Financing Opportunities in Production Hubs (and beyond) which Impart Climate Adaptation in the Agriculture Value Chain

Technologies field tested and replicated by Sustain Plus Energy Foundation in association with its founding partners CInI, Selco and Social Alpha

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Climate Adaptation and Finance in Rural India (CAFRI NABARD)

Address:
A2/18 Safdarjung Enclave
New Delhi 110029
Phone +91 49 49 53 53
Fax +91 49 49 5391
info@giz.de
www.giz.de/india

Responsible:
Shailendra Dwivedi, Director, Climate Change and Circular Economy, GIZ India

Technical Support:
Sustain Plus Energy Foundation (SPEF)

Enquiries & Feedback:
Ganesh Neelam, Executive Director, Collectives for Integrated Livelihood Initiatives (CInI)
Ayan Deb, Hub Manager, Central and Western India, Sustain Plus Energy Foundation
Chandan Thakur, Senior Vice President, Sa-Dhan
Sandeep Bhattacharya, Climate Change Advisor, GIZ India
Anindya Das, Junior Climate Change Advisor, GIZ India

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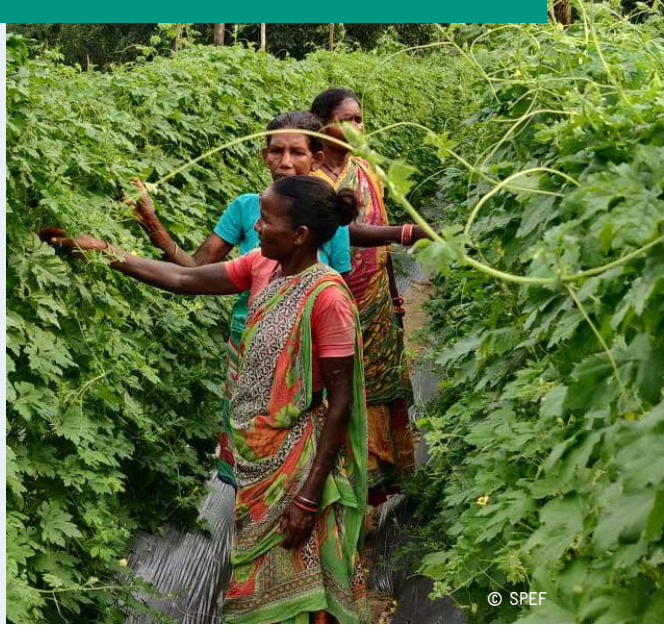
Introduction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The discussion about production clusters (**Productions Hubs for Agriculture**) highlighted how interventions in various parts of the agriculture value chain add to productivity. In the pre-production stage, quality seeds, planning and related interventions play an important role. In the production stage, irrigation, poly nurseries help. In post-harvest activities, automating grain grinding and *Roti* (flat bread) making increases productivity, creates local self-contained ecosystems and enables entrepreneurship.

A combination of such interventions has resulted in higher crop productivity, an increase in women's participation in decision making (through the involvement of self-help groups), greater nutritional security and an increase in income. This has happened in the most remote and aspirational districts of the country.

Many of the implemented technological interventions use distributed renewable energy and are easier to repair post storms. This makes them more reliable compared to equipment that use electricity from the grid and thus add to the climate resilience.[1] Some of these devices are not totally new, but enabled to function better in remote areas, by improvements in design (bio digestors made of plastic instead of concrete). Also, the quality of electricity supply from the grid in many remote areas is not the best. Thus, a decentralised source adds reliability. Processing of grain near the production centres reduces the need for transport and results in creation of storage facilities for processed food and grain, which is currently scarce in India.[2] The outcome of low transportation need and increased storage help to adapt to increasing climate vagaries. Solutions like drip irrigation, result in better utilisation of water which helps in coping with erratic rainfall levels.

The production hub also has been an enabler of women's empowerment. It has been seen that women tend to share information about community wellbeing that is important for resilience.[3] They are also more willing to adapt to environmental changes since their family lives are impacted.[4] Since women are usually first responders to natural disasters,[5] their empowerment would lead to better disaster preparedness.

In this document, we are highlighting nine technologies which have been field tested by *Sustain Plus Energy Foundation* (SPEF). The working of these nine technologies and experience of the users bringing out the economic value has been discussed at events where financial institutions were present. *The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH* and *Sa-Dhan Association* are collaborating with *CInI* and *SPEF* to enhance access to capital for the various production hubs/ technologies deployed at the production hubs to facilitate scaling up. This is being done under the Indo-German development cooperation project 'Climate Adaptation and Finance in Rural India (CAFRI NABARD)' which GIZ implements on behalf of the Federal Ministry for Economic Cooperation and Development (BMZ). Mechanisms like line of credit/ other forms of re-financing Financial Institutions to support Financial Institutions (FIs) financing these technologies are also being worked upon.

The rest of the document lists the technologies and equipment used, functioning of the equipment, economic value on use and *SPEFs* experience along with information about field installations.

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[4] IBID

[5] IBID

Solar Irrigation System + Drip and Mulch

Equipment

This typical solar pumping system consists of solar panel arrays, controller switches, a pump and a motor (AC or DC, surface or submersible) either connected to a Drip System (DS) or sprinkler. A farmer usually also uses mulching (typically in the form of plastic sheets). In this set up, drip irrigation is supported via water from a solar pump. The pump used for extraction and transport of water is powered by solar cells, which convert solar energy to electricity, which in turn runs the pump.[6]

Pumps can be connected to the grid or draw its power completely from solar panels having no link to the grid. While on-grid systems are easy to install, off-grid systems are best for places which are remote and suffer from power outages.[7]

Mulch improves the quality of the soil allowing better water and air movement through the soil and it also reduces the amount of water that evaporates from the soil.[8]

Black and transparent varieties of plastic sheets can be used as mulch. The black plastic film is ideal for eliminating weeds, warming up the soil during the cold season as well as retaining the soil's moisture. On the other hand, the clear plastic film works best for warming up the soil and encouraging faster growth early in the growing season. Transparent plastic film, however, is not as effective when it comes to suppressing weed growth.[9] Mulching is also practiced using organic material (for example bark, wood chips, grape pulp, shell nuts, green waste, leftover crops, compost, manure, straw, dry grass, leaves.)[10]

Function

A combination of solar pump, drip irrigation and mulching using plastic sheets has been adopted by the farmers at various locations. Drip irrigation is known to be the most efficient water and nutrient delivery system for growing crops as it delivers water and nutrients close to the plant's root avoiding wastage.[11]

Solar-powered pumps can be used to displace diesel engines or fossil-fuelled-grid supplied electricity. Erratic grid supply across the country has affected agricultural activities in many states, leading to a decrease in crop yields.[12] Among other places, solar pumps have been extensively used in the state of Rajasthan, under one of the largest solar-powered water pump programmes in the world.[13] Mulch is applied to bare soil or around existing plants.

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Economic Value

The key aspect that determines the economic viability of Solar Pump Irrigation Systems is how solar-powered systems compare with other forms of energy. Diesel pumps have low initial investment costs but high operational and maintenance costs. In contrast, the investment costs of solar pumps are comparatively higher, but maintenance and operational costs are substantially lesser.[14] The life cycle costs of a solar water pump are 22-56% of the life cycle costs of diesel pumps, often enabling a payback period of two years.[15] Use of drip irrigation results in 40% water conservation and 41% electricity saving over the flood system.

Another advantage of the drip systems over flood irrigation is the overall reduction by 20% in the cost of cultivation in tasks like weeding, ploughing and other preparatory work.[16] While there are many related studies, in one case, Brinjal cultivation using drip irrigation has been shown to generate 54% more profit than the conventional method of irrigation.[17] Mulch also contributes to increased water infiltration in the soil. Thus, it helps improving groundwater status.[18]

Installations

Nimbus Solar Pumps, which offers consultation, survey, design and installation services for solar pumps has installed 1,042 pumps in Jharkhand, 75 pumps in Maharashtra and 17 in Odisha.

Pumps manufactured by *Shakti Pumps (India) Ltd,* has seen about four lakh installations all over India.

SPEF has undertaken installation and facilitated the use of 2,500 pumps across India and 1,440 pumps across the five states of Gujarat, Maharashtra, Jharkhand, Odisha and Karnataka.

Experience of *SPEF*

Several types with varying capacities of solar pumps are installed under the *SPEF* programme depending on need. The specifics are as follows: Surface pumps are recommended for open wells and submersible pumps are used if the source of water is a borewell.

On an average, five HP solar pumps are used to irrigate four to five acres of land, while three HP solar pumps are used to irrigate two-three acres of land under lift irrigation projects. Drip irrigation and mulch are also integrated into these systems.

The system has helped in bringing 20% additional area under irrigation compared to the earlier situation. This has enabled at least two crops a year, which goes up to three crops a year as the production hub matures. Thus, in most of the places, farmers transition from single, rainy season food crops to relatively high value cash crops.

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Biodigesters

Equipment

A biodigester system utilises organic waste, particularly animal and/or human excreta, to produce fertiliser and biogas. Microbes and other bacteria break down organic materials in a biodigester.[19] Most food, including fat, greases and animal manure can be processed in a biodigester. The biodigesters which *SPEF* has used consists of an airtight, high density polyethylene container within which excreta from cattle diluted in water flow continuously and are fermented by microorganisms present in the waste.[20]

Function

Biogas systems that capture methane from waste and turn it into energy and fertiliser have become increasingly popular.[21] Biogas and bio fertiliser is produced from the breakdown of the manure. The gas can be stored and used as a sustainable energy source for electricity, cooking and heating.[22] Biogas systems operate using anaerobic digestion, the process by which biodegradable material is broken down by bacteria in the absence of oxygen.[23] Biogas systems not only recover the methane generated, but also the phosphorus, nitrogen, potassium and sulphur in the waste.[24]

Economic Value

As per market feedback, considering the price of LPG, the biogas by itself (without considering the value of the bio fertiliser) provides attractive economic returns. For some field trials, a payback period of 22 months was observed.[25] The organic manure reduces the need for farms to purchase commercial, fossil fuel-based fertilisers.

Installations

SPEF has enabled about 800 installations across Jharkhand, Gujarat, Maharashtra and Rajasthan.

Experience of *SPEF*

Bio digestors with three cubic metre capacity have been installed and they produce an output of 2.7 cubic metres of gas per day. This is equivalent to 1.5 cylinder of LPG per month. 40 kg of cow dung and 40 litres of water are combined daily in the bio digestor to create 2.7 cubic metres of gas. Bio digester has helped to reduce the drudgery to women and has reduced the hazardous effect of smoke from burning biomass to their health. Besides this, *SPEF* is working for promoting Phosphate Rich Organic Manure (PROM) which is a product of the slurry which comes out of the biogas. The slurry not only enhances farm productivity, but sale of surplus slurry to local slurry processing units generates additional income.

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Decentralised grain grinder using off-grid solar power

Equipment

"Atta Chakki" or flour mill, which is used to ground grain and create wheat flour is very energy-intensive and it generally depends on grid connectivity. As the grid is not a stable source of power supply in many remote areas, off grid source of power (generally solar energy) can be the solution to some of the needs. Solar energy-based flour mill consists of six parts.[26]

- Flour Mill
- Motor
- Solar panel
- Solar drive or VFD drive
- Solar panel stands
- Requisite wiring

Excess electricity from the panels installed for solar pumps has been used to run some installations of this kind in Gujarat.

Function

Solar-powered flour mill comes in various capacities and the most used one has the capacity to process 15-16 kgs of grains per hour.[27] The introduction of an efficient solar-powered flour mill allows local farmers to mill their produce locally for self-consumption as well as for selling at markets for income generation.[28] A low-cost mill at a local level is helpful for storage of flour for longer duration, after being packed properly.

Economic Value

In areas suffering from lack of stable power supply as it is the case in most remote villages, this technology can be accessed by farmers to mill their produce locally, which also significantly cuts down the travel costs leading to community savings as farmers had to travel long distances for milling of their produce.[29] An off grid solar power grain grinder provides a relatively stable power source. Using a diesel generator is not the best option given the increasing fuel prices and diesel is not easy to access in many rural areas.

This solution allowed the community, especially women and widows, to access this basic service locally saving them time and transportation costs to fetch grain as well as diesel. Due to this solution bringing access to power locally, COVID-19 induced lockdowns which inhibited movement did not affect the food security.[30]

Installations

There are over 18 solar enabled flour mills installed by *SPEF* in Gujarat.

Experience of *SPEF*

A three HP flour mill is often powered by a five kWp solar panel system. A stone-made flour mill is required for grinding maize since it creates more gluten, which can make *Roti* stickier. A flour mill constructed of stainless steel will work well for wheat and spices. *SPEF* is integrating existing flour mills with the solar panels of pumps which have got deployed till date. The additional energy generated from the panels are used to run the flour mills.

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Portable Solar Pumps

Equipment

A portable solar pump aims to enhance access to irrigation, especially for small-holder farmers. The propriety technology for this was developed at the Massachusetts Institute of Technology (MIT) for 2.5 years before it was brought to India.[31] The *Khethworks* (company manufacturing and selling the equipment) portable solar-powered irrigation pump was further researched, developed and tested in Jharkhand and West Bengal after developments at MIT.[32] The Khethworks system includes a submersible centrifugal solar pump, a controller, and two solar panels. To get the pump running, farmers connect the panels, pump and controller and then connect the pump to the piping in the field and flip switch it on.[33] It is an affordable movable solar photovoltaic system for pumping water in remote and non-accessible areas of Jharkhand and Odisha.[34]

Function

The portable solar pump is efficient on 330-watt solar panels. On an average, it can provide up to 30 kilolitres of water a day. It is suitable to lift water from dug-wells, ponds and ditches and irrigate around one acre of land under vegetables with a three-day irrigation cycle with 25mm of water for every cycle.[35] Adoption of portable solar pumps have helped farmers fulfil their irrigation needs. In areas where farmers are still out of the reach of the electrical grid and do not have access to proper irrigation facility, portable solar pumps can help overcome this issues of lack of access to energy.[36]

Economic Value

Portable solar pump helps reduce fuel consumption, which is often inconvenient to procure in remote areas, making crop cultivation cheaper and more efficient.[37] Due to its portability, vegetables and flowers can be conveniently cultivated in a few cents of land with an open source of water nearby, which was earlier not convenient to farm.[38] The rentable mobile solar pumping system via which the same pump can be used by many farmers has resulted in distribution of costs, making it more affordable for small farmers.[39] By making use of water sources which were earlier not very accessible, this technology makes use of resource whose supply is likely to be increasingly erratic.

Installations

In Jharkhand 142 pumps are deployed and in Odisha 210. Most of these installations have been done with support of *SPEF*.

Experience of *SPEF*

Where water tables are present up to ten to twelve metres below the surface of the earth, portable solar pumps are effective. One of the benefits of portable pumps is that they can be kept indoors when not in use, which reduces the risk of theft, vandalism, and burglary.

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Nursery with Poly House

Equipment

It is generally made of transparent polyethylene sheets which are thin, inexpensive and flexible, creating an indoor independently controlled environment.[40] The permanent structure is made of steel and fibre glass or a transparent polythene sheet structure is creating the cover. Small farmers can build up the polyhouse they require by using a bamboo structure on which polythene sheet is used for covering. For irrigation a facility sprinkler unit is often used. For controlling the air temperature ventilators are generally made.[41]

Function

Production in a polyhouse is a farming process wherein the microclimatic conditions around the plant body are regulated partially or entirely according to the prerequisite of plants grown as close as possible to their most ideal habitat.[42] Polyhouses prevent thermal radiation from escaping which increases the temperature and energy, which further helps in the process of photosynthesis.[43] Polyhouses can also be used to grow off-season varieties of fruits and flowers.[44]

Economic Value

Insects, pest and diseases are less in polyhouses; quality of produce is high when compared to open field cultivation. There is uniform plant growth throughout its lifecycle with less transplanting; cropping period is less, hence it can lead to an increase in production capacity. Fertiliser application is easier and controlled with the help of drip irrigation or sprinklers[45] and the overall yearly crop yield is high.[46] Among other trials, the Kyrdem village implemented a polyhouse for off-season vegetable cultivation to overcome the losses caused by high intensity rainfall and hailstorms.[47]

Often, the farmer gets back the investment on polyhouse within a period of three to five years.[48] If an entrepreneur/cultivator opt for polyhouse for nursery production of vegetable plants in an area where large scale vegetable cultivation is done, a payback period of two to three years is possible by selling quality planting materials (saplings) to vegetable or flower growers.[49]

Experience of *SPEF*

SPEF's founding partner *CInI* have established close to 100 high tech nurseries. These are run by individual entrepreneurs and the business model consists of selling healthy saplings in the local area.

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[49] IBID

Solar powered poultry lights

Equipment

Several kinds of lights are utilised by the poultry producers. The equipment used here consists of Light Emitting Diodes (LEDS) which are powered by solar panels and battery backup.

Function

Lack of proper illumination causes piling of chicks that result in high mortality. To overcome this issue, an appropriate lighting system is crucial to improve the growth, performance and welfare of broilers.[50] Also, in absence of lights at night, the chicks feed less and thus growth is stunted. This light enables enhanced growth of the chicks without any dependence on the grid.

Economic Value

Poultry requires regular feeding and light to see their surroundings, thereby enabling the regular feed. Rural areas suffer huge power failures, and the farmers need to adapt traditional lighting methods such as dhibris or diyas, emergency lights, etc.

Some of these methods are not economically viable due to the high price of kerosene. Therefore, there was a need to switch to solarisation of poultry sheds.

It has had the following benefits:

- Increases development and weight gain.
- Lowers Feed Conversion Ratio
- Provides an animal welfare friendly environment and increases feeding
- Increases income realisation.

Installations

Currently, there are 600 units with plans to install 30,000 more units.

Experience of *SPEF*

The system is installed for 600 sheds, with each having a capacity of 500–600 birds. Heating for the shed was given by a 15-watt led lamp. An 80-watt solar panel was provided to power a 15-watt led light. A battery backup of 80 Ah of 12 volts was provided. The impact of the solution is very encouraging with additional weight gain, there are additional income per chick and increased number of cycles for the rearing of chicks.

[50] Wu, Y., Huang, J., Quan, S., & Yang, Y. (2022). Light regimen on health and growth of broilers: an update review. Poultry science, 101(1), 101545.Retrieved 10 November 2022, from https://doi.org/10.1016/j.psj.2021.101545

DC Solar Refrigerator

Equipment

The main parts of the system design include a refrigerator and optimum solar powering equipment to suit the requirement. A battery backup completes the setup. The exact specifications of the battery and solar panels are driven by the need, i.e., the number of hours or days the refrigerator needs to maintain a certain temperature, the insulation of the doors and units.[51]

Function

It is a temperature control mechanism specially designed for storage of life-saving vaccines, drugs or insulin in areas where the grid does not supply reliable power. It is also used by fisheries and *Kirana* (a small grocery shop) shops for various cooling and freezing purposes.

Economic Value

The increase in average temperatures in many parts of India and lack of reliable cooling solutions has resulted in the increase in relevance of decentralised refrigeration systems, especially in rural and semi-urban geographies. Sustainable, decentralised cold storage solutions are critical in providing efficient and reliable storage to reduce post-harvest crop wastage at different stages of the food value chain, last mile cold-storage solutions for the dairy and meat value chain, keeping medicines effective at healthcare facilities that are remote or at places with no reliable electricity access. Households can also have clean refrigeration solutions to save food wastage as well as reducing commute to buy fresh perishables.[52]

Installations

Around 160 installations have been done in Jharkhand, Odisha, Maharashtra and Karnataka.

Experience of *SPEF*

Two 12 volts, 160Wp solar panel with a battery bank of 100 Ah is installed for vaccination storage. The same refrigerator can be used to store up to 40 litres of milk. The temperature ranges from one degree to elevan degrees Celsius. The vaccination storage is helping in increasing the potentiality of the vaccine and hence reduced mortality amongst animals.

[51] SELCO Foundation. (n.d.). Energising livelihoods through decentralised solar powered refrigeration solutions. Selcofoundation.org.Retrieved 10 November 2022, from https://selcofoundation.org/wp-content/uploads/2021/11/SF_Energizing-Livelihoods-through-Decentralized-Solar-Refrigerators.pdf

[52] SELCO Foundation. (n.d.). Energising livelihoods through decentralised solar powered refrigeration solutions. Selcofoundation.org.Retrieved 10 November 2022, from https://selcofoundation.org/wp-content/uploads/2021/11/SF_Energizing-Livelihoods-through-Decentralized-Solar-Refrigerators.pdf

Decentralised Solar-powered Hydroponics Cattle Nutrient Producer

Equipment

The equipment consists of a solar panel supplied power source, water pumping solution, battery for powering at night, automated sensor technology with sprinkler system whose "switch on" and "switch off" time is set. A pack of trays/racks are kept where typically maize seeds are kept for growing green fodder.

Function

The principles of the solar powered hydroponics system operate on increased oxygen in the plant roots and liquid food directly provided to plant roots. The hydroponics fodder units can help livestock farmers grow their own fodder, reducing their dependence on market availability of fodder. Most external factors like lighting, temperature and humidity can be controlled with laser-like precision.[53] This results in growth rates higher than what is possible on plants grown on land.[54] These factors elevate the growth rates of plants and heighten crop yielding.[55] All these are done without any need for soil.[56]

Economic Value

As cattle fodder is generally grown during rainy seasons and stored for use, it is tough to feed green fodder to cattle all year round. Hydroponic fodder production driven by decentralised solar power conserves water and reduces growth time.

Hydroponics fodder production units with timed sprinkler systems and powered by solar water pumping solutions for each individual farmer or for collectives can help address the need for green fodder with higher nutrition.

The equipment can result in persistent supply of green fodder. Therefore, hydroponic fodders have a positive impact on animal productivity.[57]

This solution helps provide more nutrition for cattle, improving health and increasing dairy yield by more than one litre per day per cattle. It also contributes to increased fat content in milk resulting in higher price realised per litre.[58]

The green fodder from the hydroponics is mixed with the dry fodder which is readily available to supplement the cattle feed. It is estimated that the total serviceable available market for small-scale hydroponic fodder units is approximately INR 15,965 crore for which 4.6 million hydroponic units would be required.[59]

Installations

SPEF has undertaken about 125 installations, mostly in Karnataka and Andhra Pradesh.

Experience of *SPEF*

The production of green fodder from hydroponics reduces the expenditure on externally purchased feed. Roughly this would result in savings of between INR 7,800 and INR 15,000 per annum. Milk production typically increases by about one litre per cattle and could be up to four litres for each small farmer household. This means an increase in income of approximately between INR 15,000 and INR 31,000 per annum.

A combination of the two (cost saving in procuring fodder and increase in milk yield and quality) would mean that marginal farmers owning two to four cattle can increase their annual income from INR 23,800 to INR 46,000 per annum.

[53] Hydroponics vs. Soil: Which Will Grow Plants Faster (pinduoduo-global.com) (page not found)

[54] IBID

[55] Solar Power Hydroponics - The Complete Guide || Waaree. (n.d.). Waaree Energies Ltd. Retrieved 10 November 2022, from https://www.waaree.com/blog/solar-powered-hydroponics

[56] IBID

[57] Shit, N. (2019). HYDROPONIC FODDER PRODUCTION: AN ALTERNATIVE TECHNOLOGY FOR SUSTAINABLE LIVESTOCK PRODUCTION IN INDIA. Exploratory Animal and Medical Research, 9(2). Retrieved 10 November 2022, from https://www.animalmedicalresearch.org/Vol.9_Issue-2_December_2019/HYDROPONIC%20FODDER%20PRODUCTION.pdf

[58] Decentralised Solar Power Hydroponics, Selco Foundation

[59] Enhancing India's milk and meat production: Is hydroponics green fodder the answer? Market Opportunity Analysis. (n.d.). Retrieved November 10, 2022, from https://www.ceew.in/sites/default/files/CEEW-Hydroponic-Green-Fodder-Unit-01Jun21_0.pdf

Solar-powered Millet *Roti* Rolling Machine

© SPEF

Equipment

The solar powered *roti* rolling machine consists of a solar panel of 300W capacity, a flour kneader is optional, *roti* rolling machine and batteries for power back up. It achieves a rolling speed which is five to six *rotis*/min.

Function

The entire workflow of making *rotis,* from kneading the dough, rolling the *rotis,* to cooking the *rotis* then storing them is done within the same enclosed workspace. Due to this, the business is often limited by the physical capacity of the workers and is unable to meet the market demands. Many of the regions where *roti* rolling is prevalent have erratic power supply from the grid. Using the decentralised power-driven roti rolling machines, entrepreneurs were able to increase their productivity by ten times-moving from 50-100 *rotis* per day if done manually to 500-1000 *rotis* a day (depending on the market linkage available) with less effort and labour.[60]

Economic Value

Due to this technology *roti* rolling entrepreneurs or self-help groups have mentioned a seasonal spike in income which has tripled or quadrupled their income levels.[61] It has led to an employment creation. The increased market demand has made women entrepreneurs employ others as additional labour.

This machine is used by home based enterprises with individual ownership, which serve small local shops, temples, and rural and urban hotels. Small businesses that usually use this machine and serve are small shops, canteens, weddings, and restaurants.[62]

Installations

Around 500 *roti* making machines have been installed in Karnataka, Tamil Nadu, and Kerala.

Experience of *SPEF*

There are several types of *roti* rolling machines available, differentiated based on their capacity, cost, usage and solar power system which powers them. Depending on the capacity of the machine (*roti*/day), the cost ranges from INR 72,000 to INR 89,000. For example, the cost for a machine producing 1,000 *roti*/day is INR 77,000. The machines are suitable for using wheat flour or flour from rice or Jawar (millets). Any of the *roti* making machines can be added to a flour kneading machine. The machine making 1,000 *rotis* per day when added to a flour kneading machine costs INR 1,25,000.

[60] SELCO Foundation. (n.d.). Sustainable Energy and Livelihoods [Review of Sustainable Energy and Livelihoods]. ENERGYPEDIA.INFO. Retrieved 10 November 2022, from https://energypedia.info/images/b/b4/SELCO_Foundation_-_Livelihood.pdf

[61] SELCO Foundation. (n.d.). Sustainable Energy and Livelihoods [Review of Sustainable Energy and Livelihoods]. ENERGYPEDIA.INFO. Retrieved 10 November 2022, from https://energypedia.info/images/b/b4/SELCO_Foundation_-_Livelihood.pdf

[62] SELCO Foundation. (n.d.). Sustainable Energy and Livelihoods [Review of Sustainable Energy and Livelihoods]. ENERGYPEDIA.INFO. Retrieved 10 November 2022, from https://energypedia.info/images/b/b4/SELCO_Foundation_-_Livelihood.pdf

Deutsche Gesellschaft für
Internationale Zusammenarbeit
(GIZ) GmbH

A2/18 Safdarjung Enclave
New Delhi 110029

Phone +91 49 49 53 53
www.giz.de/india