Hariyali Green Villages: Advancing Clean Energy Solutions in Rural India

Executive Summary
India attained close to 100% household electrification in 2019 under the Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya). This transformed the energy access landscape in India with the electricity grid reaching the households. However, availability of quality and reliable 24x7 electricity remains a challenge. Besides, percolation of clean energy technologies is limited especially in rural areas where 65% of India’s population resides. Clean energy technologies can improve livelihoods, reduce expenditure on fossil fuels and drudgery of women as well as contribute immensely to India’s climate change commitments. As India’s energy demand is set to increase by close to 50% in the coming decade and millions of households will be investing in electrical appliances, it is imperative that clean energy technologies are adopted by households.

Natural Resources Defense Council (NRDC) and Self-Employed Women’s Association (SEWA) with Association of Renewable Energy Agencies of States under Ministry of New and Renewable Energy (AREAS-MNRE) working in two Indian states, Gujarat and Rajasthan to implement Green Village Energy Plans as a part of the Hariyali: Green Villages initiative by NRDC and SEWA.

Green Village Energy Plans aim to enhance accessibility and affordability of clean energy technologies and improve livelihood opportunities at the household-level in rural India. This is done by supporting the implementation of clean energy and energy efficient technologies at the village level with a focus on engaging women through-out the process. The technologies in the Green Villages include a combination of clean and energy efficient appliances 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 an objective to scale to 100 villages by 2025, NRDC, SEWA and partners have effectively demonstrated several climate-friendly solutions in more than 10 villages in 2021-22 and benefitted over 300 families as summarized in Table 1 below.

Table 1: Comprehensive Assessment of the Pilot Implementation (Source: NRDC, SEWA, 2022)

<table>
<thead>
<tr>
<th>Technology</th>
<th>LED bulbs and energy efficient fans</th>
<th>Biogas for clean cooking</th>
<th>Solar water pump</th>
<th>Cool roofs</th>
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</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>₹2,100 ($28) for an appliance kit containing two LED bulbs (9W), one energy efficient fan (50W), and one solar lantern</td>
<td>₹40,000-45,000 ($530 - 600), sufficient for a family of six</td>
<td>~ ₹3 lakhs ($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</td>
<td>₹1,040 – 1,080 ($13.9 – 14.4) to cover 100 square feet roof with two coats of solar reflective paint</td>
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<td><strong>Financing</strong></td>
<td>Credit offered by SEWA with flexible installments options</td>
<td>Free demonstration for first four months, followed by 60% subsidy is available under PM-KUSUM scheme, but</td>
<td></td>
<td>Demonstration projects by SEWA</td>
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<td>Impact</td>
<td>Lessons</td>
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<td>Monthly savings of ₹100 - 150 ($1.3 - 2) in the electricity bill per household</td>
<td>Design steps to create awareness about energy efficient appliances; engage with equipment suppliers to reduce costs; demonstrate pilots to showcase monetary savings</td>
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<td>Monthly savings of ₹1,000 ($13.3) per month on LPG cylinder refilling (for a household of six)</td>
<td>Identify relevant government subsidies &amp; favourable financing options for the households; demonstrate pilots to create willingness to adopt; provide training to operate, repair and maintain the biogas plant</td>
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<td>Savings of ₹3,600 - 5,400 ($48 – 72) per cropping cycle per acre</td>
<td>Address policy hurdles regarding obtaining government subsidies; standardize procurement practices; create alternate financing mechanisms; demonstrate financial benefits through pilots</td>
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<td>Enhanced thermal comfort due to lower ambient indoor temperature by 1.5 to 5°C (3.5 to 9°F)</td>
<td>Create awareness for vulnerable communities; organize stakeholder consultations; engage with policymakers &amp; create positive discourse; scale cool roof implementation before heat season for maximum impact</td>
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The following section presents an overview of the status of Green Village Energy Plans covering key technologies, their impact and challenges. Access to finance remain a concurring challenge for all the technologies, especially in the light of economic crisis due to COVID-19 pandemic and natural calamities such as cyclone Tauktae. Thus, financing challenges and recommendations are covered in the later part of the report covering all the technologies.

* $1 = ₹75
Objective
The Hariyali: Green Villages initiative aspires to improve clean energy access for people living in rural India by supporting comprehensive policy and scalable market solutions. Working with partners, SEWA and NRDC designed and piloted effective clean energy interventions in two villages – Nagano Math in Aravalli District, Gujarat, and Beraniya in Dungarpur District, Rajasthan in 2020, which helped develop a model to scale to more villages. The project aims to reach 100 villages by 2025.

There are several guiding considerations for the Hariyali Green Villages initiative: increasing 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. The goals of the plans are to work toward a women-led policy, market, technology, financial, and social framework that reduces energy poverty and enhances 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’s memberships.

Methodology
The approach to identify clean energy interventions and design green village energy plans consisted of four main components, as depicted below in Figure 1.

First, pilot village selection was based on, but not limited to, a strong SEWA presence, large rural population, low electricity access, limited access to banking services, and low asset ownership. Second, government programs and market opportunities for clean energy were identified by review of national, state, and local government policies and opportunities that complemented SEWA’s activities. Third, between May and July 2019, household energy use surveys, group discussions, and research were conducted to determine households’ key energy uses and socioeconomic profile. Surveys were conducted in the local language and the final survey sample (excluding test surveys) included about 35% of the population of each village. Fourth, following analysis of the survey data, NRDC and partners identified key interventions to implement to increase energy access in the pilot villages. In developing the village plans, the main considerations were technical compatibility, financial viability, and skill development.
Green Village Energy 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. 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. 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 and Beraniya as well has no streetlights.

Interventions for Green Village Energy Plans
NRDC and SEWA selected several clean technologies to implement in villages in Gujarat and Rajasthan based on the survey findings under the Hariyali Green Village initiative, as depicted in Figures 2 and 3, respectively.

Figure 2: Interventions piloted in Gujarat, India (Source: NRDC, SEWA, 2022)
NRDC and SEWA navigated through COVID-19 pandemic as well as cyclone Tauktae to scale up implementation of Green Energy Village Plans. The COVID-19 pandemic disproportionately affected the most marginalized and exacerbated the economic crisis of the rural households due to unemployment. The states of Gujarat and Rajasthan also reeled under the pressure of cyclone Tauktae that destroyed the agricultural yields and village infrastructure including houses.

Due to cumulative impact of COVID-19 pandemic and cyclone Tauktae, the purchasing power of the households was significantly impacted. But this crisis presented a unique opportunity to recognize the role of energy access and use clean energy technology to enhance rural development and livelihood generation goals. SEWA worked closely with the households to provide COVID-19 relief as well as identified innovative implementation and financing mechanisms to pilot Green Energy Village Plans leveraging SEWA’s strong ground level presence. NRDC worked closely with SEWA for post COVID-19 rehabilitation and ensured that pilots get implemented irrespective of the challenges posed by COVID-19 and natural calamities.

The initial impact of these interventions has been recorded based on discussions with the rural households and has been detailed out in the later sections. However, a formal impact assessment needs to be carried out to assess the benefits and gaps. This will help in making appropriate modification in the Green Energy Village Plans to ensure more effective implementation and uptake of these technologies by rural households. Key clean energy interventions under the Green Village Energy Plans, as well as their costs, impact, and scalability, are discussed in the ensuing sections.

Expanding the use of energy efficient appliances
Energy efficiency is often referred to as the “first fuel”, it being the cheapest and cleanest resource in most cases. Energy efficient appliances use less electricity to perform the same function as their non-efficient counterparts. The Bureau of Energy Efficiency (BEE), Government of India runs a Standards and Labelling (S&L) program that sets minimum energy performance standards for 26 high-energy end-use equipment & appliances that help consumers make informed choices including Light-emitting Diode (LED) bulbs and ceiling fans that were piloted under the Green Village Energy Plans.

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. Consequently, the distribution companies (Discoms) are able to manage their load profiles better and greenhouse gas (GHG) emissions are also reduced. As per an estimate, 58% less electricity would be required to meet the additional demand that would be generated from purchase of household appliances by rural households if ensured that these appliances are energy efficient.

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

NRDC and SEWA have supported the following villages to increase the 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, 300 kits have been sold to rural households by SEWA under the green village pilots.

NRDC and SEWA, through capacity building and continuous dialogue with households, have been working towards building confidence of rural households in energy efficient appliances. The SEWA team demonstrated the technology on the ground to increase the buy-in from SEWA members. Due to COVID-19 pandemic induced lockdowns, NRDC and SEWA organized an online workshop in partnership with EESL for SEWA members to provide training on effective operation and management of these appliances so that servicing and repair needs can be minimized in the future. Further, 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 the unnecessary financial burden on the households resulting in larger uptake of the kits.

Even though a detailed impact assessment is yet to be undertaken, the initial assessment shows that the households have used LED bulbs for 5-6 hours and energy efficient fan 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 post implementation of the pilots. As the use of these appliances, specifically energy efficient fans will increase during summer season to about 15 hours a day, it is expected that the savings in electricity bill will increase.

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

Increasing biogas plants as a clean cooking solution for households

Biogas is a modern form of bioenergy produced through anaerobic digestion of various biomass sources including livestock manure, agricultural residue, and food waste. Biogas production also produces organic fertilizer, a by-product that can reduce the dependency on chemical fertilizers in the agriculture sector. In rural kitchens, biogas plants can be an energy substitute for wood or charcoal. Biogas plants can reduce indoor air pollution, which is a tremendous public health threat, particularly for women considering their greater role in cooking and resultant exposure to the pollutants. In addition, biogas plants reduce the burden of collecting wood and alleviate the workload on women and children. Biogas plants not only enhance the concept of circular economy at the village level, reduced use of wood and charcoal leads to decreased forest degradation and reduced GHG emissions. This intervention contributes to close to 11 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).

In the pilot villages, many households have access to liquified petroleum gas (LPG) cylinders for cooking, but their use has been limited due to high costs of refilling the cylinders. Thus, women farmers often used mud stoves to cook the meal, resulting in various health hazards including increased cases of asthma. Both methods were time consuming for the women. The
women spent on an average about 1.5 hours every day to collect wood or charcoal. Besides, to get the LPG cylinder refill, about one day is required to commute to and from the distribution center to collect the LPG cylinder. On the other hand, women in the households with cattle had to spend time to collect the manure and transfer to a common pit. Whereas the same time is now used to transfer the manure in the biogas plant. Thus, women are not required to invest any additional time to operate the biogas plants.

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 demonstration of the health benefits and time saving opportunities, there is an additional demand for 50 biogas plants in the Aravalli District and 10 biogas plants in Anand District in Gujarat. Households in the Surendra Nagar Districts have also expressed interest in installation of a community-owned biogas plant.

A biogas plants costs about ₹40,000-45,000 ($533-600), sufficient for a family of six members. During the pilot phase, the five households had the option of using the biogas plant free of cost for a period of four months. Post this, 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 or interest subvention scheme, credit facility by technology supplier, and community ownership models.

The initial assessment showcases a reduction in the expenditure 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 of 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 empowering women to make choices regarding selection of fuel. In addition, 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 the 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. Solar water pumps help expand access to irrigation and reduce dependence on diesel or grid-connected electricity for the farmers. The transition 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 the launch of Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme in 2019 by MNRE.

The PM-KUSUM scheme aims to install 2 million standalone solar water pumps by 2022 and focuses on boosting farmers income and providing them access to energy for irrigation, reducing government subsidy on electricity supplied to agriculture sector and decarbonizing agriculture sector. Transition 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 (MTCO₂) emissions.

Solar water pumps are also cost-effective for farmers on a lifetime basis, especially when compared with recurring cost incurred for purchase of fuel for diesel pumps. In 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. However, the 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.

| Type of crop | Wheat |
Irrigation cycles required | 4 - 6 cycles
---|---
Total diesel consumed | 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

A 5-horsepower (HP) solar water pump costs around ₹3 lakhs ($4,000) to the farmers including preventive maintenance through monthly field visit by technician and on-site warranty of 5 years. In addition, the life insurance premium of the pump owner is covered for 5 years under Pradhan Mantri Suraksha Bima Yojana.

PM-KUSUM provides 30% MNRE subsidy and at least 30% state-subsidy on pumps up to 7.5 HP size to the farmers for the uptake of solar water pumps. Though the program has received tremendous support nationally, the uptake is also dependent upon the 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, jointly signed by all the landowners. Producing this document has been a challenge for the applicants due to multiple reasons such as death of the family member, family feuds, migration to cities.\(^2\) 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 the eligibility criteria of the banks in terms of collaterals required to process the 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 engage with MNRE, SNAs, and financing institutions to address some of these barriers by sensitizing these agencies about the challenges faced by the farmers.

As part of the Green Villages Energy 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 access to energy to small and marginal farmers. SEWA also works with small and marginal farmers to organize them in groups and purchase solar pump that is 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, the subsidy support is critical for the farmers, especially small and marginal farmers, to be able to install the solar water pumps.

The adoption of solar water pumps can be supported through demonstration of financial benefits to the peers in terms of savings in the cost of diesel. It is also important to ensure that farmers can obtain government subsidies. It is also critical to generate awareness about the optimum use of water for irrigation purpose given 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 lower indoor temperatures by 1.5 to 5°C (3.5 to 9°F) as compared to conventional roofs and are particularly useful for houses with tin and cement roofs. While cool roofs can be expensive depending on the technology, 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.

Cool roofs have proven health benefits and environmental benefits as they increase thermal comfort and reduce dependence on electrified cooling appliances. Community-led initiatives in India have proven that cool roofs are an extremely cost-effective tool to reduce heat stress for rural households. Under the Green Village Energy Plans, 125 cool roofs in Rajasthan and 13 cool roofs in Gujarat have been piloted using solar reflective paint, by Mahila Housing SEWA 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 will be measured during the summer season, the households noted that post the application of solar-reflective paint, the amount of moisture that would usually seep in through the roof during rains has reduced. The demonstrations did not have any cost implications on the households. SEWA incurred the cost of about ₹1,040 – 1,080 ($13.9 – 14.4) to cover 100 square feet roof with two coats of solar reflective paint. With summer season being at its peak, demand for solar reflective paint has increased. Recently, five households have purchased the solar reflective paint through SEWA.

Given the positive impact on health and environment, large-scale adoption of cool roofs is to be accelerated through awareness generation amongst vulnerable communities about availability of cost-effective cooling solutions such as solar reflective paints. This can be done by organizing stakeholder consultations to talk about positive impacts of reduced heat exposure in the households and designing more pilots in both urban and rural areas to reach out to different communities. This can be clubbed with addressing technology and cost-related apprehensions through consultations. It is also vital to engage with policymakers to create positive policy discourse and get a buy-in from communities.
Other Clean Technologies

Precision Irrigation System through Solar Energy

Precision irrigation is a technique that enables farmers to use water optimally and improves crop yield. Through precision irrigation system, water and nutrients are supplied to the plants in a scheduled manner and in optimal quantities through pipes. This increases the input utilisation rate and improves the root development process of the plants. Clubbed with solar energy, the pilots demonstrated under the Green Village Energy Plans are zero-emission based irrigation system with a potential to reduce about 700 kilograms (kgs) of carbon emissions per pump.26

The precision drip irrigation has been deployed on grant basis by SEWA in five locations, namely (a) Nagano Math village, Aravalli District, Gujarat, (b) Khanpur, Anand District, Gujarat, (c) Bodeli village, Chota Udaipur District, Gujarat, (d) Ganeshpura village, Meshana District, Gujarat and (e) Beraniya village, Dungarpur District, Rajasthan. The system consists of 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. The farmers have reported faster growth in crops as compared to flood irrigation. In Nagano Math, the crops grew about 92 centimetres (cms) taller using precision irrigation system as compared to the crops in the nearby farm where flood irrigation method was used, while all other conditions such as type of crop, fertilisers used, etc. were same for both the farms.
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 are active during night time and can damage the crops. The device costs approximately ₹5,800 ($77.3). Solar trap lights have been used at six locations in India, namely (a) Naga Na Math village and Bordi village, Aravalli District, Gujarat, (b) Narmiyani Muvadi, 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.

Solar Hydroponic Fodder System

The solar hydroponic fodder system enables the households to grow high protein fodder for the cattle. Using this system, crops are grown without soil in trays and nutrients are supplied through water solvents in a climate-controlled environment. Using solar pump, water is transferred to the trays. Generally, one tray is sufficient for one cattle. The fixed cost of the system is approximately ₹45,000-50,000 ($600-666.6) and recurring inputs costs are required to be invested by the households 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 cattle per month.
The solar fodder system has been installed at Kaniyal village, Ahmedabad District, Gujarat. The installation was completed recently; thus, the initial assessment shows that the milk produce has increased by 1-1.5 liters and fat percentage has also increased in the milk.

**Enhancing Financial Access for Clean Energy**
In the previous sections, aspects pertaining to the technology and impact were covered. However, financing remains one of the most significant barriers in scaling the clean energy technology interventions irrespective of the technology cost. In this section, the challenges and recommendations to enhance financial access have been highlighted.

**Challenges to Financial Access for Clean Energy**
Rural consumers, often women, rely on informal sources to access credit. 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, especially women, do not own assets and limits their ability to access financial channels due to their inability to provide collaterals. In addition, most loans are to be repaid based on fixed EMIs and the cyclic nature of incomes becomes a major challenge to meet the obligation. The informal sources are more expensive and less sophisticated as compared to those offered by formal financial institutions.

At the same time, there is a high-risk perception from formal lenders. Irregular and cyclic income in the 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 increases the apprehension of the lending institutions towards credit extension. Banks may be wary of extending collateral-free loans to farmers and often insist on additional security. Lower levels of education and financial literacy contribute to rural persons, particularly women, having a hard time complying with a financial institutions’ procedures and requirements to apply for a loan or to open a savings account.

The 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.

**Recommendations**
Based on the experience gained from piloting clean energy technologies under the Green Village Energy Plan and best practices observed in the sector, implementation of the following recommendations would facilitate access to finance -

a) for borrowers:

- **Implementation of a bottom-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. This 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. The presence of SHGs or microfinance branches, even in the remotest parts of the country, implies easier access to loans and streamlined disbursal processes.

- **A savings-first philosophy that favors consolidating personal assets.** This helps prevent a person from becoming over-indebted. 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.

b) from lenders:

- **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 (GTNfW) successfully offered tailored loan to assist in solar lamp purchase to SEWA sisters. The installments matched the monthly costs that SEWA members incurred while using standard kerosene lamps. Under the Hariyali Village campaign, solar water pumps were financed and the installments matched the monthly savings derived from not using diesel anymore. Due to this, families could repay the full loan in 4 - 5 years. Based on lessons from the Green Village Energy 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. 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. Similar interventions have been explored under Green Village Energy Plans to provide user friendly access to finance for adoption of clean energy technologies.

- **Gender focused financial services and policies, especially for rural women.** In the absence of land rights, 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. Lenders, creating flexibility in loan products that cater to the circumstances of women borrowers, such as including the male family member who holds title to the asset as a co-signer on loan documentation, will go a long way in financial inclusion of rural women. Trainings and sensitizing lenders can help reduce the risk perceptions of traditional bankers.

- **Individual loan products designed for women are important to enable enterprise growth.** Savings products designed for women are a fundamental element of risk management. A diversified microfinance institution product offer should also include
other financial services that help reduce vulnerability, such as microinsurance. Adjusting collateral requirements and encouraging the registration of property in women’s names are other essential components of gendered microfinance. Microfinance institutions should therefore tailor product specifications, such as loan amounts and repayment schedules, to diverse client needs. Trainings for lenders on the importance of diversifying products can help raise awareness among lenders.

**Going Forward**

The pilot implementations of clean energy interventions under the Green Village Energy Plans have demonstrated positive impacts in terms of elevated living conditions, less drudgery for women, financial savings due to reduced fossil fuel consumption and the resultant carbon emissions. Going forward, NRDC and partners envisage scale up of these intervention 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 to address the implementation bottlenecks.
References

6. According to Census 2011, Naganomath had 155 households. However, an interview with the sarpanch (administrative village head) gave the 2019 figure for Naganomath – 256 households.
7. According to Census 2011, Beraniya had 193 households. However, an interview with the sarpanch (administrative village head) gave the 2019 figure for Beraniya – 256 households.
16. UN Climate Technology Centre & Network, Solar Water Pumps, accessed March 1, 2022, https://www.ctc-n.org/technologies/solar-water-pumps#:.text=A%20solar%20water%20pump%20system%2C%20several%20PhotoVoltaic%20(PV)%20panels.&text=The%20water%20is%20often%20pumped,not%20needed%20for%20these%20systems.


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