Off-grid electricity interventions for cleaner livelihoods: A Case study of value chain development in Dhenkanal district of Odisha

Sapna A Narula,

TERI University, New Delhi

Email: sapna.narula@teriuniversity.ac.in

and

Subhes Bhattacharyya,

De Montfort University, Leicester, United Kingdom

Email: subhesb@dmu.ac.uk

This paper has been accepted for publication in the Journal of Cleaner Production. The online version of the paper is available from the Journal site http://authors.elsevier.com/sd/article/S0959652616310721.

Please cite this article as: Narula SA, Bhattacharyya S, Off-grid electricity interventions for cleaner livelihoods: A case study of value chain development in Dhenkanal district of Odisha, *Journal of Cleaner Production* (2016), doi: 10.1016/j.jclepro.2016.07.176.

Abstract

Lack of access to electricity in rural areas hinders productive activities, which in turn affects sustainable rural development. Off-grid electrification options can offer an alternative but in order to develop productive uses of electricity in off-grid area, a detailed study of livelihoods and potential areas for improvement in the value chain is required. This paper reports such a study where a livelihood baseline survey was undertaken in a cluster of five remote off-grid village in Dhenkanal district of Odisha (India) and through a series of interviews, focused group meetings and stakeholder interactions, the study finds that value-added services can be developed through an off-grid electrification intervention. Electrification can support productive activities, thereby offering an opportunity for improved income generation and a better quality of life and a transition to cleaner energy sources. The study provides a novel value chain framework for linking off grid projects with local livelihoods replicable across multiple geographies ensuring sustainability of these projects.

Key words: off-grid electrification, Odisha, livelihood, value chain,

1. Introduction

In Sub-Sharan Africa and South Asia, around 70% of the population live in rural areas and lack of access to electricity is a major developmental challenge. As more than 1.1 billion people do not have access to electricity in these regions, the economic activities remain dependent on primary subsistence agriculture and artisanal activities. In this context, off-grid electrification has the potential of paying huge dividends in terms of provision of livelihood opportunities and raising incomes of people in rural areas of developing countries (Bastakoti, 2006; Zomers, 2003; Palit and Chaurey, 2011; World Bank, 2008; Sovacool, 2013; and Raha et al., 2014). Alazarki and Haselip (2007) suggest that solar photovoltaic technology can play an important role in providing livelihood opportunities in developing countries.

Various studies highlight the impact of off-grid solutions on local rural and regional development: for example, Rio and Burguillo (2009) highlight creation of new livelihood opportunities, setting up of domestic enterprises and creation of local industries; James et al. (1999) suggest that these may help in extending more business hours, thereby generating additional income; Wamukonya and Davis (2001) stress on the social dimension whereby off-grid electricity help children to study in evening hours and women to do more household work; whereas Youm et al. (2000) point out the contribution of off-grid electricity towards increased socializing. However, for an off-grid project to be successful, it must be able to provide new opportunities to the rural users in terms of economic empowerment (DFID, 2002 and GNESD, 2007, Chmiel and Bhattacharyya, 2015). Echegaray (2014) highlights the importance of understanding the views of consumers and institutions in promoting renewable energies, whereas Cherni and Preston (2007) consider the role of public and private sectors in ensuring rural electricity in developing countries. Creating economic linkages is important for sustainability of these projects

because these are located in rural areas where people have low disposable incomes and hence their willingness to pay for electricity remains questionable (Palit et al., 2011; Kumar et al., 2009; Shrank, 2008; Kirubi et al. 2009; Alzola et al., 2009). However, no existing study has so far specified the link of these projects in terms of creation of marketing linkages and development of value chains. As in most of these rural areas, local people follow basic livelihood activities such as agriculture and due to lack of infrastructure and communication facilities, forward and backward linkages in the value chains are weak, it becomes very pertinent to establish a connection between provision of off-grid projects and development of value chains.

Accordingly, the objective of this paper is to demonstrate how underdeveloped livelihood activities can be transformed to market efficient and sustainable value chains through collaborative efforts and resource generation and this can further lead to an overall economic empowerment of rural communities. This is done using a case study approach considering the pilot projects undertaken in selected villages of Dhenkanal district of Odisha as part of the OASYS South Asia project.

This study asks the following questions:

1) What are the primary and secondary livelihood activities of the residents of the selected villages and what are the existing value chains operating there?
2) What are existing set of natural, financial, technological and entrepreneurial resources available in the selected villages that can be utilized to develop new value chains and scaling up of existing underdeveloped value chains?
3) What are the activities in the respective value chains that can be further scaled up or developed using interventions with off-grid electricity interventions?

To find answers to the above research questions, an exploratory study was undertaken in a cluster of five villages in Dhenkanal district in Odisha and a socio-economic survey was carried out to collect primary data. This was further supplemented by extensive stakeholder interactions. On the basis of the primary data collected, the study aimed at recommending the necessary value chain interventions for socio-economic empowerment of the rural communities through off-grid electricity supply.

The paper is organised as follows: section 2 presents the research methodology, section 3 presents the results of the analysis considering the livelihood opportunities and value chain analysis while the final section presents concluding remarks and policy recommendations.

2. Research Framework and Methodology

The study has adopted the value chain framework for generation of income opportunities for the beneficiaries. Value chain approach has been used in both social science and business strategy literature quite extensively (Porter, 1985). A ***value chain*** describes the full range of activities required to bring a product from development to its end use and beyond. This includes activities such as design, production, marketing, distribution and support to the final consumer (Ruijter de Wildt et al., 2006).

The value chain concept believes that the steps where maximum value can be added need to be identified and these activities are the core activities where maximum interventions are to be carried out as they give maximum value to both producers and consumers. Any intervention in value chain (upstream and downstream) resulting into the gains for the producers is called a value chain intervention which can be of many types depending upon the type of requirement e.g. institutional

involvement and networking, re-intermediation, redesigning the chain, redesigning the activities and processes (Kaplinsky, 2004).

In developing countries, local farmers/rural producers, being unorganized, have usually little idea about who the other players in the chain are, what happens to their produce after they sell it, or what types of products consumers want. Value addition, processing, creation of market infrastructure, and bringing new technologies are some of the opportunities which can remove value chain inefficiencies and improve the social and economic lives of poor communities in these countries. Market information and transparency is another factor through which we can empower rural communities to gain more benefit. Value Chain analysis has been a quite useful approach in understanding the dynamic linkages that exist between rural people and markets and can also highlight opportunities for economic empowerment. The value chain approach for economic empowerment has been used in a number of development projects by national and international organizations (Schmitz, 2005; KIT et al., 2006; Vermeulen et al., 2008) and many frameworks have been suggested by international development agencies for value chain development for poverty alleviation (ICIMOD, 2010; Bolwig et al., 2012). Studies are available which showcase the impact of value chains on poverty, gender and environment (Warning and Key, 2002; Bolwig et al., 2010). For the purpose of our study, we have used the value chain framework in the context of livelihood generation and promotion through off-grid electricity. The first step of the value chain framework involves identifying the subsectors, actors, their roles and functions and identification of critical activities and processes across the chain. The second step involves the value chain analysis in terms of socio-economic, technical, market and financial linkages. Based on the analysis, various interventions such as market, financial, technological, entrepreneurial and capacity building were proposed.

The study was carried out in five slected villages (Rajanga, Rajanga hamlet, Kanaka, Chaddoi, and Baguli) in Dhenkenal district, which is one of the backward districts of Odisha having a total population of 1.2 million. The selected villages are all un-electrified villages and were not considered under the National Rural electrification Scheme, Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), steered by the Ministry of Power. These villages also have the least chance of getting connected to the central grid based electricity in the coming decade as they lie inside a reserve forest (Kandhara Reserve Forest) and according to existing regulations, it is not permitted to take electricity lines inside a reserve forest (Sharma 2015).

A household survey was carried out in the above villages during September 2012 with the help of a structured questionnaire. In addition, twelve focus group discussions including three women focused group discussions were also administered and each focus group consisted of 8-10 villagers. The number of focus groups in Rajanga, Kanaka, Baguli and Chaddoi were 4, 4, 3 and 1 respectively. The purpose of the focus group discussions was mainly to get inputs for the energy need assessment and to understand villagers' perceptions of energy uses and their willingness to pay. Additionally, data were collected from other stakeholders such as village head, NGO workers, and government officials through in-depth interviews. These focus group discussions were audio-recorded and data were transcribed for further analysis.

The analysis consisted of the following steps:

a) **Resource availability and need assessment:** The existing set of natural, technical, financial and entrepreneurial resources available in the selected villages was identified. In addition, an assessment of alternative combination of resources was made with the inputs from research

team and stakeholders. The energy needs of the villagers were also analysed from the survey inputs.

b) **Livelihood analysis**: The primary data collected through surveys and stakeholder interactions were analysed to develop an understanding of the primary and secondary livelihoods of the people in the concerned villages and to explore potential livelihood options based on agricultural and allied activities, and forest resources.

c) **Value chain analysis**: Based on the livelihood analysis, agricultural and forest resource based activities were found to be the ones that demanded more attention and hence it was decided to work on the same. The existing value chains were analysed with respect to all the activities, actors, technologies and resources involved. An effort was made to identify the critical steps in value chains, where technological interventions could be introduced with the help of off grid electricity. The role of both central and peripheral stakeholders was also analysed.

d) **Market linkages:** Based on the analysis**,** the possible **market linkages** were worked out highlighting both forward and backward linkages. The policy measures needed for their implementation have been recommended.

e) **Capacity Building:** For the success of the project, it was required to identify the existing skill sets in the village, as potential livelihood opportunities will depend on these skills**.** Alongside, inputs were obtained regarding capacity building needs of communities to realise potential future interventions successfully.

3. Results and Discussion

The results of the study are presented in the following sections.

3.1 Socio-demographics and resource availability of case study villages

Profile of Selected Villages

Dhenkanal district with a population of 1.2 million (as per 2011 census) and 4452 sq km. area, is centrally located in Odisha map – with Keonjhar in north, Jajpur in east, Cuttack in South and Angul in west. It has 3 subdivisions, 8 blocks and 199 gram panchayats (village committees). It is 75 km away from the State capital Bhubaneswar. The village cluster, namely Rajanga, Kanaka, Chaddoi and Baguli villages and Rajanga hamlet has a total population of 555. The selected villages for the demonstration project are un-electrified villages; they have the least chance of getting access to electricity in the coming decade as they lie inside the Kandhara reserve forest and falls under an elephant corridor in the Hindol block of Dhenkanal district. These village sites fall under the radius of 5 -10 kms from Dandiri (Gram Panchayat head quarter) and are cut off in rainy season. It is in the foothills of the mountain Gophamundia. The geographical details of the selected villages are provided in table 1.

Table 1: Geographic Information for Selected Villages

Name of Village	Rajanga	Kanaka	Baguli	Chaddoi	Rajanga Hamlet (Purana Sahi)
Gram Panchayat	Dandiri	Dandiri	Dandiri	Dandiri	Dandiri
Block	Hindol	Hindol	Hindol	Hindol	Hindol
Latitude/ Longitude	N 20°34‟07.6” E 85°16‟26.3”		N 20°33‟19.6” E 85°17‟47.2”	N 20°32‟51.9” E 85°16‟38.6”	N 20°34‟26.4” E 85°16‟24.7”
Number of hamlets	1(Purana Sahi)	0	0	0	0

Local indigenous people (the Scheduled tribe) form the major share of the local population and the total population in these villages is around 550. Majority of the houses in these villages are thatched with one to three rooms each. The demographic details of the population are given in Table 2.

Table 2: Demographic Information of Selected Villages

Name of village	Rajanga	Kanaka	Baguli	Chaddoi
Total households	44	43	35	12
Ethnic group	Tribal	Tribal	Tribal	Tribal
Number of below poverty line (BPL) families	14	23	13	6
Total Population	178	189	142	46
Average family size	4	4	4	4
Male Female ratio	88:90	94:95	64:78	20:26

The villagers belong to similar tribes and are known to each other. They have social connections and relationships and also pursue business with each other. Marriages are also very common amongst the residents of these four villages.

The approach road to all the villages under study is not well developed and is not approachable by car. These villages are inaccessible during the rainy season. The nearest approach road is up to Dandiri Village Council, which is 4 km from Rajanga Village and one has to walk up to these villages from Dandiri or rely on unpaved roads.

Resource assessment

The cluster of villages under consideration is located within a reserve forest. Accordingly, the natural resources from the forest constitute the main natural capital. The indigenous people living in the forest can access such resources for own consumption and local use. Some villagers own land but there are landless labourers and marginal farmers also. The land holding pattern in the villages is shown in table 3.

Table 3: Land Ownership and other infrastructure in the study area

Farm Size				
Farm Size (in acre)	Rajanga	Kanaka	Chaddoi	Baguli
>5	1	3	0	0
2.5-5	9	12	3	3
1-2.5	16	9	4	15
<1	0	2	4	2
Water Availability				
Number of hand pumps	2	3	1	0
Number of Wells	2	2	1	1
Infrastructure				
School	1			1
Grocery shop		1		
Health Worker (Anganwadi)		1		
Mobile handsets	-	1	1	1
TV	-	-	-	1

These villages have no access to safe drinking water. Due to this, villagers are prone to water borne diseases. There is at least one hand pump in each village and a well for drinking water (see table 3).

The villagers depend on rain for their agriculture. Delay or erratic rainfall greatly affects their agricultural output. On many occasions the villagers have hired diesel pump sets for irrigation at a cost of Rs 100/- per hour excluding fuel, which turned to be very expensive for the villagers. The water for irrigation is obtained from wells constructed by villagers for irrigation and from perennial streams.

Being remote villages, the local infrastructure is poorly developed. For example, there is no health centre in these villages but in Baguli, there is a childcare and mother care centre, where the children come for study and play around the day. There is a school in Rajanga village offering primary education but the facilities are poor and there is limited teaching staff. Mobile phone is available with a few villagers who get the batteries charged from the town. In Baguli, there is a grocery shop, the owner of which gets items from town (Dandiri) and keeps there for villagers to buy. Some additional details about the village infrastructure is presented in table 4.

Table 4: Infrastructure details of selected villages

Village	Infrastructure
Rajanga	A school is available but was non-functional last year due to unavailability of teachers. It was found to be functioning during the team visit. But the school has no infrastructure for higher classes. Two to three mobile phones are

	available in the village. They pay to get it charged in Dandiri forest guest house built by forest department. There is a community centre in the village. Two functional hand pumps were observed in the village.
Baguli	Unlike other villages, this village was found to have a grocery shop. The owner gets items from town (Dandiri) and keeps there for villagers to buy. There is also an Anganwadi (child care and mother care centre) operating out of this village. The children come here for studying and also play around the day.
Chaddoi	There is no road to the village. It is surrounded by Bhaliki forest in the west and Anishpur forest in the south. No scope for elementary education or healthcare exists. Elephants are a regular threat in the area. A small school is present but students cannot pursue higher studies as there is no facility in the school and the children have to walk through forest to go to other schools for further studies. There is only one mobile handset in the village, which is being charged in the village Dandiri (costing Rs.2 for each charging). There is no scope for entertainment –so a TV set will be of great value to the village
Kanaka	There is no pucca (concrete) road to the village. One has to wade through Kanka nal (perennial stream) to reach the village. There is one forest guard office and a primary school. One TV was supplied by the wildlife society but is not working. There are two mobile phones in the village but they have to go to nearby towns Dandiri or Rasol to get it charged.

Resource Assessment for electricity Generation: A solar resource assessment was done using average monthly values of horizontal solar radiation obtained from the online database and data released by the

Indian Meterological Department. It was inferred from the resource assessment survey that due to limited livestock and restriction on the use of biomass within the reserve forest, bioenergy options could not be used. It was also found that Solar PV would result in lower maintenance needs and thus lesser dependence on external resources as compared to other technologies.

Energy consumption habit: The energy consumption habits in the villages are almost similar. Energy is mainly used for cooking and lighting needs. Firewood is one of the main sources of energy in these villages, which is used for cooking and is sourced from the nearby forest at no private monetary cost. Each household uses around 3kg of firewood for cooking every day. Each family uses kerosene for lighting purposes. They are dependent on the Public Distribution System (PDS) for kerosene. Each household requires up to three litres of kerosene per month and purchases two litres of kerosene under PDS at a rate of INR 20/litre[1]. If this is insufficient, they purchase kerosene from the open market at a rate of INR 30-40/litre. Kerosene is used for lighting purposes. No expense is incurred in firewood as the women folk collect from the forest. They use around 3kg of firewood for cooking.

Willingness to participate: The respondents from this village showed interest in getting electricity. They want to have the pumps so that they can take up agriculture in a big way. They are also willing to work at night to prepare plates and mats (the ingredients for which are available locally). On an earlier occasion, one villager had tried to rent a pump set but it was very expensive as it consumed 1.5 litres of fuel to run the 1 HP Honda pump set, in addition to the rental charge of Rs 100 per hour. Overall, the residents were ready to participate in the project and were also willing to pay for these services provided an income source is generated.

3.2 Livelihood Analysis

After resource assessment, the next step in the analysis was livelihood analysis. The primary occupation of the villagers is agriculture, which is mostly for self-consumption. The villages have a majority of small or marginal farmers. There are very few employed persons. Men are involved in agriculture, labour work

[1] The exchange rate used in the study is 1 GBP = 85 Indian rupees.

and goat rearing and the women folk are involved in non-timber forest produce (NTFP) collection, household work and goat rearing. The households are also involved in making plates out of Sal leaves but only for use in village function and not for selling in the market. Some households are also involved in preparing bamboo products whereas households also earn their livelihood through poultry and pisciculture. The average monthly income of each family is Rs 1000/month. The villagers are involved in labour work for around 15 days a month. Each village has at least one to two self-help groups involved in medical and microfinance activities respectively. Table 5 provides the economic details of the villages.

Table 5: Economic status of the villages

Nature of job	Rajanga	Kanaka	Chaddoi	Baguli
Government Employee	1	2	0	2
Agriculture	21	29	3	23
Labour	62	22	22	23
Forest Work	1	1	0	0
Hired/Private employee	2	2	0	2

Agriculture is the prime income generating activity of these villages. Rice, mustard, horsegram, Arhar (split pigeon peas, Cajanus cajan), til (sesame seeds, Tilletia Indica), turmeric, and vegetables are grown (see table 6). Agriculture is quite primitive in these areas as hardly any technologies and implements are used. The output depends on the monsoon rain and the productivity is low.

Table 6: Agricultural activities in case study villages

Crop	**Season**	**Villages**
Rice	June-December	Rajanga , Baguli, chaddoi , Kanaka
Mustard	October-November	Rajanga, Baguli , Chaddoi, Kanaka
Horsegram	August-December	Rajanga , Baguli ,Chaddoi, Kanaka

Arhar (split pigeon peas)	October	Rajanga , Baguli , Chaddoi, Kanaka
Til (Sesame seeds)	September- December	Rajanga , Baguli, Chaddoi, Kanaka
Turmeric/ ginger	June-next June	Rajanga , Baguli, Chaddoi, Kanaka
Vegetables (cucumber, Okra, Aubergine)	January-June	Rajanga , Baguli , Chaddoi, Kanaka
Tamarind (Tamarindus Indica)	April- may	Baguli
Mango (Mangifera Indica)	June-July	Baguli

The main barriers to agriculture include: lack of irrigation facilities, loss of output due to elephant intrusion, lack of access to modern high yield variety of seeds, and lack of knowledge and experience with modern agricultural practices.

Non-timber forest produce (NTFP) collection is also one of the major livelihood activities of the villages. NTFPs are defined as any produce obtained from forests other than timber. These could be fibres, grasses, fodders, oilseeds, tannins and dyes, gums, resins, medicines etc. In this village cluster under study, various NTFPs, which are collected from forests, are honey, Sal (Shorea Robusta) leaves, oil seeds Mahua (Madhuca Longifolia) and Karanj (Milletia Pinnata), roots and honey (see table 7 for related details). Any product available in excess of own consumption is sold in the nearby market using a basic packaging. Poor packaging reduces the value and causes higher waste.

Table 7: NTFP (Non- Timber Forest Produce) collection

NTFP	Season	Use	Villages
Honey	October, March-April	For both domestic and selling purpose	Rajanga , baguli , Chaddoi
Siyari	Round the year	Used for domestic purpose	Rajanga , Baguli , Chaddoi
Sal Leaves (Shorea Robusta)	Round the year	Used for plate making for domestic purpose and these are not sold in the market	Rajanga , Baguli, Chaddoi
Karanj seeds (Milletia Pinnata)	July- September	Oil is extracted for medicinal purpose	Rajanga , Baguli , Chaddoi
Tumba (Puntius Tumba)	Round the year	Collected for food	Rajanga , Baguli, Chaddoi
Mahua seeds (Madhuca Longifolia)	July- September	Oil is extracted from the seeds	Rajanga , Baguli , Chaddoi, Kanaka
Tamarind (Tamarindus Indica)	July- September	Sold to middlemen from nearby towns	Rajanga , Baguli , Chaddoi
Amla (Phyllanthus Emblica)	July- September	Sold to middlemen from nearby towns	Rajanga , Baguli , Chaddoi

Firewood	Round the year	Cooking	Baguli , Chaddoi

A good number of families are involved in poultry and animal rearing activities. Animal resources are present in villages (e.g. goat, cows and bulls) – see table 8 for details.

Table 8: Poultry and livestock activities

Animal	Numbers / Village	Details
Goats	200 (Rajanga) 87 (Baguli) 23 (Chaddoi)	Grazing time – 9am to 5 pm and they are stall-fed at night. Litter collected – 250g/day.
Cows and bulls	60-70 bulls and 15-16 cows (Rajanga) 11-12 bulls and 7-8 cows (Baguli) Cows open grazed (Chaddoi)	Total milk collected – 5/6 litres from whole village. Cows are stall-fed in the monsoon season. Dung collection 3-4 kg. Dung is used for manure.
Poultry	20-30 chicken (Rajanga , Baguli)	Sold in retail to people from same village or from other villages who come to buy for Rs. 200-300 on the basis of chicken size (not weight). Turnover is Rs. 2000-3000 per family.
Pisciculture	Two ponds are present for fish rearing (Baguli)	Two ponds for pisciculture are available in village cluster. It has been two years since pisciculture was commissioned in the village through a community-based intervention.

The average family income is Rs 800-1000 (GBP 9 to 12) per month. Labour work is available for 2-3 months per year i.e. from July-September. The daily income from forest labour work is Rs. 92 (GBP 1.1), agricultural labour is Rs. 120 (GBP 1.4) and construction work is Rs. 150 (GBP 1.75). As the villagers do not collect sufficient quantities of forest resources, so most of them prefer labour work.

3.4 Value Chain Analysis

The livelihood activities in all the four villages are almost similar and hence the value chain analysis for all the villages is presented in an aggregated form. An analysis of the value chains in all the four villages reveals that there is hardly any value addition of commodities produced in the village. The value chains are underdeveloped with almost no technological interventions present. The villagers have started to produce vegetables on a commercial basis and understand that if these activities are scaled up, it can fetch them good profits. Similarly, there is potential for improving agricultural outputs through irrigation, turning to organic farming and adding value to the products rather than selling them in raw form. The same applies to forest-based products also. On the basis of stakeholder responses and livelihood analysis, we have identified NTFP and agricultural value chains for development and off-grid interventions.

3.4.1 NTFP (Non Timber Forest Produce) Value Chain

The rural communities are engaged in collection of the produce and selling it to the local markets or local traders. However, there is a long chain leading to making of value added products. The villagers who collect the produce are mainly not linked with the markets and sell the produce at the price given by the local trader, ultimately making low margins across the value chain. Villagers are free to collect this produce and also possess selling rights as it is concerned with their livelihoods. With the interventions related to the collection, processing of these products and markets, the villagers can earn more margins.

The analysis of NTFP activities reveals that the supply chain is highly underdeveloped and the activities are carried in a highly primitive manner. There are various constraints related to the collection of NTFPs

as it has been observed that villagers do not follow standardized collection practices (see Fig. 1). They do not have collection equipment e.g. for honey they do not have storage containers to store it under hygienic conditions. There is hardly any value addition of produce in terms of packaging and processing. For making Sal (Shorea Robusta) leaf plates, no facilities are available and it is done manually only. No extraction facilities are available in the village. The villagers either give it to the trader or go the nearby town to get it processed.

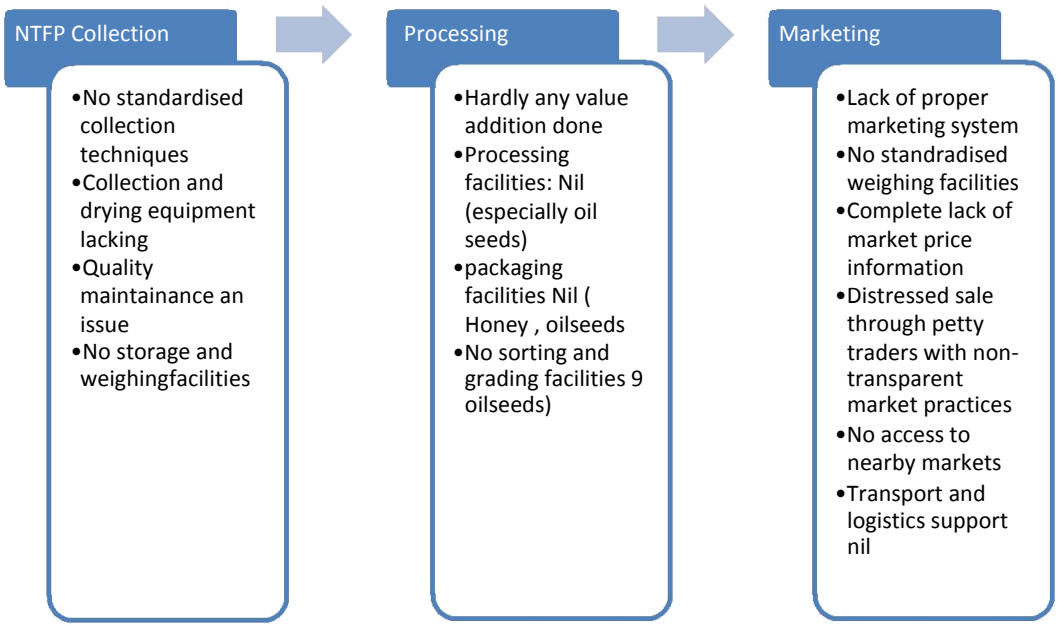


Fig. 1: Constraints in NTFP Value Chain in the Selected Village Cluster in Dhenkenal District

3.4.2 Proposed NTFP Value Chain Interventions (with off-grid electricity support):

Collection and Drying Platform: Construction of a collection and drying platform in one of the villages is proposed. This platform may help in drying the collected produce such as Sal leaves, Mahua (Madhuca Longifolia) and Karanj (Milletia Pinnata) seeds and will help in reduction of moisture and facilitating storage for shorter duration.

Supply of Polythene sheets: Another potential intervention consists of supplying polythene sheets for covering the produce in order to maintain quality of the outputs. In absence of these sheets, NTFP produce gets deteriorated in rain.

Pressed Sal leaf plate and cup making machines: Villagers collect Sal leaves from forests and use it for

making cups and leaf plates for eating during family functions. This activity also has a huge scope of scaling up in all the four villages as these products have good market in the nearby villages. The plates are biodegradable and can be promoted as an eco-friendly option. This activity could be commercially exploited with the help of introduction of compressed Sal leaf cup and plate making stitching machines. This activity like other activity would also require capacity building and market interventions.

Introduction of Electronic Oil Expeller: Villagers collect Mahua and Karanj seeds from forests to prepare oil. This is an activity they employ only for obtaining oil for domestic use. The collected seeds are given to the merchant in nearby village markets where the oil expeller facility is available. Usually, they get two parts of the oil and the balance is retained by the merchant towards his charges for oil processing. If an oil expeller facility backed by electricity is provided to them this shall reduce their dependence on the merchants. In fact, there is a huge scope for collection of Mahua, Karanj and other seeds and hence could be exploited commercially for increasing their income. An oil expeller facility will not only help them for the domestic purpose but also create new business opportunities through value addition resulting into more income. This can be a common shareable platform for all the villages in the cluster and services can be provided on a chargeable basis.

Electronic weighing Machine: The villagers mainly sell their produce to the merchants. There are around 10-15 merchants from the nearby market who regularly visit the villages for collection of their produce. They take NTFP produce, paddy, oilseeds, and poultry from them. There are no weighing scales in the villages and the merchants also do not bring one of their own. In that case, most of the times the villagers get cheated. A low cost electronic standardized weighing machine will actually bring transparency to the entire system as this will help the villagers to get the right price of their produce and building transparency in the entire system

Mobile phone/Charger: Mobile phones have been regarded as one of the affordable source of communication for poor across the world. In India too, many models are running where mobiles have facilitated the better flow of information between rural people and markets and have been able to add on to their incomes by adopting transparent market practices.

Mobile phones have already made their presence felt at these places. In Rajanga, three or four villagers have mobile phones and in Kanaka, two mobile phones are present. The villagers get it charged from other nearby markets, which have electricity on payment basis. There are one or two spots in these villages where these mobile phones catch signals. At present, this facility is used for social interactions

only and not for commercial purpose but the team saw a huge scope if mobile interventions are brought in.

The main reason for poverty in these areas is presence of weak market linkages. The merchants from nearby villages visit the people once a fortnight and collect the material from them, which include seeds, poultry, paddy etc. The major market related constraints existing in the system are lack of standardized weighing facilities, and the presence of traditional intermediaries. They do not weigh anything and only pay the price to these people based on their estimation, which makes the entire process unfair and non -transparent. Regarding the weight and the price, they have to settle with how the merchant dictates his terms. A mobile phone can actually empower them by allowing them to explore alternative market channels, approach new intermediaries and also improve price information and transparency across the system. The mobile phone service can also be a good entrepreneurial activity and also have the potential to be turned into a revenue stream.

Mobile phones will help the farmers look beyond these traditional markets and find out alternative markets. They can get better price of the commodities if they sell it in the nearby town markets.

A phone will help them co-ordinate with the other traders as well and will ensure market transparency in terms of getting better prices of commodities. They would be able to know the prevailing prices in other nearby markets and then decide on who to sell to. This will ensure an increase in bargaining power of villagers in the entire marketing process.

It will ensure better business co-ordination among the fellow farmers at a common marketing platform and also with the traders outside the village for better business practices. They can now more frequently interact with NGO workers for more technical inputs. Mobile phone will not only help farmers improve their livelihoods but will also ensure that they are connected to the outside world. They can also have access to information related to healthcare services available outside village and education for their children.

In light of the proposed off grid interventions, we see mobile phone having a great potential as a platform of information delivery as in the proposed collective market effort.

This will aid in co-ordination of activities associated with the project and are related to NTFP collection, collective marketing, repair and maintenance services, transport and logistics and also other social activities. Figure 2 provides the schematic for a mobile phone based information system.

Fig. 2: Linking farmers in Dhenkanal District to nearby Markets through Mobile based Information System

3.4.3 Agricultural Value Chains

Agriculture is the main livelihood activity in all the four villages. Villagers have land where they take up a range of activities. Since last few years, they have started cultivating paddy and aubergine, which they sell in nearby markets. Mustard, Ginger and turmeric are other commodities, which are grown in the villages. Mostly, the villagers do it for their own consumption but recently they have started selling small quantities to the dealers outside. They sell these to the intermediaries who visit the villages on a

periodic basis. The market linkages are almost non-existent as the farmers only depend on these traders. Lack of transport infrastructure also acts as a major barrier (see Fig. 3).

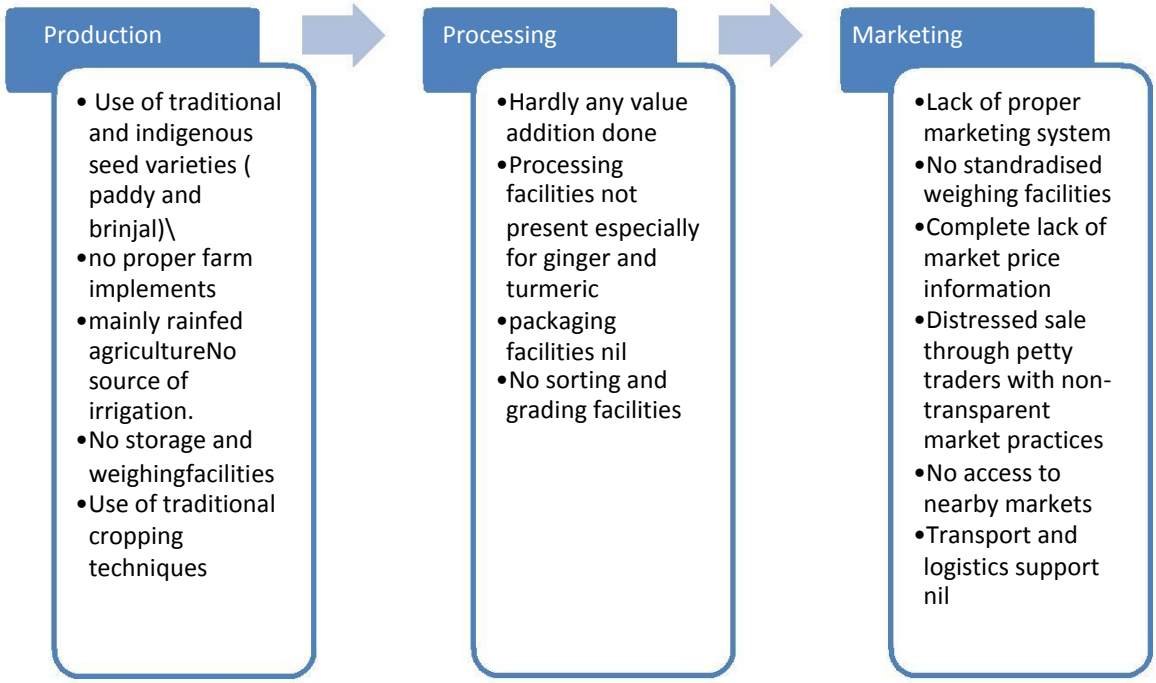


Fig. 3: Constraints in Agricultural and allied activities Value Chain in the Selected Village Cluster in Dhenkanal District

3.4.4 Proposed Interventions (Agriculture specific)

Enhancing Paddy/ Aubergine/Turmeric Cultivation:

The area has a vast potential for paddy, aubergine and turmeric cultivation.

Agricultural Pumps/Tube-wells

Paddy is grown in all the four villages. Though there are ponds in two of the four villages, providing irrigation facilities through electrical pumps would enhance the productivity. Providing hybrid varieties for paddy, fruits and vegetables would also help enhance productivity.

Electricity wires to prevent wild elephant attack

Wild elephant is a big problem in the area. Wildlife society of India Head told that they tried electric

wires manufactured by an Australian company, which helps prevent elephants away from agricultural fields. So installing these wires could be a good idea but more work is required.

These are the activities, which can be started immediately with the project. The suggested livelihood activities and electricity interventions (see table 9 for a summary) can be integrated together with all the villages in the cluster as these villages are in close proximity and are connected. The livelihood activities related to agriculture and livelihood promotion are almost similar in the entire area. The primary interventions, which are directly linked with off grid project have been presented in table 9. Figure 4 presents the proposed interventions in terms of various barriers. There are secondary interventions, which also need to be pursued in order to successfully implement these primary interventions.

Table 9: Proposed Primary Interventions for the Selected Value Chains

Livelihood Activity	**Electricity Intervention**	**Rationale**
Paddy cultivation	Agricultural Pumps/Tube wells Electricity wires to prevent wild elephant attack	Irrigation for paddy, aubergine and other vegetables. To prevent wild elephant attack
Mahua, Karanj, til seed oil extraction	Low cost oil expeller	Value addition through oil extraction
Honey collection	Packaging material Sealing machine	Value addition for marketing will fetch more revenues
Sal leaf Cup and Plate making	Pressed sal leaf plate and cup using pressing machine Drying Platforms	Marketing of Sal leaf cups and plates .

Turmeric, Ginger Value addition	Grinder/packaging material/sealing machines	Value addition of turmeric and ginger with packaging and branding will improve
Integrated across a range of livelihood activities	Electronic Standard weighing scale	Ensuring market transparency as the weighing scale will remove exploitation of farmers in the hands of intermediaries
Integrated across a Range of livelihood activities	Mobile Phone Charging Station	This will ensure market interaction and market transparency

Cost analysis: As part of the off-grid electrification project, estimates were made for various intervention options to identify their impact on for the overall project cost. The estimates include the appliance related costs because these items have to be included in the budget for the off-grid electrification project. Training for agricultural and other livelihood activities and consumables were not considered as part of the capital cost requirement. Table 10 indicates the estimated costs for different appliances. Compared to the overall project cost, the interventions do not impose a significant cost burden directly but indirectly, there is a cost implication as the power plant capacity has to be augmented to cater to such loads. The capital cost implications of livelihood interventions can be an issue for private investor-led projects.

Table 10: Cost estimation for various livelihood interventions

Appliance	Capacity	Cost estimate per unit in INR (as in 2012)
Grinder (1 at Rajanga)	1 HP capacity (750W)	14,000 (£165)
Irrigation water pump (2 in two villages)	2 HP capacity (1500 W)	20,000 (£235)
Electronic weighing scale (1 at Rajanga)	10-20 W	3,000 (£35)

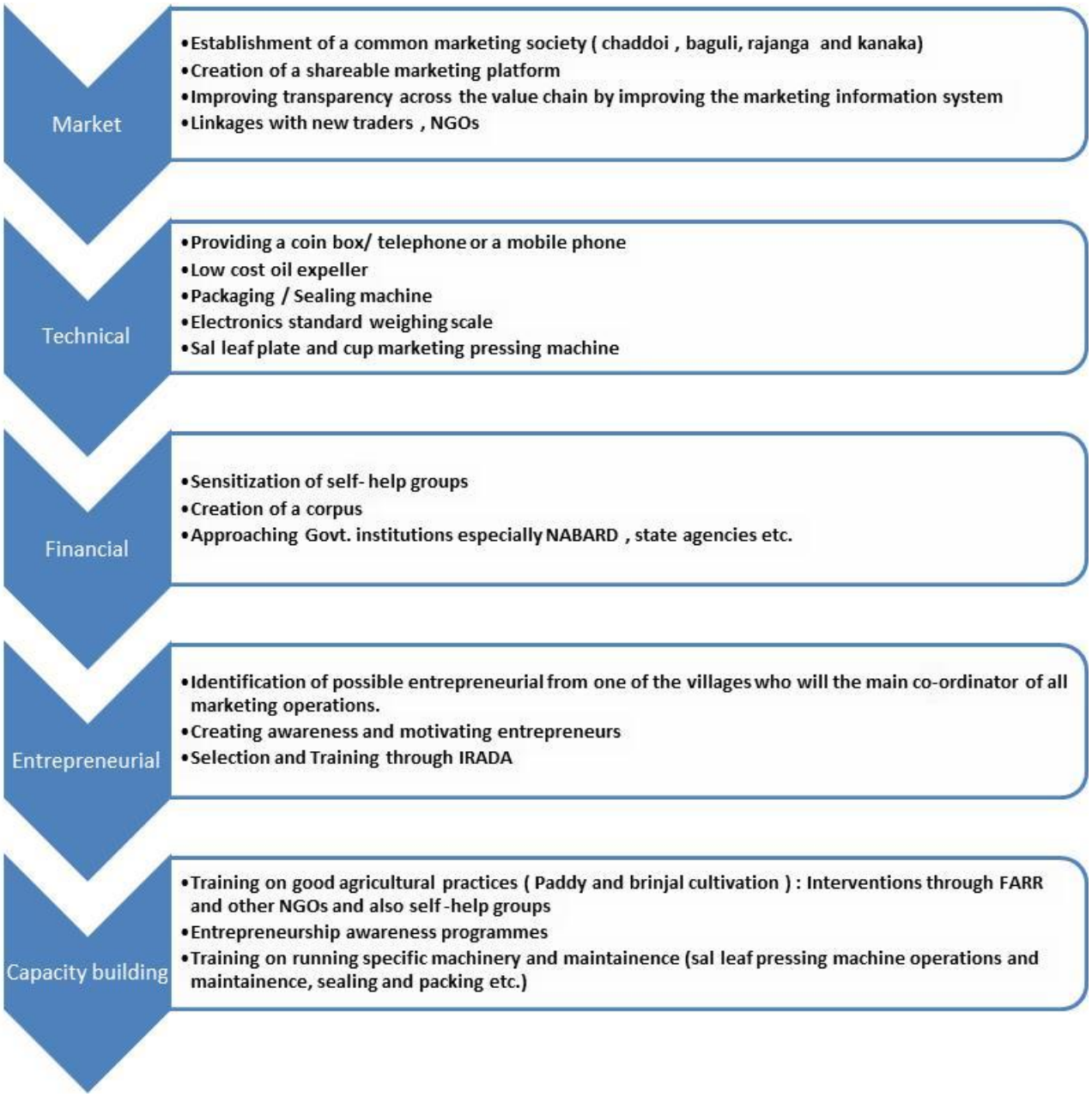
Package sealing machine (1 at Rajanga)	150 W	3,000 (£35)
Saal Leaf Plate pressing machine (1 at Rajanga)	0.5 HP (375W)	45,000 (£530)
Water Purifier (3 units in three villages)	50 litre per hour capacity, 75W per unit	55,000 (£650)
Total appliance intervention costs		270,000 (~£3200)
Off-grid power project cost estimate		7,166,150 (£84,310)

Data source: Palit et al. (2013), personal communication with

3.4.5 Market Linkages

It has been observed that the market linkages of these villages with the other nearby towns are extremely weak and this is due to weak infrastructural, transport and communication facilities. The agricultural and NTFP collection activities are almost similar in this village cluster and as discussed above, there is need to enhance marketing efforts of the produce which may include saal leaf plate, honey, Mahua and Karanj oil, dried haldi (turmeric) and ginger. Following steps may be taken:

Fig. 4: Proposed Interventions through off-grid electricity



Establishment of a marketing society: A small society with member producers from all the villages in cluster can be considered.

Packaging material:

- Containers for honey collection can be provided so that the quality can be maintained and there is less wastage. Attractive packaging material for honey (250ml, 500ml. and 1 litre) bottles can be provided. Honey produced in the area has very good taste and

health benefits.

- Small polythene bags of different sizes for dried ginger and turmeric powder can also be provided
- Packaging bottles for marketing oil (in varying sizes)

Availing shareable transport facilities: Since the produce is abundant during season time, shared transport facilities can be hired to sell the produce to nearby towns. This will help farmers gain access to new markets and also end up their sole reliance on existing middlemen who engage in unfair marketing practices. In addition, improved road infrastructure will also reduce the transport problems. This is important even for the off-grid electrification project implementation. In the absence of any government support to improve the road infrastructure, the villagers may be organised to contribute voluntary labour to marginally improve the road condition. However, significant investment will be required to make paved roads in the villages.

Tie-up with NGOs: There are already a few self-help groups working in three of the four villages so these self-help groups can be involved in market-related activities. With the business opportunities coming their way, more members will be interested in joining the societies. The level of trust members have with SHG representatives can be leveraged to create a marketing platform.

Branding: It was found during the survey that a few products being collected from the forests were really unique e.g. honey, Though not aggressive marketing strategies are needed but a little branding efforts differentiating the produce on the basis of origin i.e. collected and produced by tribal societies will also help gain better prices in the marketplace. The produce can be collectively differentiated on the basis of Origin (tribal), natural and organic and health benefits. Interventions for improving market linkages are presented in Fig. 5.

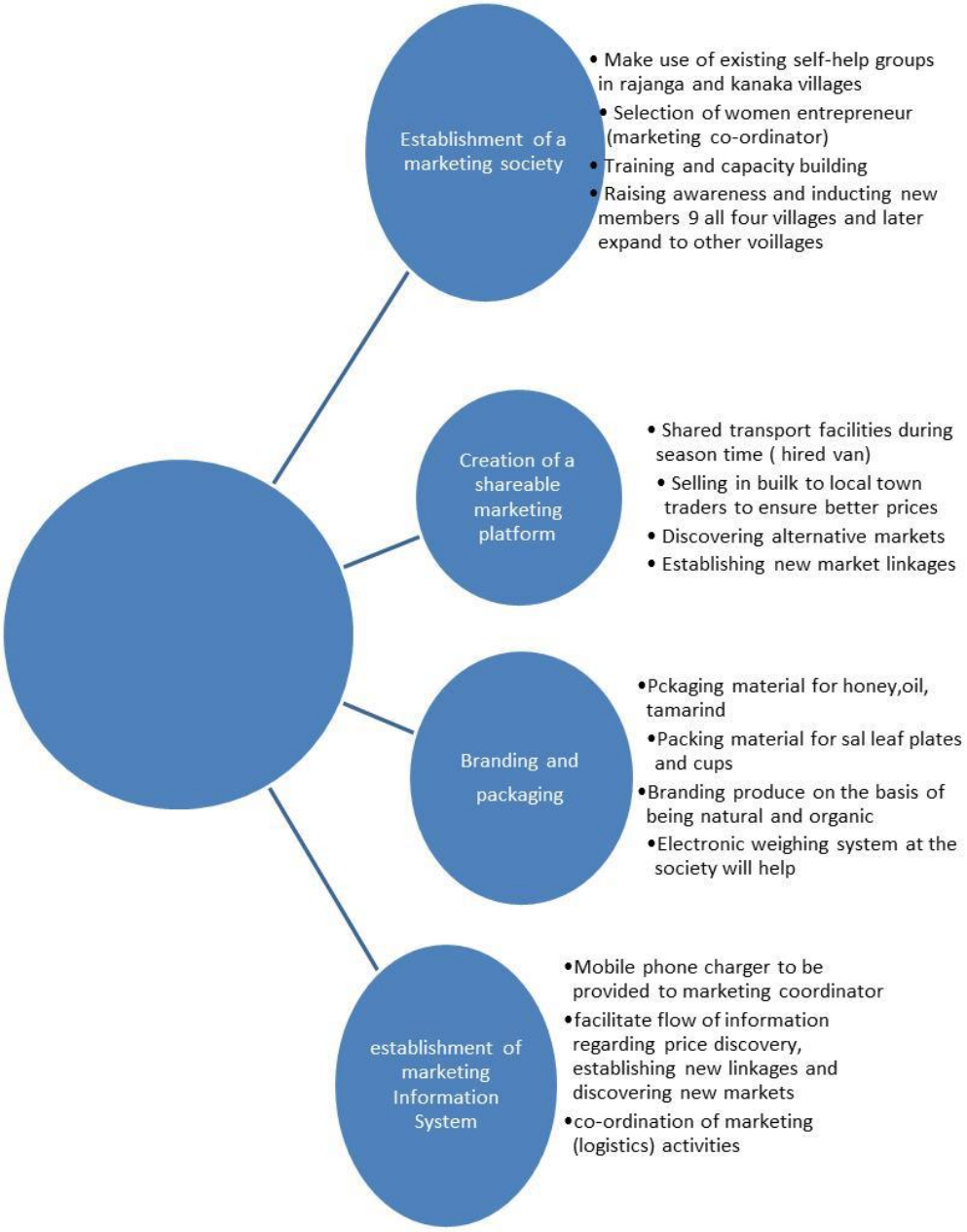


Fig. 5: Establishing Market Linkages in selected Villages of Dhenkanal Districts

3.5 Capacity Building

Alongside primary interventions supported through off-grid electricity, various secondary interventions also need to be concentrated upon. Capacity building related needs for the proper

functioning of proposed interventions have been identified (see Table 11).

Table 11: Capacity Building Needs (Secondary Interventions)

Capacity Building Needs	Institutional Interventions
Training on mat weaving	The Orissa State Co-operative Handicraft Co-operation, The Odisha State Livelihood Promotion Society
Training on sal leaf stitching	The Odisha State Livelihood Promotion Society ,IRADA
Training on turmeric/ginger mango drying and packing	FARR, The Odisha State Livelihood Promotion Society , IRADA
Training on Good Agricultural Practices	FARR, IRADA
Oil Expeller machine operations and maintenance	The Odisha State Livelihood Promotion Society

4.0 Conclusion

Through a field-based investigation for a demonstration project for off-grid electricity intervention in Odisha, we find that there is an immense scope for expanding agricultural activities in the selected villages through irrigation supported by mini-grid based electricity supply. Similarly, there are significant opportunities for developing value-added products through electrification. For example, turmeric cultivation offers a lot of scope for value addition as simple grinding and packaging can allow the commodity reach many households outside the village. Similar value addition is also possible for NTFP activities such as collection of honey, oil seeds, sal leaf where villagers can earn good income through value addition.

Market linkages were found to be very weak in the area in terms of access to market, lack of proper weighing facilities and intermediaries. The entire system was found to be dominated by traders with

lot many market efficiencies. On the production/collection side also, villagers do not have any farm implements, collection equipment, storage and packaging material. Also, they lack in their knowledge of using modern seeds/technologies. Off-grid electrification can help bring new interventions, both on the backward as well as forward side for these value chains such as irrigation, mobile phone, sal leaf pressing machine, and oil expeller may lead to empowerment of these communities through value addition of their products and removing information asymmetry across value chains. The renewable resource based electricity generation at the site can thus support better livelihoods and promote a transition to clean energy systems.

The study is novel in nature as it combines value chain approach for the provision of off grid electricity for the first time. While a lot of literature stressed upon the need for sustainability of off grid projects, the studies actually showcasing business models for poverty alleviation are limited. The value chain analysis also has been used in other developmental projects very widely except off-grid electrification projects. This study shows how off-grid electrification can support livelihood activities in rural areas. In addition, the study offers insights into a model for value chain development of unelectrified villages, which is extremely useful approach for the economic empowerment of communities at the local level with the help of off grid electricity.

References

Alazraki, R and J Haselip, 2007, Assessing the uptake of small-scale electricity production in Argentina: the PERMER project, J of Cleaner Production, 15(2): 131-42.

Alzola JS. ,Veclui I, Cablong H, Santos M, Sall M, Sow G., 2009. Micro grids project, part 2: design of an electrification kit with high content of renewable energy sources in Senegal. Renewable energy.

Bastakoti BP. The electricity-livelihood nexus: some highlights from the Andhikhola Hydroelectric and Rural Electrification Centre. Energy Sustainable Dev 2006;X(3): 26–35.

Bolwig, S., S Ponte, A du Toit, L Riisgaard, N Halberg, 2010. ”Integrating Poverty and Environmental Concerns into Value-Chain Analysis: A Conceptual Framework”, Development Policy Review, 28 (2): 173-194

Bhattacharyya, S.C., 2015. Mini-grid based electrification in Bangladesh : Technical con figuration and business analysis. Renew. Energy 75, 745–761. doi:10.1016/j.renene.2014.10.034

Chakraborty S. and Chakraborty S. 2002. Rural electrification program with solar energy in remote region. A case study in an island. Energy policy 30, 33-42.

Chaurey A, Mohanty P., 2007, Distributed generation and rural electrification in the Sundarbans India: Renewable Energy in the Sundarbans, TERI 2007.

Cherni, JA and F Preston, 2007, Rural electrification under liberal reforms: the case of Peru, Journal of Cleaner Production, 15(2): 143-152.

Chmiel, Z., Bhattacharyya, S.C., 2015. Analysis of off-grid electricity system at Isle of Eigg (Scotland): Lessons for developing countries. Renew. Energy 81, 578–588.

DFID. Energy for the poor: underpinning the millennium development goals. London:Department for International Development; 2002.

Echegarai, F., 2014, Understanding stakeholders’ views and support for solar energy in Brazil, J of Cleaner Production, 63(15): 125-33.

ESMAP. Rural electrification and development in the Philippines: measuring the social and economic benefits, joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP) report. Washington, DC: The World Bank; 2002

GNESD. Institutional reforms and their impact in rural electrification: South and South East Asia. Denmark: Global Network on Energy for Sustainable Development; 2004. GNESD. Reaching the millennium development goals and beyond: access to modern forms of energy as a prerequisite. Denmark: Global Network on Energy for Sustainable Development; 2007.

James, B., Nakatana, M., Rudek, B., 1999. Socio-Economic Impacts of Rural Electrification in Namibia: The Impact of Electrification on Rural Health Care Facilities, Education and Small Businesses. Energy & Development Research Centre, University of Cape Town.

Jinayim, T., Mungkung, N., Kasayapanand, N., 2014. Performance Analysis of Off-grid Solar Photovoltaic Electrification Systems for Sustainable ICTs Development: Field Study in 4 Regions of Thailand. Energy Procedia 61, 1925–1928. doi:10.1016/j.egypro.2014.12.243

Kirubi C, Jacobson A, Kammen DM, Mills A. 2009. Community based electric micro-grids can contribute to rural development: evidence from Kenya. World Development 37 (7), 1208 - 1221.

Kumar, A. Mohanty P, Palit D., and Chaurey A., 2009, Approach for standardisation of grid electrification project. Renew sustain energy review 2009; 13 pp. 1946-56.

Kaplinsky, R. 2004. Spreading the gains from globalisation: what can be learnt from value-chain analysis, Problems of economic transition, vol. 47, no. 2, pp. 74- 115

NRECA. Economic and social impact evaluation study of the Bangladesh rural electrification program, Dhaka, Bangladesh: NRECA International Ltd.; 2002.

Palit, D and Chaurey, A., 2011. Off-grid rural electrification experiences from South Asia: Status and best practices: Energy for Sustainable Development, 15 266– 276.

Palit, D., KR Sharma and S Sundaray, 2013, Cluster approach for effective decentralisation in off-grid energy project: A case study from Dhenkanal district, Odisha, Paper Presented at the IV th International Conference on Advances in Energy Research, Indian Institute of Technology Bombay, Mumbai (India), 10-12 December 2013.

Porter, M.E., 1985, Competitive Advantage, Free Press, New York.

Raha, D., Mahanta, P., Clarke, M.L., 2014. The implementation of decentralised biogas plants in Assam, NE India: The impact and effectiveness of the National Biogas and Manure Management Programme. Energy Policy 68, 80–91. doi:10.1016/j.enpol.2013.12.048

Ramchandani, R.A., Karmarkar, P., 2014. Sustainable Rural Livelihood Security in the Backward Districts of Maharashtra. Procedia - Soc. Behav. Sci. 133, 265–278. doi:10.1016/j.sbspro.2014.04.193

Rı´o, P.D., and Burguillo, M., 2009, “An empirical analysis of the impact of renewable energy deployment on local Sustainability”. Renewable and Sustainable Energy Reviews, vol. 13, pp. 1314–1325.

Sovacool, B., 2013 .Expanding renewable energy access with pro-poor public private partnerships in the developing world. Energy Strategy Rev.1,181–192.

Wamukonya, N., Davis, M., 2001. Socio-economic impacts of rural electrification in Namibia: comparisons between grid, solar and unelectrified households. Energy for Sustainable Development Journal V (3).

Wamukonya, N. 2007, “Solar home system electrification as a viable technology option forafrica‟s development”. Energy Policy, vol.35 , pp. 6–14.

Youm, I., Sarr, J., Sall, M., Kane, M.M., 2000. Renewable energy activities in Senegal: a review. Renewable and Sustainable Energy Reviews 4, 75–89.

Acknowledgement

The activities reported in this case study are funded by an EPSRC/ DfID research grant (EP/G063826/2) from the RCUK Energy Programme. The views expressed in this report are those of the authors and do not necessarily represent the views of the institutions they are affiliated to or that of the funding agencies. Authors also acknowledge the assistance provided by a local NGO, IRADA, TERI project staff members in Odisha, and TERI research staff Mr. Rohit Sen and Mr. Dattakiran for field activities reported in the paper. The paper also benefited from the discussions and suggestions of the Indian project team led by TERI, particularly those from Mr. Debajit Palit who oversaw the Indian activities, Mr. K Rahul Sharma, Dr. Parimita Mohanty, as well as Dr. Gopal K Sarangi and Dr. Arabinda Mishra from TERI University. Usual disclaimers apply.