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Clean Energy Access and Productive Use by Bottom of Pyramid Clients in Ethnic & Tribal Areas of Odisha: An Appraisal

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Authors' contributions

This work was carried out in collaboration among all authors. Author SSD designed the study, and wrote the first draft of the manuscript, wrote the protocol. Authors DDB and SPM managed the literature searches, performed the statistical analysis, analyses of the study. Author GP managed the Field works. All authors read and approved the final manuscript.

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ABSTRACT

Ending poverty and ensuring sustainability are the defining challenges of the recent times. Energy has the answer to both [1]. Surged right of entry to the modern energy uses is perilous but a positive support to human and their economic expansion through uninterrupted delivery of energy amenities for elementary needs to support both prolific uses and generating employments. Access to modern energy Services like electricity, natural fossil and coal gases, cooking hydrocarbons and wood fuel, etc. are essential for value-added health and agrarian yield [2]. This paper discus on actionable research undertaken for improving the quality of life of countryside individuals (mainly scheduled tribe areas) in some districts of southern zones Odisha by using clean energy systems.

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Keywords: Clean energy; BOP clients; solar lights; photovoltaic gadgets; tribal areas; South Odisha.

1. INTRODUCTION

The global community should adopt a goal line for universal access to electrical energy by 2030 as proclaims by the Secy. General, US, AGECC; (the Advisory Group on Energy and Climate Change) the year 2010,. The goals are included as one of the three objectives of the UN's Sustainable Energy for all initiatives and the year 2012 was declared the International year for the Sustainable Energy for all. ADEME, (the French Environment and Energy Management Agency) has pledged to support UN's minimum energy access to the bottom of the Economic Pyramid initiative.

For this reason, ADEME started supporting Harsha Trust for initiating a virtuous cycle that enhances access to and affordability of clean energy for the BOP (bottom of the pyramid) of economic class of people. They are the consumers in a viable manner by connecting the social finance and income generation accomplishments. Harsha Trust, a professionally managed A NGO, (Non-government Organization), professionally identified as "Harsha Trust "has implemented popular development schemes for sustainability of natural resource which generate enterprise-based living and improved health care in various South Odisha districts. These districts are the epicenter of poverty and hotspot of extremism in India. The Harsha group activities are direct interaction with the public, native NGOs, Tribes of south Odisha (Fig. 1) and federal Institutions that shapes their capabilities to withstand interventions. It endorses technology centered, market related sustainable livelihood of the countryside poor, and principally through community based organizations like SHG's (Self-Help Groups) and Cooperative societies. These establishments are primarily access resourceful and services oriented and the government or corporate orientated philanthropic institutions.

The support from ADEME was realized for the two-year study (later extended by a year), which used solar photo voltaic (SPV) energy for illumination, signaling and various utilitarian needs, besides helping in income generation activities. The study got technical support from Centurion University of Technology and Management (CUTM), located in the area.

Demand for energy is proportional to the economic development [2]. In addition to economic development, to reduce the harmful effect of fossil fuels on environment and improve quality of life of people, ensuring availability of reliable clean energy solutions at an affordable price has become essential.

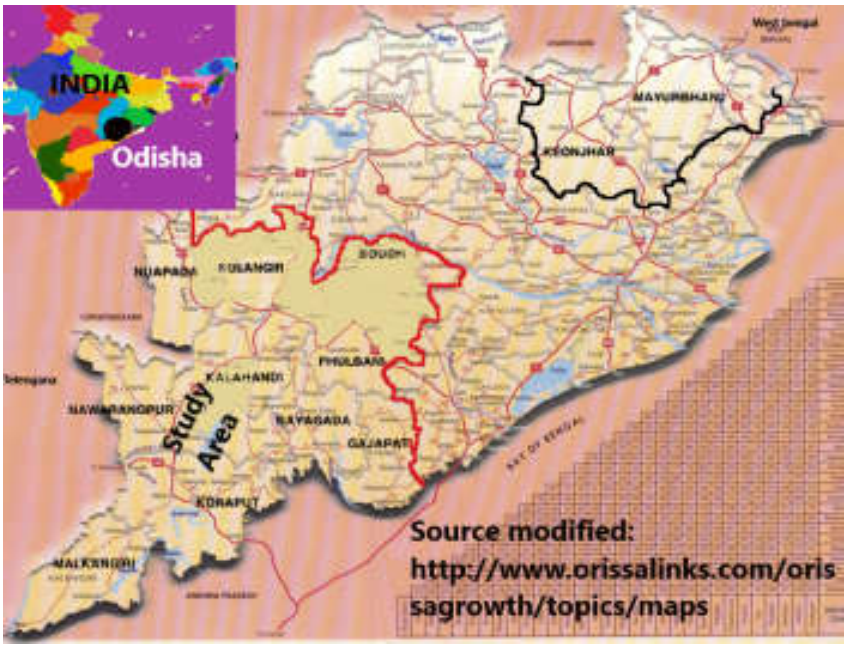

Fig. 1. The study area map of the southern districts of Odisha

People in rural areas face problems related to poor quality of life, low income and energy related problems which are characterized by availability, reliability, affordability, cost, drudgery, pollution, safety and health-related issues. Hence, there is need for a clean energy system that can address these challenges in a sustainable manner. All possible options ranging from upfront purchase of clean energy system to becoming an enabling mechanism for income generation area need to be explored. Livelihoods, powered by sustainable energy, are diverse in nature. It may cover agriculture, manufacturing and service sectors, contextually unique in different topographies. Hence, innovations in technologies, financial products and delivery models need to be developed for economic and quality of life development.

1.1 Scope of Study

The objective of this research is to pledge virtuous cycles that augments least possible clean energy access to the BOP economically underprivileged patrons in a sustainable means by involving with social backing and income generation accomplishments. The study used clean energy systems such as SPV energy to light their houses and other service requirements, besides serving in income generation events. The searches reveal that a new area ventured for possible use of clean energy in rural, ethnic and aboriginal populated areas Fig. 1.

2. METHODOLOGY

The study is undertaken with data collection, analysis, interactions, questionnaires, mobilization, institution structuring. The work also involve fulfilling procurement procedures, installation of either roof top or ground based SPP units and provision of service providers for the solar energy products and the system. As a result it will facilitate income generation actions, developing interrelation with appropriate social financing linkages and repayment of loans, training and certification.

The study shall help to develop sustainable livelihood security and improvement in quality of life of indigenous and other under-privileged communities in the economically backward and tribal region of South Odisha. Indirectly it helped developing appropriate rural energy policy for the state and country.

2.1 Study Area

Odisha ('Orissa' before 2011), geographically positioned at20.9517°N latitude and 85.0985^0 E longitude is one among the east coast states of India. Odisha has a long coastline of 480Km along the Bay of Bengal in east, with six coastal districts from Balasore in north to Ganjam towards south. The agrarian rural based state (83% of total demography) is 9^{th} largest state area wise and 11^{th} largest with population of 41.97 million [3]. It is the 3rd largest tribal populated (of about 900K tribes) state of India. Tribal population wise (schedule caste (SC) and schedule tribe (ST)), the state is 40 percent of total population of Odisha, with ST and SC population of 22.8 percent and 17.1 percent respectively [3]. There are 30 districts in Odisha which are divided in to 3 clusters containing 10 each as north, south and central divisions for better administration as per census data 2011. The largest and the smallest in areas are Mayurbhanj and Jagatsinghpur and demographically Ganjam is the most populous and Deogarh is ranking the lowest position by population.

3. SOUTH ODISHA

3.1 Socio Economic Status of People in South Odisha

Odisha has a major forest covers and is abundant with much mineral reserves. With such plenty of resources available in Odisha, still it is the 2nd highest backward region among the states and is the 2^{nd} highest incidence of poverty among the states [4]. As per National Sample Survey Organization (NSSO), ≈33% of people of Odisha are under poverty line against country average as 22%, (ibid report2011-12).

Discussing on socio-economic aspects, about 55% of the households in Odisha are in practice of using kerosene lamps for lighting purpose [5]. In Odisha, the major source of drinking water in the households is from hand pump which comprises of 41.5 percent followed by tube well with 20 percent, well with 19.5 percent and tap water with 13.8 percent only (ibid). About 65 percent of the total population uses firewood for cooking in the households in Odisha (ibid). About 14.1 percent of households in Odisha have a bath room and about 19.7 percent have a bathing facility followed by 22.4 percent of households have a latrine facility within their premises (ibid).

3.2 Administrative/ Socio-economic Status of South Odisha

Districts of South Odisha basically consist of eight districts: Ganjam, Gajapati, Koraput, Nabarangpur, Bolangir,Rayagada, Malkangiri, Subarnapur, Nuapada, .and Kalahandi. Except Ganjam and Gajapati, the other eight districts comprise of 14 sub-divisions, 80 tehsils, and many community development blocks. Details on socio-economic factors has been given in Table 1, basically focusing on the aspects related to dealing with fuel used for lighting purpose, safe and unsafe drinking water facility, environment friendly and non-environment friendly fuel used for cooking purpose and poor literacy rate.

From the Table 1; it is inferred that safe drinking water consist of water sources tap water, covered well, hand pump, tube well or bore well and spring whereas unsafe drinking water consist of water sources from rivers, canals, tanks, ponds or lakes and open wells. Similarly environment friendly fuel used for cooking is from LPG or PNG, electricity and bio-gas and non-environment friendly fuel used for cooking is from firewood, crop residue, cow-dung, coal, lignite or charcoal. From Table 1, it is found that kerosene usage for lighting purpose is highest in Nabarangpur district followed by Malkangiri and Koraput district. Likewise the use of solar and non-environment friendly fuel for lighting and cooking is low in all the eight districts of South Odisha. With such low diffusion of clean energy products, people in the South Odisha are facing many problems like poverty and deprived of many modern facilities.

The study basically focused on developing solar electricity supply system at the BOP client household and distracted community level; establishing institutional model for social financing; putting in place income generating activities; developing Clean Energy Entrepreneurs (CEE); and conducting pilot training programme on awareness development, entrepreneurship development, marketing and market linkage, social financing and management issues. The proposed study was implemented in Koraput district of Odisha. Around 2,500 households were covered during the study duration. They were selected through detail survey and participatory method.

4. IMPLEMENTATION PROCESSES

For this study ADEME, Harsha Trust and Centurion University of Technology and Management came together to implement this study in the field. ADEME is the FRENCH Eenvironment and Energy Management Agency, which provides expertise and gives advice to businesses, local authorities, communities, government bodies and general public to help them to establish and consolidate an environmental approach. ADEME's main objective is to provide assistance with project financing, from research to implementation of the project, in the areas pertaining to waste management, soil conservation, energy efficiency, clean energy, air quality, and also undertakes steps to fight against the noise pollution as well. Harsha Trust was incorporated in 2002 to work among disadvantaged indigenous communities, primarily the tribes of south and west Odisha, in order to enhance their livelihood security and quality of life. It operates in the Kandhmal, Nuapada, Malkangiri, Nawarangpur, Kalahandi, Koraput and Rayagada districts of Odisha. It has its headquarters in Bhubaneswar and units in four districts and field teams in over 1000 villages. Harsha Trust has undertaken livelihood security program for 3.6mi households in a most backward expanses of the country (South Odisha) involving indigenous and other underprivileged communities. Centurion University of Technology and Management is based at South Odisha. The university believes in "Shaping lives and Empowering Communities", skill development through'hands-on practices', 'experience based', 'practical/field oriented 'learning which shall make an appropriate difference through relevant innovation and action based active research who conducted the study.

4.1 The Initiatives

The interventions included building of community-based institutions like women Self Help Groups (SHGs) and cooperatives. Through these institutions a number of livelihood enhancement activities such as improved backyard poultry farming and improved agriculture (cereals, pulses and horticulture) were taken up [6]. In the process, these families have been able to generate an additional annual income. The productivity of poultry farming has been increased through continuous lighting at night in the poultry sheds. Unfortunately, because of poor availability and absence of grid electricity the mortality of chicks increased and feed productivity came down.

Table 1. Details of rural, categorized and total population and districts of South Odisha

Socio-Economic Factors/ Districts	Koraput	Malkangiri	Nabarangpur	Rayagada	Bolangir	Subarnapur	Kalahandi	Nuapada
Total Population	1379647	613192	1220946	967911	1648997	610183	1576869	610382
Rural Population	83.6%	91.1%	92.8%	84.8%	88.0%	91.8%	92.2%	94.4%
SC Population	14.2%	22.5%	14.5%	14.4%	17.8%	25.6%	18.1%	13.4%
ST Population	50.6%	57.8%	55.7%	55.9%	21.0%	9.3%	28.5%	33.8%
Literacy Rate(%) (Total Popul^{n})	49.2%	48.5%	46.4%	49.7%	64.7%	74.4%	59.2%	57.3%
Kerosene Usage for Lighting (Rural)	83.6%	84.9%	90.2%	80.9%	75.5%	68.9%	79.5%	73.4%
Solar Usage for Lighting (Rural)	0.52%	0.76%	0.61%	0.44%	0.39%	0.21%	0.89%	0.73%
Safe Drinking Water (Rural)	87.5%	93.8%	91.4%	91.1%	86.6%	89.2%	90.3%	88.7%
Unsafe Drinking Water (Rural)	12.2%	5.78%	8.3%	8.47%	13.0%	10.5%	9.5%	11.1%
Environment Friendly Fuel Used for Cooking (Rural)	3.3%	1.38%	0.95%	3.42%	1.32%	2.05%	2.01%	2.5%
Non- Environment Friendly Fuel Used for Cooking (Rural)	95%	98.3%	98.2%	96.3%	98.1%	96.9%	97.6%	97.2%

Source: Census, [3]

4.2 Structuring the Project

Existing arrangement involved the use of kerosene lamps throughout the night, but after the use of solar light, it lead to increased comfortable life pattern and productivity. Additionally, use of kerosene lamps pose the risk of health and fire hazards but thanks to the introduction of clean solar PV light it has led to improvement in the quality of life.

The increase in income from poultry and agricultural activities improved the quality of life of the poverty class and educational standard of children through efficient lighting system, mobile charging, entertainment through radio and television, and street lighting and have improved their standard of living.

Harsha Trust undertook the study for providing energy needs for lighting, mobile charging, other utilitarian services for domestic and community purposes and income generating activities using solar energy. Harsha Trust implemented the study in the field. Existing local institutions capacitated to undertake the task. Additional institutions and mechanisms were put in place for the smooth functioning of energy related interventions.

4.3 The Investigation Initiatives

The aim of this study initiative was to integrate and establish sustainable energy provisions for rural communities, train rural youth to cater to after-sales needs and equip them with the ability and knowledge to service infrastructure that is installed via the implementation of this study initiative. After-sales service was crucial despite the fact that solar PV systems require very little maintenance and low over all cost of lighting. The after-sales service was required for potential system failures (which should not happen very often based on the technological solution selected, but may jeopardize the success of the study initiative) and for later expansions of / new demand for systems.

For this reason a detail survey was undertaken in the framework of the study; it was conducted in the area to understand the energy use pattern. The sample included 105 families from a village Cooperative (PACL: 68 and Poultry: 7), 27 families from Self Help Groups (SHG) and 3 families from others. The households belonged to 43 villages, 19 Gram Panchayats (GPs) and 5 Blocks of Koraput district. Among them, educationally, 51 were illiterate, 15 below class 5, and 39 classes 5 and above. The family on an average comprised 6 members with 3 male and 3 female members. 42 families had school going children. According to land holding status, 16 were landless families, 26 were marginal farmers (1ha or less), 32 were small farmers (>1ha and <= 2 ha), 28 were medium farmers (>2ha and <= 5 ha), and 3 were large farmers (> 5 ha). The average annual household income for 1st quartile was Rs 25423, 2nd quartile was Rs 44115, 3rd quartile Rs 61385 and last quartile Rs 110385 (1 USD = 74.1627 INR). Forty-one houses had thatched roofs, 25 had tiled roofs and 39 houses were covered with tin sheets. Fifty households had 2 rooms and the average number of rooms for a household was found to be 3. Fifty-eight houses had mobile phones and bank accounts. Forty-one households (39 percent) had electricity connection and 19 houses (18 percent) owned solar/ rechargeable lights. Houses received on an average 4 hours to 8 hours electricity. The average electricity bill per month was Rs 100-Rs 200.

4.4 Surveying Project Outcomes

The average monthly kerosene consumption at the household level was 4.5 lit and costed Rs 100. Typically, 3 liters of kerosene was available at a subsidized rate of Rs 17/liters. The price of kerosene in the open market was Rs 30 to Rs 40 per liter (1 USD = 74.1627 INR). Rural households wanted 4 to 6 hours of light per day; they were dissatisfied with the existing poor lighting system. Sixty-two percent households were not aware of solar lights. Households were ready to pay Rs 1000 as initial payment and Rs 300 as monthly installment.

The above household survey had not specifically addressed income generation opportunities using solar energy. Focus group discussion was conducted with some members of the household and key opinion makers of the area. It was observed that, for the existing activities, there was a potential for solar lighting in tailoring, bamboo works units, carpentry, dairy farms, kirana shops, tiffin stalls, dairy farms, jaggery manufacturing units, roadside eateries, etc. These were in addition to mobile vendors, retail stores, bi-cycle and auto repair shops, and poultry sheds.

4.4.1 Comparison of potential suppliers

A comparative investigation was undertaken to ascertain the figure of potential suppliers for

employing solar lighting projects (small or large) in South Odisha. The farms are like Reliance, D-Light, Bajaj, BPL, RAL Green Light Planet, Eureka Forbes, and FOSERA. Based on the technical features, operational experience and the price it was observed that FOSERA PSHS4200 fitted best for medium- and high-end customers and Green Light Planet (Sunking) fitted well for low-end customers. Compared to other available products, PSHS4200 has higher light output, bigger panel and battery capacity and life of 5 years. Hence, the price was reasonable by considering the superior technical features.

FOSERA was manufactured and supplied by Auroville Energy Products (AEP) Pondicherry. PSHS 4200 had the provision to plug 4 lamps with a single battery pack and single solar panel. It could provide 16 to 30 hrs of lighting (in different modes) with one-day charging. Since, the battery was fixed to the wall like a switch board; its life was more than the conventional solar light, where battery was exposed to the sun. The company provided 2 years of warranty and has two products PSHS-7000 where lighting was up to 30 hours with one day charge and single lamp and Scandle-200 where lighting was up to 4 hours, and it is like a portable torch light.

It was decided to promote PSHS4200 (FOSERA) and Green Light Planet and worked hard to bring down the price further, by local value addition through assembly and service. Further, moving ahead after the introduction of FOSERA light PSHS 4200, other models such as PSHS-4200 (USB), PSHS 7000, PSHS-7000 (USB) and Scandle 200 was introduced in Jeypore, Nabrangpur and Bissam Cuttack.

As mentioned, the main target and where the largest gaps have to be bridged was training and capability-building at the sales/service provider level, i.e. making genuine and eventually successful Clean Energy Entrepreneurs (CEEs) out of energetic business (women) who want to venture into solar systems. During the study, training programs was held as close as possible to the actual study areas to get a first-hand experience from the grassroots' level. This also means that the training material was provided in the local language and experts had to be engaged for conducting the training. Later, for the expansion to other regions, it eventually led to a "train-the-trainer" program and mobilization of audio-visual tools to multiply and accelerate dissemination of the expertise. The training program comprised of assessing the market, technical and management aspects of solar energy, devices and systems, commercial aspects, including a business plan for the creation of distribution networks and ”last mile” market access.

4.5 Investigation Procedure

During the study, a series of steps were undertaken to create awareness about solar lights for improving the quality of life, taking care of risks and vulnerabilities (against snake bite, harassment in darkness, natural calamity, etc.) and creating income generation opportunities. Some of the steps included conducting meeting in the office of the cooperative offices for those farmers who come for payment and other services, they observe the use of solar light in the office, training of 30 Community Service Providers of the Cooperative for diffusing solar lights in their areas of operation, explaining and demonstrating the use of solar lights to the Self-Help Group (SHG) members at the village level during their weekly meetings, preferably in evenings, door to door demonstration of solar product, comparing with kerosene lamps and sharing the experiences of existing users through their recorded voices and photographs and training of 50 local youth of Jeypore and Kundra Block with the support of SELCO Incubation Bangalore was also undertaken. Developing audio clips for promotion of the product in the weekly Haat (market) and community level cultural programs, four training programs was held for the CEEs, in which 100 CEEs were trained for assembly, selling, installation and maintenance of solar lights. CEEs were motivated to invest in the solar light business. Partnership was developed with manufacturers and technology suppliers/companies, namely IITB, SIROUS, FOSERA, etc. It helped in expanding their reach to desirable but hard-to-access markets in the rural area. Patanesweri Agricultural Cooperative Society (PACS) has already invested for the needy BOP clients without collateral and at reasonable interest rates. Training was also provided to BOP clients for the productive use of energy and facilitating market linkage for their products.

4.6 Training Initiatives

Upon the successful completion of the training programme, the products were introduced to the

CEEs, and they were trained to communicate the benefits of using solar light such as comparison of illumination between kerosene lamps and solar light. The product can be bought with an initial down payment of 30% and the remaining 70% can be paid in several installments in monthly or weekly basis by the end-users. For this purpose, a solar energy programmecard was prepared for keeping the track of payment of installments. The card was prepared in two colours, one in green and the other in yellow colour. One card was maintained with the CEE and the other card was kept by the end-user, bearing the same serial number. To keep track of the proceedings it was further decided to conduct a review meeting with the CEEs on a monthly basis regarding the target achievement, query regarding the product if any, repair and maintenance, etc. The meetings were held in Harsha Trust Project office and PACS office with concerned officers involved in the study.

5. PROJECT OUTCOMES

By July 2016-17, about 2038 working units of solar lights (FOSERA, Green light Planet and Tata Solar Venus-25L) was sold to BOP families in the areas of Koraput district (Jeypore) and Nabrangpur district. The nature of income generation activities depended on the activities of beneficiaries such as in kirana stores, tea stalls and restaurants, poultry sheds, medicine/variety/cloth stores, agro forest products and tendu leaf plates making homes, farmers 'fields, daily market/maize sell/pan shop/chicken chop/bar/garage/check gates and others. About 1600 rural vendors are being benefitted in Koraput districts alone. Besides, 517 poultry farmers are using solar lights in their sheds, protecting the chicks from snakes and wild animals.

Members of the Cooperative and Self Help Groups (SHGs) used their own money to finance the solar lighting systems. Poor households need initial funding to gain access to the product. Members of the cooperatives were financed by their organization. The cooperatives have so far invested Rs. 1 million for the said purposes.

5.1 The BOP Clients

The BOP clients who purchased the lights for their business were linked to the market, either individually or through cooperatives. Hence, no such market intervention from outside was required. The challenges of establishing a supply chain for the solar light and pumping system had overcome.

Under the first two key objectives of the study further collaboration with Indian Institute of Technology (IIT), Bombay and Sir Dorabjee Tata Trust (SDTT), Mumbai were undertaken [7]. The study with IITB involves provision of 1 million solar lights to school-going children (without access to grid electricity) in different areas of Koraput and Nab Rangpur districts of Odisha with the help of Harsha Trust.

Till date 50,000 (25,000 units for Nab Rangpur district in 3 blocks and 25,000 for Koraput district in 5 blocks) solar lights were sold to the school-going children. With the support from IITB, saturation was achieved (covered more than 75 percent of target students) in 2 blocks of Koraput and 2 blocks of Nabarangpur covering 50,000 school going students in most remote areas. Government of Odisha (GOO) has plans to provide 50,000 lights to school children through Harsha Trust. As distribution of clean light was the major concern, 9 distributors are now carrying out the distribution work in the areas of Nabarangpur, Papadahandi and Koshagumuda Blocks of Nabarangpur district. Training Programmes were started for Clean Energy Entrepreneurs (CEEs) in Nabarangpur district and 21 youths were trained on assembling and repairing of the solar products locally (Fig. 2). They were linked with the distributors through the Harsha Trust promoted Patneswari Agriculture Cooperative (PACL). Each of the 21 service providers (managing a centre) in Koraput and Nabrangpur districts maintains about 2500 lights and earns Rs 2700/month.

6. SUCCESSES IN TRIBAL AREAS

To increase income of tribal households and bring in livelihood security, solar energy operated drip irrigation system was developed by using a PENTAIR submersible pump (70 m max head, 310 LPH discharge, 155 W solar panel producing 4.1 Amp current), open dug well, and overhead tank and drip pipes. The solar panel was mounted on a bicycle for ease of movement from one farmer's field to that of another for irrigating small parcel of land used for vegetable cultivation. Almost 10 such solar cycles have been installed in different areas of Koraput and Nabarangpur district. Presently about 730 such systems has been installed at various locations in South Odisha.

Fig. 2. Solar operated lights installed in different tribal households

6.1 Success in Agricultural Fields

About 200 small and marginal farmers are being benefitted by this technology by sharing water from a common source like deep bore well and dug well. The initiative located 11 defunct bore wells (want of electrical power supply) have been recharged for lift irrigation supply and the farmers have been able to go for year-round vegetable production enhancing their income up to 3 folds. PACS has incurred loan of Rs 5 million from the SBI (State Bank of India)for facilitating and promotion of solar technology in remote non-approachable areas for irrigation and lighting. To start with 5 farmer/farmer groups are provided with a solar energy driven irrigation system at about Rs 25000 each (1 USD = 74.1627 INR). The loan amount is planned to be recovered in 24 monthly installments. Solar energy operated pump and drip irrigation is now measured as a future prospect for the poor tribal agriculturists having inadequate financial resources. Farmers, witnessing their failure of crops due to paucity of water, have initiated integrated drip irrigation using solar pumping system to ensure assured dual crops to harvest during a crop season in their farm land. By adopting this technology only in 0.25 acre of land, a tribal farmer is expected to get a net profit of Rs. 15000 per year.

Collaboration was carried out with Solar Electric Light Company (SELCO) for setting up an Incubation Centre in Centurion University, so as to create an eco-system for solar energy entrepreneurship development by imparting value based customized training to the CEEs [8] Fig. 3. A training programme was conducted for 15 rural youths who had come all the way from Thuamul Rampur, Kalahandi Dist, Odisha; they were trained on installation and maintenance of solar home and solar portable systems for a sustainable livelihood initiative. Lastly, initiative was also undertaken on designing and developmental activities. Design and development of fish drying (Fig. 4) through solar technology intervention for a solar dryer with a capacity of 100 kg was also undertaken.

Fig. 3. Training provided to the CEEs

Fig. 4. Solar fish dryer for the livelihood of fisherwomen of South Odisha

7. RESULTS OF IMPLEMENTING THE PROJECT

This study helped to popularize the use of SPV energy generation for lighting and other utility needs, besides assisting in revenue generation.. Major achievements were Harsha Trust collaborated with Indian Institute of Technology (IIT), Mumbai, Sir Dorabji Tata Trust (SDTT), Mumbai and Centurion University of Technology and Management to carry out the studies. The study with IIT, Mumbai involved provision of 100,000 solar lights for school-going children (without access to grid electricity) in different areas of Odisha.

The study with SDTT involved design, fabrication and supply of solar energy operated submersible pump and drip irrigation system for tribal households in the Koraput, Rayagada and Kalahandi district of Odisha for vegetable cultivation. Partnership was developed with the manufacturers and technology suppliers/companies. PACS already invested for the needy BOP clients without collateral and at reasonable interest rates. Training was also provided to BOP clients to make a productive use of energy and facilitating market linkages for their products. The effective use of solar products has enhanced the efficiency of certain income generation activities like vending zones, tea stalls and restaurants, poultry sheds, betel shops, garages, medicine and cloth stores, kendu leaf plate makers, artisans, etc.. Portable (cycle mounted) solar irrigation system in collaboration with Centurion University was developed; collaboration with SELCO for the creation of Clean Energy Entrepreneurs (CEEs) was also undertaken (Fig. 5).

7.1 Analysis

From the above study about 2038 number of solar lights were used by the BoP families. About 1600 rural vendors were also benefitted in the Koraput district only. About 517 poultry farmers used the light in the poultry sheds which helped the farmers in increasing their income and protecting the chicks from snakes and other wild animals. Below table shows the solar lights used by BoP clients under various income generation activities Table 2, and Fig. 6.

Fig. 5. Portable (cycle mounted) solar irrigation system in collaboration with Centurion University

Table 2. The results of the study for use of solar light used by numbers of users

Sl. No	Nature of Income Generation Activity	No of Users (FOSERA)
1	Kirana stores	714
2	Small tea stall and hotels	577
3	Poultry shed	517
4	Daily Market/Maize Sell/Pan shop/Chicken Shop/Bar/Garage/Check Gate	55
5	Medicine/variety/cloth store	45
6	Farmers' Fields	64
7	Agro forest products, Tendu leaf plates	31
8	Miscellaneous	35
	Total	**2038**

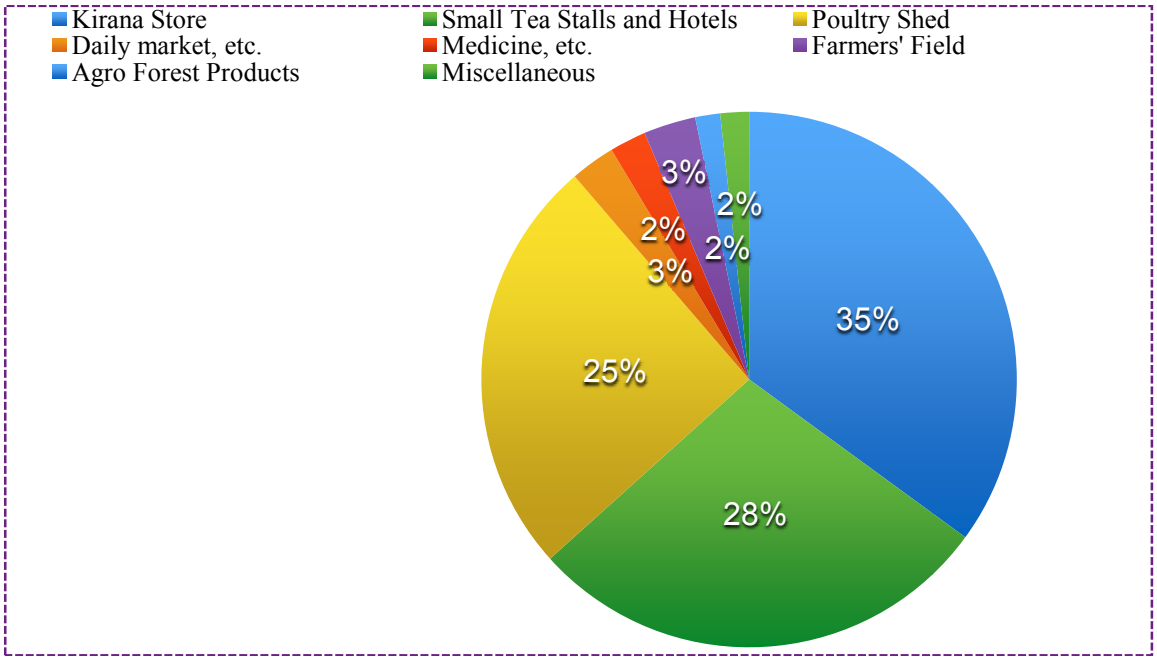

Fig. 6. The statistics of the solar lights used by BoP clients under various income generation activities

8. DISCUSSION

During the study the inferred points are:

1. Even though people had access to grid electricity in rural pockets, but they were inclined to adopt alternative sources of

clean energy as practical due to the very poor availability of electricity at the time of usage. Now-a-days many renewable energy companies have entered the rural markets and they are trying to lead the market by developing products according to the requirements of the rural population. But ensuring quality after-sale quality at minimum effort and time is always a better option. For example, people can get home light for as low as Rs. 500/- with very ordinary specification of panel, battery and lumens whereas a quality light like FOSERA may go up to Rs. 3,000/-.

2. It may be difficult for them to access the capital at the initial stage but those who have used it will never discard the product. So, if finance can be mobilized either through loan or grant, even the poorest of the poor will prefer have access to better-quality and long-lasting products. The cooperative has been successful in providing finance for this initiative and is able to sell and install good quality products even 150 km away from our office.
3. Rural haat (bazaar) is a hub of advertisement for promotion/sales of clean energy products in rural areas than any other means of communication [9]. During, the initial days, promotion of the products was carried out by door to door campaigning at village level where the progress was not so satisfactory but when the campaigning about the products and services was done in the weekly market, people from distant villages who were deprived of electricity showed their interest for clean energy.
4. Engaging and developing less competent local entrepreneur is a better option than bringing in a skilled one from other areas. In this study, there was engagement of semi-skilled local trained rural youths to mobilize people regarding the benefits of clean energy which was more fruitful than experts of clean energy engaged for the same purpose [10].
5. Opportunity for employment generation and livelihood enhancement: Local youths were directly engaged by the cooperative to mobilize, sale and provide after-sales services of the solar products. The petty shops which were usually open till sunset now remained open till 10 pm which not only enhanced the income of the shop owners but also enhanced the income of the people engaged in those businesses. For example, in cycle and tailoring shop there are two / three support workers who help the owner, by increasing the time of work their income has also increased substantially. A partnership approach needs to be undertaken among the various stakeholders for intervention of clean energy systems in the rural areas.

9. CONCLUSION

From the site investigation over use of solar PV illuminating and heating units, it is concluded that the rural, ethnic and aboriginal people of southern Odisha preferred as the solar lamps and heating gadgets are more popular, adopted as an alternative than grid based electricity. The lighting and heating by solar systems are more dependable and easy to use and cost effective in hilly and inaccessible areas of south Odisha. The change in shift from conventional electric system to solar power regeneration system can provide opportunity for employment generation, and livelihood enhancement to households, marginal farmers, marginal business community on PPP (public–private partnership or 3P) mode.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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