Review of the Sustainability of Selected Solar Mini-Grid and Solar Irrigation Systems

जर्मन सहयोग
DEUTSCHE ZUSAMMENARBEIT

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Acronyms

AEPC	Alternative Energy Promotion Centre
EDSC	Energy Development Sub Committee
ESE	Early streamer emission
GDP	Gross domestic product
DFS	Detailed feasibility study
GIZ	Deutsche Gesellschaft for Internationale Zusammenarbeit GmbH
HH	Households
ICIMOD	International Centre for Integrated Mountain Development
INGO	International non-governmental organisation
kW	Kilowatt
kWp	Kilowatt peak
LA	Lightning arrestors
LG	Local government
MFI	Microfinance institution
MoPID	Ministry of Physical Infrastructure and Development, Sudurpashim Province
MoWSIE	Ministry of Water Supply, Irrigation and Energy, Province 1
NPR	Nepalese Rupee
O&M	Operation and maintenance
POSTED	Promotion of Solar Technology for Economic Development, a development programme of GIZ
PPP	Public-private partnership
PV	Photovoltaic
REEEP	Renewable Energy and Energy Efficiency Programme, a development programme of GIZ
RERL	Renewable Energy for Rural Livelihood, a development programme of UNDP
SEMAN	Solar Electric Manufacturers Association Nepal
SIP	Solar irrigation pump
SMG	Solar mini-grid
SPD	Surge protection devices

1. Summary

Solar mini-grids (SMGs) and solar irrigation pumps (SIPs) present a promising solution for providing energy access and socio-economic development in Nepal. Alternative Energy Promotion Centre (AEPC) together with various development partners have provided technical and financial supports for promoting these technologies in various remote communities. However, the evidence suggests that their functionality is often problematic, as many of these systems break down much earlier than their economic life. To assess functionality and identify associated operational and management issues, the POSTED team recently carried out a field study in 12 SMG/SIP projects. The findings identify several factors related to design, installation, operational and management that influence performance of SMGs and SIPs. The importance is shown of local service providers for effective after-sales service, good governance, and skilled technicians to operate the systems. Similarly, the study identified a need for a guideline that will both support and encourage the fixation and collection of tariff and operation and management of such plants in a more sustainable manner. An extension of the national grid to the solar mini-grid communities was another critical challenge revealed by the study.

2. Background

Nepal has good potential for solar energy with average solar radiation of 4.4 to 5.5 kWh/m^2 and around 300 sunny days in a year. 90% of the population has access to grid electricity while 10% are without. Unserved populations typically live in remote areas where the expansion of grid electricity is economically and technically not justifiable. Due to high operating costs and low voltage issues, the extension of the grid is challenging in these areas. Hence Alternative Energy Promotion Centre (AEPC) being the nodal agency for the promotion of renewable energy had started developing solar mini-grid projects in remote areas of Nepal. To date, AEPC in collaboration with various development partners has supported 30 solar and solar/wind hybrid mini-grid systems with a total capacity of 1,262 kW powering more than 7,500 households[1]. Solar mini-grid systems have become a cleaner, cheaper, and swifter viable alternative to large hydropower-based central grid expansion in the country.

At present, solar mini-grid systems use advanced inverter technologies that enable them to safely interconnect to the national grid in case of grid extension. Grid interconnected mini-grid systems increase the energy security of connected areas, minimize power losses compared to the central grid's long-distance transmission lines, enhances the power quality to the grid, and enables sustainable utilization of the local renewable energy resources while having a minimal environmental impact.

Nepal is an agrarian economy where the agriculture sector contributes to one-third of the gross domestic product (GDP). Most of the farmers in Nepal are smallholders who rely on traditional rain-fed agriculture. Of the estimated 2.6 million hectares of arable land in Nepal, only 69% of it is irrigable, and currently, only 39% is irrigated[2]. Most of the irrigated land in Nepal lies in the Terai, where the topography is flat. Both surface water and groundwater are used for irrigation. Farmers who use groundwater rely on diesel pumps because grid electricity is not available everywhere. Irrigation using diesel pumps is both expensive and harmful to the environment. The agriculture sector (including

[1] https://aepc.gov.np/uploads/docs/guidelines-for-the-feasibility-study-of-solar-mini-grid-projects-1654685783.pdf

[2] https://solar.iwmi.org/wp-content/uploads/sites/43/2021/09/NEPAL-SITUATION-ANALYSIS-REPORT_final-version-3.pdf

irrigation) alone accounts for around 10.5% of the total diesel consumption in the country[3]. Moreover, despite employing 80% of the population in the agriculture sector, Nepal is not a food self-sufficient country and imports food from other countries. Hence, making agriculture more productive is imperative, and irrigation has a major role in it.

Solar-powered irrigation pumps (SIPs) have emerged as a viable alternative to diesel pumps. The decentralized nature of SIP technology makes it suitable for rural farms which are far away from the main electricity grid. Though globally panel costs have declined rapidly from 4.9 USD/Watt in 2000 to 0.2 USD/Watt in 2020[4], standalone off-grid SIPs remain expensive for small and marginal farmers in Nepal. SIPs are very important for Nepal because it is climate resilient technology and generate electricity during times that match irrigation demand.

2.1 Agencies supporting SMG and SIP Technologies

Various stakeholders are working in the field of SMGs and SIPs in Nepal. The major ones are the government of Nepal, development partners, private companies, and financial institutions. At the federal level, AEPC works for both SMGs and SIPs by providing both technical and financial support for the promotion. Federal government agencies like AEPC, the Department of Irrigation, and the Ministry of Agriculture plan, maintain, operate, manage, and monitor different types of environmentally sustainable and socially acceptable irrigation projects. At the province level, the Ministry of Physical Infrastructure and Development (MoPID) at Sudurpaschim and the Ministry of Water Supply, Irrigation and Energy (MoWSIE) at Province 1 develop the SMGs and SIPs projects under its division offices. Similarly, the agriculture ministry also promotes similar small irrigation pumping technologies. At the local level, local governments (LG) directly fund small-scale SIPs mostly focused on water drinking projects, but LGs matches fund with the federal and provincial government for the development and deployments of SMGs.

Development partners and INGOs have played a significant role in introducing SIP and SMG technologies in Nepal. KFW, ADB, and the WB have been collaborating with AEPC for implementing SIP and SMGs in various parts of the country. Similarly, organizations like ICIMOD and Winrock International, with support from their project partners, have developed several pilot projects with medium-scale SIPs to increase the demand and accelerate the commercialization of the same in Nepal. While other organizations like IWMI and iDE promoted small-scale SIPs, Practical Action with support from WISON developed two large-scale community-based solar lift irrigation systems in the mid-hills of Nepal. In Sudurpashim Province and Province 1, there are 87 numbers of Solar Water Lifting projects under the facilitation and technical support of the Renewable Energy and Energy Efficiency Programme (GIZ/REEEP). Mostly, REEEP provides support for the pre-feasibility study, and bid preparation for the installation of SIPs. Also, REEEP supports the budget planning of SIPs if LGs intend to install systems at their own cost.

Nepal's private sector is heavily involved in the solar energy sector. Many private organizations partnered with INGOs to develop pilot projects to introduce SIPs in the country. Over the years, the private sector has introduced many innovative business models collaborating with development partners, financial institutions, INGOs, and various levels of government. There are 77 companies selected by AEPC as competent for solar PV applications throughout Nepal. Besides that, there are 120 solar companies listed as a member of the Solar Electric Manufacturers Association Nepal (SEMAN) involved in the supply, installation, and services related to solar PV in Nepal[5].

[3] https://solar.iwmi.org/wp-content/uploads/sites/43/2021/09/

[4] https://www.iea.org/data-and-statistics/charts/evolution-of-solar-pv-module-cost-by-data-source-1970-2020

[5] https://www.aepc.gov.np/public/uploads/files/List%20of%20competent%20companies%20for%20Solar%20PV%20application-Updated.pdf

The role of financial institutions to improve access to finance for farmers is crucial. Nepal has a relatively diverse number of financial institutions active compared to its economy. Different financial institutions working in the sector are commercial banks, finance companies, cooperatives, microfinance institutes, etc. Some large commercial banks have established a dedicated department to deal with financing renewable energy projects. Some agriculture-focused cooperatives and microfinance institutes can be seen partnering with private SIP service providers to issue financing services to the farmers.

2.2 Purpose of the study

AEPC with support from various development partners has been promoting various SMG and SIP projects throughout Nepal. Though the projects are meant to provide communities with basic needs like water and electricity, it is also important to figure out if the SMGs and SIPs are providing the promised services and benefits to the users in a sustainable way. Thus, this study is to get insights into the entire project cycle from identification to execution, operation and maintenance, and the status of after-sales services and present stakeholders with empirical evidence for policy advocacy, planning, and development of SIP and SMG.

The main specific objective of the study is to assess the sustainability of the installed projects. While there has been substantial investment in community-based solar mini-grids and solar irrigation projects in Nepal, it is important to realize the impact it has created on the beneficiaries and the sphere. The second objective of the study is to draw recommendations from the field for the forthcoming amendment of the Renewable Energy Subsidy Delivery Mechanism 2022.

2.3 Methodology

2.3.1 Preparatory phase

The POSTED team carried out a desk study before the field visits. The selection of sites was done by analyzing the data collected from Renewable Energy for Rural Livelihood (RERL), REEEP, and other stakeholders who would provide the information about the probable sites. This phase of the study mainly focused on:

- Selection of site for carrying out the field visit
- Preparation of a checklist and questionnaire for the survey (Annex)
- Contacting the focal person of each selected site (Annex)
- Logistical arrangements for the visits

2.3.2 Sample selection

Using the purposive sampling technique, 6 SMGs[6] and 6 SIPs[7] projects were selected for this study. Considering the logistical constraints and the focus of the project activities, all the samples were taken from Provinces 1 and Sudurpaschim. This allowed the study team to gather qualitative responses in a very short period, which leads to better insights and more precise research results. A summary of the visited SMGs and SIPs is presented in Table 1.

[6] Approx. 20% of the total SMGs installed in Nepal

[7] Approx. 1% of the total installed SIPs in Nepal

Table 1: list of visited projects

Site Details		Municipality	District	System capacity	Province
Solar Mini-Grids - SMGs					
1.	Marangburu	Jahada RM, Ward-7	Morang	5 kWp	Province 1
2.	Saptami Saurya Bayu Pari-yojana	Miklajung RM, Ward-2	Panchthar	70 kW (50 kWp solar, 20kW wind)	Province 1
3.	Ramitekhola Ayojana	Miklajung RM, Ward-1	Morang	30 kWp	Province 1
4.	Sugarkhal	Mohanyal RM, Ward-6	Kailali	75 kWp	Sudurpaschim
5.	Danapur	Purchaudi RM, Ward-8	Baitadi	30 kWp	Sudurpaschim
6.	Kamalbazar Saurya Tatha Bayu Urja	Kamalbazar Municipal-ity, Ward-1	Achham	31 kW (20 kW wind, 11 kWp Solar)	Sudurpaschim
Solar Irrigation Pumps - SIP/SWPS					
1.	Amahi Sahakari	Dhanpalthan RM, Ward-2	Morang	7.5 HP Pump, 8.4 kWp solar array	Province 1
2.	Kholabari Gramin Sourya Urja Khanepani Ayojana	Miklajung RM, Ward-3	Panchthar	5 HP Pump, 4.6 kWp solar array	Province 1
3.	Thamdada Sunartole Saurya Urja Khanepani Ayojana	Miklajung RM, Ward-2	Panchthar	3 HP Pump, 2.4 kWp solar array	Province 1
4.	DK Agriculture Farm	Dhangadi Sub-Metro, Ward-12	Kailali	1 HP pump, 950Wp ar-ray	Sudurpaschim
5.	Aampani Lift Jal Upabhokta Samiti	Parshuram Municipal-ity, Ward-12	Dadeldhura	30 HP pump, 30.6 kWp array	Sudurpaschim
6.	Chela Lift Sichai Yojana	Parashuram Municipal-ity, Ward-6	Dadeldhura	30 HP pump, 34 kWp array	Sudurpaschim

1.1.1 Data collection

The team visited the selected SMG and SIP sites, conducted face-to-face interviews with the operator, User Committee Chairman, Ward Chairman, and, interacted with local beneficiaries. The teams also observed the solar installations and tested the functionality of the systems. The data collected from the field using the pre-drafted questionnaire/checklist were systematized during the data compilation phase. The team compiled the information collected to do the data analysis and draw recommendations. Due to the low number of samples, statistical analysis (quantitative) could not be made justifiable thus empirical evidence has been presented to support the claims made.

3. Analysis of results

3.1 AEPC's subsidy for SMG and SIP

The Subsidy Policy 2073 outlined a provision for a subsidy to SMGs depending on the project location. The country was divided into three regions viz category region A, B, and C and the amount of subsidy is different in each. Also, there were two bases for claiming subsidy, one based on total project cost and the other based on energy consumption. In 2078 this changed to a subsidy of 90% of the total project cost up to 250 kWp for rural/municipality-owned projects and 60% for privately owned or projects constructed under public-private partnership (PPP) models, cooperative or community-owned projects.

Similarly, the subsidy for SIPs in subsidy policy 2078 is similar to the subsidy policy of 2073. It is defined as a maximum subsidy amount of up to 60% of the total costs but not exceeding NPR 2,000,000 per PV pumping system for irrigation of agricultural land managed by a community or private company.

Table 2: AEPC's subsidy policy for solar mini-grid projects

Solar mini-grids				
2073	**Subsidy category**	**Subsidy amount NPR**		
		Region A	**Region B**	**Region C**
	A) Subsidy based on project cost			
	Distribution (per HH)	32,000	30,000	28,000
	Generation equipment (per kWp)	175,000	165,000	150,000
	The subsidy amount per kW for generation and distribution will be a maximum of 60% of the system costs not exceeding NPR 495,000; NPR 465,000 and NPR 430,000 for Category A, B, and C respectively. A distribution subsidy will be provided to a maximum of 10 households per kW.			
	B) Subsidy based on energy consumption			
	Energy consumption (kWh)	60%	60%	60%
2078	Areas not connected to the national grid and LG-owned mini-grid projects up to 250 kWp	90% of the total project cost		
	The subsidy for community/ cooperative/private/PPP owned solar electrification projects up to 100 kWp in areas not connected through the national grid or other mini-grid sources.	up to 60% of the total project cost only		

Table 3: Subsidy policy for solar irrigation projects

Solar irrigation (for all categories)	
2073	Subsidy of up to 60% of the total costs but not exceeding NPR 2,000,000 per system for PV pumping system for irrigation of agricultural land managed by the community or private company.
2078	Subsidy of up to 60% of the total costs but not exceeding NPR 2,000,000 per system for PV pumping system for irrigation of agricultural land managed by the community or private company (unchanged).

3.2 Ownership

The study revealed that project ownership type can influence the performance of SMGs. Out of 6 SMGs visited, 4 SMGs were found to be owned by communities (managed by user committees), one by a cooperative, and one by the LG (the user committee transferred the ownership to LG after 3 years of use). It was seen that the management of cooperative-owned SMGs was quite good compared to other SMGs managed by user committees. In the cooperative-owned SMG, the tariff collection was regular, had a good governance system, and the overall technical, social, and economical aspect of the project was good. This was not seen in user committee-owned SMGs.

In contrast to SMGs, the performance of the community-owned SIPs was found much better. Out of 6 SIPs visited, 4 were owned by communities (and managed by user committees), one was owned individually, and one was owned by the local cooperative. One of the user committees at Miklajung, Panchthar seemed to be very active in participation from the start of the project and they had good governance and practice in comparison with other systems.

3.3 Key operational issues

Out of 6 SMGs and 6 SIPs visited, 5 SMG sites and 4 SIP sites were functional. The on-ground scenario of the operational system is described below.

Table 4: Functional status of the visited projects

Project		District	Years of operation	Status	Issues
1.	Saptami Saurya Bayu Mini-Grid Pariyojana	Panchthar	4	Partly functional[8]	Lack of maintenance
2.	Marangburu Solar Mini-grid	Morang	4	Functional	
3.	Ramitekhola Solar Mini-grid Ayojana	Morang	5	Functional	Regular support service is not available. (No other issues)
4.	Danapur Saurya Urja Mini-Ggrid	Baitadi	3	Functional	
5.	Kamalbazar Saurya Tatha Bayu Urja	Achham	5	Defunct	The main transmission line from the powerhouse is cut off and grid electricity is in reach so system is neglected at present
6.	Sugarkhal Saurya Urja Cooperative Ltd.	Kailali	4	Functional	
7.	Amahi Sahakari Water Pumping Project	Morang	7	Defunct	Blockage in deep well due to debris accumulation.
8.	Kolabari Gramin Saurya Urja Khanepani Ayojana	Panchthar	1	Functional	
9	Thamdada Sunartole Saurya Urja Khane Pani Ayojana	Panchthar	1	Functional	
10.	DK Agricultural Farm, Kailali	Kailali	4	Defunct	The low water level at the source, functional only during monsoon
11.	Aampani Lift Jal Upabhokta Samiti	Dadeldhura	6	Functional	
12.	Chela Lift Sochai Yojana	Dadeldhura	None	Defunct	The sump well was washed away at the time of installation and the system has never come into full operation. However, the installation company has repaired the pump and the system is now operational

[8] The solar part is functional; the wind part is defunct

Table 5: Key operational issues and their causes

Key operational issues		Possible causes
1.	Loadshedding due to an increase in local power demand	An increase in the number of households (HH) due to migration was not considered during the project design phase (DFS stage)
2.	Untransparent governance and accounting	Inactive user committee, possibly a breakdown of trust after issues arose with the handling of tariff collections
3.	A flat tariff system for HH, as well as productive end, uses (PEU)	No guidelines to define tariff structure. Tariffs are not defined scientifically.
4.	Low fund collection for O&M	Low income from the tariff collection
5.	Operator not trained for overall maintenance	Operators assigned by the community/installer were provided with basic training only. In case of a major problem or even identification of minor problems technical manpower from outside had to be fetched
6.	Lack of technology advocacy and training of users	Due to the lack of knowledge of the technology, the users were not operating the system. Users were not confident about the workings of the system and therefore, lack of basic system operation skills (such as cold restart procedure of the system, understanding LED indicators of the inverter status, etc) causing frequent system errors and shutdowns.
7.	Wrong site selection during DFS	One of the SIP sites had a sump well-constructed at the bank of Mahakali River so during monsoon, the sump well was swept away and the system had to be reinstalled.
8.	The community does not know whom to refer to during outages	Communities are unaware of the reporting mechanism and channel, and no documentation is available for establishing communication between communities and service provider
9.	Remote monitoring defunct	Installers do not give preference to remote monitoring, so they are installed but do not work at each visited site. The issues regarding ownership and management of internet connectivity were the main reason.
10.	Short-term contract with the operator	After the expiry of the 3 years contract with the operator, there is no one to look at the system. Guideline and regulation for staff appointment, job responsibilities, and duties of operators not in place.
11.	In a wind-solar hybrid system, the wind turbines were not in operation	The installer did not visit the site despite multiple calls. No policy or regulation to penalize installers for such activities.
12.	The system was not used properly after the national grid's availability	There is no policy or act, or directive in place to connect the existing community-based SMG to the national grid.

3.4 Qualitative analysis

3.4.1 Solar mini-grids

Quality assurance

The study reveals that the quality of solar components significantly influences the performance of SMGs. Although major components like PV modules, inverters, charge controllers, and batteries have quality standards defined while preparing a technical specification and for tenders. Minor components like lightning arrestors, surge protection devices (SPD), isolators, etc. whose cost is <1% of the total project cost, are not taken care of during design, tendering process, and due diligence of the project causing severe damage to the SMGs.

- Supporting case: The location of Ramitekhola SMG was prone to lightning. Although all major components of the SMG are of standard quality, the lightning arrestor was neglected and a copper spike was installed instead of early streamer emission (ESE) air terminal type lightning arrestors (LA). During a lightning strike, 90% of the connected meters were damaged demonstrating a low standard of the LA.

After-sales service

A major problem that SMGs in remote areas face is related to after-sales services particularly in operation and maintenance after commissioning. Problems include the unavailability of trained local manpower, no service center nearby and operators' knowledge is limited to basic maintenance sometimes leaves the community in blackout for weeks and months. Out of 6 visited sites, 5 sites were supported by SASEC, and the operator's salary was mandated to be paid by the installer company for 3 years. The operator used to repair and maintain minor problems and report major problems to the installation company under a functional arrangement that stopped after 3 years.

- Supporting case: Saptami SMG has an operator appointed by the installer. The operator's salary was paid by the installer company for 3 years. After the end of the operator's contract period, the SMG had no one to look after the system and the community could not pay the operator from the generated revenue, thus leaving SMG unattended. Consequently, scheduled maintenance involving panel cleaning, battery maintenance, tariff collection, etc. stopped causing malfunction after three years. Similarly, Ramitekhola SMG had an operator appointed by the installer whose contract period ended in 3 years. After the end of the contract, the community did/could not pay the operator's salary and the regular servicing work stopped. Also due to the unavailability of a service center nearby, no support and services of any kind could be received by the SMG. This could have been avoided if an operator was trained accordingly and a local service provider was available.

  At Dhanpur Saurya Urja mini-grid site Baitadi, there is no mechanism of tariff collection due to conflict between user group committee members and users from the beginning, regarding tariff setting and collection. The tenure and salary payment for the operator were also terminated after 3 years of the contract period. Understandably, he was not motivated to continue working without a salary. So, consequently, there is no one to look after the system properly now.

Capacity needs

Due to the lack of capacity of the local technician even for minor problems, qualified technicians had to be fetched from Kathmandu causing a delay in service delivery. The SMG operators are trained to deal with basic maintenance issues only, so they are not capable of troubleshooting faults occurring mainly from the inverter and control panel side as error messages, codes, and relevant remedies might differ from one model to another.

In most of the LGs, the Energy Development Sub Committee (EDSC) is operational and sometimes backed by civil engineers and overseers of the respective R/Municipality. In R/Municipalities without EDSC, civil engineers were looking after the energy projects. However, due to lack of capacity for project due diligence and technology knowledge of the SMGs led to poor monitoring of the systems.

- Supporting case: Ramitekhola SMG had a lightning strike and the system shut down. However, the operator was unable to diagnose the problem and support had to be sought from Kathmandu. If operators were trained to read and convey error messages and minor troubleshooting by looking at the manual, then the problem could be solved by local effort and quickly. Similarly, another electrician from Marangbaru SMG could identify a low battery status but nothing more than that so support from Kathmandu had to be taken whenever faults occur in the systems.

  Saptami SMG is a solar-wind hybrid system where the operator does not have the slightest idea of how the inverter works or how to troubleshoot when some error message appears. Also, the operator was not trained to identify minor problems in the system. So besides general maintenance like battery check, panel cleaning, etc, the operator had no idea of the system's functioning. Also, the operator was not involved from the start so had no concept of how wind turbines work or what problem has caused them to work for 9 months only in 5 years of SMG operation.

All the above cases could have been handled swiftly if engineers at LG were capacitated for monitoring SMGs and if the mechanism of reporting to the concerned authority was in place.

Governance and audit

The financial audit is less practiced in solar mini-grid projects. Only one of 6 visited sites is audited yearly and complaints about discrepancies in the accounting and use of collected revenue could be heard from users in other cases who accuse the committee of not being transparent.

- Supporting case: None of the visited sites could show the tariff register or even the accounting register. They were reluctant to show the accounting and revenue-related documents. Also, when asked, yearly auditing was not in practice in all the sites but one. Sugarkhal SMG is owned and operated by a local cooperative and it follows yearly auditing while others do not.

LG participation

At present, mostly LGs are not involved from the initial phase of project development. Though LGs contribute a certain amount of money as the contribution from the community side, engagement of LGs for the technical part was very low. LGs were not involved in the feasibility study by the installation company. If the LGs are engaged from the beginning of the project, then it would be easy for the installation company and other stakeholders to get letters of completion, recommendations, etc. Similarly, by engaging LGs from the initial stage, LGs can plan for an annual contract for O&M with the installation company once the initial contract is over with the operator and the LG can also facilitate the coordination with NEA for the grid interconnection of the system.

- Supporting case: At Sugarkhal SMG, villagers and the chairperson of the cooperative are certain that the national grid will be extended to the village within a year. As the tariff for NEA is cheaper compared to the tariff of the SMG. Given a choice users would opt for grid electricity. Hence, the cooperative wants the system to be grid-connected, requesting the LG to coordinate with NEA to get connected with the grid under the net metering provision. Although the cooperative is ready to hand over the system to the LG, due to a lack of technical know-how, the LG is not able to take over the operation of the system.

Tariff structure

It was seen that tariffs were not set scientifically but solely based on decisions by the user committees without basis of calculations or by referring to existing tariff mechanisms from NEA or nearby mini-grids. The only approach used for setting tariffs was referring to the existing NEA tariff for households which may or may not be scientific to local SMG scenarios.

- Supporting case: Various tariff structures were observed. At Sugarkhal SMG, there was good tariff collection while the set tariff was different for households and enterprises. The tariff rate was NPR 12, NPR 15, and NPR 20 per unit for 6 A, 15 A, and 25 A respectively. At another site Kamalbazar SMG, Achham there was a flat tariff system i.e., NPR 100/HHs and NPR 500/enterprise whereas there was no tariff mechanism at Dhanpur SMG, Baitadi. The users at Sugarkhal were not happy with the tariff structure. At Danapur, the user committee was not able to fix and collect tariffs. There was a conflict between the community and user committee members regarding the tariff, revenue collection, and governance issues as the users blamed the user committee for mishandling of money, irregular meetings, and intransparency during the project execution phase.

Additional funding

The subsidy is delivered to new projects only but projects which are in operation for 5 years may also require additional funds if the revenue collection from the projects is insufficient. Although some of the projects had tariff collection mechanisms in place, it was seen that the collected revenue is not enough for the replacement of the battery and faulty parts after 5 years of operation.

- Supporting case: Ramitekhola SMG charges NPR 10/unit for HH as well as enterprises. The total energy consumption from 2017 to 2022 was only 2,046 units. At the rate of 10

NPR/unit, the replacement of a battery even a single inverter is not possible. The total cost of the system at Saptami SMG was NPR 52,556,962 so at least 40% of that can be attributed to the cost of the battery (NPR 21,022,784). Even if 110 households use 2 units/day at 9 NPR/unit for five years, the total generated revenue will still be only NPR 3,613,500 which is grossly insufficient despite being the best-case scenario.

Net metering

Although most of the SMGs are technically capable of net metering and the grid in the respective sites is already there, despite efforts from the community, community-based SMGs could not be connected to the grid for net metering. Also, grid-connected SMGs could use the grid to charge the batteries during the monsoon and winters.

- Supporting case: Except for Danpur and Sugarkhal SMGs, all other sites had grid electricity access at the site. Although the grid was present, it was unreliable so the communities used SMGs along with the grid. Now the community wants to take advantage of net metering and grid charging for winters and no sunshine days but there is no directive to connect community-based SMGs to the national grid. Furthermore, Birpur SMG was left lifeless after the grid arrived at Birpur. However, before the grid, the community completely relied upon the SMG. Now, without provision for connecting to the national grid, even the LG cannot help to get the system back online for backup and net metering.

Construction standards

Although some of the SMGs had well-built powerhouses, one of the SMGs was in poor condition and needed repair and maintenance.

- Supporting case: The powerhouse for Kamal Bazar wind-solar hybrid system is in bad condition. The roof leaks during the monsoon which was attempted to be mended with plastic sheets which is insufficient. The water ingress affects the control system and accessories and increases the chances of malfunction and damage. Also, the window panes are broken while the walls have insufficient strength.

1.1.2 Solar irrigation pumps

Standards

As there is no standard or benchmark for the quality of solar pumps. Anyone could use low-quality pumps that have not been tested for quality and performance in the country. Depending upon the installer and price, the quality of pumps varies widely and there is no mechanism in place to curtail the import of sub-standard products.

- Supporting case: SIP at Dhanpalthan, Morang was unused for a long and the pump had rusted so much that even the brand was not recognized. The nearest local service center was located 17 km from the site and looked after the general maintenance but could not resolve the issue. The pump was unused due to a sand deposit in the borehole. Also, the absence of service for pumps nearby is one of the issues that SIPs face.

  Similarly, Wellness Farm Gaurigunj and Jai Guru Krishak Samuha have installed solar pumps. After operating for 2 years, these pumps did not deliver water as per the demand and eventually ceased to work. Multiple calls to the installer brought no response. A local technician was unable to effect repair of the pumps. Eventually, the solar pumps were replaced by ordinary electric pumps.

Hybrid operation

Although the national grid was present at all the visited sites, none of the pumps were connected to the grid or operated in a hybrid mode (run via grid and solar PV). Thus, the communities faced problems with lifting water during monsoon and winter, when sunshine is scarce.

- Supporting case: At Nagikhola, Panchthar, Sunartole, and Panchthar 5HP and 3HP capacity solar pumps were installed respectively. The community encountered insufficient sunshine

and heavy mist during monsoons and winters so the water was lifted for no more than 3 months per annum on average. This could have been avoided by the installation of a hybrid pump and addressing provision for connection with the grid.

Construction standards

Although the technical specifications for electromechanical components of SIPs are well defined, standards and guidelines for the construction of civil structures are not available. Similarly, no procedure is available for the selection of water sources and the construction of sump wells. Local knowledge and dependency on the limited technical knowledge of the technician is the only option available.

Besides that, other civil structures such as intake canal, intake reservoir tank, and pipeline posts required to be constructed near the bank of the river are also not constructed as per the standards. This causes the constructed civil structures to be completely immersed during the monsoon. Consequently, water is not available during the dry season as experienced at the sites.

- Supporting case: Dhanpalthan, Morang SIP had ceased to work due to the poor standard of the borehole, as the height of the pipeline at the borehole was just 1 foot above the ground level and unprotected. Debris carried by the rain during the rainy season and sand deposits inside the borehole caused the pump to malfunction.

  Nagikhola PVPS, Panchthar had been shut down due to landslides causing the water source to wash away and sand and mud to deposit at the source. This was the only water source available at the site and the construction of retention walls or other protection measures for the water source would have avoided such situations. The selection of sites and construction of civil structures at this high-risk site was not taken care of during the construction phase of the project, resulting in the current situation.

Subsidy delivery

Farmers usually are members of one or more microfinance institutions (MFI) around their locality/land. MFIs provide member farmers with agricultural equipment, training, and EMI-based payment systems and ensure that the farmers are performing well and paying EMIs regularly. There is a two-way monitoring and control mechanism between farmers and MFIs which ensures that pumping systems are sustainable and affordable to farmers. Also, the MFIs have better-structured finances and accounting mechanisms. Routing subsidy delivery via MFIs could enhance the sustainability of SIPs. Also, farmers communicate with MFIs more easily rather than the installer thus reducing the time for handling support issues.

- Supporting case: Jeevan Bikas Samaj is a local MFI, who has installed SIP at Dhanpalthan, Morang. The MFI is responsible for regulating the tariff, collecting revenue from the users, and carrying out financial audits. The MFI also ensures the necessary operation and maintenance of the SIP. Thus, the SIP was governed by policy within the MFI. Also, farmers refer to the MFI for support required for the smooth operation of SIP, and the collection of revenue and transparency of earnings were shared among farmers in monthly/quarterly meetings.

  By contrast, in two other projects, the subsidy was delivered directly to the private company operating the Nagikhola SIP at Panchthar and Gaurigunj. The installers and service providers are said to have been non-responsive to service calls for the maintenance of pumps despite multiple attempts. As a consequence, they switch to ordinary electrical pumps. This could have been avoided if MFIs were involved in between AEPC.

Service in proximity

A major problem that SIP projects face is related to access to after-sales services issues particularly in the operation and maintenance of the SIP after commissioning. Problems like unavailability of trained local manpower, and no service center nearby have led systems to malfunctioning systems sometimes unattended for months, discouraging farmers and users to use the SIP technology and tarnishing the reputation of solar PV.

- Supporting case: The Dhanpalthan, Morang SIP had ceased to work due to sand deposit in the borehole and unavailability of support in proximity. The system could not be operated for more than 6 months. Similarly, Nagikhola PVPS and Panchthar have been shut down due to landslides causing the water source to wash away, and sand and mud deposits at the source. The installer company is located at Birgunj 400 km from the site and the installer does not have any provision of support services in the area. This could have been resolved with the presence of a service center nearby.

  Wellness Farm Gaurigunj and Jai Guru Krishak Samuha had installed solar pumps. After operating for 2 years, these pumps did not deliver water as per the demand and eventually ceased to work. Multiple calls to the installer brought no response. A local technician was unable to effect repair of the pumps. Eventually, the solar pumps were replaced by ordinary electric pumps. With service in proximity, this problem could have been solved easily.

4. Key recommendations

Based on the findings and analysis, the following recommendations are made for the more sustainable operation of SMGs and SIPs. Some of these recommendations can be used to revise the RE subsidy delivery mechanism, whereas the other suggestions can be helpful for upgrading/revising the project implementation guidelines and procedures.

4.1 Solar mini-grids

1) Quality assurance, standards of products, and technical specifications of minor components along with the major components should be defined and technical specifications of minor components should be included in the tender documents.
2) Long-term contracts for O&M with a local company right from the commissioning date should be established for quick service delivery.
3) Operators should be selected from the local community and trained well with a specific focus on inverter maintenance. The operator's salary should be partially paid by the installer and partially from the revenue generated by the project.
4) Local companies must be assigned as a service provider by the installer company. The assigned local service provider must be trained by the project starting right from the installation phase of the SMG so that local support services will be well acquainted with the technology, troubleshooting, and related services and the service delivery is quick.
5) Capacity development related to project commissioning, technical specification preparation, verification and due diligence of SMG, etc. is needed for engineers and sub-engineers at the LG.
6) Training related to support services and maintenance of inverter, error handling procedure, and system troubleshooting is necessary to be given to the assigned local service provider company as well as the operator.
7) Assigned local service providers and operators must be involved in the project by the installer company from the initial stage of installation as on-the-job training which is more effective than involving service providers after the commissioning of the project.
8) For any SMG generating revenue, an annual financial audit must be mandated. Along with financial audit, internal audit for good governance practice would help resolve issues of trust and transparency between users and committees.
9) Mandatory presence/involvement of LGs from the early stages of the project such as identification of the project, pre-feasibility, and detailed feasibility to project development must be there. LGs should be aware of all the projects done at their location.

10) LGs must own the project in such a way that they ensure good governance and communication with the service provider while the community is responsible for overall operation.

11) Standard tariff templates (not available yet) are recommended for tariff structures and collection considering factors such as demography, total project cost, operator's salary, land lease payment, and coverage for consumables and repairs of the project, etc.

12) Tariff determination in a scientific manner and basis of tariff setting must be submitted by the bidding/installer company beforehand so that, the tentative tariff structure can be communicated to the users and relevant stakeholders from the start and contracts can be made accordingly.

13) The mechanism for additional funding for community-managed/owned SMGs is required for the replacement of batteries and faulty parts to ensure the sustainability of projects. Additional funds could be based on the performance of the system specifically technical, social, and good governance.

14) Directives and guidelines to connect community-based SMGs to the national grid are required otherwise some of the SMGs will be lifeless once the grid arrives.

15) Construction standards for civil structures related to SMGs are required to ensure a minimum standard to be followed while constructing a powerhouse. Features like ventilation, water seepage, and heat inside the powerhouse must be taken care of for the optimum performance of the system.

4.2 Solar irrigation pumps

1) Quality assurance of pumps must be considered in the disbursement of subsidies. Pumps should have RETS certifications along with third-party certifications i.e., international certifications like CE, IEC, ISO, etc. for being eligible for the subsidy.

2) Hybrid pumps (solar and grid operated) should be promoted instead of standalone solar pumps to be an eligible subsidy for areas with a national grid (300 meters distance) or even for off-grid areas notified to be electrified soon. A provision for grid connection must be ensured to receive a subsidy.

3) Guidelines or standards are required for civil construction parts such as sump well, and intakes.

4) Similarly, there is a need for guidelines for (1) the selection of water sources and (2) the drawdown standards in cases where the river is the water source as sump wells constructed near riverbanks may get washed away during flooding.

5) Subsidy delivery via MFI is recommended as they have a pool of farmers within their reach, and are well acquainted with farmers' needs and resources of local farmers.

6) In cases of subsidy delivery via MFI, it is recommended to hand over the after-sales service budget to the MFI as well who will be responsible for handling support issues in liaison with the service provider. As MFIs are registered under government and NRB directives, the chances of financial misconduct are low.

7) MFIs should be capacitated for handling multiple SIP projects in the area with a provision of a service center within the MFI if the number of systems within the area is sufficiently high to support such.

8) Long term contract of O&M with a local service provider company right from the commissioning date should be done for quick service delivery.

9) Operators and local companies deployed as service providers should be involved and trained to start right from the installation phase of the SIP so that local support services will be well acquainted with the technology, troubleshooting, and related services and the service delivery is quick.

2. Annex

Annex I: Site visit template for solar mini-grids

Site Visit Template for Selected SMGs at P1 and P7

The objective of the Site Visit:

1. To find out the technical, financial, and social gaps at installed SMGs
2. To find Capacity gaps in the relevant stakeholders of SMGs
3. To foresee policy, planning, and implementation gaps for the sustainability of SMG

Assessment Date (DD/MM/YYYY): ……			
Project Name:			
Nos. of HH Served:			
Mun: ……	**Ward. No.: ……**	**District: ……**	**Province: ……**
Funding Agency (with % Contribution):			
Project Commission Date: …… (DD/MM/YY)			

Technical Indicators			
Is the National grid present at the Site?	Yes ☐	No ☐	
If NOT, how far is the grid from the site?	……Km.		
What is the topology of Grid & Solar connection	Isolated ☐	Grid Connected (Charging Only) ☐	
	Net metering ☐	Others (Specify):	
If Grid is present, Is the SMG redundant or still in Use	Still in Use ☐	Not in Use (Reason) ☐	
Is the system scalable to meet the future Demand?	Yes ☐	No ☐	
If yes, provide some details	Modular Inverters	Yes ☐	No ☐
	Array expansion	Possible ☐	Not possible ☐
	Powerhouse Space	Available ☐	Not Available ☐
	Tx Line Extension	Possible ☐	Not possible ☐
	Others (Mention)		

Is the system designed to prioritize PV use and minimize the use of battery (Day time use load details)	Yes ☐	No ☐
Does the balance of the system meet minimum quality standards to last for the next 10 years or warranty period? (Details below)	Yes ☐	No ☐

Components	Size	Installation Standard	Brand
PV Module		Good☐ Average☐ Bad☐	
Solar Inverter		Good☐ Average☐ Bad☐	
Battery Inverter		Good☐ Average☐ Bad☐	
Charge Controller (if any)		Good☐ Average☐ Bad☐	
Battery		Good☐ Average☐ Bad☐	
Solar Support Structure		Good☐ Average☐ Bad☐	
Lightning and Earthing devices		Good☐ Average☐ Bad☐	
Isolators (MCBs, Fuse)		Good☐ Average☐ Bad☐	
Others (Specify):			

The contract period for O & M after COD	5 years ☐	3 years ☐	1 year ☐	None ☐ Others (Specify) ☐
Is the system Grid Ready?	Yes ☐	No ☐		
Are there any issues with low voltage?	Yes ☐	No ☐		
Is the remote monitoring system installed and working?	Yes ☐	No ☐		

Were Community members involved in PFS, DFS, project planning, and Implementation	Scale (low-1 to high-5)	1 ☐
		2 ☐
		3 ☐
		4 ☐
		5 ☐

Where are LG/PG/ local Civil Society Organizations' roles and engagement is seen in the entire project?

<table>
<tr><td>Are the users Trained for maximizing daytime use?</td><td>Yes ☐</td><td>No ☐</td></tr>
<tr><td colspan="3">If yes, give some details:</td></tr>
<tr><td>Is there anyone monitoring daily activities like a system online/offline status; handling short circuit issues; tariff issues; social issues; module cleaning, etc.?</td><td>Yes ☐</td><td>No ☐</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>How prone is the site to natural disasters (e.g., flash floods, landslides, earthquakes) Follow-up question: - Is anything recorded recently?</td><td colspan="2"><table>
<tr><td>Disaster</td><td>Scale 1(Low) – 5(High)</td></tr>
<tr><td>Flash Floods</td><td>1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐</td></tr>
<tr><td>Landslides</td><td>1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐</td></tr>
<tr><td>Earthquakes</td><td>1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐</td></tr>
<tr><td>Lightning</td><td>1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐</td></tr>
</table></td></tr>
<tr><td>Are there any instances where any user/ operator is injured or electrocuted?</td><td>Yes ☐</td><td>No ☐</td></tr>
<tr><td>Does the plant have a safety harness, Fire extinguisher, Fire Alarm, etc. in Place? Is it in working condition?</td><td>Yes ☐</td><td>No ☐</td></tr>
<tr><td>Is the insurance cost of the operator and maintenance staff covered by the project?</td><td>Yes ☐</td><td>No ☐</td></tr>
<tr><td>What is the average response time of the O & M company?</td><td colspan="2"><table>
<tr><td><24 Hours</td><td>☐</td></tr>
<tr><td>Within 24 Hours</td><td>☐</td></tr>
<tr><td>2-3 Days</td><td>☐</td></tr>
<tr><td>Doesn’t Respond at all</td><td>☐</td></tr>
<tr><td>Others</td><td>☐</td></tr>
</table></td></tr>
<tr><td>Is local technical support available?</td><td>Yes ☐</td><td>No ☐</td></tr>
</table>

Social Indicators		
Can every HH as well as enterprises/businesses use the electricity as per their demand, 24 x 7?	Yes ☐	No ☐
	Others (Explain):	
Is there a provision of MCBs or load limit for HH and enterprises?	Yes ☐	No ☐
Have you ever encountered power insufficiency during peak hours?	Yes ☐	No ☐
Are any HHs left unelectrified within the community? Reasons	Yes ☐	No ☐
	If Yes, Reasons:	
Do/Can you use your own system instead of SMG?	Yes ☐	No ☐
What are the challenges for new HH to be connected to the SMGs?	Challenges	Scale 1(Low) – 5(High)
	Social	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Technical	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Financial	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Administrative	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Others (Mention)	
Does the plant have specific operating hours?	8 Hours/Day	☐
	16 Hours/Day	☐
	24 hours/Day	☐
	Others	☐
Who defines/regulates the plant operation hours, is it done with consultation from users?		
Nos. of Planned/Unplanned Outages per Month		
Major reason for power outage	Frequent Short Circuit☐	
	Overloading☐	
	Tx. Line Faults☐	
	Lack of sunshine ☐	

		Faulty parts ☐ Others (Explain):
Are Users satisfied with the O & M activity managed by the committee?	Yes ☐ → Agree: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐	No ☐ → Disa-gree: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	If No, Explain why?	
Is the operator well trained to carry out and report generic maintenance works?	Battery Management	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Log-Book entry	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Inverters maintenance	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	General maintenance	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Wiring and short circuits	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Is the user's committee roles and responsibilities well defined and active?	Yes ☐ → Agree: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐	No ☐ → Disa-gree: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Is user committee involved in daily/weekly activities including financial management?	Scale 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
How many members of the community were trained for general operation and maintenance of the system?	
Is good governance practice being implemented? (e.g. Anyone abusing the money, deliberately turning off the system? Etc.)	Scale 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	If No, Explain:

Was the tariff structure calculated in a scientific manner? Is the community satisfied with the tariff?	Yes ☐	No ☐
	If No, Explain:	
Who has the ownership of the project? (LG/PG/ Community/Private/Others?	PG	☐
	LG	☐
	Community	☐
	Private Company	☐
	Others	☐

Is community's wellbeing addressed by the project?			
	Health	Yes ☐	Agree 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
		No ☐	Disagree 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Education	Yes ☐	Agree 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
		No ☐	Disagree 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Safety	Yes ☐	Agree 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
		No ☐	Disagree 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Livelihood	Yes ☐	Agree 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
		No ☐	Disagree 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
	Women empowerment	Yes ☐	Agree 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
		No ☐	Disagree 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Who does the performance monitoring for the project? How often is it done?			

Has remoteness of the site ever been an issue for seamless operation (e.g., road condition during rainy season, heavy snowfall etc.)?		
Does the project have any expectation from the Local Govt. / Provincial Govt.	Yes ☐	No ☐
IF YES, On What specifically?		

Expansion Budget	Yes ☐	No ☐
Ownership of the project	Yes ☐	No ☐
Financial support for operation	Yes ☐	No ☐
Others (Please explain) ☐		

Financial Indicators			
How may enterprises are connected to the SMG	<1 ☐	1-5 ☐	>5 ☐
How Far is market center from the SMG Site	<1 kms ☐	1-3 kms ☐	>5 kms ☐
Is the community willing to re-invest in the project after 5 years of operation?	Yes ☐	No ☐	
Does the community have capacity to re-invest in the project from own collected funds?	Yes ☐	No ☐	
Is increase in entrepreneurial activities seen, post project implementation?	Yes ☐	No ☐	
	IF YES, what are the new businesses within the community? 1. 2. 3. 4.		
Share of revenue from the enterprise to the total income of the project?			
Is the tariff for HH and Business same?	Yes ☐	No ☐	
	HH Tariff/kWh	……. NPR.	
	Enterprise Tariff/kWh	……. NPR.	
	Step Tariff (if any)	……	
Is the current tariff structure enough to pay the operator and solve minor issues?	Yes ☐	No ☐	
Are there opportunities for grid interconnection with other nearby mini-grid projects?	Yes ☐	No ☐	
IF YES, Approx. distance of the nearby project/ Technology (SMG, MHP, Others)	Distance ……kms	Technology……..	
	Distance ……kms	Technology……..	

INSTITUTIONAL INDICATORS			
Is proper Documentation of the project available (If Yes, Collect)	Yes ☐	No ☐	
Do the user committee conduct regular meetings?	Yes ☐	No ☐	
Is the user committee registered at the Rural Municipality?	Yes ☐	No ☐	
Is External audit done on a regular/yearly basis?	Yes ☐	No ☐	
Has the project received subsidy?	Yes ☐	No ☐	
IF YES, who was the body responsible for delivering subsidy?	PG ☐	LG ☐	AEPC ☐
Was the Subsidy delivery mechanism Smooth and received in time?	Yes ☐	No ☐	
Any other Issues (Discuss and Note Down below)			

Data/ Document Collection:

1. BOQ
2. Project contract with the community(users)
3. DPR
4. Tariff Register
5. Maintenance Logbook
6. DFS report (Probably with the funding agency, nodal agency, AEPC)
7. Photographs

Annex II: Site visit template for solar irrigation pump

Assessment Date (DD/MM/YYYY): ……			
Project Name:			
Nos. of farmers directly benefitted from the solar pump:			
R/Mun……	**Ward.: ……**	**District: ……**	**Province: ……**
Funding Agency (with % Contribution):			
Project Commission Date: …… (DD/MM/YY)			
Project Ownership	**Individual**	**Community Owned**	**Cooperative owned**
Respondent Name			
Designation			
Contact Details			

1.Technical Indicators

1.1 Type of Pump: ☐Submersible ☐Surface ☐Hybrid

1.2 Capacity of Pump (HP):

1.3 Array Capacity(kWp):

1.4 Design Discharge(lps):

1.5 Is water meter installed?

☐Yes ☐No

1.6 How much water is pumped Daily(lts)

1.7 Do you have remote monitoring system installed?

☐ Yes ☐ No

1.8 Pump Operating hours per day (hrs)

☐ In summer days ☐In winter days

1.9 How many days do pump work yearly?

2. Site Observations

2.1 Quality of installation and civil structures

☐Good ☐Average ☐Bad

2.2 Safety of systems

☐Good ☐Average ☐Bad

2.3 Wiring

☐Good ☐Average ☐Bad

2.4 PV Array

☐Good ☐Average ☐Bad

2.5 Charge Controller

☐Good ☐Average ☐Bad

2.6 Lightening Arrestor

☐Good ☐Average ☐Bad

2.7 Surge Protecting Device (SPD)

☐Good ☐Average ☐Bad

2.8 Earthing

☐Good ☐Average ☐Bad

3. Social Indicators

3.1 How far is motorable road from project site? (km)

3.2 Where do you take the agricultural products?

3.3 How far is market center from your location?

3.4 Do you face any kinds of problem in market outreach?

☐Yes ☐No

If yes mention

☐Bad road conditions

☐Cheap vegetables come from outside

☐No facility for cold storage to store fresh vegetables so it gets rotten soon.

☐Others if any

3.5 Is there Tariff Collection Mechanism?

☐Yes ☐No

If yes, mention the tariff rate

3.6 How is tariff set among the members?

☐As per land holdings ☐As per liters water used

If no, how will you pay your Operation and Maintenance cost?

3.7 Is the pumped water distributed to all members equally?

☐Yes ☐No

If no, mention how and why?

3.8 Is there any kinds of conflict between the users?

☐Yes ☐No

If yes mention which type:

☐During water distribution

☐Scheduling the time for water distribution

☐Over Use of water by some individuals only.

☐Not happy for Tariff Collection

☐Others if any

3.9 Do all members in a group get adequate irrigation facility?

☐ Yes ☐No

If no, Mention why

☐Water is not sufficient as discharge is low compared to design discharge

☐Only limited number of users uses water regularly.

☐Problem in distribution system

☐Others if any

3.10 Do you have any kinds of rules, guidelines, mechanisms or legal documents for operation of this system?

☐Yes ☐ No

If yes give the exact name of documents

3.11 Is water being used for multiple purpose?

☐Yes ☐No

If yes, describe and mention the number of households being benefitted

4. Environmental Indicator

4.1 Before SIP, what was your irrigation mechanism?

☐Gravity flow ☐Electric pump ☐Diesel pump ☐Hand Pump

For Diesel Pump: What was the capacity of Diesel Pump?

4.2 How much Diesel was consumed in a per hour/day? (lts)

4.3 What is the frequency of servicing diesel generator?

☐Weekly ☐Monthly ☐Quarterly ☐ Semi Annually ☐Annually

For Electric Pump:

Why do you replace Electric pump with Solar Pump?

☐Electric motor does not run due to unreliability of electricity supply.

☐Electric motor burns frequently due to voltage fluctuations in the supply

☐Due to fear of electric hazard at field.

☐Electric pump provides less water

☐No electric maintenance center nearby

☐Others, Specify

4.4 How often electric motor burns due to voltage fluctuations?

☐Daily ☐Weekly ☐monthly ☐ yearly

4.5 How often is electricity cut off daily?

5. Economic/Financial Indicator

5.1What is the total cost of the system?

5.2 Who provided financial and technical assistance for the project and what was the amount of financial support?

5.3 Do the water user group have loan to pay?

☐Yes ☐No

If yes what is the interest rate and loan tenure

6. Post installation

6.1 Do you have repair and Maintenance fund?

☐ Yes ☐No

If yes how much is fund available and how this fund is mobilized?

6.2 Have you been briefed about general Dos and Don'ts in the system?

☐Yes ☐No

6.3 Have the installer company provided training to any individuals from the group?

☐Yes ☐No

If yes what kind of training?

☐Minor troubleshooting ☐Major troubleshooting

6.4 Are there any repairing centers nearby?

☐ Yes ☐No

If yes, is it branch office of installer company or the local company?

6.5 Have you taken any kinds of service from this repairing center?

☐Yes ☐No

If yes rate the capacity of the repairing center

☐Excellent ☐Very good ☐Satisfactory ☐Worst

6.6 Do you have a long-term contract with the installation company?

☐Yes ☐No

If yes, how many years do the contracting company provide the after sales service?

☐1 year ☐2 years ☐ >3 years up to 5 years

6.7 Do you have contact details of installer company?

☐Yes ☐No

6.8 Do the installer company have branch office or agents at near city/town?

☐Yes ☐No

If yes, who

☐Branch office ☐Agent

6.9 Mention the name location and contact details of the branch office or agent

6.10 Have you ever contacted installer company?

☐Yes ☐No

If yes why

☐System did not work

☐Insufficient water supply from the pump

☐Electrical burns in the system

☐Others if any

6.11 What was installer company's response?

☐They visited the site and maintain the system properly

☐They did not visit the site and stopped answering your phone calls

☐Others if any

6.12 Have you done insurance of the system?

☐Yes ☐No

If yes, for how many years? From which company? what is the mechanism to do insurance for SIPs?

7. Institutional Setup

7.1 How many members are there in farmer group?

7.2 How many women and DAGs are there in this group?

7.3 Is this farmer group registered?

☐Yes ☐No

If yes, where it is registered?

☐Local Government ☐ Local Cooperative

7.4 Is there regular meetings held among the members?

☐Yes ☐No

If yes how often?

☐Weekly ☐monthly ☐quarterly ☐semi-annually ☐annually ☐others specify

7.5 Do you have project Bank Account?

☐Yes ☐No

If yes is the bank account functional?

☐Yes ☐No

7.6 Is the project bank account audited?

☐Yes ☐No

If yes, what is the type of audit?

☐Financial Audit ☐Public Audit ☐Both

7.7 What is the frequency of financial audit and public audit?

7.8 Is income and expenditure are shared among all the members in a group?

☐Yes ☐No

8. Level of Satisfaction and Market Development

8.1 Are you satisfied with system?

☐1 ☐2 ☐3 ☐4 ☐5 scale (low -1 to high -5)

Reasons

☐It provides insufficient water

☐It needs good technical knowledge to operate

☐Hard to repair and maintenance

☐Others Specify

8.2 What is your opinion to escalate the promotion of this technology?

8.3 How can we enable the marginalized community to get this system?

8.4 Are there any financial institutions providing loan for SIPs?

☐Yes ☐No

If yes, name them with contact details

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