



CENTRE FOR A
**People-centric
Energy Transition**

Rajhara Trans-Mine Program for transforming lives and livelihoods in Rajhara, Jharkhand by rejuvenating climate resilient agriculture and cleaner environment

Baseline Study Report



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About Ashoka Centre for a People-centric Energy Transition (ACPET)

The Ashoka Centre for a People-centric Energy Transition (ACPET) is a research-focused, transdisciplinary centre within Ashoka University, India, established to drive a sustainable, equitable, and “people-centric” shift towards net-zero emissions. It bridges the knowledge gap in energy transition by collaborating with industry and government to create scalable solutions, covering areas like renewable energy, policy, and technology. For further information about ACPET, please visit: acpet.ashoka.edu.in

About Ashoka University

Ashoka University is a private university located in Sonipat, Haryana, providing liberal education in the humanities, social sciences, and natural sciences. The University provides a holistic education that is liberal, multidisciplinary, and interdisciplinary, offering a diverse and inclusive space for its students to think deeply and critically, learn across disciplinary boundaries, express themselves creatively, and communicate with meaning to cause impact and change. For further information about ACPET, please visit: ashoka.edu.in

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Abbreviations

ACPET	Ashoka Centre for a People-Centric Energy Transition
AARQA	Access, Affordability, Reliability, Quality, and Availability
CBO	Community-Based Organization
CMEF	Comprehensive Monitoring and Evaluation Framework
DID	Difference-in-Differences
DPDP	Digital Personal Data Protection Act
FGD	Focus Group Discussion
FPO	Farmer Producer Organization
GHG	Greenhouse Gas
GoI	Government of India
HH	Household
IDI	In-Depth Interview
KII	Key Informant Interview
MIS	Management Information System
ODK	Open Data Kit
PRI	Panchayati Raj Institution
SHG	Self-Help Group
SLF	Sustainable Livelihood Framework
SLI	Solar Lift Irrigation
ToC	Theory of Change
WUG	Water User Group

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Executive Summary

This report presents the baseline assessment of households in Rajhara Kothi and Chechanha, conducted to establish the socio-economic and livelihood conditions prior to the implementation of the Rajhara Transmine Field Site interventions by Ashoka Centre for People Centric Energy Transition. The assessment focuses on three key intervention domains: Solar Lift Irrigation (SLI) for strengthening agricultural productivity, Farmer Producer Organization (FPO) development for improving institutional access to agricultural services, and Clean Cooking transition for improving household health and energy access.

The baseline survey covered 649 households across 2 villages and 12 wards in the Rajhara region. The objective of the assessment is to generate an evidence-based understanding of household livelihoods, energy usage, agricultural infrastructure, and institutional participation. These findings will serve as the benchmark for the three-phase impact evaluation (Baseline, Midline, Endline) of the program.

Methodology and Evaluation Framework

The study adopted a mixed-methods evaluation approach, combining structured household surveys with qualitative insights from field interactions, institutional stakeholders, and community groups.

Three major analytical frameworks were used to evaluate the baseline conditions:

Sustainable Livelihood Framework (SLF):

The SLF was used to evaluate household resilience across five livelihood capitals: Natural, Physical, Human, Social, and Financial. Household-level indicators were normalized and aggregated to generate capital scores and an overall Household Livelihood Resilience (HLR) index.

The resulting Household Livelihood Resilience (HLR) score is 0.28, indicating that household livelihoods remain structurally vulnerable.

AARQA Framework for Energy Access:

The AARQA model evaluates energy systems across Availability, Accessibility, Reliability, Quality, and Affordability dimensions to assess real access to clean cooking energy.

Social Return on Investment (SROI):

The SROI framework provides a basis for evaluating the long-term social, economic, and environmental value generated by the interventions.

Key Findings

Solar Lift Irrigation (SLI)

Agriculture remains the primary livelihood for the majority of households; however, irrigation access remains highly constrained.

Key findings include:

- A large share of farmers remain dependent on monsoon rainfall.
- Irrigation infrastructure in the region is limited and unevenly distributed.
- Limited water access restricts crop diversification and reduces agricultural productivity.

The relatively low Natural Capital score (0.43) reflects these constraints in land productivity and irrigation availability. The introduction of Solar Lift Irrigation systems is therefore expected to significantly strengthen agricultural resilience and reduce climate vulnerability.

Farmer Producer Organization (FPO)

Institutional engagement among farmers remains weak.

Key observations include:

- Participation in farmer institutions is limited.
- Many farmers expressed the need for reliable access to seeds, inputs, and irrigation services through collective institutions.
- Farmers indicated willingness to join FPOs if they provide inputs at legitimate market prices and reliable agricultural support services.

Strengthening the FPO ecosystem can therefore play a crucial role in improving market access, input supply, and institutional support for farmers.

Clean Cooking

The study reveals a significant gap between clean cooking access and sustained adoption.

Key findings include:

- Many households possess LPG connections through government schemes.
- However, households frequently continue using traditional fuels such as firewood or coal.
- Barriers include affordability of refills, supply reliability, and habit persistence.

The use of traditional cookstoves exposes households, particularly women to smoke-related health risks, including respiratory problems and eye irritation.

Cross-Cutting Insights

The baseline analysis reveals several structural patterns across the intervention areas:

- Physical assets are relatively stronger (0.53) compared to other livelihood capitals, indicating that households possess some basic infrastructure and household assets.
- However, social and financial systems remain weak, limiting households' ability to access institutional services, credit, and markets.
- Irrigation constraints continue to limit agricultural productivity and increase vulnerability to climatic variability.
- Energy transition challenges highlight the difference between access to infrastructure and sustained behavioural adoption.

Overall, the HLR score of 0.496 indicates that households face moderate to high livelihood vulnerability, requiring integrated interventions that address multiple dimensions of rural livelihoods.

Recommendations

Solar Lift Irrigation (SLI)

- Expand solar irrigation systems to improve water availability for agriculture.
- Promote community-based irrigation management models.
- Encourage crop diversification and improved water-use practices.

Strengthening irrigation infrastructure will directly improve Natural Capital and agricultural productivity.

Farmer Producer Organizations (FPO)

- Strengthen FPO institutional capacity to deliver inputs, advisory services, and market linkages.
- Provide farmers with seeds, fertilizers, and irrigation services at legitimate market prices.
- Promote farmer membership through transparent governance and reliable service delivery.

This will help improve Social Capital and Financial Capital among farming households.

Clean Cooking

- Improve LPG refill supply chains and last-mile distribution.
- Promote awareness programs highlighting the health benefits of clean cooking.
- Introduce affordability mechanisms and community-based refill support systems.

These measures can accelerate the transition toward sustained clean cooking adoption.

Conclusion

The baseline findings highlight a livelihood system characterized by limited irrigation infrastructure, weak institutional networks, and incomplete clean energy transition. However, the presence of community institutions, agricultural potential, and infrastructure investments creates a strong foundation for transformative change.

Through integrated interventions in Solar Lift Irrigation, Farmer Producer Organization development, and Clean Cooking access, the Rajhara Transmine initiative has the potential to significantly improve livelihood resilience, agricultural productivity, and household well-being in the region.

Future midline and endline evaluations will track changes in livelihood capital accumulation, irrigation access, institutional participation, and clean cooking adoption to assess the long-term impact of the program.

Context, Methodology and Study Design

1.1 Perspective and Context

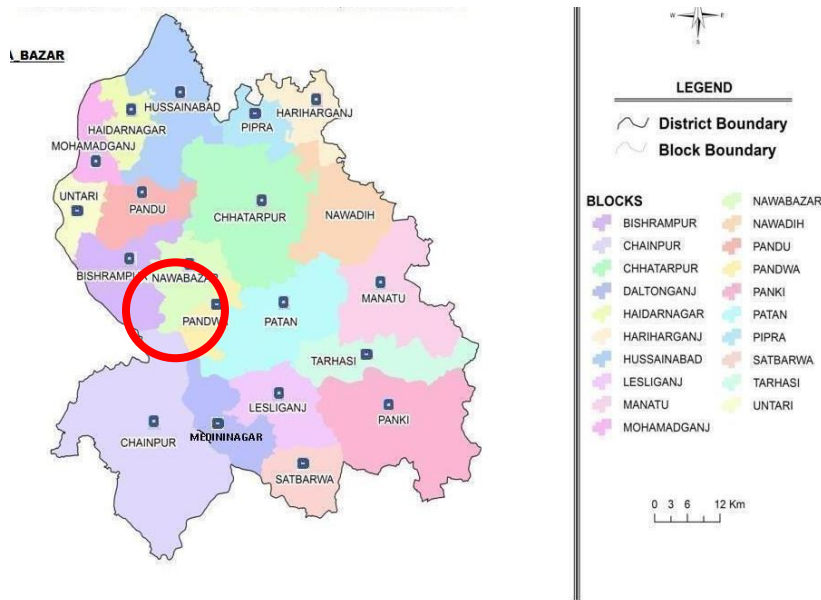


Figure 1: District Map: Palamu, Jharkhand

Closure of mines by CCL in the Rajhara area of Palamu district, Jharkhand, has caused severe livelihood disruptions after the abandonment of mines, without following the existing regulations prescribed by the Government of India, including the Ministry of Mines, as the local economy revolved around mining activities. For communities living in such regions, mine closures often lead to multiple disruptions: loss of

employment opportunities, contraction of local service economies, environmental degradation, and weakening of local institutions that once supported economic activity. While the average household income dropped significantly as mines closed, local businesses saw a 53% decline, and service providers, such as laundry and electrical repair services, fell by 55%, according to available reports. Skilled workers and youth often migrate to other areas in search of employment opportunities, weakening the local economy and community bond. Meanwhile, abandoned mine sites left behind environmental damage, including soil degradation and water contamination, causing long-term harm to human safety and health.

Field observations and available data indicate that mine closure led to several interconnected challenges. These include the loss of livelihood opportunities, as many households depended on mining or related activities, which saw a sharp decline; a reduction in local economic activities, such as small vendors, repair shops, and transport services experiencing decreased demand; outmigration of skilled workers and youth due to limited employment opportunities; and environmental degradation resulting from unplanned closures that did not comply with established regulations.

After the closure of coal mines, as with other mines, leaves a vast tract of land that is mostly unfit for immediate agricultural use unless intervention increases soil fertility by reducing the carbon content and addressing contamination. In addition, after the mine's closure, it leaves behind

infrastructure, such as water bodies and railway tracks/roads used to carry coal, which could be repurposed to create a comprehensive livelihood initiative, such as the revival of agricultural activities, combined with other livelihood initiatives like goat rearing and poultry, that could help prosper the local economy. Against this backdrop, ACEPT has designed a three-pronged intervention -



Figure 2: Landscape view of the Rajhara mining area and surrounding terrain in Palamu district, Jharkhand.

a. to provide farmers with access to irrigation water through Solar Lift Irrigation (SLI), which will increase productivity and crop intensity,

b. an FPO-level intervention to give local farmers bargaining power to sell their farm produce through aggregation, expanding access to markets and finance, and

c. assisting households (women) in shifting to clean energy-based

cooking from coal-based fuel, which increases indoor air pollution and results in multiple diseases, including respiratory problems, that can act as a model for rejuvenating the local economy, which is just and inclusive after mine closure.

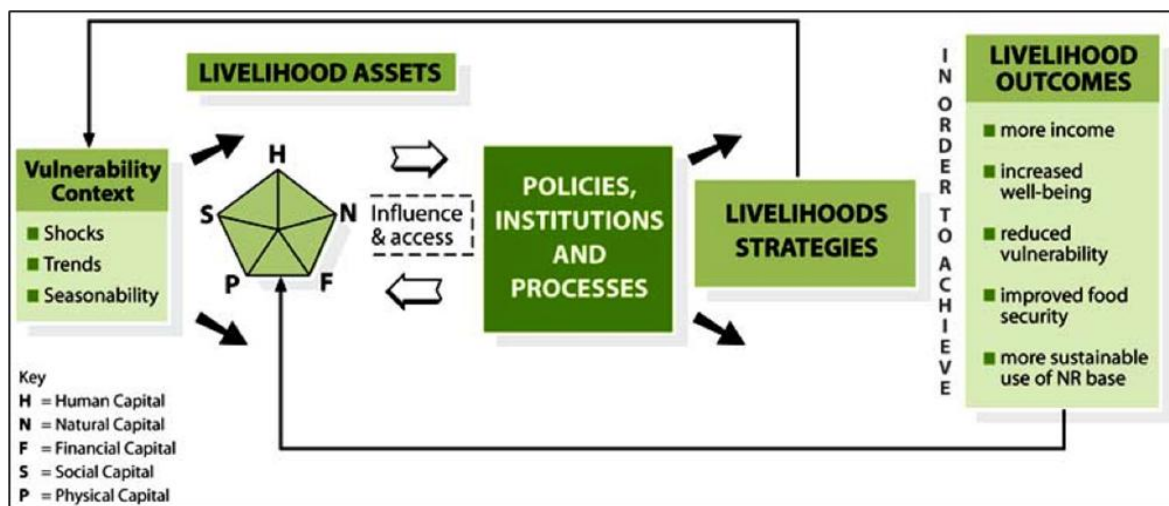


Figure 3: Sustainable Livelihood Framework - DFID

Solar Lift Irrigation (SLI)

Water bodies left behind by miners after closures are often contaminated. However, according to one of ACPET's case studies, some water bodies have been tested and found suitable for irrigation use based on lab reports. ACPET has already installed a 7.5 HP SLI, which currently supplies around 10 farmers with year-round irrigation water. This setup could be expanded to include 30 farmers, increasing crop productivity, intensifying farming practices, and boosting farmers' income. Since the local economy relies heavily on mining activities, it is reasonable to assume that farming skills - such as climate-resilient agricultural practices, harvesting, and post-harvest management are limited. To improve the profitability of local farming, the proposed baseline, conducted by Impact360 Foundation, aims to map available local resources, including human capital (skills), financial capital (access to credit), social capital (such as SLI), vulnerability factors (extreme weather, seasonality, trends), and other structures and processes (policies, institutions). This approach aligns with the Sustainable Livelihood Framework (SLF) and seeks to identify barriers to growth, with the goal of transforming lives and livelihoods in the area. It will also highlight key areas where interventions are necessary to generate meaningful progress.



Figure 4: Solar Lift Irrigation Infrastructure-Rajhara Kothi

An SLI system was installed in the area in May 2025 under this initiative to provide a group of farmers year-round access to irrigation water, where agriculture is 100% rainfed.

Most of the farmers surveyed during the baseline echoed that it will increase their agricultural income, as both productivity and crop intensity will rise.

ACPET-sponsored case study on SLI further indicates that farmers are willing to pay for the service based on acreage cultivated or on the hours each farmer uses, indicating the service's financial viability and sustainability through community ownership. Since certain baseline information has already been collected while preparing the ACPET case study on SLI, the proposed baseline, in addition to collecting baseline data, would recommend how the ACPET intervention on SLI could

be ramped up by using existing government schemes, as the current service coverage of SLI will be limited to only 40 farmers.

However, this would call for strengthening FPO intervention where the farming community builds its capacity to develop a solid business plan, which can be funded by the financial institutions under the existing available credit guarantee schemes and other government schemes such as PM KUSUM, local government schemes, DMF, Agriculture Infrastructure Fund (AIF), etc.

Farmer Producer Organization (FPO)

ACPET have helped farmers of Rajhara Panchayat form an FPO that can provide critical services to local farmers:

- a. to aggregate their agricultural produce through a collection center,
- b. to provide information on climate-resilient agricultural inputs to increase crop productivity,
- c. to facilitate access to markets and finance, and
- d. to address a critical knowledge gap in introducing good agricultural practices; that can significantly augment their income.

While the SLI initiative gained the community's credibility by accessing water resources previously unavailable to it, the FPO intervention lacked community support and credibility because the newly formed FPO was too nascent to deliver the services it intended to provide. The baseline would prepare an FPO checklist to identify areas for improvement and how the local farming community can come together to strengthen the FPO through a membership-driven entity that provides critical agricultural services to the community by facilitating climate-resilient farming practices to increase productivity and profitability, and by providing access to markets and finance. The FPO should also plan and strategise how locally available infrastructure left behind post-mine closure, such as a warehouse, can be repurposed as a storage facility to aggregate local agricultural products or for local processing to add value, and then sold at a remunerative price, thereby increasing local employment and profitability.

According to the ACPET case study, around 24% of surveyed farmers are aware of the FPO, but their membership is contingent on the FPO's readiness to provide agricultural input supply

support, market linkage facilitation through product aggregation, and network building with market actors.

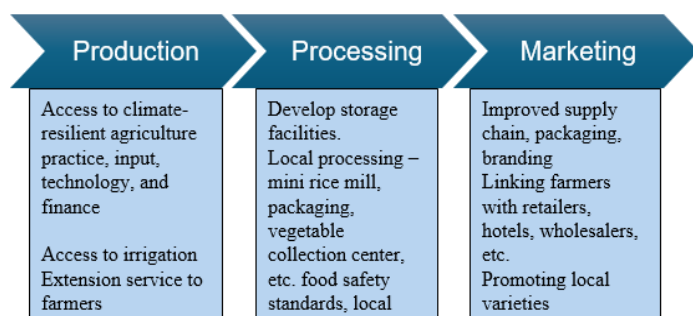


Figure 5: Local Value Chain - Rajhara

The baseline would assess the FPO's current capacity to deliver critical agricultural services - in harvest and post-harvest services outlined below – to its members, besides gauging its present governance structure.

The baseline questionnaire, combined with the KII, FGD, and IDI, will identify the gaps in production, processing, and marketing outlined earlier. While rice, maize, and pulses form the backbone of the current cropping pattern, expanding irrigation through SLI can support rabi and other high-value crops, including vegetables, spices, and medicinal plants. This will be assessed during the baseline study.

Since the program has already started and an FPO has been formed, this baseline exercise will evaluate the skills of the FPO and its potential members in enhancing climate-resilient agricultural practices, quality inputs, capital, market intelligence, enterprise development, and alignment with existing government schemes. Additionally, it will suggest course corrections to build community credibility by providing meaningful agricultural services. It will also identify potential market players who can purchase produce at better prices and explore opportunities for local value addition, including processing, packaging, and branding.

The baseline, which acts as a de facto midline, will establish the foundation for the FPO to evolve into a member-driven organization that provides meaningful services, including climate-resilient agricultural inputs, financial facilitation, and market access to the farming community in Rajhara.

Clean Cooking

Women in the target group for clean cooking transition in Rajhara spend over 2.5 hours cooking daily, and most (69%) cook indoors. Thirteen percent of women in households use both indoor and outdoor facilities, according to an ACPET-sponsored case study. Women in Rajhara mainly use wood, dung, and coal for cooking, and their homes often lack adequate ventilation, leading to eye irritation, breathlessness, respiratory problems, and other health issues from indoor air pollution. This affects children and women, who spend around 2.5 hours cooking. Most households avoid visiting doctors because treatment costs are too high, relying instead on home remedies. Chronic symptoms like dizziness, eye irritation, and breathlessness are often normalized in the absence of affordable, easy solutions.

ACPET developed a case study on the clean cooking transition in Rajhara, which gathered essential baseline data: over 90% of those surveyed are aware of clean cooking, with most knowing about LPG. Affordability has been identified as the main barrier to LPG adoption. Although the surveyed population is willing to pay Rs 672 for a refill, they currently pay Rs 1000–1200, prompting them to opt for traditional fuels like wood, dung, and goliya instead of LPG. Only 25% are aware of alternative clean cooking methods, such as electric, induction, and solar cooking, but lack the availability, accessibility, and awareness needed.

Households using LPG for cooking tend to have higher incomes than those relying on traditional fuels like wood, dung, and goliya, which further emphasizes the affordability challenge in

promoting clean cooking options. In this context, the proposed baseline will explore ways to encourage clean cooking among project participants through the ACPET intervention, including financing options and increasing access to various clean cooking solutions such as induction stoves, electric cookers, solar cookers, and more fuel-efficient stoves. Although induction cooktops appear more affordable than LPG, awareness among the target population remains low, likely due to limited local availability. The baseline will also examine how SHGs, which have wide reach and credibility, can be leveraged to promote clean cooking solutions. It will analyze and evaluate these strategies through the AARQA lens, while recommending interventions and activities aligned with the project's desired outcomes and outputs.

The baseline will assess existing local infrastructure and supply chains, focusing on availability, accessibility, and technological readiness of clean cooking solutions. It will also document fuel usage and stacking, socio-economic barriers (if any), liquidity and credit availability, as well as the health, time, and access barriers related to Pradhan Mantri Ujjwala Yojana (PMUY).

1.2 Study Objectives and Scope of Baseline Study

The baseline study was conducted to document the socio-economic and livelihood conditions of households located in the Rajhara Transmine region of Palamu district in Jharkhand. The study represents the first stage of a three-phase impact assessment under the People-Centric Energy Transition initiative implemented by ACPET.

The Rajhara landscape lies within a region historically influenced by coal mining activities. Mining operations and associated employment opportunities have shaped livelihood patterns in surrounding rural settlements. Households in the region currently depend on agriculture, wage labour, seasonal migration, and forest-based activities.

The Jharkhand Economic Survey notes that districts in the north-western region of the state, including Palamu, experience significant livelihood diversification due to limited irrigation and periodic employment in mining and construction sectors. The District Statistical Handbook of Palamu further indicates that smallholder agriculture and seasonal migration remain major livelihood strategies in rural blocks of the district.

The baseline therefore aims to establish benchmark indicators prior to the long-term outcomes of the ACPET interventions. The study focuses particularly on households located in villages connected to the Solar Lift Irrigation infrastructure and those interacting with institutions such as Water User Groups and Farmer Producer Organizations.

The objectives of the baseline include documenting household livelihoods, assessing irrigation access and agricultural production systems, analyzing the governance of irrigation institutions, understanding farmer engagement with collective marketing structures, examining household cooking energy patterns, and capturing gendered participation in community decision-making.

The baseline provides the reference point against which changes in livelihoods, agricultural productivity, institutional participation, and energy transitions will be evaluated during the midline and endline phases of the impact assessment.

1.3 Theory of Change

The Theory of Change follows a structured progression from

Inputs → Activities → Outputs → Outcomes → Impacts; as described below.

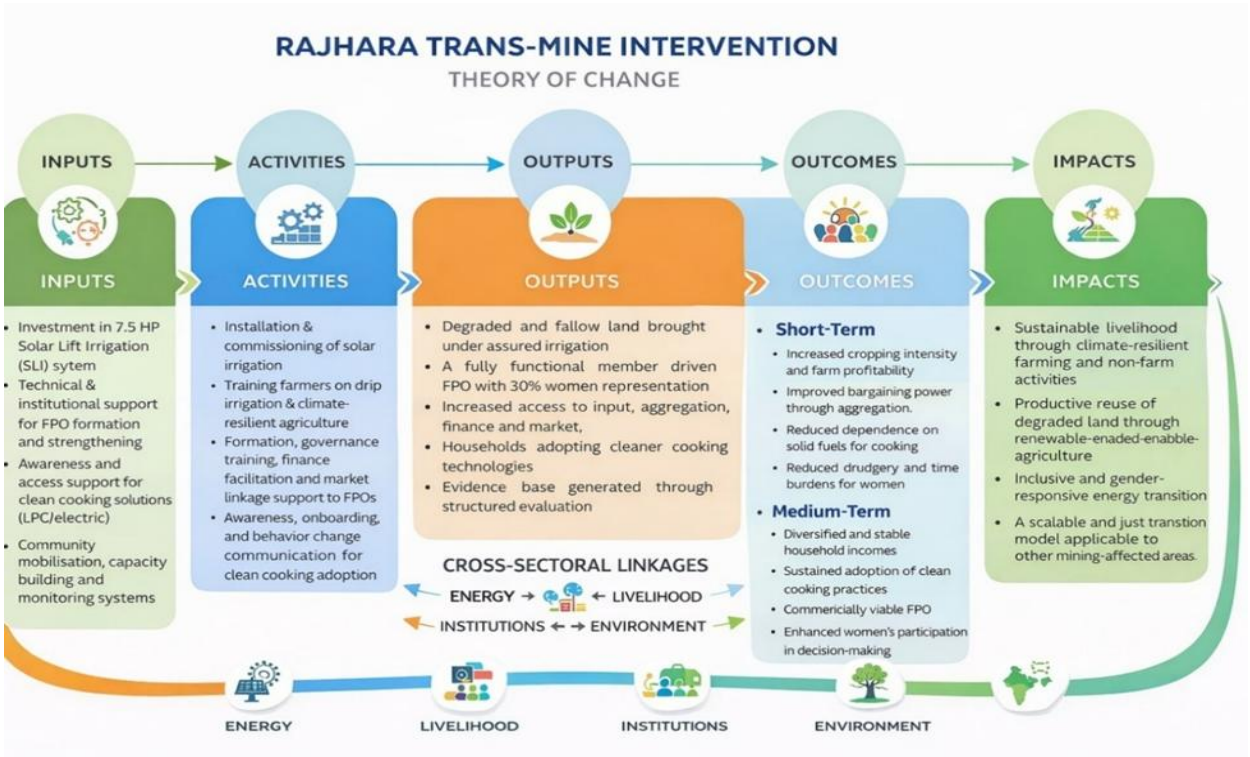


Figure 6: Theory of Change - Rajhara Transmine Project

Table 1: Theory of Change - Rajhara Transmine Project

ToC Level	Description	Key Elements
Inputs	Physical, financial, and institutional resources deployed to enable transition	<ul style="list-style-type: none"> Investment in Solar Lift Irrigation (SLI) infrastructure (solar panels, pumps, distribution networks) Technical and institutional support for formation and strengthening of FPOs and WUGs Resources for awareness generation, onboarding, and behavior change communication for clean cooking adoption Community mobilization, capacity-building inputs, and monitoring systems

Activities	Core implementation actions undertaken using the above inputs	<ul style="list-style-type: none"> • Installation and operationalization of solar-based irrigation systems using abandoned mine water bodies • Farmer training on irrigation management, crop planning, and climate-resilient practices • Formation, governance training, and facilitation of FPOs and WUGs (aggregation, market linkage, access to finance) • Household-level awareness and engagement to promote clean cooking adoption and sustained use • Periodic monitoring through baseline, midline, and endline assessments
Outputs	Immediate and tangible results of activities	<ul style="list-style-type: none"> • Degraded and fallow land brought under assured irrigation • Functioning, member-driven FPOs and WUGs with defined governance mechanisms • Improved access to inputs, aggregation services, finance, and markets through collective institutions • Households adopting cleaner cooking technologies with reduced reliance on coal-based fuels • Structured datasets and evidence generated through systematic monitoring
Short-Term Outcomes	Early changes in behavior, access, and performance	<ul style="list-style-type: none"> • Increased cropping intensity and agricultural productivity • Reduced irrigation costs and exposure to diesel price volatility • Reduced dependence on coal and biomass for cooking • Time savings for women linked to fuel collection and cooking • Increased confidence and participation in collective institutions
Medium- Term Outcomes	Consolidated changes in economic and social conditions	<ul style="list-style-type: none"> • Diversified and more stable household income portfolios • Improved price realization and bargaining power through FPOs • Sustained adoption of clean cooking practices • Improved indoor air quality and perceived health conditions • Enhanced women's participation in household and institutional decision-making
Impacts	Longer-term, systemic changes toward which the intervention contributes	<ul style="list-style-type: none"> • Sustainable livelihoods anchored in climate-resilient agriculture and allied activities • Productive reuse of degraded post-mining landscapes • Inclusive and gender-responsive energy transition • Strengthened local institutions capable of managing shared assets • Scalable and replicable model for just transitions in mining-affected regions

1.3 Mixed-Methods Research Design

The study adopted a mixed-methods research design combining quantitative household surveys with qualitative research tools. This approach enables both statistical measurement and contextual interpretation of socio-economic processes.

The quantitative component consisted of structured household interviews conducted across the selected villages. The survey captured information on demographics, livelihoods, agricultural practices, irrigation access, institutional participation, and household energy use.

Qualitative methods were used to complement the survey findings. Key Informant Interviews, Focus Group Discussions, and In-Depth Interviews were conducted with community members and institutional stakeholders.

The mixed-methods approach strengthens the reliability of the analysis. Survey findings are interpreted alongside narratives from community members and insights from institutional actors working in the Rajhara region.

The baseline survey forms the first stage of a longitudinal evaluation design that will apply a Difference-in-Differences (DiD) analytical framework during subsequent rounds of data collection. The DiD approach compares changes in key indicators between intervention households and comparison groups over time. Baseline values collected during the present study will serve as the pre-intervention reference point. Midline and endline surveys will capture changes in agricultural productivity, irrigation access, institutional participation, and household energy use. By comparing outcome trends across time and groups, the DiD framework enables estimation of the causal contribution of the ACPET interventions in the Rajhara region.

1.4 Desk Research and Secondary Data Review

Desk research was conducted prior to fieldwork to understand the historical, agricultural, and institutional context of Palamu district. The review focused on mining-linked livelihoods, irrigation systems, agricultural markets, and rural energy practices.

Information on the regional economy and livelihood structures was drawn from the Jharkhand Economic Survey and the District Statistical Handbook of Palamu. These reports describe the economic profile of the district and highlight the dependence of rural households on agriculture, wage labour, and migration.

Insights on mining-linked livelihoods were derived from publications of the Ministry of Mines and reports on mining regions in eastern India. These documents describe how mining activities influence employment patterns, land use, and local economic transitions in surrounding rural settlements.

Agricultural conditions in Palamu district were examined using publications of the Jharkhand State Agriculture Department. These reports indicate that agriculture in the district is largely rainfed and characterized by low irrigation coverage. The Minor Irrigation Census of India also highlights the limited spread of formal irrigation infrastructure in many parts of Jharkhand, including districts with undulating terrain such as Palamu.

Information on farmer collectivization and agricultural markets was drawn from studies of Farmer Producer Organizations prepared by the Small Farmers Agribusiness Consortium and NABARD. These reports explain how farmer collectives improve market access, reduce transaction costs, and strengthen bargaining power for smallholders.

The review of rural energy use relied on national studies of cooking energy transitions. Reports prepared by the International Energy Agency describe patterns of fuel stacking in rural households, while publications of the World Health Organization explain the health risks associated with household air pollution caused by biomass fuels. Government reports on the Pradhan Mantri Ujjwala Yojana were also reviewed to understand the national policy framework promoting clean cooking access.

In addition to these sources, the ACPET intervention documents and program design reports were examined to understand the objectives and operational structure of the Solar Lift Irrigation systems, Water User Groups, Farmer Producer Organization strengthening, and clean cooking initiatives implemented in the Rajhara intervention area.

The desk research helped contextualize the field survey and informed the design of the baseline questionnaire.

1.5 Household Baseline Survey Structure

The household survey served as the primary data collection instrument for the baseline study. The questionnaire was designed to capture the multiple dimensions of rural livelihoods and institutional participation in the Rajhara region.

The survey instrument consisted of seven thematic modules.

Module A recorded household identification details including village location, ward or hamlet information, and GPS coordinates. This module also captured the household roster and basic demographic characteristics.

Module B documented household socio-economic characteristics. It recorded education levels, occupational categories, migration patterns, and major sources of income.

Module C focused on irrigation and agricultural water access. This module captured information on irrigation sources, water availability, cropping practices, and utilisation of Solar Lift Irrigation infrastructure.

Module D examined the functioning of Water User Groups associated with irrigation systems. Questions focused on membership, meeting participation, institutional decision-making, and perceptions regarding water distribution.

Module E recorded farmer engagement with the Farmer Producer Organisation operating in the intervention area. It documented membership status, awareness of collective marketing services, and participation in procurement or input supply activities.

Module F focused on household energy use. It captured primary and secondary cooking fuels, expenditure on cooking energy, and perceptions related to smoke exposure and health impacts.

Module G examined women's participation in household and community decision-making. The module captured information on meeting participation, leadership roles, and perceived empowerment.

Together, these modules provide a comprehensive picture of livelihoods, agricultural systems, institutional participation, and energy use among households in the Rajhara region.

1.6 Key Informant Interviews

Key Informant Interviews were conducted with institutional stakeholders who possess direct knowledge of agricultural development, energy transitions and rural institutions in Palamu district.

Discussions were held with representatives of the Farmer Producer Organization operating in the region. Interviews were also conducted with officials from NABARD and scientists associated with the Krishi Vigyan Kendra serving the district.

Officials from the District Agriculture Department provided insights on cropping patterns, irrigation challenges, and agricultural extension activities in the region. Representatives of Water User Groups and technical personnel associated with Solar Lift Irrigation systems were also interviewed.

These interviews helped understand institutional coordination, irrigation system management, and farmer participation in collective structures.

1.7 Focus Group Discussions

Focus Group Discussions were conducted in selected villages to capture community perspectives on livelihoods, irrigation access, and institutional participation.

Separate discussions were organized with farmers, members of Water User Groups, and participants in the Farmer Producer Organisation. Women farmers and members of Self-Help Groups also participated in dedicated discussions.

These conversations explored issues related to agricultural constraints, water management practices, market access challenges, and household energy use. They also provided insights into gender roles within agricultural production and domestic work.

1.8 In-Depth Interviews

In-depth interviews were conducted with selected community members to document livelihood transitions in the Rajhara region.

The interviews explored livelihood patterns during periods when mining activities provided employment opportunities to local communities. Respondents also described changes that occurred after mining activity declined or fluctuated.

Community members discussed how households adapted through migration, diversification of agricultural activities, and engagement with emerging irrigation infrastructure. These narratives provide qualitative context to the statistical findings of the household survey.

1.9 Sampling Strategy and Household Selection

The baseline survey followed a purposive sampling approach focusing on villages located within the operational influence of the ACPET intervention.

Households were selected from villages connected to Solar Lift Irrigation systems and Water User Groups. Efforts were made to include households with different livelihood profiles, including farming households, wage labourers, and households dependent on migration.

Table 2: Sampling Strategy and Design for Baseline Study

Methods	Respondents	Sample	Sample Size	Drop-out Estimate	Total Sample Size
Quantitative	SLI beneficiary	25	40	3	43
	Potential SLI beneficiary	15			
	FPO equity member	13	150	12	162
	FPO potential member	137			
	FPO non-member	150	150	12	162
	Clean cooking	130	130	11	141
	ICS clusters	130	130	11	141
	Total	600	600	49	649
Qualitative	FGD	10	10		
	Women	4	4		
	Youth	2	2		
	FPO members & SLI	4	4		
	Total	10	10		
	IDI	6	6		
	KII	8	8		
	Case Studies	3	3		

This dual-control structure allows the evaluation to measure both the direct impact (Treatment vs. External Control) and the spillover impact (Internal Control vs. External Control) in Rajhara and Chechanha villages.

1.10 Introduction to Regression Analysis in the Study

This study employs regression analysis to understand the relationships between socio-economic variables, institutional factors, and behavioural outcomes across three key domains:

- **Solar Lift Irrigation (SLI)** – capturing water access, landholding, and willingness to pay
- **Farmer Producer Organizations (FPOs)** – capturing institutional participation, trust, and market outcomes
- **Clean Cooking** – capturing energy transition, adoption behaviour, and affordability

These three domains represent distinct but interconnected systems:

- **SLI** reflects a resource access system, where scarcity (water stress) drives behavioural responses
- **FPOs** represent an institutional system, where collective action and governance influence outcomes
- **Clean Cooking** represents a service delivery system, where adoption depends on affordability, access, and supply chains

Regression analysis enables quantification of how changes in explanatory variables (e.g., income, education, trust, water stress) influence outcomes such as willingness to pay, membership, adoption, and usage.

Across all three systems, regression is used not only as a statistical tool, but as a diagnostic framework to identify:

- responsiveness of households
- strength of relationships
- presence of latent demand
- system-level constraints

1.10.1 Theoretical Basis of Regression Analysis

Regression analysis is grounded in the principle of estimating the relationship between a dependent variable (Y) and one or more independent variables (X).

The basic linear regression model is:

$$Y = \beta_0 + \beta_1 X + \epsilon$$

where:

- β_0 = intercept (baseline level of Y when X = 0)
- β_1 = slope (marginal effect of X on Y)
- ϵ = error term (unobserved factors)

Interpretation in This Study

- **Slope (β_1)**
Indicates responsiveness.
 - Higher slope → strong behavioural or economic response
 - Near-zero slope → weak response or constrained system
- **Intercept (β_0)**
Indicates baseline level of outcome independent of explanatory variable
- **R² (Coefficient of Determination)**
Measures how much variation in Y is explained by X
 - High R² → strong explanatory power
 - Low R² → relationship influenced by other factors

Conceptual Interpretation across Systems

- **SLI**
Higher slopes (e.g., water stress → willingness to pay) indicate direct resource-driven behaviour
- **FPO**
Flat slopes indicate weak institutional traction, where participation does not strongly respond to structural variables
- **Clean Cooking**
Flat slopes with high baseline values indicate latent demand constrained by system inefficiencies

Thus, regression coefficients are interpreted not only statistically, but institutionally and behaviourally.

1.10.2 Methodology of Regression Analysis

Data Structure

The dataset consists of household-level observations across:

- socio-economic variables (income, education, landholding)
- institutional variables (trust, fairness, membership)
- behavioural indicators (willingness to pay, adoption, intent)
- access variables (distance to market, refill ease, water stress)

Many dependent variables are binary (0/1), while others are continuous (income, willingness to pay).

Model Specification

Simple linear regression models were estimated for each pair of variables:

$$Y_i = \beta_0 + \beta_1 X_i$$

Separate regressions were run for each relationship rather than a multivariate model to:

- maintain interpretability
- visually assess trends through scatter plots
- isolate pairwise relationships

1.10.3 Domains of Analysis

a. SLI (Solar Lift Irrigation)

Outcome variables:

- willingness to pay for irrigation
- usage patterns

Explanatory variables:

- water stress days
- landholding

Focus: resource scarcity and economic response

b. FPO (Farmer Producer Organization)

Outcome variables:

- membership
- income
- price realization
- engagement intent

Explanatory variables:

- education
- gender
- trust and fairness
- institutional presence

Focus: institutional performance and collective action

c. Clean Cooking

Outcome variables:

- LPG access
- clean fuel usage
- willingness to shift
- willingness to pay

Explanatory variables:

- income
- education

- awareness
- refill/electricity ease

Focus: energy transition and service delivery constraints

Estimation Approach

- Scatter plots were used to visualize relationships
- Linear trendlines were fitted
- Regression equations (slope, intercept) and R^2 values were extracted
- Interpretation focused on:
 - magnitude of slope
 - direction of relationship
 - explanatory power (R^2)

1.10.4 Assumptions of Linear Regression

The use of linear regression in this study relies on several standard assumptions:

Linearity

The relationship between dependent and independent variables is assumed to be linear.

In this study, some relationships (e.g., willingness to pay vs. water stress) approximate linearity, while others may be inherently non-linear but are approximated for simplicity.

Independence of Observations

Each observation (household) is assumed to be independent.

In reality, some clustering may exist (e.g., same village, same FPO), which may slightly violate this assumption.

Homoscedasticity

The variance of errors is assumed constant across levels of X.

In this dataset, Binary outcomes (0/1) may violate this assumption, as variance is inherently uneven.

Normality of Errors

Residuals are assumed to be normally distributed.

In practice, with small sample sizes and binary variables, this assumption is weakly satisfied.

No Perfect Multicollinearity

Independent variables should not be perfectly correlated.

Since models are bivariate, this assumption is not a concern in this analysis.

Correct Model Specification

All relevant variables should be included.

In this study, models are intentionally simple, so omitted variable bias may exist.

Limitations of Regression Analysis in This Study

While regression provides valuable insights, several limitations must be acknowledged:

- Low R^2 Values

Most regressions show low explanatory power.

This does not imply absence of relationships, but rather:

- outcomes are influenced by multiple unobserved factors
- systems are complex and multi-dimensional

- Bivariate Analysis

Only pairwise relationships are examined.

This limits the ability to:

- control for confounding variables
- capture interaction effects

A multivariate regression could provide deeper insights.

- Use of Linear Models for Binary Outcomes

Many dependent variables are binary (0/1), for which:

- logistic regression would be more appropriate

Linear regression is used here for:

- simplicity
- interpretability

- **Small Sample Size**

Limited observations reduce:

- statistical reliability
- generalizability

- **Measurement Error**

Variables such as:

- trust
- fairness
- awareness

are subjective and may introduce bias.

- **Omitted Variable Bias**

Important factors such as:

- cultural norms
- social networks
- supply chain constraints

are not explicitly modeled.

- **Causality Cannot Be Established**

Regression identifies association, not causation.

For example:

- higher income and LPG adoption may be correlated
- but causality cannot be confirmed without experimental or longitudinal data

- **Interpretation of Flat Slopes**

Many relationships show very low slopes.

While statistically weak, in this study they are interpreted as:

- indicators of latent demand
- evidence of system constraints rather than lack of interest

This interpretation requires contextual understanding beyond pure statistics.

1.11 Data Validation and Quality Assurance

Several steps were taken to ensure the reliability of the baseline dataset.

Enumerators received training on the structure of the questionnaire and interview procedures prior to field deployment. Supervisors monitored fieldwork and conducted verification checks during the survey period.

Data collection was carried out using digital tools. This approach reduced manual data entry errors and allowed real-time monitoring of responses.

Survey responses were reviewed daily to identify missing values and inconsistencies. Cross-verification was conducted by comparing survey responses with qualitative interview findings and secondary data sources.

1.12 Limitations of the Baseline Study

Certain limitations must be acknowledged while interpreting the baseline findings. Some variables, including crop yields and household income levels, rely on respondent recall. Although recall periods were defined carefully, minor reporting inaccuracies may occur.

Agricultural conditions in Palamu district vary across seasons due to rainfall fluctuations. As a result, responses related to cropping patterns and irrigation practices may reflect seasonal conditions during the survey period.

The baseline represents conditions at a specific point in time. Changes in rainfall, market prices, or institutional participation may influence household behaviour during subsequent phases of the evaluation.

Solar Lift Irrigation

The Solar Lift Irrigation (SLI) intervention implemented by ACPET in Rajhara Panchayat of Palamu district seeks to address a critical structural constraint in the region: limited access to reliable irrigation for smallholder farmers. Agriculture in the Rajhara mining belt has historically depended on rainfall variability, diesel pump irrigation, and informal water sources, resulting in low cropping intensity, limited diversification, and seasonal livelihood instability.



Figure 7: Solar Lift Irrigation System at Rajhara

The SLI initiative introduces solar-powered irrigation systems using repurposed coal-mine water, combined with community-managed Water User Groups (WUGs). The intervention is designed not only to improve irrigation reliability but also to support agricultural intensification, reduce input costs, and create pathways for a just energy transition in coal-dependent regions.

This chapter presents the baseline analysis of SLI beneficiary households, integrating quantitative household survey data with qualitative field narratives. The analysis follows a mixed-methods-cross-sectional-design approach, where statistical patterns observed in the survey are interpreted alongside community experiences and farmer narratives.

The chapter also applies the Sustainable Livelihood Framework (SLF) to understand how the SLI intervention interacts with different livelihood assets including natural capital (water access), physical capital (irrigation infrastructure), financial capital (income and cost savings), human capital (skills and labour), and social capital (Water User Groups and farmer networks).

2.1 Research Questions

To evaluate the system's long-term viability and its potential to transform local agriculture, the following research questions guided the inquiry:

R1: *How can the SLI system enhance agricultural productivity and income among coal-transitioning communities, based on current cropping patterns and irrigation-related costs?*

R2: *What is the quality of irrigation water in Rajhara and what are its potential implications for agricultural productivity and sustainable water management practices?*

R3: *What factors (cost, technical know-how, cultural norms) affect adoption of SLI and how willing are farmers to pay for water usage?*

R4: *What systems and capacities are needed to sustain solar irrigation - such as training, financing, maintenance, and effective Water User Groups (WUGs)?*

R5: *How can water bodies formed at mining sites be repurposed for irrigation to support long-term livelihoods in post-mining communities?*

2.2 Methodology

The baseline study adopted a mixed-methods design, combining quantitative household surveys with qualitative interviews and field observations.

Quantitative Survey

A structured household survey was conducted with 43 respondents of the Solar Lift Irrigation intervention. The survey collected information on:

- household demographics
- livelihood sources
- migration patterns
- agricultural practices
- irrigation infrastructure
- income and financial vulnerability
- institutional participation (WUG membership)

The survey also captured landholding size, cropping intensity, irrigation reliability, and water stress days, allowing a detailed assessment of agricultural constraints.



Figure 8: Baseline Survey - Solar Lift Irrigation

Qualitative Methods

To complement the quantitative analysis, the study included:

- Semi-structured interviews and FGD with SLI users and non-users
- Key informant interviews with WUG leaders, SLI Experts,
- In-depth discussions with ACPET implementation partners

These qualitative insights provide contextual explanations for the statistical patterns observed in the household survey.

2.3 Evaluation Framework

The analysis of the Solar Lift Irrigation intervention is structured using the Sustainable Livelihood Framework (SLF).

The Sustainable Livelihood Framework (SLF) was applied to assess the livelihood resilience of households covered under the Solar Lift Irrigation baseline. The framework evaluates household well-being across five livelihood capitals: Natural Capital, Physical Capital, Human Capital, Social Capital, and Financial Capital. For this assessment, indicators were converted into relative and normalized values, so that households could be compared on a common 0–1 scale rather than through absolute landholding, income, or asset size alone.

Indicators Used for Each Capital

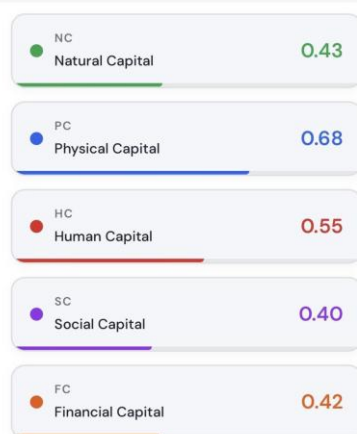


Figure 9: SLF Chart

Natural Capital (NC)

Natural capital reflects the quality, utilization, and reliability of natural resources that support agriculture and rural livelihoods. In this analysis, natural capital was assessed through indicators such as:

- proportion of cultivable land utilized
- cropping intensity
- water stress burden
- irrigation source strength
- irrigation reliability

These indicators capture how effectively households are able to use land and water resources for productive purposes.

Average Natural Capital Score: 0.430

Physical Capital (PC)

Physical capital represents the stock of household infrastructure and productive assets that enable livelihood activities and improve living conditions. Indicators included:

- housing quality
- household asset ownership index
- communication and mobility assets

These indicators reflect the material base available to households for both agriculture and daily life.

Average Physical Capital Score: 0.679

Human Capital (HC)

Human capital captures the education, labour availability, and demographic capacity of households to pursue and sustain livelihoods. Indicators included:

- educational status of household head
- educational status of main woman in the household
- working adult ratio
- labour availability within the household
- migration-related stress

These variables reflect the knowledge and labour base that shapes livelihood choices and adaptability.

Average Human Capital Score: 0.548

Social Capital (SC)

Social capital refers to the institutional and community linkages through which households access collective support, information, and public entitlements. Indicators included:

- WUG membership and participation
- access to government schemes
- decision-making inclusion

These indicators capture the extent to which households are embedded in networks and collective institutions.

Average Social Capital Score: 0.401

Financial Capital (FC)

Financial capital reflects the financial resources available to households for investment, consumption smoothing, and risk management.

Indicators included:

- Primary household income source
- Remittances or external income
- Income diversification indicators

These variables indicate the financial capacity and economic stability of households.

Average Financial Capital Score: 0.422

Household Livelihood Resilience (HLR)

The Household Livelihood Resilience (HLR) score was calculated as the mean of the five capital scores using the calculated averages:

Capital	NC	PC	HC	SC	FC
Score	0.430	0.679	0.548	0.401	0.422

Overall Household Livelihood Resilience (HLR): 0.496

Interpretation

The SLF analysis indicates that physical capital is the strongest livelihood asset among households in the study area, reflecting relatively better ownership of household assets and basic infrastructure. However, social capital and financial capital remain particularly weak, suggesting limited institutional engagement, low-income diversification, and constrained access to financial resources.

Human capital is also moderate, indicating that education levels and labour capacity may limit the ability of households to adopt improved agricultural practices or diversify livelihoods.

The overall HLR score of 0.28 suggests that the livelihood system remains vulnerable and dependent on improvements in key enabling factors. Strengthening irrigation infrastructure through the Solar Lift Irrigation system, improving access to agricultural inputs and markets through FPOs, and enhancing financial inclusion and institutional participation are likely to play a critical role in improving livelihood resilience in Rajhara.

2.4 Data Analysis and Key Insights

Demographic Characteristics

The SLI baseline survey included 43 farmer households across Rajhara Panchayat; 31 from Rajhara Kothi and 12 from Chechanha across 12 wards. This will help us understand the spillover effect of SLI Infrastructure of Rajhara Kothi in Chechanha.

However, women remain central to household agricultural labour and decision-making processes, particularly in crop management and household food security.

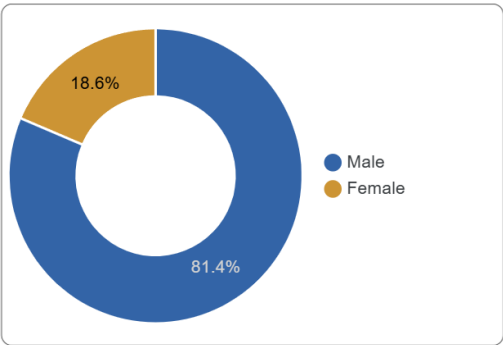


Figure 10: Baseline Comparison: Gender Ratio SLI Respondents

Household Composition

Households participating in the SLI intervention are predominantly smallholder farming families, with landholdings typically around 2.24 acres.

The survey indicates a mixed livelihood structure, where agriculture is often combined with migration income and wage labour.

Social Category and Education

The majority of SLI farmers belong to Other Backward Classes (OBC), followed by Scheduled Castes (SC) and a smaller proportion from general social categories.

The education profile suggests moderate literacy levels among household heads, while women's educational attainment is relatively lower.

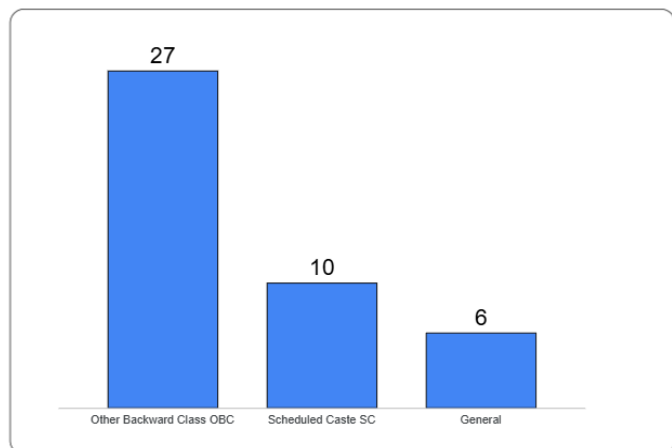


Figure 11: Caste Profile of SLI Respondents

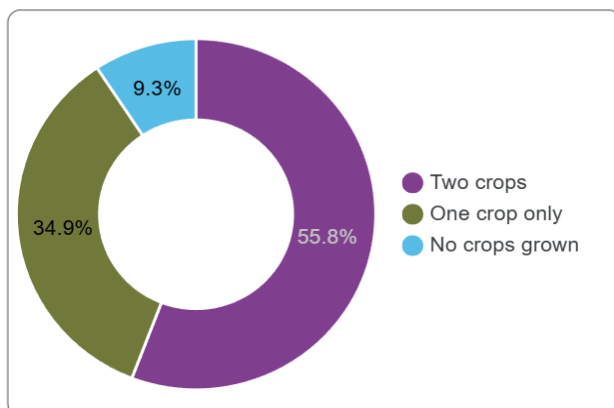


Figure 12: Crop Intensity of SLI Respondents

Primary and Secondary Livelihood Sources

Agriculture remains the primary livelihood for most SLI households, though seasonal wage labour and migration provide supplementary income.

The survey indicates that more than half of the SLI respondent households cultivate two crops annually, while a significant proportion continues to rely on single cropping.

Mining-Linked Livelihood Dependence

Rajhara is located within a coal mining region, and household livelihoods historically depended on mining-related economic activities.

However, changes in mining operations and employment patterns have pushed many households toward agriculture and migration-based livelihoods.

Household Income Distribution

Income distribution among SLI households reflects 47.5% SLI respondents having ₹ 45000-80000 income band annually small-scale agricultural income supplemented by remittances and wage labour.

Income Insecurity and Livelihood Vulnerability

Financial stress among households is often associated with:

- crop failure
- irrigation constraints

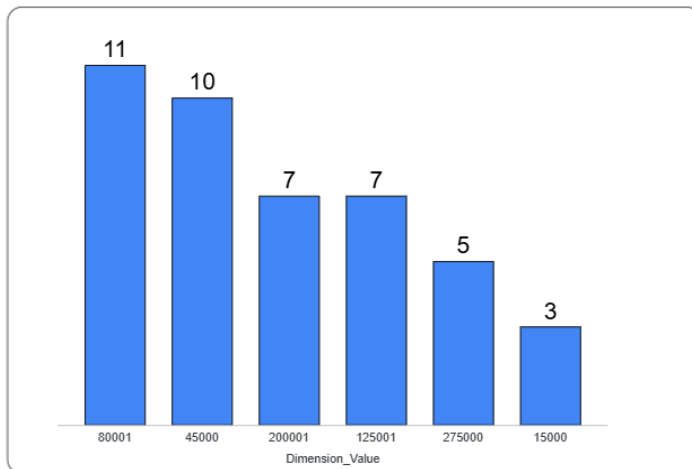


Figure 13: Income Band: SLI Respondents

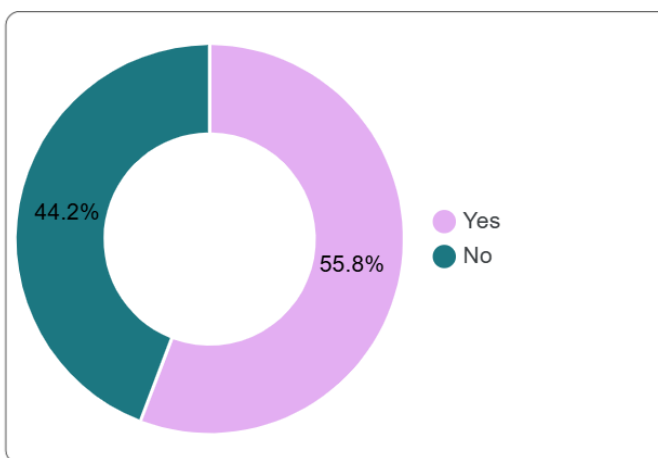


Figure 14: Migration Status Respondents' Household Members in last 36 months

- seasonal employment gaps
- health expenditures

Migration and Alternative Livelihood Strategies

Migration is a common coping strategy among households. 55.8% of the households surveyed reported migration during the last three years. Remittances received from migrants serve as an important source of financial stability.

Agricultural Production and Irrigation Constraints

Maize is the dominant crop cultivated by most farmers. Before the introduction of SLI systems, farmers relied primarily on:

- rainfall
- electric pumps
- open wells

93% of SLI respondents reported irrigation systems to be unreliable or only partially reliable, resulting in inconsistent crop production.

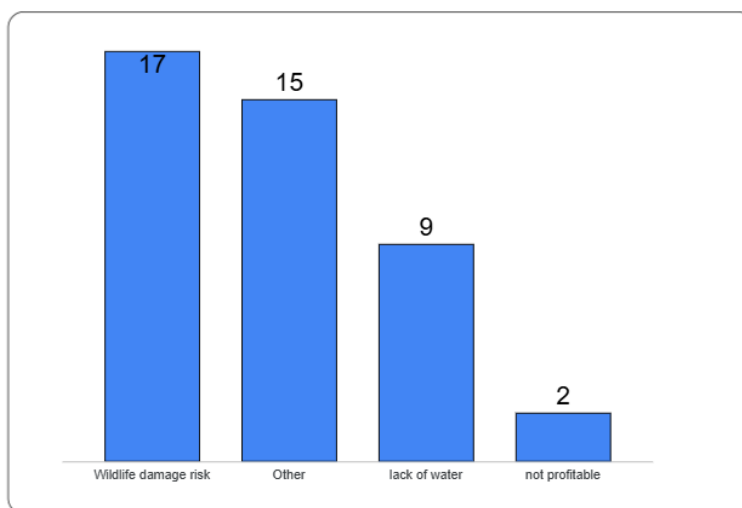


Figure 15: Reasons for Unutilized Land / Fallow Land of SLI Respondents

Landholding and Land Utilization

The majority of farmers operate on small and fragmented landholdings of a mean average of 2.24 acre, with landholding ranging from 0.4-9 acre. 40-60% of the agricultural land remains fallow due to lack of irrigation infrastructure.

Perceived Water Supply and Agricultural Risk

37.2% SLI respondents reported significant 20-30 days of water supply / availability shortage during cropping seasons, which directly affects crop productivity and income stability.

"The water is available on time, and my yields have increased."

**- Naresh Saah (79 years, Rajhara village),
Early Adopter, SLI & WUG member**

Institutional Participation

53.5% of the surveyed households are members of Water User Groups (WUGs), indicating emerging community-level governance of irrigation systems.

Regression Analysis evaluating factors affecting Solar Lift Irrigation adoption in Rajhara

Analytical Approach

Theoretical Framework

The SLI system is analysed using a **resource-response framework**, where irrigation access reduces water stress and influences agricultural behaviour and economic outcomes.

The linear regression model used is:

$$Y = \beta_0 + \beta_1 X + \epsilon$$

Where:

- YYY: Outcome variable (e.g., willingness to pay, irrigation usage)
- XXX: Explanatory variable (e.g., water stress days, landholding)
- β_1 : Marginal response to resource availability
- β_0 : Baseline level

Model Specifications and Results

1. Willingness to Pay vs Water Stress

$$WTP = \beta_0 + \beta_1 (\text{Water Stress})$$

Observed:

- Positive slope (steep)

- Moderate R^2 ($\approx 0.25\text{--}0.35$ range)

Interpretation

- Households experiencing higher water stress are significantly more willing to pay for irrigation
- Strong slope indicates direct economic response to resource scarcity

2. Irrigation Use vs Landholding

$$Irrigation = \beta_0 + \beta_1(Landholding)$$

Observed:

- Positive slope
- Moderate explanatory power

Interpretation

- Larger landholders utilize irrigation more effectively
- Indicates scale advantage in resource utilization

3. Income vs Irrigation Access

$$Income = \beta_0 + \beta_1(SLI\ Access)$$

Observed:

- Positive slope
- Moderate R^2

Interpretation

- Irrigation access contributes to income enhancement
- Reflects productivity gains through water access

Key Insight from SLI Regression

- Slopes are relatively steep compared to other domains
- Indicates strong behavioural responsiveness

SLI represents a mature, demand-driven system, where:

- scarcity $\rightarrow$ demand $\rightarrow$ payment $\rightarrow$ usage

Conclusion

Regression analysis confirms that SLI intervention:

- directly addresses a binding constraint (water)
- generates strong economic responses
- shows clear linkage between input (water) and outcome (income, WTP)

Economic Willingness and Resource Endowment

The relationship between willingness to pay for irrigation services and landholding size shows a weak positive association. The regression equation:

$$y = 1.4145x + 11.469, R^2 = 0.0286$$

indicates that for every additional acre of land owned, willingness to pay increases by approximately ₹1.41 per hour. However, the very low R^2 value of 0.0286 suggests that landholding explains less than 3% of the variation in willingness to pay. This indicates that economic capacity, as proxied by land size, is not a strong determinant of willingness to pay in this context.

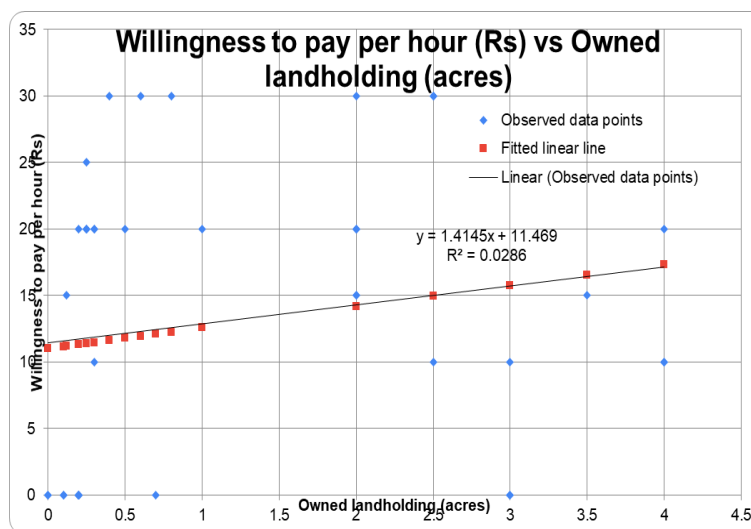


Figure 16: Effect of perceived water stress days on Willingness to pay for SLI service and usage

The relatively high intercept (₹11.469) suggests that even households with negligible or zero landholding exhibit a baseline willingness to pay, likely reflecting the perceived necessity of irrigation access rather than purely asset-based affordability.

This has important implications. The demand for irrigation appears to be need-driven rather than wealth-driven, suggesting strong potential for inclusive access models, especially for marginal farmers.

Perceived Water Stress as a Driver of Economic Behaviour

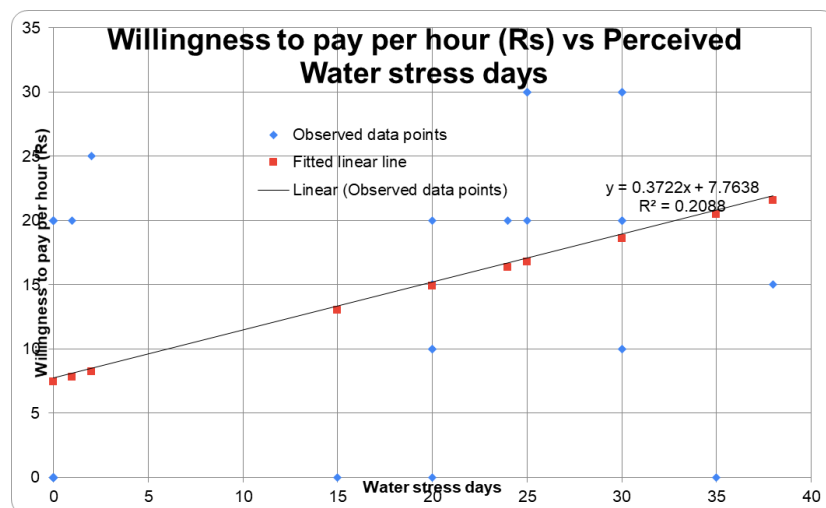


Figure 17: Effect of degree of trust on WUG on Willingness to continue with SLI

by water stress levels.

This is a significantly stronger explanatory factor compared to landholding.

The implication is clear: scarcity drives economic valuation. Farmers who experience more frequent irrigation shortages place higher value on reliable water access. The relatively lower intercept (₹7.76) compared to the landholding model further reinforces that willingness to pay is highly responsive to stress conditions rather than static economic status.

This validates the core premise of SLI: reliability of irrigation is a key economic driver.

Institutional Trust and Continuation Intent

The strongest relationship observed in the analysis is between trust in institutions and the intent to continue using the SLI system. The regression equation:

$$y = 0.3363x - 0.6448, R^2 = 0.8132$$

A much stronger relationship emerges between willingness to pay and perceived water stress. The regression:

$$y = 0.3722x + 7.7638, R^2 = 0.2088$$

shows that each additional day of water stress increases willingness to pay by approximately ₹0.37 per hour. The R^2 value of 0.2088 indicates that about 21% of variation in willingness to pay is explained

demonstrates a very strong positive relationship, with R^2 of 0.8132 indicating that over 81% of the variation in continuation intent is explained by trust score.

Each unit increase in trust score increases the probability of continuation intent by approximately 0.336. The negative intercept suggests that at very low levels of trust, continuation intent becomes negligible or even negative.

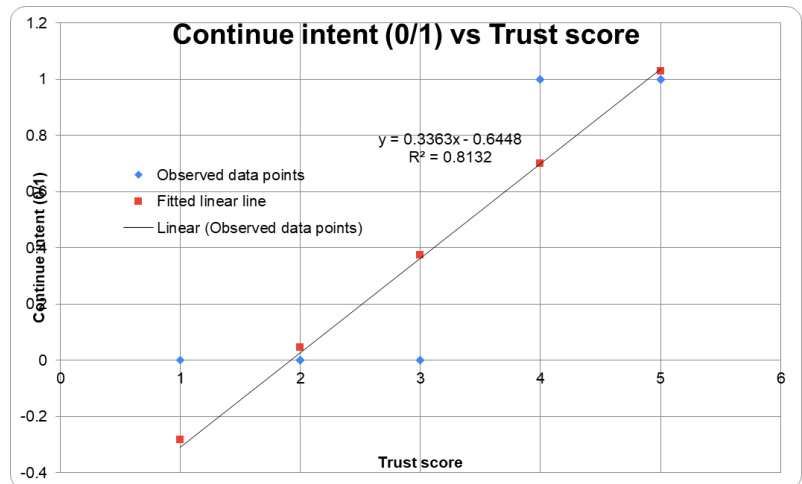


Figure 18: Effect of landholding on WUG membership

This is a critical insight. Unlike economic variables, institutional perception dominates behavioural sustainability. Trust is not just a supporting factor, it is the primary determinant of long-term adoption.

This reinforces that SLI is not merely a technological intervention, but a community-governed institutional system, where credibility, transparency, and collective management determine success.

Fairness Perception and Behavioural Outcomes

The relationship between fairness perception and continuation intent is positive but moderate:

$$y = 0.4783x - 0.6398, R^2 = 0.3348$$

This suggests that fairness plays a meaningful role, with each unit increase in fairness score increasing continuation intent by approximately 0.478. However, the explanatory power ($R^2 = 0.3348$) is significantly lower than that of trust.

This indicates that while fairness contributes to behavioural outcomes, it operates as a secondary institutional factor, possibly mediated through trust.

Interestingly, the slope is higher than that of trust, suggesting fairness has a strong marginal effect when it varies, but its overall variation across respondents may be limited.

Determinants of WUG Membership

The relationship between landholding and formal WUG membership is weak:

$$y=0.108x+0.3429, R^2=0.0778$$

Landholding increases the probability of membership slightly, but explains less than 8% of variation. This again reinforces that institutional participation is not strongly determined by asset ownership, indicating inclusivity in membership patterns.

In contrast, water stress has a much stronger influence on WUG membership:

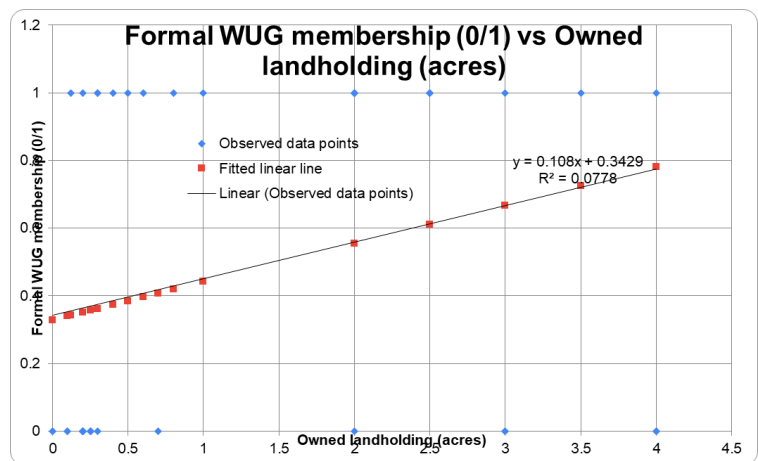


Figure 19: Membership Profiles of WUG Members

$$y=0.0251x+0.1083, R^2=0.444$$

With R^2 of 0.444, nearly 44% of variation in membership is explained by water stress. Each additional day of perceived stress increases membership probability by 0.025.

This highlights that collective action emerges from shared vulnerability. Farmers facing higher water stress are more likely to participate in institutional arrangements like WUGs.

Interplay Between Institutional Variables

The relationship between trust and fairness is also positive:

$$y=1.3913x+0.087, R^2=0.394$$

This indicates that fairness perceptions significantly influence trust levels, explaining about 39% of variation. The high slope suggests that improvements in perceived fairness can substantially increase trust.

This establishes a clear institutional chain:

Fairness → Trust → Continuation Intent

This pathway provides a powerful framework for program design and monitoring.

Synthesis and Interpretation

Across all models, a consistent pattern emerges. Economic variables such as landholding have limited explanatory power, while experiential and institutional variables such as water stress, trust, and fairness play a much larger role.

Water stress emerges as the primary driver of both willingness to pay and institutional participation. This confirms that SLI is fundamentally addressing a real and pressing constraint.

However, long-term sustainability is not driven by economic need alone. Trust in the system overwhelmingly determines whether farmers continue engagement. Fairness contributes to this trust, indicating that governance quality is central to system success.

The relatively low R^2 values in economic models and high R^2 in institutional models indicate that SLI success is less about infrastructure and more about institutional design.

Limitations of the Analysis

The use of linear regression assumes linear relationships, which may oversimplify complex behavioural dynamics. Several dependent variables, such as continuation intent and membership, are binary in nature, for which logistic regression may provide a better fit.

The sample size and distribution also appear limited in certain ranges, particularly for higher landholding categories, which may reduce robustness of estimates.

Additionally, omitted variables such as income, education, social capital, and prior exposure to irrigation systems may influence outcomes but are not included in the models.

Final Insight

The regression analysis reveals that SLI is not merely an irrigation solution—it is a behavioral and institutional system embedded within a resource-scarce environment.

Scarcity drives demand.

Fairness builds trust.

Trust ensures continuity.

And together, they determine whether the system sustains or fails.

Community Experiences with SLI

The initial phase of the Solar Lift Irrigation (SLI) intervention demonstrated high receptivity and among community members to transition towards a solar-based irrigation system using repurposed coal- mine water.

Interactions with Naresh Saah, (79 years, Rajhara village), an early adopter and active user of the SLI/WUG group, highlighted a prominent shift in his perception towards using solar-energy based systems for agriculture. Since the installation of SLI pump and becoming a member of WUG, Nareshji has successfully converted 1 acre of his fallow land into a productive agricultural asset. The intervention helped him revive agriculture and double the yield produce which was not possible prior to the intervention. As a WUG member, his dependence on rain-fed irrigation, diesel/electricity reliant water pump machines reduced considerably. His transition to SLI-based irrigation system helped him sell Rs.50,000 of agricultural (paddy) produce from this previously kept fallow land. His paddy yield doubled to 15 quintals per acre from 7-8 quintals per acre. The agricultural produce (paddy) from another 1-acre farm using diesel -reliant irrigation pump generates 7-8 quintal per acre. The gain from SLI and WUG membership encouraged him to scale his efforts; he plans to diversify cropping and harvest 'moong' dal in the upcoming cropping season.

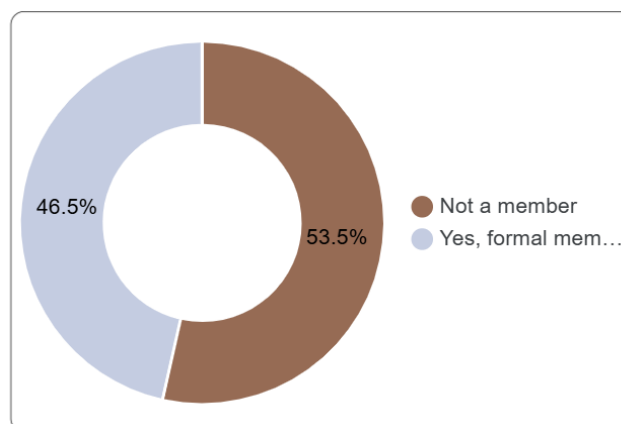


Figure 20: Experience with SLI

2.5 Experience of Early Adopters with SLI

The qualitative findings highlight several emerging impacts of the Solar Lift Irrigation intervention.

Increased Yield: Agricultural gains of using SLI have been evidenced by Naresh Saah's story. A significant surge in yield productivity (doubled productivity) has been recorded post SLI usage.

Revival of Fallow land: as a productive agricultural asset generating disposable income.

Affordability: Economic value of the SLI intervention strongly recognised by the users. The nominal membership fee of the WUG ensures inclusive access.

Solar as an alternative: SLI as an alternative system of irrigation recognised by all. Dependence on seasonal/rain-fed irrigation has reduced considerably. Upfront cost of installing electricity-run water motors completely eliminated by SLI. Reduced expenditure on recurring electricity bills or fuel-based systems (diesel)-reduced bills, zero dependence on electricity/fuel for irrigation, cost-effective; money saved can be used for other expenses or for future investment or savings.

Access: The easy availability of the irrigation water within the proximity of the farming land (24x7), with members taking turns to use the repurposed water- continued water supply.

SLI Ownership and Maintenance: Notable indicator of community ownership cited when the users collectively came forward and repaired the damaged SLI pipe despite having a provision of calling a technician.



Figure 21: Benefits of Solar Lift Irrigation

The SLI-WUG intervention establishes a sustainable blueprint for a community-led/owned model of just-energy transition in the coal-dependent regions experiencing acute water shortage.

2.6 Key Takeaways

- Strong community buy-in towards SLI/WUG model.
- Significant shift in community's perception towards solar-based energy transition (evidenced by Naresh Saah's case study).
- Although limited, there are significant cases of revival of fallow land as an agricultural asset. Notable increase in doubling of yield productivity with SLI usage; gaining prominence and trust among its users.
- SLI Pump—recognized as a cost-effective and alternative method as opposed to electricity/fuel-based options.
- There's a clear increase in the disposable income of the user; reduction in recurring cost accrued on diesel and electricity bills.
- Readiness and accountability within the user community. With right guidance and training support, WUG users/community members can be trained as skilled technicians to look after SLI pump repair and maintenance.

2.7 Emerging Concerns/Risk Perception

Physical disruption and access to SLI water once the coal-mining work starts with its re-opening, necessitating a need to find alternative measures, build additional infrastructure such as storage

tanks, bore -wells or reservoirs etc. to ensure water security.

2.8 Program Visibility & Gaps

A. While a considerable section of the community is aware of the physical installation of the solar pump structure in Rajhara, a significant majority lacks information on its purpose, usage, specific users, installer (ACPET) and long-term benefits of the SLI program. The community knows about the 'solar pump' but not the overall program. The information and benefits of the intervention only being confined to selected SLI/WUG families. The knowledge around application of the asset is limited.

B. The gains received by WUG users like Naresh ji, could not be effectively communicated to potential SLI/WUG members. Noted visibility of the SLI physical structure but lack of programmatic identity and purpose. Less recall value among the community about the program's name, purpose and application. Comprehensive understanding of SLI/WUG intervention is limited to its users/members. Information exchange is happening within the immediate beneficiaries. Transition story of WUG members like Naresh shah not being communicated to other community members effectively (community operates in silos).

C. SLI/WUG benefits can only be accessed by those owning or leasing lands for farming activities. A notable majority of community people are still struggling with the idea of transitioning to agriculture, with an exception of people engaged in vegetable farming in Chechanha village.

Future Potential - Chechchanha



Figure 22: Water User Group members

- **SLI Expansion:** Chechanha presents a huge scope for SLI expansion (high-potential region to scale SLI & FPO interventions). Unlike Rajhara Kothi, *Chechanha* has an already

established vegetable-farming culture; nearly every household is engaged in vegetable farming and selling (*okra, cauliflower etc.*). The proximity to nearby *Koel* River provides unhindered access to water. Majority (80-90%) farmers rely either on electricity or diesel based water pumps for irrigation. SLI installation would bring down this cost for the community. There were suggestions to expand and install SLI pumps in Chechanha from the community members themselves. Especially the SHG members.

- There is a scope of converting at least one member from each household as a FPO member; strong presence of active SHG groups can alleviate programmatic footprints. SHG members showed keen interest in learning and joining the FPO. Paucity of information resulted in limited participation. A robust community-mobilisation and regular interactions with community members will strengthen FPO membership as well as the program's presence here.

2.9 Recommendations / Suggestions

The baseline assessment and field consultations show that SLI has demonstrated benefits and strong potential to improve irrigation reliability and agricultural productivity for farmers using the facility in Rajhara. That said, the SLI user pool needs to be expanded by adding 17–20 more farmers, as the current infrastructure can support this increase. Farmers expressed strong interest in expanding access to solar-powered irrigation, recognizing its potential to reduce reliance on rainfall and boost cropping intensity. However, the system is still in an early operational phase, and several technical, institutional, and financial measures will be needed to ensure sustainability and scalability.

Farmers showed strong interest in expanding access to solar-powered irrigation, recognizing its potential to decrease reliance on rainfall and boost cropping intensity. However, the current system remains in the early operational stage, and several technical, institutional, and financial measures are needed to ensure sustainability and scalability. The following recommendations are suggested.

2.9.1 Strengthening SLI Infrastructure and System Design

The current SLI system has demonstrated technical functionality, but initial observations suggest that enhancements in infrastructure design and distribution networks will improve efficiency and coverage. Recommended actions include:

- **Expansion of the command area:** The current system serves only a limited number of farmers. Extending pipelines and improving distribution channels can enable more households to access irrigation services.
- **Strengthening pipeline infrastructure:** Pipeline segments that pass-through village roads and uneven terrain require reinforcement to prevent leaks, breaks, or operational disruptions.
- **Introduction of intermediate storage structures:** Small on-farm storage tanks or intermediate reservoirs can help manage water supply and reduce pressure fluctuations

in the distribution network.

- **Enhanced water distribution planning:** Developing clear irrigation schedules will ensure fair water access for farmers and decrease conflicts during busy irrigation periods.
- **Assessment of additional SLI installations:** The baseline shows substantial latent demand. Consider installing additional SLI units, with probable funding from DMF/NABARD/JSPLPS, in nearby areas where abandoned mine reservoirs or other water bodies can be utilized.

Strengthening these technical aspects will improve system reliability and increase the number of farmers benefiting from irrigation access.

2.9.2 Institutionalizing Water User Group (WUG) Governance Mechanisms

For long-term sustainability, the management of the SLI system should gradually transition from project-supported operations to community-led governance through the Water User Group (WUG). Recommended actions include:

- **Formalizing WUG structures:** Clear roles and responsibilities should be defined for members responsible for scheduling irrigation, monitoring water usage, and resolving disputes.
- **Developing irrigation scheduling protocols:** Transparent water allocation rules can ensure equitable distribution and avoid overuse by individual farmers.
- **Establishing accountability mechanisms:** Regular meetings, financial reporting, and participatory decision-making processes will strengthen institutional credibility.
- **Promoting inclusive participation:** Representation of smallholders, marginal farmers, and women should be ensured within WUG governance structures.



Figure 23: Focus Group Discussion with Water User Group members

- **Linking WUGs with the FPO:** Integrating irrigation management with the emerging FPO

platform can improve coordination between production planning and market-oriented agriculture.

Institutionalizing WUG governance will help maintain system functionality and build community ownership of irrigation infrastructure.

2.9.3 Capacity Building and Technical Training

Since many households in the region have limited experience with irrigated agriculture due to historically rainfed farming conditions, capacity building and collaboration with KVK and NABARD will be crucial to maximize the benefits of the SLI system. Key training priorities include:

- **Climate-resilient agricultural practices:** Training on crop diversification, soil fertility management, soil organic carbon enhancement and water-efficient irrigation practices.
- **Improved crop planning:** Farmers should receive guidance on crop calendars, particularly for introducing rabi crops enabled by irrigation access.
- **Technical training for WUG members:** Selected community members should be trained in basic maintenance of solar pumps, pipelines, and control systems.

2.9.4 Agricultural extension support

Collaboration with Krishi Vigyan Kendra (KVK) and the District Agriculture Department can strengthen technical advisory services.

2.9.5 Post-harvest management and value addition

Training in storage, grading, and packaging can help farmers capture higher market value for their produce.

Building technical and managerial capacities will ensure that irrigation access translates into sustained improvements in agricultural productivity and income

2.9.6 Financing and Maintenance Systems

A structured financing and maintenance system will be needed to ensure the long-term sustainability of the SLI infrastructure. Recommended actions include:

User-based fee mechanisms: Farmers may contribute irrigation fees based on the acreage cultivated or the hours of pump use. This will generate resources for operation and maintenance.

Establishment of a maintenance fund: Contributions collected through WUGs can be pooled into a dedicated fund for repairs, replacement of components, and routine maintenance.

Access to government programs: Expanding and replicating SLI systems can be facilitated by convergence with relevant schemes such as

- PM-KUSUM
- Agriculture Infrastructure Fund (AIF)
- District Mineral Foundation (DMF)
- State irrigation or renewable energy programs.

Access to credit through FPO platforms: The FPO can potentially help secure institutional credit or innovation grants for expanding irrigation and agricultural infrastructure. This requires significant capacity building for the existing FPO, which currently lacks the necessary skills to fulfil this role for its members.

Table 3: SLI Recommendations - Output Outcome Framework

Purpose and Sub-goals	Activity	Outcome
Providing farmers access to irrigation water through SLI	Outreach and integrate 20-30 more farmers cultivating in nearby farmland	Year-round access to irrigation, increased crop intensity and income
Mitigate problems faced by SLI users	Strengthening pipeline infrastructure and involve community in maintenance	Sustainable access to irrigation
Expanding SLI usage	Create one or more intermediate reservoir Propose NABARD assistance for adding more SLI	Increased farmers' access to irrigation
Strengthening WUG	Formalize WUG, clarify roles and responsibilities, introduce transparent water distribution planning	Sustainable and community driven system for irrigation access
Inclusive participation	Women and marginal farmers' participation in governance structure	Inclusive access to irrigation
Linking WUG and FPO	Facilitate WUG's active participation in FPO activity planning	Increased access to market and finance
Build WUG Capacity	Introduce, climate resilient agricultural practices, crop planning, aggregation, post-harvest management	Increased productivity, profitability and income
SLI access to Government programs	Facilitate convergence with relevant schemes – DMF, AIF, NABARD, PM KUSUM etc.	Expanded access to irrigation and convergence

Farmer Producer Organization

Farmer Producer Organizations (FPOs) have emerged as a key institutional mechanism for strengthening the economic and bargaining capacity of smallholder farmers. By aggregating farmers into collective platforms, FPOs seek to address several structural challenges faced by agricultural producers, including fragmented landholdings, weak price negotiation capacity, limited access to quality agricultural inputs, and inadequate market linkages. In rural economies where farmers are heavily dependent on intermediaries and informal markets, collective institutions such as FPOs have the potential to improve price realization, reduce input costs, and enhance the sustainability of farming systems.

The FPO intervention examined in this study aims to strengthen collective marketing systems, improve access to agricultural inputs and credit, and build institutional participation among farmers in the project area. In addition to economic objectives, the intervention seeks to enhance inclusive participation of marginalized communities and strengthen women's involvement in agricultural decision-making processes.

3.1 Research Questions

***R1:** What does the existing baseline data reveal about the current agricultural context and potential entry points for the FPO's early interventions?*

***R2:** How aware is the community of the FPO's objectives and functions and how accepting are they towards this intervention?*

***R3:** What infrastructural and operational challenges does the FPO anticipate in its early stages?*

***R4:** How do key stakeholders perceive their role in supporting the FPO?*

***R5:** What lessons can be drawn from existing FPOs in India regarding success and failure factors?*

***R6:** How can coal companies integrate support for FPOs into mine closure social responsibility plans?*

3.2 Methodology

The study adopts a **mixed-method research design**, combining quantitative and qualitative approaches to generate comprehensive insights into the functioning of the FPO.

Household Survey

A structured household survey was conducted among 324 respondents, comprising:

- 162 FPO members

- 162 FPO non-members

The balanced sample enables comparative understanding of institutional participation and agricultural outcomes among farmers exposed to the FPO ecosystem and those outside it.

The survey collected data on demographic characteristics, livelihood sources, migration patterns, agricultural marketing practices, access to credit, institutional participation, and gender dynamics.

Qualitative Methods

Qualitative insights were generated through:

- **Key Informant Interviews (KIIs)** with the FPO CEO, NABARD District Development Manager (DDM), KVK Scientist, JSLPS District Program Manager
- **Focus Group Discussions (FGDs)** with farmers, FPO members
- **In-Depth Interviews (IDIs)** with selected households engaged with FPO activities

These qualitative interactions provided contextual insights into institutional governance, farmer perceptions of collective marketing, and barriers affecting participation in the FPO.

3.3 Evaluation Framework

The evaluation applies the **SROI Framework** to analyze the institutional performance of the FPO.

3.3.1 Dimension based outcomes

Social Return on Investment (SROI) evaluates the value generated by the FPO relative to the resources invested in establishing and supporting the institution. The SROI framework captures economic, social, and institutional outcomes.

The evaluation considers outcomes across four dimensions: income enhancement, market participation, financial inclusion, and institutional empowerment.

Increased Agricultural Market Participation

A key economic outcome is the increase in farmers' participation in agricultural markets.

Among FPO members, 133 households (82.1%) reported selling agricultural produce, compared to 65 non-members (40.1%). This indicates that FPO membership more than doubles the likelihood of farmers engaging in agricultural sales.

This increased market participation represents a measurable economic benefit, as farmers gain opportunities to convert agricultural production into monetary income.

Improved Market Awareness and Price Knowledge

Market literacy is another measurable outcome. Among FPO members, 119 households (73.5%) reported selling through local traders, while 54 households (33.3%) indicated that FPO prices were comparable to local market prices.

In contrast, 124 non-members (76.5%) reported being unable to compare prices, indicating lower market awareness. This suggests that FPO participation increases farmers' knowledge of price dynamics and market opportunities, an important outcome for improving income realization.



Figure 24: SROI Framework for FPO Project

Strengthening Financial Inclusion

Financial inclusion is evaluated through access to credit systems.

Among FPO members, 70 households (43.2%) reported accessing loans, compared to 79 non-members (48.8%). However, members relied more on community-based financial institutions such as SHGs, while non-members relied more on microfinance institutions.

The stronger connection between FPO members and SHG networks indicates that collective institutions help embed farmers within local financial ecosystems, potentially reducing reliance on high-interest external lenders.

Women's Empowerment and Institutional Inclusion

Social empowerment outcomes are also measured within the SROI framework.

Among FPO members, 115 respondents (71.0%) expressed support for women assuming leadership roles, while 39 members (24.1%) reported that women's opinions are respected in group discussions.

However, gender disparities remain evident. Only 45 respondents (27.8%) among FPO members were women, indicating that while aspirations for women's leadership are high, their representation in formal membership remains limited.

This suggests that the potential social return from gender inclusion remains largely unrealized, representing a major opportunity for program expansion.

Ecological and Agricultural Sustainability

The SROI framework also considers environmental outcomes.

Among FPO members, 78 households (48.1%) reported practicing agroforestry, compared to 51 non-members (31.5%), suggesting that FPO participation may contribute to greater adoption of diversified agricultural systems.

However, climate-resilient practices remain limited overall. 151 members (93.2%) reported not practicing cover cropping, indicating that knowledge and adoption of climate-smart agriculture remains low.

3.3.2 Potential SROI Indicators for the FPO Program



Figure 25: SROI Indicators for FPO Project

Based on the dataset, several measurable indicators can be used to calculate the social return generated by the FPO:

Economic indicators

- Increase in proportion of farmers selling agricultural produce (82.1% members vs 40.1% non-members)
- Increase in agricultural income diversification
- Reduction in reliance on wage labour

Institutional indicators

- Participation in collective meetings (58.7% members attending at least occasionally)
- Trust levels within the institution (38.3% high trust)

Financial indicators

- Access to SHG credit (26.5% members vs 15.4% non-members)

Gender indicators

- Support for women leadership (71% among members)

Environmental indicators

- Agroforestry adoption (48.1% among members)

3.4 Data Analysis and Key Insights

Demographic Characteristics and Gender Inclusion

The gender distribution of respondents highlights notable disparities in institutional participation. Among the 162 FPO member households, 117 respondents (72.2%) were male, while 45 respondents (27.8%) were female. In contrast, among the 162 FPO non-member households, 97 respondents (59.9%) were female and 65 respondents (40.1%) were male.

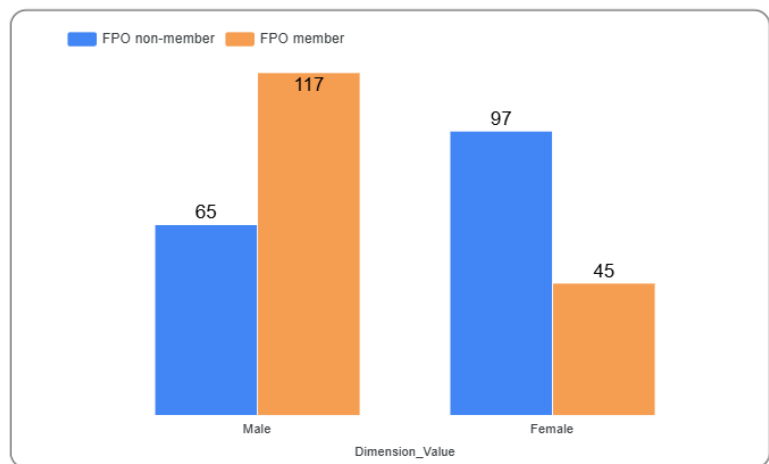


Figure 26: Gender Profile of FPO Respondents

This indicates that FPO membership is strongly male-dominated, with nearly three-quarters of members being men. Conversely, women form the majority among non-members. The findings suggest that although women play a central role in agricultural labour and rural livelihoods, their representation within formal producer organizations remains limited.

Field discussions revealed that participation in producer organizations is often linked to land ownership and formal household decision-making authority, which traditionally remains concentrated among male household members. Women's engagement in marketing activities, collective procurement, and institutional governance is therefore constrained despite their active involvement in agricultural production and household management.

This highlights a significant gender inclusion gap within the FPO structure, suggesting the need to strengthen women's participation through strategies such as SHG - FPO convergence, targeted membership drives for women farmers, and leadership capacity development programs.

Social Category and Education Profile

The social composition of respondents indicates that the FPO primarily operates within agrarian communities dominated by Other Backward Classes (OBC). Among FPO members, 83 households (51.2%) belong to the OBC category, 37 households (22.8%) belong to Scheduled Castes, and 42 households (25.9%) belong to the General category. Among non-members, 75 households (46.3%) belong to the OBC category, 57 households (35.2%) belong to Scheduled Castes, and 29 households (17.9%) belong to the General category.

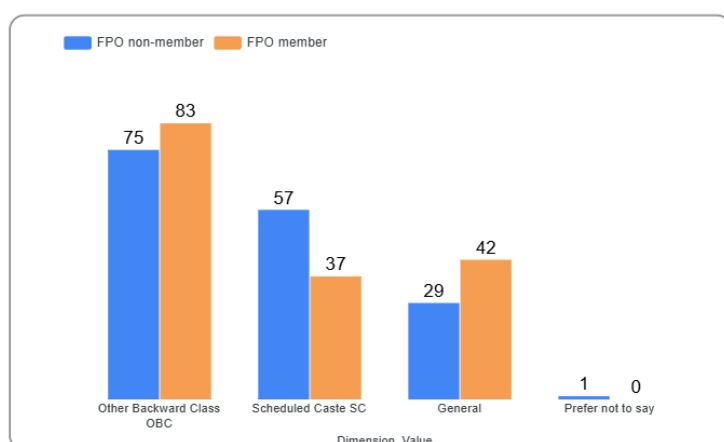


Figure 27: Social Category of FPO Respondents

The data indicates that Scheduled Caste households are relatively more represented among non-members, while General category households are somewhat more represented among FPO members. This suggests the possibility of social inclusion gaps in FPO participation, where relatively better-off or socially advantaged groups may have slightly greater representation in formal producer institutions.

Educational attainment among respondents reflects a mixed distribution. Among FPO members, 71 respondents (43.8%) have completed secondary education, 57 respondents (35.2%) have higher secondary education or above, 16 respondents (9.9%) have primary education, 11 respondents (6.8%) have no schooling, and 7 respondents (4.3%) can only sign their names.

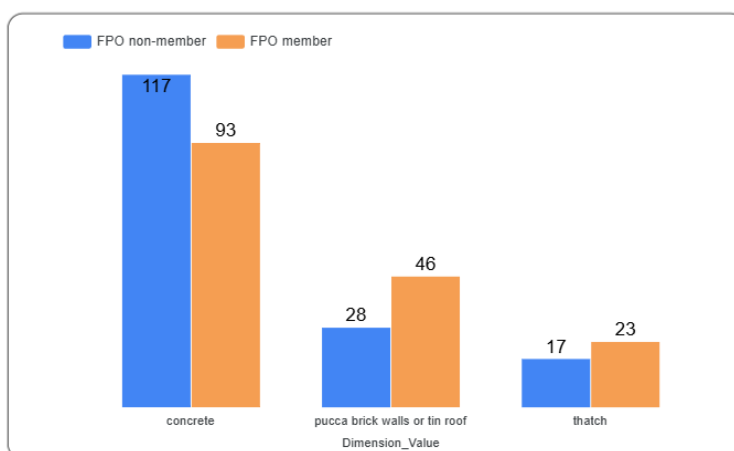


Figure 28: Housing Conditions of FPO Respondents

Among non-members, 82 respondents (50.6%) have higher secondary education or above, 55 respondents (34.0%) have secondary education, 10

respondents (6.2%) have primary education, 9 respondents (5.6%) have no schooling, and 6 respondents (3.7%) can only sign.

These findings indicate that educational attainment alone does not determine FPO membership, as many members belong to moderately educated farming households rather than highly educated ones.

Household Assets and Housing Conditions

Housing conditions serve as an indirect indicator of household economic status. Among FPO members, 93 households (57.4%) live in concrete houses, 46 households (28.4%) live in pucca brick houses with tin roofs, and 23 households (14.2%) live in thatched houses.

Among non-members, 117 households (72.2%) live in concrete houses, 28 households (17.3%) live in pucca brick or tin-roof houses, and 17 households (10.5%) live in thatched houses.

The results indicate that non-members appear slightly better off in terms of housing assets, with a larger share living in concrete houses. Meanwhile, FPO members are more concentrated in moderately resourced housing categories such as tin-roof or semi-pucca structures. Discussions with farmers suggested that relatively better-off households may prefer selling produce independently through established trader networks rather than participating in collective marketing platforms.

Primary and Secondary Livelihood Sources

Livelihood patterns reveal clear distinctions between FPO members and non-members. Among FPO members, 66 households (40.7%) report agriculture as their primary income source, compared to 39 households (24.1%) among non-members.

Conversely, 51 non-member households (31.5%) rely primarily on non-agricultural wage labour, compared to 41 member households (25.3%). Remittance income is also more common among non-members, with 26

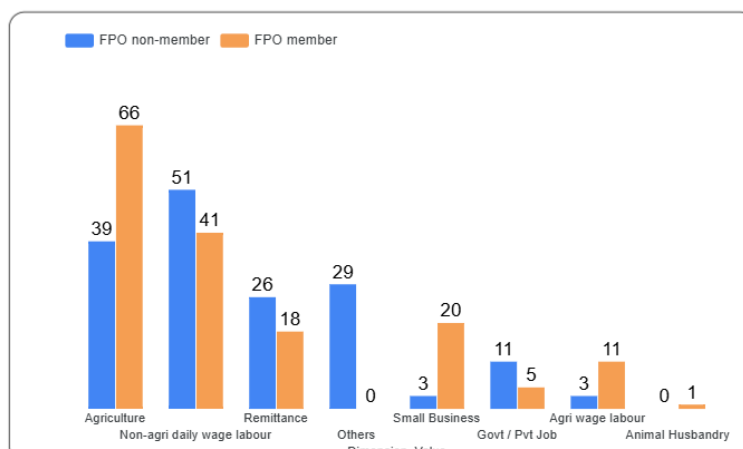


Figure 29: Primary Income Source of FPO Respondents

households (16.0%) depending on remittances, compared to 18 households (11.1%) among members.

Members also show stronger engagement in small business activities, with 20 households (12.3%) reporting small businesses as their primary income source, compared to only 3 households (1.9%) among non-members.

These findings suggest that FPO members tend to have stronger agricultural engagement, aligning with the primary purpose of FPOs as agriculture-based collective institutions.

Secondary livelihood sources further illustrate diversification. Among FPO members, 53 households (32.7%) depend on non-agricultural labour as secondary income, 37 households (22.8%) depend on agriculture, and 29 households (17.9%) depend on remittances. In comparison, among non-members, 60 households (37.0%) rely on non-agricultural labour, 30 households (18.5%) rely on agriculture, and 16 households (9.9%) depend on remittances.

Importantly, 23 non-member households (14.2%) reported having no secondary income source, compared to only 6 member households (3.7%), indicating greater economic vulnerability among non-members.

Migration and Alternative Livelihood Strategies

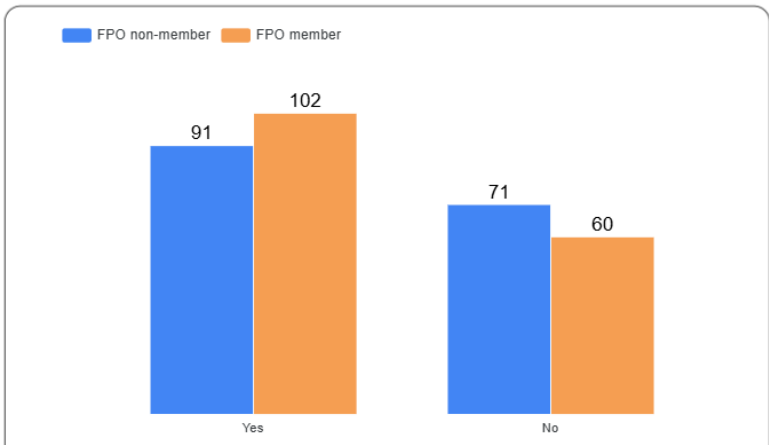


Figure 30: Migration Status: Household Member of FPO Respondents

Migration remains a common livelihood strategy across the region. Among FPO members, 102 households (63.0%) reported having a migrating member, while 60 households (37.0%) reported no migration. Among non-members, 91 households (56.2%) reported migration, while 71 households (43.8%) did not.

Migration destinations show that 62 member households (38.3%) send migrants to other states, compared to 55 non-member households (34.0%). Migration within the state was reported by 19 member households (11.7%) and 25 non-member households (15.4%), while 21 member households (13.0%) migrated within the district, compared to 8 non-member households (4.9%).

The type of work performed by migrants is largely labour-intensive. Among migrants from member households, 53 individuals (32.7%) work as daily labourers, 35 individuals (21.6%) work in factories, and 6 individuals (3.7%) work in roles such as drivers, security guards, or helpers. Among non-members, 50 individuals (30.9%) work as daily labourers, 17 individuals (10.5%) work in factories, and 10 individuals (6.2%) work in service roles.

These patterns indicate that migration remains a key livelihood coping strategy, suggesting that FPO participation has not yet significantly reduced migration pressures.

Public Safety Nets and Food Security

Public welfare programs play a crucial role in household livelihood security. Among non-members, 143 households (88.3%) possess MGNREGA job cards, compared to 105 member households (64.8%). Conversely, 57 member households (35.2%) do not possess job cards, compared to only 19 non-member households (11.7%).

This suggests that non-member households rely more heavily on public employment programs, reflecting greater dependency on social safety nets.

Food security indicators further highlight economic vulnerability. Among members, 134 households (82.7%) hold Priority Household ration cards, 22 households (13.6%) hold Green ration cards, and 1 household (0.6%) holds an Antyodaya card. Among non-members, 142 households (87.7%) hold Priority Household cards, 10 households (6.2%) hold Green ration cards, and 6 households (3.7%) hold Antyodaya cards.

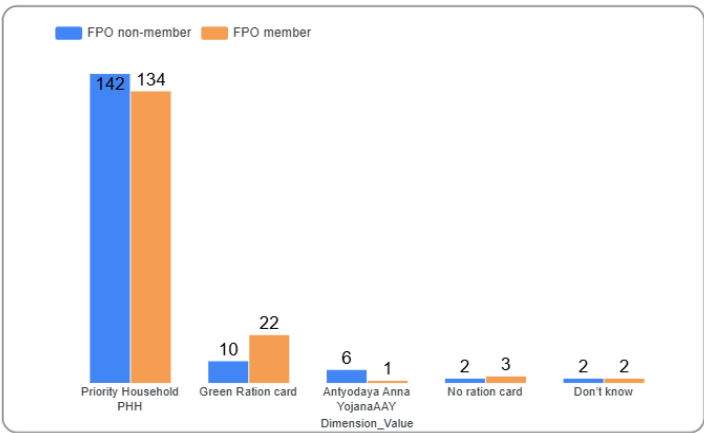


Figure 31: PDS- Ration Card of FPO Respondents

The overwhelming presence of Priority Household ration cards across both groups indicates widespread economic vulnerability in the region.

Access to Credit and Financial Systems

Credit access patterns reveal differences in financial networks. Among FPO members, 92

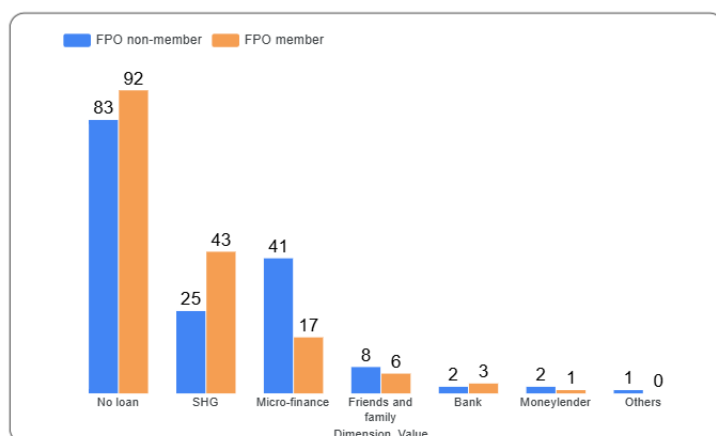


Figure 32: Credit source of FPO Respondents

households (56.8%) reported having no outstanding loan, while 70 households (43.2%) reported having taken loans. Among non-members, 83 households (51.2%) reported no loans, while 79 households (48.8%) had taken loans.

Loan sources differ significantly. Among members, 43 households (26.5%) accessed credit through Self-Help Groups, compared to 25

households (15.4%) among non-members. Conversely, 41 non-member households (25.3%) relied on microfinance institutions, compared to 17 member households (10.5%).

Formal bank credit remains extremely limited, with only 3 member households (1.9%) and 2 non-member households (1.2%) accessing bank loans.

These findings highlight the important role played by SHGs as community-based financial intermediaries, particularly for FPO members.

Market Access and Agricultural Sales Channels

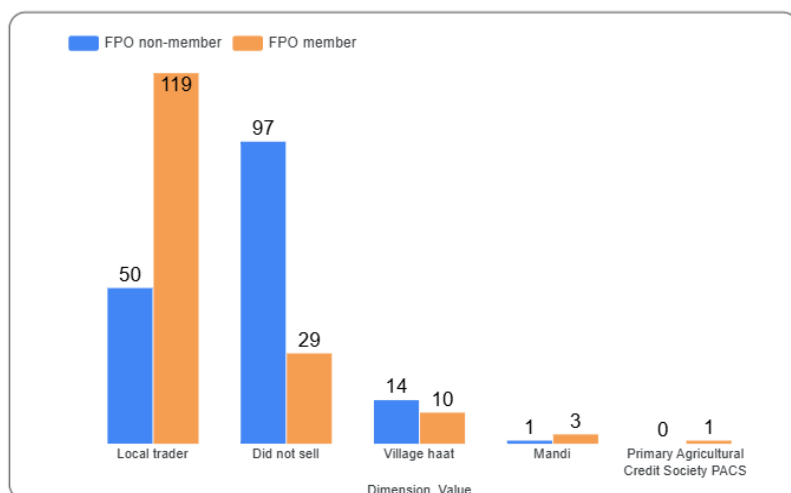


Figure 33: Market Linkage Profile of FPO Respondents

Agricultural marketing patterns reveal strong dependence on informal market systems. Among FPO members, 119 households (73.5%) sell produce through local traders, 10 households (6.2%) sell in village haats, and 3 households (1.9%) sell in formal mandis. Meanwhile, 29 member households (17.9%) reported not selling agricultural produce.

Among non-members, 50 households (30.9%) sell through local traders, 14 households (8.6%) sell through village markets, and 1 household (0.6%) sells through a mandi, while 97 households (59.9%) reported not selling produce at all.

These results indicate that FPO members are significantly more active in agricultural markets, although reliance on local traders remains dominant.

Awareness, Membership, and Institutional Trust

Awareness of the FPO remains uneven within the community. Among non-members, 81 households (50.0%) reported being aware of the FPO, while 81 households (50.0%) reported being unaware. Among members, 82 households (50.6%) reported awareness, while 80 households (49.4%) reported lack of awareness.

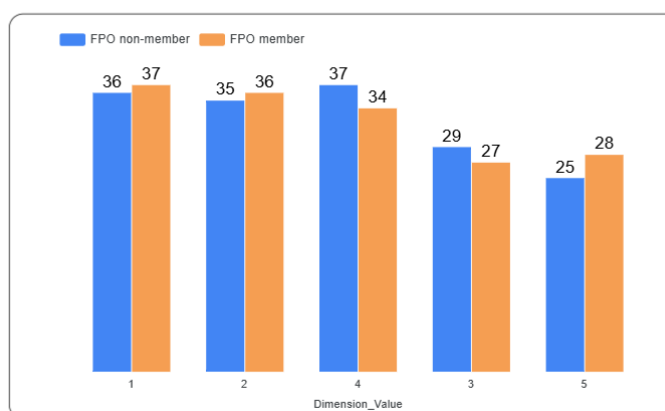


Figure 34: Trust Score on FPO

This indicates substantial visibility gaps within the FPO ecosystem, as nearly half of respondents remain unaware of the institution despite living within the same area.

Trust in the FPO also varies. Among members, trust scores are distributed across moderate levels, with 34 households (21.0%) rating trust at level 4, 28 households (17.3%) rating it at level 5, while others remain within lower trust levels.

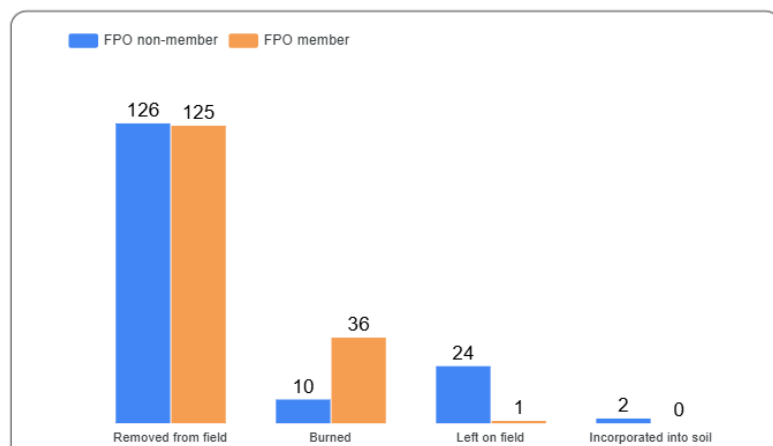


Figure 35: Usage of Crop Residue

Perceptions of transparency are mixed. Among members, 55 respondents (34.0%) believe the organization is not transparent, 46 respondents (28.4%) believe it is somewhat transparent, 7 respondents (4.3%) believe it is

fully transparent, and 54 respondents (33.3%) are unable to comment.

This suggests that institutional communication and transparency remain areas requiring improvement.

Agricultural Practices and Ecological Sustainability

Sustainable agricultural practices remain limited. Among FPO members, 125 households (77.2%) remove crop residues from fields, 36 households (22.2%) burn residues, and 1 household (0.6%) leaves residues on the field. Among non-members, 126 households (77.8%) remove residues, 10 households (6.2%) burn residues, and 24 households (14.8%) leave residues on the field.

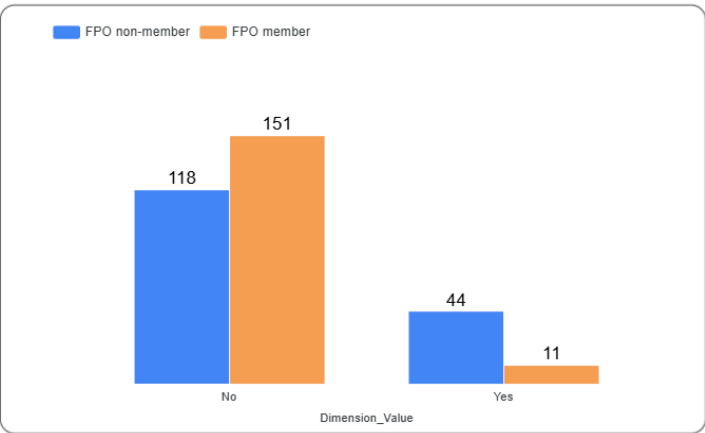


Figure 36: Cover Cropping Practices by FPO Respondents

Cover cropping adoption remains extremely low, with 151 member households (93.2%) and 118 non-member households (72.8%) reporting that they do not practice cover cropping.

Agroforestry adoption shows slightly stronger uptake among members. 78 member households (48.1%) reported practicing agroforestry, compared to 51 non-member households (31.5%).

Institutional Participation and Women’s Agency

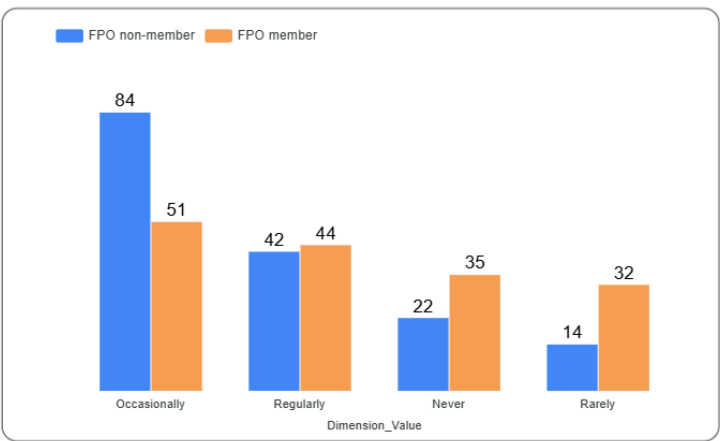


Figure 37: Institutional Participation of Women in Community Meetings

Participation in collective meetings remains moderate. Among FPO members, 44 households (27.2%) attend meetings regularly, 51 households (31.5%) attend occasionally, 32 households (19.8%) attend rarely, and 35 households (21.6%) never attend.

Among non-members, 42 households (25.9%) attend regularly, 84 households (51.9%)

attend occasionally, 14 households (8.6%) attend rarely, and 22 households (13.6%) never attend.

Women's leadership interest is notably high. Among FPO members, 115 respondents (71.0%) expressed interest in women taking leadership roles, while 27 respondents (16.7%) were unsure, and 20 respondents (12.3%) opposed the idea.

Among non-members, 113 respondents (69.8%) supported women's leadership, indicating strong potential for expanding women's participation within the FPO.

Regression Analysis of Farmer Producer Organization (FPO) System

Analytical Approach

To understand the determinants of participation, institutional performance, and economic outcomes associated with the Farmer Producer Organization (FPO) ecosystem, a series of linear regression models were applied across key variables derived from the household dataset.

Linear regression has been used for simplicity and interpretability, allowing clear identification of directional relationships between socio-economic characteristics, institutional perceptions, market access, and behavioural outcomes.

Each regression follows the form:

$$y=mx+c$$

where the slope (m) represents the marginal effect of the independent variable on the dependent variable, and the intercept (c) reflects the baseline level of the dependent variable. The R^2 value indicates the explanatory strength of each model.

A key interpretative principle applied in this analysis is that flatter slopes (low magnitude coefficients) indicate weak responsiveness of outcomes to explanatory variables, which in this context reflects latent demand and unmet expectations from the FPO system, particularly in areas such as input access, collective marketing, and financial services.

Determinants of FPO Membership

The relationship between education level and FPO membership is weak and slightly negative:

$$y=-0.0566x+0.3491, R^2=0.0377$$

The negative slope suggests that higher education does not necessarily translate into higher FPO participation. However, the extremely low R^2 (3.77%) indicates that education explains almost

none of the variation in membership.

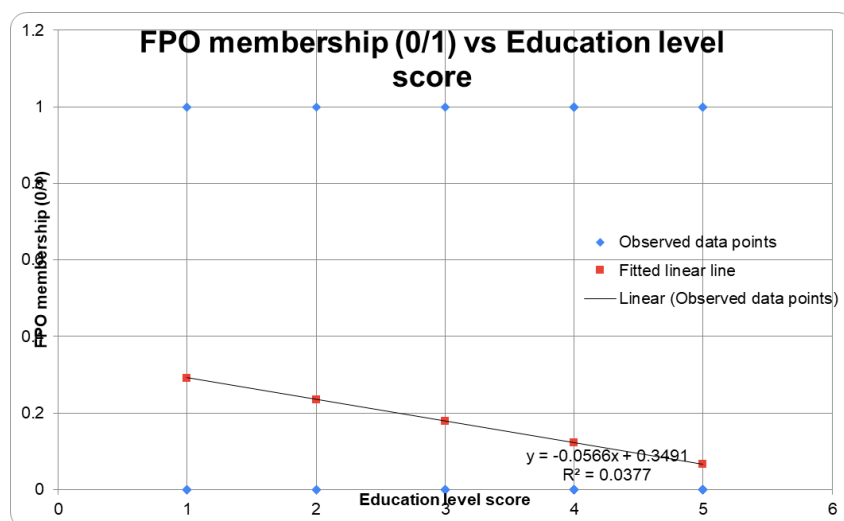


Figure 38: Effect of Education on FPO Membership

Similarly, gender shows negligible influence:

$$y = -0.0584x + 0.1429, \\ R^2 = 0.0081$$

The near-zero explanatory power suggests that female participation is not systematically different in terms of membership likelihood, indicating either inclusivity or, more likely,

uniformly low engagement across genders.

The presence of an FPO locally also shows almost no influence:

$$y = 0.0248x + 0.1056, R^2 = 0.0015$$

Despite physical proximity to FPO institutions, membership levels do not increase meaningfully.

Taken together, these flat slopes across all models indicate that membership is not being actively driven by structural or demographic factors. This suggests that FPOs are currently passive institutions rather than demand-responsive platforms.

More importantly, the lack of responsiveness indicates that farmers may not yet perceive sufficient value in joining FPOs. This reflects a deeper issue: limited traction in delivering tangible services such as input aggregation, market linkage, and credit facilitation.

Institutional Trust and Transparency

The relationship between trust and transparency is almost flat:

$$y = -0.0422x + 2.8733, R^2 = 0.0007$$

This near-zero slope and negligible R^2 indicate that transparency does not significantly influence trust levels in the current system.

Similarly, the reverse relationship:

$$y = -0.0151x + 2.0775, R^2 = 0.0007$$

also shows no meaningful association.

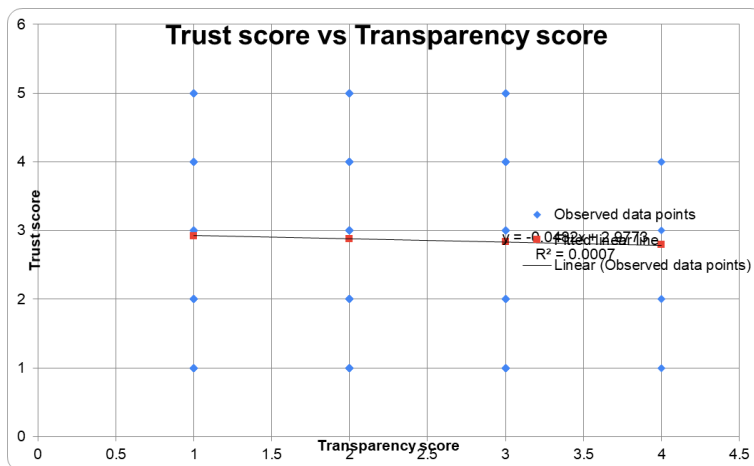


Figure 39: Effect of Perceived Transparency on people's trust on FPO

This is a critical finding. In well-functioning collective institutions, transparency is typically a strong predictor of trust. However, the flat relationship observed here suggests that either transparency mechanisms are not visible to members, or they are not yet institutionalized effectively.

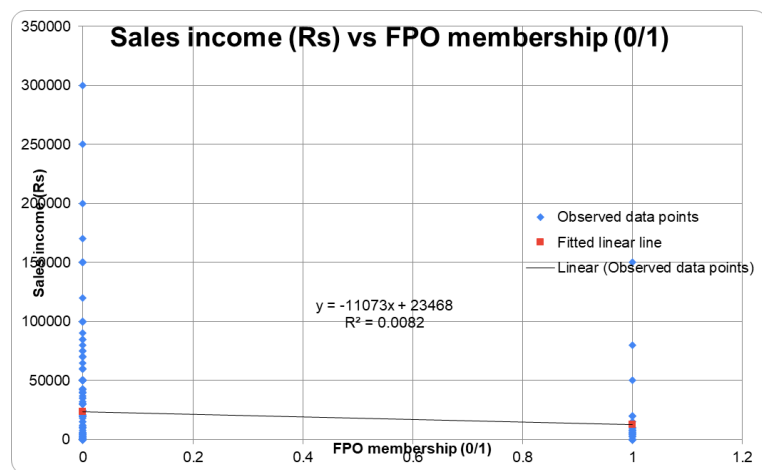


Figure 40: Effect of FPO membership on farmers' income

This again reflects early-stage institutional maturity, where governance processes have not yet translated into perceived credibility.

Economic Outcomes: Income and Market Access

The relationship between sales income and FPO membership is weak and slightly negative:

$$y = -1107.3x + 23468, R^2 = 0.0082$$

This indicates that FPO membership does not significantly improve income levels at present. The flat slope suggests that economic benefits from FPO participation are not yet being realized at scale.

In contrast, distance to market shows a stronger relationship with income:

$$y=6220.8x+7801.9, R^2=0.304$$

With R^2 of 0.304, about 30% of variation in income is explained by market distance. Interestingly, the positive slope suggests that farmers farther from markets may be engaging in higher-value or bulk sales, or that other confounding factors are at play.

However, price realization declines with distance:

$$y=-0.8467x+33.507, R^2=0.0463$$

This indicates that farmers farther from markets receive lower prices per unit, although the explanatory power is weak.

Together, these findings indicate that market access remains a critical determinant of economic outcomes, and FPOs have not yet effectively bridged this gap through aggregation or collective marketing.

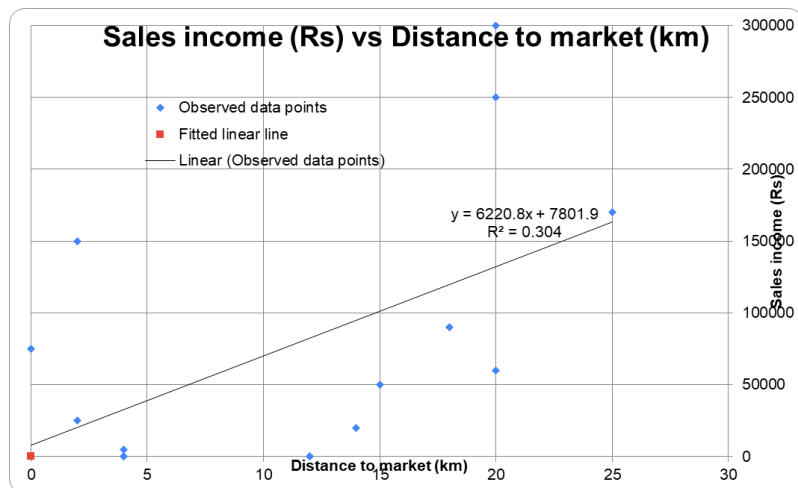


Figure 41: Effect of market distance on income of farmers

Institutional Influence on Economic Perception

The relationship between trust and price satisfaction is positive but moderate:

$$y=0.2245x+0.7959, R^2=0.13$$

This suggests that higher trust in the institution leads to improved satisfaction with prices, although only 13% of variation is explained.

This indicates that institutional confidence has some influence on perceived economic benefits, but the relationship is not strong enough to indicate a fully functioning value delivery system.

Future Engagement and Behavioural Intent

The relationship between trust and intent to increase engagement is effectively flat:

Similarly, price satisfaction also shows negligible influence:

$$y = -0.0431x + 0.1731, R^2 = 0.0047$$

These flat slopes are particularly significant. They indicate that neither trust nor satisfaction is translating into future commitment.

This reflects a critical gap: while some level of institutional presence exists, it has not yet generated sufficient confidence or value to drive deeper engagement.

From a programmatic perspective, this is a strong signal of latent demand. Farmers are present within the ecosystem but are waiting for stronger FPO performance in areas such as:

- assured market linkage
- better price discovery
- input aggregation
- access to credit
- collective bargaining power

Synthesis and Interpretation

Across all models, a consistent pattern emerges. The slopes of most relationships are flat, and R^2 values are low, indicating weak explanatory relationships.

However, rather than indicating failure, this pattern suggests a system in early-stage activation.

FPOs are present, but their functional intensity is low. Farmers are not yet responding strongly because the value proposition has not fully materialized.

The flat slopes are therefore not just statistical outcomes—they are indicators of suppressed responsiveness, reflecting unmet expectations.

This contrasts sharply with the SLI system, where resource scarcity created immediate and strong behavioural responses. In the case of FPOs, the benefits are indirect and require institutional strengthening to become visible.

Final Insight

The regression analysis suggests that the FPO system is currently structurally present but functionally under-realized.

- Membership exists, but it is not driven by strong incentives.
- Trust exists, but it is not deeply rooted in transparency.
- Economic benefits exist, but they are not clearly attributable to FPO participation.
- Engagement exists, but it is not yet expanding.

This indicates a system where FPO members are awaiting reliable and economically viable FPO services.

3.5 Key Takeaways

FPO Leadership Vacuum: Leadership vacuum in the FPO: Interactions with FPO members and representatives indicated the presence of governance and leadership gaps within the FPO management: With the exception of 1-2 members, the majority of the board members of the FPO are largely inactive. Though the majority mentioned attending monthly meetings, the follow up on actionable items is significantly low. There is a need to re-structure/re-elect individuals who can ensure full accountability, actively engage in FPO operations themselves and lead the FPO management.

FPO Awareness: Currently, operations are conducted out of the local Panchayat office. A considerable section of FPO members themselves were unable to recall the name of the FPO or explain its functioning, despite being part of the several monthly and FPO inception meetings - indicating a need to create visible visual presence through banners, posters, door-to door visits and structured community mobilisation plan. Establishing a dedicated, physical FPO office/space would provide a central point of contact to the FPO and community members, will strengthen ground-level presence, and establish organisational credibility.

SHG Integration into the FPO: The presence of 200+ functional SHGs presents a viable opportunity to expand FPO membership and build further outreach (from 21 members to 200+ in near future). Currently, all of these 200+ SHGs focus exclusively on financial loaning with no enterprise or entrepreneurial activity. These SHG members are highly active and driven- engaging them, training them through FPO would not only create new economic growth opportunities for these SHG women but would also expand FPO's footprint on the ground. Identifying a few and training them as master trainers as part of expanded functions of the FPO would benefit the program in the long-term and create a pool of active community leadership.

3.5 Program Visibility and Institutional Gaps

Survey findings and qualitative interactions suggest that the FPO currently faces significant challenges related to program visibility and institutional outreach. Nearly half of the respondents reported being unaware of the existence or functioning of the FPO.

“If the FPO can provide quality seeds, fertilizers, and irrigation facilities at fair market rates, I would gladly become a member. Access to these inputs at the right price would make farming more reliable for farmers like us.”

Focus group discussions revealed that several farmers who had attended introductory meetings were unable to clearly describe the objectives or operational mechanisms of the organization. This

suggests that community-level communication strategies require strengthening.

Limited visibility of the FPO within the community has also affected membership expansion and farmer participation in collective activities.

Future Potential: Chechanha

Despite current institutional challenges, the FPO ecosystem demonstrates considerable potential for expansion in Chechanha. The region possesses a large base of smallholder farmers and active community organizations that could support collective agricultural initiatives.

The presence of more than 200 active Self-Help Groups (SHGs) represents a strong institutional foundation that could be leveraged to strengthen FPO membership and expand collective agricultural activities.

With targeted capacity building, improved governance systems, and stronger market linkages, the FPO has the potential to become an important institutional platform for improving agricultural livelihoods in the region.



Figure 42: Interviews with FPO members

3.6 Recommendations / Suggestions

The baseline assessment shows that the Farmer-Producer Organization (FPO) initiative has the potential, but its Board Members lack expertise to significantly rebuild collective agricultural institutions in Rajhara. However, membership levels remain limited, and awareness among farmers is growing. For the FPO to become a trustworthy and effective institution that supports agricultural transformation, targeted strengthening of its institutions and improvements in service delivery are essential. The following actions are recommended to help the FPO become an effective member-driven organization.

3.6.1 Strengthening Institutional Governance and Organizational Structure

The FPO is in the early stages of developing as an institution. Strengthening governance mechanisms and operational systems will be essential for building credibility and ensuring long-term sustainability. Recommended actions include:

Clarifying roles and responsibilities: Clearly defining the roles for the Board of Directors, management staff, and members will enhance accountability and decision-making.

Establishing transparent governance systems: Regular meetings, accurate financial record keeping, and clear disclosure of decisions to members will boost trust in the institution.

Developing a clear operational plan: The FPO should create a short- and medium-term business plan that outlines priority services, revenue models, and growth strategies.

Promoting inclusive membership growth: Efforts should focus on adding smallholders, women farmers, and marginalized groups to ensure fair participation and benefit sharing. Inviting interested members from existing SHG groups could help the FPO boost its crucial membership numbers.

Strengthening linkages with Water User Groups (WUGs): Coordinating irrigation access with market-focused farming will improve agricultural productivity and collective marketing opportunities.

These measures will strengthen institutional credibility and encourage wider farmer participation.



Figure 43: Recommendations for FPO

3.6.2 Enhancing Agricultural Service Delivery

For the FPO to attract and retain members, it must demonstrate tangible value by providing effective and meaningful services that support farmers' production and marketing activities. Key service areas include:

Access to quality agricultural inputs: Bulk procurement and distribution of seeds, fertilizers, and other inputs can help lower costs for farmers.

Promoting climate-resilient agricultural practices: Working with extension agencies can help encourage the adoption of better crop varieties, soil health methods, and water-efficient irrigation.

Advisory and extension services: Regular training sessions and field demonstrations help farmers enhance productivity and farm management practices.

Post-harvest management support: Assistance with grading, sorting, packaging, and storage will enhance product quality and boost market competitiveness.

Information and Knowledge Support: Develop a WhatsApp group comprising local farmers and KVK scientists to clarify issues faced by farmers.

Strengthening these services will enhance the economic value of FPO membership.



Figure 44: Key Informant Interview: CCL Officer, Rajhara

3.6.3 Strengthening Market Linkages and Value Chain Development

One of the primary functions of the FPO is to improve farmers' bargaining power and market access by aggregating products and working with market actors. The baseline indicates that farmers currently rely heavily on local traders and have limited negotiation power. Recommended strategies include:

Aggregation of agricultural produce: Establishing collection centers will allow the FPO to aggregate produce and negotiate better prices with buyers.

Development of buyer networks: The FPO should actively build partnerships with wholesalers, retailers, institutional buyers, and local markets.

Local value addition: Opportunities for small-scale processing, such as mini rice mills, vegetable grading, or packaging units, should be explored to enhance product value.

Branding and marketing: Developing local branding for agricultural produce can help differentiate products and access higher-value markets.

Use of digital platforms: Digital marketing tools and market information systems can improve price discovery and market access.

Improved value chain integration will strengthen the economic viability of the FPO.

3.6.4 Facilitating Access to Finance and Government Schemes



Figure 45: FPO Member at Rajhara Kothi

Financial constraints pose a significant obstacle to institutional growth and service delivery. Improving access to financing options will enable the FPO to expand its operations. Key actions include:

Linkages with financial institutions: Partnerships with banks and development agencies such as NABARD can help secure working capital and enterprise financing.

Leveraging government programs: The FPO should explore opportunities within national initiatives such as the 10,000 FPO Scheme, Agriculture Infrastructure Fund (AIF), DMF, and other agricultural development programs.

Mobilizing member equity contributions: Encouraging members to invest in share capital will enhance the FPO's financial stability and ownership.

Accessing innovation grants: Development finance programs and innovation funds can support pilot projects such as expanding irrigation or adding value to products.

Improved financial access will enhance the FPO's ability to deliver services and sustain operations.

3.6.5 Building Farmer Awareness and Institutional Trust

The baseline findings indicate that farmers' awareness of the FPO's potential benefits is still limited due to inadequate outreach and inefficient service delivery, which have failed to attract farmers to become members. Increasing outreach and improving communication will be crucial for boosting participation. Recommended measures include:

- **Community awareness campaigns:** Village meetings, demonstrations, and farmer interactions help demonstrate the benefits of collective action.
- **Participation in Self-Help Groups (SHGs):** Women's SHGs can play an important role in expanding membership and supporting agricultural enterprises.
- **Showcasing early success stories:** Highlighting visible benefits for initial members will encourage more farmers to join.

- **Regular member engagement:** Ongoing communication between FPO leadership and farmers fosters trust and transparency.

Building institutional credibility will be critical for expanding membership and sustaining the FPO in the long term.

Table 4: FPO Recommendations - Output Outcome Framework

Purpose and Sub-goals	Activity	Outcome
Strengthening FPO Governance Structure and transparency	Clarify roles and responsibilities of the Board, staff and members - Training	Enhance capacity to service
Strengthen functioning of FPO	Help develop clear operation plan, including a business plan and revenue model – training, mentoring coaching	Enhance capacity to provide effective services to members
Addition of members	Regular outreach to SHGs and farming community	Increased membership participation
Strengthening linkages with WUG	Help FPO coordinate irrigation access and market focussed farming	Increased productivity, quality
Enhancing FPO service delivery	Facilitate quality agricultural input, good agricultural practices, post-harvest management	Increased quality, productivity and income
Access to information and knowledge	Training and mentoring support through KVK, WhatsApp group (KVK scientist and FPO members).	Improved access to information
Value Chain Development	Facilitate product aggregation, buyer network development, local value addition	FPO members' enhanced access to market and increased income
Access to Finance	Help leverage existing programs and schemes such as DMF, NABARD, AIF etc.	Expanded access to finance
Building Institutional trust	Engage farmers/community, support SHG groups, showcase successes	Community engagement and sustainability

Clean Cooking

Clean cooking sits at the intersection of health, gender, time use, household economics, and energy transition. In the Rajhara field site, cooking is not merely a domestic activity. It is a daily labour system shaped by fuel availability, affordability, access to LPG refilling, unpaid work burdens on women, and the wider economic vulnerability of households. The transition from coal and firewood to cleaner alternatives such as LPG, induction, or other modern cooking

options therefore cannot be assessed only as a technology issue. It must be understood as a livelihood and social equity issue.

The evidence from the field suggests a strong paradox. On the one hand, there is clear behavioural readiness and aspiration among women to shift towards cleaner cooking alternatives. On the other hand, actual sustained usage of clean cooking fuels remains low because of refill cost, weak local delivery systems, and household decision-making constraints. This creates a classic access–affordability gap. Households may possess LPG connections, but they do not necessarily use them regularly. Instead, they continue to rely on a mixed energy basket dominated by firewood and coal.



Figure 46: Smoke filled kitchens in Rajhara from Traditional Chulha

This chapter evaluates clean cooking and energy access using a mixed-methods approach that combines household survey data with findings from focus group discussions and an in-depth interview. The analysis is guided by the AARQA framework - Availability, Accessibility, Reliability, Quality, and Affordability. The chapter also interprets clean cooking through a gendered lens, particularly in relation to time poverty, unpaid labour, decision-making, and women’s agency. The findings show that the challenge in Rajhara is not one of awareness alone. It is one of converting high aspiration into sustained, affordable, and practical adoption.

4.1 Research Questions

R1: *How will the implementation of clean cooking practices impact the health and socio-economic life of communities relying on traditional fuels?*

R2: *What is the current landscape of cooking practices regarding fuel types and usage patterns?*

R3: *How do different clean cooking alternatives compare in terms of accessibility, affordability, adaptability and technical support?*

R4: *What is the community’s readiness to transition to clean cooking solutions?*

R5: *What are the potential health, social and economic outcomes of adopting clean cooking methods?*

4.2 Methodology

The clean cooking assessment followed a mixed-methods research design, combining quantitative household data with qualitative community insights. The objective was not only to measure current cooking energy practices but also to understand the lived realities behind fuel choices, refill patterns, health trade-offs, and household decision-making.

Quantitative component

The household survey captured information on:

- main cooking fuel used
- stove type
- monthly cooking fuel expenditure
- fuel collection time
- barriers to clean cooking adoption
- willingness to shift to LPG
- smoke-related health expenses
- educational status
- women's unpaid work burden
- women's participation and decision-making
- village distribution and social category composition
- migration and livelihood vulnerability.

The quantitative evidence is interpreted as a household-level baseline of cooking practices and energy burden.

Qualitative component

A qualitative assessment was undertaken using:

- 2 Focus Group Discussions, SHG women/members in Rajhara Kothi village comprising 16 participants in total
- 1 In-Depth Interview (IDI) with using a semi-structured guide
- 1 IDI with an SHG member /representative in Rajhara Kothi village.

As noted in the field findings, the majority of the households reported mixed use of fuels. There's no clear distinction between the two categories. This is important methodologically, because it confirms that "clean cooking user" and "non-user" are not rigid categories. Most households are energy stackers rather than exclusive users of one fuel.

The chapter therefore uses a mixed-method cross-design approach, where quantitative data and qualitative narratives are interpreted together under each thematic sub-section rather than being treated separately.

4.3 Evaluation Framework

The clean cooking transition in Rajhara is assessed using the AARQA framework - Availability, Accessibility, Reliability, Quality, and Affordability. This framework helps distinguish between ownership of clean cooking technologies and their sustained usage, which is critical because access does not automatically translate into adoption.

Availability

Clean cooking infrastructure is largely present in the community. Survey responses indicate that LPG connections exist in roughly 85–90% of households, largely due to government distribution schemes. However, actual primary LPG usage remains limited: only 14.5% of households (47 out of 324) reported LPG as their main cooking fuel. In contrast, 56.5% (183 households) still rely primarily on firewood and 12.7% (41 households) on coal.

Ownership of traditional cooking systems remains high, with 214 households (66%) continuing to use chulhas, indicating that biomass cooking remains the dominant energy practice despite the presence of LPG infrastructure.

Accessibility

Accessibility challenges remain significant. Although LPG cylinders are available, refill access often requires travel outside the village. Field interviews indicate that many households must spend an entire day travelling for refills, resulting in lost wages of approximately ₹500–₹600 per day.



Figure 47: AARQA Framework for Energy Access

In addition, 21 households reported refill or electricity reliability issues, indicating that physical access to clean cooking services remains uneven. These logistical barriers reduce the practical usability of LPG for daily cooking.

Reliability

Reliability concerns contribute to the widespread practice of fuel stacking. Even though most households possess LPG cylinders, only a small fraction rely on them consistently for daily cooking. Instead, households combine LPG with firewood or coal depending on availability and cost.

This behaviour reflects inconsistent supply chains and refill cycles, which weaken the reliability of LPG as a primary cooking fuel. The presence of multiple cooking systems within the same household demonstrates that clean cooking infrastructure is often treated as a backup rather than a main energy source.

Quality

Perceptions of LPG quality are overwhelmingly positive. A large majority of households recognize LPG as cleaner, faster, and more convenient than traditional biomass fuels. This is reflected in adoption intentions: 82.7% of households (268 households) expressed willingness to shift to LPG as their primary cooking fuel.

Only 2.5% (8 households) reported unwillingness to adopt LPG, while 1.9% (6 households) remained uncertain. These findings suggest that perceived quality is not a barrier to adoption.

Affordability

Affordability emerges as the dominant constraint. When asked about the primary barrier to clean cooking adoption, 72.5% of households (235 households) identified high LPG refill costs as the main challenge.

Monthly fuel expenditure patterns illustrate the financial pressure faced by households. 37.7% (122 households) spend between ₹601–₹1,000 per month on cooking fuel, while 36.4% (118 households) spend ₹301–₹600. The prevailing LPG refill cost of ₹900–₹1,000 per cylinder is therefore perceived as unaffordable for many families.

Several respondents reported leaving LPG cylinders unused for six to nine months, despite owning connections. Many households indicated that a refill price closer to ₹400–₹500 would make sustained LPG usage feasible.

AARQA Dimensions: Interpretation

The AARQA analysis highlights a clear pattern: availability and perceived quality of LPG are relatively strong, but accessibility, reliability, and affordability remain weak.

Although most households possess LPG connections and 82.7% express willingness to adopt clean cooking, high refill costs and logistical refill barriers continue to sustain biomass dependence. Consequently, the clean cooking transition in Rajhara remains incomplete, with firewood still used by 183 households (56.5%), demonstrating that ownership of clean fuel technologies does not automatically translate into sustained adoption.

Table 5: AARQA Framework for Energy Access

AARQA Pillar	Challenge Addressed	Evidence from Rajhara Baseline
Availability	Presence of clean cooking infrastructure but limited transition to primary LPG usage	LPG connections exist in 85–90% of households, largely due to government schemes. However, only 14.5% (47 households) use LPG as their main cooking fuel, while 56.5% (183 households) rely primarily on firewood and 12.7% (41 households) on coal. 66% (214 households) continue using traditional chulhas.
Accessibility	Physical access barriers reduce practical usability of LPG refills	Many households travel outside the village to obtain LPG refills, often losing ₹500–₹600 in daily wages during the trip. 21 households reported refill or electricity reliability issues affecting cooking energy access.
Reliability	Fuel stacking reflects inconsistent LPG usage and supply cycles	Despite high LPG ownership, most households combine LPG with firewood or coal depending on availability and cost. LPG is frequently treated as a backup fuel, indicating unreliable refill cycles and supply access.
Quality	Strong perception of LPG as a superior cooking technology	82.7% (268 households) expressed willingness to adopt LPG as their primary cooking fuel. Only 2.5% (8 households) rejected adoption, while 1.9% (6 households) remained uncertain. Households widely perceive LPG as cleaner, faster, and more convenient than biomass fuels.
Affordability	High refill cost prevents sustained LPG adoption	72.5% (235 households) identified high LPG refill costs as the main barrier. Monthly cooking fuel expenditure ranges from ₹301–₹600 for 36.4% (118 households) and ₹601–₹1,000 for 37.7% (122 households). With LPG refills costing ₹900–₹1,000, many households leave cylinders unused for 6–9 months. Respondents indicated that refill prices near ₹400–₹500 would enable regular use.

4.4 Data Analysis and Key Insights

4.4.1 Socio-economic profile of respondents and energy vulnerability

The clean cooking dataset reflects a socially vulnerable rural population where energy transition challenges are embedded within broader structural inequalities. In terms of social category, 46.3% of households (150 households) belong to OBC communities, 35.2% (114 households)

belong to Scheduled Castes, and only 5.6% (18 households) belong to the General category. This indicates that the clean cooking transition challenge is concentrated among socially marginalized communities that already face structural livelihood constraints.

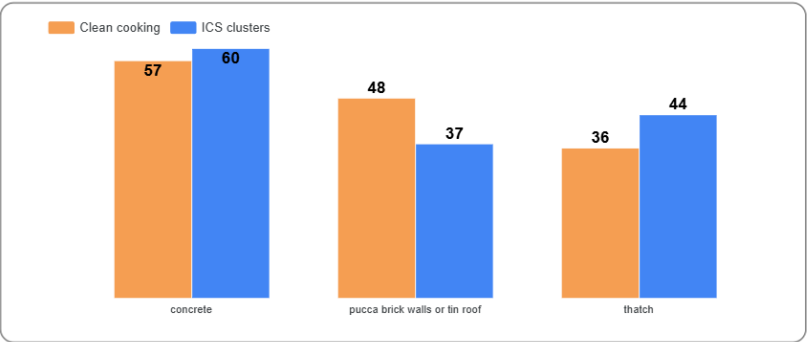


Figure 48: Housing Type of Clean Energy Respondents

The spatial distribution of respondents shows uneven program geography. 64.9% of the clean cooking households (119 households) are located in Rajhara Kothi, while 35.1% (22 households) are from Chechanha. In contrast, ICS clusters are more concentrated in Chechanha, with 77 ICS households compared to 64 in Rajhara Kothi. This indicates that clean cooking adoption and ICS interventions are geographically clustered rather than evenly distributed across villages.

Housing conditions further highlight energy vulnerability.

36.1% of households (117 households) live in concrete houses, 26.2% (85 households) live in pucca brick walls

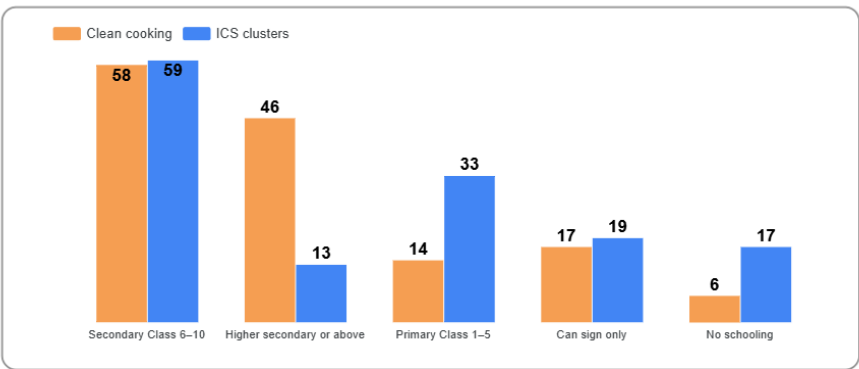


Figure 49: Educational Profile of Clean Energy Respondents

with tin roofs, and 24.7% (80 households) live in thatched houses. Thatched housing is more common among ICS households (44 households) compared to clean cooking households (36

households), indicating that poorer households remain more dependent on traditional biomass cooking systems. Such housing structures also tend to have poorer ventilation, which increases indoor smoke exposure.

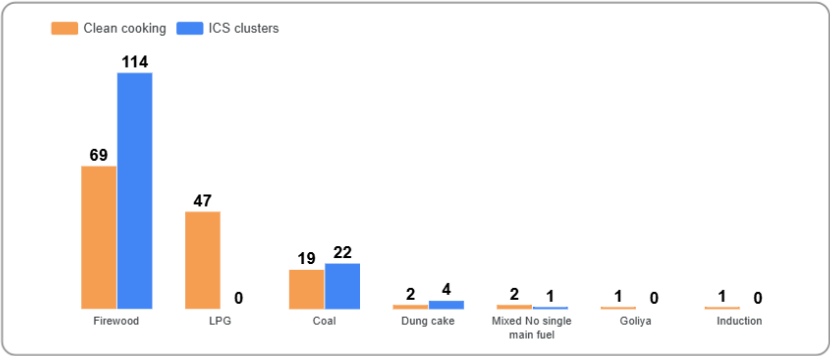


Figure 50: Primary Fuel used by Clean Energy Respondents

Education levels reveal moderate but uneven literacy among respondents. Among household heads, 36.1% (117 households) studied up to secondary level, 18.2% (59 households) up to higher secondary or above, 14.5% (47 households) up to primary, 11.1% (36

households) can sign only, and 7.1% (23 households) report no schooling. Among the main women in the household, 82 women have studied up to secondary level, 73 can sign only, 47 have no schooling, 44 studied up to primary, and 36 studied up to higher secondary or above. This uneven literacy distribution is significant because women are the primary cooks and primary victims of smoke exposure, meaning clean cooking awareness programs must be designed to accommodate varied literacy levels.

Taken together, the socio-economic profile indicates that clean cooking transitions are unfolding within economically vulnerable and socially marginalized communities, where structural inequalities shape energy access and adoption patterns.

4.4.2 Cooking energy practices: strong biomass dependence with fuel stacking

The core quantitative finding is that biomass fuels remain dominant. 56.5% of households (183 households) report firewood as their main cooking fuel, followed by 14.5% (47 households) using

LPG, and 12.7% (41 households) using coal. Dung cake is used by 6 households, while modern electric or induction cooking is virtually absent.

Stove usage patterns reinforce this dependence. Two-thirds of households (214 households, 66.0%) continue to use traditional chulhas, compared to 67 households using LPG stoves, and only one household reporting use of an improved cookstove.

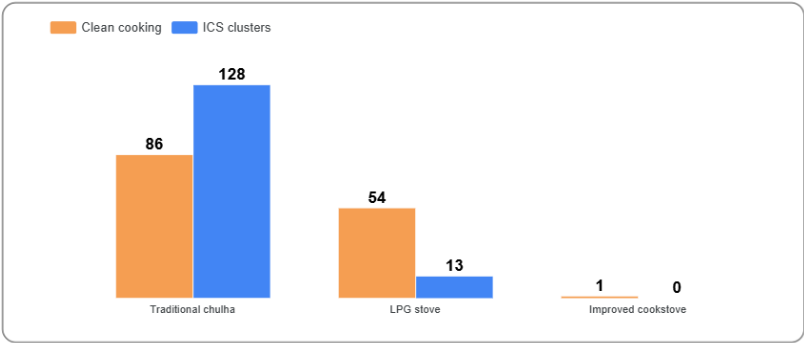


Figure 51: Stove type used by Clean Energy Respondents

The mixed-method evidence suggests that households practice fuel stacking rather than full fuel transition. Qualitative interviews indicate that 80–95% of households report owning LPG cylinders, but only around 5% regularly use LPG for daily cooking. Instead, most families combine wood, coal, and LPG, using LPG selectively when speed or convenience is required.

This triangulation between quantitative data and qualitative interviews reveals that the energy transition in Rajhara is not blocked by absence of LPG connections but by the persistence of multi-fuel strategies shaped by affordability and accessibility constraints.

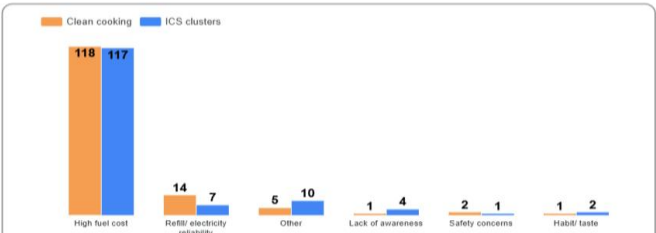


Figure 52: Barriers to Clean Energy Transition for Clean Energy Respondents

4.4.3 Availability and accessibility: improved connections but fragile sustained access

Field evidence indicates that LPG connection coverage has expanded considerably through government schemes. Qualitative findings suggest that approximately 85–90% of households now possess LPG connections, and community respondents estimate that LPG use has increased by roughly 40% over the past 4–5 years.

However, sustained access remains fragile. Quantitative responses indicate that 21 households identified refill or electricity reliability as a key barrier, indicating supply-side difficulties. In practice, the problem is less about connection availability and more about logistical accessibility.

Qualitative interviews explain that refilling LPG cylinders often requires travel outside the village, and households may lose one day of wage labour worth ₹500–₹600 when arranging a refill. Delivery services are sometimes available but require advance booking and additional fees.

These frictions transform formal LPG access into intermittent access, which explains why households frequently revert to biomass fuels despite having LPG cylinders at home.

4.4.4 Affordability: the dominant barrier to sustained clean cooking adoption

Affordability emerges as the most significant barrier to clean cooking adoption. When respondents were asked about the main barrier, 235 households (72.5% of the sample) identified



Figure 53: Focus Group Discussion with ICS Clusters

high fuel cost as the primary obstacle.

All other barriers were reported far less frequently:

- 21 households cited refill or electricity reliability
- 15 households cited other reasons
- 5 households cited lack of awareness
- 3 households each cited safety concerns or taste/habit preferences

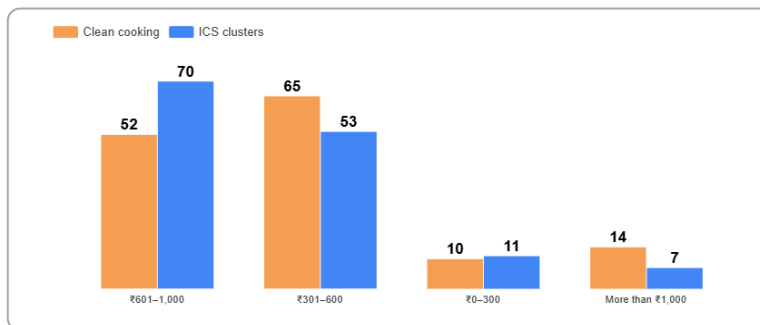


Figure 54: Monthly Cost of using Cooking Fuel

This distribution indicates that financial constraints overwhelmingly dominate behavioural or cultural barriers.

Monthly fuel expenditure patterns reinforce this finding. 122 households (37.7%) spend ₹601–₹1,000 per month on cooking fuel, while 118 households (36.4%) spend ₹301–₹600. Smaller shares of 21 households each (6.5%) spend either below ₹300 or above ₹1,000.

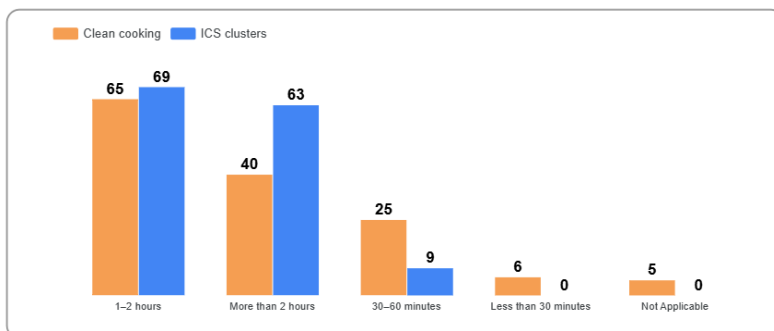


Figure 55: Fuel Collection Time

Qualitative evidence confirms that the current LPG refill cost of ₹900–₹1,000 per cylinder is widely

perceived as unaffordable, with many respondents stating that the acceptable refill price is closer to ₹400–₹500. Some households reported that their LPG cylinders had remained unused for over nine months due to rising prices.

This highlights a central structural issue: the gap between LPG access and LPG affordability.

4.4.5 Time poverty and women's unpaid labour burden

Cooking practices impose a heavy labour burden on women. 41.4% of households (134 households) spend 1–2 hours collecting cooking fuel, while 31.8% (103 households) spend more

than two hours. In contrast, only 34 households (10.5%) spend 30–60 minutes, and just 6 households report less than 30 minutes.

This means that over 73% of households spend more than one hour daily collecting fuel, representing a substantial time burden.

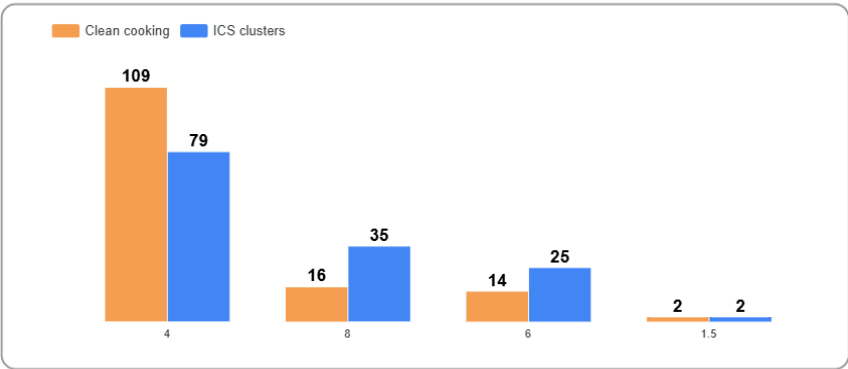


Figure 56: Unpaid hours of Women

The unpaid work data reinforces this finding. 58.0% of women (188 respondents) report four hours of unpaid work daily, while 15.7% (51 women) report eight hours, and 12.0% (39 women) report six hours.

Qualitative discussions confirm that cooking three daily meals using coal and wood often takes 4–5 hours per day, including collecting fuel, preparing the cooking space, cooking, and cleaning.

Thus, clean cooking technologies are not merely energy solutions; they represent critical time-saving interventions for women’s labour burdens.

4.4.6 Health effects: high awareness but low treatment response

Community members demonstrate strong awareness of the health risks associated with smoke exposure. Participants frequently reported symptoms such as eye irritation, breathing problems,

coughing, and headaches, particularly when coal is used.

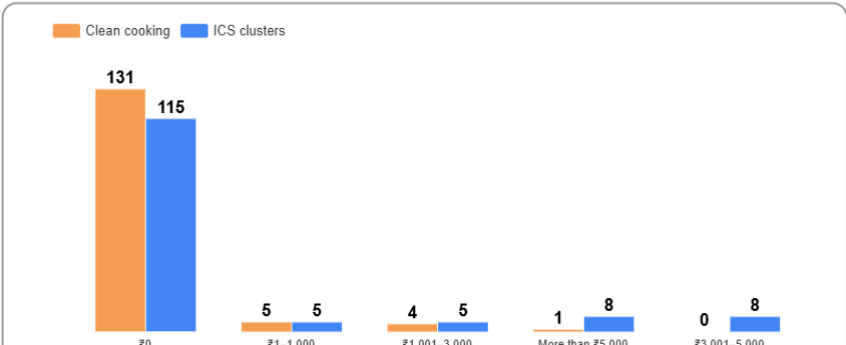


Figure 57: Annual Cost of Health Treatment due to ICS smoke emission

Despite this awareness, health treatment remains limited. Quantitatively, 75.9% of households (246 households) reported zero expenditure on smoke-related medical treatment.

Smaller numbers reported medical costs of ₹1–₹1,000 (10 households), ₹1,001–₹3,000 (9 households), ₹3,001–₹5,000 (8 households), and more than ₹5,000 (9 households).

Qualitative interviews explain this contradiction. Women reported that smoke exposure has become normalized as part of daily life, and seeking medical treatment regularly would impose additional financial and time burdens.

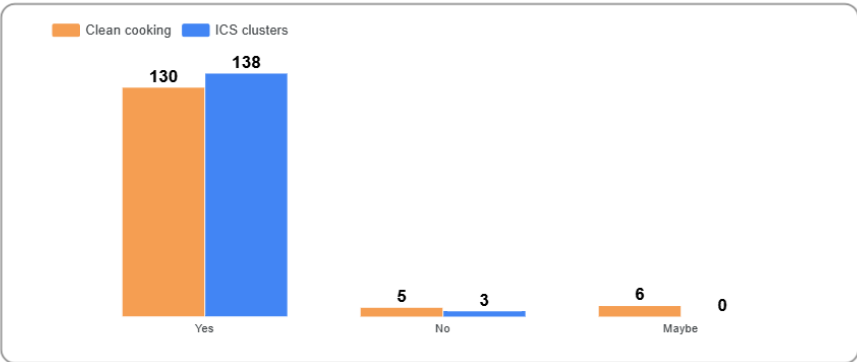


Figure 58: Willingness to shift to Clean Energy

Thus, the health burden of biomass cooking remains largely under-reported and under-treated, rather than absent.

4.4.7 Adoption readiness: strong willingness to shift

One of the strongest positive findings in the dataset is the extremely high willingness to adopt LPG. 82.7% of households (268 households) expressed willingness to shift to LPG, while only 8

households (2.5%) said no and 6 households (1.9%) reported uncertainty.

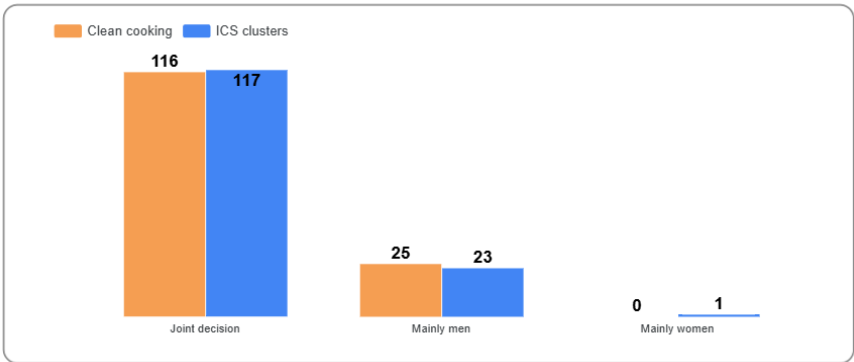


Figure 59: Decision Making of Women in Income and finance management

Qualitative interviews strongly reinforce this finding. Women consistently described LPG as cleaner, faster, and easier to cook with, particularly during busy agricultural seasons.

This indicates that behavioural readiness for clean cooking is already present in the community. The main barriers are therefore economic affordability, refill accessibility, and intra-household financial control, rather than cultural resistance.

4.4.8 Women’s agency and household decision-making

The survey indicates that women participate in household decision-making, but rarely as sole decision-makers. Approximately 72% of households (233 households) reported joint decision-making on income, while 48 households reported decisions mainly taken by men, and only 2 households reported women-led income decisions.

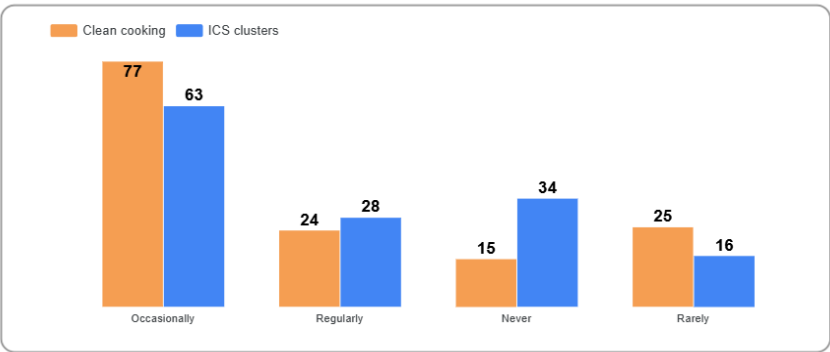


Figure 60: Women participation in community meetings

A similar pattern appears in asset decisions, where 232 households report joint decision-making, 48 report male-dominated decisions, and only one household reports women-led decisions.

Participation in community meetings shows moderate engagement. 43.2% of women (140 respondents) attend meetings occasionally, 16.0% (52 women) attend regularly, while 15.1% (49 women) never attend and 12.7% (41 women) attend rarely.

Despite these limitations, leadership aspirations remain high. 192 respondents (59.3%) expressed support for women’s leadership, while 53 respondents were unsure, and 37 respondents opposed the idea.

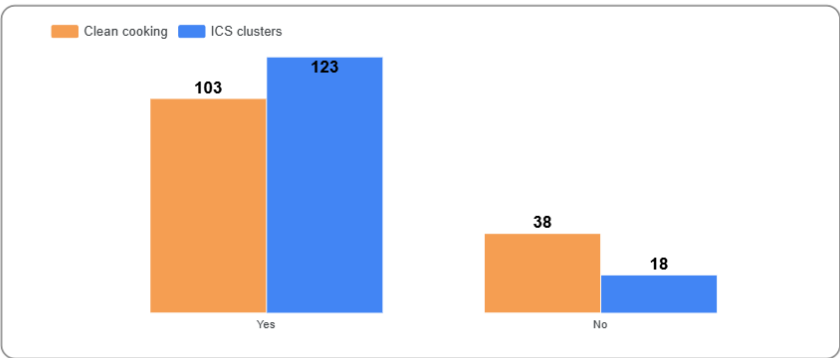


Figure 61: Migration of Household members: Clean Cooking Respondents

This suggests that women occupy an intermediate position of partial participation but high leadership potential.

4.4.9 Migration, Livelihood stress and structural constraints

The clean cooking baseline sits within a highly stressed livelihood environment. Migration is widespread, with 80.1% of households reporting migration. Migrants primarily move to other

states (163 cases), followed by within state migration (39 cases) and within district migration (21 cases).

Migrants are mainly employed in daily labour (117 households) and factory work (95 households).

Household incomes are also fragile. The primary sources of income are agriculture (95 households) and non-agricultural wage labour

(90 households). Secondary incomes are dominated by non-agricultural labour (116 households), remittances (59 households), and agricultural wage labour (44 households).

Loan usage further reflects financial stress. Loans are most commonly used for health emergencies (49 households), house repair (27 households), food consumption (22 households), and social ceremonies (16 households). Only 11 loans were used for agricultural inputs, and 7 loans for irrigation or farm equipment.

This indicates that borrowing is largely distress-driven rather than investment-oriented, highlighting the economic fragility of households attempting to transition to cleaner cooking systems.

4.4.10 Regression Analysis of Clean Cooking Adoption

Analytical Framework

This section examines the determinants of clean cooking adoption using linear regression models across key socio-economic, behavioural, and access-related variables. The primary outcomes analyzed include:

- Access to LPG/induction facilities
- Use of clean fuel as primary cooking source
- Willingness to shift to LPG
- Monthly willingness to pay for clean cooking
- Health outcomes (smoke-related medical treatment)

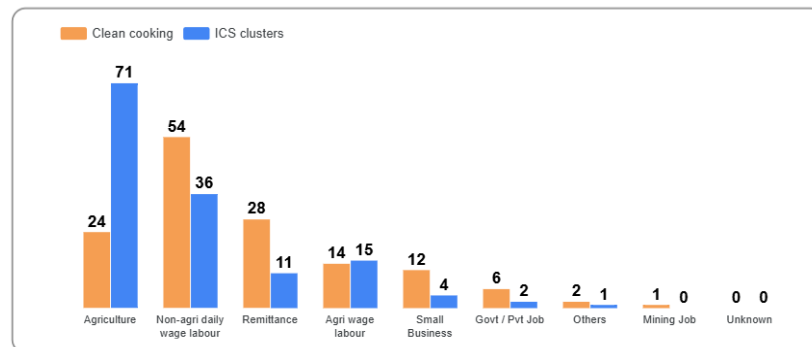


Figure 62: Primary Income Source of Clean Cooking Respondents

- System access indicators (refill/electricity ease)

Each regression follows:

$$y=mx+c$$

where, the slope (m) captures responsiveness and R^2 reflects explanatory strength.

As with previous sections, flatter slopes indicate weak responsiveness, which in this context reflects latent demand constrained by affordability, access, and system-level bottlenecks.

Access to Clean Cooking Infrastructure

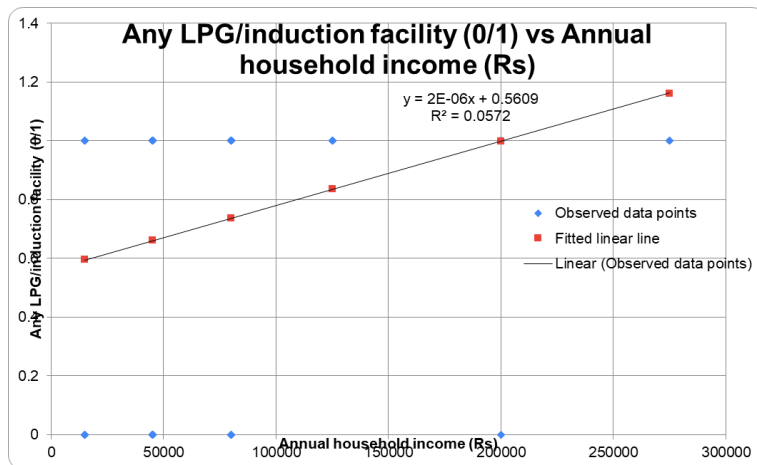


Figure 63: Effect of Household Income on Clean Cooking Facility

The relationship between LPG/induction access and income is positive but weak:

$$y=2 \times 10^{-6}x + 0.5609, R^2=0.0572$$

This indicates that higher income marginally increases access, but the very small slope and low R^2 suggest that income alone is not a strong determinant.

In contrast, Ujjwala scheme participation shows stronger influence:

$$y=0.3986x+0.5897, R^2=0.1645$$

This is one of the relatively stronger relationships in the dataset, suggesting that policy intervention (Ujjwala) plays a meaningful role in enabling access.

However, the slope is still moderate not steep, indicating that even beneficiaries may not achieve full

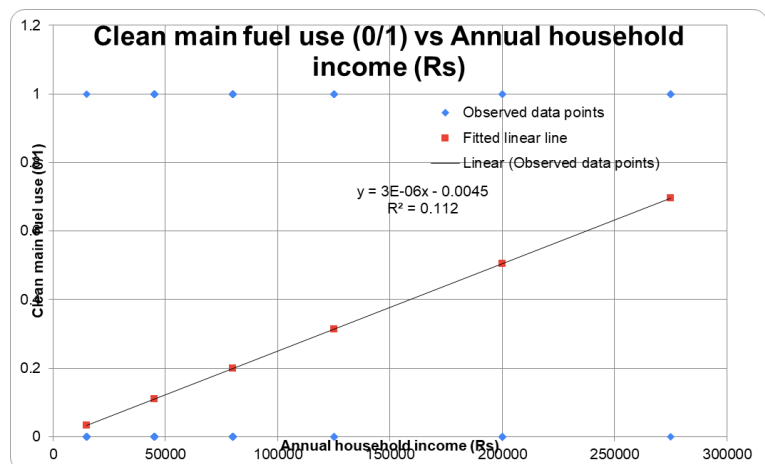


Figure 64: Effect of Household Income on Clean Fuel for primary Use

adoption, pointing to post-access constraints such as refill affordability and supply reliability.

Adoption of Clean Cooking as Primary Fuel

The relationship between clean fuel use and income:

$$y=3\times 10^{-6}x-0.0045, R^2=0.112$$

suggests a positive but modest income effect. About 11% of variation is explained, indicating that affordability matters but is not sufficient.

Education shows a similarly weak influence:

$$y=0.0805x-0.1144, R^2=0.0648$$

While more educated households are slightly more likely to adopt clean fuels, the low explanatory power indicates that awareness alone does not drive sustained adoption.

This again reflects a structural constraint: households may understand the benefits but are unable to act due to cost and access barriers.

Willingness to Shift to LPG

Across all variables, willingness to shift is consistently high but weakly explained, which is a crucial finding.

Income:

$$y=5\times 10^{-7}x+0.9152, R^2=0.0134$$

Awareness:

$$y=0.0585x+0.9, R^2=0.0088$$

Monthly fuel cost perception:

$$y=0.0462x+0.8343, R^2=0.0247$$

All these slopes are extremely flat, and R^2 values are near zero.

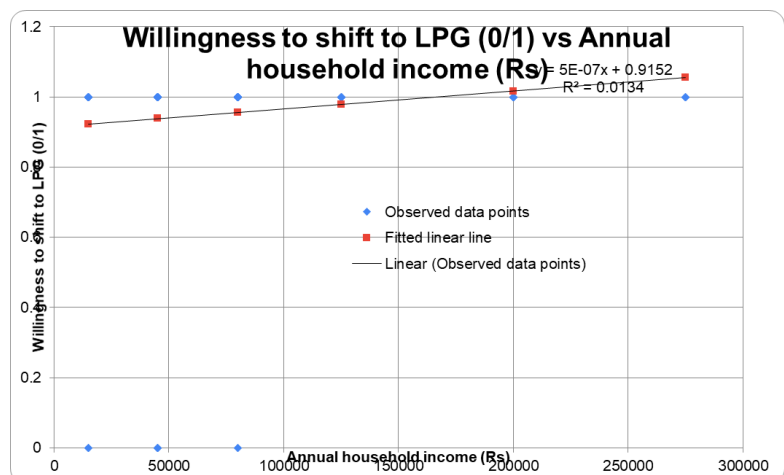


Figure 65: Effect of Household Income on Willingness to shift to Clean Cooking

This is a very important behavioural insight:

Households already have near-universal willingness to shift (~0.9 baseline). But this willingness is not sensitive to income, awareness, or access variables

This indicates that:

- The demand side is already activated
- The constraint lies entirely on the supply and system side

In other words, households are not hesitant, they are constrained.

Willingness to Pay for Clean Cooking

Income shows a mild positive relationship:

$$y=0.0009x+359.15, R^2=0.0401$$

This suggests that higher-income households are willing to pay slightly more, but the explanatory power is weak.

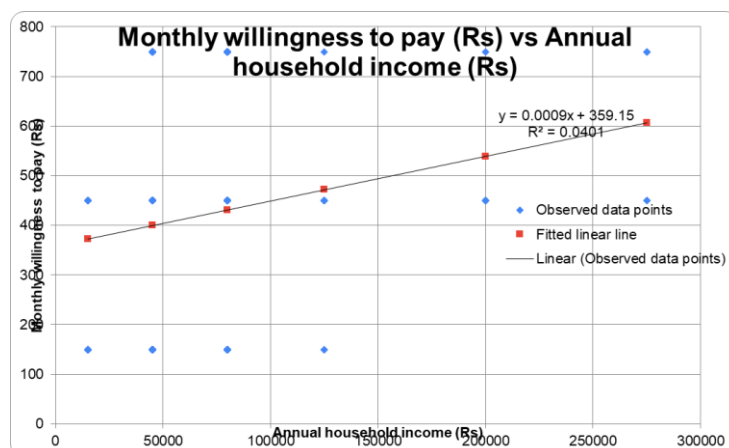


Figure 66: Effect of Household Income on Willingness to pay for LPG

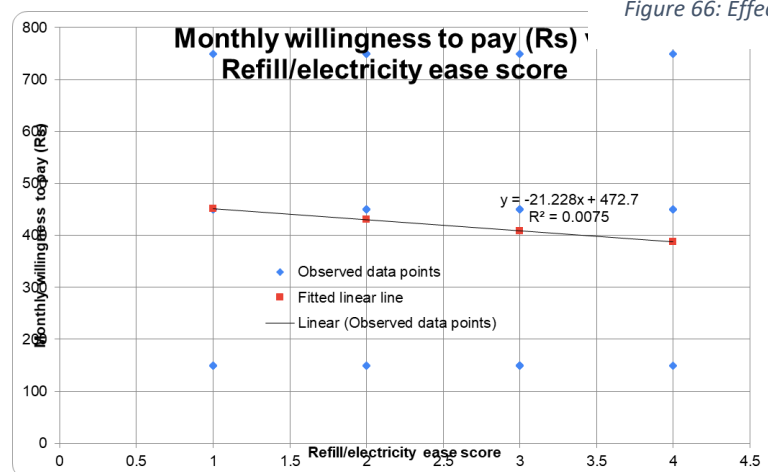


Figure 67: Effect of Ease of LPG Refill on Willingness to pay

Awareness:

$$y=36.349x+390, R^2=0.0033$$

Refill/electricity ease:

$$y=-21.228x+472.7, R^2=0.0075$$

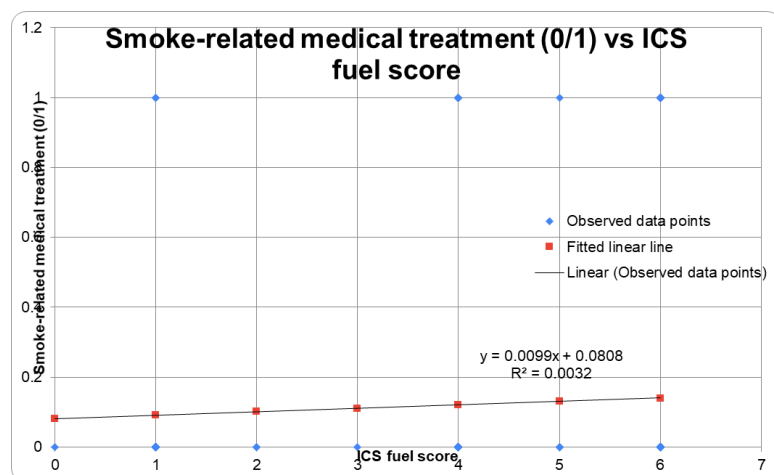
These near-flat relationships indicate that willingness to pay is not strongly driven by awareness or service quality perceptions.

Instead, the relatively high intercept (~₹350–₹470) suggests that households already have a baseline willingness to pay, but this may still be insufficient relative to actual LPG costs.

Thus, the issue is not absence of willingness, but mismatch between willingness and market pricing structures.

Health Outcomes and Fuel Use

The relationship between smoke-related medical treatment and ICS fuel score is extremely weak:



$$y = 0.0099x + 0.0808, R^2 = 0.0032$$

Similarly, treatment cost vs ICS fuel use:

$$y = 0.041x + 0.1172, R^2 = 0.0073$$

These flat relationships indicate that health impacts are not strongly perceived or internalized.

Figure 68: Effect of type of ICS fuel on Smoke related illness

This suggests that:

- Either health effects are gradual and normalized
- Or households do not directly attribute illness to cooking fuel

Thus, health messaging alone is unlikely to drive behavioural change, reinforcing the importance of economic and access interventions.

System Functionality: Refill and Usage

The relationship between refill/electricity ease and recency of LPG use:

$$y = 0.2102x + 1.9557, R^2 = 0.1309$$

This is one of the stronger relationships in the dataset.

It indicates that ease of refill and electricity access significantly affects actual usage behaviour.

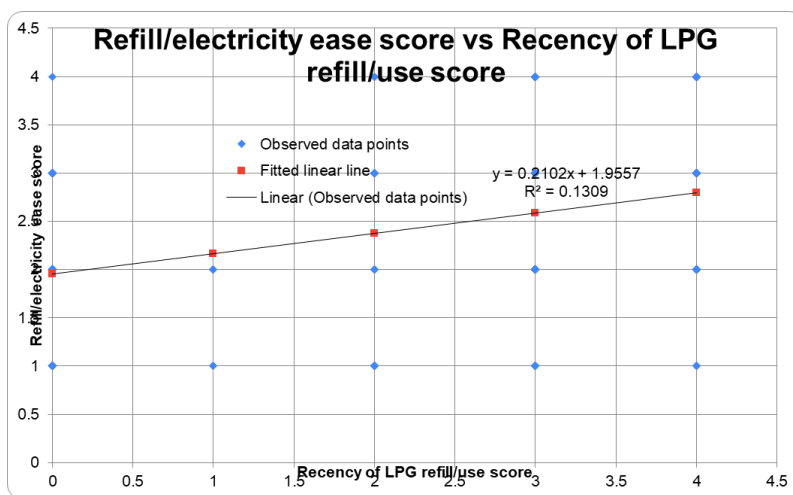


Figure 69: Effect of Ease of Refuelling on Recency of LPG refuelling

Unlike willingness (which is already high), continued usage depends on system reliability.

Synthesis and Interpretation

Across the clean cooking ecosystem, a clear pattern emerges:

1. High Willingness, Low Conversion

Willingness to shift to LPG is uniformly high (~0.9), but actual adoption and sustained use are weakly linked to socio-economic factors.

2. Flat Slopes = Structural Constraints

Most regressions exhibit very flat slopes and low R^2 values, indicating that:

- Households are not responding strongly to income, education, or awareness
- This is not due to lack of interest, but due to system-level barriers

3. Policy Matters, but Is Incomplete

Ujjwala shows relatively stronger influence, confirming that subsidized access works. However, adoption remains partial due to:

- refill costs
- irregular supply
- last-mile delivery issues

4. Usage Depends on System Reliability

Refill/electricity ease has a stronger effect on usage than any socio-economic variable. This highlights that clean cooking is a service delivery problem, not just an adoption problem.

5. Latent Demand is Extremely High

The consistently flat slopes in willingness models indicate:

- households are ready
- demand exists
- but the system has not enabled full transition

Final Insight

The regression analysis clearly shows that the clean cooking transition in Rajhara is not demand-constrained, it is system-constrained.

Households:

- are willing to adopt
- are aware of benefits
- are ready to pay to some extent

But they are waiting for a system that works.

Flat slopes across most relationships reflect:

- unmet expectations in affordability
- gaps in refill accessibility
- weak last-mile delivery systems



Figure 70: Baseline Survey of ICS Cluster Respondents

Unlike SLI (resource-driven adoption) and FPO (institution-driven adoption), clean cooking represents a service-delivery ecosystem, where success depends on:

- reliable supply chains
- affordable refill structures
- accessible distribution networks

In essence, the transition to clean cooking is already socially accepted, but not yet economically and operationally enabled.

This indicates a strong opportunity: With targeted improvements in supply-side systems, adoption can scale rapidly, as behavioural resistance is adaptable.

4.4.11 Structural interpretation: energy transition within fragile livelihoods

The mixed-method triangulation outcomes suggest that the clean cooking transition is unfolding within a fragile livelihood environment characterized by migration dependence, unstable incomes, and emergency borrowing.

Households demonstrate high willingness to adopt clean fuels, but sustained adoption remains constrained by high refill costs, supply-side frictions, and male control over financial decisions related to fuel purchase.

At the same time, biomass cooking imposes significant time, labour, and health burdens, particularly on women.

Therefore, the clean cooking transition in Rajhara should not be viewed merely as a technological change in cooking fuels. Rather, it represents a broader socio-economic transition involving affordability, gender empowerment, and livelihood stabilization.

4.5 Key Takeaways

A prominent gap exists between access and affordability of clean cooking alternatives such as LPG.

Mixed use of clean and non-clean cooking utilities is widespread. Households continue to practice energy stacking not because of preference alone, but because LPG refill cost is too high for sustained dependence.

The community shows very high willingness to shift towards cleaner cooking, especially among women. Quantitatively, this is visible in the very high willingness-to-shift responses, and qualitatively it is strongly reinforced through FGDs and the IDI.

Women remain trapped in a time-poverty and access-affordability trap. The current dependence on firewood and coal imposes substantial time burdens in fuel collection and cooking preparation, in addition to smoke exposure.

Health risks from coal and wood are clearly recognized by the community, but they have become normalized. Medical care is often delayed or avoided because it costs both time and money.

LPG connection penetration appears high due to schemes such as Ujjwala, but sustained use remains weak because refill prices are too high, access points are not localized, and subsidy reliability is poor.

The current energy transition challenge is therefore not one of awareness. It is one of making clean cooking practically usable, economically viable, and institutionally reliable.

4.6 Program Visibility and Gaps

The clean cooking findings suggest that a future ACPET intervention would enter a context of high behavioural receptivity but weak enabling conditions. The program opportunity is therefore strong, but the ecosystem around it remains underdeveloped.

The first major gap is the divide between LPG ownership and LPG use. Households may report having a cylinder, but many do not refill it regularly. This creates a false impression of energy transition success if connection data alone is used.

The second gap is in local delivery systems. Households do not have easy access to nearby refill points. Refilling involves transport costs, delivery charges, advance booking delays, and sometimes loss of daily wage income.

The third gap is household-level gender inequality in energy finance. Women carry the health and time burden of traditional fuels, but men often control the money needed for refill, creating a structural barrier to sustained adoption.

The fourth gap is institutional underuse of community structures such as SHGs. The qualitative evidence strongly indicates that SHGs could be mobilized as local knowledge conduits, demonstration platforms, and possibly as local last-mile distribution actors.

The fifth gap is the lack of a diversified clean energy basket. The field evidence suggests that over-reliance on LPG alone may not work in this context. Households need alternatives such as induction cooking, solar-based cooking, or other locally viable options.

4.7 Recommendations / Suggestions

The baseline evidence indicates that clean cooking transition in Rajhara is not constrained by aspiration, but by the gap between access, affordability, and sustained usage. A large share of households appear to have some degree of LPG access, yet continued dependence on firewood and coal remains high because refill costs, indirect transaction costs, irregular subsidy flows, and limited last-mile availability make regular usage difficult. At the same time, the findings show strong behavioural readiness among women to transition to cleaner cooking options, clear recognition of the health and time-saving benefits of LPG, and substantial scope for community-based institutional support. Based on this mixed-method assessment, the following recommendations are proposed.

4.7.1 Expand access to affordable clean cooking technologies

The first priority is to reduce the access barrier from a purely connection-based model to a sustained-use model. Strengthening convergence with existing public schemes such as Pradhan Mantri Ujjwala Yojana (PMUY) can help identify households that have connections but are unable to continue refilling regularly. In addition, efforts should not remain limited to LPG alone. A diversified basket of clean cooking options should be promoted, including electric and induction cooktops in locations where electricity is sufficiently reliable, along with other feasible alternatives such as solar-based cooking solutions. For households unable to shift immediately, improved biomass cookstoves may serve as transitional options that reduce smoke exposure and fuel inefficiency.

4.7.2 Build localized distribution and last-mile delivery systems

One of the strongest barriers emerging from the field is the absence of nearby and convenient refill channels. Households often lose a day's labour, incur transport costs, or pay delivery charges just to refill an LPG cylinder. This makes the real cost of clean cooking much higher than the sticker price of LPG. A local dealer network or decentralized refill facilitation model should therefore be explored. SHG members or local community entrepreneurs can be trained and supported to act as local energy facilitators, booking coordinators, or last-mile clean energy service providers. Such a model would improve accessibility while also creating livelihood opportunities.

4.7.3 Address affordability through financing mechanisms

Affordability remains the most important barrier to adoption. The field evidence shows that while many households are willing to shift to LPG, their willingness to pay is far below the current refill cost. Clean cooking programs in Rajhara should therefore incorporate financing innovations such as SHG-based lending, small energy loans, revolving funds, refill support through installment systems, and pay-as-you-go or staggered payment models. These options would reduce the immediate cash burden of cylinder refills and help households move from occasional use to sustained use. Additional targeted support should be considered for the most vulnerable households.

4.7.4 Strengthen awareness through community- based behaviour change communication

The findings show that women are already aware of the health risks of firewood and coal and recognize the convenience of LPG. However, awareness must now shift from general knowledge to practical decision support. Structured community campaigns should focus on the comparative benefits of clean cooking in terms of time saved, health protection, and household cost management. Live demonstrations of LPG, induction cookstoves, and other alternatives should

be organized through SHGs and village meetings. Communication strategies should be women-centered, practical, and repetitive, so that households can compare real-life costs and benefits rather than viewing clean cooking as an abstract policy message.

4.7.5 Use SHGs as core institutional anchors for the clean cooking transition

The strongest institutional opportunity lies in the SHG network. SHGs can serve as local conduits for awareness, demonstration, financing, and adoption support. They are well positioned to:



Figure 71: Focus Group Discussion of SHG Members at Rajhara Kothi

- identify households facing refill constraints,
- organize demonstrations,
- facilitate group-based financing,
- track usage patterns,
- and build peer confidence around newer technologies.

Given the trust and regular interaction already embedded in SHG systems, they can be much more effective than one-time top-down awareness campaigns. Clean cooking transition should therefore be designed not only as an energy intervention, but also as an SHG-driven women's empowerment intervention.

4.7.6 Reduce women's time poverty through energy transition design

The data clearly shows that women bear the largest burden of fuel collection and unpaid cooking labour. Clean cooking interventions should therefore explicitly frame time-saving as a development outcome. Future programming should calculate and communicate:

- total hours saved through reduced fuel collection,
- reduction in unpaid drudgery,
- potential time available for income generation, childcare, education, or community participation.

This will strengthen the social and economic case for clean cooking, especially in households where cash decisions are controlled by men but cooking burdens are borne by women.

4.7.7 Integrate health messaging with practical service support

The community widely acknowledges smoke-related irritation and respiratory discomfort, yet medical care is often delayed because such suffering has been normalized. Clean cooking programs should therefore include stronger health-oriented messaging, but in a practical and non-moralizing way. Demonstrations and awareness sessions should connect fuel use directly to:

- eye irritation,
- breathing difficulty,
- long-term respiratory burden,
- and hidden treatment costs.

Health messaging should be linked with accessible alternatives rather than awareness alone, so that households are not simply told about risks without being offered realistic solutions.

4.7.8 Improve subsidy reliability and institutional accountability

Irregular subsidy transfers weaken trust and discourage continued LPG use. A system of stronger coordination with relevant government agencies is needed so that households know whether subsidies are due, delayed, or discontinued. Local support structures should help households navigate scheme-related issues, update documentation, and track payment flows. A clean cooking transition strategy in Rajhara will remain incomplete unless the accountability side of delivery is addressed.

4.7.9 Promote a diversified clean energy basket to reduce survival-based energy stacking

The evidence suggests that energy stacking in Rajhara is often driven by price shocks and supply limitations rather than genuine fuel preference. Programs should therefore avoid assuming that LPG alone will solve the problem. A diversified clean energy approach should be promoted, including LPG, induction cooking, and other feasible technologies suited to local affordability and

supply conditions. A broader menu of options will reduce the likelihood that households revert fully to firewood and coal whenever one clean fuel becomes temporarily unaffordable.

4.7.10 Link clean cooking with wider livelihood and post-mining transition planning

Clean cooking cannot be addressed in isolation from the wider economic transition of the region. Post-mining livelihood stress, migration, irregular income, and emergency borrowing all reduce the ability of households to sustain cleaner cooking options. Clean energy planning should therefore be integrated with broader development interventions such as agriculture-based livelihoods, women’s collectives, FPO systems, and water-energy-livelihood planning.

“When we cook on the traditional stove, the smoke fills the kitchen and our eyes burn and chest feels heavy. Many women here suffer from coughing and breathing problems because of this smoke. We want cleaner cooking options so that our health does not suffer every day.”

- Lalmuni Devi, SHG Member, Rajhara Kothi

This is where the proposed Stakeholder Convergence Matrix becomes especially important. A convergent model involving administrative, financial, and programmatic stakeholders can help align the three pillars of FPO, SLI, and Clean Energy into a coherent just energy transition strategy.

4.7.11 Strategic way forward

The evidence points to a clear direction: Rajhara has the behavioural readiness required for a clean cooking transition, but not yet the enabling ecosystem for sustained adoption. The next phase should therefore focus on converting aspiration into regular use through a combination of:

- lower transaction costs,
- localized availability,
- community-based financing,
- SHG-led mobilisation,
- diversified clean energy options,
- and stronger scheme convergence.

Table 6: Clean Cooking: Output Outcome Framework

Purpose and Sub-goals	Activity	Outcome
-----------------------	----------	---------

Access to affordable clean cooking	Facilitate LPG connection and refill – PMUY	Increased usage and access to clean cooking
Promoting electric and induction cooktops	Live demonstration through SHGs, outreach to the community	Increased usage of electric/induction usage
Making community aware about clean cooking options	Outreach to the community	Increased awareness of clean cooking solutions
Making clean cooking options affordable	Help introduce SHG-based lending, pay-as-you-go model, facilitate access to subsidies under existing schemes	Increased use of clean cooking, improved health
Promoting behaviour change/awareness	Community awareness programs, demonstration program, integration with SHGs	Increased use of clean cooking
Policy Convergence	Leverage SHG network, collaborate with government department	Enhanced access to clean cooking and increased community engagement

Conclusion and Key Suggestions: Way Forward

5.1 Stakeholders Assessment and Convergence Possibilities

The District Mineral Foundation (DMF) fund, intended for the long-term welfare of mining-affected communities, supports local development both during mining and after mine closure. DMF funds are governed by the Pradhan Mantri Khanij Kshetra Kalyan Yojana (PMKKKY), which prioritizes areas directly affected by mining for long-term sustainable development, environmental restoration, and livelihood support, in line with ACPET's initiative in Rajhara. ACPET or the supported FPO/WUG can submit a proposal for expansion and sustainability to the District Administration, explaining how the initiative supports livelihood restoration, water resource development, and agricultural diversification, which are priority areas under PMKKKY.

Promoting agriculture-based and other livelihoods after mine closure, which causes unemployment and a decline in economic activity, requires the convergence of multiple government schemes because no single program can address all economic, social, and environmental challenges after mining ends. Schemes such as Deendayal Antyodaya Yojana – National Rural Livelihoods Mission (DAY-NRLM) and the Formation and Promotion of 10,000 Farmer-Producer Organizations Scheme (FPO Scheme) can play complementary roles when combined with DMF resources and district development plans.

The FPO scheme supports collective farmer institutions that improve production, aggregation, and access to markets and credit by organizing small farmers into collective enterprises, improving access to inputs (seed, fertilizer, machinery), facilitating aggregation and marketing, and enabling value addition and local processing. Though ACPET-supported FPO may not be ready to avail such support immediately, its capacity needs to be built so it can provide such facilities for its members in the long run. The DAY-NRLM focuses on SHGs, financial inclusion, and livelihood promotion by generating women-led enterprises, including community farming and local food processing. Pradhan Mantri Ksha Kaushal Vikash Yojana (PMKVY) targets local youth

to gain employable skills; Pradhan Mantri Krishi Sinchai Yojana (PMKSY) for irrigation, and Pradhan Mantri Fasal Bima Yojana (PMFBY) for crop insurance can be accessed by the local population through such interventions.

Effective engagement with key stakeholders would lead to improved irrigation access and agricultural productivity through SLI, strong farmer collectives through FPO, increased income opportunities, and clean cooking transition through SHGs in mining-affected areas.

Table 7: Stakeholder Engagement Mechanism: SLI, FPO and Clean Cooking

Stakeholder	Role in Solar Lift Irrigation (SLI)	Role in FPO Development	Role in SHG Promotion	Engagement Mechanism
District Administration / DMF Trust	Provide funding for installation of solar irrigation systems; ensure project alignment with district development plans	Facilitate registration and institutional support for FPOs	Support women-led enterprises through livelihood programs	District coordination meetings, project approvals, monitoring reviews
District Agriculture Department	Technical guidance on irrigation use, crop planning, and water management	Promote crop diversification and production planning through FPOs	Provide training for SHG-based agriculture and allied activities	Training programs, extension services, field demonstrations
Krishi Vigyan Kendra (KVK)	Provide technical training on irrigation practices and climate-resilient agriculture	Capacity building for farmers on improved cultivation and post-harvest practices	Train SHGs on agriculture, and value addition	Demonstration plots, farmer field schools, technical advisory
NABARD	Support financing models for irrigation infrastructure and watershed projects	Promote and strengthen FPOs; provide financial and institutional support	Provide financial literacy training and SHG-bank linkage programs	Workshops, financial support programs, institutional strengthening
JSLPS	Facilitate SHG members' participation in irrigation-based agriculture	Mobilize SHG members to participate in producer groups and FPO supply chains	Organize SHGs, provide enterprise training and credit linkage	Community mobilization, SHG cluster meetings, livelihood training
Central Coalfields Limited (CCL)	Support SLI systems and infrastructure through CSR or post-mining development initiatives	Support FPO-based market linkages or supply chains	Provide CSR support for SHG enterprises and skill development	CSR partnerships, local coordination meetings

Stakeholder	Role in Solar Lift Irrigation (SLI)	Role in FPO Development	Role in SHG Promotion	Engagement Mechanism
Gram Panchayat / Gram Sabha	Identify beneficiaries and suitable sites for SLI infrastructure	Encourage farmer participation and local institutional support for FPOs	Mobilize women for SHG participation and community enterprises	Village meetings, participatory planning sessions
NGOs / Implementing Partners	Facilitate project implementation, community mobilization, and training	Support FPO formation, governance, and business planning	Strengthen SHG and enterprise management and development	Field facilitation, capacity building workshops
Market Actors / Buyers	Encourage irrigated crop production aligned with market demand	Establish procurement linkages and supply chains with FPOs	Purchase products from SHG enterprises	Contract farming arrangements, buyer-seller meetings
Financial Institutions / Banks	Provide loans for irrigation equipment and agricultural inputs	Provide credit and working capital for FPO operations	Facilitate SHG bank linkage and enterprise financing	Credit programs, financial advisory meetings
Farmers and SHG Members	Operate and maintain irrigation systems and adopt improved farming practices	Participate as shareholders and suppliers to FPOs	Run microenterprises and savings groups	Training sessions, regular group meetings

While conducting FGD with farmers, it emerged that making the target group of farmers aware of the program, the assistance program aims to provide on the ground, and the benefits farmers can get from the proposed initiative, including the SLI and FPO-level interventions, are critical to the initiative's success. To reach out to more farmers, it is suggested that the implementing team on the ground needs to organize community-level meetings regularly to promote the initiative among farmers and explain how the community and its leaders can also strengthen some of the initiatives on the ground that will build trust on the one hand and bring sustainability in the long run. Many farmers reported lacking expertise and knowledge of high-quality agricultural inputs, such as seeds and fertilizers, to improve productivity and quality.

Impact360 Foundation experts' interactions with KVK scientists shed light on how they can address the knowledge gaps identified by farmers during FGDs and IDIs. KVK scientists were keen to impart training on critical issues such as the quality and availability of seeds, the right kinds of fertilizers to select and apply, and other good agricultural practices in the context of local farming. They are also interested in teaching farmers about the existing portal, which provides critical information for their farming. In addition, the local KVK is open to forming a WhatsApp group comprising FPO members, SLI users, and KVK scientists, where farmers can ask questions on crop damage, pest control, or other problems they are facing for expert suggestions or solutions from

KVK scientists. Currently, dedicated staff to implement these crucial activities do not seem to be present on the ground. These activities, if implemented on the ground, will provide critical input for future case studies.

Households in Rajhara and Chechanha use wood-based fuel, improved cookstoves, and LPG for cooking, while wood remains a fuel, but its use seems to be on the wane because wood collection takes considerable time. While most households in the LPG and ICS categories have improved cookstoves, they keep LPG as a standby because it is considered more expensive, though it is safe, hygienic, and easy to use. While many surveyed households aspire to use LPG regularly and are willing to pay Rs 400–500 per cylinder, as against the market price of Rs 1000+. Households surveyed during the baseline were unaware of other cooking methods, such as electric/induction cooking, as these are not available in the region, nor had they heard of their efficiency and effectiveness. One major task to promote cleaner alternatives like electric/induction-based cooking would be to establish a local dealer through whom the product can be made available, in line with LPG. In addition, government incentives need to be available through the local dealer to make the solution attractive to households in Rajhara and Chechanha. Even an interested SHG member can be persuaded to become a local dealer, given the program's time frame.

Annexures

Annexure A: Raw Data - Impact Assessment Framework

A1: Raw Data - Sustainable Livelihood Framework

Natural Capital

HH_ID	Village	Land Owned (Acre)	Cultivated Last Year (Acre)	Unutilized Land (Acre)	Land Utilization Ratio	Cropping Intensity Score	Irrigation Reliability Score	NC Score
21	Rajhara Kothi	0.2	0.1	0.1	0.500	0.333	0.000	0.2
22	Rajhara Kothi	0.2	0	0.2	0.000	0.000	0.000	0.0
24	Rajhara Kothi	0.2	0.05	0.15	0.250	0.333	0.000	0.1
25	Rajhara Kothi	0.2	0.05	0.15	0.250	0.333	0.000	0.1
26	Rajhara Kothi	0	0	0	0.000	0.000	0.000	0.0
27	Rajhara Kothi	0.1	0.05	0.05	0.500	0.333	0.000	0.2
30	Chechanha	3	2	1	0.667	0.333	0.700	0.5
32	Rajhara Kothi	4	4	0	1.000	0.667	0.400	0.6
33	Rajhara Kothi	0.8	0.5	0.3	0.625	0.667	0.400	0.5
34	Rajhara Kothi	0.2	0.2	0	1.000	0.667	0.400	0.6
35	Rajhara Kothi	0.4	0.3	0.1	0.750	0.667	0.400	0.6
36	Rajhara Kothi	0.12	0	0.12	0.000	0.667	0.700	0.4
37	Rajhara Kothi	0.6	0.4	0.2	0.667	0.667	0.400	0.5
47	Chechanha	0.2	0.1	0.1	0.500	0.333	0.000	0.2
49	Chechanha	0.2	0	0.2	0.000	0.000	0.000	0.0
50	Chechanha	0.2	0.05	0.15	0.250	0.333	0.000	0.1
51	Chechanha	0.2	0.05	0.15	0.250	0.333	0.000	0.1
53	Chechanha	0	0	0	0.000	0.000	0.000	0.0
55	Chechanha	0.1	0.05	0.05	0.500	0.333	0.000	0.2
61	Rajhara Kothi	4	4	0	1.000	0.667	0.400	0.6
100	Rajhara Kothi	2.5	2.5	0	1.000	0.667	0.400	0.6
102	Rajhara Kothi	0.3	0.3	0	1.000	0.667	0.400	0.6

Figure 72: Raw Data- Natural Capital

Physical Capital

HH_ID	Village	House Type	House Quality Score	Asset Ownership Index	PC Score
21	Rajhara Kothi	pucca brick wall	0.600	0.667	0.633
22	Rajhara Kothi	pucca brick wall	0.600	0.833	0.717
24	Rajhara Kothi	pucca brick wall	0.600	0.833	0.717
25	Rajhara Kothi	pucca brick wall	0.600	0.500	0.550
26	Rajhara Kothi	pucca brick wall	0.600	0.500	0.550
27	Rajhara Kothi	concrete	1.000	0.333	0.667
30	Chechanha	concrete	1.000	0.833	0.917
32	Rajhara Kothi	concrete	1.000	0.833	0.917
33	Rajhara Kothi	concrete	1.000	0.667	0.833
34	Rajhara Kothi	concrete	1.000	0.667	0.833
35	Rajhara Kothi	concrete	1.000	0.500	0.750
36	Rajhara Kothi	concrete	1.000	0.500	0.750
37	Rajhara Kothi	concrete	1.000	0.500	0.750
47	Chechanha	concrete	1.000	0.167	0.583
49	Chechanha	concrete	1.000	0.167	0.583
50	Chechanha	concrete	1.000	0.167	0.583
51	Chechanha	thatch	0.200	0.167	0.183
53	Chechanha	thatch	0.200	0.167	0.183
55	Chechanha	concrete	1.000	0.167	0.583
61	Rajhara Kothi	thatch	0.200	0.333	0.267
100	Rajhara Kothi	concrete	1.000	0.500	0.750
102	Rajhara Kothi	concrete	1.000	0.500	0.750

Figure 73: Raw Data- Physical Capital

Human Capital

HH_ID	Village	HH Head Edu Score	Main Woman Edu Score	Working Adult Ratio	Livelihood Skill Diversity	Migration Resilience Score	HC Score
21	Rajhara Kothi	0.500	0.000	0.800	0.167	1.000	0.493
22	Rajhara Kothi	0.750	0.000	0.400	0.000	1.000	0.430
24	Rajhara Kothi	1.000	0.750	0.400	0.333	0.600	0.617
25	Rajhara Kothi	0.750	0.750	0.500	0.167	1.000	0.633
26	Rajhara Kothi	0.750	0.500	0.750	0.333	0.700	0.607
27	Rajhara Kothi	1.000	0.750	1.000	0.167	0.400	0.663
30	Chechanha	1.000	1.000	1.000	0.333	1.000	0.867
32	Rajhara Kothi	0.750	0.000	0.778	0.167	1.000	0.539
33	Rajhara Kothi	0.750	0.750	0.667	0.333	1.000	0.700
34	Rajhara Kothi	0.750	0.750	1.000	0.333	0.600	0.687
35	Rajhara Kothi	1.000	1.000	0.500	0.333	0.200	0.607
36	Rajhara Kothi	1.000	0.750	0.500	0.333	1.000	0.717
37	Rajhara Kothi	0.750	0.250	0.667	0.333	0.600	0.520
47	Chechanha	0.000	0.500	1.000	0.333	0.200	0.407
49	Chechanha	0.000	0.000	0.833	0.333	0.200	0.273
50	Chechanha	0.000	0.000	0.667	0.333	0.200	0.240
51	Chechanha	0.500	0.250	1.000	0.333	0.200	0.457
53	Chechanha	0.000	0.000	0.333	0.167	0.200	0.140
55	Chechanha	0.000	0.000	1.000	0.333	0.600	0.387
61	Rajhara Kothi	0.750	0.750	0.500	0.000	0.700	0.540
100	Rajhara Kothi	0.750	0.000	1.000	0.333	1.000	0.617

Figure 74: Raw Data- Physical Capital

Social Capital

HH_ID	Village	WUG Member			SC Score
		Score	Meeting Participation Score	Info Level Score	
21	Rajhara Kothi	0.000	0.000	0.000	0.000
22	Rajhara Kothi	0.000	0.000	0.000	0.000
24	Rajhara Kothi	0.000	0.000	0.000	0.000
25	Rajhara Kothi	0.000	0.000	0.000	0.000
26	Rajhara Kothi	0.000	0.000	0.000	0.000
27	Rajhara Kothi	0.000	0.000	0.000	0.000
30	Chechanha	0.000	0.000	0.000	0.000
32	Rajhara Kothi	0.000	0.000	0.000	0.000
33	Rajhara Kothi	1.000	0.500	0.670	0.723
34	Rajhara Kothi	1.000	0.500	0.670	0.723
35	Rajhara Kothi	1.000	1.000	1.000	1.000
36	Rajhara Kothi	1.000	1.000	1.000	1.000
37	Rajhara Kothi	1.000	1.000	1.000	1.000
47	Chechanha	0.000	0.000	0.000	0.000
49	Chechanha	0.000	0.000	0.000	0.000
50	Chechanha	0.000	0.000	0.000	0.000
51	Chechanha	0.000	0.000	0.000	0.000
53	Chechanha	0.000	0.000	0.000	0.000
55	Chechanha	0.000	0.000	0.000	0.000
61	Rajhara Kothi	0.000	0.000	0.000	0.000
100	Rajhara Kothi	1.000	1.000	1.000	1.000

Figure 75: Raw Data- Social Capital

Financial Capital

HH_ID	Village	Income Level Norm	Income Diversification Index	Remittance Stability Score	Financial Stress Resilience	Loan Burden Resilience	FC Score
21	Rajhara Kothi	0.250	0.167	0.200	0.250	0.000	0.173
22	Rajhara Kothi	0.115	0.000	0.200	0.167	1.000	0.296
24	Rajhara Kothi	0.250	0.333	0.400	0.833	1.000	0.563
25	Rajhara Kothi	0.000	0.167	0.200	0.833	1.000	0.440
26	Rajhara Kothi	0.115	0.333	0.800	0.167	0.000	0.283
27	Rajhara Kothi	0.115	0.167	0.800	0.333	1.000	0.483
30	Chechanha	1.000	0.333	0.200	0.417	0.000	0.390
32	Rajhara Kothi	0.712	0.167	0.200	0.083	0.000	0.232
33	Rajhara Kothi	0.423	0.333	0.200	0.167	0.000	0.225
34	Rajhara Kothi	0.712	0.333	0.800	0.083	0.000	0.386
35	Rajhara Kothi	0.423	0.333	0.800	0.083	0.000	0.328
36	Rajhara Kothi	0.423	0.333	0.200	0.167	0.000	0.225
37	Rajhara Kothi	0.712	0.333	0.800	0.083	1.000	0.586
47	Chechanha	0.250	0.333	0.800	0.250	1.000	0.527
49	Chechanha	0.115	0.333	0.800	0.250	1.000	0.500
50	Chechanha	0.115	0.333	0.800	0.250	1.000	0.500
51	Chechanha	0.250	0.333	0.800	0.250	1.000	0.527
53	Chechanha	0.115	0.167	0.800	0.250	1.000	0.466
55	Chechanha	0.115	0.333	0.800	0.250	1.000	0.500
61	Rajhara Kothi	0.000	0.000	1.000	0.250	0.000	0.250
100	Rajhara Kothi	0.250	0.333	0.200	0.000	1.000	0.357
102	Rajhara Kothi	0.250	0.333	0.800	0.167	1.000	0.510

Figure 76: Raw Data- Financial Capital

Annexure A2: Raw Data - Regression – Solar Lift Irrigation (SLI)

HH_ID	Village	Gender	Landholding_Acre	Cultivated_Acre	WaterStressDays	WTP_Hour_Rs	LN_WTP_Hour	ContinueIntent_raw	ContinueIntent_bin	Trust_raw	Trust_ord	Fairness
Linked from DATA_RAW	Linked from DATA_RAW	Linked from DATA_RAW	Owned land in acres	Cultivated land last year in acres	Water stress days	Willingness to pay per hour in Rs	Natural log of (1 + WTP/hour)	Raw category	1 if Yes, else 0	Raw category	No Trust=1 ... Full trust=5	Raw ca
21	Rajhara Kothi	Male	0.2	0.1	15	0	0	0 Depends on performanc	0	0 No Trust	1	Cannot say
22	Rajhara Kothi	Male	0.2	0	0	0	0	0 Depends on performanc	0	0 Less Trust	2	Cannot say
24	Rajhara Kothi	Male	0.2	0.05	0	0	0	0 Depends on performanc	0	0 Less Trust	2	Cannot say
25	Rajhara Kothi	Male	0.2	0.05	0	0	0	0 Depends on performanc	0	0 Neutral	3	Cannot say
26	Rajhara Kothi	Male	0	0	0	0	0	0 Depends on performanc	0	0 Less Trust	2	Cannot say
27	Rajhara Kothi	Male	0.1	0.05	0	0	0	0 Depends on performanc	0	0 Neutral	3	Cannot say
30	Chechanha	Male	3	2	0	0	0	0 Depends on performanc	0	0 Less Trust	2	Cannot say
32	Rajhara Kothi	Male	4	4	20	10	2.397895273	0 Depends on performanc	0	0 No Trust	1	Cannot say
33	Rajhara Kothi	Male	0.8	0.5	30	30	3.433987204	Yes	1	1 Little-bit trust	4	Sometimes
34	Rajhara Kothi	Male	0.2	0.2	25	20	3.044522438	Yes	1	1 Little-bit trust	4	Sometimes
35	Rajhara Kothi	Male	0.4	0.3	30	30	3.433987204	Yes	1	1 Little-bit trust	4	Yes, mostl
36	Rajhara Kothi	Male	0.12	0	38	15	2.772588722	Yes	1	1 Little-bit trust	4	Yes, mostl
37	Rajhara Kothi	Male	0.6	0.4	25	30	3.433987204	Yes	1	1 Little-bit trust	4	Yes, mostl
47	Chechanha	Female	0.2	0.1	15	0	0	0 Depends on performanc	0	0 Less Trust	2	Cannot say
49	Chechanha	Male	0.2	0	0	0	0	0 Depends on performanc	0	0 No Trust	1	Cannot say
50	Chechanha	Female	0.2	0.05	0	0	0	0 Depends on performanc	0	0 Less Trust	2	Cannot say
51	Chechanha	Female	0.2	0.05	0	0	0	0 Depends on performanc	0	0 Neutral	3	Cannot say
53	Chechanha	Female	0	0	0	0	0	0 Depends on performanc	0	0 Neutral	3	Cannot say
55	Chechanha	Male	0.1	0.05	0	0	0	0 Depends on performanc	0	0 Less Trust	2	Cannot say
64	Dehara Kothi	Female	4	4	20	40	3.697895273	0 Depends on performanc	0	0 Less Trust	2	Cannot say

Figure 77: Raw Data - Regression Analysis SLI

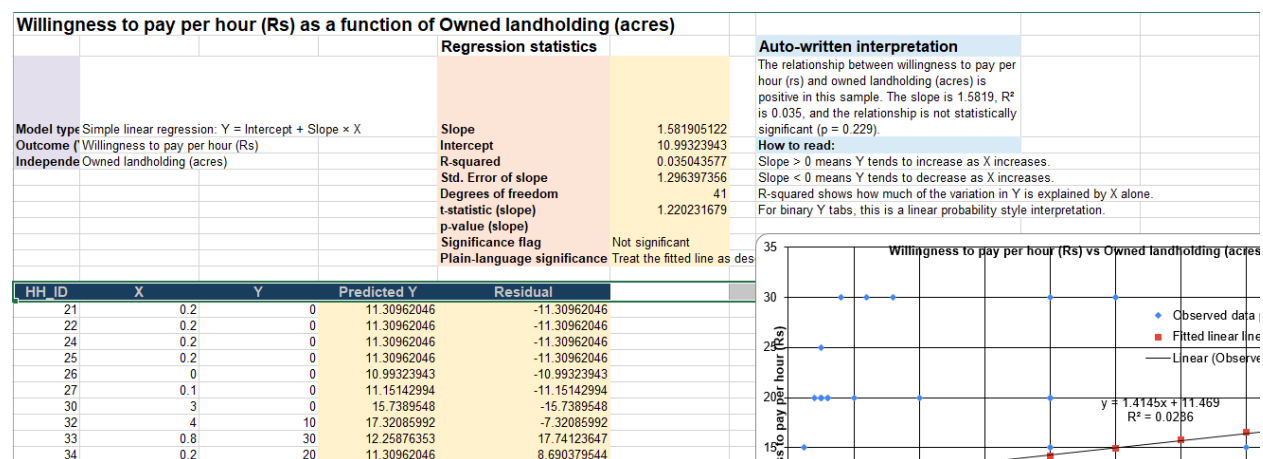


Figure 78: Raw Data Analysis - SLI Rajhara

Annexure A3: Regression – Farmer Producer Organizations (FPO)

FPO membership (0/1) as a function of Annual household income (Rs)

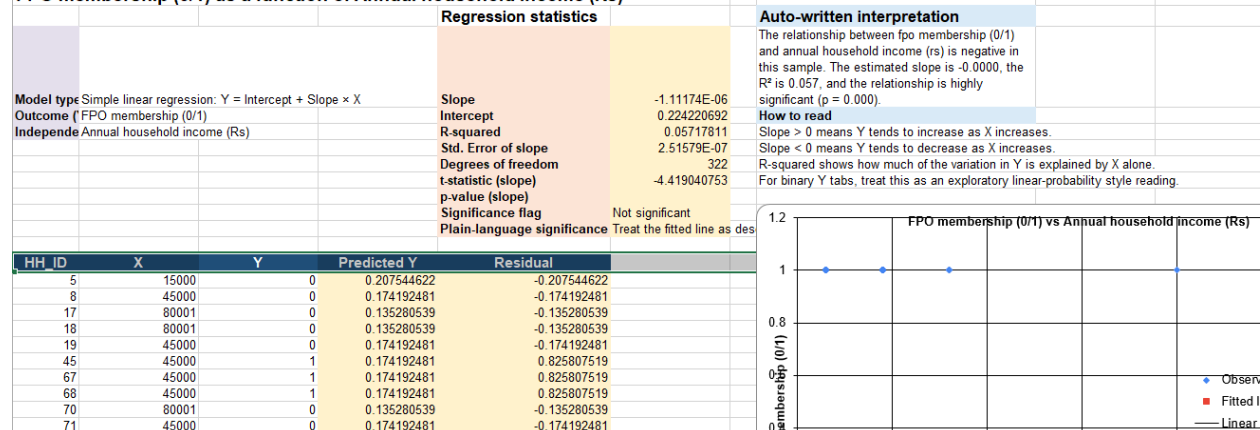


Figure 79: Raw Data - Regression FPO Rajhara

Trust score as a function of Transparency score

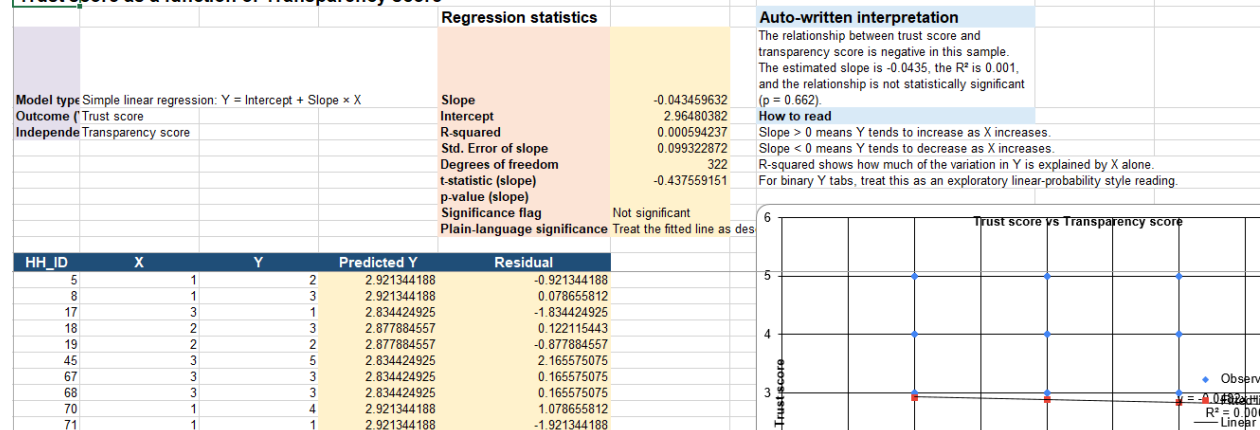


Figure 80: Raw Data - Regression Analysis FPO

Refill/electricity ease score as a function of Recency of LPG refill/use score

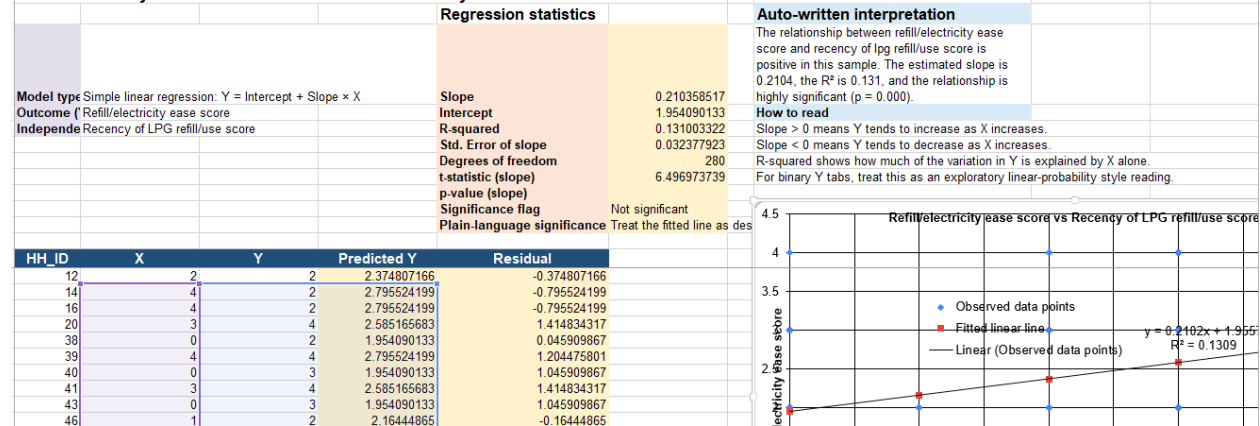


Figure 81: Raw Data-Regression FPO Rajhara

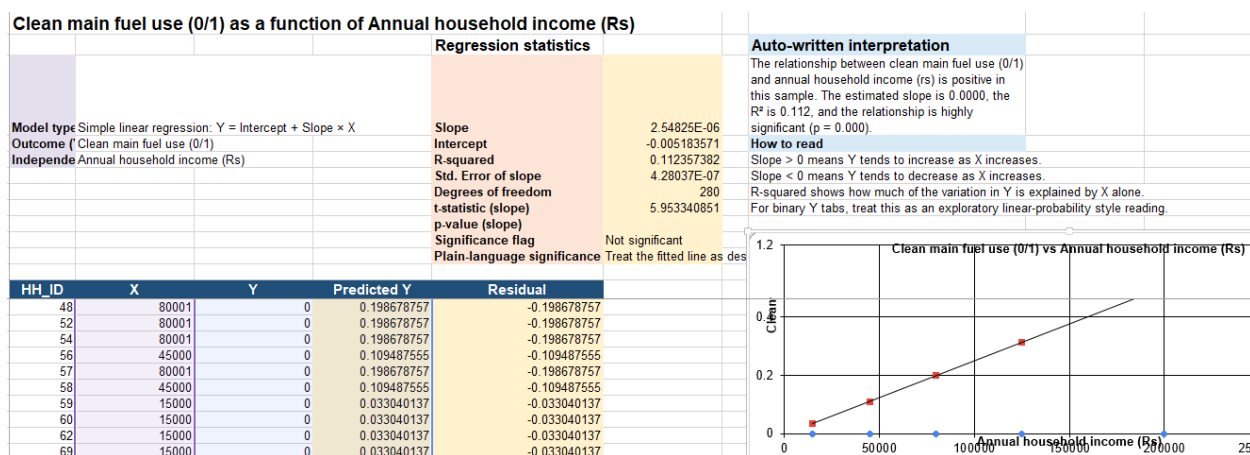


Figure 82: Raw Data - Regression FPO Rajhara

Annexure A4: Baseline Questionnaires

A0. Consent & Respondent Validation

A0_1. Informed Consent

“We are conducting a study to understand livelihoods and living conditions in this area. Your answers will be confidential and used only for research. Participation is voluntary and will take around 35-40 minutes of your time.

Do you agree to participate?”

- ☐ Yes
- ☐ No → **Terminate survey**

A0_2. Respondent Role Check

“Are you involved in household decisions related to farming, income, or cooking?”

- ☐ Yes
- ☐ No

➡ If No, enumerator should request to speak to main decision-maker or primary cook.

Categories of Respondent

SLI-.....	1
FPO member.....	2
FPO non-member.....	3
Clean cooking.....	4
ICS clusters.....	5

MODULE A

SOCIO-ECONOMIC PROFILE & STRUCTURAL VULNERABILITY

A1. Household Identification (Tracking Variables)

A1_1. Household ID

- Auto-generated (CAPI)

A1_2. GPS Location

- Auto-captured (lat/long)

A1_3. Village Name

- Select_one

A1_4. Panchayat Name

- Select_one

A2. Household Composition

A2_1.

“How many people usually live and eat from this household?”

- Numeric (total HH members)

A2_2.

“How many working age adult men (18–60 years) are there in the household?”

- Numeric

A2_3.

“How many working age adult women (18–60 years) are there in the household?”

- Numeric

A2_4.

“How many children (below 18 years) are there?”

- Numeric

A3. Social Identity & Inclusion

A3_1. Social Category

“Which social category does your household belong to?”

- ☐ Scheduled Tribe (ST)
- ☐ Scheduled Caste (SC)
- ☐ Other Backward Class (OBC)
- ☐ General

A3_2. Religion

“What is your religion?”

- ☐ Hindu
- ☐ Muslim
- ☐ Tribal religion
- ☐ Christian
- ☐ Other

A4. Education (Structural Capability)

A4_1. Education of Household Head

“What is the highest education level of the household head?”

- ☐ No schooling
- ☐ Can sign only

- ☐ Primary (Class 1–5)
- ☐ Secondary (Class 6–10)
- ☐ Higher secondary or above

A4_2. Education of Primary Adult Woman

“What is the highest education level of the main adult woman in the household?”

- ☐ No schooling
- ☐ Can sign only
- ☐ Primary (Class 1–5)
- ☐ Secondary (Class 6–10)
- ☐ Higher secondary or above

A5. Housing & Basic Assets

(SLF–Physical Capital | Resilience anchor)

A5_1. Type of House

“What kind of house do you live in?”

- ☐ Kutchha (mud/thatch)
- ☐ Semi-pucca (brick walls or tin roof)
- ☐ Pucca (brick/concrete)

A5_2. Asset Ownership

“Which of the followings is present in your household?” *(Select all that apply)*

- ☐ Smartphone
- ☐ Bicycle
- ☐ Motorcycle/scooter
- ☐ Television
- ☐ Refrigerator
- ☐ Electric fan

A6. Migration & Structural Stress

A6_1.

“In the last 12 months, did any household member migrate outside the village for work?”

- ☐ Yes
- ☐ No

A6_2. (If Yes)

“What was the nature of migration of the main earning member?”

- ☐ Seasonal (few months, returns home)
- ☐ Long-term (more than 6 months)

A7. Food Security & Safety Net Access

(SLF–Social | Inclusion | Shock buffering)

A7_1. Ration Card Type

“What type of ration card does your household have?”

- ☐ Antyodaya (AAY)
- ☐ Priority Household (PHH)
- ☐ State green card
- ☐ White card
- ☐ No ration card

A7_2. MGNREGA Job Card

“Does your household have an MGNREGA job card?”

- ☐ Yes, and worked in last 12 months
- ☐ Yes, but did not get work
- ☐ No

MODULE B

LIVELIHOOD PORTFOLIO & POST-MINING ECONOMIC SECURITY

B1. Livelihood Composition (Main + Secondary)

B1_1. Primary Livelihood (Rank 1)

“In the last 12 months, what was the main source of income for your household?”

- ☐ Own farming (cultivation on own/leased land)

- ☐ Agricultural wage labour
- ☐ Non-agricultural daily wage labour (construction, labour, etc.)
- ☐ Livestock / poultry / goatery
- ☐ Small business / shop / services
- ☐ Migration / remittances (income sent from outside)
- ☐ Mining employment (formal/contract)
- ☐ Coal collection / coal selling (informal)
- ☐ Other (specify)

B1_2. Secondary Livelihood (Rank 2) (optional)

“What is the second most important income source for your household?”

- ☐ Own farming (cultivation on own/leased land)
- ☐ Agricultural wage labour
- ☐ Non-agricultural daily wage labour (construction, labour, etc.)
- ☐ Livestock / poultry / goatery
- ☐ Small business / shop / services
- ☐ Migration / remittances (income sent from outside)
- ☐ Mining employment (formal/contract)
- ☐ Coal collection / coal selling (informal)
- ☐ Other (specify)
- ☐ None

B1_3. Any mining link historically (for attribution/control)

“Was any household member previously employed in coal mining (in the past)?”

- ☐ Yes
- ☐ No
- ☐ Don't know / not sure

B2. Income Estimation

B2_1. Approx. total annual household income (all sources)

“Thinking of all sources together, what is your household's approximate total income in the last 12 months (annual income)?”

- ☐ <30,000
- ☐ 30,000–60,000
- ☐ 60,001–1,00,000

- ☐ 1,00,001–1,50,000
- ☐ 1,50,001–2,50,000
- ☐ 2,50,000 → 3,00,000

B2_2. Approx share of income by source (quick split)

“Out of 10 parts, how many parts came from each source?” (*Enumerator ensures total = 10*)

- Farming: __ /10
- Wage labour (agri + non-agri): __ /10
- Livestock: __ /10
- Business/services: __ /10
- Remittances/migration: __ /10
- Coal collection/sale: __ /10
- Other: __ /10

➔ Constraint: **sum must equal 10.**

B3. Economic Volatility / Insecurity

B3_1. Months of income insecurity

“In the last 12 months, for how many months did your household face income difficulty (not enough for basic needs like food/medical/education)?”

- Numeric (0–12)

B3_2. Major reason for insecurity (select one)

“What was the main reason for this income difficulty?”

- ☐ No local work available
- ☐ Drought / rainfall failure
- ☐ Health expense / illness
- ☐ Crop loss (pest, wildlife, flood, etc.)
- ☐ Debt/interest burden
- ☐ Migration disruption / job loss outside
- ☐ Other (specify)

B4. Migration Economics (Post-mining adjustment)

B4_1. Migration income reliance *(only if A6_1 = Yes)*

“Did migration/remittance become necessary mainly due to lack of local work after mine closure / reduced local opportunities?”

- ☐ Yes
- ☐ No
- ☐ Partly
- ☐ Don't know

B4_2. Remittance frequency *(if migrant HH)*

“How often does the household receive money from outside work?”

- ☐ Weekly
- ☐ Monthly
- ☐ Once in 2–3 months
- ☐ Rare/irregular

B5. Social Safety Nets

B5_1. MGNREGA status *(if already asked in A7_2, skip; else keep here)*

“Does your household have MGNREGA job card and got any work in last 12 months?”

- ☐ Yes, worked in last 12 months
- ☐ Yes, but did not get work
- ☐ No

B5_2 Social Safety Net Scheme Coverage

“Which of the following government social security or support schemes has any member of your household availed benefits from in the last 12 months?”

Response type: Select multiple

- ☐ National Social Assistance Programme (NSAP – pension)
- ☐ PM-KISAN (income support)
- ☐ PM Fasal Bima Yojana (crop insurance)
- ☐ Ayushman Bharat (PM-JAY health insurance)
- ☐ PM-KUSUM (solar pump / solar agriculture scheme)

- ☐ Other government schemes
- ☐ None of the above

B6. Debt & Financial Stress (SROI + resilience)

B6_1. Loan taken in last 12 months

“In the last 12 months, did your household take any loan?”

- ☐ Yes
- ☐ No

B6_2. Loan source (if Yes)

“From where was the main loan taken?”

- ☐ Bank
- ☐ SHG
- ☐ MFI / NBFC
- ☐ Moneylender
- ☐ Friends/relatives
- ☐ Other (specify)

B6_3. Main purpose of loan (if Yes)

“What was the main purpose of this loan?”

- ☐ Food / daily consumption
- ☐ Health emergency
- ☐ Agriculture inputs (seed/fertiliser/pesticide)
- ☐ Irrigation / farm equipment
- ☐ House repair / construction
- ☐ Education
- ☐ Social ceremony (marriage etc.)
- ☐ Business investment
- ☐ Other (specify)

B6_4. Approx interest rate category (if Yes)

“What is the approximate interest rate of the main loan?”

- ☐ 0% (interest-free)

- ☐ Up to 12% per year
- ☐ 13% – 24% per year
- ☐ Above 24% per year
- ☐ Don't know

MODULE C

AGRICULTURE, LAND & WATER SECURITY (SOLAR LIFT IRRIGATION)

C1. Landholding & Land Use (Structural Constraint)

C1_1. Total land owned by household

“How much total land does your household own?”

- Numeric (acres or decimals; enumerator selects unit)

C1_2. Total land cultivated in last agricultural year

“Out of this land, how much was actually cultivated in the last year?”

- Numeric (same unit)

C1_3. Total land left fallow/unutilized (*auto-calc preferred*)

- Numeric OR auto = $C1_1 - C1_2$

C2. Reasons for Fallow Land (Causal Diagnosis)

C2_1. Reason for land remaining fallow (*multiple select*)

“What are the main reasons for keeping the land unused?”

- ☐ No irrigation / lack of water
- ☐ Poor soil quality
- ☐ Wildlife damage risk
- ☐ Labour shortage
- ☐ Low returns / not profitable
- ☐ Land disputes / tenure issue
- ☐ Other (specify)

C3. Cropping Pattern & Intensity

C3_1. Crops grown in last 12 months

“Which crops did your household grow in the last 12 months?”

(Enumerator records up to 3 crops)

- Crop 1 (name)
- Crop 2 (optional)
- Crop 3 (optional)

C3_2. Cropping intensity

“How many crops did you grow on the same land in one year?”

- ☐ One crop only
- ☐ Two crops
- ☐ Three or more crops

C4. Yield & Income (Baseline Benchmark)

C4_1. Main crop for the household

“Which crop was the most important for income last year?”

- Crop 1 (name)
- Crop 2 (optional)
- Crop 3 (optional)

C4_2. Approximate yield of main crop

“What was the average yield per acre for this crop?”

- Numeric (local unit; enumerator standardises)

C4_3. Approximate annual agricultural income

“About how much income did your household earn from agriculture last year?”

- ☐ Less than ₹25,000
- ☐ ₹25,001 – ₹50,000
- ☐ ₹50,001 – ₹1,00,000
- ☐ ₹1,00,001 – ₹2,00,000
- ☐ More than ₹2,00,000

C5. Existing Irrigation Access (Before SLI)

C5_1. Main irrigation source currently used

“What is the main source of irrigation for your fields?”(*select multiple*)

- ☐ Rainfed only (no irrigation)
- ☐ Diesel pump
- ☐ Electric pump
- ☐ Canal
- ☐ Open well
- ☐ Pond / mine pit water
- ☐ Borrowed/shared pump
- ☐ Other (specify)

C5_2. Reliability of irrigation source

“How reliable is this irrigation source during the crop season?”

- ☐ Very unreliable (often fails)
- ☐ Sometimes reliable
- ☐ Mostly reliable
- ☐ Fully reliable

C5_3. Average irrigation cost per season

“Approximately how much do you spend per season on irrigation (fuel, rent, repair)?”

- Numeric (₹)

C6. Water Stress Experience (Reliability Lens)

C6_1. Water stress days

“During the last crop cycle, for how many days did crops face water stress due to lack of irrigation?”

- Numeric (days)

C7. Wildlife & Environmental Risk

C7_1. Wildlife-related crop damage

“Did wildlife damage your crops in the last year?”

- ☐ Yes
- ☐ No

C7_2. If yes: severity of loss

“Approximately how much crop loss did this cause?”

- ☐ Less than 10%
- ☐ 10–25%
- ☐ 26–50%
- ☐ More than 50%

C8. Perception of Mine-Pit / Lift Water (Transition Readiness)

C8_1. Perception of using mine-pit / lifted water for irrigation

“What is your view about using lifted mine-pit water for irrigation?”

- ☐ Very safe
- ☐ Somewhat safe
- ☐ Unsafe
- ☐ Don’t know

C8_2. Main concern (if unsafe / unsure)

“What is the main concern?”

- ☐ Water quality
- ☐ Health impact
- ☐ Crop damage
- ☐ Pump reliability
- ☐ Lack of information
- ☐ Other (specify)

C9. Irrigation Energy Use (Pre-SLI / Non-SLI Baseline)

C9_1. Pump runtime (last crop season)

“In the last crop season, approximately how many hours did you run your irrigation pump?”

- Response type: Numeric (hours/season)

C9_2. Main pump type used

“What type of irrigation pump did you mostly use?”

- ☐ Diesel pump
- ☐ Electric pump
- ☐ Shared / rented pump
- ☐ Manual / other

C9_3. Diesel consumption (if diesel pump)

“If diesel pump was used: approximately how many litres of diesel were used in one season?”

- Response type: Numeric (litres/season)
- Enumerator note: Encourage estimation if exact value not known.

C9_4. Electricity cost for irrigation (if electric pump)

“If electric pump was used: what was the average monthly electricity cost attributable to irrigation?”

- Response type: Numeric (₹/month)

C9_5. Pump capacity (optional)

“If known, what is the pump capacity?”

- ☐ Less than 3 HP
- ☐ 3–5 HP
- ☐ More than 5 HP
- ☐ Don’t know

C10. Solar Lift Irrigation (SLI) Exposure & Usage

C10_1. SLI usage status

“Did your household use Solar Lift Irrigation (SLI) water in the last season?”

- ☐ Yes
- ☐ No

C10_2. Number of irrigations from SLI

“If yes: approximately how many irrigations did you receive from SLI last season?”

- Response type: Numeric (count)

C10_3. Area irrigated using SLI

“If yes: how much land was irrigated using SLI water?”

- Response type: Numeric (acres/decimals)

MODULE D

SOLAR LIFT IRRIGATION: WATER USER GROUP (WUG) & IRRIGATION GOVERNANCE

D1. Awareness of Water Governance Structure

D1_1. Awareness of any water user group or committee

“Is there any water user group, committee, or local body that manages irrigation or lifted water in your area?”

- ☐ Yes
- ☐ No
- ☐ Not sure

D2. Membership & Inclusion

D2_1. Household membership status

“Is any member of your household part of this water user group or committee?”

- ☐ Yes, formal member
- ☐ Participates informally
- ☐ Not a member
- ☐ No such group exists

D2_2. If not a member: main reason

“What is the main reason your household is not a member?”

- ☐ Not invited / not aware
- ☐ Membership fee too high
- ☐ Do not see benefit
- ☐ Group dominated by few people
- ☐ Social barriers (caste/gender)
- ☐ Other (specify)

D3. Participation & Engagement

D3_1. Meeting attendance (last 6 months)

“In the last 6 months, how often has your household attended WUG meetings?”

- ☐ Regularly
- ☐ Occasionally
- ☐ Never
- ☐ No meetings held

D3_2. Information flow

“How well are you informed about irrigation schedules, rules, or decisions?”

- ☐ Very well informed
- ☐ Somewhat informed
- ☐ Poorly informed
- ☐ Not informed at all

D4. Trust & Fairness (Institutional Quality)

D4_1. Trust in WUG leadership

“On a scale of 1 to 5, how much do you trust the WUG leadership to manage water fairly?”

- 1 ☐ No trust
- 2 ☐
- 3 ☐
- 4 ☐
- 5 ☐ Full trust

D4_2. Perception of fairness

“Do you feel water distribution is fair across all households?”

- ☐ Yes, mostly fair
- ☐ Sometimes unfair
- ☐ Mostly unfair
- ☐ Cannot say

D5. Reliability & Conflict Resolution

D5_1. Irrigation reliability after group management

“Compared to earlier, has irrigation reliability improved since group management started?”

- ☐ Much improved
- ☐ Slightly improved
- ☐ No change
- ☐ Became worse
- ☐ Not applicable

D5_2. Conflict occurrence

“In the last year, were there any conflicts related to water access?”

- ☐ Yes
- ☐ No

D5_3. If yes: conflict resolution

“How were these conflicts resolved?”

- ☐ Resolved within group
- ☐ Required village mediation
- ☐ Not resolved
- ☐ Led to exclusion of some users

D6. Cost Sharing & Sustainability

D6_1. Contribution to O&M

“Does your household contribute money or labour for maintenance of irrigation systems?”

- ☐ Yes, regularly
- ☐ Sometimes
- ☐ No contribution
- ☐ Not asked to contribute

D6_2. Perceived affordability

“Is this contribution affordable for your household?”

- ☐ Easily affordable
- ☐ Somewhat difficult
- ☐ Not affordable
- ☐ Not paying currently

D6_3. Contribution Willingness to Irrigation

“How is your household willing to pay for irrigation?”

- ☐ per acre
- ☐ per hour
- ☐ others

If per acre, go to D6_4, If per hour, go to D6_5

D6_4. Contribution Willingness to Irrigation per acre (skip logic)

“How much is your household willing to pay for irrigation (per acre)?”

- Numeric (₹)

D6_5. Contribution Willingness to Irrigation per hour (skip logic)

“How much is your household willing to pay for irrigation (per hour)?”

- Numeric (₹)

D7. Voice, Inclusion & Gender Lens

D7_1. Women’s participation

“Do women from your household participate or speak in WUG meetings?”

- ☐ Yes, actively
- ☐ Attend but rarely speak
- ☐ Do not attend
- ☐ No women in household

D7_2. Leadership opportunity

“Do you feel women and marginalised households can become leaders in the WUG?”

- ☐ Yes
- ☐ No
- ☐ Not sure

D8. Willingness to Sustain the System

D8_1. Willingness to continue participation

“Would you like to continue participating in the water user group in the future?”

- ☐ Yes
- ☐ No
- ☐ Depends on performance

D8_2. Key improvement needed

“What is the most important improvement needed for the group to work better?”

- ☐ More reliable water
- ☐ Transparent rules
- ☐ Fair distribution
- ☐ Better leadership
- ☐ Inclusion of all households
- ☐ Other (specify)

MODULE E

FPO & AGRICULTURAL MARKET SYSTEM

E1. Awareness & Information Access

E1_1. Awareness of FPO

“Have you heard about any Farmer Producer Organisation (FPO) operating in or near your village?”

- ☐ Yes
- ☐ No

E1_2. Source of information (if Yes)

“From where did you first hear about the FPO?”

- ☐ Other farmers
- ☐ Village meeting / Panchayat
- ☐ NGO / Project staff
- ☐ FPO representative
- ☐ Social media / phone
- ☐ Other (specify)

E2. Membership & Inclusion

E2_1. Household FPO membership status

“Is any member of your household currently a member or shareholder of the FPO?”

- ☐ Yes, active member
- ☐ Yes, but inactive
- ☐ Applied but not accepted
- ☐ No, not a member

E2_2. If not a member: main reason

“What is the main reason your household is not an FPO member?”

- ☐ Not aware of benefits
- ☐ Entry cost/share too high
- ☐ Landholding too small
- ☐ Trust issues
- ☐ Dominated by big farmers
- ☐ Social barriers (caste/gender)
- ☐ Prefer independent selling
- ☐ Other (specify)

E3. Participation & Engagement

E3_1. Participation in FPO activities

“In the last one year, how often has your household participated in FPO-related activities?”

- ☐ Regularly (meetings, procurement, training)
- ☐ Occasionally
- ☐ Rarely
- ☐ Never

E3_2. Understanding of FPO services

“How well do you understand the services offered by the FPO?”

- ☐ Very well
- ☐ Useful
- ☐ Somewhat useful
- ☐ Not so useful
- ☐ Not useful at all

E4. Trust, Transparency & Governance

E4_1. Trust in FPO leadership

“On a scale of 1 to 5, how much do you trust the FPO leadership to work in farmers’ interest?”

- 1 ☐ No trust
- 2 ☐
- 3 ☐
- 4 ☐
- 5 ☐ Full trust

E4_2. Transparency perception

“Do you feel pricing, payments, and decisions in the FPO are transparent?”

- ☐ Yes, fully transparent
- ☐ Somewhat transparent
- ☐ Not transparent
- ☐ Cannot say

E5. Market Channels & Price Realisation

E5_1. Main sale channel (last season)

“Where did your household sell most of its produce last season?”

- ☐ Local trader
- ☐ Commission agent
- ☐ Village haat
- ☐ Mandi
- ☐ FPO
- ☐ Did not sell

E5_2. Price comparison

“Compared to local traders, what price did you receive through this channel?”

- ☐ Much higher
- ☐ Slightly higher
- ☐ Same
- ☐ Slightly Lower
- ☐ Much Lower

E5_3. Payment timing

“How soon do you usually receive payment after selling produce?”

- ☐ Same day
- ☐ Within 3–7 days
- ☐ After more than a week
- ☐ Often delayed / uncertain

E5_4 Distance to Market

“How far is the market where you usually sell? (in km)”

Response type: Integer (km)

E5_5 Price Received

“What average price did you receive for your main crop? (₹/kg)”

Response type: Decimal (₹/kg)”

E5_6 Total Amount Earned

“How much total money did you earn from selling your produce? (₹)”

Response type: Integer

E5_7 Satisfaction with Price

“Are you satisfied with your current price realization?”

Response type: Select one

Options:

- ☐ Yes
- ☐ No
- ☐ Not sure

E6. Input and Credit Access

E6_1. Main source of agricultural inputs

“From where do you mainly purchase seeds, fertilisers, or pesticides?”

- ☐ Local dealer
- ☐ Trader / commission agent
- ☐ FPO
- ☐ Cooperative
- ☐ Government outlet

- ☐ Other (specify)

E6_2. Input cost perception

“Compared to local dealers, are input prices through FPO cheaper?”

- ☐ Yes, cheaper
- ☐ About the same
- ☐ More expensive
- ☐ Not applicable

E6_3 Average Input Cost per Season

“Approximately how much do you spend on inputs in one season? (₹)”

Response type: Integer

E6_4 Loan for Agriculture

“Do you take loans for agriculture?”

Response type: Select one

Options:

- ☐ Yes
- ☐ No

E6_5 Source of Credit

“From where do you take the loan?”

Response type: Select multiple

Options:

- ☐ Bank
- ☐ SHG
- ☐ FPO
- ☐ MFI / NBFC
- ☐ Moneylender
- ☐ Friends/relatives
- ☐ Others

E6_6 Interest Rate

“What is the interest rate of the loan? (%)”

Response type: select_one

- ☐ 0% (interest-free)
- ☐ Up to 12% per year
- ☐ 13% – 24% per year
- ☐ Above 24% per year
- ☐ Don't know

E7. Risk Sharing & Collective Benefits

E7_1. Risk reduction perception

“Has FPO membership reduced your market risk (price fluctuation, cheating, rejection)?”

- ☐ Yes, significantly
- ☐ Slightly
- ☐ No
- ☐ Not applicable

E7_2. Collective services used (*multiple allowed*)

“Which of the following FPO services have you used?”

- ☐ Collective selling
- ☐ Bulk input purchase
- ☐ Storage / aggregation
- ☐ Market linkage / buyer access
- ☐ Training / advisory
- ☐ None

E8. Women's Participation & Inclusion

E8_1. Women's involvement in FPO

“Do women from your household participate in FPO meetings or activities?”

- ☐ Yes, actively
- ☐ Attend but rarely speak
- ☐ Do not attend
- ☐ No women in household

E8_2. Leadership opportunity for women

“Do you feel women can realistically hold leadership roles in the FPO?”

- ☐ Yes
- ☐ No
- ☐ Not sure

E9. Willingness to Deepen Engagement

E9_1. Future engagement intent

“Would you like to increase your engagement with the FPO in the future?”

- ☐ Yes
- ☐ No
- ☐ Depends on performance

E9_2. Most important improvement needed

“What is the most important improvement needed for the FPO to work better?”

- ☐ Better prices
- ☐ Timely payments
- ☐ More transparency
- ☐ Inclusion of small farmers
- ☐ Better leadership
- ☐ Better market linkages
- ☐ Other (specify)

E10. Good Agricultural Practices and Land Management Practices (SOC Drivers)

E10_1. Use of organic inputs

“Do you apply any organic inputs to your fields?”

- ☐ Yes
- ☐ No

E10_2. Type of organic inputs (if Yes)

“Which types of organic inputs do you use? (Select all that apply.)”

- ☐ Farmyard manure (FYM)
- ☐ Compost
- ☐ Vermicompost
- ☐ Green manure
- ☐ Other (specify)

E10_3. Crop residue management (main crop)

“What do you usually do with crop residues?”

- ☐ Burned
- ☐ Removed from field
- ☐ Incorporated into soil
- ☐ Mulched
- ☐ Left on field

E10_4. Tillage practice

“Do you practice minimum or reduced tillage?”

- ☐ Yes
- ☐ No

E10_5. Legumes / cover crops

“Do you grow legumes or cover crops in any season?”

- ☐ Yes
- ☐ No

E11. Fertilizer & Cropping Change Drivers**E11_1. Fertilizer use (optional)**

“For the main crop, approximately how many bags of urea/DAP are used per acre per season?”

- Response type: Numeric (bags)
- Optional

E11_2. Cropping season change planned

“Do you plan to grow additional crops due to improved irrigation?”

- ☐ Yes
- ☐ No

E12. Trees & Biomass on Farm**E12_1. Trees on farmland/boundaries**

“Do you have trees on your farmland or boundaries?”

- ☐ Yes
- ☐ No

E12_2. Approximate number of trees

“If yes: approximately how many trees?”

- ☐ 1–10
- ☐ 11–25
- ☐ 26–50
- ☐ More than 50

MODULE F**Energy, Health & Time Poverty****F1. Cooking Fuel Use & Energy Behaviour****F1_1. Primary cooking fuel**

“What is the main fuel your household currently uses for daily cooking?”

- ☐ Firewood
- ☐ Coal
- ☐ Dung cake
- ☐ LPG
- ☐ Electric / Induction
- ☐ Mixed (no single main fuel)

F1_2. Secondary fuel use (fuel stacking) *(multiple allowed)*

“Apart from the main fuel, do you use any other fuel for cooking?”

- ☐ Firewood
- ☐ Coal
- ☐ Dung cake
- ☐ LPG
- ☐ Electric / Induction
- ☐ No secondary fuel

F1_3. Reason for fuel stacking *(if secondary fuel selected)*

“Why do you continue using more than one fuel?”

- ☐ LPG/electric is costly
- ☐ Refill / electricity not reliable

- ☐ Habit / taste preference
- ☐ Used only for specific dishes
- ☐ Fuel not always available
- ☐ Other (specify)

F2. Access, Reliability & Refill Behaviour

F2_1. LPG / electric connection ownership

“Does your household have an LPG connection or electric/induction cooking facility?”

- ☐ Yes
- ☐ No

F2_2. Refill / usage status (if Yes)

“When was your last LPG refill or regular electric cooking use?”

- ☐ Within last 30 days
- ☐ 1–3 months ago
- ☐ More than 3 months ago
- ☐ Have connection but not using

F2_3. Ease of access

“How easy is it for your household to refill LPG or access electricity for cooking?”

- ☐ Very easy
- ☐ Somewhat easy
- ☐ Difficult
- ☐ Very difficult

F3. Fuel Collection & Time Poverty

F3_1. Who mainly collects cooking fuel?

“Who in the household usually collects firewood/coal/dung?”

- ☐ Adult women
- ☐ Adult men
- ☐ Children
- ☐ No collection required

F3_2. Time spent per trip

“On average, how much time is spent per fuel collection trip?”

- ☐ <60 min → 30
- ☐ 60–120 min → 90
- ☐ 120–180 min → 150
- ☐ 180–240 min → 210
- ☐ >240 min → 270

F3_3. Frequency of collection

“How often is fuel collected?”

- ☐ Daily
- ☐ 3–4 times a week
- ☐ Weekly
- ☐ Less than weekly

F4. Health Impacts of Cooking Fuel

F4_1. Smoke-related health symptoms *(multiple allowed)*

“Does anyone in your household regularly experience any of the following due to cooking smoke?”

- ☐ Breathing difficulty
- ☐ Persistent cough
- ☐ Eye irritation
- ☐ Headache
- ☐ Chest pain
- ☐ None

F4_2. Medical treatment related to cooking smoke

“In the last one year, has any household member taken medical treatment for smoke-related problems?”

- ☐ Yes
- ☐ No

F4_3. Annual medical expenditure (estimated)

“Approximately how much did your household spend on medical treatment related to breathing, cough, or smoke exposure last year?”

- ☐ ₹0
- ☐ ₹1–1,000
- ☐ ₹1,001–3,000
- ☐ ₹3,001–5,000
- ☐ More than ₹5,000

F5. Monthly Energy Expenditure

F5_1. Monthly expenditure on cooking fuel

“Approximately how much does your household spend per month on cooking fuel?”

- ☐ ₹0–300
- ☐ ₹301–600
- ☐ ₹601–1,000
- ☐ More than ₹1,000

F6. Awareness & Perception of Clean Cooking

F6_1. Awareness of clean cooking benefits

“Are you aware that LPG or electric cooking can reduce health risks and save time?”

- ☐ Yes
- ☐ No

F6_2. Perceived main benefit of clean cooking

“What do you feel is the biggest benefit of clean cooking?”

- ☐ Better health
- ☐ Time saving
- ☐ Clean kitchen
- ☐ Convenience
- ☐ Not sure

F7. Willingness to Transition & Willingness to Pay

F7_1. Willingness to shift fully to clean cooking

“If reliable and affordable, would you be willing to shift fully to LPG or electric cooking?”

- ☐ Yes
- ☐ No
- ☐ Maybe

F7_2. Willingness to Pay (monthly)

“What is the maximum amount your household would be willing to pay per month for clean cooking fuel?”

- ☐ ₹300 or less
- ☐ ₹301–600
- ☐ ₹601–900
- ☐ More than ₹900

F7_3. Main barrier to transition

“What is the biggest barrier preventing full adoption of clean cooking?”

- ☐ High fuel cost
- ☐ Refill / electricity reliability
- ☐ Safety concerns
- ☐ Habit / taste
- ☐ Lack of awareness
- ☐ Other (specify)

F8. Fuel Quantity

F8_1. Weekly traditional fuel use

“In a typical week, how much fuel do you use for cooking?”

- Firewood: ____ kg/week (or bundles)
- Coal: ____ kg/week
- Dung cake: ____ pieces/week

F8_2. LPG consumption (last 3 months)

“If LPG is used: how many cylinders were used in the last 3 months?”

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3 or more

F8_3. LPG cylinder size

“What size LPG cylinder do you use?”

- ☐ 14.2 kg
- ☐ 5 kg
- ☐ Other

F9. Stove Efficiency**F9_1. Primary stove type**

“What is the main stove used for cooking?”

- ☐ Traditional chulha
- ☐ Improved cookstove
- ☐ LPG stove
- ☐ Electric / induction

MODULE G**Women’s Agency, Care Economy & Empowerment****G1. Decision-Making Power (Agency & Control)****G1_1. Decision on household income use**

“Who usually decides how the household income is spent?”

- ☐ Mainly men
- ☐ Joint decision (men and women together)
- ☐ Mainly women

G1_2. Decision on major household purchases

“Who decides on major household purchases like livestock, equipment, or assets?”

- ☐ Mainly men
- ☐ Joint decision
- ☐ Mainly women

G1_3. Decision on agricultural activities

“Who decides what crops to grow and when to sell agricultural produce?”

- ☐ Mainly men
- ☐ Joint decision
- ☐ Mainly women

G2. Labor Allocation & Unpaid Care Economy

G2_1. Daily unpaid work responsibility

“Who in the household does most of the following unpaid work?”

(Enumerator: read one by one, record dominant role)

Activity	Men	Women	Shared
Cooking & kitchen work	☐	☐	☐
Fuel collection	☐	☐	☐
Water collection	☐	☐	☐
Child care / elder care	☐	☐	☐

G2_2. Time spent by women on unpaid work (daily)

“On an average day, how many hours do women in the household spend on unpaid household and care work?”

- ☐ Less than 3 hours
- ☐ 3–5 hours
- ☐ 5–7 hours
- ☐ More than 7 hours

G3. Voice, Confidence & Participation (Dignity)

G3_1. Attendance in group meetings

“Do women from your household attend meetings of SHGs, WUGs, FPOs, or village groups?”

- ☐ Regularly
- ☐ Occasionally
- ☐ Rarely
- ☐ Never

G3_2. Speaking up in meetings

“When women attend meetings, are they comfortable speaking or expressing opinions?”

- ☐ Yes, freely
- ☐ Sometimes
- ☐ No, mostly silent
- ☐ Do not attend

G3_3. Perceived respect

“Do women feel their opinions are respected in household or community decisions?”

- ☐ Yes
- ☐ Sometimes
- ☐ No

G4. Leadership & Institutional Presence

G4_1. Leadership roles held by women

“Is any woman from your household currently holding a leadership role?” *(Multiple allowed)*

- ☐ SHG office bearer
- ☐ FPO / cooperative board member
- ☐ WUG committee member
- ☐ Panchayat committee
- ☐ None

G4_2. Willingness to take leadership

“If given training and support, would women from your household be willing to take leadership roles?”

- ☐ Yes
- ☐ No
- ☐ Not sure

G5. Control Over Time & Benefits of Transition

G5_1. Change in time availability (perceived)

“In the last one year, has women’s available time for rest, work, or learning changed?”

- ☐ Increased

- ☐ No change
- ☐ Decreased

G5_2. Use of freed time (if Increased)

“How is this additional time mainly used?”

- ☐ Income-generating work
- ☐ Agriculture / livestock
- ☐ Skill training / SHG activities
- ☐ Household rest / care
- ☐ Other

G6. Aspirations & Perceived Empowerment

G6_1. Confidence to influence future decisions

“Do women in your household feel confident they can influence important decisions in the future?”

- ☐ Yes
- ☐ Somewhat
- ☐ No

G6_2. Biggest barrier to women’s empowerment

“What do you think is the biggest barrier to women having more decision-making power?”

- ☐ Lack of income
- ☐ Heavy household workload
- ☐ Social norms
- ☐ Lack of education / exposure
- ☐ Lack of institutional support



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