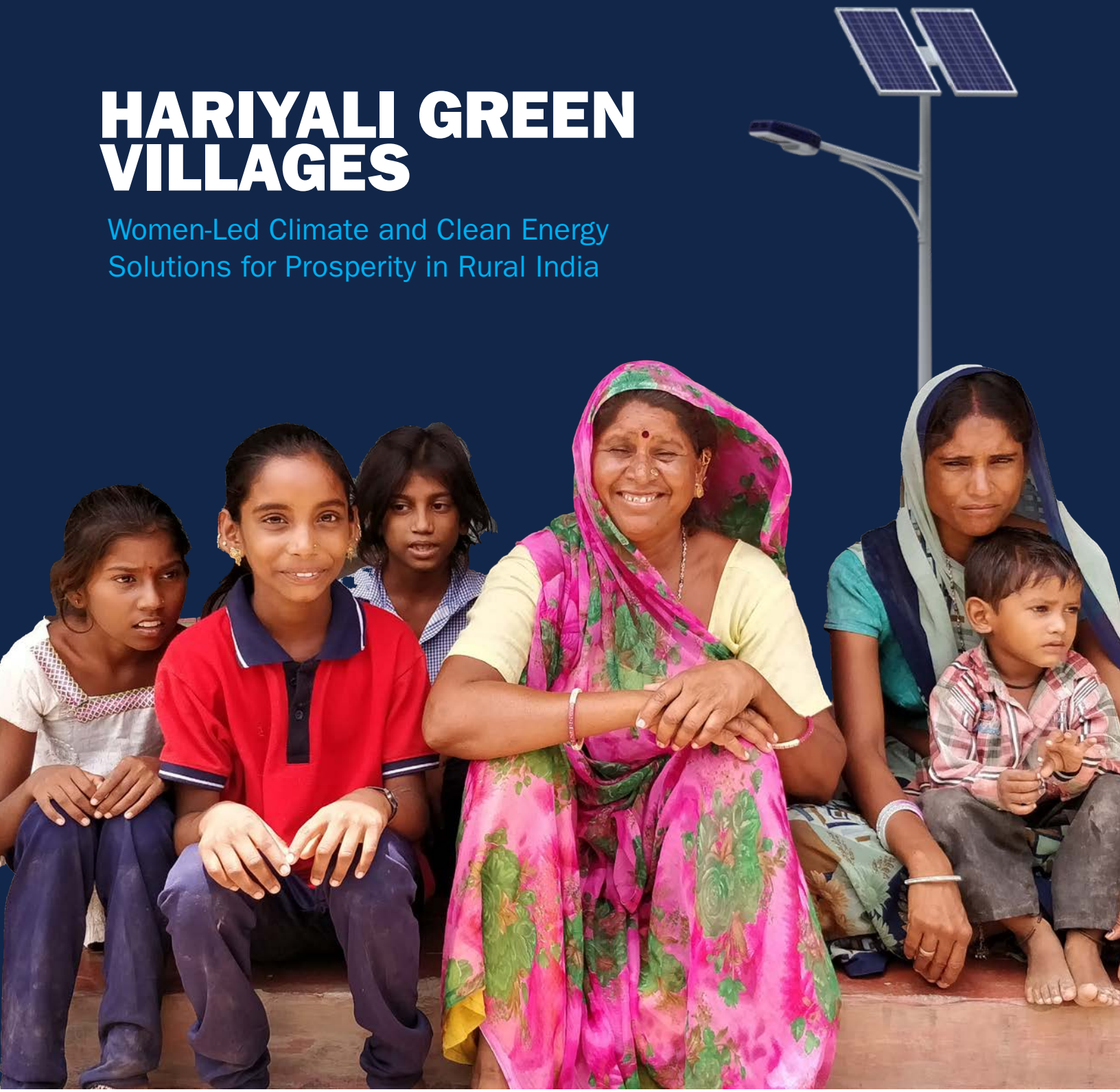
REPORT

JUNE 2022

HARIYALI GREEN VILLAGES

Women-Led Climate and Clean Energy Solutions for Prosperity in Rural India



NRDC
NATURAL RESOURCES DEFENSE COUNCIL

AREAS

SEWA
SELF EMPLOYED WOMEN'S ASSOCIATION

About the Report

The overall objective of this report "Hariyali Green Villages: Women-Led Climate and Clean Energy Solutions for Prosperity in Rural India" is to cover the progress made under the Hariyali Green Villages initiative. The report covers four main interventions implemented under the Hariyali Green Village initiative: (a) expanding the use of energy efficient appliances, (b) increasing biogas plants as a clean cooking solution for households, (c) expanding the use of solar water pumps, and (d) expanding cool roofs to reduce heat stress. In addition, the report covers interventions on precision irrigation system through solar energy, solar trap light, and solar hydroponic fodder system. The report discusses pilot implementation progress, initial impact of the interventions on the rural households and recommendations to enhance financial access for clean energy by rural households.

About AREAS

Association of Renewable Energy Agencies of States (AREAS) has been formed and registered as a society on 27 August 2014 under Society Registration Act 1860. Ministry of New & Renewable Energy (MNRE) is the nodal agency at the central level for promotion of grid-connected and off-grid renewable energy in the country. Ministry's programmes are implemented in close coordination with State Nodal Agencies (SNAs) for renewable energy (RE). Over the period the SNAs have developed considerable knowledge and experience in planning and implementation of RE programmes. With this background, it is important that SNAs interact and learn from each other's experiences and also share their best practices and knowledge regarding technologies and schemes/programmes. All SNAs are the member of the Association.

www.areas.org.in

About NRDC

With over 50 years of experience, the Natural Resources Defense Council (NRDC) combines the power of more than three million members and online supporters with the expertise of over 700 scientists, lawyers, and policy experts to drive climate and clean energy action, protect nature, and promote healthy people and thriving communities. NRDC works in the United States, China, India, and key geographies to advance environmental solutions. In India, NRDC partners with leading organizations on clean energy access, climate resilience, and clean air and healthy cities. For over 10 years, NRDC has also worked with government officials at the national, state, and city level partnering with local groups and businesses to combine scientific research and policy acumen to implement impactful climate solutions.

www.nrdc.org; Twitter @NRDC_India

About SEWA

Self Employed Women's Association (SEWA) is a member-based organization of poor, self-employed women workers in India. SEWA is spread across 14 states of India with deep penetration at grassroots level in villages. SEWA also works in Afghanistan, Nepal, Sri Lanka, and Myanmar. SEWA has membership reach of 1.7 million globally. SEWA organizes the women into self-help groups and cooperatives based on their respective trades and then channelizes information, awareness, health interventions, trainings for skill development, financial support (e.g. savings, insurance, credit, and pension), and market linkages to enable members to become self-sustainable in their trades, including salt production. SEWA's twin goals are "Full Employment" and "Self-Reliance." "Full employment" includes work security, income security, food security and social security (at least healthcare, childcare, nutrition, shelter) whereas "self-reliance" means making members autonomous economically and in decision-making.

www.sewa.org

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सत्यमेव जयते

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Foreword

"The future of India lies in its villages." To enable a sustainable future for India, we must follow Mahatma Gandhi's words and empower villages. The Ministry of New and Renewable Energy (MNRE) recognises that harnessing the full power of India's clean energy transition requires empowering the rural areas where billions of people reside. As such, MNRE has been focusing on expanding the use of clean energy technologies in villages. A clean energy transition of India requires enhancing the accessibility, availability, and affordability of energy for all.

Distributed Renewable Energy (DRE), or locally generated clean energy technology systems, can not only ensure last mile availability of affordable and reliable clean power, but also provide livelihood opportunities and economically empower women through access to energy and reducing drudgery. Key DRE interventions include biogas plants, solar pumps and precision irrigation systems, solar powered appliances and equipment, and more. To scale up DRE implementation, concentrated efforts by grassroot organizations, along with stakeholder support and favourable interplay of policies, technologies, and finance across the RE value chain are key.

Natural Resources Defense Council (NRDC) and Self-Employed Women's Association (SEWA)'s Hariyali Green Villages Initiative empowers women to be change agents through access to clean and affordable energy. Association of Renewable Energy Agencies of States under Ministry of New and Renewable Energy (AREAS-MNRE) is supporting to scale up the Hariyali Green Villages initiative in villages across the states India.

MNRE has always recognized, celebrated and encouraged women's vital involvement in India's successful Renewable Energy movement. MNRE has initiated various programmes, such as the "Women in Renewable Energy: Call for Action," to acknowledge the role of women entrepreneurs and leaders in the RE sector. Women, who represent close to 50% of India's population, have a significant role to play in India's trajectory to clean energy pathways through partnership and participation. Access to clean energy solutions can support women leaders in villages improve livelihoods, create jobs, and meet sustainable development goals.

I congratulate NRDC and SEWA on this report's release and providing insightful findings about clean technology implementation. The report, which includes key inputs from the beneficiaries as well as early analysis of the impact of DRE interventions, could provide a positive push to the sector and encourage more focus on implementation of clean energy technologies along with policy interventions. I wish NRDC, SEWA and their partners my best for this initiative.

(Dr. Vandana Kumar)

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Executive Summary

India's push for 100% household electrification under the Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya) scheme has transformed the energy access landscape in India—electricity supply now reaches millions of households previously not connected to the grid.[1] The next step in fully empowering rural households is to provide reliable 24x7 electricity. Increase in access to modern energy provides a good opportunity to introduce livelihood and income generation options that are based on clean energy and environment friendly technologies. Adoption and use of clean energy in India's villages, home to two-thirds of the country's population, is still very limited.[2] Clean energy solutions can improve livelihoods by increasing income through productive use applications and reducing expenditure on fossil fuels. Additionally, mechanization of activities or reducing the time spent to collect and process traditional fuels such as wood can reduce drudgery, especially for women who are traditionally engaged in these roles. Clean energy technologies also have the potential to contribute immensely to meeting India's climate commitments. As India's energy demand is set to increase by nearly 50% in the coming decade and millions of households are expected to invest in electrical appliances, early adoption of clean energy technologies can make a big difference in reducing greenhouse gas emissions and avoiding costly energy imports.[3]

To advance access to clean energy and environment friendly technologies, the Natural Resources Defense Council (NRDC) and the Self-Employed Women's Association (SEWA) along with the Association of Renewable Energy Agencies of States under the Ministry of New and Renewable Energy (AREAS-MNRE) are implementing a unique and comprehensive initiative, called the Hariyali Green Villages, in several villages in Gujarat and Rajasthan.[4]

The Hariyali Green Villages initiative aims to enhance accessibility and affordability of clean energy technologies and improve livelihood opportunities at the household level in rural India. Each Green Village, or *Hariyali Gram*, includes a suite of clean energy and environment friendly technologies such as Light-emitting Diode (LED) bulbs and energy efficient fans for lighting and thermal comfort, biogas plants for clean cooking, solar-powered water pumps for irrigation, and cool roofs to reduce heat stress in the houses. With the objective of scaling up to 100 villages by 2025, NRDC, SEWA and partners have effectively demonstrated these solutions in more than 10 villages in 2021-22 and benefitted over 300 families (Table 1).

TABLE 1: Brief Summary of the Pilot Implementation under the Hariyali Green Villages Initiative

Technology	LED bulbs and energy efficient fans	Biogas for clean cooking	Solar water pumps	Cool roofs
Cost* 	₹2,100 ($28) for an appliance kit containing two LED bulbs (9W), one energy efficient fan (50W), and one solar lantern	₹40,000-45,000 ($533.3 - 600), sufficient for a family of six	~ ₹300,000 ($4,000) for a 5-HP solar water pump including on-site warranty and life insurance premium of the pump owner for a period of 5 years	₹1,000 – 2,500 ($13.3 – 33.3) to cover 100 square feet roof with two coats of solar reflective paint, depending on the type of paint used
Financing 	Credit offered by SEWA with flexible installments options (maximum five installments)	Free demonstration for first four months, followed by monthly payments by households	60% subsidy is available under PM-KUSUM scheme, but its uptake has been a challenge in Gujarat; the remaining portion is financed through personal equity and/or bank loans	Demonstration projects by SEWA and Mahila Housing Trust (MHT)
Impact 	Monthly savings of ₹100 - 150 ($1.3 - 2) in the electricity bill per household	Monthly savings of ~ ₹1,000 ($13.3) per month on LPG cylinder refilling (for a household of six)	Savings of ₹3,600 - 5,400 ($48 – 72) per cropping cycle per acre	Enhanced thermal comfort due to lower ambient indoor temperature by 1.5 to 5°C (2.7 to 9°F)
Lessons 	Design steps to create awareness about energy efficient appliances; engage with equipment suppliers to reduce costs; demonstrate pilots to showcase monetary savings	Identify relevant government subsidies & favourable financing options for the households; demonstrate pilots to create willingness to adopt; provide training to operate, repair and maintain the biogas plant	Address policy hurdles regarding obtaining government subsidies; standardize procurement practices; create alternate financing mechanisms; demonstrate financial benefits through pilots	Create awareness for vulnerable communities; organize stakeholder consultations; engage with policymakers & create positive discourse; scale cool roof implementation before heat season for maximum impact

Source: NRDC, SEWA, 2022

** US $1 = ₹75*

Objective of Hariyali Green Villages Initiative

The Hariyali Green Villages initiative aspires to improve clean energy access for people living in rural India by supporting comprehensive energy policy and scalable market solutions. Working with partners, SEWA and NRDC designed and first piloted effective clean energy interventions in two villages – Nagano Math in Aravalli District, Gujarat, and Beraniya in Dungarpur District, Rajasthan in 2020. Lessons from this two-village pilot helped develop a scalable model that is being applied to reach a goal of 100 Green Villages by 2025.[5]

Hariyali Green Villages initiative serves multiple objectives - increasing energy affordability; enhancing energy supply for household and livelihood activities; expanding clean energy and energy efficiency; improving living conditions and reducing drudgery; and improving health, air quality, and environment by reducing emissions. Hariyali Green Villages initiative have a women-led policy, market, technology, financial, and social framework that enhances energy access and affordability as well as traditional livelihoods through climate solutions. As women typically have limited decision-making authority on household energy choices, the plans also focus on involving women throughout the process of selecting and using technology as well as understanding finances through SEWA members.

The Hariyali Green Villages initiative started in 2019 with research and framework development. The approach to identify clean energy interventions and design Green Village Plans consisted of four main components, as depicted in Figure 1.

FIGURE 1: Components for Developing Green Village Plans

Selection
- Framework for identifying districts
- Select pilot villages

Identify Opportunities
- Review national, state, and local government policies
- Identify market programs for clean energy
- Complementarity with SEWA activities

Survey
- Socio-economic profile
- Energy use: existing energy use, energy supply conditions, challenges and clean energy opportunities

Village Plans
- Survey analysis
- SEWA expertise
- Social acceptance
- Policy linkages
- Technical and nancial linkages
- Skill requirement

The pilot villages were selected using multiple criteria including a large rural population, low electricity access, limited access to banking services, low asset ownership, and presence of SEWA members. For each village, government programs at both national and state level, and market opportunities for clean energy were identified. A comprehensive primary research was conducted in summer 2019 to determine households' key energy uses and socioeconomic profile. Surveys and group discussions were conducted in the local language and included about 35% of the population of each village. Finally, based on survey findings, NRDC and partners identified a suite of key climate and clean energy interventions based on technical compatibility, financial viability, and skill development.

Navigating through the COVID-19 pandemic as well as cyclone Tauktae which destroyed the agricultural yields and village infrastructure in Gujarat and Rajasthan, made Green Village Plans implementation more challenging but also more urgent.[6] The COVID-19 pandemic disproportionately affected the most marginalized. Many village inhabitants in India migrate to urban areas for finding jobs, and mobility restrictions due to public health concerns led to widespread unemployment among these groups exacerbating the economic crisis in rural households.[7] At the same time, the multiple climate and health crises also showcased the role of energy access and how clean energy technology could enhance climate resilience. NRDC and SEWA worked closely with households to provide COVID-19 relief while making progress on implementing Green Village Plans.

Green Village Plans: Profiles of the Pilot Villages: Nagano Math, Gujarat and Beraniya, Rajasthan

Nagano Math is a village with about 250 households, most of which include four to six family members.[8] Agriculture is the primary source of livelihood. Other occupations include animal husbandry and daily wage labor. There is no bus service to the village and people largely use private shared-taxis or three-wheelers to travel. Household electricity supply in Nagano Math is nearly universal and available for most of the day, however there are no streetlights in most parts of the village.

Beraniya is a village with about 250 households, with most households consisting of six to nine family members.[9] Agriculture is the primary occupation, and most households engage in marginal farming or work as agricultural or manual laborers. Farming is largely rainfed. Other occupations include animal husbandry and wage labor. Beraniya is not connected by public transport and the community largely relies on private taxis or three-wheelers for its transport needs. Most households have electricity connections, almost half of which were only recently electrified. The electricity supply is intermittent with an average of nine hours per day. Beraniya has no streetlights.

Interventions for Green Village Plans

NRDC and SEWA selected several clean energy technologies to implement in villages in Gujarat and Rajasthan based on the survey findings. Several of these solutions have been implemented in villages in Gujarat and Rajasthan (Figures 2 and 3).

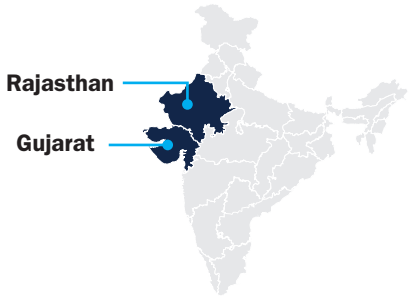
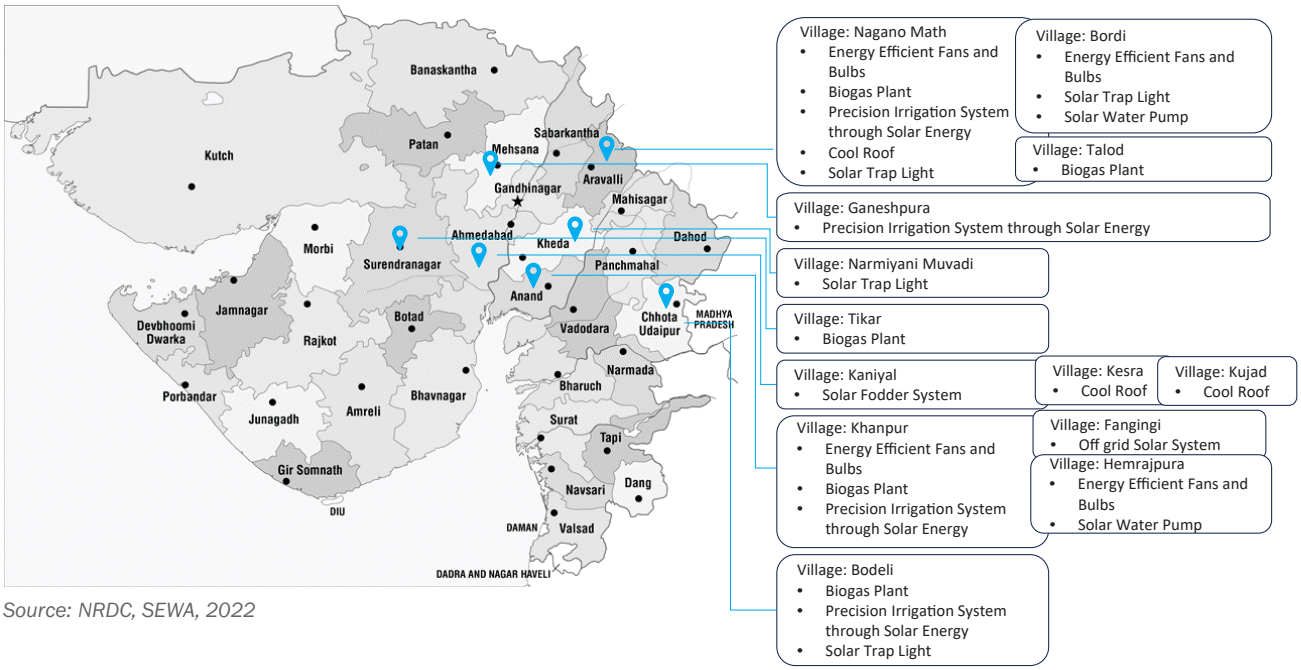


FIGURE 2: Interventions piloted in Gujarat, India



Village: Nagano Math
- Energy Efficient Fans and Bulbs
- Biogas Plant
- Precision Irrigation System through Solar Energy
- Cool Roof
- Solar Trap Light

Village: Bordi
- Energy Efficient Fans and Bulbs
- Solar Trap Light
- Solar Water Pump

Village: Talod
- Biogas Plant

Village: Ganeshpura
- Precision Irrigation System through Solar Energy

Village: Narmiyani Muvadi
- Solar Trap Light

Village: Tikar
- Biogas Plant

Village: Kaniyal
- Solar Fodder System

Village: Kesra
- Cool Roof

Village: Kujad
- Cool Roof

Village: Khanpur
- Energy Efficient Fans and Bulbs
- Biogas Plant
- Precision Irrigation System through Solar Energy

Village: Fangingi
- Off grid Solar System

Village: Hemrajpura
- Energy Efficient Fans and Bulbs
- Solar Water Pump

Village: Bodeli
- Biogas Plant
- Precision Irrigation System through Solar Energy
- Solar Trap Light

Source: NRDC, SEWA, 2022

FIGURE 3: Interventions piloted in Rajasthan, India

Village: Paldi Mangaliya
- Cool Roofs

Village: Ralawas
- Cool Roofs

Village: Lohri Pandit Ji
- Cool Roofs

Village: Shri Yade Nagar
- Cool Roofs

Village: Beraniya
- Energy Efficient Fans and Bulbs
- Precision Irrigation System through Solar Energy
- Cool Roof
- Solar Trap Light

Village: Favta
- Energy Efficient Fans and Bulbs
- Solar Trap Light

Village: Ghata ka Gau
- Energy Efficient Fans and Bulbs
- Precision Irrigation System through Solar Energy

Source: NRDC, SEWA, 2022

The initial impact of these interventions has been determined based on discussions with the rural households and has been detailed out in the later sections. The project team plans to conduct a more detailed impact assessment to assess the benefits and gaps after one year of the pilot.

Expanding the use of energy efficient appliances

Energy efficient appliances use less electricity to perform the same function as their non-efficient counterparts. With increasing energy access and rising incomes in India, the use of household appliances is also expected to increase. Energy efficient appliances reduce overall electricity consumption and enable customers to save money on their electricity bill. As per an estimate, the electricity demand from new appliances can be reduced by 58% if rural households buy energy efficient appliances.[10]

Based on the survey conducted under the Hariyali Green Village initiative in 2019, the households highlighted the need for appliances like light bulbs and ceiling fans. NRDC and SEWA partnered with Energy Efficiency Services Limited (EESL) to offer the households energy efficient appliance bundles consisting of one energy efficient fan (50 Watts (W)), two LED bulbs (9W), and one solar lantern. Through bulk procurement and bundling of equipment, the cost of kits to households were brought down to approximately ₹2,100 ($28).

NRDC and SEWA have supported the following villages in increasing their uptake of energy efficient appliances: (a) Nagano Math village and Bordi village in the Aravalli District, Gujarat, (b) Khanpur village and Hemrajpura village in the Anand District, Gujarat, and (c) Beraniya village, Ghata ka Gau village and Favta village in the Dungarpur District, Rajasthan. So far, under the Green Village Plans initiative, SEWA has sold 300 appliance kits to rural households.

NRDC and SEWA, through capacity building and continuous dialogue with households, have been working towards building rural households' confidence in energy efficient appliances. During the COVID-19 pandemic lockdowns, NRDC and SEWA, in partnership with EESL, organized an online workshop so that SEWA members could get training on effective operation and management of these appliance to minimize future servicing and repair needs. Furthermore, to facilitate better repayment terms, specifically considering the impact of COVID-19 pandemic on the economic activities of the households and reduced purchasing power, SEWA accepted payment through monthly installments. The financing was structured in a flexible manner to match the income cycle of the households. The households had the option of paying up to five installments at zero rate of interest. This avoided unnecessary financial burden on the households, and therefore resulted in a larger uptake of the appliance kits.

Initial assessment shows that on an average households have used LED bulbs for 5-6 hours and energy efficient fans for close to 8 hours every day. Consequently, the households have reported savings in the range of ₹100 - 150 ($1.3 - 2) per month in their energy bills. These initial impacts have been assessed for three winter months, between December 2021 to

FIGURE 4: Snapshots of Kits Comprising of Energy Efficient Appliances being Distributed at Beraniya village, Dungarpur Block, Rajasthan

February 2022, post implementation of the pilots. With rising summer temperatures, use of energy efficient fan will increase to about 15 hours a day, leading to higher electricity bill savings.

The high cost of energy efficient appliances as compared to their cheaper but inefficient counterparts is a major deterrent to technology uptake. To scale up and expand the use of efficient appliances, it is important to demonstrate that the initial higher cost of appliance will be offset through reduced energy bills. In addition, there is a need to streamline the approach to generate awareness about the Standards & Labeling programme of Bureau of Energy Efficiency in rural areas through more focused communication strategies. NRDC and SEWA continue to engage with households to aggregate demand, as well as work with technology suppliers to procure equipment at affordable rates.

Increasing biogas plants as a clean cooking solution for households

Biogas is produced through anaerobic digestion of various biomass sources including livestock manure, agricultural residue, and food waste.[11] Biogas production also produces organic fertilizer, a byproduct that can reduce dependency on chemical fertilizers in the agriculture sector. Thus, biomass sources that were previously considered waste can be converted into useful resources, enhancing the concept of circular economy at the village level.

In rural kitchens, biogas plants can be an energy substitute for wood or charcoal. By replacing these polluting solid fuels, biogas can improve health outcomes, particularly for women considering their greater role in cooking and resultant exposure to the pollutants.[12] In addition, biogas plants reduce the burden of collecting wood reducing drudgery for women and children.[13] Further, reduction in wood and charcoal use can lead to decreased forest degradation and reduced GHG emissions. Effective implementation of biogas plants can contribute to multiple Sustainable Development Goals (SDGs), including SDG 3: Good health and well-being, SDG 7: Affordable and clean energy, SDG 13: climate action and SDG 15: Life of Land (due to reduced deforestation).[14]

In the pilot villages under the Hariyali Green Villages initiative, many households have access to liquified petroleum gas (LPG) cylinders for cooking, but their use is often limited due to high costs of refilling the cylinders.[15] Thus, women farmers often used mud stoves to cook the meal, resulting in various health hazards including increased cases of asthma due to high level of pollutants such as carbon dioxide, carbon monoxide, methane and particulate matter PM10 & PM2.5.[16] In the pilot villages, women also spent on an average about 1.5 additional hours every day collecting wood or charcoal and about one day commuting to the distribution center when it was time get the LPG cylinder refill.[17] Women in households with cattle can transfer the manure, which they anyway used to collect, to the biogas plant, saving time overall.

Household level biogas plants have been installed at five locations in Gujarat: one each in (a) Nagano Math village and Talod village, Aravalli District, (b) Khanpur village, Anand District, (c) Bodeli village, Chota Udaipur District, and (d) Tikar village, Surandranagar District. Due to potential health benefits and time

FIGURE 5: Snapshots of Biogas Plant Installation and Awareness Generation Activity in Aravalli District, Gujarat

saving opportunities, village households have shown keen interest in biogas plants adoption. SEWA is further working to procure 50 biogas plants in the Aravalli District and 10 biogas plants in Anand District in Gujarat.[18] Households in the Surendra Nagar Districts, Gujarat have also expressed interest in installation of a community-owned biogas plant.

A biogas plant costs about ₹40,000-45,000 (~$533-600), sufficient for a family of six members. During the pilot phase, five households had the option of using the biogas plant free of cost for a period of four months. After the pilot, the households are required to pay 20% of the cost and remaining amount can be repaid in 12 equated monthly installments (EMIs). NRDC and SEWA are discussing financing mechanisms and business models with multiple stakeholders to reduce the overall cost of biogas plants, including options such as reduced down payment requirement, favorable interest rates, credit facility by technology supplier, and community ownership models.

The initial assessment showcases a reduction in expenditures on LPG cylinder refilling by an average of ₹1000 ($13.3) per month for a household of six members. This has also enabled households to have more time for family and has reduced drudgery for women members.

Considering limited credit availability and the high cost of biogas plants, it is essential to identify relevant government subsidies and innovative financing mechanisms to enable large scale implementation by rural households. In addition, efforts are required to influence the social norms around male-dominated decision-making processes and empower women to make choices regarding selection of fuel. Requisite emphasis must be placed on showcasing the ill health-effects of traditional fuels and the benefits of moving away from what is considered free fuel. Proper training to operate and maintain biogas plants would build requisite skills among users, leading to enhanced confidence in the technology.

Expanding the use of solar water pumps

A solar water pump is an electrical water pumping system that uses electricity generated by solar Photovoltaic (PV) panels.[19] Solar water pumps help expand farms' access to irrigation and reduce dependence on diesel, or grid-connected electricity which is not always available. Transition to solar powered irrigation is particularly important for India to meet its climate commitments as about one-third of the 30 million agricultural pumps installed in India were diesel-based prior to 2019 when MNRE launched the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme.[20]

The PM-KUSUM scheme has a goal to install 2 million standalone solar water pumps by 2022. The resultant benefits are many: boosting farmers' incomes, providing them with energy access for irrigation, reducing government electricity subsidies to the agriculture sector, and decarbonizing the agriculture sector.[21] Moreover, transitioning to solar water pumps could provide additional livelihood opportunities as electricity generated from solar water pumps during non-irrigation hours could potentially be used for other productive purposes. Replacement of about five million diesel pumps in India could abate an estimated 26 metric tons of carbon dioxide ($MTCO_2$) emissions.[22]

Solar water pumps are cost-effective for farmers on a lifetime basis, especially when compared with the recurring costs incurred for purchase of fuel for diesel pumps. In the case of diesel pumps, one hour of operation consumes an average of 1-1.25 liters of diesel. Irrigation of about one acre of land for six to eight hours consumes close to 10 liters of diesel for each irrigation cycle. Water requirement varies depending on the season and the crops. With the installation of solar water pumps, farmers can save expenditure on diesel.

Table 2 provides a snapshot of cost savings from adoption of solar water pumps per cropping cycle.[23]

TABLE 2: Computation of Diesel Cost Savings by Adopting Solar Water Pumps

Type of crop	Wheat
Irrigation cycles required per cropping cycle	4 - 6 cycles
Total diesel consumed per acre	40 - 60 liters
Cost of diesel in Gujarat	₹ 90 ($1.2) per liter (approximately)
Total diesel cost saved by farmer in case solar water pump is installed	₹ 3,600 to 5,400 ($48 – 72) per cropping cycle per acre

Source: NRDC, SEWA, 2022

A SEWA-provided 5-horsepower (HP) solar water pump costs farmers around ₹300,000 ($4,000), including preventive maintenance costs, such as monthly field visits from technicians and on-site five-year warranty. In addition, the life insurance premium

of the pump owner is covered for five years under Pradhan Mantri Suraksha Bima Yojana.

The central government provides farmers with a 30% subsidy and state governments provide a minimum 30% subsidy on solar pumps to incentivize uptake.[24] Though the program has received tremendous support nationally, uptake is also dependent upon state-level incentives and implementation mechanisms notified by the State Nodal Agencies (SNAs).

For instance, the state of Gujarat requires the submission of a no objection certificate that is jointly signed by all the landowners. Producing this document has been a challenge for applicants for multiple reasons: death of family members, family feuds, migration to cities, etc.[25] This has resulted in low uptake of solar water pumps in the state as many farmers are not able to access the stipulated scheme benefits. Furthermore, many farmers do not meet banks' eligibility criteria in terms of collaterals required to process loans even if they are willing to install solar water pumps without subsidies. To address this and scale up the implementation of solar water pumps, innovative financing structures are required. NRDC and SEWA are engaging with MNRE, State Nodal Agencies (SNAs), and financing institutions to address some of these barriers.

As part of the Green Village Plans, SEWA and partners installed seven solar water pumps in Gujarat: six in Hemrajpura village, Anand District, and one in Bordi village, Aravalli District. SEWA also sent a purchase order for six additional pumps. These pumps are scheduled for installation in 2022 at three sites in the Aravalli and Bodeli Districts. The key consideration for installation of solar water pumps in Gujarat is to replace the existing diesel pumps or to provide energy access to small and marginal farmers. SEWA also works with small and marginal farmers to organize them in groups and purchase solar pumps that are otherwise unaffordable. Farmers in Gujarat have shown keen interest in installation of solar pumps as agricultural power supply is available mostly at night. However, considering the ticket size of investment, subsidy support is critical for farmers, especially small and marginal farmers.

Demonstrating financial benefits to peers can support the adoption of solar water pumps. It is also important to ensure that farmers can obtain government subsidies. Generating awareness about the optimum use of water for irrigation purposes is also key—the negligible cost of water pumping through solar pumps may lead to excessive water use. At this point, it is also important to standardise procurement practices to ensure quality control and provision of proper post sale services of the pump. NRDC and SEWA also engage with financing institutions to identify alternate financing mechanisms and to ensure ease of credit. For instance, the farmers are required to pay fixed equated monthly instalments (EMIs) whereas the income is cyclic in nature. If the EMIs can be structured to match the income cycles, the farmers would be at ease to make the repayments and possibility of payment default would reduce.

Expanding cool roofs to reduce heat stress

Cool roofs use materials that have high reflectivity and high emissivity. As a result, the roofs retain less heat and reflect more sunlight. Cool roofs can keep indoor temperatures 1.5 to 5°C (2.7 to 9°F) lower than conventional roofs.[26] While more advanced cool roofs can be expensive, affordable cool roof solutions such as solar reflective paint has been used for the pilots done with rural households. This paint can also be used on tin and cement roofs. Cool roofs are a successful climate change adaptation solution, especially for poor and vulnerable communities that have limited access to cooling appliances, as well as limited financial resources.

Cools roofs have shown health benefits and environmental benefits as they increase thermal comfort and reduce dependence on electrified cooling appliances.[27] Community-led initiatives in India have proven that cool roofs are an extremely cost-effective tool to reduce heat stress for rural households.[28] In 2021, 125 cool roofs in Rajasthan and 13 cool roofs in Gujarat have been piloted using solar reflective paint, by the Mahila Housing Trust (MHT) and SEWA. Training sessions on the application of solar reflective paint were organized along with cool roof demonstrations to empower rural women. While reduction in temperature and impact on energy bill, if any, will be measured during the summer season of 2023, the households noted that after the application of solar-reflective paint, the amount of moisture that would usually seep in through the roof during rains has reduced.

Some of the pilot cool roof installations done by SEWA did not cost anything to the households. On the other hand, for the installations undertaken by MHT, the households contributed a nominal 10% of the cost of solar reflective paint. To provide additional benefit and feature energy efficiency intervention, MHT provided one LED bulb to the households to replace incandescent bulb against this payment.[29]

The cost of solar reflective paint may range from ₹1,000 – 2,500 ($13.3 – 33.3) to cover 100 square feet roof with two coats of solar reflective paint, depending on the type of paint used. With summer season at its peak, demand for solar reflective paint has increased.

Awareness generating campaigns aimed at informing vulnerable communities about availability of cost-effective cooling solutions, such as solar reflective paints, can increase adoption of cool roofs leading to positive impacts on health and environment. Stakeholder consultations including village representatives, technology providers and policymakers can help ensure that simple yet effective solutions can be adequately scaled up.

FIGURE 6: Snapshots of Cool Roof Demonstration at Nagano Math Village, Aravalli District, Gujarat

Other Climate Friendly Technologies

Precision Irrigation System through Solar Energy

Precision irrigation is a technique that enables farmers to optimize water use and improve crop yield. Through precision irrigation systems, water and nutrients are supplied to plants in a scheduled manner and in optimal quantities through pipes. Since they are powered by solar energy, the pilot precision irrigation system demonstrated under the Green Village Plans are zero-emission.

FIGURE 7: Snapshots of a Farm without Drip Irrigation System at Nagano Math Village, Aravalli District, Gujarat

FIGURE 8: Snapshots of a Farm with Drip Irrigation System at Nagano Math Village, Aravalli District, Gujarat

SEWA has deployed the precision drip irrigation system in five locations:(a) Nagano Math village, Aravalli District, Gujarat, (b) Khanpur village, Anand District, Gujarat, (c) Bodeli village, Chota Udaipur District, Gujarat, (d) Ganeshpura village, Meshana District, Gujarat, and (e) Beraniya village and Ghata ka Gau village, Dungarpur District, Rajasthan.

The system consists of a 150W/12V solar panel, drip pump, irrigation pipes and power management box along with other equipment at a cost of ₹85,000 ($1,133.3). Even though the initial cost is high, the resultant savings from this intervention are encouraging. Farmers have reported faster growth in crops as compared to flood irrigation. In Nagano Math, fennel crop was sown in a farm and the crop was divided into two sections. One section was irrigated using a precision irrigation system. Another section used the flood irrigation method. All other conditions including input materials and fertilisers remained same. Crop growth was measured over a period of time. The crops in the section irrigated using a precision irrigation system grew taller by close to 10 centimetres between October 2021 to March 2022. As a result, farmers could harvest more produce from the crops irrigated using precision irrigation system.

Solar Trap Light

A solar trap light is a pest control device that replaces chemical pesticides. It is a self-operating device that effectively eliminates pests such as flying nocturnal insects that can damage crops.[30] The device costs approximately ₹5,800 ($77.3). As a result of the installation of a solar trap light, the cost of insecticides has reduced by 20-25%. Solar trap lights have been used at six locations in India: namely (a) Nagano Math village and Bordi village, Aravalli District, Gujarat, (b) Narmiyani Muvadi village, Kheda District, Gujarat, (c) Bodeli village, Chota Udaipur District, Gujarat, and (d) Beraniya village and Favta village, Dungarpur District, Rajasthan. Solar trap lights have proven to be a cost-effective solution for pest control in all the pilot locations.

FIGURE 9: Snapshots of a Farmer with Solar Trap Light at Nagano Math Village, Aravalli District, Gujarat

Solar Hydroponic Fodder System

The solar hydroponic fodder system enables households to grow high protein fodder for cattle. Using this system, crops are grown without soil in trays and nutrients are supplied through water solvents in a climate-controlled environment. Water is transferred to the trays via solar pumps. Generally, one tray is sufficient for one cow. The fixed cost of the system is approximately ₹45,000-50,000 ($600-666.6). Households are required to invest recurring costs on seed and other inputs to grow the fodder. On the other hand, fodder procurement from outside costs on an average about ₹3000-5000 ($40-66.6) per cow or buffalo per month.

The solar fodder system has been installed at Kaniyal village, Ahmedabad District, Gujarat. The installation was completed in 2021. The farmer has reported increased milk production by 1-1.5 liters per cow. The farmer has also been able to fetch more price per liter of milk due to increased fat percentage post installation of solar fodder system.

FIGURE 9: Snapshots of a farmer with Fodder Tray, Kaniyal Village, Ahmedabad District, Gujarat

Enhancing Financial Access for Clean Energy

Financing remains one of the most significant barriers in scaling the clean energy technology interventions irrespective of technology cost. Rural consumers, often women, rely on informal sources to access credit.[31] This is primarily because banking infrastructure is limited in rural areas and customers have a limited choice in terms of both lending institutions and financial products available to them. In most cases, consumers, particularly women consumers, do not own assets, which limits their ability to provide collateral required by financial channels. In addition, most loans are to be repaid based on fixed EMIs. With the cyclic nature of incomes, the timetable becomes a major challenge to meeting obligations. Informal sources are more expensive and less sophisticated as compared to those offered by formal financial institutions.

At the same time, commercial lenders perceive this market to be high-risk. Irregular and cyclic income, common in rural areas due to self-employment or heavy reliance on agriculture sector, increases the risk profile of potential borrowers. In addition, lack of insightful and updated data on rural and agricultural value chains further increases lending institutions' apprehension. Banks may be wary of extending collateral-free loans to farmers and often insist on additional security. Lower levels of education, financial literacy, and time contribute to rural persons, particularly women, having a hard time complying with a financial institution's procedures and requirements to apply for a loan or to open a savings account.[32]

Challenges exist for both the borrowers and the lenders. These challenges indicate the need for streamlined policies, capacity building, and customized products with affordable and flexible repayment installments, as discussed in the next section.

Based on the Green Village Plans implementation experience, the following recommendations could facilitate access to finance for rural consumers:

- **Implementation of a bottoms-up, demand-driven, community approach through the formation of Self-Help Groups (SHGs).** For example, SEWA-sponsored SHGs allow members to save money collectively, receive group training, and gradually become more financially secure and independent.[33] Peer learning facilitates financial literacy and overall capacity building, focused mostly on strengthening skills such as business management, resource management, account keeping, and financial needs' evaluation. Within the SHGs, SEWA encourages capital formation through a combination of savings and credit services, first at the household level and then at enterprise level.

- **Training on budgeting and personal finance.** Trainings can include simple budgeting and expense management tips to avoid over indebtedness, as well as information on savings options. This is particularly effective for poor women in rural and agricultural areas, as traditional lack of viable savings makes them particularly exposed to the economic and non-economic consequences of extreme natural events and health emergencies.

- **Customized loan and adaptive financial products.** With a better understanding of financial challenges, lenders can offer customized products. For instance, Grassroot Trading Network for Women, a SEWA subsidiary, successfully offered tailored loans to assist in solar lamp purchase for SEWA members. The installments matched the monthly costs that SEWA members incurred while using standard kerosene lamps.[34] Under the Hariyali Village campaign, solar water pumps were financed and the installments matched the monthly savings derived from not using diesel anymore. Families could then repay the full loan in 4 - 5 years.[35] Based on lessons from the Green Village Plans pilot, NRDC and SEWA have been working with SEWA Bank and other financiers for customized financing solutions.

- **Pay-as-you-go (PAYG) models and digital financial technologies play a crucial role in keeping rural borrowers connected to essential services.** PAYG business models can provide affordable energy access from renewable sources to off-grid communities, using available technologies to facilitate payment by installments. For instance, Simpa Networks installed off-grid solar systems in rural households coupled with a metering and collection system.[36] The project allowed rural customers with low and irregular incomes to buy energy credits in small packages. Claro Energy built a PAYG irrigation service using solar panels to help farmers save energy costs by replacing diesel.[37] Similar interventions have been explored under Green Village Plans to provide user friendly access to finance for adoption of clean energy technologies.

- **Women-focused financial services and policies can make a difference.** In the absence of land rights generally, female agricultural laborers, farm widows, and tenant farmers are left bereft of recognition as farmers, and the consequent entitlements. The official lack of recognition of female agricultural workers results in a lack of access to rural credit, assets, technology, irrigation, and inputs.[38] Lenders, creating flexibility in loan products that cater to the circumstances of women borrowers, such as allowing the male family member who holds the title to the asset to act as a co-signer on loan documentation, will go a long way to supporting the financial inclusion of rural women. Adjusting collateral requirements and encouraging the registration of property in women's names are other essential components of equitable rural finance.[39] A diversified financial institution product offer could also include other financial services that help reduce vulnerability, such as microinsurance. Training and capacity building and inclusive and equitable lending practices can help diversify the pool of borrowers and improve risk profile for lenders.

Way Forward

The pilot implementations of clean energy interventions under the Green Village Plans have demonstrated positive impacts in terms of improved living conditions, less drudgery for women, financial savings and reduction in carbon emissions. Going forward, NRDC and partners aim to scale up these interventions in 100 villages by 2025, leveraging the experience gained during the pilot phase. NRDC and SEWA will continue to engage with policy makers, financial entities, and technology suppliers for effective implementation and scaling up.

Image Source: shutterstock.com

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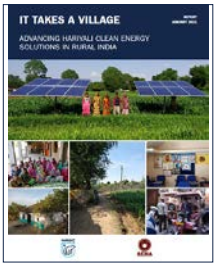

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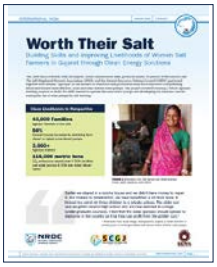
India's Expanding Clean Energy Workforce: Opportunities in the Solar and Wind Energy Sectors



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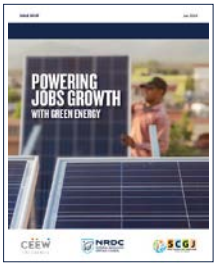

Filling The Skill Gap in India's Clean Energy Market: Solar Energy Focus

Creating Jobs and Income: How Solar Mini-Grids are Making a Difference in Rural India

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