A REVIEW OF PRIVATE SECTOR PARTICIPATION IN BUILDING A SOLAR ENERGY BASED MICRO-ENTREPRENEURIAL ECOSYSTEM IN RURAL INDIA

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ABSTRACT

Two-thirds of the Indian population resides in rural areas, with 50% of the Indians employed in agriculture, contributing to 20.2% of our G.D.P. (G.O.I.). While agriculture remains the primary source of income for rural Indians, the recent trend of rising income from rural micro-enterprise sectors is definitely of interest. Fortunately, both these sectors can use energy from sustainable resources like solar energy to meet their requirements. As per available records, 90% of rural households are connected to the grid. Despite this, supply gaps continue leading to the emergence of a market for sustainable energy sources to meet their requirements. Solar energy farming, both grid-connected and non-grid connected, can be used by farmers to operate pumps to irrigate their farms and excess energy produced to be sold to the grid. As far as micro-enterprises in rural India are concerned, the availability of cheap power can lead to mechanization and increased productivity. Some livelihood solutions based on solar energy launched so far include sewing machines, looms, milking machines, threshers, welding machines, cold storage units, and many more. The Government of India, the Ministry of Renewable Energy, through its various flagship programs, policy initiatives, is making an effort to create awareness and incentivize the acceptance and subsequent use of solar energy-based livelihood solutions in rural India. Harnessing solar energy can help farmers and people engaged in other livelihood activities in rural India earn a steady income. Based on secondary research, we examine the opportunities and challenges in the adoption of both solar energy farming and solar energy-based livelihood solutions in rural India. This paper concludes with a discussion on the potential role of the private sector in the development of the solar energy-based rural micro-entrepreneurial ecosystem.

INTRODUCTION

Need for Sustainable Energy Sources

The share of Agriculture and Allied Sectors in G.D.P. of the country stands at 20.2% (G.O.I.) in the year 2020-2021. With about 42.6% of the workforce employed in agriculture and related area. Agriculture is the primary sector giving employment in India (Aaron, 2021). While the contribution of the other sectors like Industries and Services is fast-growing, agriculture lags, raising productivity concerns. Lack of irrigation is cited as the most common cause; irrigated area accounts for nearly 48.8% of the total area under cultivation, the remaining 51.2% is rainfed. The mean productivity of rainfed areas is about 1.1 tonnes per hectare compared to 2.8 tonnes per hectare of irrigated areas (Jitendra, 2019).

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The results of a high of above 50% area of irrigated land are seen in states of Punjab, Haryana, and Western Uttar Pradesh, which has seen great success in terms of agriculture productivity. Another problem in this sector is related to crop patterns. Crops are seasonal, and most of the farmers are deprived of a regular source of income all through the year as their land lies uncultivated during some months of the year (The Economic Times, 2019).

To improve irrigation infrastructure, India has primarily focused on groundwater structures such as wells and tube wells. Pumps are used to draw water from these sources. Conventionally these pumps are either diesel-based or draw electricity from the grid. Approximately 20 million pump sets are being used in India. Out of which 8 million use diesel as fuel and 12 million use highly subsidized electricity from the grid. Diesel pumps consume around 2000 million liters of diesel per annum, costing about Rs. 15000 crores. 20% of total electricity consumption in India is in the agriculture sector (Renewables Numerical in Agriculture,2019). The electricity supplied to the rural sector is subsidized and hence grid companies, find it uneconomical to supply here. The grid services provided are also erratic. Solar energy farming (S.E.F.) provides a practical option for generating required energy locally to run the irrigation pumps and sell the excess electricity generated back to the grid. S.E.F. also provides an opportunity to generate income from uncultivable lands and from land that may be lying fallow for an intermittent period SunFarmer (2015).

Apart from agriculture, rural India is also home to over 32 million people earning their livelihood from unincorporated micro-enterprises here. These enterprises are involved in various kinds of value addition activities like agriculture-processing, dairy farming, and custom tailoring to little shops and restaurants (Jha, et al. 2019). According to N.S.S. figures, there are 149,948,993 women in the labour force. Many women residing in rural areas are involved in agriculture as laborers, sharecroppers, small farmers, and livestock managers. Rural India is also home to women producing textiles and garments, processing eatables, and making various products such as bidis and incense sticks in their homes. The productivity of all these enterprises can be enhanced by mechanization. Mechanization requires the availability of affordable energy sources. At present, access to power in some regions is not a constraint, but the availability of cheaper and environment-friendly sources certainly is. In the regions which are energy-starved solar energy can be the panacea.

From the discussions mentioned above, the following picture emerges on the ecosystem in rural India a) The farmers in rural India have an opportunity in S.E.F. b) Solar Livelihood solutions can increase the productivity and earning potential of rural Indians. In a developing country like India, solar energy generation and its application products are nascent development. Technology providers in this field are facing various structural challenges and bottlenecks. Market penetration is poor, particularly with smallholder farmers. Despite having Governmental support, this technology has not seen wide acceptance and adoption. Based on secondary research, the objective of this paper is to identify the critical challenges in the solar energy-based micro-entrepreneurial ecosystem in rural India and suggest necessary interventions that the private sector can bring to provide an enabling ecosystem for these micro-entrepreneurial ventures.

Electricity Generation from Solar Energy

The B.P. energy outlook 2018 reports that in 2016, India's overall energy consumption was 724 million tons of oil equivalent (Mtoe) and India was the fourth-largest consumer of energy. Approximately 74% of the energy demand is supplied by coal and oil.

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India is the world's largest importer of coal for use in thermal power plants. India is ranked fourth in carbon dioxide emissions, contributing 6.65% of total carbon dioxide emissions. India is aiming to attain 175 GW of renewable energy, which would consist of 100 GW from solar energy, 10 G.W. from bio-power, 60 G.W. from wind power, and 5 G.W. from small hydropower plants by the year 2022 (Majid, 2020).

In the year 2014-2015, the Ministry of Renewable Energy announced a scheme for solar energy parks, intending to generate 20 GW capacity of electricity by 2020. India has now established 42 solar parks and a further 36.03 GW (as of January 31, 2021) of solar projects are under various stages of implementation, and 23.87 GW are in the tendering process.

Solar Energy in agriculture

Solar energy farming is broadly defined as "*mixed systems associating solar panels and crop same time on the same land area*."

The categories of solar farming applications based on purpose can be classified as:

1. Standalone systems: Large utility installations (so-called solar farms) with no agriculture; this produces rents for landowners.
2. Combined systems: Hybrid systems of agricultural land use and solar energy production on the same land unit, the land is used for low-intensity purposes such as conserving biodiversity, protecting land from erosion, or providing grazing for livestock and high-intensity use possible through changing the configuration of solar panels to allow for crop production underneath them.
3. Systems for agricultural modernization: Incorporation of renewable energies to modernize agriculture, e.g., programs supporting farmers in deploying solar pumps or solar-powered irrigation systems (SPISs).

Based on Institutional setup, they can be classified under two categories; a) With a Power Purchase Agreement (P.P.A.). Solar energy use on farms with the option to sell part or all of produced at a certain Feed-In-Tariff (F.I.T.) to the grid. Second, farmers can convert their farms and become solar entrepreneurs, giving up agricultural livelihoods and selling their produced solar power. b) Without a P.P.A., Use of produced energy entirely on farms for agricultural modernization or other purposes (Mohammad and Nisreen, 2019).

Farmers adopting either of these two models can benefit from it; those areas having grid connections can benefit from P.P.A., which allows them to create value for the excess solar energy produced. Those without P.P.A. arrangements can redirect this excess energy to other productive activities like heating, chilling, grinding, and distribution. In areas where the grid connection is neither practical nor, economic other off-grid models may be considered. In China, for example, solar energy generated by S.E.F. is being used in the agricultural greenhouse for wastewater purifications, water pumping, and rural electrification (Xue, 2017).

Solar Energy-Based Livelihood Solutions

Just as solar energy farm has the potential to improve farmers' productivity, availability of decentralized renewable energy (D.R.E.) also has the potential of moving people away from a life of drudgery. The ministry of Renewable Energy has identified the following application areas for D.R.E. based on solar energy cold storage rooms and refrigeration, Dryers, Rice milling and processing, Horticulture produce processing. Irrigation, Textile both silk and cotton (Ministry of New & Renewable Energy, 2020)

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Cold storage facilities using sustainable sources, for example, have great potential; globally, around 30% of the food produced is lost post-harvest. Availability of cold storage facilities helps prolong the shelf life of crops and improves the income of the farmer and the middlemen like processors, distributors, and retailers. For products like milk, flowers cold storage is critical. The availability of cold storage facilities enables farmers to store their produce when prices are low and sell when prices are high. It is often witnessed that farmers are forced to sell their vegetables like onion and tomatoes due to the non-availability of storage facilities. While agricultural products can spoil at any point along the agricultural value chain, losses disproportionately occur within the "*first mile*" between harvest and processing. To maximize shelf life, it is advisable to maintain low temperatures through all value chain stages. The relationship between clean energy and agriculture is a virtuous cycle harnessed to maximize developmental impacts in rural areas. Farms in Kenya consume a large amount of electricity for powering their cold storage rooms. Ariya Finergy offered a solution to them in the form of solar arrays; this reduced their dependence on expensive power supplied by Kenya power (KPCL). In India, Promethean Power systems offered two solutions to farmers of Gujarat. The smallholder farmers would collect their milk and take it to collection centers. Ideally, the milk is to be chilled here before transporting to the centralized processing center. Since rural electricity is unreliable, milk is taken to centralized centers in ambient temperatures. Even if collection centers had chillers, milk tankers coming to the collection point might not be able to operate their pumps to transfer the milk if there is no electricity. Promethean Power offered a solar-based chiller for cooling milk and solar-based pumps that could help fill tankers, thus moving the milk farmers away from their dependence on erratic grid supply (USAID).

Besides agriculture, many other industries stand to be benefitted from the availability of power. An example case is the Indian silk industry, known for its quality but requires support to enhance its productivity. Manual reeling is a slow process, impeding productivity. Resham Sutra, a social entrepreneurial venture collaborating with India's Central Silk Board, has developed solar-powered spinning, reeling, and weaving machines for silk yarn production (DIPTI). Many silk weavers located in remote tribal villages of Jharkhand, North-east states, etc., which are energy deficient areas or even those in areas whether electricity is available to face 2-3 hours cut leads to a loss in productivity. Powering machines through solar power is a good option for them. SELCO, a social entrepreneurial venture, has launched a series of solar power-based livelihood solutions such as sewing machines, looms, milking machines, printer and photocopy machines, flour milling machines, milk chillers, cold storage units, carpentry tools, welding machines, aerators, fishing boats, and many more. A study done by SELCO on 200 entrepreneurs operating Lok Seva Kendra's (L.S.K.'s are digital solutions centers that provide comprehensive sets of solutions from single photocopy machines to multiple systems such as a printer, laptop, photo camera, etc., all powered by solar energy) and 385 solar-powered sewing machine users. This report states that the entrepreneurs using solar-based livelihood solutions on average reported an increase of 39% in their income (Shaily et al., 2019).

According to the International Energy Association, women's energy access is more important than men's because women play multiple roles. Women not only discharge domestic responsibilities but are also producers and workers engaged in income-generating activities. A reliable source of electricity has a significant impact on rural women's time use by doing chores, especially cooking is more efficient. Time saved from daily chores, in turn, has been shown to increase women's employment by nine percentage points (compared to no change for men) (Kohlin and Pattanayak, 2011). The contribution of energy access to a reduction in women's time

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in poverty is well-documented. Women can redirect their time to start and grow enterprises (Nelson and Kuriakose, 2017).

A study on two programs in India, lighting a Billion Lives and Hariyali Green Energy (focused on energy-efficient stoves and solar lanterns), found that access to solar lanterns led to income-generating opportunities for women in such areas as midwifery, childcare, tutoring, home-based piecework, and food preparation for catering. Other opportunities include food processing and marketing based on improved refrigeration and other small enterprises, such as livestock breeding, I.T., and residential accommodation (Baruah, 2015). Cheap energy access can save women from hard physical labor; a study conducted by extraordinary Task Force Women in the informal economy identified 44 different types of work that women perform. There is a scope for the mechanization of most of this task. Besides this introduction of small-scale energy technologies such as solar cookers can increase the health and quality of life of women and members of their households; besides this, improved air quality and reduced respiratory illness, among other benefits. Women may also enjoy a reduction in time use for cooking and collection of fuelwood (Shakti Sustainable Energy Foundation). Solar water pumping provides clean water and solar refrigeration for vaccines, as in Zimbabwe's Rural Sustainable Energy Project (RuSED). These pumps have supplied women, as well as men, with water for their crops and reduced the time spent collecting water by as much as 6 hours (IRENA, 2016).

Ecosystem for S.E.F. and Solar Energy based Livelihood Solutions

Solar energy farming potentially solves two problems of the farmer. One is it addresses the productivity issues by supplying water for irrigation. It also earns revenue even when their farms remain uncultivated land or fallow land unfit for cultivation**.** The Indian Government has launched various schemes to promote and support grid-connected solar power plants and solar pumps. Under the scheme, both individual farmers and panchayat cooperatives are given an option for setting up plants and supplying this to the grid. Large farms with capacity ranging from 500 kW to 2 M.W. can be set up in grid-connected areas, and a power purchasing agreement would be signed for 25 years. Under the second category comes the farmers whose farms are not grid-connected. They are encouraged to move away from diesel-powered pumps with a standalone solar pump of 7,5 HP capacity the farmers, and if their area is facilitated with grid, they may supply them to the grid. The third scheme is for grid-connected farmers; this scheme will give support to solar their grid-connected agricultural pumps. Two times the pump capacity in kW is the permissible generation capacity of the solar P.V. system to be installed. The generation capacity can be lower, as per the state's decision, but it cannot be less than pump capacity in H.P (The Economic Times, 2019).

One of the major concerns around the solar pump is its misuse in terms of water withdrawal. This can be easily checked by offering drip or micro-irrigation options; additionally, a cap of pump size also addresses this question (Shah and Verma 2014; Shah et al., 2016). These regulations can potentially address the issue in a regulated environment, but sustaining these measures may almost be impossible as the market opens up. The farmers can be made to rationalize the energy use by connecting their systems to the grid and earning revenue. S.E.F. thus provides opportunities a) to partially engage in agriculture and supply the surplus power to fully engage in S.E.F. The shift from partial to full S.E.F. can only be gradual and dependent upon other institutional support factors favouring the transition.

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On the other hand, the solar energy-based livelihood solutions market is relatively new, based on evolving technology that lacks both familiarity and financial support from institutions. Unlike S.E.F., where various piloted studies have been done, there is little documentary evidence supporting these livelihood solutions' performance efficiencies. The presence of lesser-known, relatively newer brands has added to uncertainty around these products. Besides this, the need for services and the non-availability of trained staff is the other challenge.

Key Challenges in the Solar Energy based Micro Entrepreneurial Ecosystem

Any new technology requires institutional support, especially in rural India, where literacy rates are low in many areas. Compelling evidence has been presented in a report by IRENA on various pilot projects in rural areas of many countries like Benin, Nigeria, and India, and Bangladesh evidencing an improvement in livelihood across the communities. To create an enabling ecosystem, the following needs consideration.

Technological Support

Solar energy harnessing in rural India is a decentralized intervention aimed at making the rural community sustainable in terms of its energy requirement and making a positive contribution to the nation's carbon footprint. The traditional method of using non-renewable sources of energy is not only compelling in terms of being easy. In comparison use of solar-powered equipment requires skill sets and a network of support. A SEF to succeed requires an extensive project design, depending upon farm size and type of S.E.F. selected, the size of the solar panel and size of the pump needs to be calibrated (Mohammad and Nisreen, 2019).

P.P.A.: Increasingly, many states Governments in India have been revoking their P.P.A.; the farmers can be voluntarily encouraged to shift to solar farming provided there is stability in policies on P.P.A., and the higher F.I.T. is offered to them.

Distribution Channels: Any products need distributing channels, service centers, and last-minute suppliers to popularize the product and aid in its adoption; besides, each farmer requires customized solutions for their problems. Early users are expected to face challenges, while this is expected to ease out as deployments grow.

Access to Finance: The prohibitively high cost of solar pumps can detriment its mass adoption. To encourage off-the-shelf purchasing of solar pumps, various delivery models need to be designed. Since the costs are prohibitive, many farmers organize themselves into cooperatives and purchase solar pumps. This creates excess capacity, and they are compelled to offer irrigation services to earn more. Farmers need to be supported financially. Capital incentives, subsidies, and tax-free loans are being granted, but an enabling environment must be created to make the process user-friendly.

Policy and Regulatory Frameworks

A substantial nexus exists between water, agriculture, and energy, there is a need to give tailor-made solutions for farmers in different regions of the country, greater coordination between different nodal ministries, and availability of key experts is required; favourable policies and regulatory framework is required to balance all three. A framework that moves farmers away from conventional choices is needed.

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Awareness Raising and Capacity Building

Finally, the adoption of S.E.F. requires advocacy, persuasion, and demonstration of the viability and reliability of the technology. S.E.F. is to be further supported by the development of capacity building to ensure long-term operability (Majid, 2020).

Solar energy-based livelihood solutions for appliances face a different challenge; they are considered unreliable as they are relatively new and are yet to find acceptance. The economic impact of this equipment is yet to be proven and documented. These products can find acceptance only when easy credit facilities are available. Financiers are skeptical about the technology; they also believe that this equipment requires good after-sales service, and as often manufacturers are relatively new, they will fail to provide this. Availability of collateral, securities, the administrative cost of the loans, and their collections have been reported as other concerns of the financiers.

Enabling Role of the Private Sector In the Solar Energy-based Micro Entrepreneurial Ecosystem

The private sector has transformed the agri-food landscape since the early 1990s as India shifted from import substitution and protectionism to more open markets. The dairy sector illustrates this. Food supply chains, in general, are undergoing profound change in India because of private sector participation. This is true in midstream segments (processing, wholesale, and logistics) and downstream (retail). Today, the private sector in India today has thus both exposure, knowledge, and expertise on the prevailing opportunities in rural India. A true understanding of the challenges and a sense of responsibility towards sustainability is needed.

The private sector as aggregators: The power of the farmers in negotiating with grid suppliers is relatively low; the private sector in such situations can play the role of the aggregator and negotiate better prices with grid operators. This would largely reduce the uncertainties surrounding P.P.A. In Dhundi village in Gujarat, International Water Management Institute has organized six solar pump irrigators into a Solar Pump Irrigators' Cooperative Enterprise. These solar farmers are connected through a mini-grid which will pool their surplus power and evacuate it at a single point (Nair, 2015). The informal cooperative will be responsible for the operation and maintenance and distribute the earnings among the farmer members. Further aggregation can be made at the feeder level wherein solar capacity (1-2 megawatts) is developed, feeding directly into the rural distribution network.

Manufacturing of non-conventional pumps: It is estimated that there are around 800 odd manufacturers of conventional pumps on large, medium, and small scales. The pump manufacturers can meet most of the domestic market demand and export pumps worth Rs. 1200 crores in 2014-15. The agriculture sector uses 43% of these pumps manufactured. Currently, India has many regional vendors manufacturing pumps at relatively lower prices (ASCON). Tata Power and Shakti power are amongst the world's leading vendors of solar pumps. Shakti pump has entered into collaboration with Government; in 2013, it became a channel partner with MNRE; this enabled the company to expand its distribution network and increase market penetration (Business Line, 2013). India requires more such established companies to collaborate with the Government to take the solar pump mission forward. When scalability delivery good quality technology with reliable after-sales services is not an issue, then both financiers and deployers would trust the product.

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Micro lending especially for sustainability initiative: India has a well-developed micro-financing system with some banks playing a leading role. There is a need for greater availability of finance and a mandate for greater flow of funds towards micro-enterprises using solar energy. This is to be backed by Innovative schemes for loan dissemination and loan collection. An increase in tenure for payments can significantly impact the adoption of solar energy-based equipment. Sun Farmer is adopting a form of the rent-to-own model in Nepal, where affordable financing at three-year terms is provided to farmers. The model works closely with cooperatives that identify the farms and collect monthly payments on behalf of Sun Farmer.

Agri services: S.E.F. or Solar energy-based equipment requires a sectoral approach. Institutions offering these are required to be provided with training and support. Intermediaries such as extension services and private sector companies offering advice and services to farmers and farmer associations can positively develop capacities (Mohammad Al-Saidi and Nisreen Lahham, 2019).

Use of C.S.R. funds: New technologies require creating awareness among all stakeholders; this requires disseminating information about the value proposition, identifying the stakeholders and the end-users in the ecosystems. This may also entail preparing a comprehensive manual and toolbox for solar-based equipment, specifically targeting practitioners, supporting pilot projects, etc. In India, many N.G.O.'s like SEWA and other Social Entrepreneurial ventures SELCO are working in partnership to educate people on the opportunities in this sector. Through its C.S.R. spending, the private sector must collaborate with such institutions to grow the micro-entrepreneurial ecosystem in rural India.

CONCLUSION

Solar-based solutions provide a reliable, viable, cost-effective option for decentralized growth of both grid-connected and off-grid areas. The energy access provided improves the livelihoods of the millions of poor, who are part of the larger informal economy. Excess power generated and supplied to the grid can thus be diverted to power-starved industries. Sustainable energy sources can transform the lives of millions of women engaged in manual labor as the availability of sustainable and cheap power improves their quality of life and their children.

Any new technology deployed is to be measured by its ability to generate jobs; sustainable energy is considered as the next boom. In the year, 2017 the employments figure reached 164,400, of which 92,400 were on-grid use.

The Indian solar industry heavily depends on imports of important components like solar cells, modules, and solar inverters as domestic manufacturers do not meet up to quality requirements. Suppose the Government of India revives its policy of reserving capacities in the projects bid for solar cells and modules for Indian manufacturers. In that case, this industry can create more job opportunities, enabling Indian manufacturers to leverage the volumes and build technical competence to be global suppliers of these products. India's demand for energy is expected to reach 11% of the global demand for energy by 2040 from 5% in 2016; this and the expected carbon footprint target should give the needed force to embrace sustainable energy. Without the private sector's assistance and contribution, the sustainable energy fueled the growth of the rural sector will be a distant reality.

Acknowledgment

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The paper was presented at the AICTE International Conference on Circular Economy, Management and Industry, Bharati Vidyapeeth's Institute of Management Studies and Research, Navi Mumbai and Apeejay School of Management, Dwarka, Delhi, India. October 2021.

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