ASHOKA UNIVERSITY

CENTRE FOR A
People-centric Energy Transition

Transforming Lives and Livelihoods in Coal Mine-Affected Communities: **A Study of Livelihood and Clean Energy Interventions**

May 2025

Table of Contents

List of Figure

List of Table

Abbreviations

ACPET	Ashoka Centre for a People-centric Energy Transition
CCL	Central Coalfields Limited
FGD	Focus Group Discussion
FPO	Farmer Producer Organisation
IDI	In-Depth Interview
IWRM	Integrated Water Resource Management
KII	Key Informant Interview
LPG	Liquefied Petroleum Gas
NABL	National Accreditation Board for Testing and Calibration Laboratories
OBC	Other Backward Classes
SC	Scheduled Caste
SHG	Self Help Group
SLF	Sustainable Livelihoods Framework
SLI	Solar-Based Lift Irrigation
ST	Scheduled Tribe
WUG	Water User Group

Acknowledgement

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Executive Summary

Study Context and Objectives

This study assesses the design, early implementation and readiness for scale of three community-focused initiatives piloted in Rajhara, a mining-affected region in Jharkhand. Anchored by the Ashoka Centre for a People-Centric Energy Transition (ACPET) and supported by implementation partner Ek-Gaon, these initiatives aim to enable a sustainable socio-economic transition for households historically dependent on coal-based livelihoods. The study examines: (i) the Solar-Based Lift Irrigation (SLI) system, (ii) the formation of a Farmer Producer Organization (FPO), and (iii) the landscape of household cooking practices to inform future clean energy solutions. While the first two components are active interventions designed to repurpose existing water bodies at discontinued mine areas and revive agriculture, the clean cooking study is intended to explore the scope, demand patterns, and feasibility of low-income households transitioning away from traditional fuels toward cleaner alternatives. Together, these components reflect ACPET's research focus on facilitating an inclusive, climate-resilient development in post-mining communities.

Methodology

A mixed-methods, cross-sectional design was adopted, with tools and frameworks tailored to each intervention. The Sustainable Livelihoods Framework (SLF) and Integrated Water Resource Management (IWRM) approach informed the assessment of the SLI system, while the Stakeholder Analysis, and Social Capital Theory guided the FPO evaluation. The clean cooking study was evaluated using the AARQA framework (Availability, Accessibility, Reli- ability, Quality, Affordability), integrating both quantitative and qualitative tools. Quantitative surveys were conducted with 258 households for the clean cooking fuel study and 42 households under the SLI intervention. In total, approximately 27 qualitative interviews were carried out across the three components, including KIIs with implementation partners, Panchayati Raj Institution (PRI) members, financial institutions, and market stakeholders, as well as FGDs with SHG members, farmers and Water User Group (WUG) participants.

Key Findings

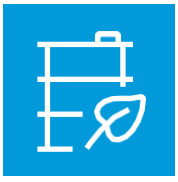
Solar-Based Lift Irrigation (SLI)

- At baseline, 100% of farmers were dependent on rainfall, with nearly no access to reliable irrigation systems.
- The SLI system, inaugurated in December 2024, became fully operational in May 2025. Although initial technical issues delayed uptake, farmers are now preparing to use the system in the upcoming crop cycle.
- Nearly 98% of surveyed farmers believe the system will increase their agricultural income and allow for crop diversification, particularly toward vegetables, pulses, and water-intensive crops.

- The average pre-intervention annual farm income was ₹15,286, highlighting the importance of reliable irrigation in improving household earnings.
- While almost all farmers surveyed were enrolled in Water User Groups (WUGs), awareness of governance responsibilities and water-use protocols remains limited, indicating a need for orientation and institutional strengthening.
- Farmers expressed strong willingness to pay for irrigation services:
  - 83.3% preferred a pay-per-acre pricing model, with a median willingness to pay of ₹100 per acre per cropping cycle.
  - A smaller segment (14.3%) opted for a pay-per-hour model, with a median willingness to pay of ₹10 per hour of usage.
- Laboratory testing of the irrigation water confirmed that it is chemically balanced, non-saline, and free of microbial or heavy metal contamination, making it suitable for long-term agricultural use and supporting the technical validity of the intervention.

Farmer Producer Organisation (FPO)

- The FPO in Rajhara has been formally registered, with implementation led by local partner EkGaon. However, apart from the 10 designated board members, no additional farmers have enrolled as members yet, and core operations such as service delivery, input procurement, or collective marketing have not yet been initiated..
- Agriculture in this intervention site is mainly subsistence-oriented, with low post-harvest value capture due to lack of cold storage, poor access to quality inputs, pest damage, and frequent crop losses from stray animals (e.g., nilgai).
- While only 23.8% of surveyed farmers were aware of the FPO's formation, there is strong latent interest in joining, provided irrigation, input support and market linkages are reliably delivered.
- Stakeholder engagement with market actors and financial institutions remains limited, and no formal convergence with government schemes or support systems has yet been established.
- Confusion exists between the roles of WUGs under the irrigation intervention and FPO membership, with many farmers mistakenly assuming that SLI enrolment includes automatic FPO participation.



Clean Cooking Fuel

- Among 258 surveyed households (all women respondents), 56.6% rely exclusively on traditional fuels (wood, dung, coal, goliya), 31.4% use a mix of traditional and clean fuels, and only 12% use clean fuels (LPG) exclusively.
- Wood (62.6%) is the most commonly used cooking fuel, followed by cow dung (47.6%), goliya (31.7%), and coal (16.3%). The average collection time per trip is 127 minutes for wood, 126 minutes for dung, 143 minutes for goliya, and 179 minutes for coal–with women responsible for over 90% of all fuel collection.

- Cooking remains a time-intensive task, with women spending an average of 2 hours and 42 minutes (162 minutes) daily on cooking, mostly indoors, increasing exposure to smoke and indoor air pollution.

- Only 12% of households rely exclusively on LPG. Most reserve it for emergencies or guests due to high refill costs ranging between ₹1,000-₹1,200.

- Affordability emerged as the most significant barrier: 92.2% of households cited high cost as the primary reason for irregular LPG use. The median willingness to pay was ₹672 per month, much less than the actual refill amount.

- Health risks from traditional fuels are widely recognised. 84.5% of respondents were aware of health implications. Still, 10.1% reported respiratory ill- ness and 10.9% reported eye irritation in the past year.

- Goliya fuel testing confirmed poor combustion properties (low calorific value: 3053 kcal/kg; high ash content: 48.73%), directly contributing to increased smoke exposure, eye irritation, and respiratory symptoms. These findings validate user-reported experiences of discomfort and smoke-heavy cooking environments.

- Women face a dual burden—both as collectors of biomass fuels and as those most exposed to smoke during cooking. This imposes a significant opportunity cost on their time and health, further compounding existing vulnerabilities.

- SHG networks show strong potential as peer educators and community champions for clean cooking transitions. Many members expressed willingness to conduct demonstrations, support behaviour change, and facilitate credit-linked access to clean cooking technologies if equipped with the right tools and training.

Cross-Cutting Insights

- Economic affordability remains the most binding constraint across all three interventions, even where physical infrastructure or awareness exists.

- Gender dynamics were central: women bear the dual burden of fuel collection and exposure in cooking but also emerged as key potential drivers of change through SHG networks.

- There is limited convergence with national/state schemes currently. PM Ujjwala is the only active scheme observed. Opportunities for alignment with SFAC, JREDA, or PM-KUSUM remain untapped.

- Community trust and uptake hinge on visible early results and transparent governance, especially in SLI and FPO components.

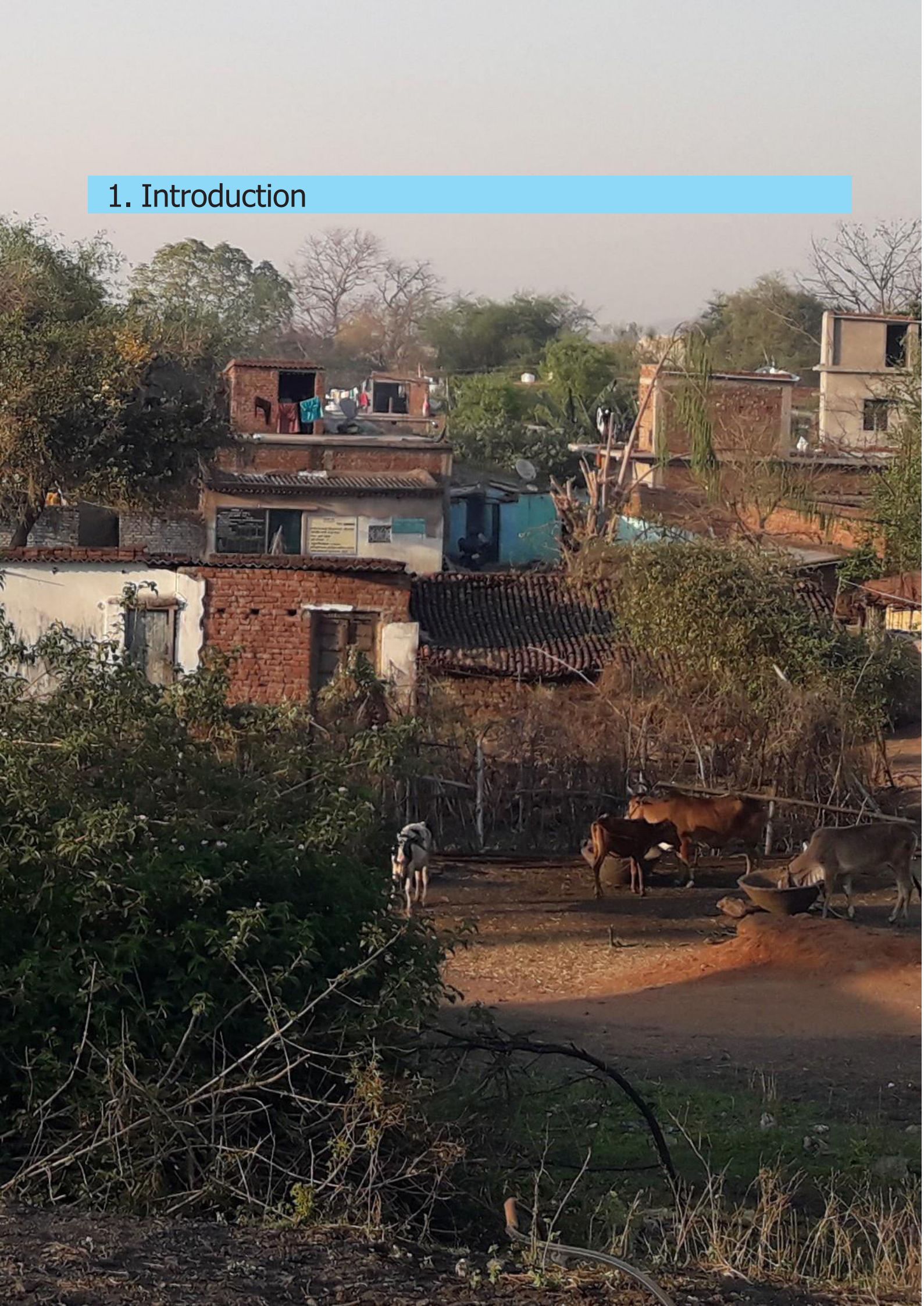
Recommendations

- **SLI:** Expand pipeline coverage, demonstrate yield gains through pilot plots, strengthen WUG governance and implement phased cost-recovery mechanisms.

- **FPO:** Launch high-visibility services (e.g., bulk input procurement), build strategic partnerships with KVK and SFAC, and clarify institutional roles.

- **Clean Cooking:** Enable targeted subsidies, introduce low-cost alternatives like induction stoves, create SHG-based credit models, and operationalise SHGs as behavioural change agents.

1. Introduction



Introduction

1.1. Context of the Study Impact of Mine Closure on Livelihoods

Coal mining has been a key driver of employment in India, providing direct and indirect jobs to millions, particularly in coal-rich states like Jharkhand, Odisha, Chhattisgarh and West Bengal[1]. However, mine closures create an economic void, leading to loss of livelihoods, forced migration and socio-economic distress in these regions[2]. Mining closures also lead to land degradation and the deterioration of infrastructure, making economic diversification challenging[3]. The lack of alternative livelihoods exacerbates poverty, as local economies remain heavily reliant on mining activities with little preparation for a transition.

Mining activities significantly alter land use patterns, often leaving behind infertile land that remains economically unproductive. In many cases, mining companies fail to rehabilitate the land effectively, leading to long-term degradation and restricted agricultural use[4]. Unplanned abandonment results in unsafe mining voids and waste dumps that further restrict land utilisation. While mine reclamation plans exist, their implementation remains weak due to a lack of enforcement mechanisms[5].

Communities dependent on mining for employment and ancillary businesses experience immediate economic shocks upon closure. Affected workers often lack the necessary skills to transition into alternative employment, thereby deepening their economic vulnerability[6]. Furthermore, compensation and rehabilitation measures are usually inadequate, leading to social unrest and migration to urban areas in search of low-paying employment opportunities[7]. Women and marginalised groups, particularly, suffer from a lack of access to reskilling programs and alternative livelihood opportunities[8].

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[1] *Khanna, A. A. (2013). Governance in Coal Mining: Issues and Challenges. TERI-NFA Working Paper. Microsoft Word - NFA-WkP9-3B-Coal Governance*

[2] *Pillalamarry, M. R., & Pathak, K. (2014). Latent Variable Modeling Approach for Assessing Social Impacts of Mine Closure. Open Journal of Applied Sciences. Latent Variable Modeling Approach for Assessing Social Impacts of Mine Closure*

[3] *Tripathi, N., Singh, R. S., & Hills, C. D. (2016). Reclamation of mine-impacted land for ecosystem recovery. Springer. (PDF) Reclamation of Mine-Impacted Land for Ecosystem Recovery.*

[4] *Sarkar, A. N. (2013). Review of strategic policy framework for re-evaluating 'CSR' programme impacts on the mining-affected areas in India. Emerald Insight. Review of Strategic Policy Framework for Re-Evaluating 'CSR' Programme Impacts on the Mining-Affected Areas in India | Emerald Insight.*

[5] *Husain, H. J., Wang, X., Pirasteh, S., & Mafi-Gholami, D. (2024). Review and assessment of the potential restoration of ecosystem services through the implementation of the biodiversity management plans for SDG-15 localization. Heliyon. Review and assessment of the potential restoration of ecosystem services through the implementation of the biodiversity management plans for SDG-15 localization - PubMed.*

[6] *Heerden, V., Johannes, J. (2016). Sustainable mining communities post mine closure: Critical reflection on roles and responsibilities of stakeholders towards local economic development in the City of Johannesburg. Stellenbosch University. Sustainable mining communities post mine closure: Critical reflection on roles and responsibilities of stakeholders towards local economic development in the City of Matlosana.*

[7] *Dhyani, S., Santhanam, H., & Dasgupta, R. (2023). Exploring synergies between India's climate change and land degradation targets: Lessons from the Glasgow Climate COP. Land Degradation & Development. Land Degradation & Development | Environmental & Soil Science Journal | Wiley Online Journal.*

[8] *Singh, G. (2008). Mitigating environmental and social impacts of coal mining in India. India Environment Portal. Singh, G. (2008). Mitigating environmental and social impacts of coal mining in India. India Environment Portal - Search.*

1.2. About the Programme

The "Transforming Life and Livelihood of Coal Mine Communities" (Trans-mine) project was initiated by the Ashoka Centre for a People-centric Energy Transition (ACPET) to explore and address the issues faced by communities surrounding discontinued and abandoned coal mines. In India, over 100,000 hectares of land remain unutilised due to the cessation of coal mines. Over 299 regions have witnessed the closure of mines, resulting in approximately five million job losses. Communities around the coal mines are heavily dependent on its operation for their life and livelihoods. Closing these mines has a drastic change in their eco-system. A similar story exists at the discontinued coal mine in the Rajhara area of Jharkhand, in eastern India. ACPET designed empirical research for promoting people-centric mine closures. Field surveys were conducted to identify the challenges faced by local communities. Subsequently, a list of key interventions was developed to address the identified issues.

Following a comprehensive review of the literature and baselining surveys, three interventions were identified for on-ground implementation. These initiatives are –

- **Solar-Based Lift Irrigation System:** The intervention aims to improve agricultural irrigation by harnessing solar energy, ensuring farmers in the abandoned coal mine area of Rajhara have reliable access to water. This initiative also strives to breathe new life into underutilised land, transforming it into productive agricultural spaces.

- **Farmer Producer Organization (FPO):** This intervention is designed to enhance farmers' incomes in areas where coal production has ceased. By focusing on capacity building, promoting gender equity and facilitating knowledge sharing, ACPET envisions effectively strengthening both the forward and backward linkages of the agricultural sector in the Rajhara Coalfield region.

- **Clean Cooking Practices:** An intervention is proposed to introduce healthier cooking alternatives, aiming to reduce health risks associated with the use of coal residue as a cooking fuel in communities near coal mines. This initiative will help improve indoor air quality and overall health within the community.

1.4. Study Objectives

While specific research questions under each of the interventions are mentioned in their respective chapters, the overarching objective of this study is stated below:

- To generate baseline evidence on the current socio-economic and environmental landscape in Rajhara and Pandwa, including agricultural practices, water availability, fuel use patterns and health outcomes.

- To evaluate the feasibility, adoption readiness and potential impact of introducing solar-powered irrigation, collective farming institutions (FPOs) and clean cooking solutions in the local context.

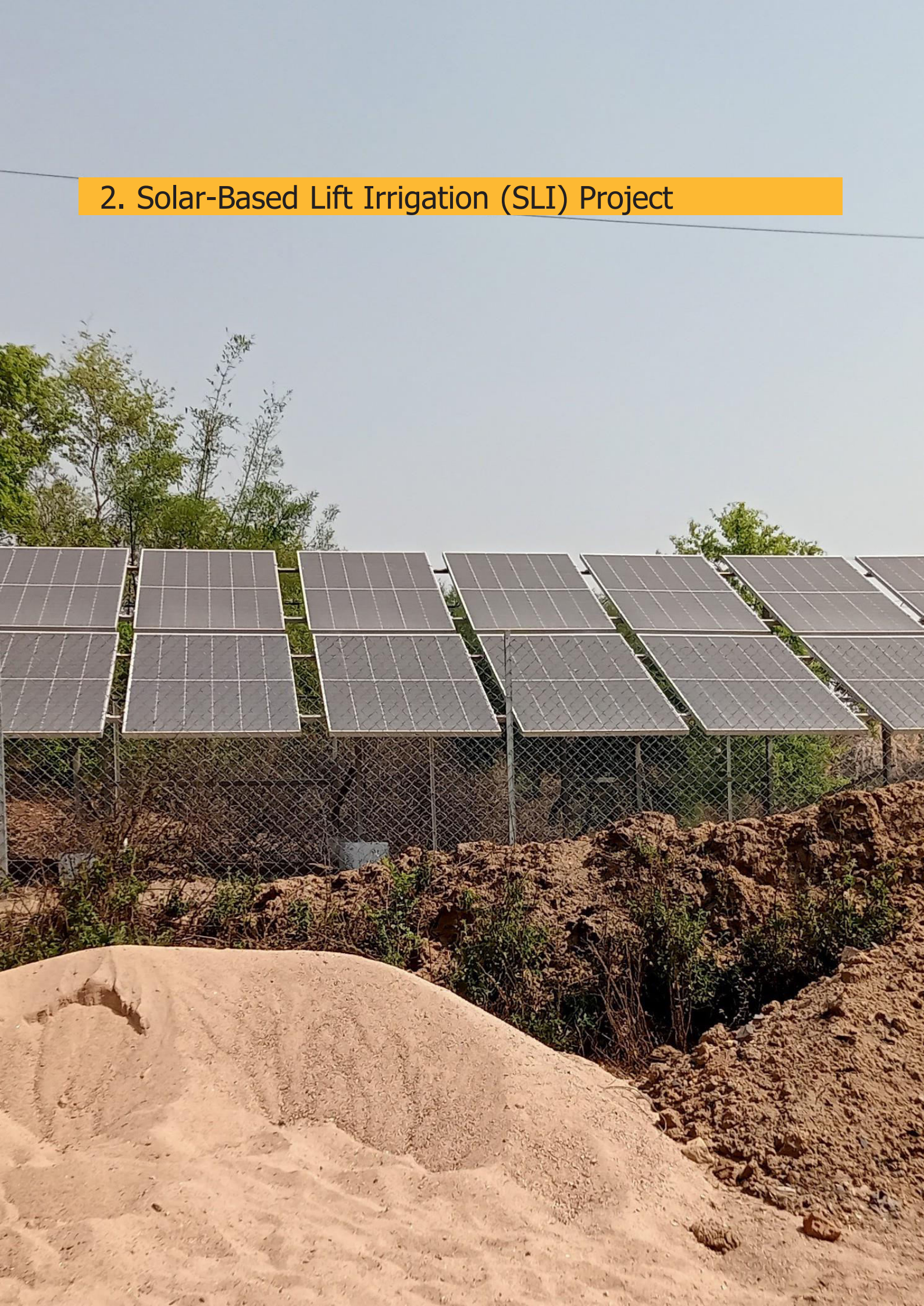
- To identify key enablers and barriers—economic, technical, institutional and cultural—that influence community uptake of these interventions.

- To propose context-specific strategies and recommendations that can support the scalability, sustainability and integration of these interventions into long-term post-mining development planning.

1.5. Report Structure

This report is structured to provide a clear, evidence-based assessment of the three key interventions designed to support sustainable transitions in mining-affected communities. Chapter 1 presents the broader context and objectives of the study. Chapters 2, 3 and 4 are each dedicated to one intervention—Solar-Based Lift Irrigation, farmer-producer organisation and Clean Cooking Fuel—and present the corresponding research questions, methodological approach, key findings and targeted recommendations to strengthen program design, implementation and long-term sustainability.

2. Solar-Based Lift Irrigation (SLI) Project



Solar-Based Lift Irrigation (SLI) Project

As part of its post-mining livelihood transition strategy, ACPET has prioritised the revival of agriculture through sustainable irrigation solutions in Rajhara. A significant milestone in this effort is the installation and commissioning of a solar-based lift irrigation (SLI) system, which was inaugurated on December 10, 2024. This system harnesses solar energy to draw water from mining pits and deliver it to agricultural fields, addressing longstanding constraints around erratic rainfall and unreliable irrigation.

The intervention emphasises decentralised management through Water User Groups (WUGs), which will be responsible for system upkeep and equitable water distribution. It also aims to reduce farmers' operational costs and enhance cropping intensity through improved access to irrigation. However, ensuring the long-term sustainability of the SLI model requires attention to several key enabling factors, such as water quality, user willingness to pay and robust institutional mechanisms for maintenance and governance.

2.1. Research Questions

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

- How can the SLI system enhance agricultural productivity and income among coal-transitioning communities, based on current cropping patterns and irrigation-related costs?
- What is the quality of irrigation water in Rajhara and what are its potential implications for agricultural productivity and sustainable water management practices?
- What factors (cost, technical know-how, cultural norms) affect adoption of SLI and how willing are farmers to pay for water usage?
- What systems and capacities are needed to sustain solar irrigation–such as training, financing, maintenance, and effective Water User Groups (WUGs)?
- How can water bodies formed at mining sites be repurposed for irrigation to support long-term livelihoods in post-mining communities?

Solar Panel Unit

2.2. Methodology

2.1.1. Study Design and Approach

To capture current conditions, community preparedness and early indications of the adoption of the solar-based lift irrigation project, we adopted a mixed-methods **cross-sectional design**.

The **Sustainable Livelihoods Framework (SLF)**[9] has been utilised as a key analytical tool to assess how the Solar-Based Lift Irrigation (SLI) system contributes to sustainable livelihoods in Rajhara's post-mining communities. The SLF is a widely used conceptual framework that examines how people access and combine various types of capital i.e., human, social, physical, financial, and natural, to sustain their livelihoods, especially in contexts marked by vulnerability or transition. It is particularly well-suited for rural and resource-dependent communities, making it an appropriate choice for Rajhara, where households are rebuilding livelihoods after mining decline.

Through SLF, we assessed how improved irrigation access potentially enhances agricultural productivity and income (financial and natural capital), how capacity-building initiatives strengthen farmers' knowledge and governance structures of WUG (human and social capital) and how solar irrigation infrastructure contributes to sustainable water use and resilience (physical and natural capital). The frame- work also helped identify barriers to adoption, willingness to pay and alignment with government initiatives, ensuring a comprehensive understanding of the intervention's sustainability and potential for scaling.

The evaluation also aimed to utilise the **Integrated Water Resource Management (IWRM) Framework**[10], a globally recognized approach that promotes the coordinated development and management of water, land, and related resources to optimise economic and social welfare without compromising the sustainability of ecosystems. The IWRM framework was selected for its relevance to assessing the solar lift irrigation system's potential to improve resource efficiency, equity, and environmental sustainability in a water-scarce, post-mining context like Rajhara. The framework was used to assess:

- **Water-Use Efficiency:** Examine current irrigation practices and potential adjustments to irrigation practices once solar irrigation is widely adopted.
- **Equity and Environmental Considerations**: Evaluate whether all groups (marginalised, smaller landholders and women-headed households) have a voice in WUG decisions, the potential environmental impact of solar irrigation compared to diesel pumps and the documentation of sustainable practices being integrated into irrigation management plans.
- **Water Quality:** Conducted water quality testing at source to assess potability, suitability for irrigation and any risks of contamination, thereby reinforcing the system's environmental sustainability.

2.1.2. Sampling and Respondent Categories

A census survey was conducted among the direct beneficiaries of the intervention, involving semi-structured interviews with all 42 households that benefited from this project. This included 24 families that directly benefited from the project, as well as 18 households adjacent to them that are expected to benefit from the project in the near future. This was complemented by purposive qualitative sampling to conduct key informant and in-depth interviews with relevant institutional stakeholders, allowing for triangulation of beneficiary

experiences with broader implementation and governance perspectives. The table below summarizes the various stakeholders that were covered.

Table 1: Sampling Plan for Solar-Based Lift Irrigation Project

Stakeholder	Method of data collection	Sample Size
Farmers (Direct beneficiaries)	Semi-structured interview	42
Panchayat Raj Institution (PRI members)	Key Informant Interview	1
Implementation partner of ACPET	In-depth interview	1

2.1.3. Data Analysis

Quantitative data from semi-structured interviews were analysed using descriptive statistics to explore irrigation access, cropping patterns, income effects, and related livelihood indicators. **Qualitative data** from KIIs and IDIs were analysed thematically using a combination of deductive codes drawn from the SLF and IWRM principles, along with inductive codes to surface contextual insights such as community governance, adoption hesitancy, and perceived benefits.

Participant quotes have been embedded within the main text to contextualize and triangulate quantitative findings, offering direct insight into lived experiences and perceptions.

[9] *https://www.livelihoodscentre.org/documents/114097690/114438878/Sustainable%2Bliveli-hoods%2Bguidance%2Bsheets.pdf/594e5ea6-99a9-2a4e-f288-cbb4ae4bea8b?t=1569512091877*

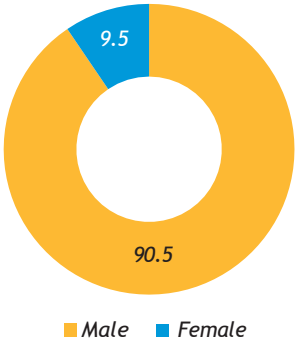
[10] *https://www.un.org/waterforlifedecade/iwrm.shtml*

2.1.4. Limitations of the Study

Given the nascent stage of this intervention, the following are a few limitations of this study:

- **Inability to Assess Actual System Functionality:** At the time of data collection, the solar-powered lift irrigation system had been installed but was not yet fully operational due to technical challenges. This restricted the study's ability to assess real-world outcomes related to irrigation performance, reliability and user satisfaction.
- **Limited Testing of Institutional and Governance Mechanisms:** The evaluation was thus unable to fully assess the operational effectiveness of Water User Groups (WUGs) in managing irrigation schedules, maintaining infrastructure or ensuring equitable access, as these functions were contingent upon pump activation.
- **Partial Application of the SLF and IWRM Frameworks:** While the SLF and IWRM Frameworks were used to assess potential impacts, several components–such as physical capital transformation and water-use efficiency–remain unvalidated due to the absence of actual water delivery through the system.

Figure 1: Gender Profile of the Respondents (in %)



2.3. Empirical Insights

2.3.1. Socio-Economic Profile of SLI Beneficiary Farmers

This section outlines the demographic and economic characteristics of surveyed households, including landholding size, cropping patterns, irrigation dependency before SLI adoption and primary sources of income.

The SLI beneficiary sample is drawn entirely from Rajhara village, reflecting the current operational footprint of the intervention. The sample is overwhelmingly male (90.5%), with limited female representation (9.5%), highlighting a gendered pattern of agricultural engagement or registration practices in the area.

In terms of caste demographics, Other Backward Classes (OBC) constitute the majority (69%) of respondents, followed by General (19%) and Scheduled Castes (11.9%). No Scheduled Tribe households were recorded in the sample.

The average landholding among beneficiaries is 2.32 acres, with a median of 2 acres, indicating a predominance of small to marginal farmers. Landholdings range from 0.20 acres to a maximum of 8 acres. On average, each household grows three types of crops annually, suggesting moderate crop diversification. However, this may also reflect limited access to irrigation or markets, which can constrain the ability to diversify further.

Figure 2: Caste Profile of the Respondents (in %)

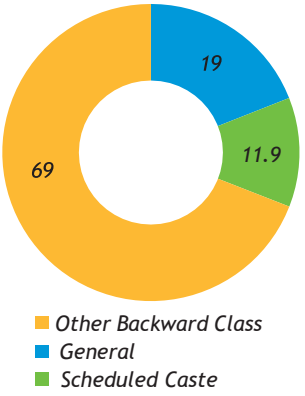
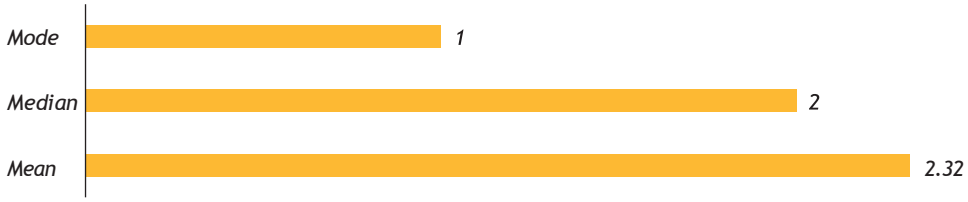


Figure 3: Size of Landholding(s) Among Respondents (in Acres)

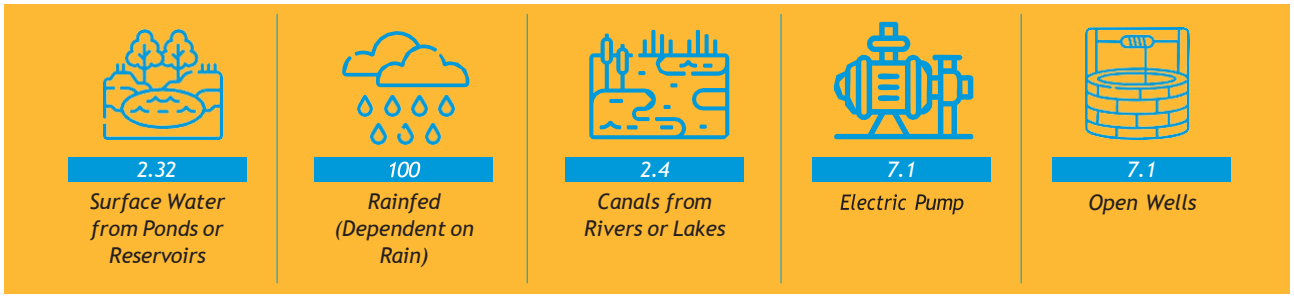


This was reinforced during field interactions, where farmers commonly expressed a strong interest in growing higher-value or water-intensive crops but noted that such diversification remained aspirational until reliable irrigation access could be ensured.

2.3.2. Availability, Accessibility & Adoption of SLI

Status of SLI Infrastructure & Operational Readiness

Figure 4: Sources for Irrigation (pre-SLI) (in %)



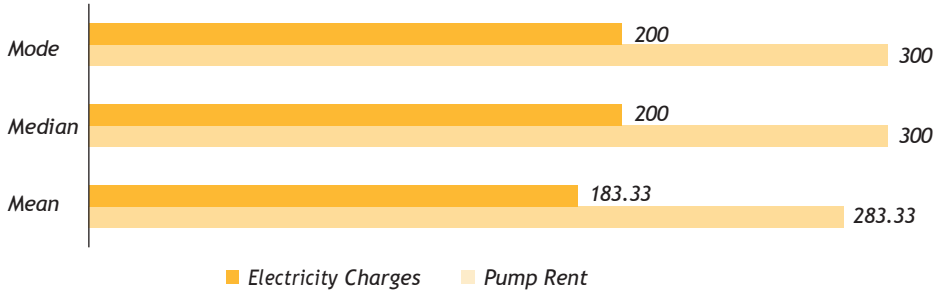
All surveyed farmers (100%) reported exclusive dependence on rainfall for irrigation, with minimal supplementary sources, including open wells (7.1%), electric pumps (7.1%) and surface water from ponds or canals (2.4% each). The absence of diesel pump usage (0%) further highlights a deficit in conventional irrigation support systems.

These findings underscore the strategic relevance of the SLI system, which seeks to convert an underused resource into a driver of agricultural revival in this post-mining region.

Prior primary survey done at this site during Phase I of this project in early 2024 also revealed a severe lack of irrigation infrastructure, with only 3 out of 49 farmers reporting any access to irrigation. Most cultivation was entirely dependent on rainfall, leaving farmers highly vulnerable to seasonal variability. During community interactions, residents pointed out that mine water pumped out by CCL was being wasted, despite its potential to support nearby farmland. As one PRI member noted, directing this water toward agricultural use "would facilitate the much-needed irrigation facilities that would, in turn, lead to increased agricultural output." These findings underscore the strategic relevance of the SLI system, which seeks to convert an underused resource into a driver of agricultural revival in this post-mining region.

Concrete ring lining installation to prevent soil collapse

Figure 5: Irrigation-Related Costs (pre-SLI) (in ₹)



Where electric pumps were used, they were deployed in a limited and ad hoc manner. Respondents who had access to these systems reported using them for an average of 31.7 hours per farming cycle, spanning approximately 2.3 days across two cropping cycles annually. Rental costs averaged ₹283 per cycle and electricity charges were reported at ₹183 per cycle. This underscores the modest scale and limited affordability of existing irrigation alternatives.

> *When they first started the system, we received water for only three days. After that the motor stopped working and nobody came to check. We thought we would be able to grow vegetables this season, but now even our regular crops are at risk. Some fields haven't seen a drop of water.*
>
> ***— Farmer, Rajhara***

Status of SLI Infrastructure & Operational Readiness

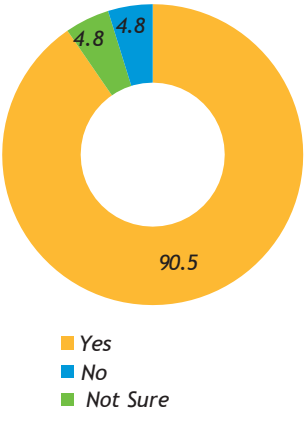
At the time of the primary data collection under this study, the SLI system, though installed and inaugurated, had not yet reached full functionality due to a series of minor technical challenges. These early-stage issues had temporarily affected farmers' ability to access water.

However, the SLI system has since become operational. Field follow-ups conducted in early May 2025 confirmed that water delivery through the system began around 4–5 days prior to reporting, with supply currently active for 1 to 1.5 hours per day. Local farmers expressed that while the water was not being used immediately, owing to the completion of the current cropping season, there is strong intention to utilise the system for the upcoming crop cycle.

Farmer Adoption & Usage Patterns

An overview of who accesses the SLI system, how frequently they use it and whether they have adjusted their farming strategies in response to its availability is provided below.

Figure 6: Perceived Benefits of SLI for Crop Diversification (in %)



Even before the system became operational, sentiment toward the intervention was highly positive. According to household interviews, 90.5% of respondents believe that adopting the SLI system will allow them to grow a greater variety of crops, indicating strong aspirational potential linked to improved irrigation access: only a minority expressed uncertainty (4.8%) or scepticism regarding its impact on crop diversification. While actual usage was limited prior to activation, this optimism, now supported by early operational performance, positions the intervention for high uptake in the next agricultural season.

With visible water delivery now in place, households are planning to adjust their sowing and input strategies to take advantage of the irrigation system in the weeks ahead. Households farther from the pump site, who previously lacked access, are particularly keen to see extended pipeline coverage to ensure equitable reach.

Water Distribution & Governance Challenges

While a majority of respondents reported awareness of WUG structures, there was limited understanding of specific roles, responsibilities, or grievance mechanisms. Field interviews revealed that several farmers were unclear about how decisions would be made regarding water scheduling or maintenance responsibilities, particularly in the absence of clear communication or formal orientation from project teams. A few respondents also suggested appointing a designated caretaker for pump monitoring and publicly displaying contact details of WUG members to facilitate accountability indicating that grassroots solutions for transparent governance already exist within the community.

Highlights: Availability, Accessibility & Adoption of SLI

- **Irrigation gap was stark:** 100% of surveyed farmers depended on rainfall, with no use of diesel pumps–highlighting the critical need for the SLI system.
- **SLI is now operational:** As of May 2025, water is being delivered for 1-1.5 hours/day; farmers are planning to adapt cropping strategies in the upcoming season.
- **Adoption intent is high:** Over 90% of respondents believe SLI will enable crop diversification, particularly for vegetables and pulses.
- **However, governance and coverage gaps remain:** Households further from the pump await pipeline extension, and Water User Groups (WUGs) need clearer roles and better communication.

2.3.3. Impact on Agriculture & Livelihoods

Changes in Crop Yield & Diversification

Access to reliable irrigation through solar-based lift systems is expected to enhance cropping options for farmers significantly. When asked about intended cultivation under solar irrigation, farmers expressed a strong interest in expanding or introducing a variety of water-reliant and market-oriented crops. Specifically, 84.2% of respondents plan to grow wheat, 81.6% plan to grow vegetables and 76.3% plan to grow rice once the system becomes fully functional. Pulses (55.3%) and oilseeds (50.0%) were also mentioned as planned additions or expansions. Notably, no farmer reported plans to grow fruits or other crop types outside these main categories.

Figure 7: Crops Farmers Intend to Cultivate Using SLI (in %)

These responses suggest that the SLI intervention is expected to enable diversification into water-intensive and high-value crops, particularly vegetables, beyond the traditional rainfed crop cycles. Such diversification may enhance household food security and create new income-generating opportunities through market-oriented farming.

Economic Impact on Farmers

Expectations around income enhancement are high. 97.6% of respondents believe that the introduction of SLI will result in increased agricultural income. This optimism is fundamental, given the fragile baseline: The average pre-SLI annual farm income was reported as ₹15,286, with some respondents reporting no income at all (only subsistence farming). The median income stood at ₹10,000, indicating that a majority of farmers operate at a marginal level with limited returns. These economic constraints amplify the importance of a functioning irrigation system. Several respondents noted that without irrigation, their land remains fallow during dry periods, further depressing annual income.

Figure 8: Farmers Expecting Increase in Income Due to SLI (in %)

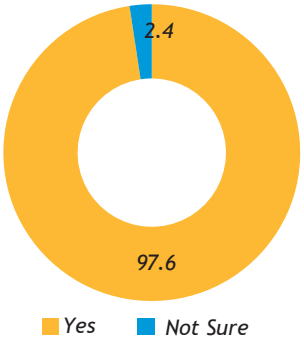
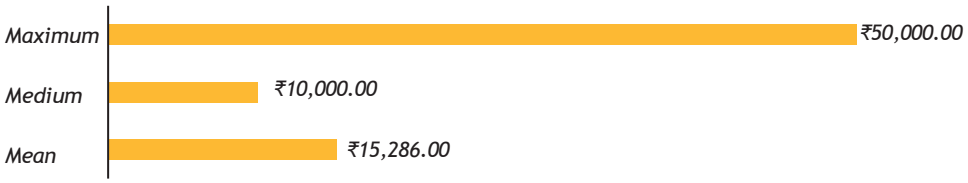


Figure 9: Total Farm Income from Agriculture per Year (Before Solar Irrigation)



This data reinforces the transformative potential of reliable irrigation infrastructure—not only in enabling diversification but also in strengthening economic resilience for smallholder farmers in the region.

Recent feedback from farmers confirms that while the water is not being used immediately (as the rabi season has ended), most households see the next crop cycle as a critical opportunity to increase acreage and returns. The prospect of growing a second crop, or shifting toward higher-value produce, is expected to improve household resilience, especially among smallholders.

As usage picks up in the upcoming season, the project will be able to provide early evidence of economic gains. Ensuring consistent delivery and timely input access will be key to translating potential into measurable impact.

Highlights: Impact on Agriculture & Livelihoods

- **Farmers are planning a shift to higher-value crops:** Over 80% intend to grow wheat, vegetables or rice under SLI; pulses and oilseeds are also gaining traction.
- **SLI is expected to enable a second crop cycle,** reducing dependency on a single rainfed season and improving household food and income security.
- **Income expectations are high:** 97.6% believe SLI will increase earnings, especially important as many currently earn just ₹10,000-₹15,000 annually from farming.
- **Farmers see the upcoming season as a turning point,** with plans to increase acreage and diversify produce as soon as consistent water access is ensured.

2.3.4. Financial Feasibility & Willingness to Pay for SLI Services

The water sample tested by Qualissure Laboratory Services, an NABL (National Accreditation Board for Testing and Calibration Laboratories) accredited lab, confirms that the source identified for the SLI system in Rajhara meets potable and agricultural safety standards as per IS 10500:2012 (RA-2018). The table below presents the key test findings and their implications for agriculture. The full test report has been added to the Annexure of this document.

Table 2: Key Findings based on Water Quality Assessment

Parameter	Test Result	Acceptable Limit	Implication for Agriculture and Irrigation
pH	7.49	6.5 – 8.5	Neutral pH supports crop growth and avoids soil acidification or alkalinity.
Total Dissolved Solids (TDS)	174 mg/l	≤ 500 mg/l	Low TDS ensures water is non-saline and suitable for a wide range of crops.
Total Hardness (as $CaCO_3$)	91.1 mg/l	≤ 200 mg/l	Safe level for irrigation; does not impact soil permeability or crop health.
Calcium	22.2 mg/l	≤ 75 mg/l	Supports plant nutrition without contributing to soil scaling.
Magnesium	8.6 mg/l	≤ 30 mg/l	Within limit; beneficial for chlorophyll production in plants.
Iron	0.15 mg/l	≤ 1 mg/l	Safe level; will not cause toxicity or stain plants/soil.
Chloride	23.7 mg/l	≤ 250 mg/l	No risk of salinity; supports soil structure integrity.
Sulphate	13.8 mg/l	≤ 200 mg/l	Safe concentration; not harmful to plants.
Fluoride	< 0.1 mg/l	≤ 1.0 mg/l	Within safe limits; avoids toxicity risks.
Nitrate	< 0.5 mg/l	≤ 45 mg/l	Not excessive; supports plant growth while avoiding groundwater contamination.
Microbiological (E. coli & Total Coliform)	Not Detected	-	Water is microbiologically safe–reduces risks of contamination in edible crops.
Heavy Metals (Lead, Arsenic, Mercury, Cadmium)	<0.01 - <.001	As per IS 3025 (<.01 - <.001)	Near absence of such heavy metals ensures long-term soil and crop safety.

These results validate the technical viability of the SLI intervention from a water quality standpoint and reinforce its relevance in addressing water scarcity in the post-mining context.

The tested water source is chemically balanced, non-saline and free from microbial or heavy metal contamination. It is well-suited for irrigation in terms of both crop health and long-term soil sustainability. These results validate the technical viability of the SLI intervention from a water quality standpoint and reinforce its relevance in addressing water scarcity in the post-mining context.

2.3.5. Financial Feasibility & Willingness to Pay for SLI Services

Farmers' Willingness to Pay for Water Services

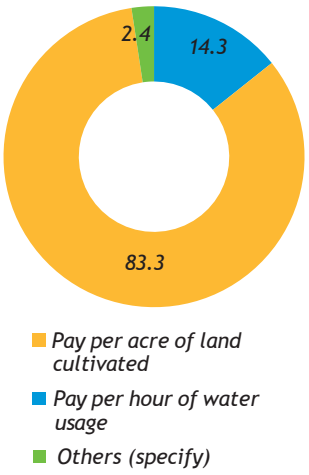
Survey findings indicate a strong inclination among farmers to contribute financially toward the sustainability of the SLI system, provided that water delivery remains reliable and accessible.

A clear majority (83.3%) expressed a preference for a per-acre pricing model, citing its simplicity and alignment with existing landholding practices. Only a tiny segment (14.3%) preferred a per-hour usage model, often associated with greater flexibility but also higher monitoring overhead.

In terms of payment capacity, the median and modal amount farmers are willing to pay per acre of cultivation is ₹100, while for those preferring a per-hour basis, the willingness to pay stands at ₹10. Despite the variation in willingness to pay, a common preference emerged for low initial rates, particularly among farmers with marginal incomes.

A few respondents advocated for a phased pricing approach, where lower charges would apply in the early operational period, increasing gradually once crop yields and incomes improved. Others highlighted the need for transparent communication on how fees would be used, especially for maintenance and spare part procurement.

Figure 10: Farmers' Preferred Payment Model (in %)



Cost-Sharing & Sustainability of WUGs

Water User Groups (WUGs) are emerging as a foundational governance mechanism for managing the solar lift irrigation system in Rajhara. A large majority (95.2%) of surveyed farmers reported being members of WUGs, indicating strong initial uptake and recognition of the collective model. This high level of participation suggests an existing platform for coordinated action around irrigation planning, cost-sharing and maintenance. However, participation in these groups often does not translate into detailed knowledge of governance processes. Field interviews revealed that several members were unaware of specific rules regarding water allocation, cost-sharing norms, or grievance redress procedures. In a few cases, farmers reported confusion over who held responsibility for technical troubleshooting or decision-making, suggesting that formal mechanisms for WUG orientation and accountability may require strengthening.

Structured Interview with a beneficiary

However, while participation is widespread, the long-term sustainability of WUGs will depend on their institutionalisation, financial transparency and decision-making autonomy. To date, there is limited evidence of formalised mechanisms to calculate operational costs or maintain the infrastructure, highlighting the need for capacity-building inputs. Establishing clear water-use rules, conducting periodic reviews of user contributions and implementing grievance redressal systems will be crucial in ensuring these groups transition from informal collectives to sustainable rural water governance institutions.

Highlights: Financial Feasibility & Willingness to Pay

- 83.3% of farmers prefer a per-acre payment model. **₹100 per acre** is the median and most common amount farmers are willing to pay while for those preferring a per-hour basis, the willingness to pay stands at **₹10**, indicating affordability concerns among marginal households.
- **WUG participation is high (95.2%)** but deeper engagement is limited; many farmers lack clarity on cost-sharing, roles and grievance redress.
- A phased payment model and clearer accountability mechanisms can help build long-term trust and ensure shared ownership of the system.

2.4. Conclusion

The Solar-Based Lift Irrigation project in Rajhara demonstrates significant promise as a transformative intervention to support post-mining livelihood transitions through improved agricultural productivity and irrigation access. While the infrastructure has been installed and initial governance structures like Water User Groups (WUGs) have been established, the system was not fully operational at the time of data collection. However, it has since become functional, with water delivery initiated in early May 2025. Early reports from farmers confirm that the system is now operational, though active use will only begin with the next crop cycle.

Farmers exhibited strong aspirations toward crop diversification, income enhancement, and collective governance. Although early technical challenges—such as pump malfunction and incomplete pipeline extensions—temporarily delayed uptake, these have begun to be addressed, and the intervention is now poised for utilisation in the upcoming crop cycle. Households are preparing to adjust their cultivation strategies in response to the newly available irrigation supply.

Laboratory testing of the irrigation source confirms that the water is chemically balanced, non-saline and free from microbial or heavy metal contamination, making it highly suitable for sustained agricultural use and reinforcing the technical soundness of the intervention. Despite early limitations, community willingness to pay, strong interest in water-intensive crops and near-universal WUG enrolment reflect substantial latent potential. The successful rollout of irrigation in the next season offers an opportunity to demonstrate value, strengthen trust, and gather evidence of impact.

SLF Perspective: Contribution to Sustainable Livelihoods

The SLI project directly advances multiple forms of capital as defined under the Sustainable Livelihoods Framework (SLF). By enabling irrigation for previously rainfed farms, it **strengthens natural capital,** offering protection against rainfall variability. Farmers' plans to diversify into vegetables, pulses and oilseeds signal a pathway to **enhanced financial capital,** especially in a region with pre-intervention median agricultural incomes of just ₹10,000 per year.

The project also contributes to **social capital** through the formation of WUGs, where 95.2% of surveyed farmers are members. However, the governance capacities of these groups remain uneven, highlighting the need to invest in human capital through structured orientation and transparent decision-making mechanisms. The solar-based infrastructure, once stabilised and scaled, will also contribute to physical capital through renewable, cost-effective water supply infrastructure.

IWRM Perspective: Advancing Water Equity and Efficiency

Viewed through the lens of Integrated Water Resource Management (IWRM), the project holds strong potential for **improving water-use efficiency,** replacing scattered and limited irrigation methods (open wells, surface ponds) with a consolidated, community-managed system. However, real efficiency gains will depend on supporting farmers with crop planning and input access once irrigation becomes reliable.

In terms of **equity,** the project has successfully enrolled small and marginal landholders while also ensuring participation by women. Strengthening governance within WUGs will be essential to achieving equitable water access. On the **environmental** front, the utilisation of mine water via solar energy avoids groundwater depletion and fossil fuel dependence, aligning the project with sustainable, climate-resilient water use goals.

With the infrastructure in place, community enthusiasm high and water quality validated, the SLI initiative is now well-positioned to deliver on its promise of low-carbon, inclusive agricultural renewal in a post-mining context. Maximising its impact will require fine-tuning governance, extending pipeline reach, and closely supporting farmers through the first full season of use.

2.5. Recommendations

The SLI intervention in Rajhara is now entering a critical phase, with water delivery functional and farmer intent high. To fully realise its transformative potential, the project must now focus on consolidating governance, financial mechanisms, and agronomic planning to ensure both uptake and sustainability in the upcoming crop cycle and beyond.

1. Extend Water Access to All Enrolled Households

- Extend pipelines to currently uncovered plots, prioritising marginal and distant farmers.
- Share a clear rollout timeline with the community.

2. Demonstrate Early Results in the Next Crop Cycle

- Set up a few pilot plots (e.g., vegetables, pulses) using SLI water to show viability.
- Track yields and cost savings to build farmer confidence and encourage uptake.

3. Strengthen Water User Group (WUG) Governance and Participation

- Support Water User Groups (WUGs) through regular check-ins for at least two crop cycles.
- Hold an orientation with clear role definitions (e.g., caretaker, treasurer, grievance contact).
- Display water schedules, caretaker details, and WUG roles publicly at the pump site.
- Create simple, shared rules for water use and conflict resolution to avoid misuse.

4. Introduce Fair and Transparent Payment Systems

- Start with the preferred per-acre payment model, which is easy to manage and matches local landholding patterns.
- After one full crop cycle, consider shifting to a per-hour model—only after showing benefits and consulting users.
- Keep a simple ledger of contributions and expenses, updated monthly and available to all WUG members.
- Review payment uptake and fairness mid-season and adjust if needed.

3. Farmer Producer Organization (FPO) Project

Farmer Producer Organization (FPO) Project

In Rajhara's shifting economic landscape, the establishment of a Farmer Producer Organization (FPO) represents a critical step in organising local farmers into a collective that can improve productivity, reduce input costs and secure better market access. The FPO has already been formally registered. EkGaon, a local partner with experience in rural development and digital agriculture, is implementing this project. A comprehensive baseline survey of all farmers in the area has been completed and the process of mobilising and enrolling members into the FPO is currently underway.

3.1. Research Questions

To assess the FPO's relevance, acceptance and institutional robustness, the following research questions are explored:

- What does the existing baseline data (on productivity, farming practices, gender dynamics and market access) reveal about the current agricultural context and potential entry points for the FPO's early interventions? - Focus is on utilising the social resource mapping survey to identify opportunities and constraints before significant FPO-led changes take effect.
- How aware is the community of the FPO's objectives and functions and how accepting are they towards this intervention? What is their potential interest in joining the FPO and what factors influence their acceptability and anticipated challenges in participation and support?
- What infrastructural and operational challenges (e.g., lack of office spaces, warehousing and storage) does the FPO anticipate in its early stages and what strategies can be implemented to address these challenges and support the FPO's growth and sustainability?
- How do key stakeholders (e.g., CCL, district authorities, financial institutions) perceive their role in supporting the FPO and what resources, motivations and barriers influence their engagement and contribution to the FPO's success?
- What lessons can be drawn from existing FPOs in India regarding success and failure factors and how can these insights inform strategies to ensure the sustainability of the Rajhara FPO? - An extensive desk review will be conducted to analyse documented case studies and evaluations of FPOs across India, helping identify best practices and challenges.
- How can coal companies integrate support for FPOs into their mine closure social responsibility plans to promote sustainable livelihood transitions? - A case study will be developed, utilising both desk review and primary field data, to argue for the involvement of coal companies in strengthening FPOs as part of sustainable mine closure planning and post-mining economic diversification.

3.2. Methodology

3.2.1. Study Design and Approach

The study adopted a qualitative design. This involved qualitative interactions with multiple stakeholders, as well as a comprehensive desk review. To capture the multifaceted nature of community dynamics, stakeholder interactions and the strategic pathways leading to desired outcomes, the following frameworks were used as the guiding principles for the evaluation:

- **Stakeholder Analysis** is a systematic process used to identify and evaluate the interests, influence and relationships of all parties involved in or affected by the FPO Project. This framework is crucial for understanding the diverse perspectives and motivations that different stakeholders bring to the table. By mapping out the roles and levels of influence of each stakeholder, Stakeholder Analysis helps assess their potential contributions, support and barriers to the FPO's success.

- **Social Capital Theory**[1] focuses on the networks, relationships and norms within a community that facilitate collective action and cooperation. In evaluating the FPO Project, elements of this theory were utilised to adopt a lens for examining the underlying social dynamics that influence the community's ability to support and sustain the FPO. This theoretical perspective complements the Stakeholder Analysis by providing deeper insights into the social fabric of the community, thereby enriching the evaluation with a comprehensive understanding of the factors that underpin the FPO's potential for fostering a vibrant business ecosystem and enhancing livelihoods in a post-mining setting.

3.2.2. Sampling and Respondent Categories

The table below lists the various stakeholders covered under the scope of this evaluation. A mix of FGDs, KIIs and an IDI was conducted using purposive sampling, aimed at capturing diverse insights across community, institutional, and market actors.

Table 3: Sampling Plan for FPO Project

Stakeholder	Method of data collection	Sample Size
Farmers (non-FPO members; male)	Focus Group Discussion (FGD)	4
Farmers (non-FPO members; female)	FGD	3
Farmers (registered FPO members)	FGD	1
FPO Leadership Team (current board members)	FGD	1

1 https://open.ncl.ac.uk/theories/16/social-capital-theory/

Stakeholder	Method of data collection	Sample Size
Panchayat Raj Institution (PRI members)	Key Informant Interview (KII)	1
Market stakeholders (any input supplier, wholesaler, etc., who can potentially be linked with the FPO)	KII	3
Financial institutions (nearby bank/ microfinance institutions' representatives)	KII	4
Successful FPOs	KII	1
Implementation partner of ACPET	IDI	1

3.2.3. Data Analysis

In the absence of quantitative data, the evaluation relied entirely on qualitative data collected through FGDs, KIIs, and IDIs. A thematic analysis approach was adopted, using deductive coding aligned with key areas of enquiry such as mobilisation, governance, capacity-building and market linkage, etc. Participant quotes are embedded throughout the report narrative to illustrate stakeholder perspectives and triangulate findings across respondent groups.

3.2.4. Limitations of the Study

Similar to the SLI project, the following are the limitations of this component of the study:

- **Early Stage of Implementation:** At the time of this study, the FPO had only been registered with the mandatory ten founding members. Broader farmer onboarding was still ongoing and community mobilisation activities had only recently begun. As such, the evaluation could not assess actual participation trends, effectiveness of FPO-led services or early business outcomes–limiting the ability to gauge tangible impacts or behavioural shifts among the wider farming community.

- **Nascent Stakeholder Engagement:** Although stakeholder analysis was central to the evaluation, the project's current stage meant that many key stakeholders, including market stakeholders and financial partners, had not yet been engaged. This limited the depth of insights that could be drawn on institutional alignment, partnership viability or convergence strategies.

3.3. Empirical Insights

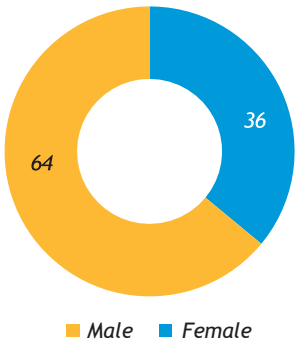
3.3.1. Socio-Economic Profile of FPO Farmers

The following section draws on detailed baseline data collected by the implementation agency EkGaon from a total of 745 farmers across the intervention area. The survey provides critical insights into the demographic characteristics, landholding patterns, income sources, irrigation access, digital and financial inclusion and cropping practices of the local farming community. These insights serve as a foundational input to assess the relevance and design of the FPO, helping identify key entry points for early interventions and long-term institutional strengthening.

Demographic Characteristics

The baseline survey covered 745 farmers, with a strong representation of women, who made up 64% of the sample. Farming activity is primarily concentrated among the working-age population: 29% of respondents were between 31-40 years, and 26% were aged 41-50. Elderly farmers (aged 61 and above) accounted for 13%, while youth under 20 comprised less than 1%, highlighting the limited engagement of younger generations in cultivation.

Figure 14: Gender Profile of the Respondents (in %)



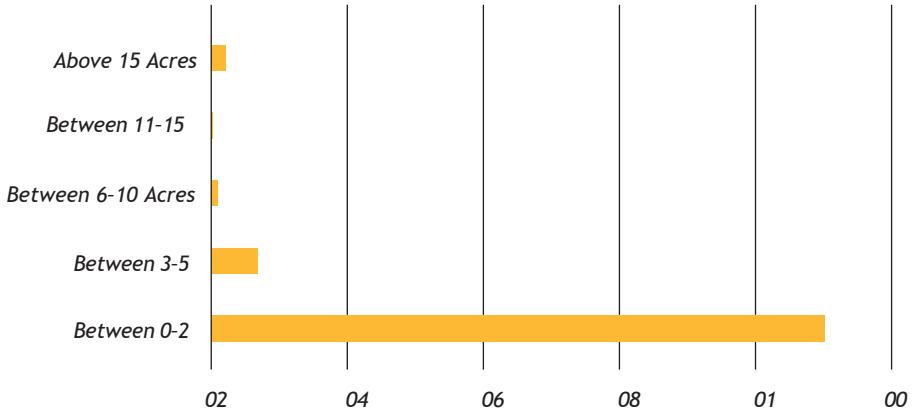
Educational levels remain low, especially among women. More than 50% of farmers were illiterate, including a disproportionately high share of female farmers. Only 6% of the farmers had completed graduation or higher. This low educational attainment potentially limits farmers' ability to access schemes, adopt new technologies, or engage with digital platforms.

Landholding and Irrigation Access

Land ownership is widespread, yet overwhelmingly small in scale. Over 90% of farmers owned less than two acres of land, while just 2% reported holdings above 15 acres. Lease-in arrangements were negligible.

Irrigation infrastructure remains underdeveloped: the majority of cultivated land (over 75%) relied on traditional sources such as open wells and streams. Only a small fraction was served by electric pumps, tube wells, or canals, indicating poor penetration of modern irrigation systems. A significant portion (over 30%) of the area was irrigated through blended, variated sources, pointing to fragmented and improvised irrigation practices.

Figure 15: Size of Landholding(s) Among Respondents (in %)



Livelihoods and Income Sources

Agriculture is reported to be the primary livelihood for the surveyed households, but most farmers depend on multiple sources of income. More than 95% of respondents reported engaging in wage labour, horticulture, fisheries, and forest produce collection in addition to cultivation. Livestock rearing was reported by 85%, and 69% were involved in allied agricultural activities. Non-farm income sources remain limited among these targeted households: only 9% reported income from remittances, 5% from rent, and 1% from small businesses.

Digital Access and Financial Inclusion

Mobile phone access is widespread among the surveyed farmers, with 77% (571 out of 745) owning their own mobile phones. Ownership is higher among women in absolute numbers, with 364 female users compared to 207 male users. However, a significant gender gap persists in relative terms: 23% of all farmers reported not having a mobile phone, including 63 men and 111 women. No respondents reported accessing mobile phones through others, indicating that those without a phone likely remain digitally disconnected. This suggests that while device penetration is strong overall, targeted efforts may be required to close the access gap—particularly for women in mobile-deficit households.

Use of digital and mass media platforms is growing: 81% reported accessing information through mobile phones, 47% through television, and 48% through

the internet. Radio use stood at 21%. Despite this, only 9% of farmers had received information on government schemes via digital or institutional channels.

Financial inclusion remains weak. While 89% of farmers had bank accounts, only 1% possessed a Kisan Credit Card. Access to credit was extremely limited: 86% reported having no access to any formal or informal credit source. Among those who did borrow, Self-Help Groups and cooperative societies were the most common sources.

Asset Ownership and Mobility

Asset ownership was modest. While 96% of farmers owned a mobile phone and 79% had electric fans, fewer than 30% owned televisions and only 15% had refrigerators. Transport and mobility assets were scarce: 62% of farmers did not use any vehicle, and ownership of tractors, three-wheelers, or four-wheelers was negligible. Bicycles, bullock carts, and cars were also present in trace numbers.

Highlights: Socio-Economic Profile of FPO Farmers

- **Majority are smallholder farmers:** Over 90% own less than 2 acres of land, with low irrigation coverage and heavy reliance on traditional water sources.
- **Women form a majority of the baseline sample (64%)** but face lower literacy and digital access.
- **Farming households depend on multiple income streams:** Over 95% engage in wage labour, livestock or forest-based work alongside agriculture.
- **Formal credit access is minimal:** Only 1% hold Kisan Credit Cards; 86% reported no access to formal or informal loans.
- **Technology use is growing,** with 81% using mobile phones for information. However, only 9% have received updates on schemes digitally.

3.3.2. Current Agricultural Practices and Farming Challenges[11]

Crop Production and Farming Practice

Seasonal Crop Patterns and Farming Systems

Agricultural activity in Rajhara follows a tri-seasonal cropping calendar, aligned with the Kharif (monsoon), Rabi (winter) and Zaid (sulmmer) seasons.

Across all farmer groups consulted, the Kharif season emerged as the most agriculturally active period. Paddy is the dominant crop cultivated during this time, with supporting crops such as arhar (pigeon pea), maize and sesame grown in smaller quantities. These are primarily rainfed and cultivated by both men and women for household consumption, with occasional surplus sold in local markets.

During the Rabi season, cropping is undertaken by those with access to water from borewells or seasonal wells. Typical crops include wheat, mustard, gram and peas. Households with limited land and water availability often supplement these resources with small-scale vegetable cultivation–typically featuring cauliflower, chilli, tomato and garlic–grown close to the homestead. Garlic, in particular, is often cultivated using stored household water and is primarily used for self-consumption.

Baseline Findings (ekGaon Baseline Survey, n=745)

- Paddy was the dominant crop, cultivated by 90% of farmers, while pulses (such as pigeon pea and gram), vegetables, and oilseeds were cultivated by smaller segments
- Paddy occupied the most land and labour, despite average sales returns
- Vegetables, though cultivated by fewer farmers, yielded the highest returns per farmer during the last crop season


Ripened wheat fields


Vegetable cultivation

> *"We have to buy seeds and often they're expired or poor quality. It's a betrayal. We don't trust the shop-keepers or the block-level distribution. Only some seeds, such as corn, are viable; others, like bhindi and tomato, are not. We no longer wish to have the government seed facility.*
>
> ***— Male Farmer, Rajhara village***

Summer cultivation, also known as Zaid cultivation, is a rare practice, primarily due to widespread water scarcity. Where residual water or stored sources are available, some farmers cultivate moong, cucumbers, or select vegetables such as brinjal and ladyfinger. However, such efforts are sporadic and opportunistic rather than part of a structured seasonal cropping strategy.

Orientation Toward Self-Consumption

A consistent pattern across FGDs is the mixed intent of cultivation. While vegetables and pulses may be sold in nearby markets such as Padwa or Daltonganj, most cereals–especially paddy, wheat and gram–are retained for household consumption. This dual-use approach reflects the subsistence nature of agriculture in Rajhara, particularly among smallholder and marginal farming households.

Key Challenges Faced by Farmers

Despite the diversity of crops and seasonal farming activities observed in Rajhara, agricultural productivity remains severely constrained by a set of recurring structural, environmental and institutional barriers.

1. Water Scarcity and Limited Irrigation Infrastructure

The most frequently cited constraint was the lack of reliable water for irrigation. Farmers across all study sites reported high dependency on monsoon rains, with wells, ponds and borewells often drying up during the summer months. Even during the Rabi season, cultivation was primarily restricted to households with access to private borewells.

Many respondents attributed the declining groundwater levels to coal mining operations in the vicinity, which have reportedly disrupted the natural balance of the aquifer. The absence of community irrigation systems or reliable alternatives makes summer cultivation virtually impossible for most.

2. Crop Damage from Wild and Stray Animals

Crop depredation by blue bulls (also known as nilgai) has emerged as a pervasive challenge. Farmers reported recurring losses, especially during the Kharif

and Rabi seasons, with crops like arhar, moong and gram being particularly vulnerable. In some instances, farmers had abandoned gram cultivation entirely due to repeated attacks. The lack of fencing or any form of collective crop protection further exposes fields to damage.

> *I sold arhar at ₹100 per kg, but by the time I reached the mandi, I had to settle for ₹10 per kilo—same with til. We sold 15 kg for ₹150 per kg, but that money was spent on basic household needs. Earlier, we would sell dal and use the money for vegetables—now we're just sitting in deprivation."*
>
> ***— Male FGD Participant, Rajhara***

3. Poor Access to Quality Inputs

Farmers face considerable hurdles in sourcing seeds and fertilisers. Inputs are usually purchased from Daltonganj, located 18-20 km away, adding significant transportation costs to already expensive products. Several respondents expressed mistrust toward local vendors, citing the sale of expired fertilisers and low-quality seeds. There is little to no availability of subsidised or certified inputs through public distribution and no reported access to agricultural extension services.

4. Pests and Crop Losses

The challenge of pest infestations, particularly those caused by green insects and grasshoppers during the monsoon—were a significant contributor to crop failure. Furthermore, some farmers stated total crop loss overnight, as existing pesticides were either too costly or ineffective. The absence of timely pest control support owing to access barriers further compounds these risks.

5. Absence of Post-Harvest Storage Facilities

Post-harvest management is a critical gap. Perishable produce, such as tomatoes and potatoes, is often stored at home, where it frequently spoils due to a lack of cold storage or warehousing infrastructure. As a result, farmers are often forced to sell quickly to local intermediaries at suppressed prices—sometimes as low as ₹10 per kilogram, even when prevailing market rates are double that amount.

> *Last year, bhindi was selling for only ₹2-₹ 10 per kilogram. A cauliflower didn't cost more than ₹5. We stopped plucking tomatoes because they were selling at ₹5 per kg—just the transport cost was more than the money we earned."*
>
> ***— Male Farmer, Chenya village***

6. High Labour Costs and Low Returns

Farmers cited rising labour costs as another stress point. In many cases, the cost of hiring labour—especially for harvesting—exceeded the income from crop sales. The government-mandated daily wage, under Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) and related schemes, was reported as unviable for workers, further reducing the availability of affordable labour.

7. Limited and Inequitable Institutional Support

While some farmers had received small cash transfers (e.g., ₹2,000 during monsoon or Rabi seasons), these were seen as infrequent, insufficient and poorly targeted. Multiple respondents flagged corruption and the capture of benefits by intermediaries, which prevented eligible farmers from accessing loans, subsidised inputs or information about relevant schemes.

These intersecting challenges have created a precarious farming environment in Rajhara. The lack of basic infrastructure, combined with inadequate institutional outreach and environmental vulnerabilities, has eroded farmer confidence and reduced the viability of agriculture as a primary source of livelihood, particularly for small and marginal farmers.

Highlights: Current Agricultural Practices & Key Challenges

- **Farming in Rajhara is mostly subsistence-based,** with paddy, wheat, gram and some vegetables grown primarily for household use.
- **Water scarcity is the biggest constraint,** limiting Rabi and Zaid (summer) cultivation. Most land remains rainfed or reliant on seasonal wells.
- **Crop damage by stray animals and pests,** coupled with **poor access to quality inputs,** further undermines productivity.
- **Post-harvest losses are high** due to the absence of cold storage or warehousing, forcing distress sales of perishables at very low prices.
- **High labour costs and low market returns** make farming economically unviable for many, especially smallholders.
- **Government support is seen as inadequate and poorly targeted,** with frequent mentions of delays and exclusion from schemes.

> *Yes, if FPO is established and we receive training and facilities, people will join. But awareness must come first. Train us and we will understand; then we will participate. Once we see the benefits, people will support it fully."*
>
> *— FGD Respondent, Male Farmer*

3.3.3. Awareness, Perception and Readiness to Join FPO

Awareness of FPO

Awareness of the Farmer Producer Organization (FPO) initiative remains low across the surveyed villages. Quantitative data collected from the farmers under the SLI project confirms that only 23.8% of respondents were aware that an FPO was being formed in their village, while a majority (76.2%) reported no such knowledge. This limited awareness was also evident in FGDs, where participants commonly confused the FPO with the solar pump user group, pointing to inadequate differentiation between overlapping community interventions.

Among those who were aware, knowledge remained fragmented and superficial. Some respondents broadly understood that the FPO could facilitate farming-related support, such as access to irrigation or inputs, but few had clarity on its governance, structure, or operational processes. Even local influencers, such as PRI members and SHG participants, reported minimal involvement or communication from the implementing agency.

FGD with female farmers

Crucially, no systematic sensitisation or capacity-building activities had been carried out at the time of fieldwork. Respondents across FGDs uniformly stated that no village-level meetings, training sessions, or orientations had been held to explain the FPO model or its potential benefits. As a result, community engagement remains weak, particularly among women and marginal farmers who typically depend on proactive outreach for inclusion in such initiatives.

Factors Influencing Decision to Join FPO

Despite low baseline awareness, farmers across all FGDs consistently expressed a strong willingness to join the FPO—conditional on the delivery of clearly communicated, tangible benefits. Four core considerations shaped their decision-making:

> *"If this group is formed and the work begins, then all people will be aware. People will gather, talk and share farming methods. People will show increased interest. If you work well for our village, we will follow you."*
>
> ***— FGD Respondent, Chenya village***

1. Reliable Irrigation as a Prerequisite

Access to water emerged as the most decisive factor influencing interest in the FPO. Farmers repeatedly stated that without assured irrigation, collective cultivation or procurement efforts would have limited utility. Conversely, if the FPO could guarantee regular water supply, participation would follow almost automatically.

2. Access to Affordable, Quality Inputs

The second primary motivator was the promise of cheaper and more reliable access to seeds and fertilisers. Farmers noted that current input costs are high, especially when procured from distant markets like Daltonganj and quality is often uncertain. If the FPO could bulk procure certified inputs at better rates, it would significantly lower production risks.

3. Improved Market Access and Price Realization

Several respondents also highlighted the potential benefits of aggregated marketing, whereby farmers could negotiate better prices for their produce through collective bargaining. This was particularly appealing to small and marginal farmers, who often sell at distress prices to local intermediaries due to the absence of storage or transport facilities.

4. Trust and Track Record of Implementation Partners

Trust in the implementing agency was a recurring theme. Some participants cited prior disappointments—such as the non-functional solar pump system—which had eroded confidence in external interventions. As a result, many farmers are adopting a "wait-and-see" stance, deferring their decision to join until there is visible progress or continued engagement.

Additional Considerations:

Landholding size was not a deterrent; small and marginal farmers showed equal enthusiasm, contingent on affordable membership and demonstrated value. Gender inclusion was generally welcomed, particularly by women, who saw the FPO as an opportunity for income generation and financial autonomy. Governance integrity was critical. Respondents emphasised that leadership roles should be filled transparently, warning against the inclusion of politically connected or inactive individuals who may undermine group effectiveness.

Highlights: FPO Awareness, Perception & Readiness

- **Only 23.8% of farmers were aware of the FPO,** with widespread confusion between the FPO and other interventions like the solar pump user group.
- **Despite low awareness, interest in joining is high,** driven by hopes of improved irrigation, access to affordable inputs and collective market advantage.
- **Small and marginal farmers, including women, are open to participating,** provided the FPO delivers tangible support and remains inclusive in structure.

3.3.4. Infrastructural and Operational Challenges in Establishing the FPO

Despite initial interest and partial enrolment, the establishment of the FPO in Rajhara has been hindered by a range of infrastructural and operational bottlenecks. While a few farmers reported paying membership fees, the organisation hadn't started with any community-level activities at the time of this assessment.

1. Infrastructure Bottlenecks Undermining Confidence

The SLI system, which was seen as a foundational enabler for the FPO's success, became a source of disillusionment. Farmers reported that the system stopped functioning shortly after installation due to technical failures, including sand accumulation and insufficient borewell depth. These issues disrupted irrigation access and weakened community trust in the larger collective initiative. As several respondents emphasised, without a functioning irrigation system, the FPO cannot deliver on its most fundamental value proposition.

2. Lack of Institutional Clarity

Operational clarity is another major challenge. Across all FGDs, respondents reported a near-complete absence of communication regarding the structure, roles, responsibilities, or expected benefits of FPO membership. In some cases, confusion persisted between the solar pump user group and the proposed FPO, with farmers mistakenly believing their irrigation membership also covered FPO participation.

3. Absence of Follow-Through and Field Presence

Following initial mobilisation to collect necessary farm-related data, no training, orientation, or follow-up engagement was reported by members or local leaders. PRI members and SHG participants confirmed that there had been no visible presence of the implementing agency in the field in recent months. This lapse in continuity has eroded early interest and created a perception that the initiative has been abandoned or indefinitely delayed.

3.3.5. Stakeholder Engagement and Support for FPOs

Market Stakeholders

At present, farmer engagement with external markets remains fragmented and individualised. Produce is primarily sold either at local mandis in Padwa and Daltonganj or directly to traveling buyers who visit the village. In the absence of any aggregation mechanism, individual farmers–particularly those with small

surpluses—lack bargaining power and often sell at rates significantly below prevailing market prices. Several respondents reported selling produce, such as arhar or vegetables, at half their value due to a lack of storage or immediate liquidity needs.

Financial Institutions

Linkages with formal financial systems are minimal and largely underdeveloped. While a few farmers reported accessing Kisan Credit Card (KCC) loans, these were secured individually and typically involved procedural delays, unclear eligibility norms and documentation challenges. There is currently no institutional arrangement—either through the FPO or through SHG federations—to facilitate group-level financing or credit guarantees.

Interviews with representatives from financial institutions confirmed that engagement with farmer groups remains limited. Several institutions noted prior difficulties with recovery and default when lending to informal collectives, leading to a reluctance to re-engage. Others expressed a preference for working with women's SHGs, which they viewed as more accountable and more straightforward to monitor. A recurring logistical constraint was distance: most financial institutions operate within a fixed catchment area and many of the study villages, including Rajhara, fall outside their routine service radius, making regular engagement unfeasible.

3.4. Conclusion

The establishment of the Rajhara Farmer Producer Organization holds considerable potential for transforming agricultural practices, reducing production costs and enabling market integration in this post-mining region. However, the initiative is still at a nascent stage, with member onboarding underway and limited community awareness or field-level activity. The absence of sustained mobilisation, infrastructural support (particularly around irrigation) and operational clarity has constrained farmer confidence and stalled momentum. Despite these limitations, there is strong latent demand among small and marginal farmers—particularly for access to irrigation, quality inputs and better price realisation through collective marketing. Stakeholders such as financial institutions and market actors remain largely disengaged but could play a vital role in scaling the FPO once implementation deepens. Moving forward, the success of this initiative will depend on revitalising ground-level engagement, strengthening trust through early service delivery and building institutional mechanisms that foster transparency, inclusivity, and resilience.

3.5. Recommendations

Based on the empirical insights gathered pertaining to this component, following are some of the process-related recommendations.

1. Strengthen Community Awareness and Buy-In

- Organise 3-step outreach campaign: (i) Initial orientation through village meetings, (ii) Field demonstrations of planned services (e.g., input kits), (iii) Doorstep visits to small/marginal households.
- Create simple, visual, local-language Information, Education, and Communication (IEC) kits (posters/ pamphlets/ audios/ videos) to explain what the FPO does and how it differs from other components like the WUG.
- Train field staff to deliver consistent messages using these materials.

2. Rebuild Trust Through Quick Wins

- Launch one or two easy-to-execute services–like a bulk fertiliser order–through a small group of early members.
- Publicly track and share the outcomes to show value and encourage others to join.

3. Improve Access to Inputs and Markets

- Partner with SFAC/State Nodal Agency under the 10,000 FPOs scheme to get a dedicated Cluster-Based Business Organisation (CBBO) support (technical and operational) for Rajhara.
- The Rajhara FPO could initiate a formal collaboration with Krishi Vikas Kendra Palamu (under Birsa Agricultural University) for:
  - Bulk procurement of improved seed varieties for wheat, gram, mustard and vegetables.
  - Tailored trainings for FPO members on soil health, pest control and cost-effective farming models.
  - Demo plots showing cost-effective farming models
- Pilot small weekly hubs to collect and sell produce from 3-4 households at better prices.

4. Strengthen Financial Linkages

- Actively link the FPO to national schemes such as Equity Grant Scheme and Credit Guarantee Fund Scheme under SFAC (Small Farmers' Agribusiness Consortium) and NABKISAN financing for working capital and infrastructure.
- Hold basic finance workshops for board members on how to manage loans, sales revenue, and audits.
- Start a small, rotating fund for urgent expenses (e.g., packaging or transport), with clear records and monthly reviews.

5. Set up Simple, Transparent Governance

- Create a simple 2-page governance booklet in Hindi outlining member rights, leadership roles and decision-making rules.
- Organise peer learning visits to successful FPOs in Jharkhand to help board members understand how to run operations effectively.

4. Clean Cooking Fuel Project

Clean Cooking Fuel Project

In mining-affected regions like Rajhara, the reliance on traditional fuels such as wood, coal and cow dung remains widespread, especially among low-income households. While these fuels are perceived as affordable, they impose significant costs in terms of time, health and environmental impact, particularly on women who bear the burden of fuel collection and food preparation. Recognising this, ACPET is exploring interventions that promote the adoption of clean cooking technologies. The success of this transition requires a deeper understanding of the community's readiness, affordability thresholds, gendered experiences and the socio-cultural factors that shape fuel preferences.

4.1. Research Questions

To inform the design of scalable clean cooking initiatives, the following research questions are pursued:

- How will the implementation of clean cooking practices impact the health and socio-economic life of communities that primarily rely on traditional cooking fuels?
- What is the current landscape of cooking practices regarding fuel types and usage patterns? What are the health effects of various traditional fuels, particularly on women and children?
- How do different clean cooking alternatives compare in terms of accessibility, affordability, adaptability and the technical support needed for effective community adoption?
- What is the community's readiness to transition to clean cooking solutions, considering their levels of awareness, willingness to pay and access to clean cooking technologies?
- What are the potential health, social and economic outcomes of adopting clean cooking methods, particularly in terms of gender dynamics and time-labour implications for women and children?

4.2. Methodology

4.2.1. Study Design and Approach

A mixed-method, cross-sectional design was used to evaluate the adoption, feasibility and health impacts of transitioning from traditional cooking fuels to cleaner cooking solutions in mining-affected households. The AARQA Framework was utilised to assess the availability, accessibility, reliability, quality and affordability of clean cooking solutions.

In addition, laboratory testing of locally used traditional fuels, *goliya*, was conducted to assess key parameters including moisture content, ash content, volatile matter and emissions profile, thereby providing empirical insight into the health and environmental risks posed by legacy fuel use.

4.2.2. Sampling and Respondent Categories

To determine a statistically appropriate sample size, we assume that the key indicator for determining the sample size for the survey is the percentage of households dependent on clean cooking fuel. Considering a 95% level of confidence, 80% power and an 8% non-response rate, the suggested sample size would be sufficient to measure a change of at least 15% post-intervention. The required sample size is calculated using the following formula:

$$n = \frac{deff \times \left[Z_{1-\alpha}\sqrt{2P(1-P)} + Z_{1-\beta}\sqrt{P_1(1-P_1)+P_2(1-P_2)}\right]^2}{(P_2-P_1)^2}$$

Using this calculation, a total of 240 households require the administration of a structured interview schedule. In addition to the quantitative survey, a few qualitative interactions were also undertaken. The table below lists the same.

Table 4: Sampling Plan for Clean Cooking Practices Project

Stakeholder	Method of data collection	Sample Size
Households	Structured Interview Schedule	258
SHG members	FGD	4 (2 each in Rajhara and Pandwa)
Medical staff at the CLC clinic	KII	1
Medical staff at the nearest PHC/CHC/private clinic	KII	1

A total of 8 hamlets were covered under the scope of this evaluation wherein, on average, 30 households were interacted with. These households were selected via systematic random sampling method. The table below lists the hamlets covered.

Table 5: Hamlets covered under the Clean Cooking Fuel component

Stakeholder	Method of data collection
Rajhara Colliery School	Pandwa
Hamlet No. 7	Pandwa
Hamlet No. 14	Pandwa
Rajhara Kothi	Rajhara
Rajhara Kurkutia Pati	Rajhara

Rajhara Basti	Rajhara
Cluster nearest to the CCL mine	Chechanha
Cluster nearest to the CCL mine	Chaneya

4.2.3. Data Analysis

Quantitative data collected through household surveys were analysed using descriptive statistics and cross-tabulations to assess adoption rates, affordability perceptions, usage patterns, and reported health effects. **Qualitative data** from FGDs and KIIs were thematically analysed using the AARQA Framework (Availability, Accessibility, Reliability, Quality, and Affordability), with additional inductive codes used to explore behavioural preferences, fuel stacking, and gendered decision-making. Quotes from participants have been embedded within the report narrative to support and deepen interpretation of quantitative trends.

Figure 16: Social Group of the Household (in %)

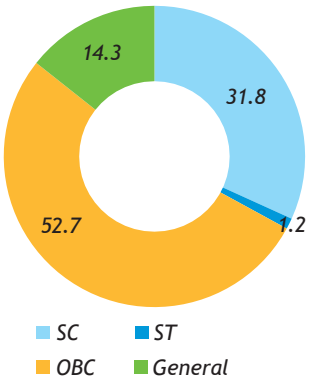
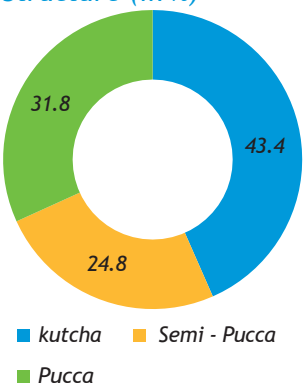


Figure 17: Household Structure (in %)



4.3. Empirical Insights

4.3.1. Socio-Economic Profile of Respondents

All 258 respondents were women. The average age of respondents was 38 years, with ages ranging from 19 to 80 years.

Social Group and Housing Structure

The majority of respondents belonged to marginalised social groups, with 52.7% identifying as Other Backward Classes (OBC) and 31.8% as Scheduled Caste (SC). Only 14.3% were from the General category. In terms of housing conditions, 43.4% lived in kutcha houses, while 24.8% lived in semi-pucca and 31.8% in pucca homes. These figures suggest that a substantial proportion of the respondent population is socio-economically disadvantaged, with a significant proportion still residing in structurally vulnerable dwellings.

Household Composition

The average household size was five members, with two women and two children per household, underscoring the daily exposure of women and young children to indoor air pollution from cooking fuels.

Educational Background

A large proportion of respondents reported no formal education (43%), with only 12.8% having completed Class 10 and just 5% reporting graduation. This limited educational attainment may constrain their access to information about clean energy technologies, health risks and available government schemes–making targeted, low-literacy-friendly awareness campaigns essential.

Livelihood and Income Profile

Figure 18: Educational Status of Respondents (in %)

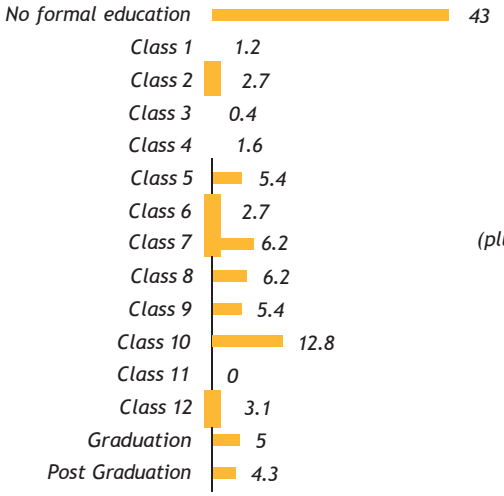


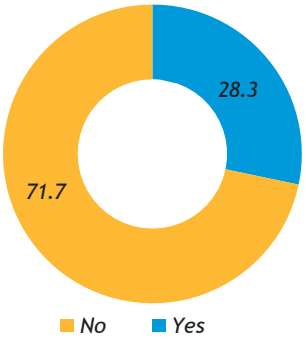
Figure 19: Primary Occupation of the Household (in %)

The primary source of household income for the majority was non-agricultural daily wage labour (61.6%), followed by private jobs (15.9%) and a small share engaged in agriculture, government jobs, or skilled self-employment. Only a couple of respondents (less than 1%) reported earning a living from coal mining activities at Rajhara, indicating a shift away from direct dependence on mining as a primary source of livelihood.

The average monthly household income was ₹10,925, with the most commonly reported income (mode) being ₹8,000, indicating that low-income levels were prevalent across most households.

Only 28.3% of women reported working outside their homes. Among these, 80.8% were engaged in non-agricultural labour and 2.7% in private jobs. A smaller fraction worked in self-employed services (5.5%) or agriculture-related activities (8.2%). This highlights the crucial importance of considering women's time-use patterns and exposure risks when promoting clean energy solutions.

Figure 20: Female Labour Force Participation (in %)



These intersecting factors—caste-based disadvantage, economic insecurity and limited education—compound the health and environmental risks posed by traditional cooking fuels. They also present critical barriers to transitioning to cleaner alternatives. This highlights the importance of context-sensitive and affordable interventions to facilitate a meaningful shift toward clean cooking solutions.

4.3.2. Current Cooking Practices & Fuel Usage

An in-depth analysis of prevailing cooking practices among women in mining-affected communities, focusing on the types of fuels used, patterns of usage, accessibility and affordability of different fuels, as well as associated challenges is explored in the section that follows. By examining both quantitative data from household surveys and qualitative insights from community interactions, the section highlights the entrenched reliance on traditional fuels, such as wood, dung, coal and goliya, while also noting the partial adoption of clean alternatives, including LPG. The analysis also draws attention to cultural preferences, labour burden and logistical barriers that influence fuel choice and cooking behaviour..

Cow dung cakes stacked outside the home

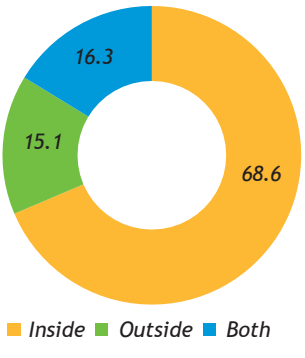
Cooking Habits

Cooking is a central household activity, with the majority of women preparing two meals per day, as indicated by both the median and mode values. The average daily time spent on cooking was approximately 2 hours and 42 minutes (162 minutes), with some households reporting cooking durations of up to 4 hours and 30 minutes. This reflects a significant time investment that could be reduced with more efficient cooking technologies.

A majority of households (68.6%) reported cooking inside their homes, while 15.1% cooked outside and 16.3% used both indoor and outdoor spaces. Indoor cooking, combined with traditional fuels, can significantly contribute to indoor air pollution, raising health concerns, particularly for women and children who spend more time in these enclosed environments.

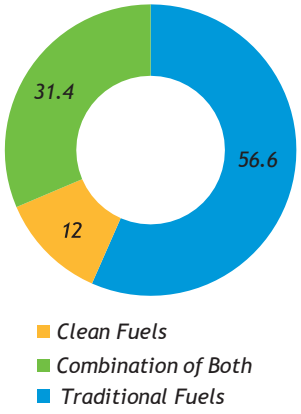
Fuel usage patterns reveal a complex picture of fuel stacking, where households use multiple fuel types depending on availability, affordability and cooking needs. While 56.6% of households rely primarily on traditional fuels such as wood, dung, coal and goliya, a significant 31.4% use a combination of both conventional and clean fuels and only 12% exclusively use clean fuels like LPG.

Figure 21: Primary Cooking Location in the Households (in %)



Collected firewood stacked near homestead

Figure 22: Cooking Fuel Usage Patterns (in %)



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Traditional Cooking Fuels

Figure 23: Usage of Traditional Fuels (in %)

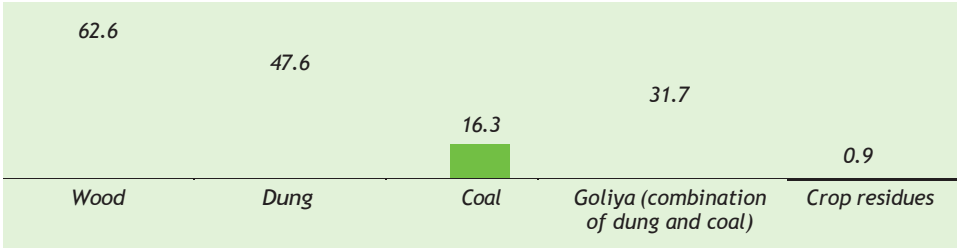
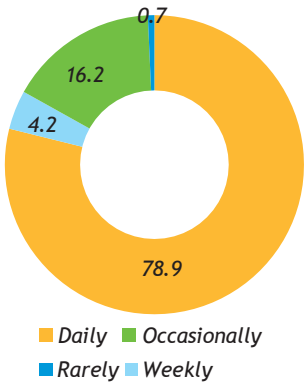


Figure 24: Frequency of usage - Wood (in %)



Traditional fuels remain the primary source of energy for cooking among the surveyed households. Among those who utilise such fuels, 62.6% reported using wood, 47.6% used dung and 16.3% reported coal as part of their cooking fuel mix. Notably, nearly one-third (31.7%) used goliya–a locally prepared mixture of dung and coal–highlighting the prevalence of homemade, biomass-derived fuels.

Wood

As noted above, wood was the most commonly used traditional cooking fuel, reported by 62.6% of households. Among them, nearly 79% used it daily, reinforcing its status as a staple fuel in the region.

Despite this, only 13% found wood to be "very accessible," with the majority (87%) rating access as "somewhat accessible." Half of the respondents reported that the wood source was within 1 km, while the rest cited travel distances of up to 5 km.

On average, households spent ₹18 per month on wood, indicating low monetary expenditure but high reliance on collection, with the majority of them not spending anything on its procurement. Almost all of them (84.5%) confirmed that a household member had to go out to collect wood.

> *We have to get wood from at least 1.5 to 2 km away. "It is very far."*
>
> ***— An SHG member from Pandwa village.***

One-third of users (33.3%) collected wood daily, 39.2% collected wood weekly and for 25% of the respondents, this was a fortnightly exercise. This was predominantly the responsibility of adult women (91.7%) who were members of a household. Each collection trip took an average of 127 minutes, with some trips lasting as long as 4 to 5 hours, underscoring the significant time burden that women bear.

> *We leave the house in the morning and return by 12 or 1 pm. Our whole day goes into this."*
>
> ***— An SHG member from Rajhara village.Pandwa village.***

This time burden was consistently echoed in interactions with all the SHGs. Women described walking long distances–up to 5 km–and spending multiple hours daily collecting wood.

Many households face significant challenges in storing firewood, with over one-third (32.4%) reporting difficulties due to limited space within their homes. This issue is particularly acute during the monsoon season, when keeping wood dry becomes problematic in the absence of covered or dedicated storage areas.

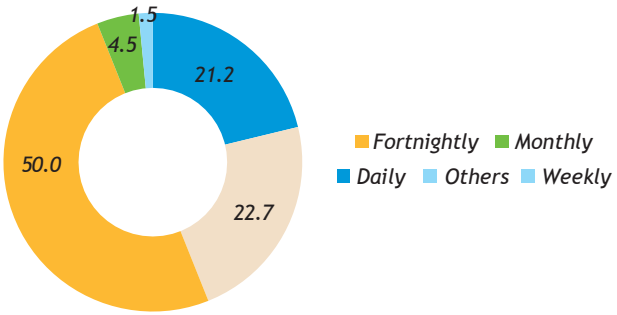
Cow Dung

Cow dung was used by 47.6% of households, with a striking 82.4% using it daily. Similar to wood, most users rated dung as "somewhat accessible" (71.3%), though 83% reported it was available within 1 km. Even for cow dung, the monetary cost was negligible, averaging ₹16 per month, with most people paying nothing at all.

Approximately 61% of users, primarily adult women (87.9%), manually collected dung. The frequency of this activity varied, as depicted in the graph, with trips averaging 126 minutes in duration. The burden of safe storage, reported by nearly 39% of respondents, especially during the rainy season, was a recurring concern.

However, qualitative interactions suggest that cow dung was not typically used in its raw form but instead combined with coal dust and sand to create goliya (see below). The process of preparing dung for this purpose was physically demanding and tightly scheduled around household routines.

Figure 25: Frequency of Collection - Cow Dung (in %)



Cow dung cakes stored overhead in a narrow corridor

Coal

Coal was used by 16.3% of households, with 65% reporting daily usage. Accessibility was a concern–only 2.7% found it "very accessible," while the others deemed it "somewhat accessible." About 41% of the respondents needed to travel 1-5 km to obtain it. Despite this effort, households spent relatively little on coal, with an average monthly expenditure of ₹ 174 and a modal value of ₹0.

Among those who collected coal (49% of users), 94% were women and the average collection time stood at 179 minutes (almost 3 hours), the highest among all traditional fuels. However, only 19% faced storage issues, possibly due to more controlled quantities or better containment.

The qualitative data reveals that coal collection is not only time-consuming but often entails personal risk, as households resort to unauthorised mining land or guarded zones to collect coal dust.

This aligns with the extremely low accessibility score and underscores that coal's "cost-effectiveness" comes at the expense of safety and legality, disproportionately borne by women.

Figure 26: Frequency of Collection - Coal (in %)

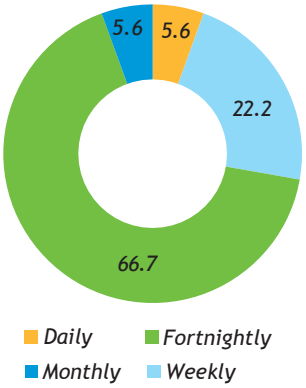
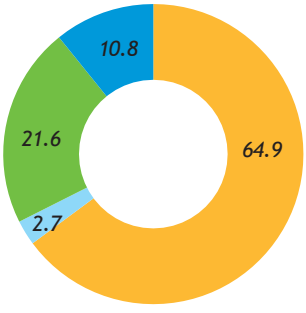


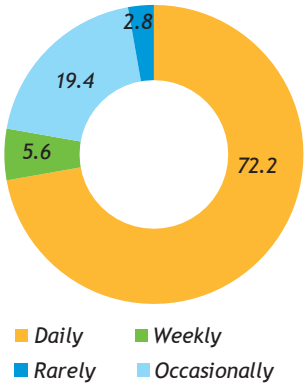
Figure 27: Frequency of Usage - Coal (in %)



> *"If we start buying everything, then we won't be able to manage our other essential household expenses. We resort to making goliya because coal is too expensive to use in its raw form*
>
> ***— An SHG member from Pandwa village.***

> *"Guards don't allow us to enter the area. " We have to sneak in to get the coal dust."*
>
> ***— An SHG member from Pandwa village.***

Figure 28: Frequency of Usage - Goliya (in %)



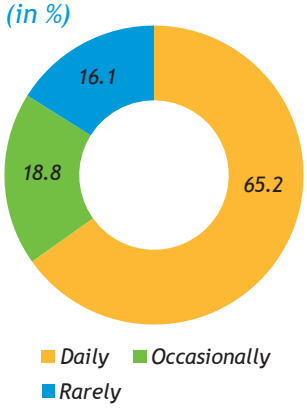
"It takes a whole day to make them." We make it at 4-6 am before the sun comes out."

— An SHG member from Rajhara village.

"If we make rice, then dal cannot be made using the same goliya. " We have to add more."

— An SHG member from Rajhara village.

Figure 29: Frequency of Usage - LPG stoves (in %)



Goliya: A Local Composite Fuel

Goliya, a mix of dung and coal dust, was used by 31.7% of respondents, with 72% relying on it daily. Accessibility mirrored other fuels, with 98.6% rating it as "somewhat accessible" and 78% reporting a source within 1 km.

Like dung and wood, 85% of households collected goliya themselves, primarily women (90.2%). The collection took approximately 143 minutes per trip and was typically done weekly (39.3%) or fortnightly (39.3%). Storage challenges were reported by 29%, which is slightly lower than for wood and dung but still notable.

SHG members unanimously described goliya as a cheaper but time-consuming and inefficient fuel. The preparation process—mixing cow dung, coal dust and sand—required substantial manual labor and early morning scheduling.

In terms of burning efficiency, goliya was reported to last only 30 minutes, necessitating repeated additions during cooking. This matched the survey's insights on short burn duration.

In addition to the standard form of goliya—a composite fuel made from coal dust, cow dung and sand—SHG respondents also described a locally adapted variant sometimes referred to as "golith" or "goitha." This version incorporates agricultural residues, such as the waste of arhar dal (pigeon pea husk) mixed with cow dung and coal dust to create fuel balls. While structurally similar to goliya, this variant reflects an improvisational response to fuel scarcity, mainly when coal dust is not readily available or becomes unaffordable. The inclusion of arhar residues, which are available as a by-product of household consumption or small-scale agriculture, enables households to stretch their limited resources and maintain cooking routines with minimal monetary input. However, despite being a cost-saving measure, this blend does not mitigate the adverse effects associated with traditional fuels—such as excessive smoke, short burn duration and adverse health outcomes. Instead, it underscores the extent of fuel insecurity in these communities and the heavy reliance on women's labour and ingenuity to adapt under resource constraints.

Crop residue being sun-dried before using it to prepare Goliya

Clean Cooking Fuels

Among the 43% of surveyed households that use clean cooking fuel, all users reported using Liquefied Petroleum Gas (LPG) stoves. At the same time, no usage was recorded for biogas, electric cookers, solar cookers, or other alternative energy sources. However, only 65.2% of LPG users reported using it daily, while 34.8% used it occasionally or rarely, indicating that while LPG ownership may be shared, sustained daily usage is limited.

This partial adoption is strongly reflected in SHG discussions. While several women reported having LPG connections, many explained that gas was reserved for emergencies or special guests due to the high cost of refills. The average monthly expenditure on LPG was ₹915, with a minimum of ₹860 and a maximum of ₹1,200, making it a significant financial burden for low-income households.

Despite financial constraints, LPG is reasonably accessible in terms of physical supply. Nearly 70% of users rated LPG as "very accessible," and 41.1% reported home delivery of refills. Another 32.1% had to travel 1-5 km, while 22.3% had access within 1 km. Only 8.9% said it was "not accessible."

SHG members corroborated these findings, confirming that delivery systems were in place; however, accessibility was perceived as less in terms of distance and more in terms of affordability.

Moreover, the lack of subsidies—either due to administrative exclusion or unclear processes—was a recurring issue. Only 55.4% of LPG users confirmed receiving a subsidy on their LPG. While 10.7% of them were unsure, 33.9% were confident that no subsidy was provided to them. Some women noted that they received LPG connections under schemes like Ujjwala but could not afford to refill regularly, nor did they receive promised financial support.

Encouragingly, 99.1% of LPG users reported no issues with safe storage, indicating a generally safe handling environment at the household level. There were no widespread safety concerns raised by SHG members either.

> *We use LPG to make tea when we have guests at home. Otherwise, we think it is better to use Goitha or wood for cooking daily meals,"*
>
> ***— said an SHG member from Rajhara village.***

> *"If our husband is earning 2000 rupees in total and we use it for gas, how will we buy food?"*
>
> ***— An SHG member, Rajhara village***

> *"It was easy when the price was ₹600. Now, it is from ₹900 to ₹1,200. " We save it for emergencies."*
>
> ***— An SHG member from Rajhara village.***

Highlights: Traditional Fuel Use Persists Despite Cost and Health Burden

- **56.6% of households still rely on traditional fuels** such as wood, cow dung, coal, and goliya; only 12% exclusively use clean fuels like LPG.
- **Fuel stacking is common,** with 31.4% of households using both traditional and clean fuels to balance affordability and availability.
- **Fuel collection imposes a heavy time and physical burden on women**—e.g., 127 minutes per trip for wood, 179 minutes for coal and early morning labour for goliya preparation.
- **Storage challenges affect over one-third of users,** especially during the monsoon, exacerbating daily inconvenience and indoor pollution risks.
- **Goliya, a local composite fuel, is widely used (31.7%)** but is inefficient, short-burning, and smoke-intensive, underscoring the lack of viable alternatives for the poorest.
- **LPG adoption is partial and irregular:** While 43% own LPG stoves, only 65.2% of them use it daily. Cost (₹915/month average) remains the key barrier.
- **Cultural or taste-based resistance is minimal**—fuel choice is primarily driven by cost, access, and availability, not social norms.
- **SHG members confirm that LPG is used sparingly,** mostly for guests or emergencies, highlighting the need for affordability and subsidy access.

4.3.3. Health Impact of Traditional Cooking Fuels

Exposure to traditional cooking fuels remains a significant health risk in the study area, particularly affecting women, who are primarily responsible for collecting fuel and preparing food. While reported clinical cases remain relatively low, both quantitative and qualitative findings reveal a broader picture of unaddressed symptoms, limited care-seeking and heightened awareness of adverse health effects.

Emissions Profile of Goliya and Associated Health Implications

To better understand the potential health risks of traditional cooking fuels used in mining-affected communities, a laboratory test was conducted on Goliya (a composite biofuel made from cow dung, coal dust, and sand). The fuel sample was tested at a NABL-accredited Laboratory. Full report has been added to the Annexure. The goal was to assess key emission parameters and compare them against standard limits for household fuels, thereby identifying the potential health hazards posed by its continued use in poorly ventilated domestic environments.

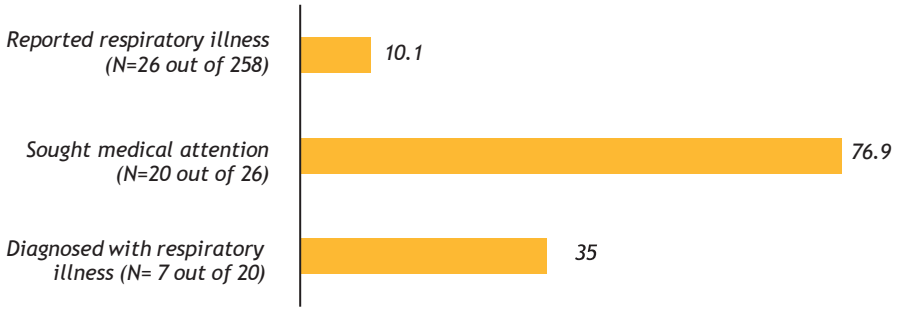
Table 6: Emission Profile of Goliya and its Health Implications

Test Parameter	Observed Value	Interpretation & Health Implications
Volatile Matter (%)	15.57	A low volatile matter content limits flame stability and ignition ease. This may lead to incomplete combustion, generating higher emissions of carbon monoxide (CO) and particulate matter, both linked to respiratory illness.
Ash Content (%)	48,73	Extremely high ash content means low energy output per unit mass and heavy residue post-combustion. Ash particles can contribute to indoor dust and, when inhaled, cause eye and respiratory irritation, especially in closed kitchens.
Fixed Carbon (%)	32.93	Moderate fixed carbon provides some sustained heat through embers, but not enough to compensate for low volatile matter and high ash.
Sulphur Content (%)	0.20	Though low, this sulphur level may still release small quantities of SO_2 during combustion. Chronic exposure, even at low levels, can exacerbate asthma, bronchitis, and other respiratory problems.
Gross Calorific Value (Kcal/kg)	3053	A relatively low calorific value indicates limited energy output, requiring greater fuel quantity per meal. This increases cumulative smoke exposure, especially dangerous for women and children due to longer exposure during cooking.

The laboratory analysis of the goliya sample reveals serious limitations in its suitability as a household cooking fuel. The fuel's extremely high ash content and low volatile matter significantly compromise its combustion efficiency and energy output. The combination of poor combustion and high particulate residue elevates household exposure to indoor air pollutants such as fine ash, carbon monoxide, and sulphur dioxide. These are known contributors to respiratory ailments including asthma, eye irritation, chronic bronchitis and long-term risk

of Chronic Obstructive Pulmonary Disorder (COPD), especially among women and children who spend extended periods in smoke-filled kitchens. These results reinforce the need for urgent promotion of safer alternatives and behaviour change communication to reduce dependency on hazardous traditional biofuels.

Figure 30: Pathway of Reported Respiratory Cases (in %)



Despite the evident health risk posed by the traditional fuels, only 10.1% of households reported that a member had experienced respiratory illness in the past year. Of these, 60% were women and 22.2% were children under the age of 18 years. In the majority of these cases (76.9%), people approached a health professional. Among these, only 35% received a definite diagnosis, with asthma in all cases. The rest were prescribed medicines to address the symptoms.

> *Our house fills with smoke. We feel dizzy. We tell our children to go out."*
>
> ***— An SHG member, Rajhara village.***

Although the overall reported incidence is modest, the financial burden of treatment was substantial, with an average out-of-pocket medical expense of ₹10,725 per household, reaching up to ₹25,000 in some cases. This includes the consultation fee, cost of medicines, transportation and diagnostic tests.

Among those who did not seek care, high treatment costs were the primary deterrent (83.3%), followed by the belief that symptoms would resolve on their own (16.7%). Instead, respondents turned to home remedies (16.7%), over-the-counter medications (33.3%), or continued their daily activities without intervention (50%).

This reluctance to seek care was also reflected in SHG narratives. While women described experiencing respiratory symptoms such as breathlessness and nausea during cooking, these appeared to be normalised over time–suggesting, based on our interpretation, a potential desensitization due to chronic exposure rather than explicit recognition of a health issue..

The smoke makes our eyes tear up. " We get head-aches and irritation."

— An SHG member from Rajhara village.

"We have to go out after using the chulha. " It's hard to breathe and our eyes burn."

— An SHG member from Rajhara village.

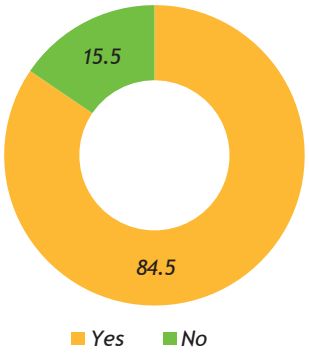
Eye Irritation

Eye-related complaints were slightly more prevalent than respiratory issues, with 10.9% (28 out of 258) of households reporting that at least one member had experienced eye irritation in the past year. The majority of them were women (85%). Despite the commonality of symptoms—such as watery eyes, burning and discomfort in vision—only 53.6% (15 out of 28 households) sought medical care. Treatment costs averaged ₹3,547, with some spending up to ₹20,000.

Similar to respiratory cases, the cost of care (76.9%) was the most cited barrier for those who did not seek treatment. Many relied on home remedies (53.8%) or purchased eye drops from a pharmacy (23.1%), while nearly one-third ignored the symptoms altogether (30.8%).

This pattern was consistently echoed across SHGs. Respondents described smoke from goliya, wood and coal as a constant source of eye discomfort, especially in poorly ventilated homes.

Figure 31: Awareness of Health Risks Associated with Traditional Fuels (in %)



"We know it is harmful to our health... but we can't afford gas every month."

— An SHG member from Rajhara village.

Awareness of Health Risks Associated with Traditional Fuels

Despite the limited availability of medical consultations, 84.5% of respondents were aware that traditional fuels pose health risks. Among these, 87.6% identified eye irritation, 49.5% noted respiratory diseases and 42.2% cited headaches as the key health impacts. Other conditions, such as heart disease (14.7%), skin issues (3.2%) and burns or accidental injuries (5.5%) were also acknowledged, though less frequently.

This high level of awareness coexists with economic barriers that restrict action, reinforcing the need for targeted public health messaging, financial support mechanisms and affordable clean cooking alternatives.

Perspectives from Health Providers

Interviews with two local healthcare professionals iin Rajhara present a nuanced and, at times, contrasting understanding of the health impacts stemming from the use of traditional cooking fuels. While both acknowledge the widespread reliance on coal, wood, cow dung and goliya for daily cooking needs, their accounts diverge in terms of observed health outcomes, attribution and systemic response.

A medical professional at the CCL dispensary reported very few respiratory cases, stating that he did not see significant illness attributable to cooking smoke. He attributed most health issues to factors like diet quality, seasonal conditions and water contamination—particularly highlighting fluoride and iron-rich water in Rajhara as a source of skin irritation. However, he admitted that diagnostic capacity is lacking and referrals are routinely made to Daltonganj for further testing. No record-keeping is maintained at the local level, which limits formal tracking of illness trends over time.

In contrast, a second healthcare worker—a private pharmacist and health assistant—provided a more direct linkage between traditional fuel use and a noticeable rise in health complaints over the past five years. He cited increasing cases of breathing difficulty, asthma, skin rashes and eye infections, especially among the elderly and children. While formal diagnoses remain rare due to absent infrastructure, he attributed these symptoms to prolonged exposure to household smoke. Still, he acknowledged that many affected individuals do not seek treatment at formal facilities and instead rely on home remedies or informal consultations. Treatment is primarily symptomatic and the absence of diagnostic laboratory results means that underreporting is likely widespread.

Crucially, both practitioners pointed to a fundamental behavioural and economic constraint. Although people are aware that smoke affects their health, they are unable to switch to cleaner alternatives due to the prohibitive cost of LPG refills and lack of reliable employment.

These insights reinforce the broader evaluation findings: that while awareness of health risks is high, action is constrained by affordability, access and system-level gaps.

Highlight: High Health Risks, Low Care-Seeking and Limited Alternatives

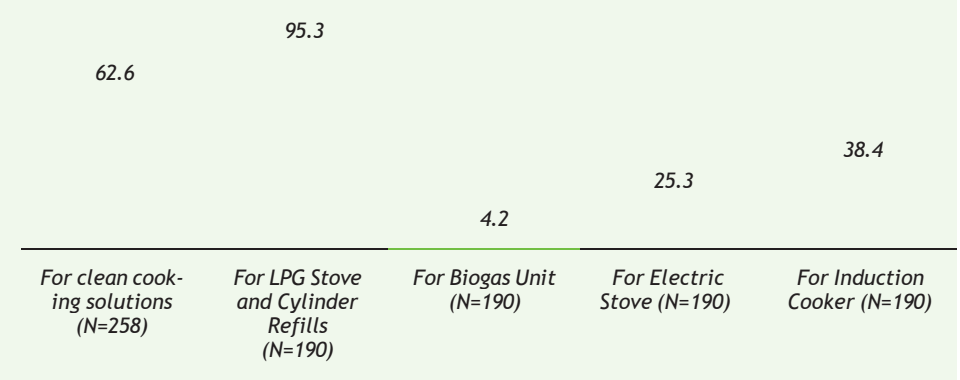
- **Respiratory and eye issues are prevalent,** reported by 10.1% and 10.9% of households respectively, primarily affecting women and children.
- **Cost of treatment is prohibitive,** with average medical expenditure for respiratory illness at ₹10,725 and for eye issues at ₹3,547. Many households forego care or rely on home remedies.
- Chronic symptoms such as eye irritation, dizziness and breathlessness are often normalised by women, who continue using smoke-emitting fuels in poorly ventilated homes.
- Healthcare providers offer mixed perspectives, with one citing minimal evidence and another confirming rising symptoms from household smoke, pointing to underreporting due to poor infrastructure and symptom-based treatment.
- **84.5% of respondents are aware of the health risks** associated with traditional fuels, yet **economic barriers prevent action.**

4.3.4. Community Readiness for Transition to Clean Cooking

Building on the context above, this section delves into the community's openness and preparedness to adopt clean cooking alternatives, with a focus on willingness to pay, key barriers to adoption and the potential role of women's Self-Help Groups (SHGs) in facilitating behavioural change. While there is broad awareness of the health and environmental drawbacks of traditional fuels, the actual transition to cleaner options remains constrained by affordability, limited information and low exposure to technological alternatives beyond LPG. The data suggests that while economic factors remain the primary deterrent, social networks like SHGs can be strategically mobilised to drive demand generation, peer-led demonstrations and long-term adoption–if supported with training and targeted subsidies. The insights presented here are derived from household survey data (n = 258) and qualitative discussions with SHG members across the Rajhara and Pandwa clusters.

Willingness to Pay for Clean Cooking Solutions

Figure 32: Willingness to Pay for Clean Cooking Solutions (in %)



FGD with Self Help Group Members

A strong willingness to transition to clean cooking fuels was evident across the community, with 73.6% of households indicating they would be willing to pay for clean cooking solutions. Among these, 95.3% were willing to pay for LPG stove and cylinder refills, far outpacing other alternatives. However, the enthusiasm for LPG was tempered by clear affordability thresholds. The mean amount respondents were willing to pay for monthly refills was ₹672, with a modal value of ₹500 and a maximum of ₹960—well below the prevailing refill cost of ₹1000–₹1200 reported in qualitative discussions. This mismatch between affordability and actual refill costs explains the irregular use of LPG discussed in the preceding section.

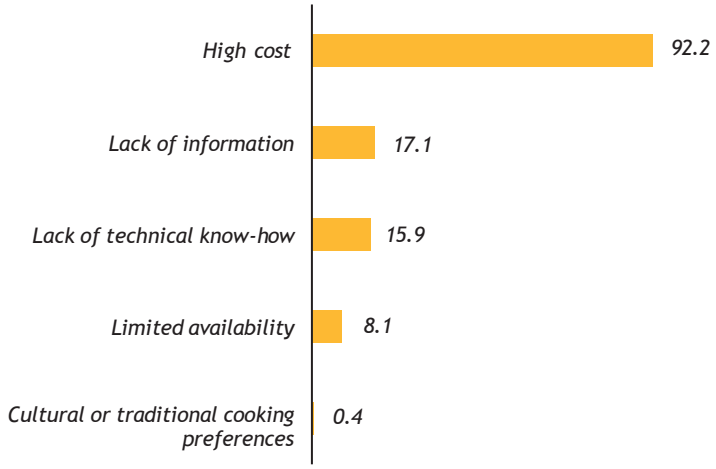
Interest in alternative clean cooking technologies was modest. Among those willing to pay, only 4.2% expressed interest in biogas units, with an average willingness to invest of just ₹356, revealing limited feasibility for such systems. Electric stoves were preferred by 25.3%, while 38.4% expressed openness to induction cookers, with a mean willingness-to-pay of ₹703 and ₹585, respectively.

While LPG remains the most favoured and familiar clean fuel, these figures underscore a broader openness to alternatives, provided costs are brought down and product familiarity is built through demonstrations and training.

Barriers to Adoption

Despite the expressed willingness to adopt clean cooking methods, a range of systemic and sociocultural barriers hinder actual uptake. The most prominent among them is cost: 92.2% of all households identified high expense as the primary barrier to using clean fuels regularly. This aligns with the willingness-to-pay data, where affordability ceilings were far below market prices. Other adoption barriers included a lack of information, a lack of technical know-how, limited availability and cultural or traditional preferences.

Figure 33: Barriers to Adoption of Clean Cooking Fuel (in %)



Quantitative analysis further supports this affordability gap. A one-way ANOVA test revealed statistically significant differences in monthly household income across the three cooking fuel user groups — traditional fuel users, clean fuel users and those using a combination of both ($F(2,255) = 37.43$, $p < .001$).

> *We have gas, but we can't afford ₹1000 every month. That's why we use wood and goliya. We know it is harmful to our health, but what can we do?*
>
> ***— An SHG member from Pandwa village.***

Post hoc testing using the Games-Howell method (to account for unequal variances) confirmed that households exclusively using clean fuels had significantly higher incomes than those using either traditional fuels or a combination. No significant income difference was found between the latter two groups. These findings underscore that exclusive adoption of clean cooking solutions is closely tied to higher household income, whereas those with lower or unstable incomes are more likely to rely on traditional fuels or adopt a mixed-use strategy due to affordability constraints.

These figures are particularly revealing, challenging the often-assumed notion that traditional fuel use is culturally entrenched. Qualitative insights from SHG discussions confirmed that economic constraints, rather than social norms, remain the primary reason households continue to use polluting fuels.

> *We have to cook food on the chulha for Chhath Pooja." It is considered auspicious."*
>
> ***— An SHG member from Rajhara village.***

While the broader data shows minimal cultural resistance, one specific religious practice emerged where members noted that during Chhath Puja, traditional stoves are preferred:

This suggests a ceremonial preference for cooking with wood or dung during festivals, indicating that even LPG-owning households may temporarily revert to traditional fuels for ritual purposes. However, across all other SHGs, respondents explicitly stated that no religious taboos or superstitions were preventing them from adopting clean fuels.

In addition, taste preferences also surfaced in several SHGs, with some women—especially older members—reporting that food cooked on a chulha has a more prosperous or smokier flavour. Yet others downplayed the issue, emphasising health, convenience and the need for habit formation over flavour.

Thus, while religious practices and taste preferences may influence behaviour in isolated instances, they do not represent a systemic constraint. Instead, economic affordability and limited exposure to clean cooking technologies remain the overriding barriers to adoption.

SHGs' Role in Clean Cooking Transition

> *"We will help. Just give us the training and we'll share it with other women as well. " Everyone listens to us when we approach them."*
>
> ***— An SHG member from Rajhara Village.***

While many SHGs in the region are currently dormant in terms of economic activity, their members nonetheless demonstrate strong potential to act as community catalysts for the adoption of clean cooking. During FGDs, several SHG participants expressed eagerness to support awareness efforts, deliver demonstrations and relay key messages to other women—especially if equipped with basic training and informational resources.

The social fabric of SHGs positions them well for informal peer education, particularly in close-knit village settings. Members suggested organising small group meetings (10–15 women) at the neighbourhood level to share the benefits of clean cooking, discuss cost-saving strategies and dispel myths. Notably, there was no resistance to clean fuels on religious or cultural grounds, further supporting the role SHGs can play in enabling behavioural shifts.

Notably, many SHG members highlighted the importance of credibility and firsthand experience. Several noted that they would only feel comfortable promoting clean fuels if they had used them themselves and seen tangible benefits–underscoring the need to bundle SHG training with early access to clean technologies.

> *Many of us struggle to read, but we can easily remember things. " If we learn how to use it, we can teach others."*
>
> ***— An SHG member from Pandwa village.***

In summary, SHGs represent a high-potential yet underutilised channel for promoting clean fuels. With modest investments in training, financial incentives and product demonstrations, they could serve as community-level multipliers in accelerating the adoption of clean fuels across Rajhara and Pandwa.

Highlight: Strong Intent, Limited Means; SHGs Can Lead the Transition

- **High readiness to adopt clean cooking:** 73.6% of households are willing to pay for clean fuels; 95.3% of them prefer LPG. However, their average willingness to pay (₹672/month) falls short of actual refill costs (₹1000-₹1200).
- **Affordability remains the biggest barrier** (cited by 92.2%), not cultural beliefs. Other challenges include lack of technical know-how and limited exposure to alternatives.
- **SHGs are eager to support the transition:** Members volunteered to lead community awareness efforts, demonstrations, and peer training provided they receive basic orientation and tools.
- **Taste preferences by a few and occasional religious practices (e.g., Chhath Puja)** lead to temporary use of traditional fuels but do not inhibit overall transition potential.

FGD with Self Help Group Members

4.4. Conclusion

The evaluation reveals a complex yet encouraging picture of the clean cooking landscape in mining-affected communities of Rajhara and Pandwa. While traditional fuels like wood, dung and coal continue to dominate due to economic necessity and accessibility, there is widespread awareness of their harmful health impacts. The community demonstrates a strong aspirational intent to transition to cleaner fuels, especially LPG, though affordability remains the foremost barrier. Alternative technologies such as electric and induction stoves also hold promise but require greater familiarity and financial support. Importantly, cultural or religious opposition to clean cooking methods was found to be minimal and episodic, not systemic. SHGs, despite limited current activity, emerge as vital channels for awareness generation and behavioural change, provided they are supported with training and exposure.

To systematically assess the readiness and barriers to clean fuel adoption in Rajhara and Pandwa, the study applied the AARQA framework—examining the Availability, Accessibility, Reliability, Quality and Affordability of clean cooking solutions, while integrating gender, governance and community perspectives throughout.

- **Availability**: Clean cooking solutions, particularly LPG, are physically available across Rajhara and Pandwa. All clean fuel users reported LPG usage, and 41.1% reported doorstep delivery. However, there is no local availability of alternate clean cooking options like biogas, induction, or improved biomass cookstoves. In contrast, traditional fuels like wood, coal and goliya are readily available, driving continued reliance despite known health drawbacks.

- **Accessibility**: While LPG is geographically accessible, financial accessibility remains highly constrained. Though 70% of users rated it as “very accessible,” the majority reserved it for emergencies. Women consistently noted that price hikes and subsidy exclusion have rendered regular use unaffordable. Despite availability, administrative barriers (such as lack of KYC linkage or subsidy delays) further reduce effective access, especially for low-literacy or digitally excluded households. Meanwhile, traditional fuels like goliya require 143 minutes per collection trip, primarily by women (90.2%), adding a hidden cost in time, effort, and safety. This dual burden limits accessibility in practice, especially for economically fragile households.

- **Affordability**: Affordability is the single greatest barrier to adoption. Households are only willing to pay a median of ₹672/month, far below the market refill cost of ₹1000–₹1200. As a result, LPG is often rationed for special use. While SHGs are willing to facilitate credit-based purchasing or instalment plans, no formal financing models currently exist to support fuel affordability at scale.

- Traditional fuels are preferred not because they are efficient or safe, but because they incur no direct financial cost. However, this masks the real opportunity cost of fuel collection and preparation. For instance, each trip to collect or prepare goliya takes an average of 143 minutes, not including the 162

minutes spent daily on cooking. This time could otherwise be invested in income-generating activities or rest. The compounding effect of opportunity cost, long-term health implications, and irregular LPG subsidy access illustrates how affordability must be understood beyond price alone. It includes the economic value of unpaid labour and the cumulative cost of not transitioning.

- **Reliability**: From the user perspective, LPG is a reliable and efficient fuel, with no safety concerns reported and nearly universal satisfaction with its performance. However, economic unreliability undermines its consistent use. Meanwhile, traditional fuels such as wood and cow dung are seen as reliably available in physical terms but suffer from severe inefficiencies.

- **Quality (Health and Social Impact):** The quality dimension reveals stark gendered health impacts. Majority of the respondents acknowledged that traditional fuels cause health problems, with 10–11% reporting recent cases of respiratory illness or eye irritation. Women and children, who spend the most time indoors, face chronic exposure. Field interviews and SHG discussions suggest significant underreporting, with several women describing constant eye watering, dizziness, and breathing difficulty during cooking. Out-of-pocket medical expenses (up to ₹25,000) for such ailments further strain fragile household incomes. Despite this, financial barriers prevent consistent use of cleaner alternatives, creating a recurring cycle of health risk and economic burden.

- **Governance and Gender Lens**: Women stand at the frontline of both the problem and the solution. They are the primary collectors, preparers, and users of traditional cooking fuels and bear the heaviest burden of fuel-related health and time costs. Yet institutional support for clean cooking transitions remains minimal. While SHGs in the area are well-networked and enthusiastic about leading behavioural change efforts, they lack access to training, finance, or demonstration tools. Many have suggested peer-led information sessions and supported the idea of SHG-managed credit pools or staggered payment models for clean stoves or refills. However, no government or NGO programme currently anchors this potential.

4.5. Recommendations

To accelerate a sustained shift from polluting fuels to cleaner cooking alternatives in Rajhara and Pandwa, the project must adopt a phased and community-anchored transition strategy. This could combine targeted affordability support, peer-led awareness generation and improved exposure to a range of clean technologies beyond LPG.

1. Help Households Access Subsidies and Support

- Set up a local helpdesk (ideally SHG-led) to assist families with KYC issues, subsidy delays, and enrolment gaps under Pradhan Mantri Ujjwala Yojana (PMUY) or Direct Benefit Transfers-LPG systems.
- Train SHG members to guide others through basic paperwork and subsidy checks.

2. Introduce Affordable Clean Cooking Alternatives

- Partner with agencies like Jharkhand Renewable Energy Development Agency (JREDA), MNRE-accredited suppliers, or private enterprises to introduce low-cost electric induction cookers, improved smokeless chulhas or solar cookers on a trial basis.
- Organise kitchen-side demonstrations where women compare traditional and clean stoves for smoke, cooking time, and ease of use.
- Explore SHG-facilitated instalment payment models for induction cookers or improved stoves, with a repayment period of 6-9 months.

3. Reduce Cost Barriers Through Community-Based Financial Support

- Pilot SHG-based revolving clean cooking funds, allowing members to borrow small amounts for LPG refills or electric stove purchases with low-interest or zero-interest repayment cycles.
- Encourage timely repayment through peer accountability and public record-keeping.

4. Use SHGs to Spread Awareness and Build Comfort

- Add clean cooking to monthly SHG meetings, using simple tools like visuals, stories, or demo sessions.

Annexure

5.1. Water Quality Test Results

Qualissure Laboratory Services
361, Prantick Pally, 45/361, Bose Pukur Road, Kolkata -700107
Email : qualissure@gmail.com; info@qualissure.com ; Mob.No. 98312 87086 ; 9830093976
TC-6271

DOC NO : QLS/SAMP/08-D/00

TEST REPORT

Name & Address Of the Customer : **Athena Infonomics** 12, Murrays Gate Rd, Vannia Teynampet, Chennai, Tamil Nadu 600018	ULR No. : TC627125000001865F Report No. : QLS/P-05/25-26/C/19 Date : 19.05.2025 Sample No. : QLS/P-05/25-26/19 Sample Description : Drinking Water Sample Code : RSPL/DHN/OFS/0820/2025-26 Sample Submitted On : 12.05.2025 Dates of Performance : 13.05.2025 - 17.05.2025 Ref No. Date : Mail Confirmation

Analysis Result

(A) Microbiological Analysis

Sl.No.	Characteristic	Limit as Per IS 10500 :2012, RA: 2018 Amd. 2	Test Method	Result
1.	E.Coli/100ml	Not Detectable	IS 15185-2016 RA: 2021	Not Detected
2.	Total Coliform Bacteria/100ml	Not Detectable	IS 15185-2016 RA: 2021	Not Detected

(B) Chemical Analysis

Sl.No	Test Parameter	Test Method	Limit As Per IS 10500 :2012, RA: 2018 Amd. 1 & 2		Result
			Acceptable Limit	Permissible Limit	
1.	Odour	IS 3025(Part 5)-2018	Agreeable	Agreeable	Agreeable
2.	pH Value at 25^0C	IS 3025 (Part 11)-2022	6.5-8.5	No Relaxation	7.49
3.	Turbidity in NTU	IS 3025 (Part 10)-2023	1	5	<1.0
4.	Total Dissolved Solids (as TDS) in mg/l	IS 3025(Part 16)-2023	500	2000	174
5.	Aluminium (as Al) in mg/l	IS 3025(Part 55): 2003 (RA 2019)	0.03	0.2	<0.01
6.	Ammonia (as total ammonia – N) in mg/l	IS 3025 (Part 34): 1988;RA:2019	0.5	No Relaxation	<0.1
7.	Anionic Detergents(as MBAS) in mg/l	IS 13428-2005(Annex K) ; RA:2018	0.2	1.0	<0.02
8.	Boron(as B) in mg/l	IS 13428-2005(Annex L); RA:2018	0.5	2.4	<0.5
9.	Calcium(as Ca) in mg/l	IS 3025 (Part 40)-1991, RA: 2019	75	200	22.2
10.	Chloride(as Cl) in mg/l	IS 3025 (Part 32)-1988, RA: 2019	250	1000	23.7
11.	Copper(as Cu) in mg/l	IS 3025 (Part 42): 1992 ; RA 2019	0.05	1.5	<0.02
12.	Fluoride(as F) in mg/l	APHA 24th Edition 2023, 4500 F D	1.0	1.5	<0.1
13.	Free Residual Chlorine in mg/l	IS 3025 (Part 26) ;2021	0.2	1.0	<0.1
14.	Iron (as Fe) in mg/l	IS 3025(Part 53)-2003 RA: 2019	1.0	No Relaxation	0.15
15.	Magnesium(as Mg) in mg/l	APHA 24th Edition- 2023, 3500 Mg B	30	100	8.6
16.	Manganese (as Mn) in mg/l	IS 3025 (Part 59): 2023	0.1	0.3	<0.02
17.	Nitrate (as NO_3) in mg/l	IS 3025 (Part 34)-1986 RA: 2019	45	No Relaxation	<0.5
18.	Phenolic Compounds(as C_6H_5OH) in mg/l	IS 3025 (Part 43)- Sec 1, 2022	0.001	0.002	<0.001
19.	Selenium(as Se) in mg/l	IS 15303-2003; RA : 2018	0.01	No Relaxation	<0.01
20.	Sulphate (as SO_4) in mg/l	IS 3025 (Part 24)-Sec 1, 2022	200	400	13.8
21.	Sulphide (as H_2S) in mg/l	IS 3025 (Part 29): 2022	0.05	No Relaxation	<0.05
22.	Alkalinity(as $CaCO_3$)in mg/l	IS 3025 (Part 23)- 2023	200	600	126.7
23.	Total Hardness (as $CaCO_3$) in mg/l	IS 3025 (Part 21)-2009, RA: 2019	200	600	91.1
24.	Cadmium(as Cd) in mg/l	IS 3025(Part 41)-2022	0.003	No Relaxation	<0.002
25.	Cyanide(as CN) in mg/l	IS 3025(Part 27)-1986;RA: 2019	0.05	No Relaxation	<0.02
26.	Lead(as Pb) in mg/l	IS 3025(Part 47)-1994;RA: 2019	0.01	No Relaxation	<0.01
27.	Mercury(as Hg) in mg/l	IS 3025(Part 48)-1994;RA: 2019	0.001	No Relaxation	<0.001
28.	Arsenic(as As) in mg/l	IS 3025 (Part 37)-2022	0.01	No Relaxation	<0.01
29.	Zinc(as Zn) in mg/l	IS 3025(Part 49)-1994;RA: 2019	5	15	<0.02
30.	Total Chromium (as Cr) in mg/l	IS 3025 (Part 52): 2003 RA: 2019	0.05	No Relaxation	<0.05

Remarks: Water is potable in respect to the above parameters of IS 10500:2012(RA- 2018)

Report Prepared By

for Qualissure Laboratory Services
Reviewed & Authorized By
Soumy Chakraborty, Microbiologist
(Authorized Signatory)

for Qualissure Laboratory Services
Reviewed & Authorized By
Bishnupriya Banerjee, Chemist
(Authorized Signatory)

-------End of Report--------

5.2. Fuel Testing Report

REXEON SOLUTIONS (P) LTD.

(FOOD, WATER, SOIL, FUEL, ENVIRONMENTAL SAMPLES TESTING & CONSULTANCY SERVICES)

S. No.-209, City Centre, Luby Circular Road, Dhanbad-826001, JHARKHAND (INDIA)

Our Collaboration Ensures Your Reputation

Test Report Issue Date/Time		19.05.2025		Report Unique ID	RSPL002526050973
Discipline	Chemical	Group	Water	Sub Group	Water

TEST REPORT

CUSTOMER DETAILS	SAMPLE DETAILS
M/s. ATHENA INFONOMICS **Add.** :- 12, Murrays Gate Rd, Vannia Teynampet, Chennai, Tamil Nadu 600018	**Sample ID** : RSPL/DHN/W/821/2025-26 **Sample Description** : Biofuel **Date of Sampling** : 08.05.2025 **Sampling Done by** : Customer **Sample Receipt Date** : 08.05.2025 **Test Start Date** : 08.05.2025 **Test Completion Date** : 19.05.2025

Analysis Result

Sl No	Test Parameter	Method Used	Result (with units)
1	FIXED CARBON (FC)	IS:1350(PART-1)-1984, RA 2019	32.93 %
2	VOLATILE MATTER (VM)	IS:1350(PART-1)-1984, RA 2019	15.57 %
3	TOTAL MOISTURE(TM)	IS:1350(PART-1)-1984, RA 2019	5.56 %
4	ASH	IS:1350(PART-1)-1984, RA 2019	48.73 %
5	GCV	IS:1350(PART-2)-2017	3053 kcal/Kg
6	MOISTURE	IS:1350(PART-1)-1984, RA 2019	2.77 %
	ULTIMATE		
7	Carbon	IS: 1350 (Part-4)	42.0 %
8	Hydrogen		2.00 %
9	Nitrogen		1.72 %
10	Sulphur		0.20 %
11	Oxygen		5.35 %

Contractual Notes:

1. The laboratory accept responsibility for content of this report.
2. Test performed at laboratory's permanent facility and results relate only to the sample tested in prescribed Date & Time.
3. Laboratory is maintaining. Temperature 25 ± 2°C and Relative Humidity 60 ± 5% in all testing area as per IS 196, 1966.
4. The Test Report shall not be reproduced full or in part & can't be used as proof in the court of law.
5. Any complaint about this report should be communicated in writing within 10 days of its issue. (rexeonspl@gmail.com)
6. Total liability of Rexeon Solutions Pvt. Ltd. Will be limited to invoiced amount only.
7. Options does not imply endorsement of the tested product by laboratory. Under no circumstances laboratory accepts any caused by use or misuse of this report.
8. When the results are from external provider are marked as*mark.

Rishav Kumar Thakur

Rishav Thakur
(Chemist)
Checked By

Rajan Kumar

Rajan Kumar
(Quality Manager)
Verified & Issued By

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People-centric Energy Transition

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