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Solar Irrigation for Agricultural Resilience (SoLAR)

Appropriate Institutional Modalities for grid-connected solar irrigation pumps in Nepal

Summary Report of Webinar 4

4 February 2021

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List of Abbreviations

IWMI	International Water Management Institute
SIP	Solar Irrigation Pumps
AEPC	Alternative Energy Promotion Centre
NEA	Nepal Electricity Authority
DISCOM	Distribution Companies
GW	Groundwater
ICIMOD	International Centre for Integrated Mountain Development
VDC	Virtual Design and construction
PV	Photo Voltaic

Webinar 4: Appropriate Institutional Modalities for Grid-Connected Solar Irrigation Pumps in Nepal

The region's focus for webinar 4 was Nepal and was titled *'Appropriate Institutional Modalities for Grid-Connected Solar Irrigation Pumps in Nepal'*. It was held on 4 February 2021 with 51 participants and was moderated by Dr Manohara Khadka, IWMI Nepal. The webinar aimed to facilitate a discussion on the future of SIPs in Nepal, especially in the context of grid-connection of SIPs.

The discussion revolved around three major themes where experts deliberated on – low SIP utilisation and potential causes and solutions, the feasibility of micro-grid in the country, and appropriate institutional modality for this grid connection if feasible. So far, Nepal has taken the off-grid route to solar irrigation, but the need for grid connection is increasingly felt due to various reasons. Subsequently, federal, and provincial and local governments are emphasising expanding SIPs to enhance access to irrigation.

Grid connection of SIPs is a planned pilot in the SoLAR project. We respond to requests made by the Alternative Energy Promotion Centre (AEPC)[1] and Nepal Electricity Authority (NEA) to demonstrate the institutional modalities and effectiveness of such grid connection.

Table 1:Schedule of webinar 4

Webinar	**Date & time**	**Speakers/Presenters**	**Panellists**
Webinar 4	4 February 2021(9:45 AM to 11:15 AM IST)	Dr Ram Fisherman R Vishnu Pandey	Mr. Madhusudhan Adhikari Ms Ranju Pandey Mr Resha Piya Ms Kiran Kumari Thakur Mr Anjal Niraula

Recording of webinar 4: https://www.youtube.com/watch?v=0gAVQG50auE

I. Presentations

a) Are SIPs utilised to its full potential? Early evidence from SIPs installed in Nepal Terai

Dr Ram Fishman of Tel Aviv University, Israel, gave a presentation in this session.

[1]Alternative Energy Promotion Centre (AEPC) is the nodal agency responsible for developing and promoting renewable energy technologies in Nepal.

A simple equation that balances cost and benefit for installing SIPs can be used as a research framework. While some subsidies may be necessary, one cannot just rely on them for real market viability. The SIP, over time, should generate enough revenue for the returns to justify the investment. There are two aspects to this challenge: firstly, that with an appropriate interest rate, one needs to make sure that the farmer can obtain a loan for the SIP (finance) and secondly, that the benefits be sufficiently large (profitability).

Finance:

Is this available with a reasonable interest rate for smallholders? Is providing smallholders with finance also market viable? Is there a model where they could repay the loan, so it is profitable for the bank as well? Usually, this is not available for them as the microfinance model does not lead to economic growth, which is the consensus from research.

In Saptari in Tarai, we offered different VDCs different models: benchmark model (where a farmer has to pay total cost upfront), loan model (had to pay some portion upfront, but the rest is a loan), and rental model (minimal upfront cost). This checked how much demand was shown for SIP for each model – starting from collecting forms (shows initial interest), making a deposit, and then purchase. In the VDCs where we offered these flexible models, demand was much higher- out of twenty pumps bought, eighteen were from under these financial models; demand was still low in absolute numbers

Will farmers repay the loans? Financial institutions often have this concern, but results here are encouraging as 19 out of 20 farmers pay on schedule. We need more research like this, probably with demand growth, to see how reflective these results are.

Profitability:

We looked at a sample of 53 SIP owning farmers, and these farmers reported daily (about the number of hours they use the pump for, the amount of water they pump, and for which crop)

Findings: on average, SIPs are used 40% of the time (5% used it 90% of the time, some hardly at all). Even in the summertime, when the sunshine is abundant, SIP use is not above 75% at most times. This is puzzling because the cost is 0%. Usage also differs based on the crop being grown - they use it for paddy, aquaculture, pulses, and wheat. The number of hours used for fish farming per hectare is most extensive, followed by paddy, pulses and wheat.

What are the barriers to full utilisation? Firstly, maybe there is no need for irrigation because of abundant precipitation. Secondly, the land in the vicinity of the pump is fully irrigated and with the most intensive water use per ha. (Like fish farming). The land cultivated by SIP is relatively low as there is land cultivated/irrigated by other means by diesel pumps and not irrigated. This suggests that there is land

that is not cultivated/or by other sources, but this is not being replaced by SIP cultivation. It is hard to imagine that land is fully irrigated and that all land around the pump would be fully irrigated. Less than 10% of farmers sell any water at all. So, data does not tell us what is happening.

Storage of water could be one solution if soil moisture is sufficient, but this is expensive. Limited land cultivation, less water-intensive activity could be because of food security, habit, risk aversion etc. This needs to be understood to make SIPs more profitable. Without that, market viability for SIP will be reduced. We probably need more data, experiment with new interventions, and maybe connect SIPs to the grid so that pumps become more profitable.

b) Institutional modalities of grid-connected SIPs: A review

Professor Dr Vishnu Pandey, Tribhuvan University/IWMI Nepal, gave a presentation in this session.

Three key questions were covered here, viz., are grid-connected SIPs an excellent solution to increase capacity utilisation of SIPs? How feasible is the idea, given the small size of SIPs in Nepal? And what could be an appropriate institutional grid-connected modality for Tarai, Nepal?

The scenario of SIPs in Nepal:

About 1800 SIPs have been installed in Nepal, wherein an AEPC subsidy has supported nearly 1400. These have mostly been installed in the Terai (Province 1, 2 and 5). 22% SIPs are granted to female applicants, and most pumps are between 1-2 HP. The cost is usually high, and even with the 60% subsidy, farmers still have to pay 2,180 USD to get a SIP (this varies with pump size). The water-energy connection has implications for groundwater (GW) extraction. Therefore, it is necessary to incentivise surplus energy to the grid to generate extra income, mitigate GW over-extraction, and stabilise the grid system.

The scenario of grid-connected SIPs in South Asia:

In Bangladesh, the SIP operators are small independent power producers (there is a standalone pump with panel connected to the grid with solar inverter and smart metering system, i.e., a bulk revenue system wherein the utility meter is bidirectional to calculate energy export and import for consumption. The Net Metering Guideline 2018 has clear policy and procedures.)

In the case of India, there is a pilot project in Karnataka named Surya Raita Scheme (unidirectional metering – farmers' cooperatives are facilitating – high feed-in tariffs at Rs. 7.2). In Gujarat, the pilot is named Surya Shakti Kisan Yojana, which has bidirectional metering with a feed-in tariff at Rs 3.5. The PM KUSUM plan is an ambitious programme of the government of India which has three components. Here, component A includes a 10,000 MW grid-connected solar project and is set up by farmers' cooperatives, project developers, WUAs, and power to be purchased by DISCOM at a pre-fixed tariff; Component C proposes solarisation of 1.5 million grid-connected SIPs up to 7.5 HP. Grid connection thereby is not

something new and already practised by our neighbours.

In Chitwan of Nepal, NEA had piloted technical testing feasibility of connecting SIP to the grid. They collected two pumps in two locations, tariff as per net metering policy, but no precise institutional modality was worked out.

This review indicates that there are three typologies of grid-connected solar systems**:**

1. Based on the scale (single/standalone; micro/mini-grid (several pumps connected to the local grid), and grid-connected (using national power transmission system)
2. Based on methods (direct connection to grid or through mini/microgrid system using local feeder lines)
3. Based on ownership (private/community-owned/government-owned)

Grid connection options:

1. Direct net metering of solar pump system (pump gets electricity from both solar grid inverter and power grid network)
2. Solar microgrid systems (pumps and panels connected to M.G. and then connected to one location at national grid)
3. Solar-powered agricultural feeder (tail-end grid-connected solar P.V. plants)
4. On-grid solar pump inverter (advanced net metering system)

The institutional modality for grid connection of SIPs: critical questions on-

1. Ownership (majority so far is private, followed by community ownership and the government)
2. Beneficiaries (what types of households to target with what kind of characteristics?) How to ensure that different sections are targeted well?)
3. Benefits/energy sharing/ access mechanisms (also measures for equitable benefit sharing? how to share losses? how to account for total energy use?)
4. Linkage with government (what kind of regulatory regime should be in place? – fully regulated by government/jointly handled with the community?)
5. Business models (arrangement for capital investment – the split of grant, loan and equity, revenue generation, basis for charging flat rate etc.)

II. Panel Discussion

Following were the panellists for the session:

1. Mr Madhusudhan Adhikari, Executive Director, AEPC, Government of Nepal
2. Ms Ranju Pandey, Manager System Operation Department, NEA, Government of Nepal
3. Ms ReshaPiya, Renewable Energy Advisor, British Embassy Kathmandu
4. Mrs Kiran Kumari Thakur, Deputy Mayor, Gaur Municipality, Rautahat district
5. Mr. Anjal Niraula, CEO, Ghampower

Theme 1: SIP utilisation

The main concerns are sustainability and financing – how to make the technology work for several years with farmer's level knowledge? How can they access repair and maintenance easily? The technology being provided (by AEPC) may not be of the best quality as there may be many issues that may need spare parts; also, there are life cycle concerns of a controller. Panels at least work for many years without major problems. A single farmer would have a specific pattern of cropping– a pump is used when required accordingly. There will be a capacity surplus at the farmer level wherein they will (usually) own a small pump that cannot sufficiently cover paddy cultivation. There may be some surplus if a medium-sized pump is used. Utilisation then could be limited at the individual farmer's level.

The lowest levels of operation and management need to be looked at; D.C. pumps are very tricky – specific to the manufacturer in terms of quality and maintenance. So, if AEPC needs to revise and redesign their program, they would need to request the government for more budget.

For Gham Power's customers, those who use the SIP for 20%-30% of the time are either already displacing their old diesel costs or increasing yield, increasing land utilisation, and going into commercial usage. Pump size needs optimising for farmers – subsidy is mainly based on 1-2HP pumps and not on the specific kind of agriculture that the farmer is engaged in; therefore, looking at individual farmer requirements is essential. Enabling environment is necessary; a service delivery model is needed, whether grid-tied or not, the service provider/water entrepreneur will try to maximise SIP utilisation.

Theme 2: Is micro/mini grid a good solution?

A grid connection is a good idea to increase utilisation. It can also increase revenue for the farmer; there is also already a policy that allows PV systems to be connected. But many challenges exist:

1. SIPs promoted until now have been relatively small, and the government has also specified that only those SIPs installed in areas with no grid connection are eligible for subsidy.
2. If there is no grid connection (infrastructure) already, this possibility is minimised in such an area.
3. In the area where there is grid connection and thereby electricity, farmers would probably prefer the electric pump because the tariff for irrigation is very low (4.3NRs. only) – for the farmer, it may not make sense to choose SIP in this case
4. Voltage fluctuation is another common issue in areas with grid connection
5. It may not make economic sense for NEA as well because they would be buying this generated electricity at a higher rate and selling it at a lower rate
6. Net metering, inverter cost, human resource cost will be comparatively expensive - the sale will also be down, so the farmer will not profit as much.

7. For larger systems, this may be feasible.

Marginal gains that can be received from connecting to the grid are not significant enough – there are further other issues, viz., how can private investment be encouraged in this sector? Are public funds being channelised properly? Is subsidising capital cost the right way to go? Can this be done differently to leverage a different kind of private capital?

Theme 3: Appropriate institutional modality:

For water sharing:

AEPC had 13000 applications this year but could select only 500. Many people look for pumps in the same area, and AEPC selects them based on VDC recommendation/priority listing. If arrangements can be made for farmers, who are excluded from the system also to be able to access water, maybe working with a cluster and working out a water-sharing modality could help. Another way is to have bigger pumps awarded to groups/cooperatives, and then they could share the water among themselves.

For grid connection:

There are two ways to do this for NEA: net metering (individually selling by farmers, NEA has a tariff for that); or through the mini grid (with a power purchase agreement for 25 years). The feed-in tariff is at 7.3 NRs per unit. NEA guarantees to buy energy for a specific price; this will be profitable for farmers, but farmer willingness needs to be ascertained. The government of Nepal has the policy to buy energy from an alternative source (solar, biogas, wind) – based on a white paper published in 2075 B.S. (2018/19). NEA has plans to buy 10000-15000 MW of energy. Any of the models (private, community, government-owned) could be appropriate based on context and the community where one is working. The main barriers of SIP need to be identified to connect to the grid and then develop policy and regulation to address these barriers – the subsidy is also limiting the market. There is a need to establish a mechanism where farmers can easily access and then connect to the grid. The current process is very challenging. The farmer is not a technical person; there is a need for an energy service/water entrepreneurship model, and then sell water to those who need it – it does not matter to the farmer where the water is coming from. Local government has been given policy right over alternate energy –policy can be made in partnership with AEPC and NEA to facilitate grid connection. Local governments can support this by providing land (for installation), making farmers aware of this source/resource - its potential and energy selling prospects.

They could also give space to alternate energy programs/projects in their local budgets. Simple AC pumps could be distributed in different locations and operated as per farmer group requirements or have a pipeline water distribution system. Even with big pumps connected to the microgrid, they may still not be fully utilised – in that case, a power exchange with microgrid could work (where to locate, cost, impact -- mostly these issues are connected to local utility NEA); government support is imperative

here to optimise power generation.

Table 2: Q&A with panellists

Sl no	Questions	Answers
1.	**Kashi Kafle:** Dr Fishman, when you talk about SIP utilisation, do you mean SIP is not used even when they cultivate the plot where SIP is installed, or SIP is not utilised because there is no cultivation?	**Ram Fishman:** It seems to be both. Some land remains uncultivated, even though there is energy and water available which is not utilised. What is stopping it? And even when land is cultivated, is it cultivated with the crops that show the greatest water returns? It does not seem to be so.
2.	**Kashi Kafle:** Also, what is the threshold hours or days you are taking as a reference to calculate under/over utilisation?	**Ram Fishman:** Ideally, whenever there is sunlight. Anything else would mean under-utilisation of the potential. Perhaps we need to take out the rainy days from this calculation. On rainy days, you won't need to irrigate, right?
3.	**Bishal Silwal:** I am not an agricultural expert, but do all the crops need water all the time? Maybe not. Could that also explain the low usage of the pump seen in your survey?	**Ram Fishman:** Good question. Crops may not require water all the time, but water is offered in rotation across crops. Why is the rotation not fully utilised?
4.	**Bishal Silwal:** There could be many factors attributing to that; for example, do the farmers still use the old large gasoline pumps with higher flow simultaneously with the SIPs?	**Kiran Timilsina:** Crops do not require water all the time. During the plant's growth, there are some stages for which they need water; it's the critical water requirement stage. If we do not provide water during these critical stages, crop production may decrease significantly. Overwatering may cause stress to plants, even hampers the

		yield of crops.
5.	**Kashi Kafle:** Vishnu sir, Dr Fishman's study shows SIPs are underutilised. Then we are talking about SIPs that are small in size. If the smaller pumps are not fully 'utilised', why go for larger pumps? Should we not be thinking about increasing the utilisation of SIPs rather than increasing the size or grid connecting them? Just a thought.	**Vishnu Pandey:** They are two different issues - 1) if we aim at maximising utilisation - we can consider grid-connection as one of strategy; 2) if we aim at promoting grid-connected SIPs, our preference could be for higher size pumps as they minimise losses.
6.	**Kashi Kafle:** All the markets, primarily input and output markets. SIPs are just one element of the equation, so utilisation of SIPs is based on access and availability of other inputs and some access to the formal/informal output market.	**Aditi Mukherji:** Yes, I think that's precisely where we need to focus; my hunch is that crop economics (input costs to output price ratio) is unfavourable, hence farmer's decisions. So, it is essential to collect this information for our planned work.
7.	**Shisher Shrestha:** Is there any data on the agriculture produce from the farmers? Were the farmers using the SIPs at their optimal potential? If they do not require water, they can perhaps sell water or make overhead tanks to store water for non-sunny days, etc.	**Aditi Mukherji:** Interesting points; we have all the data, and we need to check. I guess that growing crops is just not that profitable given high input costs and low market price.
8.	**Shisher Shrestha:** One answer based	**Vishnu Pandey:** No

	on my ground experience is that some farmers are full-time commercial farmers, and others do subsistence farming. So, while we look at the data, we may need to be more specific and categorise the farmers. Are there any detailed studies done about the sustainability of groundwater in the Terai region in Nepal?	
9.	**Bikash Uprety:** Dr Pandey, what shall be the optimum size of the pump that can be connected to the grid?	**Vishnu Pandey:** There is no specific recommendation except that larger is better in terms of minimising losses. That could be a research question to consider for the next step.
10.	**Shisher Shrestha:** Are the SIPs oversized? Should there be different sizes of pumps depending on the uses of farmers? Currently, there seem to be uniform sizes for the majority of AEPC supported SIP. Perhaps we can integrate another technology such as drip irrigation to reduce the SIP size and make it financially more affordable with or without subsidies	**Vishnu Pandey:** Good idea, but will it push up the prices, wanting to customise it for every farmer? They mostly replace 3-5HP diesel pumps, so why not design something that delivers equivalent water to those 3-5HP diesel pumps and reduce capital costs.
11.	**Bikash Uprety:** Dr Pandey, what is the cost comparison for grid operated pumps and SIPs? What are the preferences in terms of choice for the farmers (grid or SPIS)?	**Vishnu Pandey:** Some literature has made comparisons. Grid-connected electric pumps are often cheaper. But SIPs are more applicable and more affordable than diesel pumps where the grid is not available. We have not done analysis and have not come across those studies in literature as well (I might have missed them too).

12.	**Shree Thakur:** Thanks to Prof Pandey for the modality of grid connection of SIPs. Groundwater extraction is not much problem to the environment if extracted from below aquifer stratum. That is only one way to use water sources in the Terai region.	**Vishnu Pandey:** In terms of general perception, yes, you are right. However, we don't have scientific studies on groundwater storage, spatial distribution, and sustainable yield from Terai aquifers. Those studies are necessary to make evidence-based decisions on a safe level for groundwater extraction.
13.	**Prachanda Pradhan:** AEPC is an implementing agency, not a policy analysis institute and subsidy implication are to be analysed. Subsidy alone cannot be a policy, of course, subject of analysis; which makes its impact now?	**Aditi Mukherji:** In SDC supported SoLAR project, we are undertaking impact evaluation of AEPC pumps.
14.	**Kashi Kafle:** I am puzzled. Are we trying to make small farmers net sellers of energy or net seller of agricultural products?	**Aditi Mukherji:** Good question, that's a policy question, what's the priority, and could be both. Need not be either-or, no?
15.	**Shisher Shrestha:** Perhaps we must try to optimise agriculture production for the farmer while thinking about making SIP affordable. Net-metering may be one idea.	**Kashi Kafle:** It seems at the moment, small and marginal farmers have not received the pumps. There needs to be a graded subsidy model and a high subsidy for small farmers, gradually reducing the subsidy with farmer's wealth status.
16.	**Shisher Shrestha:** Fully agreed. Also,	**Aditi Mukherji:** Yet, let's not forget that

	some innovative business models for landless farmers and improving access to SIP.	AEPC data shows that at the AEPC level, they have tried to choose the smaller farmers and women farmers from among the people who have applied. It's just that very small and marginal farmers did not apply. But AEPC did very well in applying GESI principles, not many nodal agencies in South Asia have done that, and credit is due there, IMHO.
17.	**Shisher Shrestha:** Resa Piya, I just wanted to hear your views on where the SIP market in Nepal is going? Is there any landing plan for the post-subsidy market for SIP?	**Resha Piya:** We are working with AEPC through NRPP to encourage private sector investment in the sector.
18.	**Shisher Shrestha:** Anjal ji, Gham Power has installed many SIPs, and you are one of the market leaders in the field. I just wanted to hear your views on the lifecycle of SIP. Panels, pumps and controller has a different lifetime. Do you guys plan to reuse the panels from old SIPs or replace the pump and controller (if the farmer pays off course) to improve the sustainability aspect?	**Anjal Niroula:** Thanks, Shisher Ji - panels have a warranty period of 25 years, pumps and controllers have a warranty of 3 years, although pumps and controllers last longer if appropriately designed.
19.	**Naveen Mangal Joshi:** In the case of Terai, lifting would be less compared to the Tar in the Hills. Most of the Tars are in lack of water in Nepal. What is the general economic lifting height for	Because the lift is so much higher in Terai, costs are also higher.

	Solar Pumps for irrigating?	
20.	**Nirman Shrestha:** It seems like all these SIPs are privately owned; are there any of these SIPs owned by community or farmer cooperatives, and if so, is there an analysis of how the pumps are used in those cases? Is there any study done about the usage of pump and system management modality in those cases?	Not sure about the details, Dr Fraser (former IWMI-Nepal head) led qualitative study confirms the benefit of the solar collectives for landless and marginal farmers. Under the SoLAR [SA] project, we have plans to explore this model. This will be again more of a qualitative study. But we will appreciate your inputs in terms of questions that could be beneficial for the research.
21.	**Prachanda Pradhan:** What policy analysis support institutions exist in Nepal to promote a solar irrigation project?	There is AEPC and subsidy program.
22.	**Prachanda Pradhan:** Can the Institute of Engineering, Pulchowk, take the role of policy analysis for long term implications? This question is to Dr Vishal Pandey.	**Vishnu Pandey:** Certainly yes, sir.
23.	**Nirman Shrestha:** In addition to Bishal Silwal's question above, most of the crops negatively affect irrigation; if they are not selling water or collecting it for future use, was that taken into account for analysis for underuse of the water?	But there is always the possibility of switching to crops that need more water and have higher market prices, such as vegetables. Why don't farmers shift to those given water is free? We found that after SIP, many farmers took up aquaculture as KTM is a good market for fresh fish. The answer possibly lies in larger agrarian distress; agriculture is not that profitable, then why invest in more input

		costs when market prices of crops are low and not profitable?
24.	To add to that question, crop switching is always possible with higher profitability, but to take the switching into account, are there studies done about the social issues, resources available and market accessibility for switching the crops?	Aquaculture is mainly popular with elite farmers. It is profitable since it is less laborious and time intensive. The possible options for efficient water utilisation might be selecting high yielding high-value crops, increasing land acreage, shifting a part of agriculture to aquaculture. These options might be capital intensive at first. A regulatory and advisory system must advise and control farmers from over-irrigation and maintain the aquifer's water level.
25.	**Gitta Shrestha:** Has anyone investigated the impact of power theft in less adoption or usage of Solar [Irrigation] Pumps?	**Shisher Shrestha:** In ICIMOD projects, anti-theft nut bolts were used. So, theft was not a major issue. But people faced problems such as broken panels as someone threw stones at the panels, etc.
26.	**Gitta Shrestha:** Aquaculture requires a substantial initial investment and new technical knowledge. Have these been taken into account when we talk about switching the crops?	**Naveen Mangal Joshi:** NEA is the only authority presently for distribution and purchasing the energy produced in Nepal. Until the NEA does not promote or have a mechanism for buying from grid connection of individual solarised electricity producers, it would not be appropriate, in my opinion. **Vishnu Pandey:** I fully agree with this. Therefore, this project is trying to pilot it in collaboration with NEA to give good insights for scaling up/out to other areas.

27.	**Nirman Shrestha:** Anybody knows if there is any study done here in Nepal or abroad regarding financing a higher capacity solar farm with irrigation pump for farmer cooperatives or collectives which the water user groups can manage?	**Vishnu Pandey:** I am not aware of such studies.

Top three take away from the webinar, and how and whether SoLAR future work can address them?

Take away 1: On SIP – utilisation seems low when considering that farmers are getting free energy. More research is needed to determine exact factors. One way for farmers to increase utilisation and thereby profits could be by connecting the pumps to a mini-grid. Additionally, private players pointed out that 40% utilisation was not very low. SoLAR could further explore barriers to utilisation in future research work.

Takeaway 2: It was thought by quite a few that it was a good idea, and links and linkages (partnerships, technical and financial feasibility) could be addressed to implement the concept. However, opinions on farmer's willingness, the small size of pumps, electricity instability and access to finance were presented as counter arguments. A pilot project may help better understand if it would be feasible, which SoLAR is working on with NEA, AEPC and a suitable local government partner.

Take away 3: On appropriate institutional modality – many options to consider from neighbouring India and Bangladesh, but the most appropriate one would be context-specific and supported by relevant authorities (local government, NEA and AEPC). Greater clarity could be achieved once the pilot commences and is evaluated by the project.