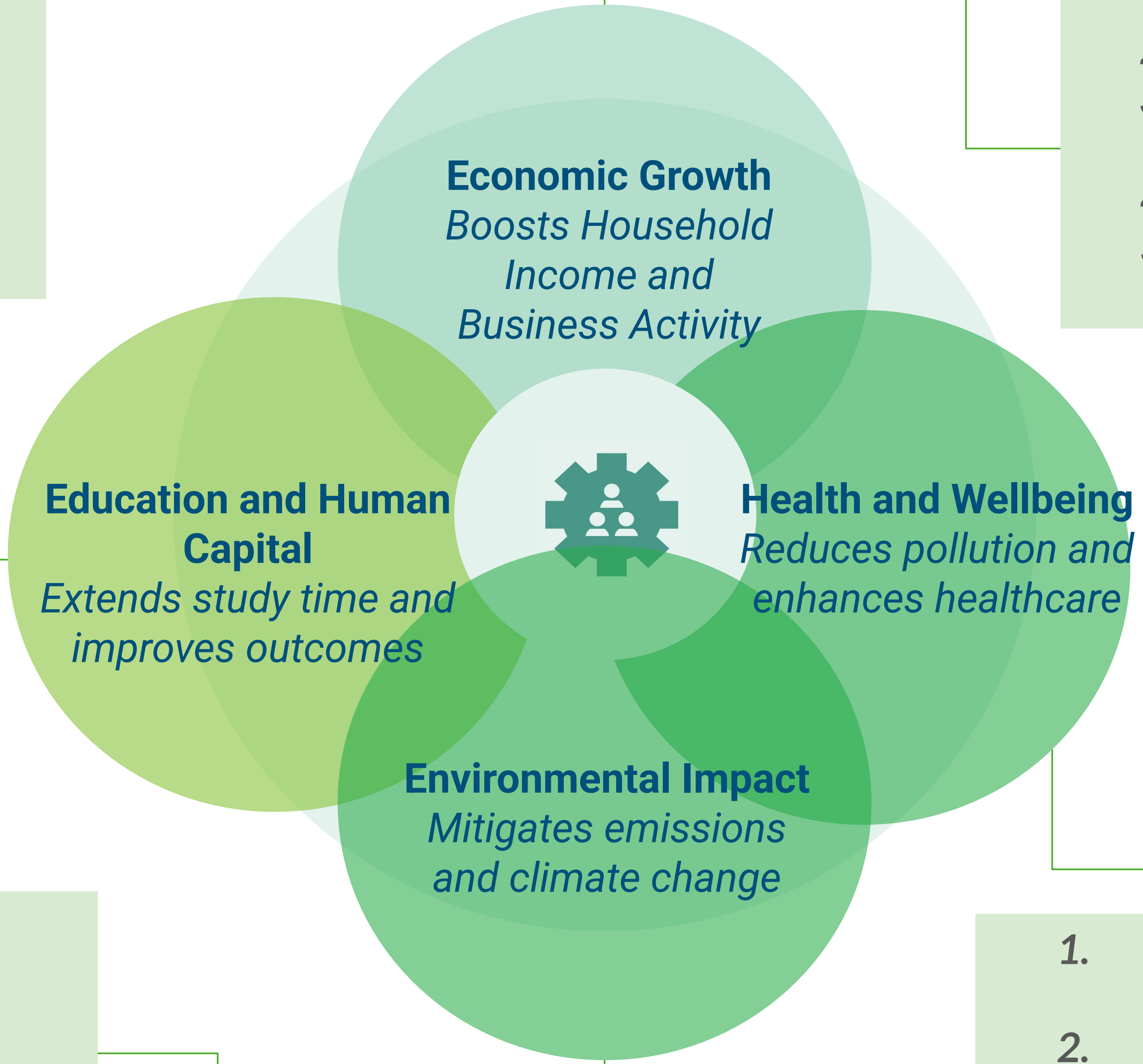
Background and Scope

According to World Bank, electrification catalyzes profound socioeconomic improvements across multiple dimensions of daily life.

According to the World Bank, electrification acts as a powerful catalyst for socioeconomic development by influencing multiple dimensions of household welfare and economic activity. Access to reliable electricity enables households and businesses to expand productive activities, extend working hours, and adopt productivity-enhancing appliances such as irrigation pumps, sewing machines, and other electrical equipment.

1. *Electric Lighting Extends Evening study hours*
2. *Contributes to better Schooling Outcomes*
3. *Increases Years of Completed Schooling*

1. *Increases Per Capita Income and Expenditure*
2. *Extends Business Operating Hours*
3. *Enables Productive Appliance Use (e.g. pumps, sewing machines)*
4. *Increases Non-farm Income*
5. *Labour Supply Increases (India: 17% women, 1.5% Men)*



1. *Replaces Kerosene and Diesel*
2. *Reduces Carbon dioxide and Black Carbon Emissions*
3. *Contributes to Climate Change Mitigations*

1. *Drastically Reduces Indoor Air Pollution(No Kerosene Lamps)*
2. *Mitigates Respiratory Illnesses*
3. *Enables Refrigeration of Vaccines*
4. *Powers Medical Equipments Operations*

Samad, H. & Zhang, F. (2019). *Electrification and Women's Empowerment.* World Bank.
https://openknowledge.worldbank.org/bitstreams/db10d6f5-42b8-5d9c-bcc1-35ecbb88ddbf/download?utm_source=chatgpt.com

India has achieved near-universal electrification (99.5% households), with clean energy initiatives now playing an increasingly critical role

From a post-independence focus on agricultural survival, India has transitioned into a global leader in universal energy access through the landmark Electricity Act of 2003 and the Saubhagya Scheme, which electrified 28 million households. This journey has shifted from building basic infrastructure to ensuring 24/7 reliability and green energy integration, supported by massive institutional financing from the Rural Electrification Committee

Key Phases of Electrification in India

Post-Independence to 1960s

At the time of independence in 1947, only about 1,500 villages had electricity.

In the 1960s, responding to famine and food shortages, the focus shifted to electrifying irrigation pump sets to boost agricultural yield. This era prioritized food security over household lighting

Institutional Building (1970s–1990s):

The journey began with the 1969 establishment of the REC, which secured dedicated financing for rural infrastructure.

By 1980s, Kutir Jyoti Yojana (1989) became a landmark initiative, providing the first single-point power connections to Below Poverty Line (BPL) households across India.

Universal Access Drive (2000s–Present)

The Electricity Act (2003) legally mandated power for all, paving the way for the RGGVY (2005) to build out massive rural infrastructure.

Saubhagya Scheme (2017), closed the last-mile gap by electrifying over 28 million households, achieving near-universal access.

SDG Target Year: 2030

Global target for universal energy access. India is on track to have 50% non-fossil power capacity by this year

Today, India's energy transition is entering a new phase focused on **reliability, affordability, and sustainability**. While earlier efforts focused on expanding access, current policies are increasingly oriented toward ensuring **24/7 reliable electricity supply and integrating renewable energy sources**, with India aiming to achieve **50% non-fossil fuel power capacity by 2030**, aligned with global Sustainable Development Goal targets.

World Bank, World Development Indicators, "Access to electricity (% of population) - India (2023)"
IEA (2020) *India Energy Policy Review: https://iea.blob.core.windows.net/assets/2571ae38-c895-430e-8b62-bc19019c6807/India_2020_Energy_Policy_Review.pdf*
Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) – Scheme Guidelines (2005).
Electricity Act 2003
World Bank (2021) Tracking SDG7: The Energy Progress Report

Thus the institutional and policy frameworks in India have been evolving to cater to the shift to green and renewable energy

1947

Independence

Only 1500 villages electrified across India

1969

Rural Electrification Corporation

created to finance and accelerate rural electrification, initially focusing on agriculture.

2003

Electricity Act 2003

It mandated the central and state government to extend electricity to all villages and hamlets

2005

Rajiv Gandhi Grameen Vidyutikaran Yojana

aimed at electrifying all villages and providing free connections to BPL households.

2014

Deen Dayal Upadhyaya Gram Jyoti Yojana

focused on feeder separation (agriculture vs. domestic) and strengthening sub transmission systems

2019

Universal Household Access

Government declared near-universal household electrification

2024

PM Surya Ghar Muft Bijli Yojana

launched with target to install rooftop solarsystems in 10 million household by 2027

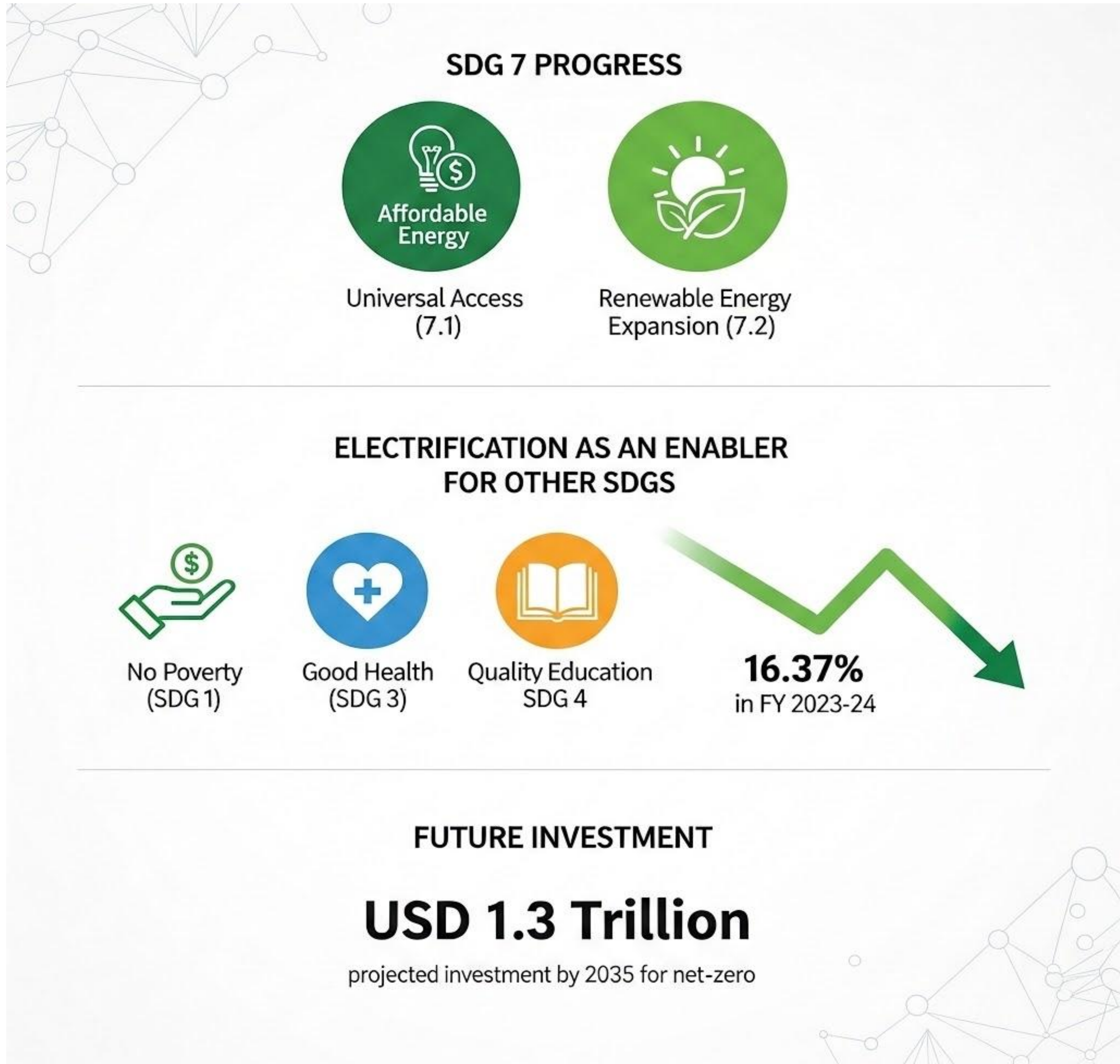
IEA (2020) *India Energy Policy Review: https://iea.blob.core.windows.net/assets/2571ae38-c895-430e-8b62-bc19019c6807/India_2020_Energy_Policy_Review.pdf*
Ministry of Power (2005). RGGVY
Electricity Act 2003
World Bank (2021) Tracking SDG7: The Energy Progress Report

Energy access is a foundational enabler of broader development, accelerating progress across multiple SDGs

"Energy is the golden thread that connects all the Sustainable Development Goals"—is a world-renowned quote attributed to Ban Ki-moon, the former Secretary-General of the United Nations. India has also adopted the 2030 Agenda during the United Nations Summit held in September 2015. Energy is intimately connected with 74% of the 169 targets related to the 17 Sustainable Development Goals (SDGs) to be achieved by 2030.

India is advancing SDG 7 through the Saubhagya scheme and a major shift to wind/solar power, increasing renewable capacity. This energy transition also boosts SDGs 1, 3, and 4 (poverty, healthcare, education).

Operational efficiency peaked in FY 2023-24, with Aggregate Technical and Commercials loses dropping to 16.37% from 25% in 2015. To maintain momentum and hit net-zero goals, India is expected to attract $1.3 trillion in clean power investment by 2035, cementing its role as a global sustainable infrastructure leader.



United Nations. (2012). Sustainable Energy for All Initiative.
Transforming our World: The 2030 Agenda for Sustainable Development. https://sdgs.un.org/2030agenda
Energy Access Outlook 2017 – From Poverty to Prosperity
World Bank (2021) Tracking SDG7: The Energy Progress Report

"India's path to 100% access is not a single roadmap, but a response to diverse terrains—moving from the centralized efficiency of urban grids to the decentralized necessity of tribal solar mini-grids."

Context	High density and economic concentration make centralized grids economically viable.	Scattered settlements and vast distances drive up infrastructure costs per capita.	Extreme topography (jungles/mountains) and highly dispersed, isolated hamlets.
Primary Challenge	Safely servicing marginalized groups in informal settlements/slums	High upfront costs and intermittent supply lead to continued fossil fuel reliance.	Physical impracticality of wires and Forest Rights Act constraints.
Strategic Solutions	Simple distribution line extensions for near-universal, consistent coverage.	Supplementing the national grid with Decentralized Renewable Energy (DRE).	100% reliance on tailored Solar Mini-grids and Standalone Home Systems.

India's path to universal electricity access uses varied approaches based on location. In densely populated urban areas, centralized grids are cost-effective due to lower per-household infrastructure costs, though servicing informal settlements remains a challenge.

Rural areas with scattered populations face higher per-capita grid extension costs, necessitating targeted government programs.

The greatest difficulty is in remote tribal regions where geographic barriers (forests, mountains) and regulatory constraints make conventional grid expansion difficult and inefficient. Decentralized renewable solutions like solar mini-grids and home systems are the most viable option for these communities.

Agrawal, Shalu, Sunil Mani, Abhishek Jain, and Karthik Ganesan. 2020. State of Electricity Access in India: Insights from the India Residential Energy Survey (IRES) 2020. New Delhi: Council on Energy, Environment and Water.
IEA (2017) Energy Access Outlook
World Bank (2021) Tracking SDG7: The Energy Progress Report
IRENA (2019) Off-grid Renewable Energy Solutions

Green Switch Programme Model: Community-Managed Solar Microgrid Approach

The Green Switch programme adopts a decentralised and community-centred energy model that combines renewable energy infrastructure with institutional mechanisms to ensure long-term sustainability.

At the core of the programme is the installation of solar microgrids, which generate and distribute electricity locally within the village. These systems are designed to provide reliable power for household lighting, small appliances, and selected productive uses.

To ensure community participation and effective management, the programme facilitates the formation of Village Energy Committees (VECs). These committees play a key role in overseeing electricity usage, supporting tariff collection, coordinating maintenance, and acting as a local governance body for energy management.

Key Components of the Model

1. Solar Microgrid Installation

- Decentralised solar power systems in remote hamlets
- Electricity distributed to households and community infrastructure

2. Community Governance

- Formation of Village Energy Committees (VECs)
- Local oversight of electricity distribution and system management

3. Cost-Sharing & Sustainability

- Community-based tariff system
- Supports long-term operation and maintenance of the microgrid

4. Capacity Building

- Training and awareness sessions on electricity usage
- Encouraging productive energy use for local economic activities

The model combines clean energy infrastructure with community governance to ensure long-term sustainability.

Key Demographic Characteristics

• Kurdeg, Kersai and Bolba are entirely rural blocks within Simdega district, with populations distributed across numerous small villages and hamlets, reflecting a low-density settlement pattern.

• Scheduled Tribes form the majority population (72–80%), with communities such as Oraon, Kharia and Munda playing a central role in the social and economic structure of the region.

• Literacy levels range between 63–68%, slightly below state averages, indicating ongoing challenges in educational access and infrastructure in remote rural areas.

• Dispersed settlements and difficult terrain make the delivery of infrastructure and public services—such as electricity, healthcare and schooling – more complex and resource intensive.

Indicator	Kurdeg	Kersai	Bolba
Population	47,984	39,218	30,786
Households	9,847	7,580	6,182
Gram Panchayats	8	6	6
Villages	25	36	32
Sex Ratio (F/1000 M)	1009	~1003	~1021
Literacy Rate (%)	–	67.8	63.3
Scheduled Tribes (%)	–	80.3	72.9
Scheduled Castes (%)	–	5.1	6.9

Census of India 2011
SECC 2011.

Evaluation Framework and Methodology

A four-phased approach has been used to conduct impact assessment

The design phase included co-creation exercises to ensure alignment on the indicators for the study. The below mentioned timeline includes a week of buffer for reviews and feedback across each phase.

Phase	Design	Execute	Analyse	Report
Activities	• Review documents • Define the hypothesis • Map relevant indicators • Sample for the study • Develop DCTs • Pilot DCTs internally • Translate the tool (if needed)	• Create a data collection plan • Onboard data enumerators • Train data enumerators • Finalise the DCTs • Monitor data (daily) • Conduct audio audits	• Clean and transcribe data • Analyse data • Triangulate primary and secondary information • Visualise data post analysis • Generate relevant insights	• Create an insights deck • Include actionable recommendations • Finalise the insights deck • Create an Executive Summary

Sattva has adopted the Organization for Economic Cooperation and Development's (OECD) Development Assistance Committee (DAC) framework this impact assessment

INPUT & PROCESS

OUTPUT & IMPACT

Relevance

Is the intervention doing the right things?
Assessing to what extent the program objectives and design respond to the target group's global, country, and partner/institution needs, policies, and priorities, and continue to do so if the circumstances change

Coherence

How well does the intervention fit? *Assessing the alignment of the program, or what it is likely to deliver with the needs of the community. Also checking its alignment with the priorities of the region, at a state, national or international level*

Effectiveness

Is the intervention achieving its objective?
Assessing the supporting systems and processes influencing the achievement or non-achievement of program objectives, through concurrent measurement of program outputs

Efficiency

How well are the resources being used?
Assessing the budget allocation versus actual spend to inform utilisation. Unit cost spend is assessed to understand the cost variance and suggest effective ways of saving costs.

Impact

What difference does the intervention make?
Assessing the extent to which the program has generated significant positive or negative, intended or unintended impact, in terms of local, social, economic, environmental and other development indicators

Sustainability

Will the benefits last?
Assessing to what extent the impact of the program is likely to continue after funding support has been withdrawn by determining operational, financial and institutional sustainability

Evaluative framework approach for holistic understanding

Sattva has utilized a combined evaluative framework that brings together direct, indirect, and economic impact pathways to enable a holistic understanding of the programme outcomes.

Direct Impact

Reach

Equity

Everyday Life

Education

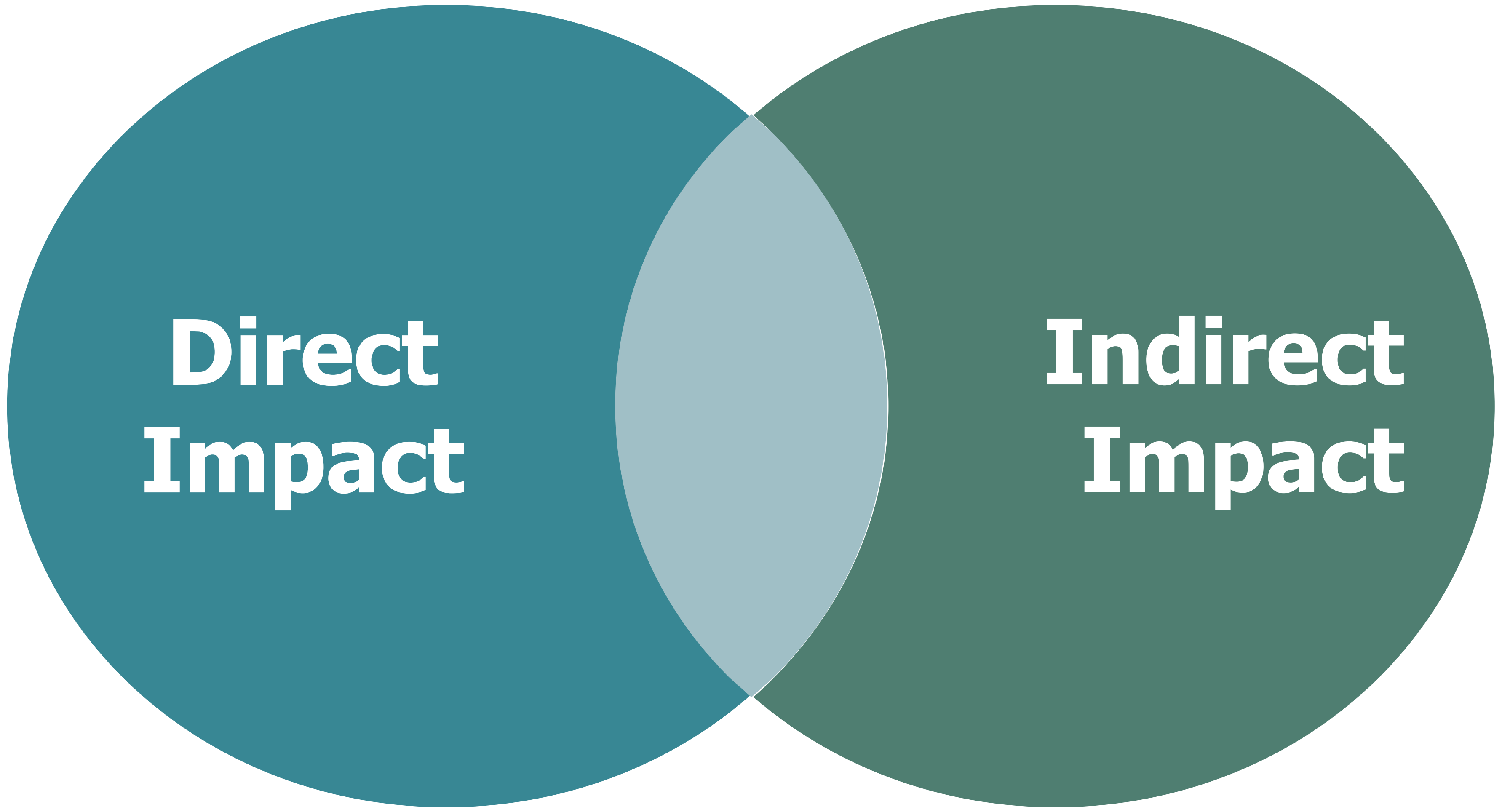
Livelihood and Economic

Gender and Household Dynamics

Health and Wellbeing

Institutions and Governance

Financial Inclusion Readiness



Indirect Impact

Spillover Effects

Substitution Effects

Normative Shifts

Unintended Consequences

Cross-Cutting: Household Economic Profile and Financial Risk

Economic Progress and Financial Readiness

Livelihood Diversification & Productivity

Household Financial Resilience

Entrepreneurial Growth & Credit Readiness

Gendered Economic Agency

Financial Stress & Risk Management

Sample Methodology - The Green Switch

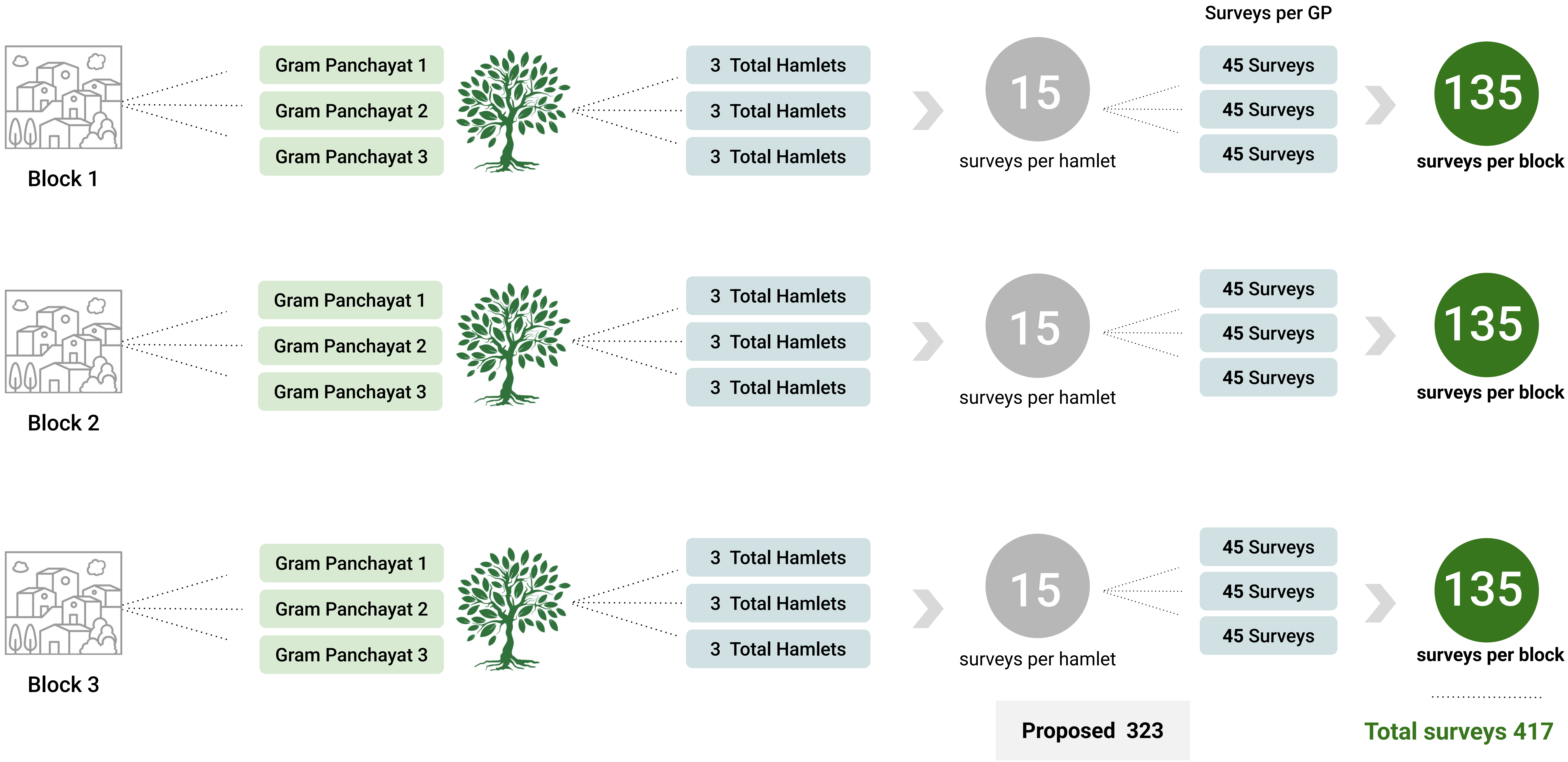
A stratified random sampling method was followed to ensure adequate representation of the population. The total sample size for the project is estimated using the Cochran's Formula based on a 95% Confidence Interval and 5% margin of error. The sample was further detailed and designed for stratification and distribution during the design phase

Sample Size and Stakeholder Mapping

Stakeholder	Sample Size	Location	Data source	Mode of data collection
Primary stakeholders Household (HH) 1 respondent each HH	417	Jharkhand	Survey In Depth Interview	On Ground
Community members	3		Focus Group discussion	On Ground
Women	3		Focus Group discussion	On Ground
Farmer	1		Focus Group discussion	On Ground
Operator	2		In Depth Interview	On Ground
Village Electricity Committee	5		In Depth Interview	On Ground
AWW/AWH	2		In Depth Interview	On Ground
Teachers	2		In Depth Interview	On Ground
Total	**417 surveys** **18 IDIs & FGDs**			

Sample for the study

A stratified random sampling method is followed to ensure the adequate representation of the population.



Key Insights

Green Switch Impact Assessment: Respondents Demography

417

Survey Respondent

27

Hamlets

9

Gram Panchayats

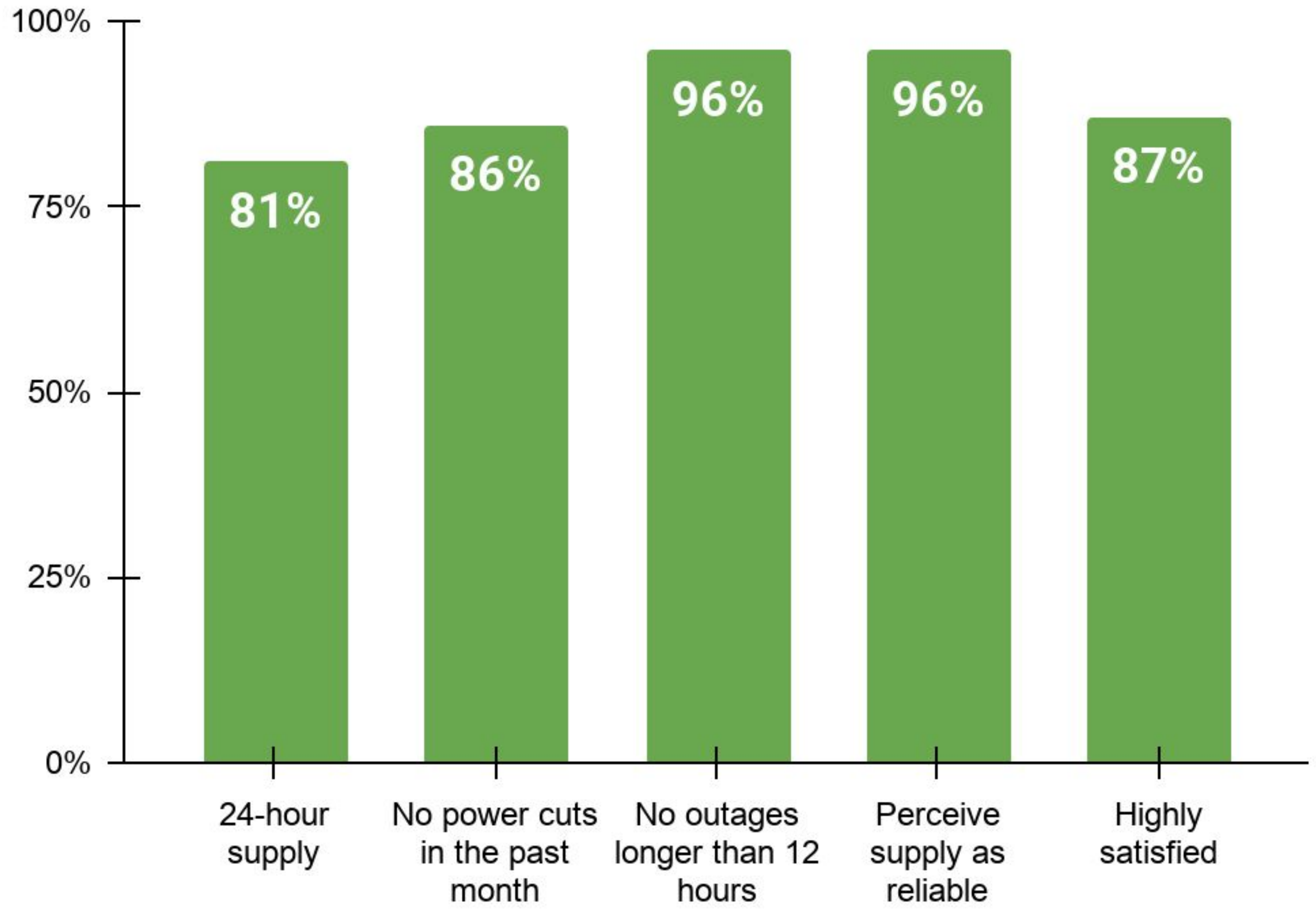
Gender	Family type	Educational status	Average Age
43% Male 57% Female Respondents	56% Joint 41% Nuclear	42% Primary 29% Secondary	41 years

Earning members	Income Source	Bank a/c status	Access to smartphone
44% Sole earners 40% double (but wage labor)	61% Farming 22% wage labor	94% had a bank a/c 6% did not have a bank a/c	84% had access from which 46% had 2 devices

n= 417

100% electrification with 81% receiving 24-hour supply and 96% experiencing minimal outages

Key Reliability Indicators (n=417)



Electrification under the Green Switch programme has achieved **100%** household coverage, with most households reporting reliable and continuous supply. When probed on outages, **96%** of households indicate that outages, if any, are short-term (less than 12 hours), and **86%** report experiencing no outages in the past month, reinforcing the overall stability of supply.

These strong reliability indicators translate into high levels of user confidence, with **96%** of households perceiving supply as reliable and **87%** reporting high satisfaction. Qualitative feedback further reinforces this, highlighting that outages are infrequent, short-lived, and quickly resolved, contributing to a dependable user experience.

However, these aggregate trends mask variation in service quality across hamlets, where differences in infrastructure, local conditions, and system constraints lead to uneven reliability experiences.

Qual Evidence

"Electricity is available all day and all night. Power cuts hardly ever happen, and if they do, it's only because the battery is low. Otherwise, there is power 24 hours a day."

"If there's ever an issue, it gets fixed the same day. The power never stays out for long."

The programme has successfully transitioned households from access to dependable, round-the-clock electricity; establishing a strong foundation for downstream impacts.

94% households perceive electricity as affordable, with 13% managing usage based on their income levels

Electricity is widely perceived as affordable, as reported by 94% of households, and they are able to manage the monthly payments. However, payment patterns reveal a more dynamic financial reality, where households align payments with cash availability.

Around 37% of households report missing payments, and an additional 8% delay payments occasionally, reflecting timing mismatches rather than inability to pay.

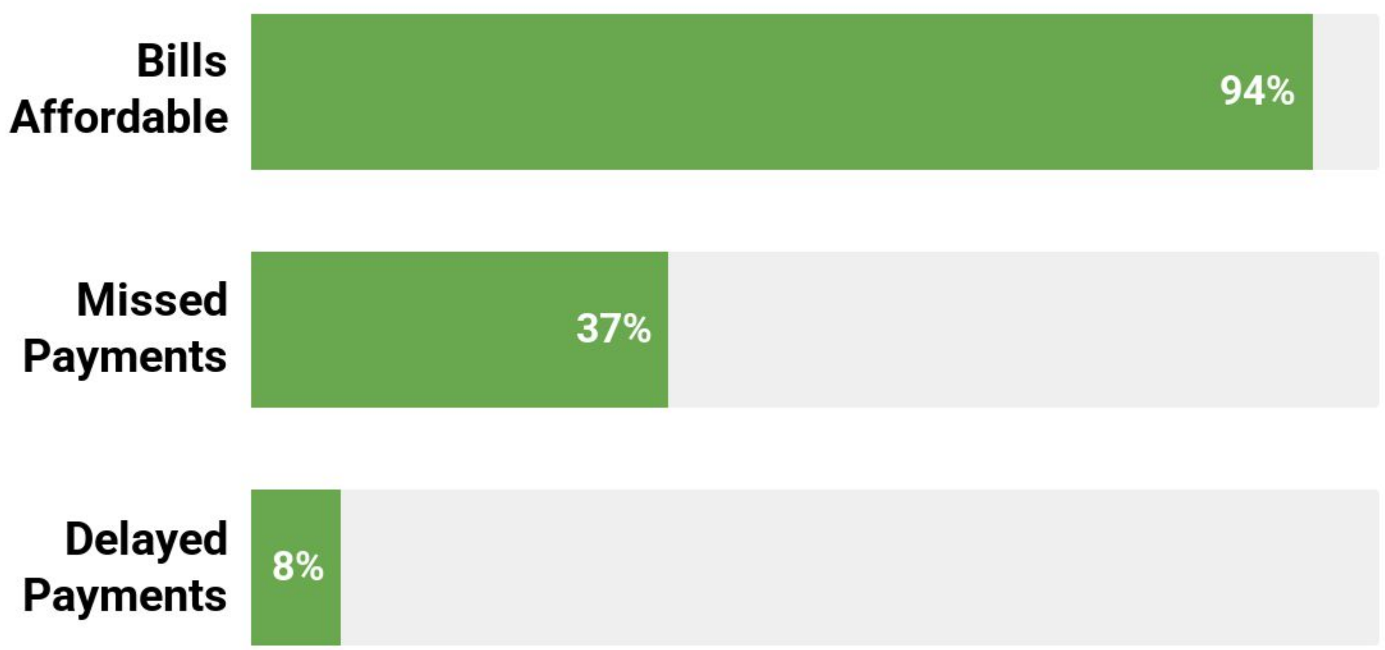
These patterns suggest that while **electricity is not prohibitively expensive, it does impose liquidity pressures on households,** particularly in managing monthly cash flows.

This behaviour is closely linked to irregular income patterns, particularly in agriculture and daily wage work, where earnings are not aligned with fixed monthly billing cycles. As a result, households rely on flexible payment timing; **since out of those who have ever missed a monthly bill payment because of lack of money available in that duration (37% of 417), ~96% report deferring payments to subsequent periods instead of resorting to borrowing or reducing essential expenses.**

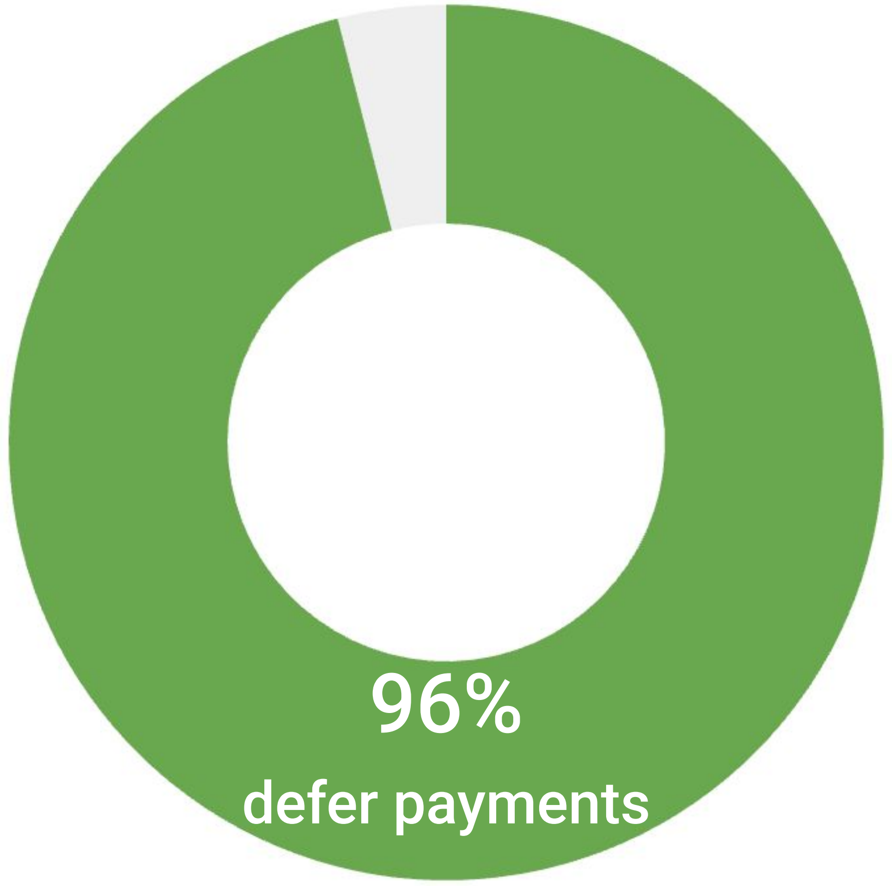
Overall, this indicates that households are actively managing electricity payments within their financial cycles, supported by system flexibility, rather than facing prohibitive cost barriers.

13% of households (n=417), a notable share, report deliberately **limiting their electricity consumption**, despite having access.

Perception vs. Reality (n=417)



Coping Strategy for Payment Stress (n=156)
sample drawn from people who have missed payments



From 89% to 1% i.e near-elimination of kerosene drives immediate health gains for locals; 68% report reduced symptoms & exposure

Kerosene Usage (n=417)

Pre - electrification	Post - electrification
89%	1%

Prior to this transition, kerosene was predominantly used for lighting (83% of households), exposing households to high levels of indoor smoke and associated health risks.

With the shift to electric lighting, households have moved away from smoke-intensive sources, resulting in visible improvements in respiratory comfort and overall indoor air quality.

Before electrification, nearly **83%** of households reported symptoms of smoke induced discomfort such as coughing, eye irritation, and breathing discomfort, directly linked to kerosene use. Post electrification, **68%** of households report a reduction in these symptoms, reflecting a significant improvement in everyday well-being.

The findings highlight how access to reliable electricity can drive rapid health improvements without requiring major behavioural change, as households naturally shift to cleaner lighting alternatives when available.

Smoke Induced Discomfort (n=40)

Pre- reported symptoms	Post- reported reduction
83%	68%

Qual Evidence

"Earlier, kerosene lamps caused burning in the eyes and discomfort due to smoke. Now, with electric light, the air feels cleaner and living conditions have improved."

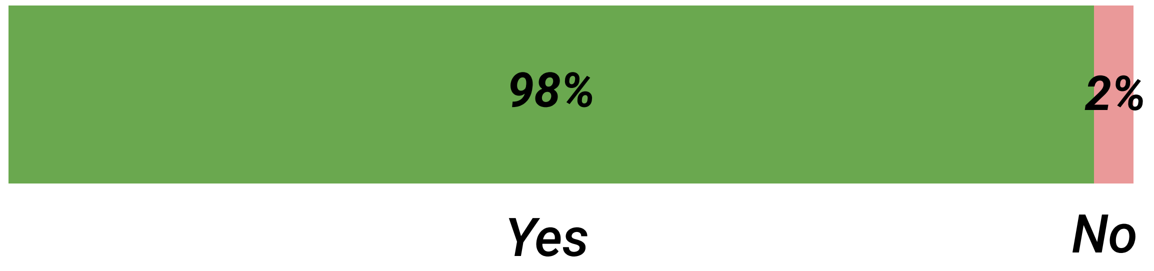
Fuelwood Usage (n=417)

Fuelwood consumption has declined only marginally post-electrification, from **10.66 to 9.82 kg per month**. Before electrification, fuelwood served multiple needs including cooking, lighting, and farming & livelihood activities. While electrification has reduced its usage, overall consumption remains largely unchanged as fuelwood continues to be used predominantly for cooking.

Transition to clean lighting delivers immediate, high-impact health gains by reducing indoor air pollution exposure at the household level

92% household have invested and brought 1030 electric appliances post electrification , 98% households reported fulfilment of their electricity needs

Electricity needs fulfillment (n=417)



Electrification has significantly improved the reliability and usability of energy at the household level, with **98%** of households reporting that their electricity needs are being met. This indicates a high level of satisfaction with the current electricity infrastructure and its ability to support daily requirements.

1030 Appliances bought
(n=407)

Top 4 appliances adopted post electrification (n=407)

Light bulbs*	69%
Table fans	39%
Kitchen appliances	28%
Mobile phones	31%

Details present in the annexure

The Households indicates trends of utilizing electricity beyond lighting and basic needs indicating strong spillover impact and willingness of the HH to invest in their household growth

58% pay ₹101-₹200 per month

Majority remain **below ₹300**

Affordability supports sustained usage (n=416)

Electrification has moved households from basic access to functional usage but broader development outcomes depend on ecosystem readiness beyond the household

Adoption of electric irrigation remains limited, though it reflects early productive use of electricity

Electric pumps **40%**
(n=338)

134 out of 338 HH reported investing in electric pumps, this indicates that while electrification has begun enabling productive agricultural applications. The use of electric pumps represents an **indirect but important outcome** of the Green Switch program, signalling early-stage transition toward income-generating use of electricity.

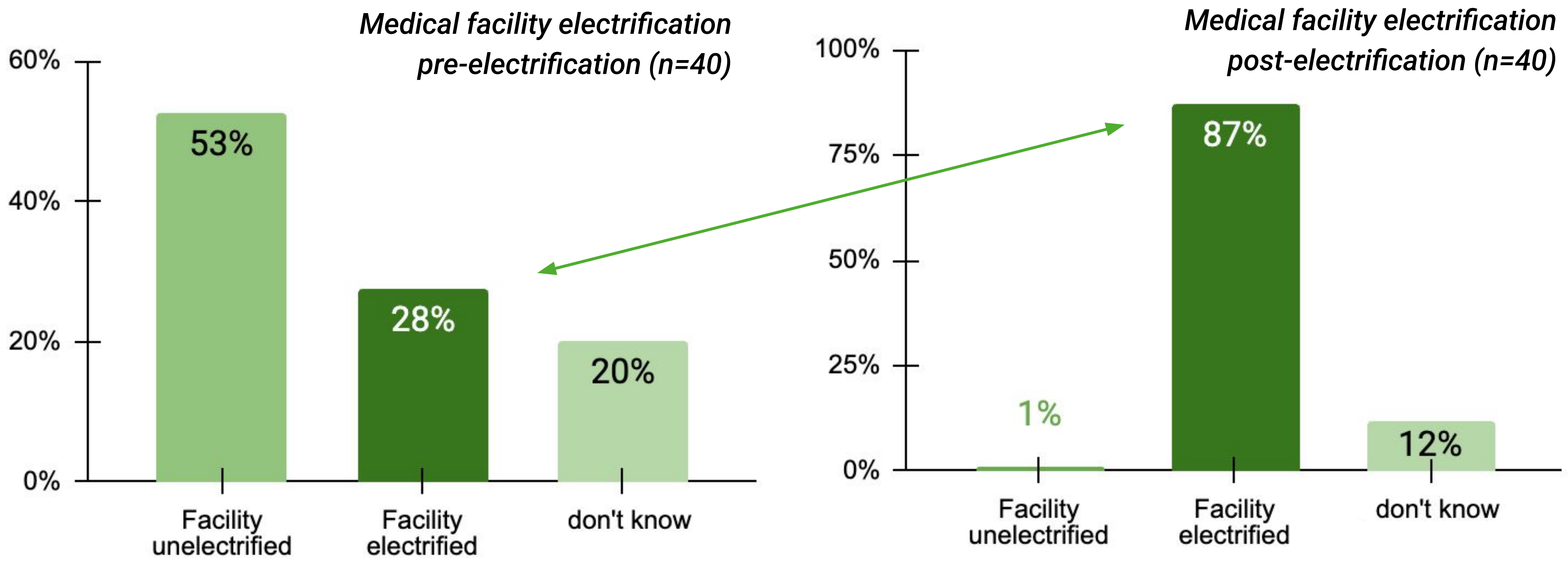
* Lightbulbs mentioned here are what households bought in **addition** to the ones given by Tata Capital.

63% report improved access to care and facility* readiness rises to 87%, yet only ~10% have direct access; highlighting a critical access gap

Electrification has significantly improved the **functional accessibility** of healthcare, particularly during emergencies. Around ~63% of households report that accessing care at night has become easier and safer, enabled by reliable lighting and the ability to charge mobile phones, allowing faster coordination with doctors and frontline workers.

At the same time, health system readiness has improved substantially, with facility electrification increasing from 28% to 87%. This has **strengthened service delivery** at local centres, improving equipment usage, hygiene conditions, and frontline worker engagement.

"It's also much easier now to distribute medicines and nutritional supplies."



However, these gains are constrained by limited physical access to healthcare infrastructure. Despite improvements in availability, only ~10% of households report direct access to a medical facility, with many located **1–3 km** or more away, often connected by poor road infrastructure.

"The village's biggest need right now is a proper road. The path from the village to the Block office is in bad shape, which causes a lot of trouble. If a good road is built, it would be a huge help."

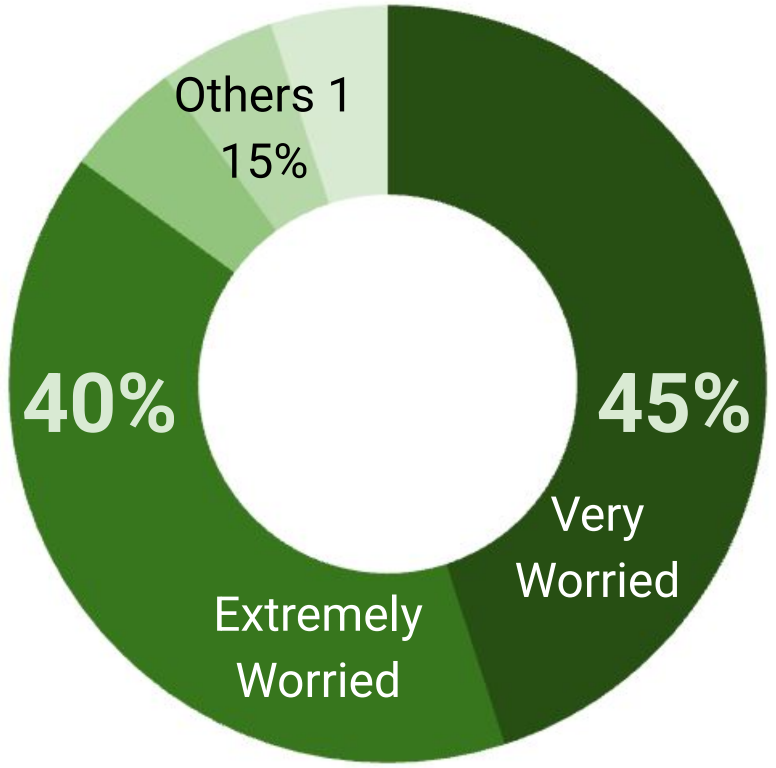
As a result, while electricity improves when and how care can be accessed, **distance and infrastructure** continue to determine whether care is actually received in time, particularly in critical situations.

Electricity improves healthcare responsiveness, but **physical access remains the binding constraint** for utilisation.

* Facility/ies in this context means any of the medical facilities like Sub-centre, PHC, CHC, Private clinic, Pharmacy/chemist, Mobile Health Clinic

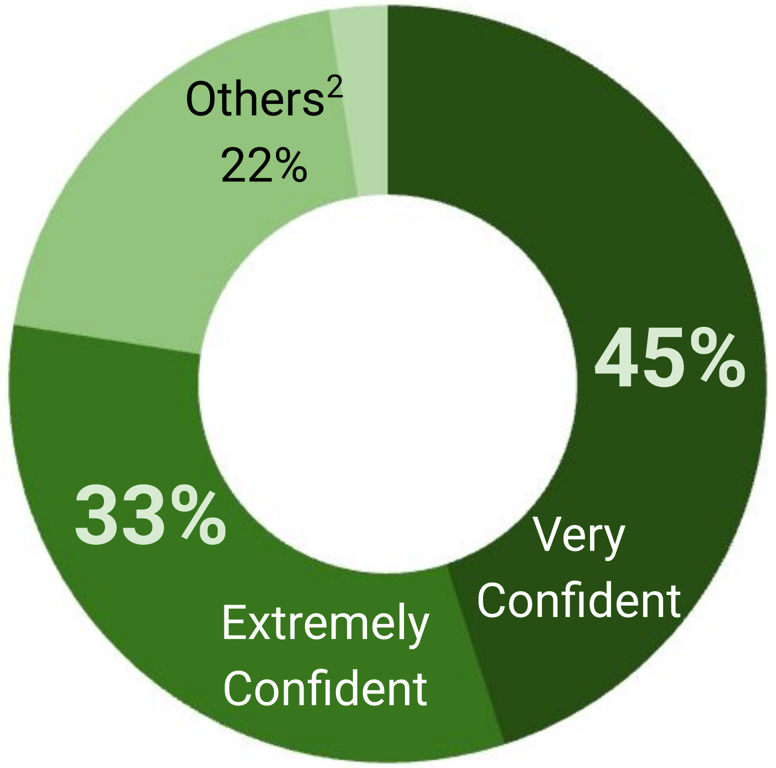
76% of households reported reduced night-time stress and anxiety; indicating a major shift in perceived safety and well-being

Electrification has brought about broad-based improvements in household well-being, with **~90%** of households, out of the ones reporting to have access to a medical institution reporting moderate to significant improvements in overall health. These **gains extend beyond clinical health** to include better sleep, comfort, and a stronger sense of security in daily life.



Anxiety during night-time emergency pre-electrification (n=40)

[1]Others range from not to moderately worried



Confidence about night-time emergency post-electrification (n=40)

[2]Others range from not to moderately confident

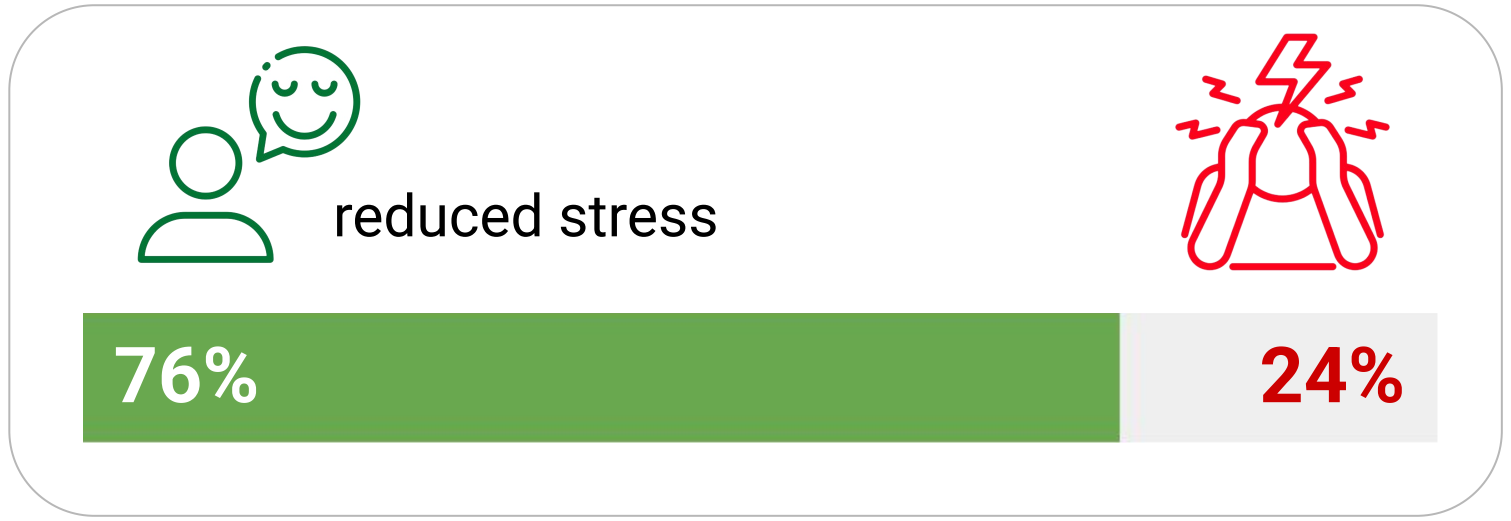
One of the most transformative impacts is observed in night-time conditions. Before electrification, **~85%** of households experienced high levels of anxiety during night-time medical emergencies, driven by **darkness, limited mobility, and lack of access to help**. With the introduction of reliable electricity, this has shifted significantly with **~78%** of households now reporting confidence in managing such situations.

"If someone falls sick at night, it has helped in that situation too. Earlier... doctors did not like to come at night. But now... we call the doctor and they are ready to come and they come."

At the same time, **~76%** of households report reduced stress and anxiety at night, reflecting how electricity has fundamentally changed the lived experience of darkness; from a period of vulnerability to one of relative safety and control.

"It used to be so scary in the dark... but now we can easily go outside."

"Now we can finally sleep comfortably at night... because the fan stays on."

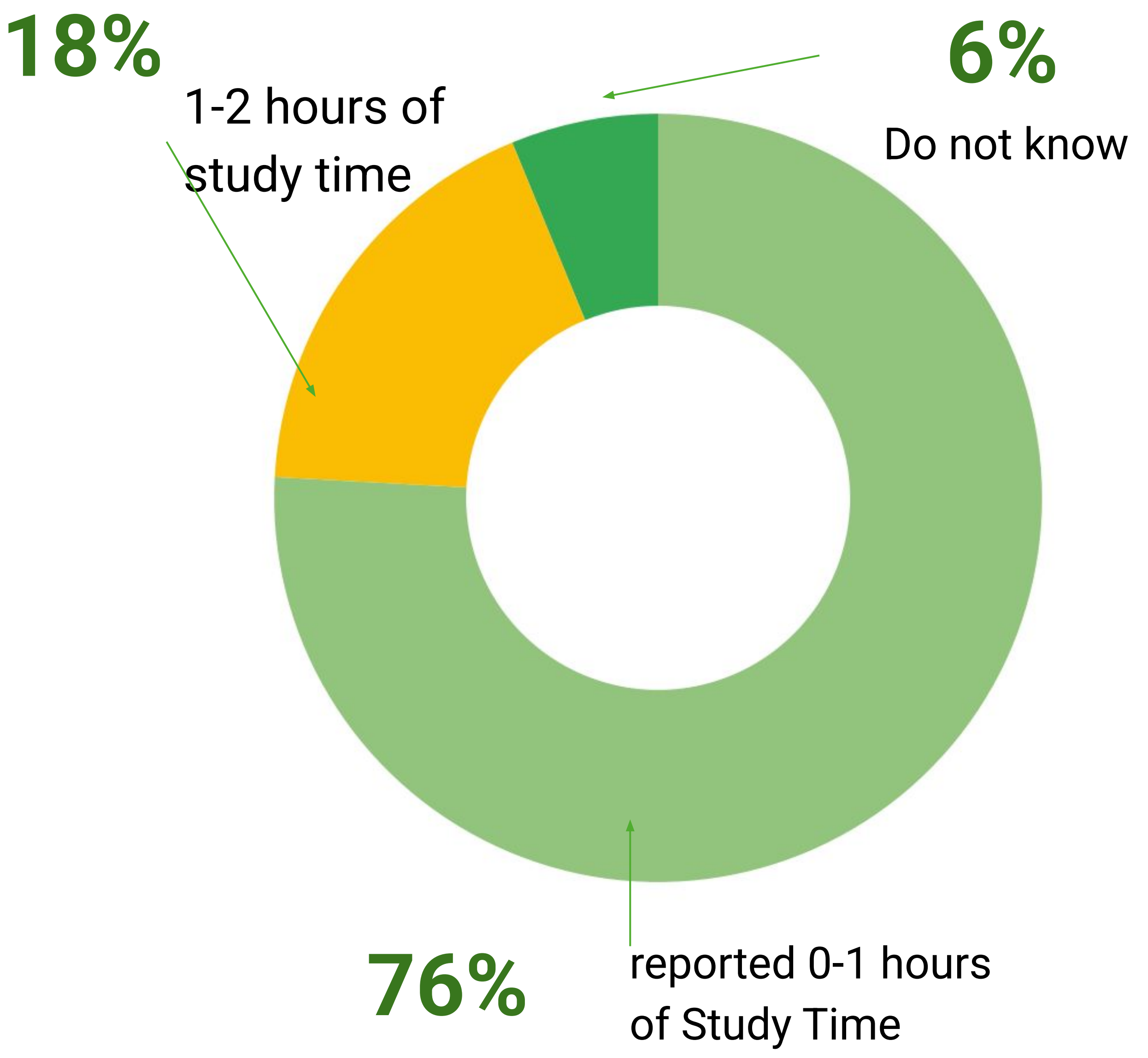


Stress reduction at night post-electrification (n=417)

93% of households report increased study hours as electrification transforms evening study time

Electrification has fundamentally improved the home learning environment by removing a major constraint on children's ability to study after sunset. Prior to electrification, around 76% of children studied less than one hour in the evening, largely due to reliance on dim kerosene lamps (dhibri), which made it difficult for children to study comfortably for extended periods.

Study Time before the Green Switch Connection
n=145



Increase in Study Hours after electrification

100% 100% of households reporting better or much better lighting conditions for studying

93% Reported increase in study hour after electrification

84% Reported **1-3 hours increase** in study time after electrification

66% Reported dedicated lightning for study.

Electricity has removed a major constraint on evening study time, enabling longer study hours and significantly improving lighting conditions for children. As a result, evening hours have shifted from a period of constraint to a productive time for learning, supported by better lighting, improved comfort, and more structured study routines at home.

"Earlier children did not like studying with dhibri, but now in electric light they study attentively."

"The biggest change is that children now come to school with homework completed."

"Now children can study late at night whenever they want."

By removing lighting constraints and improving the quality of the home study environment, electrification has transformed evening hours from a period of limited activity into productive learning time, allowing children to study longer, complete homework more consistently, and engage more effectively with their education.

Electrification is shifting households from passive support to active learning ecosystems driven by 88% parental involvement & increased learning hours in the evening

+88% households report higher involvement

Parents now actively monitor and guide studies in evening hours

+65% report improved ability to support during exams

Parents are now more aware of the school activities like exams

A key shift observed across households is the growing role of parents, particularly mothers and guardians, in supervising children's studies. With access to electric lighting, parents can now monitor homework, check notebooks, and ensure children study regularly during evening hours. This has transformed parental roles from passive observers to active participants in their children's education.

Qualitative Evidences

1. **Greater Parental Supervision of Studies**

   "Yes, with electricity our role in decision-making has changed, we are now able to keep a watch/supervise children's studies and children also study in the evening)."

2. **Emergence of Structured Evening Study Routines**

   "Earlier when there was no electricity, we used to cook early and sleep, and now after electricity, even after cooking we give some time to children. Children also sit in front and study while food is being cooked, so we are able to supervise them."

3. **Teachers Observing Greater Parental Engagement**

   "Earlier... parents used to wake up late & couldn't prepare children for school, but now that there is electricity... parents wake up on time & prepare children on time & send them to school."

Electricity is enabling not only longer study hours but also a more structured and supportive learning environment at home, with increased parental supervision, stronger study routines, and improved engagement with schools.

92% of the households reported being confident about their child's future post Green Switch, and 90% observed overall growth in their child's' education

Improvements in study time following electrification are also translating into perceived learning gains among children. Quantitative findings indicate that 83% of households report moderate or significant improvements in children's grades or learning, while around 90% of respondents at the village level believe that children are learning better overall. These findings suggest that the expansion of evening study time is beginning to influence children's academic engagement and learning outcomes.

HH reporting confidence in Children's future after Green Switch Connection n=145

92% reported confidence about their children's future.

Improved lighting and longer study hours have strengthened children's learning engagement at home. With the removal of dim kerosene lighting, children can study for longer and with greater focus. Better study conditions are reflected in stronger academic behaviours, with students arriving better prepared, completing homework more regularly, and participating more actively in class. Increased study time also encourages greater parental supervision and support for learning.

"Yes, compared to earlier, now children come to class with better preparation, now children come with more cleanliness compared to earlier and come having done more of their homework"

"Electricity has brought a lot of changes... especially in children's studies, now children are able to read comfortably in more light"

Increase in Study Hours after electrification

83% households report moderate or significant improvements in children's grades or learning

90% Household believes that they have observed overall growth in their education

"Earlier children did not like to study in dhibri, but now in the light, children study attentively"

"After electricity came, there has been a change in the way of studying. Earlier children could not study attentively in the dark, now children study attentively"

Electrification is improving the current learning and also creating hope for a better future for their children.

84% smartphone access, but only 22% adoption for learning highlights a significant utilisation gap

Despite widespread digital device ownership (84% of households have a smartphone), access to digital learning is limited, with only ~22% using devices for educational purposes. Although the infrastructure exists, educational use is low, likely because smartphones are shared household devices. Only ~16% of households lack a smartphone, but 38% have only one, limiting the time children have for learning.

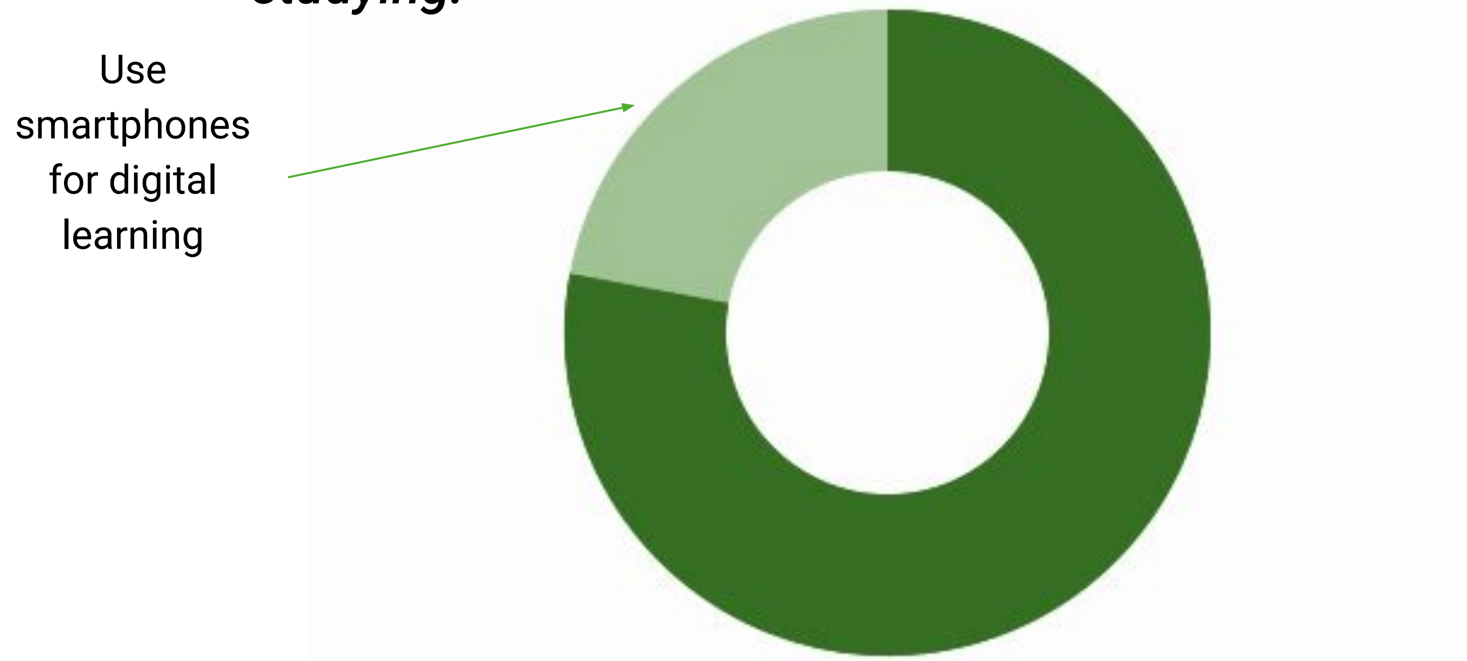
Qualitative insights show that digital access significantly expands children's learning exposure and engagement. Teachers note that smartphones, televisions, and other digital platforms expose children to new forms of knowledge. Through digital content like videos and cartoons, children are developing new skills, observing different behaviors, and expanding their world understanding.

"In the last few years, the biggest change for students is that children watch cartoons through mobile phones and TV and are learning a lot, they do plays, do acting, learn to study."

"There has been a change in the students' ability to concentrate... through online YouTube videos that we teach in school, the children's enthusiasm increases and the desire to learn awakens, they study it attentively."

While electricity is the first step for digital education, educators stress the need for stronger digital infrastructure (smartphones, smart classrooms, platforms) to boost outcomes. The expansion of digital learning was only possible because electrification enabled device charging and operation.

22% ***HH reporting children using smartphone usage for studying.***



- **Extremely Confident:** Parents of children using digital learning apps are more than **2.5 times** as likely to be "Extremely Confident" (31%) compared to those who do not (12%).
- **Combined High Confidence:** When combining "Extremely" and "Very" confident responses, the figure reaches **90%** for digital learning users, versus **70%** for non-users.

While electricity has laid the foundation for improved learning conditions, expanding access to digital tools is emerging as the next important step in transforming educational outcomes and opportunities for children.

Perceptions of school infrastructure improved significantly, with positive facility ratings increasing from 31% before electrification to nearly 70% after electrification.

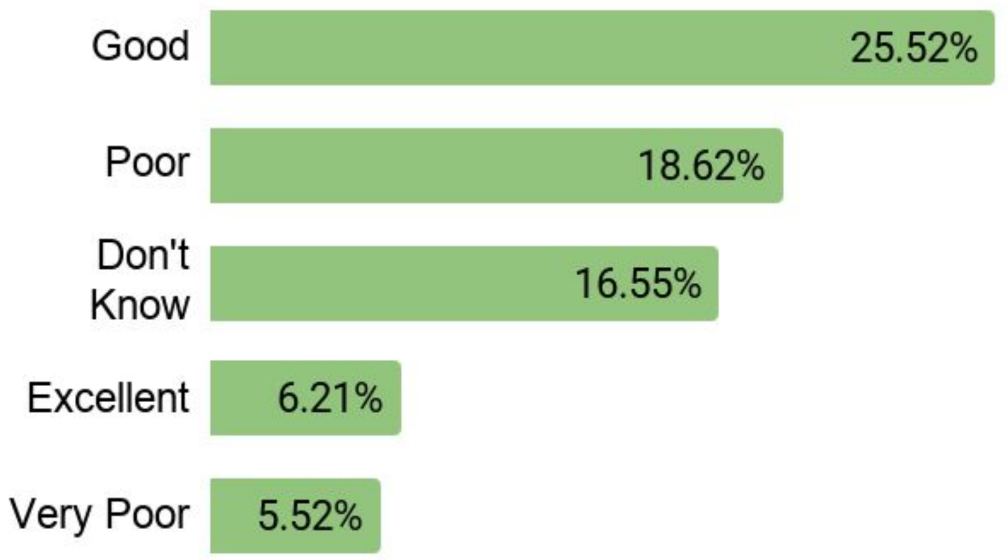
Electrification has also improved education quality at the institutional level by strengthening school infrastructure and classroom environments. Before electrification, school facilities were often rated poorly, with only about 31% of respondents rating school facilities as good or excellent, while nearly 46% rated them as fair or poor. Following electrification, perceptions of school infrastructure improved significantly, with approximately 70% of respondents now rating school facilities as good or excellent.

"Before electricity, people faced difficulties during the rainy season, it used to get completely dark due to clouds and it was difficult for children to study in school... and now that electricity has come, there is light in the classroom and things have become good"

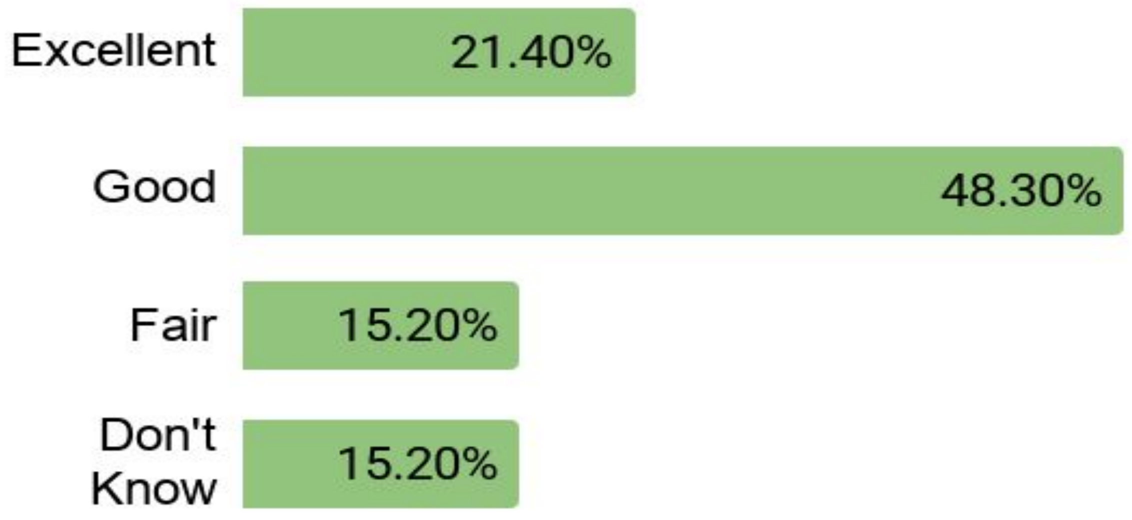
"With electricity coming, there is a better arrangement of light and air in the classroom. During the summer season when children feel hot, they go and sit where fans are installed and study comfortably."

These improvements reflect better classroom lighting, ventilation, and overall learning conditions enabled by electricity. In addition, respondents report noticeable improvements in teaching and learning outcomes. Around 76% of households report that the quality of teaching and learning has improved after electrification, with 17% describing the improvement as "much better." Together, these findings suggest that electrification has strengthened institutional learning environments by improving school infrastructure and supporting more effective teaching practices.

Overall Facility Rating Before Electricity (n=145)



Overall Facility Rating After Electricity (n=145)

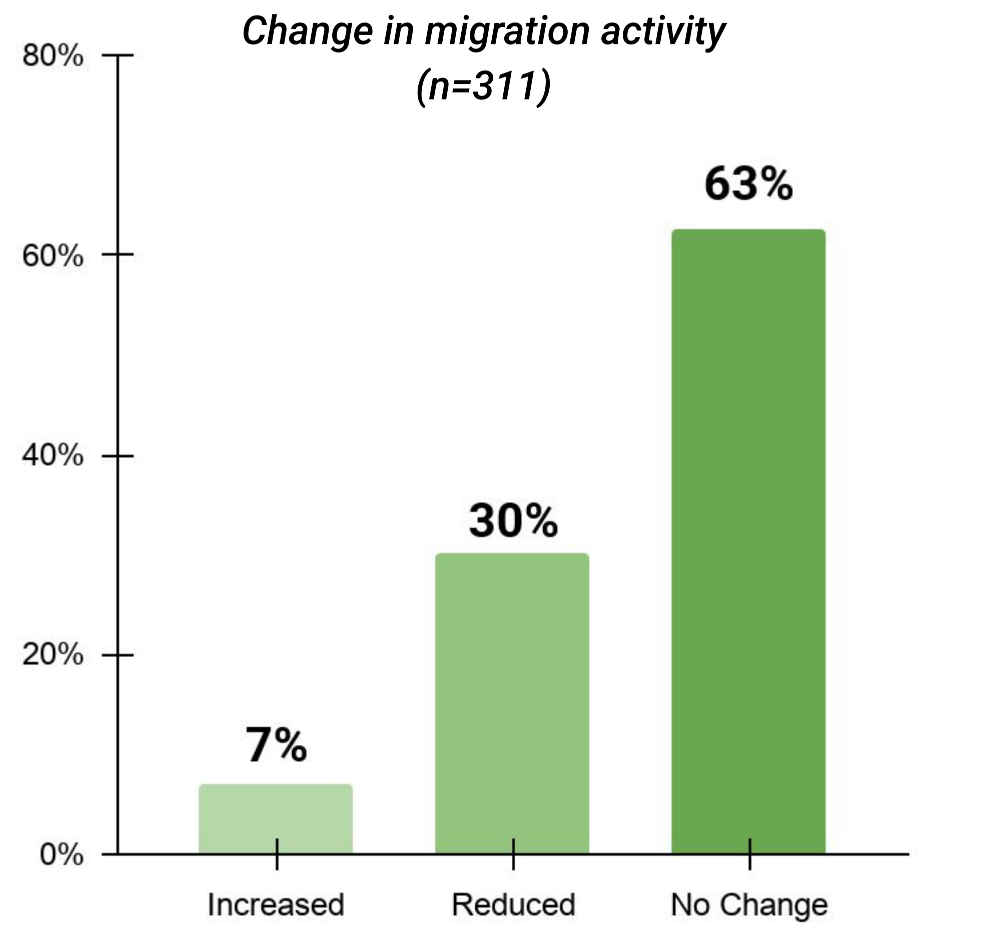


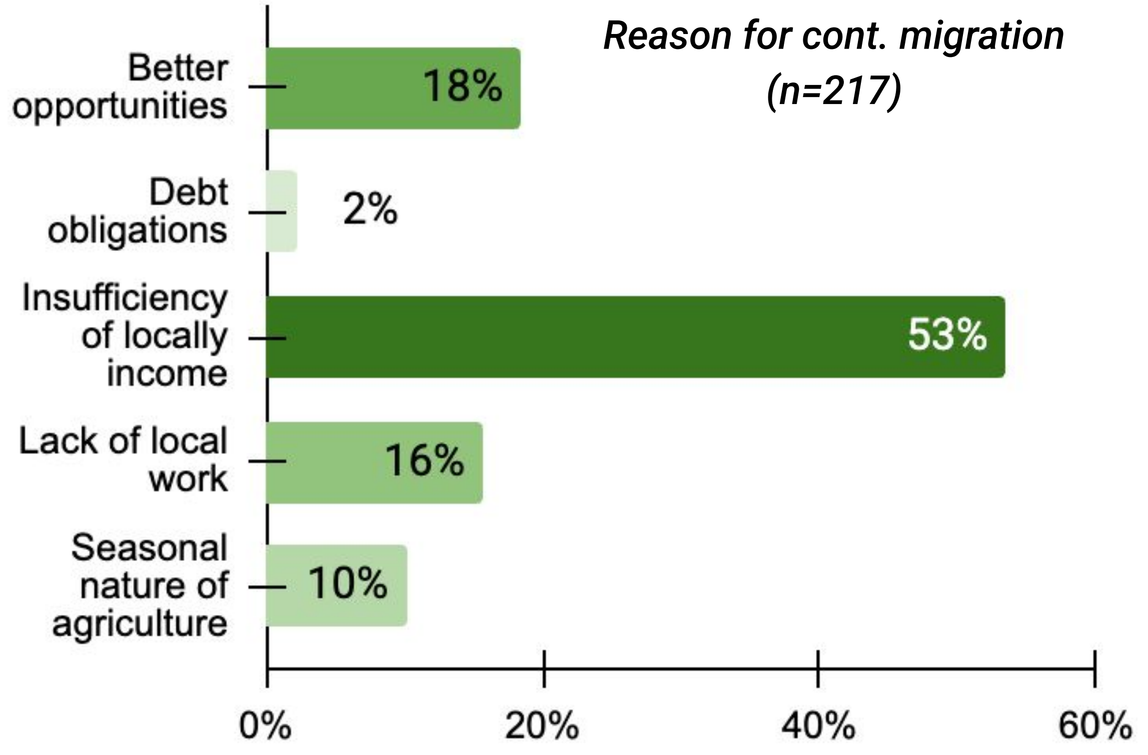
"We teach children in a digital way through tabs, and with electricity coming to the school, charging the tab has become easy, we easily charge the tab and teach children through that, due to which children study with great enthusiasm"

"Yes, children now come to school prepared. Compared to earlier, children now come having done their homework... earlier when there was no electricity, children had to study with kerosene lamps because of which they couldn't study for long at home... now that electricity has come, all children do their homework and are regular to school."

These findings indicate that electrification is strengthening institutional learning environments by improving classroom infrastructure, enabling better teaching practices, and supporting more effective learning conditions for students.

Villagers reported that electrification reduced migration for ~30% households, while strengthening local livelihoods within seasonal economic contexts





Migration patterns show modest yet impactful shifts, with 30% of households reporting **reduced** migration, often linked to **incremental increases in local work opportunities** enabled by electrification, as reported by 30% of households. This indicates a slow but steady impact of electrification on unintended areas like livelihood and migration.

Among those who still migrate, 53% of households reported the insufficiency of local income and 16% reporting the lack of local opportunities.

"There is no source of employment here, due to which people still have to go out of the house/village to work. Because there is no irrigated land, they cannot even do farming."

"There is a lot of lack of employment in the village, many people are unemployed even after getting a good education... even now many people are unemployed in this village."

This persistence is rooted in the **seasonal nature of local livelihoods**. With agriculture largely dependent on the monsoon, households continue to face periods of low or no income, forcing them to migrate during the off-season. As a result, migration follows a cyclical pattern , i.e., households return for agricultural seasons and migrate out again in search of work during lean periods.

"Farming is done here only in the Kharif [monsoon] season, so they come to farm in Kharif, do the farming, and then go back to other places to work because farming cannot be done in the Rabi season due to lack of water and irrigation facilities."

Electricity improves local conditions, but in the absence of year-round livelihoods, migration remains a **structural necessity rather than a choice**.

Electrification drives productivity gains, 44% higher yields and strengthens income stability for 52%, particularly where enabling assets exist (n-338)

Electrification has led to **visible improvements in agricultural productivity,** particularly through enhanced irrigation and crop diversification. Around 31% of households report **improved irrigation reliability** and 44% report **increased crop yields**, indicating tangible gains in output.

However, these benefits are **unevenly distributed**. Adoption of electricity-powered equipment remains limited, with only 40% of households using electric pumps, while the majority 62% continue to rely on manual or rain-fed methods. This reflects the importance of pre-existing assets, such as access to water sources, landholding size, and financial capacity and an opportunity to provide support on improving the gaps in mechanisation of agricultural for all.

"Electricity has brought a lot of changes in the village, now people are doing farming of different types of crops, earlier they could only [monsoon] farming"

"There is a lot of trouble with irrigation in the village, boring wells are few due to which people do less farming. If there is a means of irrigation in the village... people can use electricity for farming".

Despite these productivity gains, income improvements remain limited and uneven, with only 27% of households reporting increased income. Gains are largely incremental, driven by **improved output within existing activities**.

Electrification has had a stronger effect on income stability, with 52% reporting **improved stability**, particularly among households able to diversify income sources. **Electricity enables income certainty by supporting secondary activities and reducing dependence on a single seasonal livelihood.**

However, broader livelihood structures remain unchanged. Work availability continues to be a key constraint, with only 16% of households reporting year-round employment, and many still dependent on seasonal agriculture and migration. The 30% reduction in migration reported post electrifications indicates the potential to utilize agricultural improvement to rescue the migration further, since significant agri-improvements.

This gap between productivity and income reflects structural constraints including limited irrigation access, weak market linkages, and lack of local employment which restrict households' ability to convert efficiency gains into sustained income growth.

93% households strengthen existing livelihood due to electrification, ~7% initiated new income activities indicating new income-generating opportunities enable due to electrification

93% of households reported using grid electricity in some form to strengthen their existing livelihoods. This includes both direct uses and indirect benefits such as extended working hours, improved lighting, and enhanced safety which collectively contribute to livelihood improvement.

Where new activities have emerged, they are largely enabled through the use of **electric machinery** 69%, such as refrigerators for retail and milling machines for crop processing. However, these **opportunities remain concentrated among a small subset of households**, typically those with pre-existing assets, capital, or established businesses, allowing them to absorb the upfront costs and risks.

"The power isn't strong enough for new industries yet, but it's been a huge help for agriculture.

"Local shops are now stocking cold drinks since they can run refrigerators."

From 417 HH **~7%** of households reporting the start of a new income-generating activity, electrification under the Green Switch programme shows spillover impact impact on generating new livelihoods.

69% use of electric machines

14% attracted more customers

10% extended working hours

7% digitally found work

How did the electricity help start or support this new work?

Electrification has become a vital resource for the community, 7% of households have initiated new livelihood opportunities since grid access. This reflects a growing willingness to invest in place-based income generation. An increase in local shops is thereby improving the availability of goods within the village, with positive spillover effects for the entire community.

"Some people are using electricity for their livelihoods and income, but the power trips if there's too much load. Because of that, they can't really use electric motors or pump enough water for their crops."

This indicates that electricity functions as an **enabler of incremental livelihood improvement** rather than a catalyst for broad-based livelihood transformation, with benefits **closely tied to households' existing economic position.**

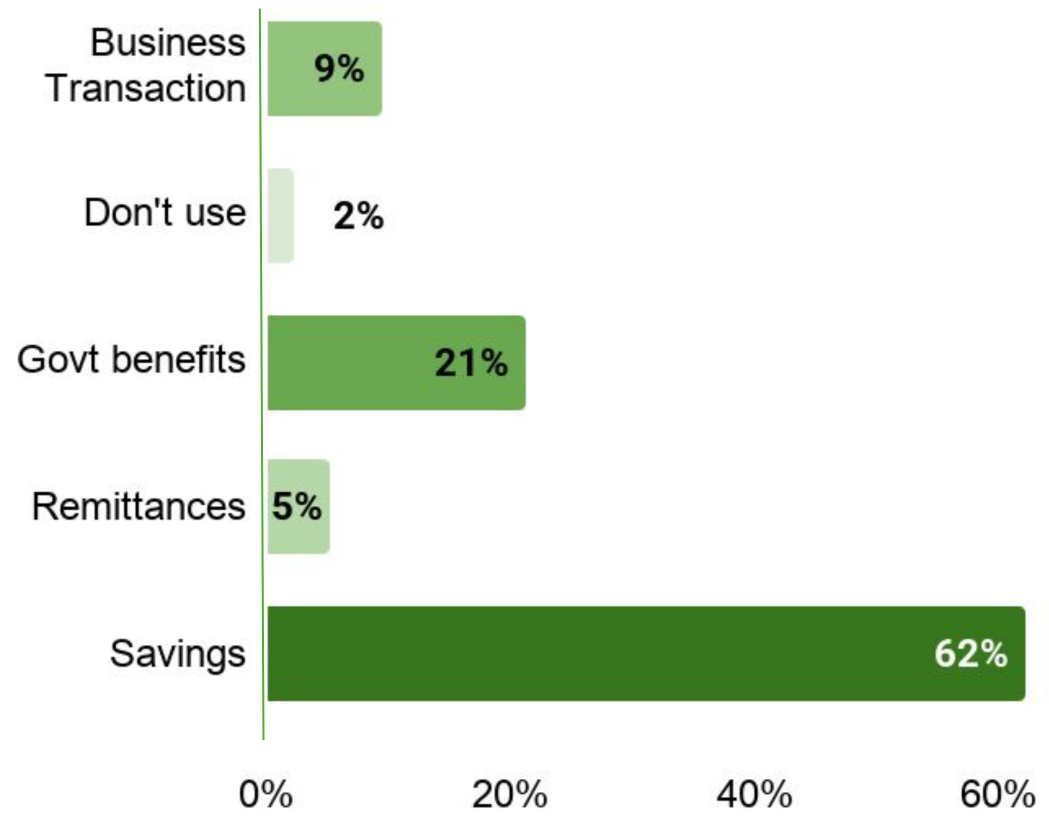
94% have bank accounts, but only 17% use digital payments and 99% electricity payments remain cash-based, indicating need to strengthen financial inclusion

Electrification has coincided with high levels of formal financial access, with **94%** of households holding active bank accounts. However, this access has not translated into active financial engagement or deep inclusion.

Most households use bank accounts primarily for basic functions such as savings, **62%**, or receiving government transfers, **21%**, with limited use for transactions or financial planning.

Digital financial adoption remains modest. **17%** of households report using digital payments, while **99%** of electricity payments continue to be made in cash, indicating that electrification has not yet catalysed a concrete shift toward digital or formal financial ecosystems.

Purpose of Bank Account (n=393)



"On a day-to-day basis, people make payments in the form of cash. At the beginning of the month, the operator goes to every house to check... and on the 7th of the month, a meeting of the Gram Sabha and VEC committee is held, in that meeting the bill is collected from everyone"

At the same time, access to credit remains minimal (**1.7% households**), and is largely used for consumption rather than income generation, limiting the potential for electricity to drive financial mobility.

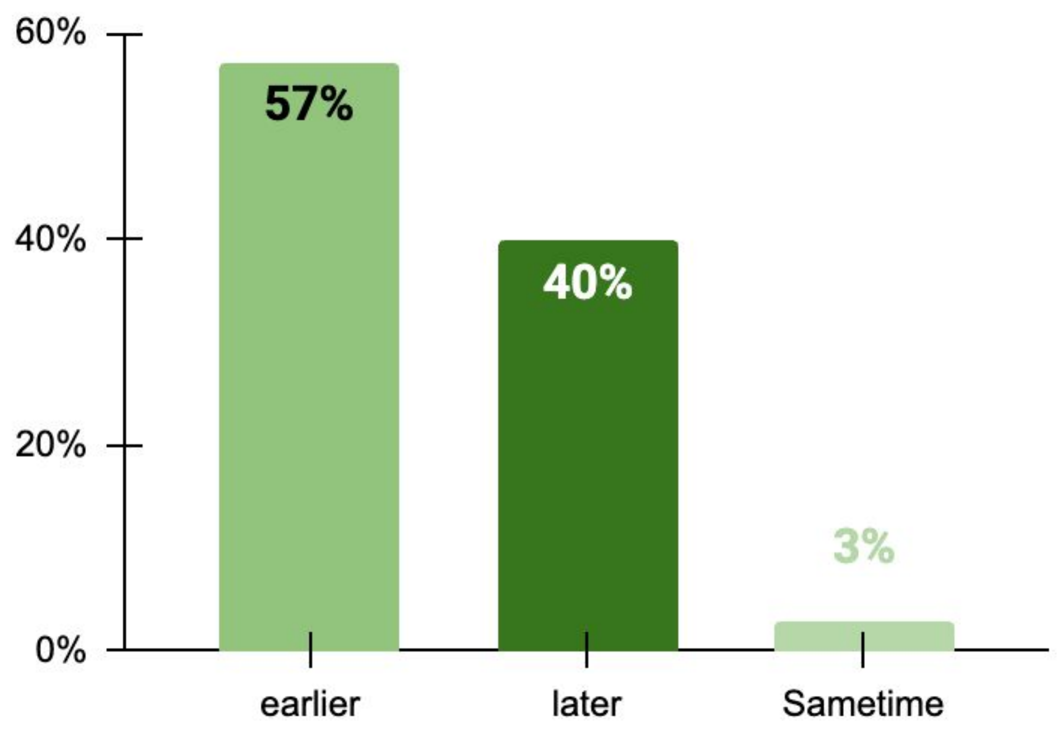
Despite this, perceived value remains high, with at least **8 in 10** households reporting that electricity is **worth the cost**, suggesting that benefits are primarily driven by **quality-of-life improvements rather than direct economic returns.**

Women's financial participation is also evolving, with **23%** households reporting women as financial decision-makers, but this is not yet supported by broader institutional inclusion (e.g., low insurance uptake, limited financial literacy).

Financial inclusion has **expanded in access**, but remains **shallow in usage**, limiting its role in enabling economic mobility.

96% of women report increased leisure time and 57% complete tasks earlier; indicating significant gains in efficiency and control over daily routines

Household chores timing shift post-electrification (n=236)



Electrification has led to a fundamental shift in women's daily lives, particularly in how time and labour are structured. With the introduction of appliances and improved access to water, manual and **time-intensive tasks have reduced significantly**, allowing women to complete household work more efficiently. This is reflected in the fact that 57% of women reported completing tasks earlier than before.

"With electricity, there has been help in household chores. Earlier, we had to use a silbatta (stone grinder) to grind spices, which took a lot of hard work and time. Now we use a mixer grinder, which prepares the spices quickly, in less time, and with less effort."

Beyond efficiency, electricity has also introduced **greater control over time.** Women are no longer constrained by daylight hours, instead, they are able to shift tasks across the day, with 40% reporting completing activities later, indicating increased flexibility rather than just reduced workload.

"After sunset, we cook food. After cooking, we spend some time weaving mats or making bamboo items. When there was no electricity, we used to cook in the evening, eat quickly, and sleep. Now we do some work at night too."

As a result, 96% of women report having time to **rest, relax, or engage socially**, marking a significant improvement in overall well-being and daily comfort. However, much of this saved time continues to be reinvested into domestic responsibilities and childcare, rather than translating into economic or independent activities.

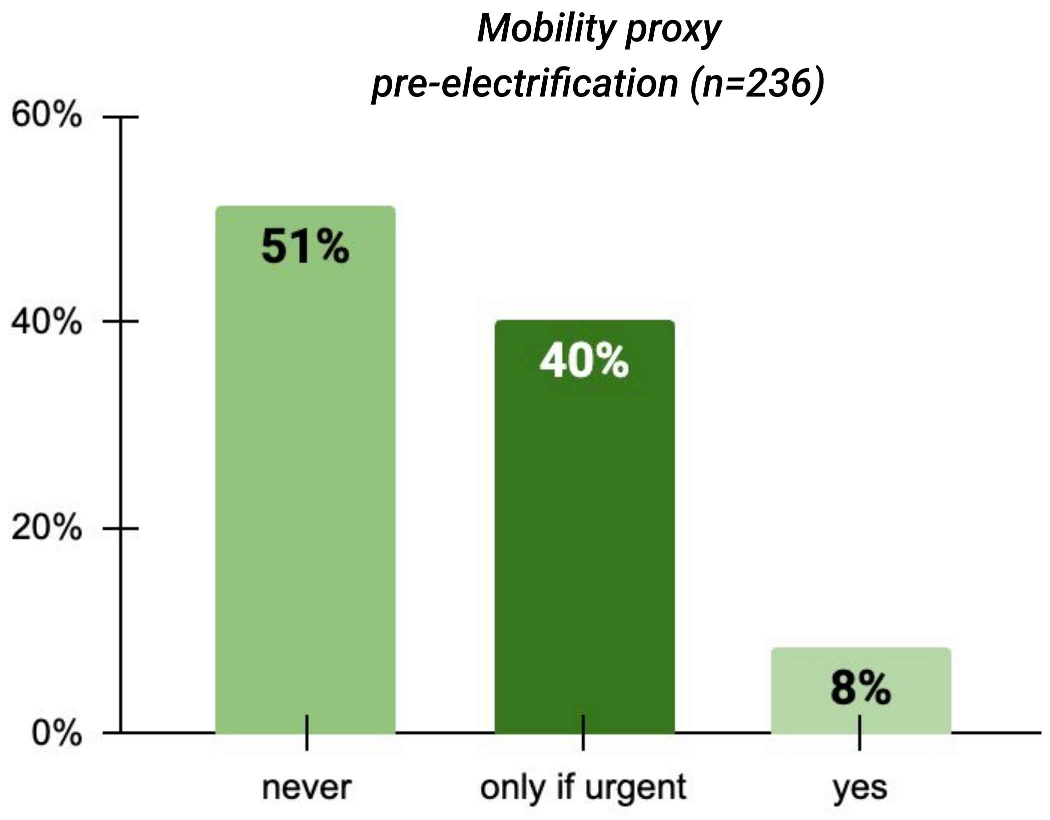
"Yes, with electricity, the way we spend our time has changed. We are able to converse with people around for a while, stay awake till late at night, and spend time with family."

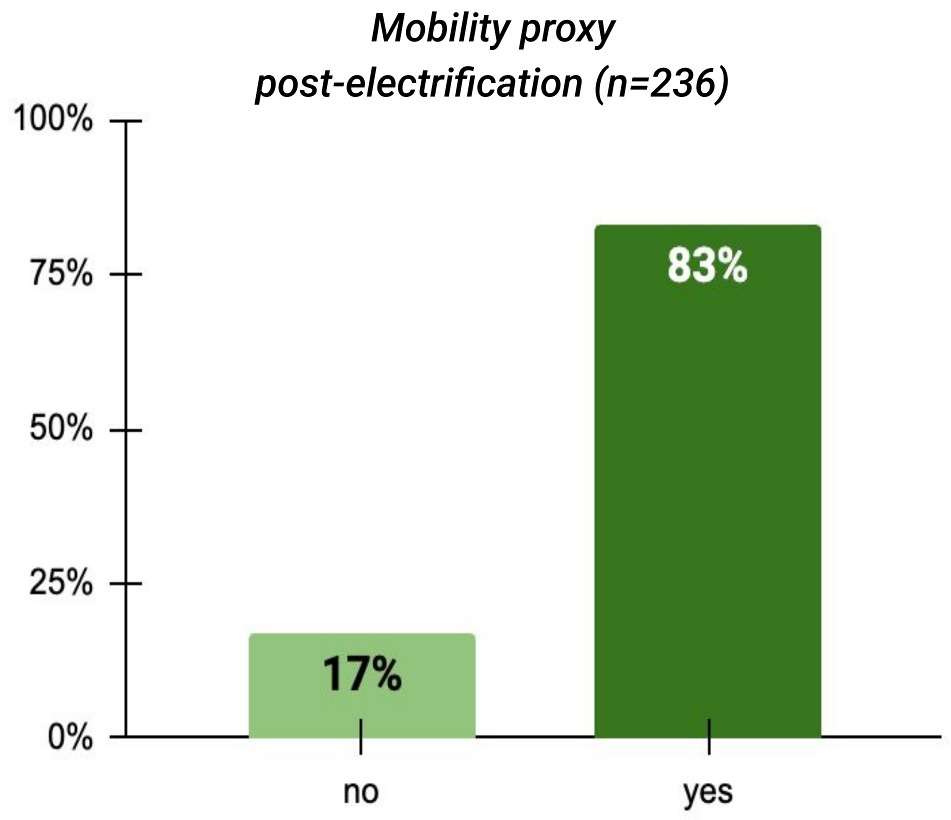
"Yes, with electricity some of our time is saved, we use that time for our household chores and taking care of children"

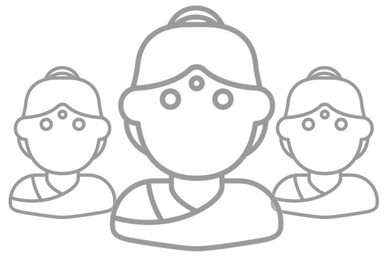
From over 90% feeling restricted mobility to 83% participating in evening activities, electrification transforms night-time into a space of safety and social engagement

Electrification has dramatically transformed women's mobility and sense of safety, particularly after dark. Prior to electrification, over 90% of women either never stepped out alone at night or did so only in emergencies, due to fear of darkness, wildlife, and lack of visibility.

With the introduction of consistent lighting, this constraint has been effectively removed. Women now report feeling safe moving within the village at night, enabling a **shift from restricted movement to active participation in community life**. This is reflected in the fact that 83% of women now participate in evening social gatherings.







"Yes, now women are able to hold meetings till late in the evening. In our village, an SHG group also runs where we sometimes hold meetings late in the evening. Earlier, due to no electricity, we had to hold meetings during the day."

"Now when electricity has come, all the women of the village feel safe going out around the house or if they have to go to the community. There is light in the whole village and people feel safe going anywhere."

This increased mobility is closely linked to greater social participation and inclusion. Women are now able to attend Self-Help Group (SHG) meetings, community discussions, and informal gatherings, many of which were **previously limited to daytime hours**.

At the same time, improvements in lighting have led to near-universal perceptions of safety, reducing anxiety around night-time movement and emergencies, and increasing overall confidence in navigating public spaces.

Lighting transforms night-time from a constraint to an opportunity; enabling mobility, safety and social inclusion directly contributing towards improved agency especially for women.

While 60% of households report joint decision-making, 32% report women as primary decision-makers; highlighting gradual, shifts in agency

Green Switch Programme has expanded women's participation in household and community life, which has also been reflected in individually-led decisions. Women emerge as the most **prominent** decision-makers on electricity usage, 32%, significantly higher than male-only decision-making, 7%. This suggests that **women's voice** within the household has **strengthened** and become more **visible**.

"Yes, with the coming of electricity our role in decision-making has changed, we are now able to supervise the children's studies."

However, this improvement in agency is uneven across domains. Women's influence is most pronounced in traditional and caregiving roles, such as managing household routines and overseeing children's education, ~79% report increased involvement. In contrast, financial and administrative decisions continue to be largely male-dominated, 42%, particularly in interactions with external institutions and systems.

Electrification also intersects with migration-driven household dynamics, where women increasingly take on greater operational responsibility in the absence of male members. In such contexts, women manage daily household and livelihood activities in 58% of cases, including agriculture and local coordination.

84%

women report improvement in health

Alongside, 84% of women (n=236) have reported an overall improvement in health post electrification that was earlier caused due to cooking or any other usage of kerosene. This also indicates that reduced kerosene exposure is a key pathway through which electrification is improving women's health outcomes.

Overall, while electrification is enabling incremental shifts toward greater agency and participation, deeply embedded gender norms continue to shape how and where this agency is exercised, resulting in partial and domain-specific empowerment rather than a complete transformation.

Electrification from Green Switch is strengthening last-mile service delivery within its limited scope, however large systemic gaps continue to constrain outcomes

Where Electricity is Working

Learning & Education

Electrification has improved classroom usability through better lighting and ventilation, enabling longer and more consistent learning hours. This has increased student attentiveness and participation, particularly during early mornings and evenings, creating more stable learning environments.

Institutional Functioning

Access to reliable electricity has enhanced administrative efficiency in schools and Anganwadis. Frontline workers are now able to charge devices, maintain records digitally, and coordinate services more effectively, leading to improved implementation of education, health, and nutrition programs.

Last-mile Health Responsiveness

Electrification has strengthened last-mile coordination by enabling better communication among frontline workers and improving emergency responsiveness. Communities can now reach healthcare providers more easily, including during night-time, improving service access at the point of delivery.

Where the System Breaks

Despite these operational gains, improvements in outcomes remain constrained by broader system-level gaps outside the project scope, including healthcare access and infrastructure. Hospitals and well-equipped health centres are often located far from villages, requiring long travel times, while poor road connectivity delays access during emergencies. Additionally, gaps in local healthcare infrastructure, including under-equipped sub-health centres and limited institutional capacity, continue to restrict the effectiveness of improved frontline coordination, highlighting the need for parallel systemic investments beyond the project scope.

"Earlier doctors would not come at night, but now they are willing to visit."

"The hospital is far and roads are poor, so treatment gets delayed."

"There are no proper facilities nearby, so people struggle to get treated in time."

Electrification from the Green Switch Programme has improved frontline responsiveness and service delivery within its limited scope; however, persistent systemic gaps in healthcare infrastructure, connectivity, and institutional capacity continue to constrain outcomes.

Community-led governance through VECs is enabling local system management, but capacity-building and handholding can support long term sustainability

Structure of VECs

Solar microgrids in these villages are governed through decentralized, community-led institutions known as Village Electricity Committees (VECs). These committees are responsible for managing day-to-day operations, including tariff collection, system maintenance, & resolving user concerns. Governance is conducted through open village meetings, where households participate in billing discussions, deposit payments, & raise service-related issues. Funds are managed transparently through designated accounts, & the committees are formed through democratic village processes, ensuring collective ownership & accountability in managing local energy systems.

Outcomes / Impact

This governance model has enabled effective local management of electricity systems, supported by transparent tariff structures & regular community engagement. The system has also fostered inclusive participation, with women actively involved in VECs across multiple villages & taking on leadership roles such as President & Treasurer in some cases. These dynamics have strengthened trust, improved financial transparency, & contributed to the operational sustainability of the microgrid system, while also creating pathways for local leadership development.

Scope for Improvement

Despite these strengths, several challenges may affect long-term sustainability. Some households find fixed monthly tariffs financially burdensome, particularly in areas with limited income opportunities. In addition, VEC members often lack the technical capacity to independently manage infrastructure-related issues, indicating a need for ongoing training & technical support. Sustaining active participation in community meetings has also become difficult in some villages, leading to operational responsibilities being concentrated among a few members. These constraints highlight the need for continued institutional strengthening alongside community-led governance.

Qualitative Evidence

"Most of the work is handled by only a few committee members."

"₹100 every month feels difficult for some households."

"VEC members have not received training, but they should receive training so they can fix problems themselves."

Carbon Sequestration

Primary sources reveal carbon reduction of 41,970 kgCO_2e and secondary consumption data reveals carbon saving of 134,329 kgCO_2e

Collated Carbon Emission Reduction / Saving				
Source of Emission	Baseline Emissions (kgCO_2e/year)	Post-Green Switch Emissions (kgCO_2e/year)	Carbon Emission Reduction / Saving (kgCO_2/year)	Carbon Emission Reduction / Savings (kgCO_2/year)
Primary Data	232.13	131.48	-100.65	-41970.03
Secondary Data			322.133	134,329.26

The analysis captures the program's environmental impact through both primary and secondary data lenses.

Based on primary data on fuel usage across sampled households, the Green Switch has resulted in an estimated **41,970 kgCO_2e** annual reduction, equivalent to the carbon sequestration capacity of approximately **23,971 trees** per year.

To further contextualize this impact, a counterfactual scenario using secondary data on average household electricity consumption estimates that, in the absence of the program, emissions would have reached **134,329 kgCO_2e** annually, requiring nearly **76,723 trees** to offset. While the program currently operates on solar power, effectively resulting in a near-zero emission factor at the point of consumption, this comparison highlights the substantial emissions prevented across hamlets due to the Green Switch.

Note: Detailed methodology, assumptions, and calculation parameters are provided in the annexure.

~42 tonnes KgCO₂e annual emissions reduced through the Green Switch Programme across sample of 417 households, driven by clean energy transition

Sr No	Fuel Type	Measurement Units	Baseline Annual Consumption	Post-Green Switch Annual Consumption	Standardised Fuel Emission Factors (kgCO2/kWh)	Baseline Energy Use (kWh/year)	Post-Green Switch Energy Use (kWh/year)	Baseline Emissions ($kgCO_2$/year)	Post-Green Switch Emissions ($kgCO_2$/year)	Carbon Emission Reduction / Saving ($kgCO_2$/year)
1	Kerosene	litres	33.12	0.32	0.26	322.01	3.08	83.35	0.80	-82.55
2	Fuelwood	kg	65.32	57.64	0.40	366.54	323.43	147.79	130.41	-17.38
3	Coal	kg	0.14	0.14	0.33	0.67	0.67	0.22	0.22	0.00
4	Diesel	litres	3.74	0.29	0.25	3.10	0.24	0.77	0.06	-0.71
5	Solar	kWh	-	26.20	0.00	-	26.20	0.00	0.00	0.00
6	Solar Grid Electricity	kWh	-	133.72	0.00	-	133.72	0.00	0.00	0.00

Carbon Emission Reduction per Household	**-100.65**
Sample Size	**417.00**
Overall Carbon Emission Reduction	**-41970.03**

Result: Based on our assessment of the sample of 417 households in Jharkhand , Tata Capital's Green Switch Programme has enabled annual carbon emission reductions of **41,970 $kgCO_2e$ (~42 tonnes CO_2e)**

Note 1: Analysis based on primary survey conducted by Sattva Consulting (n = 417 households across 28 hamlets)
Note 2: Baseline and post-green switch consumption estimated using common averages of the sample to reflect population distribution
Note 3: Monthly consumption data annualised to align with standard carbon accounting practices
Note 4: Energy conversion derived using fuel density and Gross Calorific Values (GCV); GCV is used (instead of Net Calorific Value) to ensure consistency across varying methodologies
Note 5: Solar as a source has zero carbon emission during usage – Emission factor has been taken 0 for the same reason
Note 6: Emission reductions calculated at household level and extrapolated to population because of weighted average approach usage
Note 7: Fuelwood assumptions based on dominant broadleaf species in Jharkhand region
Note 8: Diesel density standardised at 827.5 kg/m³ (midpoint of 810–845 kg/m³ range)
Note 9: Detailed methodology, assumptions, and calculation parameters are provided in the annexure.

Emissions saved by bypassing the standard electricity grid to solar electricity grid

The program currently operates on solar power, effectively resulting in a zero emission factor at the point of consumption. To capture the true environmental benefit of this Green Switch, we estimate the prevented emissions under a counterfactual scenario, i.e., if these households had used standard grid electricity. Using secondary data on average household consumption, the analysis quantifies the emissions prevented across hamlets, with detailed estimates provided in the annexure (comprehensive table is attached in the annexure).

Hamlets	Average Household Units of Consumption (monthly/kWh)	Annualised Average Household Units of Consumption (yearly/kWh)	Emission factor (unit- tCO_2/MWh) unit applicable to us - $KgCO_2e$/kWh	Average Emissions Prevented yearly per HH (unit - $KgCO_2e$)
Baki Kona	29	343	0.729	250.140
Bala Pani	25	306	0.729	222.935
Bandatoli	19	230	0.729	167.320
Tukupani	33	401	0.729	292.138
Urunkela	51	608	0.729	442.907
Vantoli Sugadongar	25	304	0.729	221.399
Average of Total Hamlets	37	442	0.729	**322.133**
Total 417 HHs	15,355.42	**1,84,265.10**	0.73	**1,34,329.26**

Thus, by relying on clean solar energy, the program successfully prevents an average of **~322 $kgCO_2e$** of emissions per household annually, averting a total of over **1,34,000 $kgCO_2e$** across the 29 hamlets.

Primary data suggests the plantation of 23,971 trees annually for 417 households to neutralize the carbon emissions released, while secondary data suggests the plantation of 184 trees annually

Carbon Emission Reduction / Saving					Sequestration	
S. No.	Fuel Type	Baseline Emissions ($kgCO_2e$/year)	Post-Green Switch Emissions ($kgCO_2e$/year)	Carbon Emission Reduction / Saving ($kgCO_2$/year)	Sequestration per month per tree (21.01/12 KgCO2/month)	Trees needed to offset
1	Kerosene	83.35	0.80	-82.55	1.75	47
2	Fuelwood	147.79	130.41	-17.38	1.75	10
3	Coal	0.22	0.22	0.00	1.75	0
4	Diesel	0.77	0.06	-0.71	1.75	0
5	Solar	0.00	0.00	0.00	1.75	0
6	Electricity	0.00	0.00	0.00	1.75	0
	Carbon Emission Reduction per Household			**-100.65**	**1.75**	**57**
	Sample Size			**417.00**		
	Overall Carbon Emission Reduction			**-41970.03**	**1.75**	23971

Electricity Consumption Secondary Data Carbon Sequestration			
Hamlets	Average Emissions generated yearly in HH (unit - $kgCO_2e$)	Sequestration per month per tree (21.01/12 $kgCO_2e$/month)	Trees needed to offset
Baki Kona	250.140	1.75	143
Bala Pani	222.935	1.75	127
Bandatoli	167.320	1.75	96
……	……	……	……
……	……	……	……
Tukupani	292.138	1.75	167
Urunkela	442.907	1.75	253
Vantoli Sugadongar	221.399	1.75	126
Average of Total Hamlets	322.133	1.75	**184**

In the absence of the project, if households had relied on conventional grid electricity, the resulting carbon emissions would have required **~184 trees annually to offset**, highlighting the environmental value of the solar transition.

Note 1: Total consumption details based on primary survey conducted by Sattva Consulting (n = 417 households across 28 hamlets)
Note 2 : Electricity consumption details have been utilized from the secondary source received by TRIF rather than Sattva Consulting primary data
Note 3: Sequestration rate (21.01 $kgCO_2e$/tree/year) derived from secondary research; Ref -http://www.ijcrbp.com/vol-1-4/B.C.%20Oraon,%20et%20al.pdf
Note 4: Represents average for mature trees under typical Indian conditions with assumptions as - Trees are fully grown (not saplings) & Trees survive and sequester carbon consistently each year
Note 5: Does not account for species variation, soil conditions, or climate differences
Note 6: Linear sequestration assumed (no growth curve applied)
Note 7: Detailed methodology, assumptions, and calculation parameters are provided in the annexure.

Recommendations

Recommendations

VECs are the backbone of the programme's long-term sustainability. The recommendations below are designed to deepen their capacity in established villages and build proactive, impact-oriented committees from the outset in newer ones.

Increase Frequency and Quality of VEC Refresher Trainings

VECs have expressed a need for more frequent refresher training , requesting a shift from annual to bi-annual refreshers to strengthen their technical knowledge and governance confidence. In newer villages, capacity building should begin at the point of grid commissioning. Early investment in VEC capability sets the right norms from the outset and builds the kind of informed, confident committees that can independently manage and grow the grid's reach over time.

Expand the VEC Mandate to Cover Productive Use of Electricity

The role of the VEC can be further evolved toward actively facilitating productive use of electricity within the community. This is particularly important in the context of agriculture and livelihoods, where the grid holds significant untapped potential. VECs, given their community trust and local presence are well-placed to drive awareness of solar-powered irrigation, mechanisation options, and relevant government schemes among farming households. In newer villages, introducing this broader mandate early ensures that productive use is embedded as a key role of the committee from the beginning. Having these conversations early creates a sensitised, aware VEC that can meaningfully enhance the reach and developmental impact of the grid.

Engage VECs as Facilitators of Women's Economic Participation

The observed improvement in women's mobility and leisure time post-electrification represents a strategic opportunity that VECs can facilitate and tap into. As trusted community bodies, VECs can serve as a bridge between women in the village and relevant livelihood opportunities . including SHG linkages, government programmes, and electricity-enabled income-generating activities. Formalising this facilitation role within the VEC's mandate, supported by appropriate training and guidance, would allow the programme to extend its social impact beyond household welfare into women's economic agency. This is a can be built as an extension of the VEC's existing community role and one that aligns with the broader goals of the programme along with right capacity building and knowledge transfer.

Annexure

Annexure A : Hamlet × Hours of Electricity Availability (Demarcated by Year)

COUNTA of hours_avail		***hours_avail***							
yr of inception	***hamlet***	**<6hours**	**12-16**	**16-20**	**20-23**	**24**	**6-8**	**8-12**	**Grand Total**
2021-22	Dabanipani					86.67%	13.33%		100.00%
	Girang				13.33%	73.33%		13.33%	100.00%
	Jharan_Tangertoli					87.50%		12.50%	100.00%
	Saraipani			6.25%	12.50%	68.75%		12.50%	100.00%
	Urunkela				12.50%	75.00%	12.50%		100.00%
2021-22 Total				1.28%	7.69%	78.21%	5.13%	7.69%	100.00%
2022-23	Dhorijor					88.89%	11.11%		100.00%
	Partappur				6.25%	81.25%	6.25%	6.25%	100.00%
	Samardema					66.67%		33.33%	100.00%
	Tukupani					86.67%	13.33%		100.00%
2022-23 Total					1.82%	83.64%	9.09%	5.45%	100.00%
2023-24	Bakikona					86.67%	6.67%	6.67%	100.00%
	Balapani					85.71%	14.29%		100.00%
	Bandatoli					100.00%			100.00%
	Chandaritoli	6.25%	6.25%			62.50%	6.25%	18.75%	100.00%
	Churichokha_Purvi					100.00%			100.00%
	Dhangari Nacha					73.33%	20.00%	6.67%	100.00%
	Dodapani					100.00%			100.00%
	Domrabandh					100.00%			100.00%
	Kinkel_Paharkona					100.00%			100.00%
	Lukaltoli				25.00%	62.50%		12.50%	100.00%
	Machiyaghat				27.27%	63.64%	9.09%		100.00%
	Mudiyadih Tangratoli					71.43%	28.57%		100.00%
	Sarlatoli			6.25%	31.25%	43.75%	6.25%	12.50%	100.00%
	Tinatoli					84.21%		15.79%	100.00%
2023-24 Total		0.47%	0.47%	0.47%	5.66%	81.13%	6.13%	5.66%	100.00%
2024-25	Bansgada					90.91%		9.09%	100.00%
	Gatigada_Soreangtoli					100.00%			100.00%
	Kudpani_Girjatoli					73.33%	6.67%	20.00%	100.00%
	Rengarbahar					75.00%		25.00%	100.00%
	Vantoli_Sugadongar					80.00%		20.00%	100.00%
2024-25 Total						83.33%	1.39%	15.28%	100.00%
Grand Total		**0.24%**	**0.24%**	**0.48%**	**4.56%**	**81.29%**	**5.52%**	**7.67%**	**100.00%**

Annexure B : Hamlet × Average Monthly Income X Choosing not to use electricity

COUNTA of notuse_elecavail		*notuse_elecavail*		
hamlet	*avg_total_mon_inc*	0	1	Grand Total
Bakikona	>₹15,000	100%		100.00%
	₹2,501–₹5,000	100%		100.00%
	₹7,501–₹10,000	100%		100.00%
	I_dont_know	100%		100.00%
Bakikona Total		100%		100.00%
Balapani	<₹2,500	100%		100.00%
	>₹15,000	50%	50%	100.00%
	₹10,001–₹15,000	100%		100.00%
	₹2,501–₹5,000	60.00%	40.00%	100.00%
	₹5,001–₹7,500	100.00%		100.00%
	I_dont_know	66.67%	33.33%	100.00%
Balapani Total		71.43%	28.57%	100.00%
Bandatoli	<₹2,500	100.00%		100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	33.33%	66.67%	100.00%
	₹2,501–₹5,000	33.33%	66.67%	100.00%
	₹5,001–₹7,500	100.00%		100.00%
	₹7,501–₹10,000	100.00%		100.00%
Bandatoli Total		75.00%	25.00%	100.00%
Bansgada	<₹2,500	100.00%		100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	75.00%	25.00%	100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500		100.00%	100.00%
	I_dont_know	100.00%		100.00%
Bansgada Total		81.82%	18.18%	100.00%
Chandaritoli	<₹2,500	100.00%		100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	100.00%		100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500	100.00%		100.00%
	₹7,501–₹10,000	100.00%		100.00%
	I_dont_know	100.00%		100.00%
Chandaritoli Total		100.00%		100.00%
Churichokha_Purvi	<₹2,500	100.00%		100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	80.00%	20.00%	100.00%
	₹2,501–₹5,000	50.00%	50.00%	100.00%
	₹5,001–₹7,500	100.00%		100.00%
	₹7,501–₹10,000	100.00%		100.00%
	I_dont_know	100.00%		100.00%
Churichokha_Purvi Total		86.67%	13.33%	100.00%
Dabanipani	<₹2,500	100.00%		100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	100.00%		100.00%
	₹2,501–₹5,000	66.67%	33.33%	100.00%
	₹5,001–₹7,500	50.00%	50.00%	100.00%
	₹7,501–₹10,000	100.00%		100.00%
	I_dont_know	100.00%		100.00%
Dabanipani Total		86.67%	13.33%	100.00%
Dhangari Nacha	>₹15,000	100.00%		100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹7,501–₹10,000	100.00%		100.00%
	I_dont_know	66.67%	33.33%	100.00%
Dhangari Nacha Total		93.33%	6.67%	100.00%
Dhorijor	<₹2,500	50.00%	50.00%	100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	100.00%		100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500		100.00%	100.00%
	₹7,501–₹10,000	75.00%	25.00%	100.00%
Dhorijor Total		83.33%	16.67%	100.00%
Dodapani	<₹2,500	100.00%		100.00%
	>₹15,000	50.00%	50.00%	100.00%
	₹10,001–₹15,000	100.00%		100.00%
	₹2,501–₹5,000	80.00%	20.00%	100.00%
	₹5,001–₹7,500	100.00%		100.00%
	₹7,501–₹10,000	100.00%		100.00%
	I_dont_know	100.00%		100.00%
Dodapani Total		85.71%	14.29%	100.00%
Domrabandh	<₹2,500	33.33%	66.67%	100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	66.67%	33.33%	100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500	66.67%	33.33%	100.00%
	₹7,501–₹10,000		100.00%	100.00%
Domrabandh Total		68.75%	31.25%	100.00%
Gatigada_Soreangtoli	<₹2,500	66.67%	33.33%	100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	100.00%		100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500	100.00%		100.00%
	₹7,501–₹10,000		100.00%	100.00%
	I_dont_know	100.00%		100.00%
Gatigada_Soreangtoli Total		86.67%	13.33%	100.00%
Girang	<₹2,500	100.00%		100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	100.00%		100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500	100.00%		100.00%
	I_dont_know	100.00%		100.00%
Girang Total		100.00%		100.00%
Jharan_Tangertoli	<₹2,500	100.00%		100.00%
	>₹15,000		100.00%	100.00%
	₹10,001–₹15,000	100.00%		100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500	50.00%	50.00%	100.00%
	I_dont_know	66.67%	33.33%	100.00%
Jharan_Tangertoli Total		75.00%	25.00%	100.00%
Kinkel_Paharkona	<₹2,500	50.00%	50.00%	100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	66.67%	33.33%	100.00%
	₹2,501–₹5,000	75.00%	25.00%	100.00%
	I_dont_know	100.00%		100.00%
Kinkel_Paharkona Total		73.33%	26.67%	100.00%
Kudpani_Girjatoli	<₹2,500	75.00%	25.00%	100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	100.00%		100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500	100.00%		100.00%
	I_dont_know	100.00%		100.00%
Kudpani_Girjatoli Total		93.33%	6.67%	100.00%
Lukaltoli	<₹2,500	100.00%		100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000	66.67%	33.33%	100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500	100.00%		100.00%
	₹7,501–₹10,000	100.00%		100.00%
Lukaltoli Total		93.75%	6.25%	100.00%
Machiyaghat	<₹2,500	100.00%		100.00%
	₹10,001–₹15,000	100.00%		100.00%
	₹2,501–₹5,000	66.67%	33.33%	100.00%
	₹5,001–₹7,500	100.00%		100.00%
	₹7,501–₹10,000	50.00%	50.00%	100.00%
	I_dont_know		100.00%	100.00%
Machiyaghat Total		72.73%	27.27%	100.00%
Mudiyadih Tangratoli	<₹2,500	100.00%		100.00%
	>₹15,000	100.00%		100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500	100.00%		100.00%
	₹7,501–₹10,000	100.00%		100.00%
	I_dont_know	100.00%		100.00%
Mudiyadih Tangratoli Total		100.00%		100.00%
Partappur	<₹2,500	100.00%		100.00%
	>₹15,000	100.00%		100.00%
	₹10,001–₹15,000		100.00%	100.00%
	₹2,501–₹5,000	100.00%		100.00%
	₹5,001–₹7,500	100.00%		100.00%
	₹7,501–₹10,000	100.00%		100.00%
	I_dont_know	100.00%		100.00%
Partappur Total		93.75%	6.25%	100.00%

Annexure C : Hamlet × Pattern of Powercuts/Outages (Demarcated by Year)

COUNTA of pattern_powercuts		pattern_powercuts						
yr of inception	hamlet	fewtimes_day	fewtimes_month	fewtimes_week	Don't Know	no	Once_day	Grand Total
2021-22	Dabanipani		6.67%			93.33%		100.00%
	Girang		13.33%		6.67%	73.33%	6.67%	100.00%
	Jharan_Tangertoli					100.00%		100.00%
	Saraipani	12.50%	12.50%	12.50%		56.25%	6.25%	100.00%
	Urunkela	6.25%	6.25%		6.25%	81.25%		100.00%
2021-22 Total		3.85%	7.69%	2.56%	2.56%	80.77%	2.56%	100.00%
2022-23	Dhorijor					100.00%		100.00%
	Partappur					100.00%		100.00%
	Samardema					83.33%	16.67%	100.00%
	Tukupani		33.33%	6.67%		46.67%	13.33%	100.00%
2022-23 Total			9.09%	1.82%		83.64%	5.45%	100.00%
2023-24	Bakikona				6.67%	93.33%		100.00%
	Balapani		14.29%			78.57%	7.14%	100.00%
	Bandatoli					100.00%		100.00%
	Chandaritoli					93.75%	6.25%	100.00%
	Churichokha_Purvi					100.00%		100.00%
	Dhangari Nacha					100.00%		100.00%
	Dodapani					100.00%		100.00%
	Domrabandh					100.00%		100.00%
	Kinkel_Paharkona		6.67%		6.67%	86.67%		100.00%
	Lukaltoli		12.50%			87.50%		100.00%
	Machiyaghat		27.27%		9.09%	54.55%	9.09%	100.00%
	Mudiyadih Tangratoli		7.14%	7.14%	7.14%	57.14%	21.43%	100.00%
	Sarlatoli	25.00%	12.50%	31.25%		18.75%	12.50%	100.00%
	Tinatoli					100.00%		100.00%
2023-24 Total		1.89%	5.19%	2.83%	1.89%	84.43%	3.77%	100.00%
2024-25	Bansgada					90.91%	9.09%	100.00%
	Gatigada_Soreangtoli					100.00%		100.00%
	Kudpani_Girjatoli					100.00%		100.00%
	Rengarbahar					100.00%		100.00%
	Vantoli_Sugadongar				6.67%	86.67%	6.67%	100.00%
2024-25 Total					1.39%	95.83%	2.78%	100.00%
Grand Total		**1.68%**	**5.28%**	**2.16%**	**1.68%**	**85.61%**	**3.60%**	**100.00%**

Annexure D : Hamlet × Perception (Demarcated by Year)

COUNTA of satis_qual_supplyHH		satis_qual_supplyHH			
yr of inception	hamlet	High_sat	Neutral	Sat	Grand Total
2021-22	Dabanipani	86.67%		13.33%	100.00%
	Girang	73.33%		26.67%	100.00%
	Jharan_Tangertoli	100.00%			100.00%
	Saraipani	93.75%	6.25%		100.00%
	Urunkela	62.50%	6.25%	31.25%	100.00%
2021-22 Total		83.33%	2.56%	14.10%	100.00%
2022-23	Dhorijor	88.89%		11.11%	100.00%
	Partappur	87.50%		12.50%	100.00%
	Samardema	100.00%			100.00%
	Tukupani	93.33%		6.67%	100.00%
2022-23 Total		90.91%		9.09%	100.00%
2023-24	Bakikona	100.00%			100.00%
	Balapani	85.71%		14.29%	100.00%
	Bandatoli	100.00%			100.00%
	Chandaritoli	87.50%		12.50%	100.00%
	Churichokha_Purvi	100.00%			100.00%
	Dhangari Nacha	80.00%		20.00%	100.00%
	Dodapani	92.86%		7.14%	100.00%
	Domrabandh	81.25%		18.75%	100.00%
	Kinkel_Paharkona	100.00%			100.00%
	Lukaltoli	75.00%		25.00%	100.00%
	Machiyaghat	90.91%		9.09%	100.00%
	Mudiyadih Tangratoli	92.86%		7.14%	100.00%
	Sarlatoli	81.25%		18.75%	100.00%
	Tinatoli	84.21%		15.79%	100.00%
2023-24 Total		89.15%		10.85%	100.00%
2024-25	Bansgada	90.91%		9.09%	100.00%
	Gatigada_Soreangtoli	86.67%		13.33%	100.00%
	Kudpani_Girjatoli	46.67%		53.33%	100.00%
	Rengarbahar	100.00%			100.00%
	Vantoli_Sugadongar	93.33%		6.67%	100.00%
2024-25 Total		83.33%		16.67%	100.00%

Annexure E : List of Appliances Owned & Bought

Appliances	Percentage of ownership
Light Bulb	28
Tubelight	1
Ceiling Fan	6
Table Fan	13
Cooler	2
Mixer/Grinder	8
Cloth Iron	1
Mobile Phone	27
Irrigation Pump	9
Inverter	1
TV	2
Laptop/Tablet	0
None of these	1
Grand Total	100

Appliances	Percentage of Bought Appliances
Light Bulb	27
Tubelight	2
Ceiling Fan	10
Table Fan	15
Cooler	2
Mixer/Grinder	11
Cloth Iron	1
Mobile Phone	12
Irrigation Pump	13
Inverter	0
TV	3
Laptop/Tablet	0
None of these	3
Grand Total	100

Annexure F : Hamlet x Use of Appliances (bought on credit)

COUNTA of For what use have you bought these machines?		***For what use have you bought these machines?***		
Year of Inception acc to Hamlets_Distr Sheet	***Hamlet***	**biz/inc**	**prsnl**	**Grand Total**
2021-22	Dabanipani		100.00%	100.00%
	Jharan_Tangertoli		100.00%	100.00%
2021-22 Total			100.00%	100.00%
2023-24	Bandatoli		100.00%	100.00%
	Kinkel_Paharkona		100.00%	100.00%
2023-24 Total			100.00%	100.00%
2024-25	Vantoli_Sugadongar	50.00%	50.00%	100.00%
2024-25 Total		50.00%	50.00%	100.00%
Grand Total		**14.29%**	**85.71%**	**100.00%**

Annexure G : Carbon Sequestration of Hamlets

Hamlets	Average Household Units of Consumption (monthly/kWh)	Annualised Average Household Units of Consumption (yearly/kWh)	Emission factor (unit- tCO_2/MWh) unit applicable to us - KgCO2e/kWh	Average Emissions generated yearly in HH (unit - KgCO2e)	Sequestration per month per tree (21.01/12 KgCO2e/month)	Trees needed to offset
Baki Kona	29	343	0.729	250.140	1.751	143
Bala Pani	25	306	0.729	222.935	1.751	127
Bandatoli	19	230	0.729	167.320	1.751	96
Bansgada	12	146	0.729	106.715	1.751	61
Chadri Toli	20	241	0.729	175.846	1.751	100
Churichokha East	31	371	0.729	270.363	1.751	154
Dabanipani	32	384	0.729	279.758	1.751	160
Dhangri Nacha	19	231	0.729	168.331	1.751	96
Dhorijor-1	55	666	0.729	485.346	1.751	277
Dhorijor-2	49	589	0.729	429.695	1.751	245
Dodapani Dipatoli	23	272	0.729	198.129	1.751	113
Dodapani Khas	18	220	0.729	160.540	1.751	92
Domrabandh	20	239	0.729	174.538	1.751	100
Gatigorha Sorengtoli	9	104	0.729	76.106	1.751	43
Girang	229	2743	0.729	1999.982	1.751	1142
Jharan Tangertoli	63	756	0.729	550.954	1.751	315
Kudpani Girjatoli	8	100	0.729	73.001	1.751	42
Machiya Ghat	21	250	0.729	182.105	1.751	104
Mudiyadih- Tangertoli	29	351	0.729	255.919	1.751	146
Paharkona	15	177	0.729	129.306	1.751	74
Partappur	26	310	0.729	225.861	1.751	129
Rengarbahar Girjatoli	22	261	0.729	190.216	1.751	109
Samardema	34	413	0.729	300.812	1.751	172
Saraipani	61	735	0.729	535.974	1.751	306
Sarla Toli	70	842	0.729	613.492	1.751	350
Tina Toli	19	222	0.729	162.016	1.751	93
Tukupani	33	401	0.729	292.138	1.751	167
Urunkela	51	608	0.729	442.907	1.751	253
Vantoli Sugadongar	25	304	0.729	221.399	1.751	126
Average of Total Hamlets	37	442	0.729	322.133	1.751	184
Total 417 HHs	**15355**	184265	0.729	**134329**	1.751	**76723**

Appendix: Methodology & Key Assumptions for estimating household carbon emissions (1/2)

Household-level carbon emissions are estimated by converting fuel consumption into energy units and applying standard emission factors across fuel types.

1 Capture Consumption

Household-level consumption collected across fuel types - Electricity (kWh), Firewood & Coal (kg/bundles), Kerosene (Litres), Diesel (Litres)

2 Annualisation

Monthly consumption converted to annual consumption (Monthly Consumption × 12)

3 Unit Standardisation

All fuels converted into common energy units (kWh/year) to enable comparison across diverse fuel types

4 Apply Emission Factors

Fuel-wise emission factors applied, eg. Electricity: 0.729 $kgCO_2e/kWh$
Emissions calculated: Energy Consumption × Emission Factor

5 Aggregation

Emissions summed across:

- Fuel types → Household level
- Households → Hamlet / Programme level

Assumptions

Energy & Emission Factors

- Electricity emission factor derived from CEA (2023–24) grid emission factor and converted from tCO_2/MWh to $kgCO_2/kWh$
- Uniform emission factor applied across all households

Grid & Regional Context

- Jharkhand assumed to follow Eastern Grid emission intensity
- In absence of hyper-local data, national/regional average used as proxy
- Electricity generation assumed to be predominantly thermal-based

Consumption Assumptions

- Reported monthly consumption assumed to be representative across the year with no seasonal variation applied

Data & Coverage

- Analysis based on sample households (n = 417)
- Hamlet-level averages used where household-level data unavailable
- Secondary data used for electricity consumption (TRIF dataset)

Note 1: Emission Factor of Electricity, Kerosene, Coal reference - https://static-cdn.publive.online/saur-energy/media/pdf_files/2025/01cea-report.pdf
Note 2: Emission Factor of Diesel; reference - https://archive.org/details/gov.in.is.1460.2017/zIS1460Amd.2%3A2021/page/5/mode/2up
Note 2: Emission Factor of Fuelwood; reference - https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf

Appendix: Methodology & Key Assumptions for estimating household carbon emissions (2/2)

Estimation of household-level carbon emissions also requires certain established mathematical basis -

Conversion Factors			
1.00	kWh	3.60	MJ
1.00	TJ	1000000.00	MJ
1.00	tonne	1000.00	kg
1.00	kCal	0.00	kWh
1.00	kg	1000.00	g
1.00	MJ	1000.00	kJ
1.00	m3	1000.00	litres

Gross Calorific Value			
Kerosene	43752.00	kJ/kg	Source: MOSPI
Fuelwood	20.20	MJ/kg	Source: Stanford
Coal	4000.00	kCal/kg	Source: BEE India

Density Values		
Kerosene Density	0.80	kg/litre
Diesel Density	827.50	kg/m3

Sequestration Assumptions

- Sequestration rate **(21.01 kgCO_2e/tree/year)** derived from secondary research; Ref -http://www.ijcrbp.com/vol-1-4/B.C.%20Oraon,%20et%20al.pdf
- Represents average for mature trees under typical Indian conditions with assumptions as -
  - Trees are fully grown (not saplings)
  - Trees survive and sequester carbon consistently each year
- Does not account for species variation, soil conditions, or climate differences
- Linear sequestration assumed (no growth curve applied)

Thank you