Socio-Economic Impact Analysis of Introduction of Renewable Energy Technologies in Five Tribal Villages of Gujarat

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Foreword

India's substantial and sustained economic growth is placing enormous demand on its energy resources. Economic growth, increasing prosperity and urbanization, rise in per capita consumption, and spread of energy access are the factors likely to substantially increase the total demand for electricity in future as well. Thus, there is an emerging energy supply-demand imbalance. The role of new and renewable energy has been thus assuming increasing significance in recent times in India with the growing concern for the country's energy security. India has a vast availability of renewable energy resources, and it has one of the largest programs in the world for deploying renewable energy products and systems. Renewable energy technologies are clean sources of energy that have a much lower environmental impact than conventional energy technologies. The shifting to renewable energy can help us meet the dual goals of reducing greenhouse gas emissions, thereby limiting future extreme weather and climate impacts, and ensuring reliable, timely, and cost-efficient delivery of energy. Investing in renewable energy can have significant dividends for our energy security. With this backdrop, as a part of research project undertaken by SPRERI on 'Renewable Energy Intervention for Rural Development', the present study was undertaken at the Centre to find out the socio-economic impact of introduction of renewable energy technologies in five tribal villages of Gujarat.

The study is based on the primary data collected from the two selected tribal districts in Gujarat, where RE devices were set up by the SPRERI, i.e. Dahod and Chhota Udaipur/Vadodara. The study covered the total ten RE devices, viz. improved biomass cook stove-ceramic liner, improved biomass cook stove-air insulated-top feeding, improved biomass cook stove-air insulated-side feeding, solar light LED, solar light CFL, solar light HLS, biogas plant, solar cooker, solar dryer and glass roof tiles. The data were collected on total 166 RE devices from the selected 105 beneficiary households from five villages of two selected districts. In order to get some idea about demand and feedback on these RE devices from non-users, the data were collected from 42 non-beneficiary households from same villages. The study indicate that the renewable technology instruments set up at subsidized rate among the tribal population in two districts of Gujarat found useful and had impacted positively on various parameters of livelihood. On the basis of the findings, relevant policy suggestions have been made.

I would like to congratulate the entire project team for preparing this excellent research report. I hope findings of the study would be useful for academicians, policy makers and researchers.

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We have benefited immensely from various scholars and officials from different government departments while carrying out this study. At the outset, we would like to thank **Dr. Harish Padh**, Vice Chancellor of our University and Chairman, AERC Governing Body as well as **Dr. Mahesh Pathak**, Honorary Advisor of our Centre for their constant encouragement and support for undertaking such research activity at the Centre. We are grateful to the **Dr. M. Shyam,** Director of SPRERI for approaching us for this study, providing required information and support for conducting the field work and necessary inputs in completing the study.

The study would not have reached to this stage without the active co-operation of the sample beneficiary as well as non beneficiary households, who provided all the required data for the study without any hesitation and expectation. We thank each one of them for their invaluable support.

We have also received support and encouragements from our colleagues in the Centre while carrying out the study. We would thank Dr. S. R. Bhaiya (Field Officer, CCS) of our Centre for his support. We are also thankful to Shri T. B. Parihar, Shri N. G. Chauhan, Shri Jasawant Singh, Shri Hitesh A Prajapati, Shri Jitendra S Suthar for collecting data from field and other sources. Thanks to Shri T. B. Parihar, Ms. Kalpana Kapadia, Ms. Priyanka Patel, for excellent data feeding and processing work.

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List of Abbreviations

BCS-AISF	Biomass cook stove- Air insulated -Side feeding
BCS-AITF	Biomass cook stove- Air insulated -Top feeding
BCS-CL	Biomass cook stove- Ceramic liner
BGP	Biogas Plant
C.I.	Cropping Intensity
CFL	Compact fluorescent lamp
DC	Domestic chulha
DES	Directorate of Economics and Statistics
FAO	Food and Agriculture Organization
FY	Financial Year
FYP	Five Year Plan
GCA	Gross Cropped Area
GEB	Gujarat Electricity Board
GIA	Gross Irrigated Area
GOG	Government of Gujarat
GOI	Government of India
GRT	Glass Roof Tiles
GUJAGRO	Gujarat Agro Industries Corporation Ltd
GW	Gega Watt [equal to thousand million (10^9) watts]
ha	Hectare
HH/hh	Household
HLS	Home light system
Hrs	Hours
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
INM	Integrated Nutrient Management
IPM	Integrated Pest Management
kg	kilograms
LED	Light emitting diode
Lit	Liter
LPG	Liquid Petroleum Gas
mha	Million hectares
MOA	Ministry of Agriculture
MW	Mega Watt [equal to one million (10^6) watts]
mt	Metric Tonnes
NA	Not Available

NABARD	National Bank for Agriculture and Rural Development
NCA	Net Cropped Area
NIA	Net Irrigated Area
NPK	Nitrogen (N), Phosphorus (P), and Potassium (K)
NSA	Net Sown Area
NSS	National Sample Survey
OBC	Other Backward Classes
R&D	Research and Development
RE	Renewable Energy
SANDEE	South Asian Network for Development and Environmental Economics
SC	Scheduled Caste
SCD	Solar Cooker Device
SD	Solar Dryer
SL-CFL	Solar Light CFL
SL-HLS	Solar Light HLS
SL-LED	Solar Light LED
SPRERI	Sardar Patel Renewable Energy Research Institute
ST	Scheduled Tribe

Chapter I
Introduction

1.1 Introduction

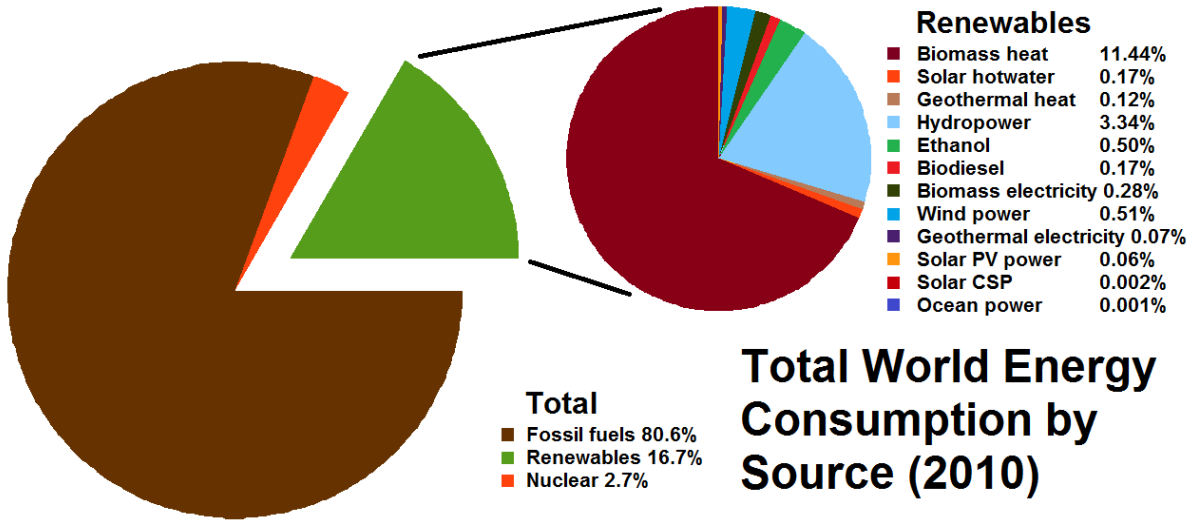
Rising world fuel prices, the growing demand for energy and concerns about global warming are the key factors driving the increasing interest in renewable [1] energy sources (Rosegrant et al., 2006). The shifting to renewable energy can help us meet the dual goals of reducing greenhouse gas emissions, thereby limiting future extreme weather and climate impacts, and ensuring reliable, timely, and cost-efficient delivery of energy. Investing in renewable energy can have significant dividends for our energy security (Omar, et.al, 2014).Therefore, there is considerable interest within the international community in the socio-economic implications of moving society towards the more widespread use of renewable energy resources. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hot water/space heating, motor fuels, and rural (off-grid) energy services (REN21, 2010). Harnessing clean and green sources of energy on a large scale in the country is a necessity to ensure sustainable economic development without seriously damaging the environment while also addressing the need for energy security (SPRERI, 2014).

Renewable energy markets– electricity, heating and transportation have been growing sharply over the last five years. The deployment of established technologies, such as hydro, as well as newer technologies such as wind and solar photovoltaic, has risen quickly, which has increased confidence in the technologies, reduced costs and opened up new opportunities. It is estimated that global electricity generation from renewable energy sources is expected to grow by 2.7 times between 2010

[1] Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat (Omar et al., 2014).

and 2035 (Omar et al, 2014). Renewable energy resources are innovative options for electricity generation and their potential is enormous as they can, in principle, meet the world's energy demand many times over. Renewable energy supplies around 17 percent of global final energy consumption, counting traditional biomass, large hydropower, and "new" renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels).

Fig 1.1: Energy Resources of the World



Why is renewable energy important[2]?

Renewable energy is important because of the benefits it provides. The key benefits are:

- *Environmental Benefits*: Renewable energy technologies are clean sources of energy that have a much lower environmental impact than conventional energy technologies.
- *Energy for our children's children:* Renewable energy will not run out ever. Other sources of energy are finite and will someday be depleted.

[2] http://www.renewableenergyworld.com/rea/tech/why.

- *Jobs and the Economy:* Most renewable energy investments are spent on materials and workmanship to build and maintain the facilities, rather than on costly energy imports.
- *Energy Security:* After the oil supply disruptions of the early 1970s, our nation has increased its dependence on foreign oil supplies instead of decreasing it. This increased dependence impacts more than just our national energy policy.

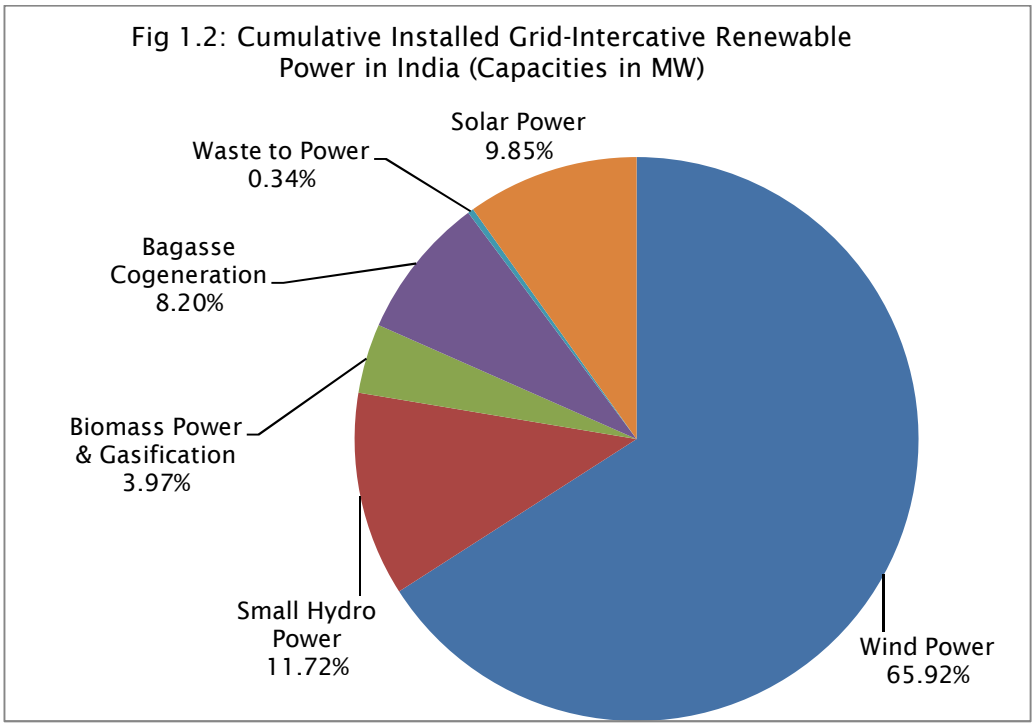
Status of RE in India

India has a vast availability of renewable energy resources, and it has one of the largest programs in the world for deploying renewable energy products and systems. The role of new and renewable energy has been assuming increasing significance in recent times in India with the growing concern for the country's energy security. Energy self-sufficiency was identified as the major driver for new and renewable energy in the country in the wake of the two oil shocks of the 1970s. The sudden increase in the price of oil, uncertainties associated with its supply and the adverse impact on the balance of payments position (http://www.mnre.gov.in). Therefore, government had established Commission for Additional Sources of Energy in the Department of Science and Technology in March 1981 with responsibility of formulating policies and their implementation, programmes for development of new and renewable energy apart from coordinating and intensifying R&D in the sector. India was the first country in the world to set up a ministry[3] of non-conventional energy resources, in early 1980s.

[3] The Ministry of New and Renewable Energy (MNRE) is the nodal Ministry of the Government of India for all matters relating to new and renewable energy. The broad aim of the Ministry is to develop and deploy new and renewable energy for supplementing the energy requirements of the country. Creation CASE and Ministry: Commission for Additional Sources of Energy (CASE) in 1981; Department of Non-Conventional Energy Sources (DNES) in 1982; Ministry of Non-Conventional Energy Sources (MNES) in 1992; and Ministry of Non-Conventional Energy Sources (MNES) renamed as Ministry of New and Renewable Energy (MNRE) in 2006.

The power generation from renewable sources is on the rise in India, with the share of renewable energy in the country's total energy mix rising from 7.8 per cent in FY 2008 to 12.3 per cent in FY 2013. India's renewable installed capacity has reached 35.49 GW, as of February 29, 2015. The Cumulative grid tied wind power capacity has reached 22644 MW's, while solar grid tied power capacity has reached 3382 MW's. Also during the month of February 2015, wind power, contributed largest share of new installed power capacity, while small hydro power ranked in a close second. How India develops will have widespread implications for global energy markets.

Fig 1.2: Cumulative Installed Grid-Intercative Renewable Power in India (Capacities in MW)



India has the fifth-largest power generation portfolio worldwide. The country transitioned from being the world's seventh-largest energy consumer in 2000 to the fourth-largest one within a decade. This rapid growth of power capacity and a subsequent rise in demand can be attributed to several factors:

- Economic growth and increasing prosperity
- Growing rate of urbanization
- Rising per capita energy consumption
- Widening access to energy in the country

Key drivers of renewable energy in India

- *Energy security concerns:* India ranks fourth and sixth globally as the largest importer of oil, and of petroleum products and LNG, respectively. The increased use of indigenous renewable resources is expected to reduce India's dependence on expensive imported fossil fuels.
- *Government support:* The government is playing an active role in promoting the adoption of renewable energy resources by offering various incentives, such as GBIs and tax holidays.
- *Climate change:* The National Solar Mission aims to promote the development and use of solar energy for power generation and other uses, with the ultimate objective of making solar energy compete with fossil-based energy options.
- *Increasing cost competitiveness of renewable energy technology:* Renewable energy is becoming increasingly cost competitive compared to fossil fuel-based generation.
- *Distributed electricity demand:* Renewable energy is a distributed and scalable resource, making it well suited to meet the need for power in remote areas, which lack grid and road infrastructure.
- *Favorable foreign investment policy:* The government has created a liberal environment for foreign investment in renewable energy projects.
- *Vast untapped potential:* India has abundant untapped renewable energy resources. India also has significant potential to produce energy from biomass derived from agricultural and forestry residues.

India's substantial and sustained economic growth is placing enormous demand on its energy resources. Economic growth, increasing prosperity and urbanization, rise in per capita consumption, and spread of energy access are the factors likely to substantially increase the total demand for electricity. Thus, there is an emerging energy supply – demand imbalance. The renewable energy sources in India are, a) wind energy; b) solar energy; c) biomass, and d) small hydro.

1.2 Brief Review of Literature:

The brief overview of the studies related to work undertaken is presented below.

Domac, et al., (2005) reviewed the studies on socio-economic drivers in implementing bio-energy projects and noted that bio-energy is a source of fuel for subsistence to the people in developing countries. It is also a source of income particularly during off-harvest seasons. Among other renewables, bio-energy is the most promising for the developing countries as its mobilization can provide large employment generation schemes, can be linked to ecosystem conservation, and even rehabilitation; furthermore, investments in biomass energy can be an effective tool to combat desertification, can have a significant impact on global climate change and can become a valuable tool in promoting gender equity within the associated natural resources management activities. Author noted that the encouraging trend in many countries, the policy makers are beginning to perceive the potential economic benefits of commercial biomass, e.g. employment/earnings, regional economic gain, contribution to security of energy supply and all others.

Rio and Burguillo (2009) analyzed the impact of renewable energy deployment on local sustainability in three renewable energy technologies in three different places in Spain. The authors argue that the contribution of RE systems to the economic and social dimensions of sustainable development might be significant. Particularly important is employment

creation in these areas. Although, in absolute terms, the number of jobs created may not be high, it may be so with respect to the existing jobs in the areas considered. Socio-economic benefits depend on several factors, and not only on the type of renewable energy, as has usually been mentioned. The specific socio-economic features of the territories, including the productive structure of the area, the relationships between the stakeholders and the involvement of the local actors in the renewable energy project may play a relevant role in this regard. Furthermore, other local (socio-economic) sustainability aspects beyond employment creation should be considered.

Adkins, et al (2010) had conducted a survey evaluation of household biomass cook stoves in rural sub-Saharan Africa and found that the manufactured stoves, in general, yielded a substantial reduction in specific fuel wood consumption relative to the three-stone fire, with results varying by stove type and type of food cooked. Survey data suggested that while cooks recognize fuel wood savings as an important benefit, overall stove preference depends upon a combination of this and other factors, including cooking time, stove size and ease of use. These findings highlight the importance of testing multiple cook stoves for preparation of a variety of food items, as well as combined use of quantitative stove tests in combination with qualitative surveys in efforts to determine suitability of cook stoves for household use in a given community.

Singh et al (2012) analyzed the impact of solar lights for tribal homes in Gujarat and found that solar lights were one of the most effective and sought after RE gadgets in the villages. The economic conditions of *the village were such that many villagers desirous of owning* solar light could not manage to pay the amount of Rs. 1000, even if it was broken up in installments. There was a need to properly train the elders of each beneficiary family in order to ensure satisfactory performance of the gadget. The quality and reliability of materials used to create the solar

lantern ought to be excellent for the smooth running of the gadget and for its maintenance free operation. The study also revealed that proper training of all grown-up members of each beneficiary family and the provision of a dependable, low cost and easily accessible facility for repairs and maintenance are the most important aspects to ensure that the lanterns continue to remain in regular use.

Sinha (2013) conducted the socio-economic impact of renewable energy equipment on the life of 5 tribal villages of Chhota Udepur and Dahod districts of Gujarat. The study found that that there was various changes by using the equipments in the life of tribal people. The work efficiency of the people increased as they were left with more hours after the accomplishment of household work. They used the saved time at their own fields or at other field leading to increase in income. The income increment changes the economic status. The usage of renewable energy equipment gives clean and carbon free environment at domestic level decreasing the health risk. The more amount of renewable energy usage leads to reduction in non-renewable energy exploitation creating greener and cleaner natural environment. The research in further analysis showed that the female drudgery decreased phenomenally as less time is used in cooking and co-related activities. It showed that the use of equipments also brought change in children's life increasing their study hours at home. The interviews in the research showed that most of the beneficiaries lacked proper appreciation for the equipments and lack the knowledge of proper handling and maintenance.

Hazra et al (2014) studies the adoption and use of improved stoves and biogas plants by collecting data from 8 districts of rural Odisha during the year 2011 and 2012. The study results indicated that greater fuel expenditure and time spent in the hospital for respiratory disease are significantly associated with traditional stove use, while socioeconomic factors are significantly related with adoption of improved stoves. The analysis of the factors associated with continued functionality of biogas

plants finds that households with greater spending capacity and more biogas-producing livestock are more likely to own biogas plants that still work. Households that spent less time gathering and money purchasing traditional fuels, and those that received a greater subsidy during plant construction were significantly more likely to own working biogas plants. The latter suggests that the subsidy may indicate a higher plant quality or greater government oversight. Village location in an industrial area and access to loan facilities were not significantly associated with stove ownership. Reduced fuel wood consumption is significantly associated with ICS ownership. Similarly, households with working biogas plants use significantly less fuel wood than households with biogas plants that are no longer functional – this suggests that although stove stacking may occur in households with biogas plants, some replacement occurs as well. Study suggests that biogas plants have the potential to reduce firewood use, time spent gathering fuel, and respiratory disease caused by household air pollution. Future policies encouraging the construction and maintenance of biogas plants have the potential to provide tremendous health and environmental gains.

While presenting the up-to-date and detailed current status and future projection of major renewable energy resources, as well as their benefits, growth, investment and deployment, Omar et al, (2014) projected that global electricity generation from renewable energy sources is expected to grow 2.7 times between 2010 and 2035. They opined that renewable energy resources are innovative options for electricity generation and their potential is enormous as they can, in principle, meet the world's energy demand many times over. The integration of renewable energy resources into smart grid system, keeping in mind all challenges, will help in meeting ever- increasing electric energy demands effectively.

While studying the viability of solar pumps in India, Bassi (2015) mentioned that because of the huge energy crisis, India will have to look

for different sources of energy, both conventional and non-conventional. But, detailed analysis of the technical feasibility, economic viability, and equity of access needs to be carried out before large-scale promotion of such technologies with heavy public subsidies. Ideally, public subsidies for any technology or production system are preferred when the private benefits from the use of the system do not offset the full costs, but the social benefits far exceed the social costs, and with the introduction of subsidy, the private costs to the user are lowered. But, this does not seem to be the case for solar pumps. Therefore, in-stead of investing heavily in solar pumps, the government should invest in rural infrastructure, such as roads and electrification, and develop good models for administering subsidies for micro diesel engines for marginal farmers of Eastern India.

1.3 RE Technology introduced by SPRERI in Tribal Gujarat

SPRERI continues its research and development in renewable energy technologies. Many renewable energy devices and systems developed at SPRERI are now manufactured by selected industries for meeting requirements of the end users. The manufacturing and marketing rights of the SPRERITECH improved biomass cook stoves have been transferred to three firms. These cook stoves are now available commercially in three different models to meet the requirements for domestic as well as community/small commercial applications. The Institute continued working actively in five selected tribal villages of Chhota Udaipur (Vadodara) and Dahod districts for the fifth consecutive year. Therefore, it is important to study the impact of introducing useful renewable energy technologies such as biogas plants, improved biomass cook stoves, solar light, provision of the natural sun light into the tribal homes though glass roof tiles, etc. on the socio-economic life of the communities.

The major RE devices that SPRERI has provided to tribal households in Gujarat are:

- Improved Biomass Cook Stove – Ceramic liner
- Improved Biomass Cook Stove – Air Insulated- Top feeding
- Improved Biomass Cook Stove – Air Insulated - Side feeding
- Solar Lantern LED
- Solar Lantern CFL
- Solar Light HLS
- Biogas Plant
- Solar Cooker device
- Solar Dryer
- Glass Roof Tiles
- Improved Biomass Cookstove - Dhabha size
- Biomass Cookstove -Community size
- Solar Water Heater

1.4 Research Problem

The study was undertaken to find out the answer to the questions such as whether or not the selected renewable energy gadgets/devices used by the beneficiary households had any impact on the various socio-economic parameters?. Whether or not the selected households adopted the technology/instruments and are they still using the same? What are the benefits realized by the beneficiary households while using these RE devices? What is the rate of willingness to pay for particular RE device by beneficiary households as compared to its present value?, What are the suggestions of users for improvement in these selected RE devices? What is the demand and willingness to pay by non beneficiary households for these RE devices?

1.5 Objectives

The specific objectives of the study were as follows:

1) To analyse the extent of adoption of renewable energy technologies in selected tribal villages of Gujarat.
2) To analyse the impacts of renewable energy technologies on selected tribal villagers of Gujarat.
3) To suggest the measures to raise the adoption level of renewable energy technologies in selected tribal areas of Gujarat.

1.6 Data and Methodology

The study is based on the primary data collected from the two selected tribal districts in Gujarat, where RE devices were set up by the agency (SPRERI), i.e. Dahod and Vadodara/Chhota Udaipur[4]. There were two villages (Simal Faliya, Raysingpura/Oliamba) from Chhota Udaipur taluka of Chhota Udaipur/Vadodara district and total three villages from Dahod district [i.e. two villages (Chilakota, Chaidiya) from Limkheda taluka and one village (Dageria) from Zalod taluka] covered under the scheme (see, Map 1.1). The study covered the total ten RE devices, viz. (a) Improved Biomass Cook Stove – Ceramic liner, (b) Improved Biomass Cook Stove – Air Insulated- Top feeding, (c) Improved Biomass Cook Stove – Air Insulated - Side feeding, (d) Solar Light LED, (e) Solar Light CFL, (f) Solar Light HLS, (g) Biogas Plant, (h) Solar Cooker, (i) Solar Dryer, (j) Glass Roof Tiles.

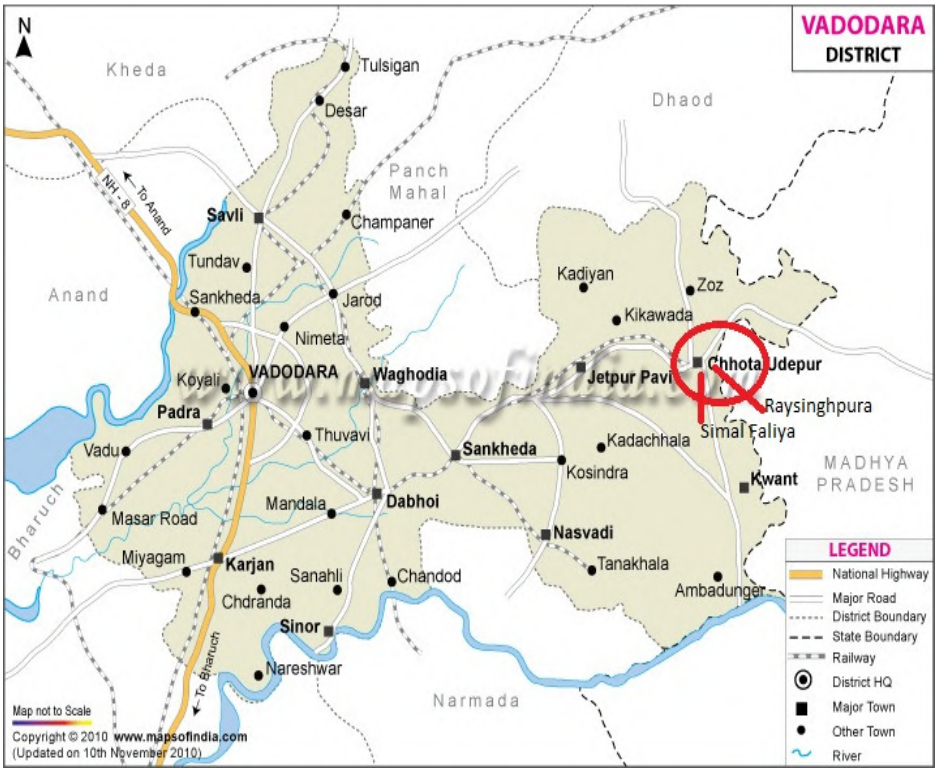
Table 1.1: Details on Selected Villages and Sample Households

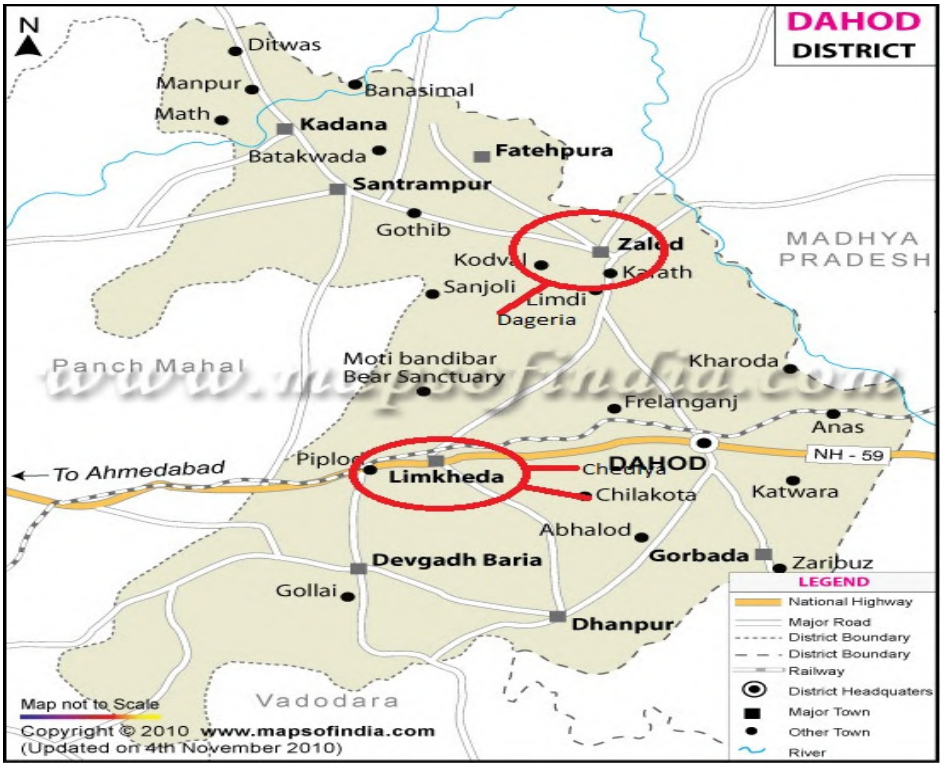
Sr. No.	Particulars	Dahod district	Chhota Udaipur district	Total
1	Number of beneficiary households	70	35	105
2	Number of non-beneficiary households	29	13	42
3	Total	99	48	147

Source: Field survey data.

[4] Chhota Udaipur district (also known as Chhota Udepur district) is the 28th district of Gujarat which was carved out of the Vadodara district on January 26, 2013.

Map 1.1: Location of Study Area





The village-wise RE devices-wise list of beneficiary was obtained from the SPRERI. As per the proportion of RE devices set up on subsidy rate in respective village, the 20 percent of total[5] beneficiary households for selected RE device in that village were drawn as a sample selected beneficiary households for the study. The data were collected on 166 RE devices from the selected 105 beneficiary households from these five villages (Table 1.1 and 1.2). In order to get some idea about demand and feedback on these RE devices from non-users, the data were collected from 42 non-beneficiary households (25 percent of total number of beneficiary units) from same villages (Table 1.1).

Table 1.2: Distribution of Sample Households

Sr. No.	Particulars	Beneficiary Households								Non Beneficiary households
		Vadodara/ Chhota Udaipur			Dahod				Grand Total	
		Simal Faliya	Raysingpura / Oliamba	Total	Dageriya	Chediya	Chilakota	Total		
1	Biomass Cook Stove – Ceramic liner	14	0	14	10	11	12	33	47	42
2	Biomass Cook Stove – Air Insulated- Top feeding	2	3	5	3	0	8	11	16	
3	Biomass Cook Stove – Air Insulated- Side feeding	4	2	6	9	0	10	19	25	
4	Solar Light LED	3	0	3	2	1	5	8	11	
5	Solar Light CFL	8	2	10	7	0	12	19	29	
6	Solar Light HLS	8	2	10	0	0	5	5	15	
7	Biogas Plant	1	1	2	1	1	5	7	9	
8	Solar Cooker	0	0	0	0	0	3	3	4	
9	Solar Dryer	0	0	0	0	0	2	2	2	
10	Glass Roof Tiles	0	0	0	3	0	5	8	8	
	Total	**40**	**11**	**51**	**35**	**13**	**68**	**115**	**166**	42

Source: Field survey data.

[5] See, Annexure I for total RE devices set up by the agency.

Besides formal survey through filling up of schedules, informal group discussions with beneficiaries and non-beneficiaries were also held. The conscious efforts have also been made to get the views of women and non-beneficiary households. The required data have been collected by canvassing a pre-designed and pre-tested schedule[6] during the period from January to February 2015. The due care was taken in selecting beneficiary households in order to avoid the effect of one device[77] on other.

The simple tabular analysis was carried out to know the change in various parameters related to livelihood in the selected villages.

1.7 Limitation of the Study

The major limitation of the study was that there was no benchmark survey (without RE devices) done in selected villages. Thus, data on impact of use of these RE technology was taken by asking question to the respondent on before and after use situation on selected livelihood parameter. Thus, data is based on recall memory of the respondent. The data on willingness to pay for RE device without subsidy was found under-quoted /less quoted by the respondents. In order to identify the beneficiary and some data, help of the agency personal was taken. Though selected area was tribal area, selected beneficiary households were found relatively well equipped with other technology/instruments, thus, carelessness about the devices was noticed which had effect on data reporting.

[6] The pretesting of schedules was done in January 2015.

[7] The beneficiary households had used more than one RE devices. In order to avoid effect of one RE device on other, due care was taken while selecting beneficiary households for particular RE device. The sample for three types of cook stove was selected separately as well as cook stove and biogas were kept different. Same procedure was followed for Solar light and glass roof tiles.

1.8 Structure of the Report

The present report is organized in five chapters. The first chapter discusses the background, rationale, objectives of the study and methodology used for data collection and data analysis. The coverage, sampling design and conceptual framework of the study have been discussed in this chapter.

The second chapter discusses the socio-economic profile of sample households, main features of the sample households including land ownership pattern, livestock holding with production and consumption of livestock products, cropping pattern and sources of irrigation, farm assets holdings and the details of agricultural credit availed, consumption pattern and nature of migration have been analyzed in Chapter II. The third chapter discusses the impact of RE Technology on various aspect of life of beneficiary households. The next chapter (i.e., chapter IV) examines the benefits of and constraints faced in using RE devices. The suggestions made by the beneficiary for availing benefits under NFSM have been presented in this chapter. The last chapter presents the concluding observations and policy implications of the study.

After introductory chapter, next chapter presents socio-economic profile of sample households.

CHAPTER II

Socio-Economic Profile of Selected Households

In order to assess the impact of RE technologies on the standard of living of selected households and the extent of adoption by these poor rural households (HHs), it is essential to know about existing socio-economic characteristics of these households. In this context, the present section discusses the socio-economic profile of the sample households.

2.1 Introduction

The SPRERI targeted to provide benefits of renewable energy (RE) technologies to underprivileged rural people in selected two districts of Gujarat (Dahod and Chhota Udaipur) on pilot basis. The 147 sample households were interviewed from five study villages which are scattered in nature and non-remote (Table 2.1). The major RE devices that SPRERI had provided to tribal households were solar light, biomass cook stove, glass roof tiles, biogas plant, solar cooker and solar dryer. Out of 887 RE devices set up in five villages of two districts (Dahod and Chhota Udaipur), about 31 per cent were solar light, 26.4 per cent were ceramic liner biomass cook stove, 23 per cent were air insulated biomass cook stove, 9.8 per cent were glass roof tiles and only 5 per cent were biogas plant (see, Annexure I).

Table 2.1: Distribution of Sample Households across Study Villages

District Name:		Dahod		Chhota Udepur	Total
Taluka Name:		Limkheda	Zalod	Chhota Udepur	
Type of villages	Scattered	2	1	2	5
	Compact	0	0	0	0
	Remote	0	0	0	0
	Non Remote	2	1	2	5
	Total	2	1	2	5
Total number of households		69	30	48	147

Source: Field survey data.

The sample consisted of two types: beneficiary (105 HHs), and non-beneficiary households (42 HHs). The 71.4 per cent of total sample households were beneficiary households and remaining 28.6 per cent were non-beneficiary households. Thus, our sample included proportionately more beneficiary households.

2.2 Occupation, Education and Caste

The average age of head of a beneficiary household was 45.4 years while that of non-beneficiary households was 41.3 years (Table 2.2). About 93.3 per cent of heads of beneficiary households and 100 per cent heads of non-beneficiary households were male. The majority of both beneficiary (94.3%) and non-beneficiary households (100%) were dependent on agriculture as their main occupation. However, dairy sector was identified as their source of subsidiary occupation in both groups. The average farming experience of heads of beneficiary and non-beneficiary households was found 20.6 years and 20.1 years, respectively. The average years of education of heads of beneficiary households and non-beneficiary households were 7.2 years and 5.2 years respectively. Thus, beneficiary household heads were relatively younger and more educated than non beneficiary heads.

The caste composition of our sample beneficiaries revealed that, the proportion of ST population was the highest among the sample selected households (96.2 per cent for beneficiary HHs and 83.3 per cent for non-beneficiary HHs). Whereas, the proportion of SC population was as low as 3.8 per cent in case of beneficiary HHs and as high as 16.7 per cent in case of non-beneficiary HHs. The OBCs and General categories HHs were not found among sample households. The proportion of BPL HHs were more among non-beneficiaries (50.0%) compared to beneficiaries (41.0%). The majority of beneficiary households (58.1 per cent) were above poverty line (APL) ration card holders.

Table 2.2: Socio-economic status of sample households

Sl. No.	Particulars	Unit	Beneficiary HHs	Non-Beneficiary HHs
1	Age of Head of households (year)	No. of years	45.43	41.29
2	Head of household			
	Male (%)	(% to total HHs)	93.33	100.00
	Female (%)	(% to total HHs)	6.67	0.00
3	Main occupation:			0.00
	Crop farming	(% to total HHs)	94.29	100.00
	Dairy		0.95	0.00
	Service		2.86	0.00
	Farm labour		0.95	0.00
	Others		0.95	0.00
4	Subsidiary Occupation:			0.00
	Crop farming	(% to total HHs having subsidiary occupation	6.74	0.00
	Dairy		48.31	48.48
	Service		10.11	0.00
	Farm labour		32.58	48.48
	Others		2.25	3.03
5	Farming experience (year)	Avg. no. of years	20.60	20.07
6	Education (year of schooling)	Avg. no. of years	7.24	5.21
7	Caste			
	SC	(% to total HHs)	3.81	16.67
	ST		96.19	83.33
	OBC		0.00	0.00
	Others		0.00	0.00
8	Have Ration card	(% to total HHs)	99.05	97.62
	APL	(% of HHs having ration card)	0.95	2.38
	BPL		58.10	47.62
	AAY		40.95	50.00
9	Have Saving Accounts:	(% to total HHs)	88.57	73.81
	Bank	(% of HHs having saving account)	11.43	26.19
	Post office		83.81	71.43
	Cooperative society		3.81	2.38
10	Toilet at home	(% to total HHs)	50.48	28.57
11	LPG at home	(% to total HHs)	15.24	4.76
12	GEB grid at home	(% to total HHs)	95.24	90.48

Source: Field survey data.

The average family size of a beneficiary household was smaller (5.5) than that of non-beneficiary households (6.3) (Table 2.3). The analysis of age composition of beneficiary and non-beneficiary households reveals that male members of beneficiary households were more aged (28.0 yrs) compared to non-beneficiary households (26.4 yrs), whereas female members were almost same aged (27.4 yrs) for both the categories. The

beneficiary households enjoyed better status over non-beneficiary households in term of education since the average numbers of education was higher for their members (7.3 years for male and 4.5 years for females) compared to that in non-beneficiary households (4.9 years for male and 3.4 years for females).

Table 2.3: Family background of Sample households

(Average of all household members)

Sl. No.	Particulars	Beneficiary HHs	Non-Beneficiary HHs
1	Family Size (No./hh)	5.52	6.31
	Male	2.92	3.38
	Female	2.60	2.93
2	Age (Years)		
	Male	28.00	26.44
	Female	27.39	27.43
3	Education (Years)		
	Male	7.26	4.87
	Female	4.46	3.42
4	Working in agriculture (% to total no. family members))		
	Male	54.07	54.23
	Female	53.48	55.28
5	Working in other area (% to total no. family members)		
	Male	5.86	4.23
	Female	4.03	0.81
6	Not working (% to total no. family members)		
	Male	40.07	41.55
	Female	42.49	43.90

Source: Field survey data.

About 54 per cent male members of both beneficiary households and non-beneficiary households were working in agriculture sector. However, slightly more female members in non-beneficiary category (55.3%) were engaged in agriculture sector compared to about 53.5 per cent female members of beneficiary households. Overall, the dependency rate (% non working members) was found more in case of beneficiary households (41.7% male and 43.2% females) compared to that in non-beneficiary households (38.0% male and 39.8% females).

2.3 Livestock Holding, Production and Consumption Pattern

As discussed in previous section, the livestock was found the major subsidiary source of income and employment for the sample HHs. Since agriculture in the both districts is highly risky venture depending on vagaries of rainfall, livestock holding provides the main platform for risk sharing. The details of livestock holding by the sample households have been presented in Table 2.4. The livestock holding by beneficiary and non-beneficiary HHs was mainly consist of cows and buffalos. The average number of cows held by a beneficiary and a non-beneficiary HH was 1.85 and 1.10 respectively. The average number of buffalos held by beneficiary and a non-beneficiary HH was 1.37 and 0.81 respectively. The average numbers of goats hold by a beneficiary and a non-beneficiary HH was 1.03 and 0.29 respectively. The average number of poultry birds held by a beneficiary was 0.5 while no poultry bird was reared by non-beneficiary HH. Thus, the beneficiary households were found to hold more livestock and poultry compared to that by non-beneficiary households.

Table 2.4: Livestock holding of Sample household

(No. of livestock/HH)

Sl. No.	Particulars	Beneficiary HHs			Non-Beneficiary HHs		
		Local	Cross bred	Total	Local	Cross bred	Total
1	Cow:						
	Milch	0.14	0.02	0.16	0.21	0.05	0.26
	Dry	0.30	0.00	0.30	0.21	0.00	0.21
	Young	0.90	0.00	0.90	0.38	0.00	0.38
	Male/Draught	0.48	0.00	0.48	0.24	0.00	0.24
	Total	**1.83**	**0.02**	**1.85**	**1.05**	**0.05**	**1.10**
2	Buffalo:	0.00	0.00	0.00	0.00	0.00	0.00
	Milch	0.40	0.02	0.42	0.29	0.00	0.29
	Dry	0.45	0.00	0.45	0.38	0.00	0.38
	Young	0.29	0.00	0.29	0.07	0.00	0.07
	Male/Draught	0.22	0.00	0.22	0.07	0.00	0.07
	Total	**1.35**	**0.02**	**1.37**	**0.81**	**0.00**	**0.81**
3	Sheep	0.00	0.00	0.00	0.00	0.00	0.00
4	Goat (He)	0.29	0.00	0.29	0.00	0.00	0.00
5	Goat (She)	0.74	0.00	0.74	0.29	0.00	0.29
6	Poultry	0.50	0.00	0.50	0.00	0.00	0.00

Source: Field survey.

Table 2.5: Production and Consumption of Livestock Products

(unit/household having livestock)

Sl. No.	Particulars	Beneficiary HHs	Non-Beneficiary
1	Average milk per day (lit)		
	Cow	4.9	4.1
	Buffalo	4.0	3.3
	Goat	0.2	0.6
2	Consumption of milk		
	Cow (lit/day)	1.5	1.7
	Buffalo (lit/day)	2.0	2.3
	Goat (lit/month)	0.2	0.6
3	Income from the milk (per month)		
	Cow	2802.3	1873.3
	Buffalo	3644.1	1588.8
	Goat	0.0	0.0
4	Income from the poultry bird (per month)	100.0	0.0
5	Income from renting out animal (Rs/month)	0.0	0.0
6	Total income (Rs./month)		
	Cow	36430.0	16860.0
	Buffalo	58305.0	19065.0
	Goat	0.0	0.0
	Sheep	0.0	0.0
	Poultry	200.0	0.0
7	Dung collection (Kg/day)		
	Cow	26.3	31.4
	Buffalo	26.3	24.2
	Goat	3.8	2.5
8	Dung animal waste use (kg/day)		
8A	Dung cake		
	Cow	9.6	13.5
	Buffalo	8.1	9.0
	Goat	0.9	0.0
8B	FYM (kg/day)		
	Cow	13.2	16.1
	Buffalo	16.1	15.2
	Goat	2.0	2.5
8C	Bio-gas (kg/day)		
	Cow	3.4	1.8
	Buffalo	1.6	0.0
	Goat	0.9	0.0
8D	Any other (kg/day)		
	Cow	0.1	0.0
	Buffalo	0.5	0.0
	Goat	0.0	0.0

Source: Field survey

The details of production and consumption of livestock products by the sample households have been presented in Table 2.5. The average amount of livestock products and income generated from them was higher in case of beneficiary households compared to non-beneficiary households. The average annual income generated from livestock products was found to be about Rs 36430/- from cow and Rs 58305/- from buffalos in case of beneficiary households. Whereas in case of non-beneficiary households, the average amount of income generated from cow and buffalos was Rs 16860/- and Rs 19065/-, respectively.

2.3 Land Ownership Pattern and Sources of Irrigation

The net sown area (NSA) and gross cropped area (GCA) of a beneficiary household was found to be 3.54 acre and 5.68 acre, respectively which imply that the cropping intensity was 160.6 per cent (Table 2.6 & Table 2.10). On the other hand, the net sown area (NSA) and gross cropped area (GCA) of non-beneficiary household was 3.21 acre and 4.10 acre, respectively which imply that the cropping intensity for non-beneficiary households was 127.8 per cent. Thus, the agricultural lands had been utilized more intensively by the beneficiary household.

The size of available own area for cultivation for beneficiary households and non-beneficiary households was 3.43 acre and 3.13 acre, respectively. The size of operational holding for beneficiary households and non-beneficiary households was 3.54 acre and 3.21 acre respectively. It may be noted that the proportions of leased-out land was nil in case of both category of our sample farmers. The average size of land leased-in for beneficiary households and non-beneficiary households was 1.57 acre and 1.75 acre respectively. In case of beneficiary households, the term of lease-in land for about 71.4 per cent of HHs was share cropping and for remaining 28.6 per cent HHs, it was fixed rent in cash (Table 2.9). On the other hand, the term of land lease-in case of non-beneficiary households was equally distributed (50% each) between share cropping and fixed rent

in cash. It can be further noted that the area under irrigation for beneficiary households and non-beneficiary households was 51.1 per cent and 45.2 per cent of total operated area, respectively. In case of beneficiary households, the irrigated area for the categories of marginal farmers, small farmers, semi-medium farmers and medium farmers was 70.0 per cent, 62.2 per cent, 49.6 per cent and 25.6 per cent, respectively (Table 8). There was no farmer from large farm holdings size gorup in our sample.

Table 2.6: Land Ownership Pattern

(area in acre)

Sl. No.	Indicators	Beneficiary	Non-Beneficiary
1	Total own land		
	Irrigated	1.74	1.38
	Unirrigated	1.69	1.74
	Total	3.43	3.13
2	Leased-in-land		
	Irrigated	1.07	1.50
	Unirrigated	0.50	0.25
	Total	1.57	1.75
3	Leased-out-land		
	Irrigated	0.00	0.00
	Unirrigated	0.00	0.00
	Total	0.00	0.00
4	Operational holding		
	Irrigated	1.81	1.45
	Unirrigated	1.72	1.76
	Total	3.54	3.21

Source: Field survey data.

As far as different sources of irrigation are concerned, as high as 63.9 per cent of total operated area of beneficiary farmers was irrigated by open well or dug wells followed by tube wells (24.5%), usually energized by electricity and/or diesel (Table 2.8). Canal and tank and other source of irrigation were minor contributors to irrigation coverage in the study regions as their joint contribution was about 2.1 per cent in the case of beneficiary households. The area irrigated through canals and check dams was nil for both categories of sample households.

Table 2.7: Classification of Land Ownership Pattern

(area in acre)

Sl. No.	Indicators	Beneficiary						Non-Beneficiary					
		MF	SF	SMF	MDF	LF	Total	MF	SF	SMF	MDF	LF	Total
1	Total own land												
	Irrigated	1.05	1.92	2.77	3.14	0.00	1.74	0.67	1.38	3.00	3.33	0.00	1.38
	Unirrigated	0.41	1.14	3.50	9.14	0.00	1.69	0.63	1.72	3.21	7.33	0.00	1.74
	Total	1.46	3.05	6.27	12.29	0.00	3.43	1.29	3.09	6.21	10.67	0.00	3.13
2	Leased-in-land												
	Irrigated	0.58	4.00	0.00	0.00	0.00	1.07	0.00	3.00	0.00	0.00	0.00	1.50
	Unirrigated	0.58	0.00	0.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.00	0.25
	Total	1.17	4.00	0.00	0.00	0.00	1.57	0.50	3.00	0.00	0.00	0.00	1.75
3	Leased-out-land												
	Irrigated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Unirrigated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Operational holding												
	Irrigated	1.01	1.91	3.07	3.14	0.00	1.81	0.67	1.38	2.67	4.50	0.00	1.45
	Unirrigated	0.43	1.16	3.13	9.14	0.00	1.72	0.65	1.72	3.25	6.25	0.00	1.76
	Total	1.44	3.07	6.19	12.29	0.00	3.54	1.31	3.09	5.92	10.75	0.00	3.21

Note: Categorize the sample farmers under four classes such as 0 - 2.5 Acre - Marginal, 2.51 to 5.0 - Small, 5.01 - 10.0 – Semi medium, 10.01 - 22.5 Medium, 22.51 to above large

Source: Field survey data.

Table 2.8: Source of irrigation of sample household

(Area in acre/HH)

Sl. No.	Indicators	Beneficiary		Non-Beneficiary	
1	Canal	0.00	(0.0)	0.00	(0.0)
2	Check dam	0.00	(0.0)	0.00	(0.0)
3	Farm pound	0.01	(0.5)	0.05	(3.3)
4	River	0.03	(1.6)	0.10	(6.6)
5	Tank	0.00	(0.0)	0.00	(0.0)
6	Well	1.15	(63.9)	0.94	(64.8)
7	Tube well	0.44	(24.5)	0.32	(22.1)
8	Any other	0.17	(9.5)	0.00	(0.0)
9	Total area under irrigation (Ha per hh)	1.81	(100.0)	1.45	(100.0)
10	Area under irrigation (percent of NSA)	51.11		45.27	

Note: Figures in parentheses are the percentages of total area under irrigation.

Source: Field survey

Table 2.9: Terms of Land Lease-in and Leased-out

(Area in acre/HH)

Sl. No.	Indicators	Beneficiary	Non-Beneficiary
1	Total leased-in-land	1.57	1.75
2	Total leased-out-land	0.00	0.00
3	Terms of lease (% of household)		
	Share cropping	71.43	50.00
	Fixed rent in cash	28.57	50.00
	Fixed rent in kind	0.00	0.00
	Both	0.00	0.00
	Against labour	0.00	0.00
	Others	0.00	0.00

Source: Field survey data.

2.4 Cropping Pattern

The cropping pattern of the sample household (HH) is presented in Table 2.10 shows that the distribution of area under different crops and under different crop groups. The GCA per HH of a beneficiary household and non-beneficiary household was estimated to be 5.68 acre and 4.10 acre, respectively. Overall, the per-HH area under *Kharif* and *Rabi* crops cultivated by a beneficiary household was 3.72 acre and 1.90 acre, respectively. The per-HH area under *Kharif* and *Rabi* crops cultivated by a non-beneficiary household was 2.70 acre and 1.39 acre, respectively. The area under summer crops was meager in case of both categories. The share of kharif crop and rabi crop in GCA was 65.49 per cent and 33.45 per cent respectively for beneficiary households. The same for non-beneficiary households was 65.85 per cent and 33.90 per cent respectively.

Among various *Kharif* crops, the area under cereals (such as maize and paddy), pulses (such as urad/black gram), cotton and oilseeds (such as groundnut and soybean) constituted the major proportion of total kharif area for both beneficiary and non-beneficiary households.

Table 2.10: Cropping Pattern

Sl. No.	Crops	Irri/Unirri	Beneficiary (Area in acre/HH)	Beneficiary % to GCA	Non-Beneficiary (Area in acre/HH)	Non-Beneficiary % to GCA
A	Kharif season					
	Maize	Irrigated	0.79	13.91	0.66	16.10
		Unirrigated	0.72	12.68	0.71	17.32
	Paddy	Irrigated	0.61	10.74	0.39	9.51
		Unirrigated	0.38	6.69	0.21	5.12
	Soyabean	Irrigated	0.33	5.81	0	0.00
		Unirrigated	0	0.00	0	0.00
	Cotton	Irrigated	0.17	2.99	0.23	5.61
		Unirrigated	0.28	4.93	0.02	0.49
	Tur	Irrigated	0.08	1.41	0.17	4.15
		Unirrigated	0.16	2.82	0.1	2.44
	udad	Irrigated	0.01	0.18	0	0.00
		Unirrigated	0.06	1.06	0.13	3.17
	Groundnut	Irrigated	0.07	1.23	0.07	1.71
		Unirrigated	0	0.00	0	0.00
	Vegetables	Irrigated	0.03	0.53	0.01	0.24
		Unirrigated	0.04	0.70	0	0.00
	Total Kharif Crops	Irrigated	2.09	36.80	1.52	37.07
		Unirrigated	1.63	28.70	1.18	28.78
		Total	3.72	65.49	2.7	65.85
B	Rabi Season					
	Maize	Irrigated	0.46	8.10	0.67	16.34
		Unirrigated	0.14	2.46	0.07	1.71
	Wheat	Irrigated	0.68	11.97	0.49	11.95
		Unirrigated	0.16	2.82	0.01	0.24
	Jowar	Irrigated	0	0.00	0	0.00
		Unirrigated	0.01	0.18	0.02	0.49
	Gram	Irrigated	0.23	4.05	0.12	2.93
		Unirrigated	0.2	3.52	0	0.00
	Vegetable	Irrigated	0.03	0.53	0.01	0.24
		Unirrigated	0	0.00	0	0.00
	Total Rabi Crops	Irrigated	1.39	24.47	1.29	31.46
		Unirrigated	0.51	8.98	0.1	2.44
		Total	1.9	33.45	1.39	33.90
C	Summer Season					
	Maize	Irrigated	0.02	0.35	0	0.00
		Unirrigated	0	0.00	0	0.00
	Groundnut	Irrigated	0	0.00	0.01	0.24
		Unirrigated	0	0.00	0	0.00
	Watermalon	Irrigated	0.03	0.53	0	0.00
		Unirrigated	0	0.00	0	0.00
	Total Summer Crops	Irrigated	0.05	0.88	0.01	0.24
		Unirrigated	0	0.00	0	0.00
		Total	0.05	0.88	0.01	0.24
D	Gross Cropped Area					
		Irrigated	3.53	62.15	2.82	68.78
		Unirrigated	2.15	37.85	1.28	31.22
	GCA	Total	5.68	100.00	4.10	100.00
E	Cropping Intensity (%)		160.6		127.8	

Note: * Partial/protective irrigation (one/tow) area counted under irrigation
Source: Field survey.

Among various *Rabi* crops, the area under maize, wheat, cotton, groundnut, tur, gram and vegetables constituted the major proportion of total rabi area for both beneficiary and non-beneficiary households. The 51.5 per cent of total area under *Kharif* crops of beneficiary households was provided with protective irrigation whereas corresponding figure was 55.1 per cent for non-beneficiary households, which implies that the level of production risk induced by rainfall variability was quite high in the study areas.

2.5 Asset Holdings and Facilities at Home

The overall asset base and facilities available at home of the sample households in Chhota Udepur and Dahod districts are presented in Table 2.11 and Table 2.12. It was observed that non-beneficiary households were better off than beneficiary households in terms of having number houses and cattle sheds. However, beneficiary households had better position in terms of having two wheeler and four wheeler, tractors and other agricultural implements and infrastructures. About 92.4 per cent beneficiary households had houses (kuchha/pucca) against 95.2 per cent of non-beneficiary households (Table 2.11).

The number of kuccha houses were slightly more in case of non-beneficiary households, whereas the number of pucca houses were more in case of beneficiary households. About 11.4 per cent beneficiary households had pucca houses against 9.5 per cent of non-beneficiary households. As regards kuchha houses, about 81.0 per cent beneficiary households had kuchha houses against 85.7 per cent of non-beneficiary households. However, the number of cattle sheds were higher in case of non-beneficiary households (0.79) compared to 0.66 number of cattle sheds of beneficiary households.

On an average, a beneficiary household (HH) had 0.38 number of TV connection and 0.03 number of Local Cable connection (Table 2.12). They had paid Rs 203.33 per month for Local Cable connection. On

contrary, a non-beneficiary had 0.14 number of TV connections. Non beneficiary households did not have any local cable connection. The beneficiary households had 0.30 number of Dish TV connection for which they had paid Rs 177.0 per month. On the other hand, the non-beneficiary households had 0.12 number of Dish TV connection per HH for which they had paid Rs 260.0 per month.

Table 2.11. Assets and farm machinery of sample households

Sl. No.	Types of assets	Beneficiary Households		Non-Beneficiary Households	
		Number per HH	% HHs having the asset	Number per HH	% HHs having the asset
1	Own house:	0.92	92.38	0.95	95.24
	Kuchha	0.81	80.95	0.86	85.71
	Pucca	0.11	11.43	0.10	9.52
2	Farm house(cattle shed):	0.66	65.71	0.79	76.19
	Kuchha	0.64	63.81	0.74	71.43
	Pucca	0.02	1.90	0.05	4.76
3	Two wheeler	0.47	45.71	0.19	19.05
4	Four wheeler	0.06	3.81	0.00	0.00
5	Tractor and implements	0.07	6.67	0.00	0.00
6	Combined harvester	0.01	0.95	0.00	0.00
7	Threshing machine	0.02	1.90	0.00	0.00
8	Tube well/bore well/open well	0.29	28.57	0.19	19.05
9	Oil engine	0.18	19.05	0.19	19.05
10	Any other (Floor mill)	0.01	0.95	0.00	0.00

Source: Field survey

The beneficiary households had used 4.6 number of cylinders per annum for which they had paid Rs 434/-. On the other hand, the non-beneficiary households had used 3.0 number of cylinders per annum for which they paid Rs 427/-. Almost every beneficiary household had mobile phones, where as corresponding figure was about 69 per cent for non-beneficiary households.

Table 2.12: Facilities at the Home of Sample Households

Sl. No.	Types of Assets	Units	Beneficiary	Non-Beneficiary
1	TV	No. of units/HH	0.38	0.14
	Local cable connection	No. of units/HH	0.03	0.00
	Monthly Expenditure	(Rs./month)	203.33	0.00
2	Dish TV connection	No. of units/HH	0.30	0.12
	Monthly Expenditure	(Rs./month)	176.97	260.00
3	LPG Gas stove	No. of units/HH	0.11	0.07
	Monthly Expenditure	(Rs./month)	155.75	95.00
4	No. of cylinder per year	No. of units/HH	4.55	3.00
	Cost of cylinder	(Rs./cylinder)	434.00	427.00
5	Mobile	No. of units/HH	0.91	0.69
	Monthly Expenditure	(Rs./month)	157.45	163.01
6	GEB	No. of units/HH	0.94	0.88
	Monthly Expenditure	(Rs./month)	296.15	201.14
	No. of bulbs	No. of units/HH	2.45	1.86
	Watt.	No. of units/HH	54.97	39.91
	Hrs.	No. of units/HH	4.04	4.67
	No. of tube light	No. of units/HH	1.71	2.20
	Watt.	No. of units/HH	26.89	18.75
	Hrs.	No. of units/HH	2.47	3.33
	Day watt. Hrs	No. of units/HH	1.64	2.19
	Night watt. Hrs	No. of units/HH	3.32	2.68
7	Water supply Connection	No. of units/HH	0.55	0.31
	Monthly Expenditure	(Rs./month)	50.00	50.00
	Government pipe	No. of units/HH	0.32	0.10
	River	No. of units/HH	0.00	0.00
	Pond	No. of units/HH	0.00	0.00
	well	No. of units/HH	0.10	0.02
	Hand pump	No. of units/HH	0.15	0.12
8	Tube well or Bore well	No. of units/HH	0.37	0.10
	Monthly Expenditure	(Rs./month)	820.00	500.00
	Average depth of water	in feet	168.20	50.00
9	Water lifting machine	No. of units/HH	0.24	0.10
	Average horse power	HP/HH	2.48	3.00
	Use per day	Hrs/HH	3.50	3.13

Source: Field survey

2.6 Sources of Borrowings

Table 2.13 shows the details of borrowing by the sample HHs. It is very much clear that the about 23 percent beneficiary HHs and about 17 percent non beneficiary households had taken loan. Beneficiary hh had succeeded to avail more credit compared to non-beneficiary HHs. A beneficiary HH had availed Rs. 9062/- of credit loans from various commercial banks and cooperatives as against of Rs. 48857/- of institutional loans by a beneficiary HH. Borrowings from informal sources such as landlord, employers and traders-cum-money lenders which are generally very costly were not found to prevail in study areas. As far as the purpose of borrowing is concerned, crop cultivation, tractor purchase, land reclamation and purchase of agricultural implements and livestock were the major purposes for which loans were taken.

Table 2.13: Sources of credit of sample household

Sl. No.	Details of credit	Beneficiary (n=24)	Non-Beneficiary (n=7)
1	Total Households taken loan (% to total)	22.9	16.67
	Average amount of loan (Rs/HH)	90625	48857
2	Source of loan (% of all HHs):		
	Commercial bank	75.00	85.71
	Cooperative bank	20.83	14.29
	Land development bank	0.00	0.00
	Government programme	4.17	0.00
	Traders/money lenders	0.00	0.00
	Ahartia/Commission agent	0.00	0.00
	Friends/relatives	0.00	0.00
3	Purpose of loan (% of all HHs)		
	Crops	58.33	71.43
	Tractor purchase	8.33	14.29
	Land reclamation	4.17	14.29
	Any other (Buffalo, Bore well, Shop, Oil Engine, Home loan)	29.17	0.00
5	Average rate of interest (% per annum)	6.56	5.14
6	Average to total debt outstanding at the time of survey (Rs/HH)	40167	23143
7	Amount of loan utilized for (% of all HHs):		
	Crops	58.33	71.43
	Tractor purchase	8.33	14.29
	Land reclamation	4.17	14.29
	Any other (Buffalo, Bore well, Shop, Oil Engine, Home loan)	29.17	0.00

Source: Field survey

In case of beneficiary households, about 13.3 per cent of households were taken loans for agricultural crop growing purpose, 6.7 per cent of them resorted loans for the purchase of agricultural implements and livestock, among others. However, in case of non-beneficiary households, about 11.9 per cent of households were taken loans for agricultural crop growing by whereas none of them resorted for loans for purchase of purchase of agricultural implements and livestock. The average rate of interest paid was found slightly higher for beneficiary households (6.56 %) compared to non-beneficiary households (5.1 %).

2.7 Consumption Pattern

The per-household consumption of food and non-food items by the beneficiaries and non-beneficiaries were found to be reasonable in the study areas. The beneficiaries had enjoyed better status with regard to consumption of different food and non-food items over non-beneficiary households. They had spent more on most items compared to that by non-beneficiary HHs. Among different kinds of food items consumed by beneficiary households, major proportion of expenditure was on rice, wheat, maize, tur, cotton and groundnut oils, milk and ghee for both categories of households (Table 2.14).

Among non-food items, the annual expenses on education, clothes, Fuel & electricity, medical expenses and loan repayment accounted major proportion of total household spending by the sample HHs (Table 2.15). Except few exceptions, there were no much differences observed between beneficiary and non-beneficiary HHs with respect to monthly and annual consumption pattern. Beneficiaries were found to spend more on rice (Rs. 453.9 per month) compared to non-beneficiaries (Rs 386.4 per month). The amount spent on loan repayment was Rs 17651.0 per annum by a beneficiary household against Rs 9532.1 by a non-beneficiary household.

Table 2.14 : Monthly Consumption Expenditure of sample household

(Unit/household)

Sl. No.	Items	Beneficiary HHs		Non-Beneficiary HHs	
		Quantity	Expenses (Rs/hh)	Quantity	Expenses (Rs/hh)
1	Rice (kg)	15.2	453.9	12.9	386.4
2	Wheat (kg)	13.9	348.6	13.0	348.7
3	Jowar (kg)	0.0	0.0	0.0	0.0
4	Bajra (kg)	0.2	1.5	0.0	0.0
5	Maize (kg)	25.8	258.2	22.5	230.2
6	Gram (kg)	1.8	70.9	1.3	180.0
7	Tur (kg)	3.2	259.4	2.8	305.8
8	Moong (kg)	0.2	12.4	0.2	116.7
9	Udad (kg)	1.0	50.5	1.2	170.0
10	Cotton oil (lit)	5.8	467.8	5.2	496.0
11	Groundnut oil (lit)	0.5	70.0	1.0	1100.0
12	Sugar (kg)	5.1	177.5	4.5	159.2
13	Gud khandsari (kg)	0.6	11.2	1.4	96.7
14	Salt (kg)	2.3	46.5	1.6	37.3
15	Spices (gms)	1037.1	165.9	842.9	202.3
16	Milk (lit)	12.6	377.1	9.1	635.0
17	Ghee (lit)	0.1	28.9	0.0	0.0
18	Butter milk (lit)	0.6	6.3	0.0	0.0
19	Curd (lit)	0.1	10.4	0.0	0.0
20	Vegetables (kg)	10.8	215.3	11.5	292.1
21	Furits (kg)	1.8	88.6	1.4	133.0
22	Kerosene oil (lit)	4.9	73.4	5.4	80.7
23	Bread, biscuits	0.1	1.0	0.0	0.0

Source: Field survey DATA.

Table 2.15 : Yearly Consumption Expenditure of Sample Household

(Rs/HH)

Sl. No.	Items	Beneficiary HHs	Non-Beneficiary HHs
1	Education	2457.1	2381.0
2	Fuel & electricity	1894.1	2049.0
3	Medical expenses	1770.5	1652.4
4	Transport & communication	1421.9	1571.4
5	Clothing	817.1	807.1
6	Footwear	192.5	348.8
7	Recreation	4.8	0.0
8	Loan repayment	489.5	154.8
9	Repair of consumer durables	22.9	0.0
10	Social function (marriage/shradh)	17651.0	9532.1
11	Any other	0.0	0.0

Source: Field survey data.

2.8 Nature and Causes of Migration

As evident from Table 2.16 and Table 2.17 (also Figures 2.1 and 2.2), non-beneficiary households were more affected on migration front. Some members of about 42.9 per cent of non-beneficiary HHs as against 18.1 per cent of beneficiary HHs had migrated out to get wage employment and income. Out of households having migrated members, about 83.3 per cent of non-beneficiary HHs as against 73.37 per cent of beneficiary HHs had some members migrated out every year. About 16.7 per cent of non-beneficiary HHs and 26.3 per cent of beneficiary HHs had migrated out during bad monsoon years. The duration of migration was much higher for non-beneficiary households (129.7 days) compared to 85 days for beneficiary households. However, the non-beneficiary migrants earned better wages (Rs. 245.5 by males and Rs 242.5 by females) than beneficiary migrants (Rs. 235.5 by males and Rs 234.4 by females). The majority of migrant workers were engaged in labour intensive works.

As far as causes of migration is concerned, it was observed that majority of sample migrant households had to migrate out for earning wages since they were not economically sound. About 84.2 per cent of beneficiary households cited the motive to earn wages as a major cause of migration, whereas about 55.6 per cent of non-beneficiary households cited that their family had to migrate out since they were not economically sound. About 22.2 per cent of non-beneficiary households expressed that they wanted to migrate out since they were not having any work and they were free of their traditional agricultural works which is mainly seasonal in nature.

Table 2.16: Details of migration of sample households

(% of HHs)

Sl. No.	Particulars	Beneficiary	Non-Beneficiary
1	% of Households having some members migrated	18.1	42.9
2	Nature of migration (% of migrated HHs):		
	Every year	73.7	83.3
	Alternate year	0.0	0.0
	Bad monsoon year	26.3	16.7
3	Migration during season(% of migrated HHs)*		
	Kharif	31.6	27.8
	Rabi	68.4	83.3
	Summer	94.7	94.4
4	Duration of migration (days/Year)	85.0	129.7
5	Distance (kms.)	273.7	282.4
6	Family migrate		
	Male	71.1	45.9
	Female	28.9	27.0
7	Wages earned (Rs./day)		
	Male	235.5	245.5
	Female	234.4	242.5
8	Nature of work at new place(% of migrated HHs)		
	Labour work	52.63	50.00
	Company work	10.53	11.11
	Machinery work	10.53	11.11
	Tractor work	5.26	11.11
	Tiles work	5.26	0.00
	Construction work	10.53	11.11
	Agri. Work	5.26	5.56

Note: * Multiple responses.
Source: Field survey data.

Table 2.17: Causes of migration

(% of HHs migrated)

Sl. No.	Reason	Beneficiary	Non-Beneficiary
1	To earn wages	84.2	16.7
2	Economically not sound	21.1	55.6
3	Less land	10.5	11.1
4	Free of agriculture work	5.3	22.2
5	Drought	0.0	5.6
6	Heavy loan amount	0.0	5.6

Source: Field survey

Fig. 2.1: Causes of Migration for Beneficiary hh

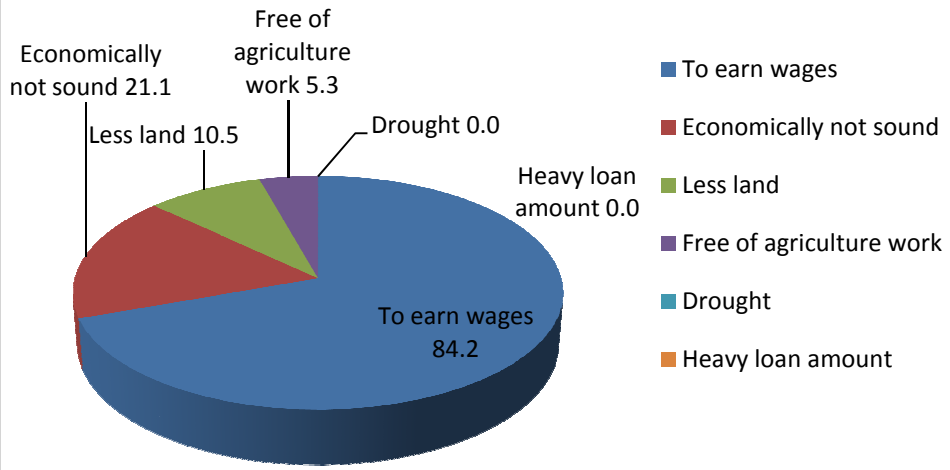
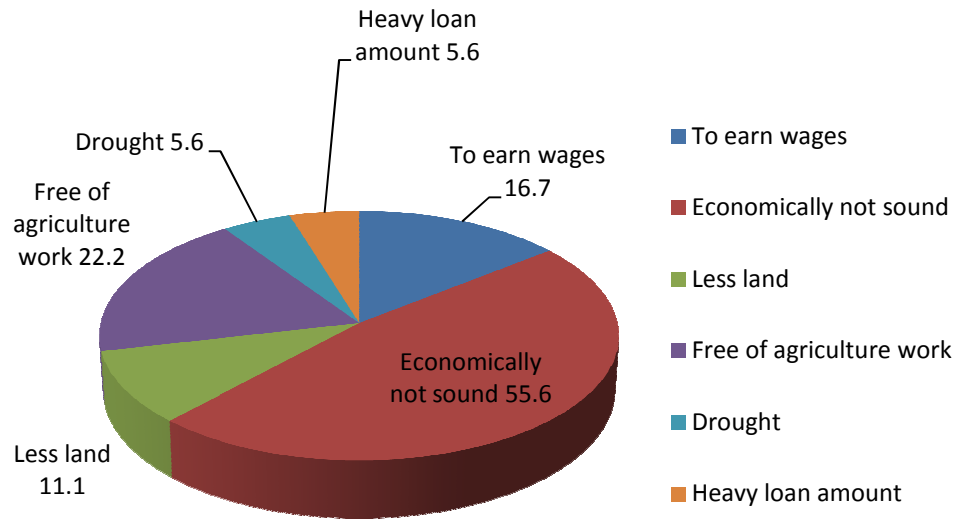


Fig. 2.2: Causes of Migration for Non-Beneficiary hh



The next chapter presents the impact of RE devices on various parameters of livelihood of beneficiary households.

CHAPTER III

Impact of RE Technology

3.1 Renewable Energy Devices- Cost and Subsidy:

The details on numbers of unit set up and cost per unit paid by the beneficiary households after subsidy amount are presented in Table 3.1. It can be seen from the table that all the beneficiary households were using the renewable energy devices set up at subsidized cost by the SPRERI. The maximum numbers of RE devices set up among these households were improved biomass cook stove- ceramic liner, followed by solar light CFL and improved biomass cook stove-air insulated-side feeding. Solar dryer was the least preferred in selected study area.

Table 3.1: Renewable technologies used by beneficiary households

Sl. No.	Particulars	No. of unit purchased*		Cost per unit (Rs.)		
		Total	Units/ HH	Amount paid	SPRERI paid	Total cost
1	Biomass cook stove- Ceramic liner (BCS-CL)	47	0.45	200	800	1000
2	Biomass cook stove- Air insulated -Top feeding (BCS-AITF)	16	0.15	200	900	1100
3	Biomass cook stove- Air insulated -Side feeding (BCS-AISF)	25	0.24	200	1110	1310
4	Solar light LED (SL-LED)	11	0.1	1000	3095	4095
5	Solar light CFL (SL-CFL)	32	0.3	1000	3095	4095
6	Solar light HLS (SL-HLS)	16	0.15	1000	2675	3675
7	Biogas Plant (BIOP)	10	0.1	3500	19000	22500
8	Solar Cooker (SCOOK)	5	0.05	750	1450	2200
9	Solar Dryer (SDRY)	2	0.02	100	1300	1400
10	Glass Roof Tiles (CRT)	11	0.1	50	390	440

Note: *All devices were provided by SPRERI.
Source: Field survey data.

The RE devices were set up at very high subsidized rate[1] by the SPRERI. The amount paid by the beneficiary households after subsidy amount was ranging from 15 to 20 percent in case of cook stove, 24 to 27 percent in case of solar light, around 16 percent in case of biogas, 11 percent in glass roof tiles and about 7 percent in case of solar dryer.

3.2 Sources of information:

The details on sources of information of the renewable technologies used by beneficiary households presented in Table 3.2 indicates that the SPRERI personnel was the major source of information about these RE technologies, followed by village level workers, fellow farmers as well as information received/collected by him on his own. It was very strange to note here that no other agency[2] (viz., Newspaper, TV/Radio as well as NGOs) working in study area had extension/renewable technology dissemination programme.

Among the sources of information for various RE technologies, village level workers had played important role in disseminating the information about the RE devices to the various households. Most of the village workers identified by the implementing distributing agency were the first user of the RE device as they work as contact hub for any demand request for any RE device by any villager. They also hold the stock of RE devices as desired by the agency in order to minimize the time lag as well as hassle in meeting with agency person for same.

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[1] In order to have sense of usefulness and care attitude towards the use of these RE devices, the nominal amount was charged to the beneficiary households. The amount generated from the collection on account of beneficiary payment was kept aside and was used by SPRERI towards repair and maintenance of these RE devices.

[2] While addressing India's energy security challenges, Ministry of New and Renewable Energy (MNRE), Government of India and the Jawaharlal Nehru National Solar Mission (JNNSM). In order to achieve this objective, the MNRE has launched a capital cum interest subsidy scheme for creation of off-grid, decentralised solar powered energy harvesting devices through application of photo voltaic technology for the purpose of lighting, heating, etc. at the level of domestic and mini commercial applications (source: https://www.nabard.org/english/Eligibleschemes.aspx).

Table 3.2: Sources of information of the renewable technologies used by Beneficiary households

Sr. No.	Particulars	Sources of information (% of total HHs – RE device-wise)							
		Own	Fellow farmers	Village level worker	Any Other NGOs	SPRERI Personnel	News paper	TV/ Radio	Any other Source
1	Biomass cook stove-Ceramic liner	2.1	4.3	17.0	0.0	68.1	0.0	0.0	8.5
2	Biomass cook stove-Air insulated -Top feeding	12.5	0.0	18.8	0.0	68.8	0.0	0.0	0.0
3	Biomass cook stove-Air insulated -Side feeding	0.0	8.0	20.0	0.0	68.0	0.0	0.0	4.0
4	Solar light LED	0.0	9.1	18.2	0.0	63.6	0.0	0.0	9.1
5	Solar light CFL	3.1	6.3	9.4	0.0	75.0	0.0	0.0	6.3
6	Solar light HLS	0.0	0.0	12.5	0.0	68.8	0.0	0.0	18.8
7	Biogas Plant	10.0	0.0	10.0	0.0	80.0	0.0	0.0	0.0
8	Solar Cooker	0.0	0.0	20.0	0.0	80.0	0.0	0.0	0.0
9	Solar Dryer	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
10	Glass Roof Tiles	12.5	12.5	0.0	0.0	75.0	0.0	0.0	0.0

Source: Field survey data.

3.3 Improved Biomass Cook Stove and Domestic Chulha:

It was observed that almost all the selected households are using improved Biomass Cook Stove and preferred same due its mobility (TABLE 3.3 and Figures 3.1 to 3.4). However, in case of improved BCS Top Feeding, most of the households reported that it is very tedious/cumbersome to cook rotla on top feeding cook stove as every time one need to remove the fry pan. Thus, these households are still using domestic chulha for the purpose of rotla making and hot water purpose whereas BCS-TF is mostly used for preparation of tea, rice, sabji, dal, etc. The rotla is main item in food and therefore beneficiary households had kept both BCS-TF and domestic Chula in use.

Table 3.3: Comparison among types of biomass cook stoves and domestic chulha

(% of HHs availing devices)

Sr. No.	Particulars		Units	Domestic chulha	BCS - CL	BCS-AI-TF	BCS-AI-SF
				N=86	N=47	N=16	N=25
1	Use of present stove		% of total HHs	100.00	97.87	93.75	100.00
2	Place of kitchen	Inside	% of total HHs	98.84	95.74	68.75	36.00
		Outside		1.16	4.26	31.25	64.00
3	Place of stove	Inside	% of total HHs	94.19	14.89	43.75	12.00
		Outside		5.81	80.85	56.25	88.00
		Both		0.00	4.26	0.00	0.00
4	Mobility of stove	Movable	% of total HHs	15.12	100.00	100.00	100.00
		Fixed		84.88	0.00	0.00	0.00
5	Height of stove		In mm	150.63	330.00	325.00	325.00
6	Weight of stove		Kg	10.38	14.50	8.00	8.50
7	Stove used for:		% of total HHs				
	Rotla making			100.00	80.85	68.75	84.00
	Tea/Sabji/Rice/Dal			87.21	97.87	100.00	96.00
8	Requirement of fuel for cooking (Approx.)		kg/week				
	Wood			24.54	13.72	12.31	16.40
	Agri. Waste			11.69	7.07	6.77	7.71
	Dung cake			11.94	8.06	6.30	10.30
	Kerosene		lit/week	2.01	1.08	1.14	0.81
	Any other		kg/week	0.00	0.00	0.00	0.00
9	Costing of fuel –cooking		Rs./week				
	Wood			265.16	140.39	75.94	185.52
	Agri. Waste			56.69	34.70	14.70	41.90
	Dung cake			128.60	89.03	26.87	104.00
	Kerosene			42.69	18.76	17.85	14.15
	Any other			0.00	0.00	0.00	0.00
10	Time in collection of fuel material						
	Wood		Man days/Year	13.33	11.78	10.66	11.46
	Wood		hrs./day	4.22	4.31	4.37	4.72
	Agri. Waste			2.12	1.47	2.75	1.58
	Dung cake			0.83	0.45	2.20	0.49
11	Cooking time required		hours				
	Day time			1.83	1.21	1.06	1.33
	Night time			1.72	1.08	1.03	1.15
12	Expenditure on health		Rs./month	543.66	218.18	275.00	118.75
13	Willing to Pay for stove:		Rs./HH				
	With subsidy			0.00	200.00	200.00	200.00
	Without subsidy			0.00	342.31	343.75	345.00
14	Working hrs on field		hours	4.25	4.07	3.41	3.79
15	Income from field		(Rs./year)	21198	20574	20044	21200
16	Income from wages			8357	9214	6791	9408
17	Other business with saved time		hours	0.00	0.00	0.00	0.00
18	Increase in study hrs of children		hours	0.00	0.00	0.00	0.00

Note: * Estimated Costing of fuel for cooking (Rs./week); Approx-approximately.

It can be seen from the table that fuel wood requirement for cooking was found almost fifty per cent less in case of BCS than domestic chulha. In case of agri waste and dung cake also, the requirement was found less in BCS than its counterpart. The need/consumption of Kerosene was also reduced to about half level in BCS. Therefore, costs of fuel item were found to be higher in case of domestic chulha than BCS. Despite of half reduction of requirement of fuel wood for BCS, the time for collection of wood had recorded marginal decline in BCS than domestic. This may be due to the fact that time for search, collection of fuel wood as well as preparing wood suitable for cooking purpose has done together by beneficiary households for both kinds of chulha and therefore, they could not separate it into two.

The cooking time requirement during day as well as night time was found less in case of BCS than domestic chulha. The saved time was used on field. The expenditure on health was found relatively similar in both the cases. The beneficiary households were asked about their willingness to pay for BCS, and it was observed that they are willing to pay around Rs. 350/- per unit. It was observed that some of the households were not using the cook stove, mainly BCS-CL (2.1% HHs) and BCS-AITF (6.3% HHs). These instruments were not used for about 3 months. The reason towards same was mentioned that these households' requirement was less and thus they did not use it regularly.

Table 3.4: Reason for the Unused Stove

Sl. No	Particulars	Domestic chulha	BCS-CL (n=1)	BCS-AITF (n=1)	BCS-AISF
1	Stove not used:				
	No. of Households having Stoves not used (% of HHs)	0	2.13	6.25	0
	No of days stove not used (No. of days)	0	90	90	0
2	Reasons:				
	They didn't required more meal for serve (% of HHs)	0	2.13	6.25	0

Source: Field survey data.

Figure 3.1 Conventional Chulha

Figure 3.2 Ceramic Liner Cook Stove (in use)

Figure 3.3a Biomass cook stove-Air insulated -Top feeding

Figure 3.3b Biomass cook stove-Air insulated -Top feeding (in use)

Figure 3.4a Biomass cook stove-Air insulated –Side feeding

Figure 3.4b Biomass cook stove-Air insulated -Side feeding (in use)

The use of the BCS also depends on the training and maintenance provided by the agency. It can be seen from the Table 3.5 that training was provided by the agency and maintenance back up was also provided as and when required. No equipment was transferred to other person and all were in use with selected households.

Table 3.5: Training, Maintenance and Transfer of Improved Biomass Cook Stove

(% of total HH)

Sl. No.	Particulars	BCS-CL (n=47)	BCS-AITF (n=16)	BCS-AISF (n=25)
1	Training/Instructions provided by agency at the time delivery (Yes)	87.23	93.75	88.00
2	Maintenance backup provided as and when required (Yes)	46.81	75.00	52.00
3	Transfer of equipment (Yes)	0.00	0.00	0.00
4	Used by beneficiary (Yes)	100.0	100.0	100.0

Source: Field survey.

3.4 Solar Light:

In order to have the impact of solar light on various aspect of life, it is important to have details on house of beneficiaries. It can be seen from the table 3.4 that the selected houses were of mixed in nature, i.e. compact and spacious. The average number of rooms in selected households was around two having maximum windows as well as direction of house towards east-west. The adequate ventilation in house was observed in case of 49 percent houses. More than 40 percent houses of solar light beneficiary households were with mangalore roof whereas around 25 percent households were with *desi* roof. About half of the selected households had good ventilation, however during the rainy and cloudy days, they had made some arrangements to reduce the darkness. The use of solar light followed by kerosene and GEB electricity were the prominent source to reduce darkness in the house. After availability of solar light, it has been used heavily to reduce the darkness in the house. Thus, it must have saved the expenditure on kerosene.

Table 3.6: Details on Houses of beneficiary of Solar Light

(% to total HH)

Sl. No.	Particulars	Solar Light (n=55)
1	Types of house	
	a) Compact	49.09
	b) Spacious	50.91
2	Average no. of room in house	2.38
3	Location of window:	
	a) East-West	54.55
	b) South-North	45.45
4	Average no. of window (Number)	1.78
5	Type of roof (% to total hh)	
	a) Desi	25.45
	b) Mangalore	40.00
	c) Asbestos	21.82
	d) Tin/ Terrace	12.73
6	Direction of house (% to total hh)	
	a) East-West	76.36
	b) South-North	23.64
7	Ventilation (% to total hh)	
	a) Adequate	49.09
	b) Inadequate	50.91
8	Average Height of roof (av. feet)	16.76
9	Arrangement of minimize darkness (multiple responses)	
	(i) Kerosene light	80.00
	(ii) Electric light	80.00
	(iii) Removal of tile/cowelu	1.82
	(iv) Use of glass roof tile	27.27
	(v) Solar light	100.00

Source: Field survey Data.

The details on use of solar light by selected beneficiary households presented in Table 3.7 (Figure 3.5 to 3.8 & 3.11 to 3.12) indicate that except one each in LED and CFL, all other LED and CFL as well as HLS units were in use at the time of survey. All the solar light units were charged for about 6 hours by solar recharge system, whereas supportive recharge was also provided by electric supply to some CFL and HLS units to the extent of 2.67 and 1.0 hour respectively. More than 86 percent of beneficiary households had done recharge every day. About 90.0 per cent beneficiary households of LED and 93.3 per cent beneficiary households of HLS had to recharge their solar light every day. About 36 percent and

16 percent beneficiary households of LED and CFL respectively mentioned that they themselves repaired the units, as and when they had faced problem in same. About 48 percent CFL users, more than 63 percent LED and HLS users recorded that agency had provided them maintenance backup. No unit of solar light was transferred and all were with beneficiary household.

Table 3.7: Use of Solar Light by Sample Households

Sl. No.	Particulars	Unit	LED (n=11)	CFL (n=29)	HLS (n=15)
1	Presently using solar light:	% of HHs	90.91	89.66	100.00
2	Everyday recharge	Hrs/day			
	(i) By solar recharge system		5.55	5.31	5.43
	(ii) By electric supply		0.00	2.67	1.00
3	Recharge	% of HHs			
	(i) Everyday		90.00	86.21	93.33
	(ii) Alternative day		10.00	3.45	6.67
4	If problem, repaired solar light by self	% of HHs	36.36	15.38	0.00
6	Training provided by agency	% of HHs	100.00	68.97	100.00
7	Maintenance back up provided	% of HHs	63.64	48.28	66.67
8	Transfer of equipment to others	% of HHs	0.00	0.00	0.00
	Self use		100.00	100.00	100.00

Notes: HLS: Home light system; LED: Light emitting diode; CFL: Compact fluorescent lamp Source: Field survey
Source: Field survey data.

The impact of use of solar light on selected aspects is presented in Table 3.8. It can be seen from the table that before solar light situation, selected beneficiary households were used to have light for about 6 hours in a day, mostly through GEB electric supply and through use of kerosene. Whereas after use of solar light, total light hours had increased to around 8 hours and major source was solar light, supported by GEB supply and also use of kerosene. However, significant decline in use/consumption of kerosene has been noticed, i.e. from around 3.8 liters per month to around 0.8-1.0 lit per month. Thus, expenditure on kerosene has reduced by about two third of cost incurred earlier. The impact could be also seen in total electricity bill, which was declined from Rs. 289/- per month to

less than Rs. 252/- per month. The increase in studying hours of their children was another positive feature of use of solar light. HLS system was first choice of children for studying followed by CFL, whereas households having LED experienced relatively less studying hours.

In case of total working hours on the field, it was observed that there was increase in numbers of working hours on the field after having availability of solar light with beneficiary household. During the night hours, beneficiary households had used the solar light on field to complete some works. On the response to willingness to pay, beneficiary households opined that they would pay around Rs. 350-600/- extra than the subsidy amount paid by them to the agency. Thus, despite of having numbers of benefits from the solar lights, the willingness to pay amount seems to be lower.

Table 3.8: Impact of use of Solar light on selected aspects

Sl. No.	Particulars	Unit	Before solar light	After solar light		
				LED (n=11)	CFL (n=29)	HLS (n=15)
1	Power supply used in 24 hrs	Hrs/day/HH				
	a) Electric supply grid		3.98	3.68	2.92	3.20
	b) Kerosene		2.05	1.83	1.10	1.00
	c) Any other-solar		0.00	4.09	4.63	4.71
2	Kerosene use	Lit/month	3.79	1.33	0.78	1.38
3	Kerosene cost	Rs/month	56.81	44.15	35.40	29.25
4	Electricity bill		288.75	252.73	228.52	229.33
5	Cost of repair/replace		42.86	40.00	35.71	13.33
6	Study hours of children	Hrs/HHs	0.86	0.95	1.35	2.00
7	Total working hrs on field		4.54	5.12	4.44	4.35
8	Use of light:	Hrs/day				
	Studying		0.00	0.43	0.84	0.80
	House lights		0.00	1.39	1.56	1.85
	Cooking		0.00	0.95	0.62	1.02
	Travelling/outside work:		0.00	0.00	0.09	0.03
	Agriculture field		0.00	1.32	1.46	1.00
	Handicraft work		0.00	0.00	0.07	0.00
	Any other		0.00	0.00	0.00	0.00
9	Income from field	Rs./year	23536	24455	23448	23933
10	Willing to pay for solar light: With subsidy	Rs./HHs	0.00	1000.00	1000.00	1000.00
	Without subsidy		0.00	1475.00	1354.55	1611.11

Notes: HLS: Home light system; LED: Light emitting diode; CFL: Compact fluorescent lamp
Source: Field survey data.

Figure 3.5. Solar light-CFL

Figure 3.6. Solar light-CFL (Damaged)

Figure 3.7. Solar light-CFL (Maintenance provided by SPRERI)

Figure 3.8. Simultaneous use of Solar HLS and electric bulbs at home

Figure 3.9. Use of Glass roof tiles used at home

Figure 3.10. Benefit of Glass roof tiles at home

Figure 3.11. Battery set up for Solar Home Light System (HLS)

Figure 3.12. Solar Home Light System (HLS) being used by rural households

3.5 Glass Roof Tiles:

The details on houses of beneficiary household of glass roof tiles are presented in Table 3.9 and Fig 3.9 & 3.10 with average two rooms and adequate ventilation. The average height of the house was about 16 feet and 75 percent houses were with mangalore roof whereas 25 percent households were with *desi* roof. In order to reduce the darkness in house, besides use of glass roof tiles, use of kerosene and grid electric supply were the prominent sources.

Table 3.9: Details on Houses of beneficiary of Glass Roof Tiles

(% to total HH)

Sl. No.	Particulars	Glass Roof Tiles (n=8)
1	Types of house	
	a) Compact	25.00
	b) Spacious	75.00
2	Average no. of room in house	2.13
3	Location of window:	
	a) East-West	62.50
	b) South-North	37.50
4	Average no. of window (Number)	1.50
5	Type of roof (% to total hh)	
	a) Desi	25.00
	b) Mangalore	75.00
	c) Asbestos	0.00
	d) Tin/ Terrace	0.00
6	Direction of house (% to total hh)	
	a) East-West	62.50
	b) South-North	37.50
7	Ventilation (% to total hh)	
	a) Adequate	75.00
	b) Inadequate	25.00
8	Average Height of roof (av. feet)	15.75
9	Arrangement of minimize darkness (multiple responses) (% to total hh)	
	(i) Kerosene light	87.50
	(ii) Electric light	87.50
	(iii) Removal of tile/cowelu	12.50
	(iv) Use of glass roof tile	100.00
	(v) Solar light	50.00

Source: Field survey Data.

The details on glass roof tiles used indicated that half of the beneficiary households had used one tile whereas remaining had used two tiles (Table 3.10) and no one had faced any problem. Training and maintenance facility was provided by the agency and all the units were with beneficiary households. The selected beneficiary households mentioned that they are willing to pay Rs. 50/- for one tile and Rs. 100/- for two tiles with subsidy and Rs. 103/- for one tile and Rs. 150/- for two tiles without any subsidy.

Table 3.10: Details of Glass Roof Tile used

Sl. No.	Particulars		Unit	Glass Roof Tiles (n=8)
1	No. of Tiles used	Only One tile	% of HHs	50.00
		Two tiles		50.00
2	Faced any problem in using/handling (No)		% of HHs	100.00
3	Training provided by agency (Yes)		Per HHs	100.00
4	Maintenance back up provided (Yes)		Per HHs	100.00
5	Transfer of roof tiles/ Used by beneficiary			
	Self use		Per HHs	100.00
	Transferred			0.00
6	Willing to pay for glass roof tile:		Rs./unit	
	With subsidy for one tile			50
	With subsidy for two tiles			100
	Without subsidy for one tile			103
	Without subsidy for two tiles			150

Source: Field survey

The details on impact of glass roof tiles on various parameters are presented in Table 3.11. It can be seen from the table that before glass roof tiles, total light hours in beneficiary households due to use of GEB supply and use of kerosene were found around 6.3 hours, which had reduced to around 3.5 hours after use of glass roof tiles. Due to reduction in consumption of kerosene, the expenditure on same had reduced to one third of earlier one, i.e. from Rs. 45/month to Rs. 15/month.

Table 3.11: Impact of Glass Roof Tiles

Sl. No.	Particulars	Unit	Before glass roof tiles	After glass roof tile
1	Power supply used in 24 hrs: a) Electric supply grid	Hrs.	4.00	2.88
	b) Kerosene (hrs.)		2.29	0.67
	c) Any other (hrs.)		0.00	0.00
2	Kerosene use	Lit/month	3.00	1.00
3	Kerosene cost	Rs./month	45.00	15.00
4	Electricity bill (Rs./month)		253.75	203.75
5	Cost of repair/replace		0.00	0.00
6	Study hours of children	Hrs.	0.50	0.50

Source: Field survey data.

3.4 Biogas Plant:

The constructed family size solid state modified deenbandu biogas plant of 2 cum gas capacity and cattle dung based units. The feeding pipe was of PVC with small slurry dragging area. The water and dung requirement ratio suggested to be used was as 5 parts of dung and 2 part of water. Everyday around 23 kg dung was used for charging biogas, thus requirement of 9-10 liters of water for same (Table 3.12, Fig 3.13 and 3.14). The selected biogas beneficiary households had feeding the dung every day by spending about half an hour and thus no requirement of additional labour was mentioned by the beneficiary households. The dung feeding in biogas plant by sometime by male, female and even children of these households as per their availability and engagements.

The digested slurry was used mainly for FYM purpose, as well as for making vermicompost. The use of digested slurry for FYM was preferred most because of the fact that digested slurry has no seed of weed or any unwanted crop and thus results in no problem of weeds after use of FYM of slurry made. The less expenditure on control of weeds thus benefits the beneficiary households during crop cultivation.

The agency had provided the training to all the beneficiary households on operation and use of biogas plant. Some of beneficiary households had faced problem in operation and they themselves had solved the same. One biogas plant was found non-working because of pipe was broken and same was informed to the agency for maintenance backup. The gas was used by beneficiary households for their uses and no one had shared to other nearby household. All the households had mentioned that they would continue with the present biogas systems and their willingness to pay for biogas plant was upto the extent of Rs. 5000/- only.

About 67 percent households had mentioned that they would like to go for toilet linked biogas plant, whereas remaining households mentioned that they would not to prefer for same.

Table 3.12: Details of biogas plant and its use

Sl. No.	Particular		units	Biogas plant (n=9)
1	Biogas plant area (size) in meter		In meter	3.5* 3.5
2	Biogas plant capacity		m^3	2
3	Types of Biogas		Animal waste	100.00
			Human waste	0.00
4	Water requirement		Dung: Water	50:10
5	Daily Dung feeding		kg/day	22.78
6	Dung feeding and Slurry handling		minutes	0.35
7	Required any additional labour (No)		% to total	0.00
8	Who add dung and water (1st & 2nd) in day (multiple responses)		Male	77.78
			Female	66.67
			Children	22.22
9	Feeding pipe:		PVC	100.00
			RCC	0.00
11	Slurry drying area:		Small	100.00
			Large	0.00
12	Digested slurry used for:		Vermi compost	33.33
			FYM	66. 67
	If any problem arise, self repair		Yes	11.11
13	Training provided by agency		Yes	100.00
14	Maintenance back up provided		Yes	77.78
15	Transfer to gas to others from biogas		Self use	100.00
			Transferred	0.00
16	No. of Plant not in use (n=1)		% to total	11.11
	If yes, since how many days		days	90
	Reason for same		Pipe broken	11.11
17	Continue with biogas			100.00
18	Willingness to Investment (Rs.)	With subsidy	Rs.	4667
		Without subsidy	Rs.	5000
19	Present working biogas		Yes	88.89
20	Would like to go for Toilet linked biogas plant		Yes	66.67
			No	33.33

Source: Field survey data.

The details on effect of biogas use on time spend by selected households on cooking, field work and study hours of children are presented in Table 3.13 shows that drastic decline in cooking time was noticed after use of biogas, i.e. from almost 2 hours to 1 hour/day. Thus, cooking time was reduced by half because of biogas use. The time spent on field also increased use which may be due to time saved in cooking. Surprisingly, no change was noticed in case of study hours of children.

Table 3.13: Effects of biogas use on time spent by households

Sl. No.	Particular	Time spent (hrs/day)	
		Before Biogas	After Biogas
1	Cooking time	1.58	0.88
2	Time for field work	2.35	2.93
3	Study hours of the children	1.00	1.00

Source: Field survey data.

Figure 3.13 Biogas plant at village Simal Faliya of Chhota Udepur

Figure 3.14. Slurry generated from Biogas plant at Simal Faliya of Chota Udepur

3.5 Solar Cooker:

The details on use of solar cooker use by the beneficiary households are presented in Table 3.14 and Figures 3.15 and 3.16.

Table 3.14: Details on Use of Conventional and Solar Cooker

Sl. No.	Particulars	Unit	Conventional cooker	Solar cooker (n=4)
1	Cooker used for:			
	Rice/Dal	Per HH	100.00	100.00
	Any Other / Sp.Dish		0.00	0.00
	Boiling of pulses/other		0.00	50.00
2	Use of solar cooker:	Per HH		
	Every day afternoon		100.00	75.00
	Alternative day		0.00	25.00
	weekly		0.00	0.00
	Rainy	Hrs/day	1.75	0.00
	Winter		2.25	2.63
	Summer		1.50	2.50
3	Cooking time required:			
	Rainy (hrs/day)	Hrs/day	1.75	0.00
	Winter (hrs/day)		1.75	2.63
	Summer (hrs/day)		1.50	2.50
4	No change in food taste	Yes	0.00	0.00
	Training provided by agency			100.00
	Maintenance back up provided			0.00
	Transfer of cooker to other			0.00
	Used by beneficiary			100.00
5	During the rainy season:			
	If problems repair solar cooker	Per HH	0.00	0.00
6	Willing to pay solar cooker			
	With subsidy	Rs./HHs	0.00	750.00
	Without subsidy		0.00	812.50

Source: Field survey

It can be seen from the table that both conventional and solar cooker was used for preparation of rice and dal only mostly on every day afternoon. The use of conventional cooker was found throughout the year, whereas solar cooker was used mainly in winter and summer season. Because during the rainy season, non availability of adequate and high intensity sun rays due to cloudy weather results in non use of solar

cooker by beneficiary households. The cooking time required in solar cooker was found one and half times higher than the conventional cooker. No problem was faced by the beneficiary households in use of solar cooker. Also all of them mentioned that no change in food taste was realized by them in food cooked in solar cooker. The households opined to pay Rs. 813 per solar cooker as compared to Rs. 750/- per cooker paid by them as subsidy amount for getting the same. The training on use of cooker was provided by the agency and as no problem was faced by the users, no maintenance back was provided. All the cooker were found to be used by the beneficiary households themselves and no one transferred to other.

Figure 3.15. Solar Cooker distributed to rural households

Figure 3.16. Solar Cooker being used by rural households

3.6 Solar Dryer:

Another solar unit distributed by the agency was solar dryer. The details on same are presented in Table 3.15 and Fig 3.17. The weight of the solar dryer was of 0.5 to 1.0 kg and it was found that solar dryer was mostly used for drying vegetables sometime every day or on alternative day. It was used heavily during summer followed by winter season, while during rainy season, it was used rarely.

Table 3.15: Details of Solar Dryers

Sl. No.	Particulars	Unit	Solar dryer (n=2)
1	Capacity of solar dryer	Kg	0.5 to 1.0
2	Use of solar dryer:		
	Drying vegetable	Per HHs	100.00
	Any other use		0.00
3	Frequency of use of solar dryer:		
	Every day afternoon	Per HHs	50.00
	Alternative day		50.00
	Weekly		0.00
	Rainy	Hrs/day	0.25
	Winter		1.25
	Summer		2.5

Source: Field survey

The use of solar dryer had impact on saving time in drying the vegetables with no change in food taste (Table 3.16). The agency had provided training on use of solar dryer and no one had faced any problem in use of same. All solar dryer were used by beneficiary households and no one had transferred unit. Without subsidy, the beneficiary households mentioned their willingness to pay was Rs. 150/ per unit.

Table 3.16: Impact of Use of Solar Dryer on saving of time

Sl. No.	Particulars	Unit	Solar dryer (n=2)
1	Saving in drying time	% to total HH	100.00
2	time saved	(%)	50.00
3	Change in food taste (No)	% to total HH	100.00
4	During rainy season use	% to total HH	0.00
5	If any problem, self repair of solar dryer	% to total HH	0.00
6	Training provided by agency	% to total HH	100.00
7	Maintenance back up provided	% to total HH	0.00
8	Transfer of solar dryer to others (Yes)	% to total HH	0.00
9	Used by beneficiary	% to total HH	100.00
10	Pay for solar dryer	Rs/HH	
	With subsidy		100.00
	Without subsidy		150.00

Source: Field survey

Figure 3.17. Solar Dryer being used by rural households

The next chapter presented the benefits and constraints in use of re technology instruments.

CHAPTER IV

Benefits & Constraints in Use of RE Technology

After having discussed about the use of renewable energy devices and its impact on various aspect of life, the benefits and constraints in use of technology is discussed in this chapter.

4.1 Improved Biomass Cook Stove

The major advantages of use of improved biomass cook stove set up by the agency presented in Table 4.1 and Fig 4.1 indicates that more than 93 percent beneficiary households opined that use of improved biomass cook stove helped them in reduction of use of the fuel wood followed by reduction in indoor air pollution and consumption of kerosene (more than 84 percent hh). More than 70 percent of households mentioned that due to use of improved BCS, not only cooking time has reduced but also suffocation in kitchen and female hard work had reduced significantly. The other major benefits of improved BCS cited by the beneficiary households were reduction in time of wood collection, better cleanliness of kitchen and thus may be better livelihood/ better family life.

The constraints in use of improved biomass cook stove are presented in Table 4.2. In case of top feeding BCS, feeding of wood from top generally disturb the cooking thus results in more cooking time or less preference of unit for cooking. Also cutting of wood in small pieces which is requirement of top feeding cook stove was major constraints faced by beneficiary household. The major food items of selected beneficiary households was rotla (chapatti) which can be cooked properly on BCS, for which they have to use domestic chulha is another constraint faced by the beneficiary households. This is one of the reasons why beneficiaries wanted more side feeding BCS. However, beneficiary HHs faced problem in moving the cook whenever necessary due to handles are

broken in BCS-SF. About 4 per cent HHs of side feeding BCS raised this issue.

Table 4.1: Advantages of use of biomass cook stove

(% of HHs)

Sl. No.	Advantages	BCS(all) N=88	BCS-CL N=47	BCS-TF N=16	BCS-SF N=25
1	Reduce female hard working/drudgery	72.73	72.34	87.50	72.00
2	Reduce fuel material collection time	67.05	72.34	62.50	64.00
3	Reduce wood usages	93.18	91.49	100.00	96.00
4	Reduce inside cooking smoke	67.05	72.34	68.75	60.00
5	Reduce suffocation in kitchen	75.00	78.72	75.00	72.00
6	Reduce indoor air pollution	89.77	70.21	87.50	100.00
7	Reduce use of Kerosene	84.09	70.21	81.25	76.00
8	Reduce cooking time required	78.41	65.96	68.75	84.00
9	Better kitchen cleanness	65.91	57.45	68.75	64.00
10	More time to work on field/home activities	23.86	17.02	18.75	28.00
11	Saved time used for home/other work	37.50	23.40	37.50	44.00
12	Reduce expenditure on health/medicine	13.64	8.51	18.75	16.00
13	Increase study hours of children	7.95	4.26	0.00	8.00
14	Easiness of use of cooker	28.41	27.66	18.75	36.00
15	Better lifestyle/livelihood	21.59	19.15	25.00	24.00
16	Use of dung for other purposes	17.05	19.15	12.50	8.00
17	Increase income from field	10.23	6.38	0.00	16.00
18	Increase income from wages	3.41	0.00	0.00	4.00

Source: Field survey

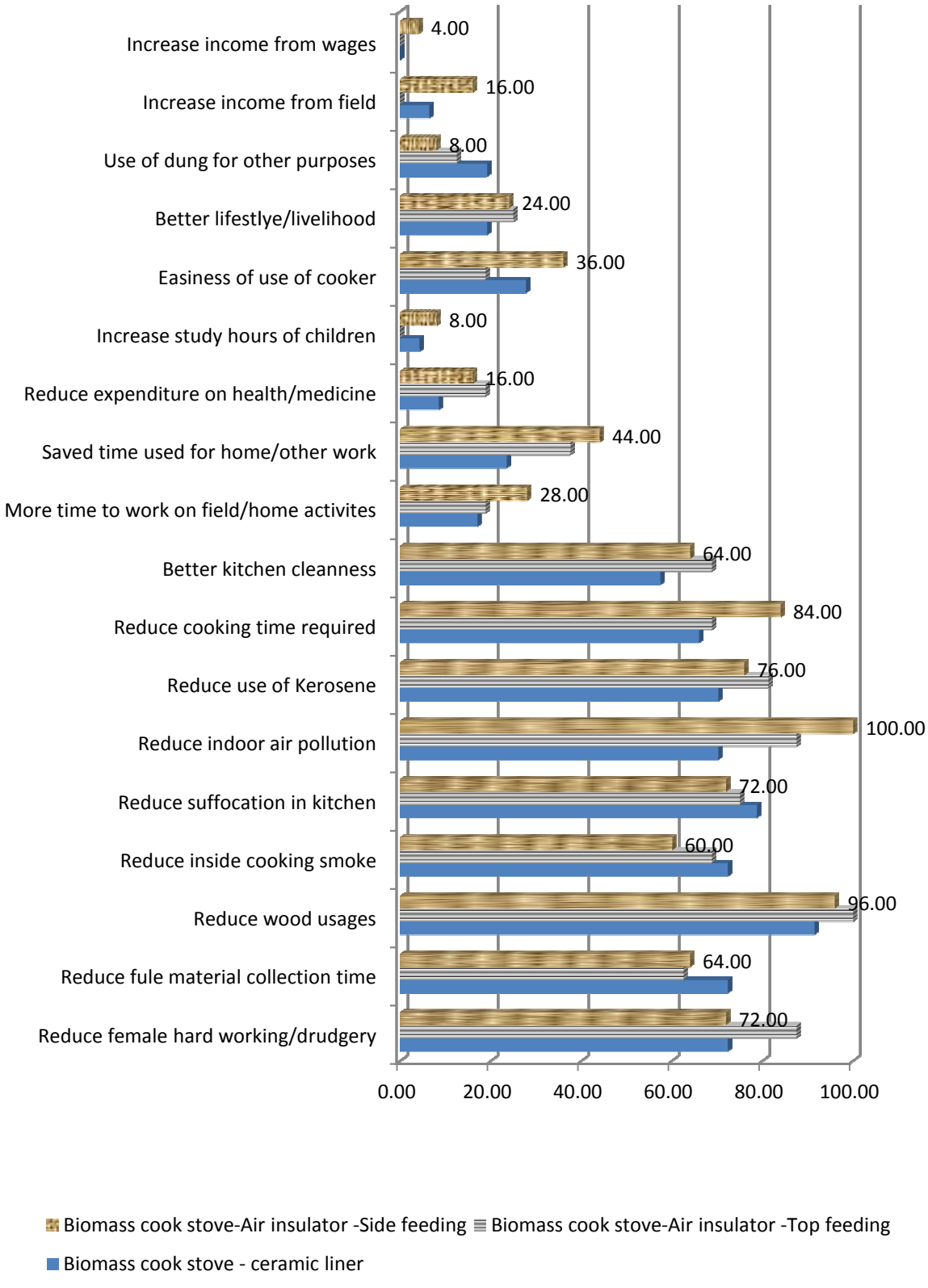
Table 4.2: Constraints in use of biomass cook stove

(% of HHs)

Sl. No.	Constraints	BCS(all) N=88	BCS-CL N=47	BCS-TF N=16	BCS-SF N=25
1	Top feeding- feeding of wood from top disturb the cooking which result in more cooking time	21.59	31.91	12.50	0.00
2	Top feeding- rotla cannot be cooked properly	32.95	42.55	37.50	0.00
3	Top feeding- cutting of wood in small pieces consume more time	44.32	59.57	56.3	0.00
4	Height of stand for vessel is high	1.14	0.00	0.00	4.00
5	Handle broken in BCS-SF	1.14	0.00	0.00	4.00
6	Smoke creates suffocation	1.14	0.00	6.25	0.00

Source: Field survey

Fig. 4.1: Advantages of use of Biomass Cook Stove



4.2 Solar Light

About 93 percent households opined that the use of solar light has benefited by significant reduction in consumption of kerosene, followed by reduction in darkness in the house (87.27 percent hh), reduced the dependency on GEB supply (about 69.09 percent hh) and also reduced the electricity bills (Table 4.3 and Fig 4.2). With the use of the solar light, house indoor pollution due to use of kerosene for lighting has reduced (69.09 percent hh), which resulted in better lifestyle/livelihood (49.09 per cent hh). Besides, reduction in cooking hours, reduction in fire incidents and health hazards, more time for field work (by using light on field during night time) are some of the benefits experienced by the beneficiary households.

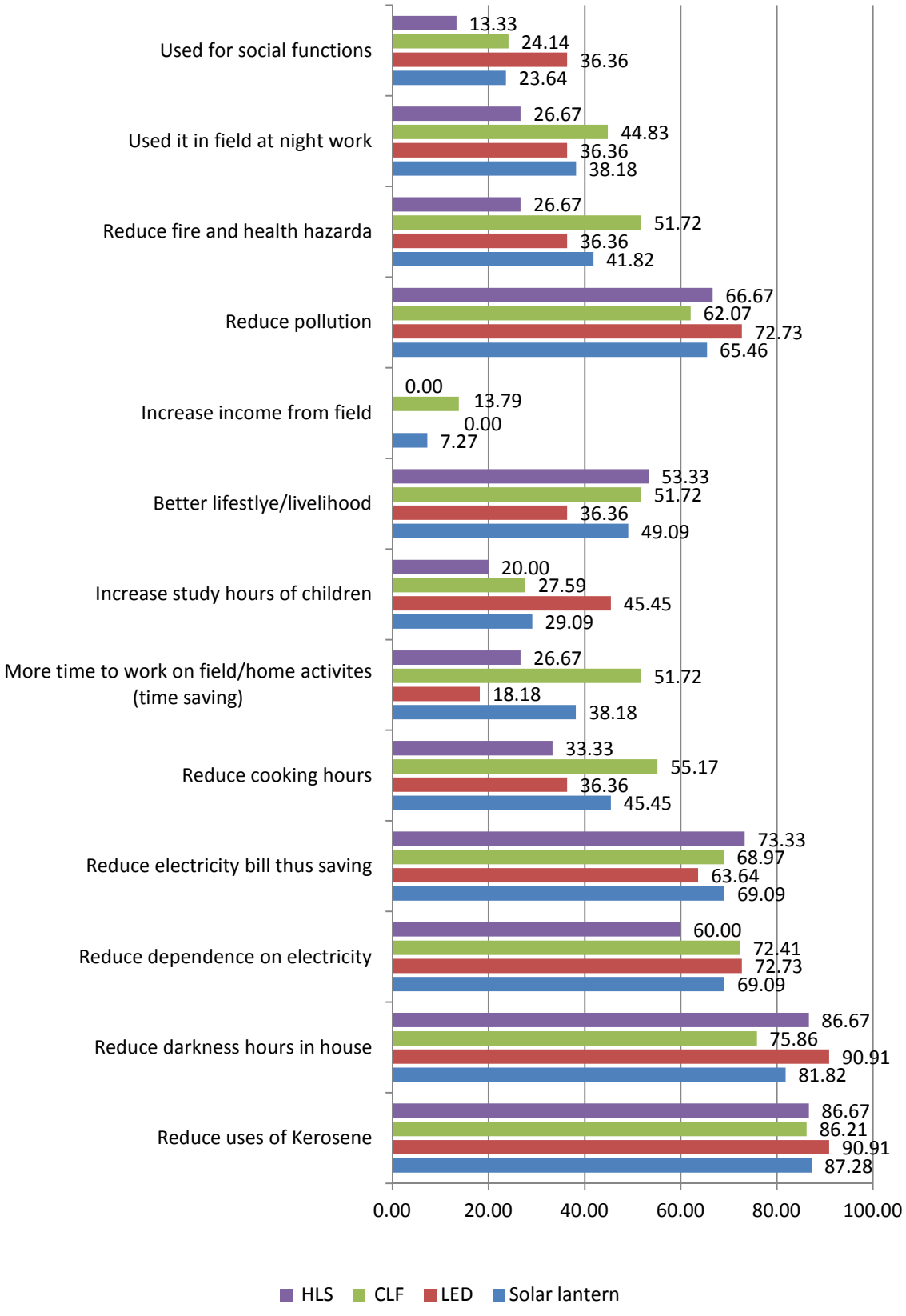
Table 4.3: Benefits of Solar Light

(% of HHs)

Sl. No.	Benefits	Solar light (all) N=55	LED =11	CLF=29	HLS= 15
1	Reduce uses of Kerosene	87.28	90.91	86.21	86.67
2	Reduce darkness hours in house	81.82	90.91	75.86	86.67
3	Reduce dependence on grid electricity	69.09	72.73	72.41	60.00
4	Reduce electricity bill thus saving	69.09	63.64	68.97	73.33
5	Reduce cooking hours	45.45	36.36	55.17	33.33
6	More time to work on field/home activities (time saving)	38.18	18.18	51.72	26.67
7	Increase study hours of children	29.09	45.45	27.59	20.00
8	Better lifestyle/livelihood	49.09	36.36	51.72	53.33
9	Increase income from field	7.27	0.00	13.79	0.00
10	Reduce pollution	65.46	72.73	62.07	66.67
11	Reduce fire and health hazards	41.82	36.36	51.72	26.67
12	Used it in field at night work	38.18	36.36	44.83	26.67
13	Used for social functions	23.64	36.36	24.14	13.33

Source: Field survey

Fig. 4.2: Benefits of Solar Light



There were some of the constraints reported during the survey time by the beneficiary households in the use of solar light. The major constraint experienced by the more than 52 percent of beneficiary household was low battery backup, followed by frequent battery problem (41.82 percent) and low intensity of LED lights (Table 4.4). Besides, some of the households have reported that problem in charging of battery, no availability of immediate support from agency as well as no local repair expert were some of the problems faced by them.

Table 4.4: Constraints in use of Solar Light

(% of HHs)

Sl. No.	Constraints	Solar light (all) N=55	LED =11	CLF=29	HLS= 15
1	Low battery back up	52.73	72.73	55.17	26.67
2	LED Low intensity of light	16.36	18.18	13.79	20.00
3	More weight of light	7.27	0.00	10.34	6.67
4	Frequent battery problem	41.82	45.45	41.38	33.33
5	Charging problem	3.64	9.09	3.45	0.00
6	major battery problem	3.64	0.00	6.90	0.00
7	nobody come for repair	1.82	9.09	0.00	0.00
8	Repaired, but not working	1.82	0.00	0.00	6.67
9	Time for repairing very long	1.82	0.00	3.45	0.00

Source: Field survey

Among the suggestions given by the beneficiary households, majority of households opined that requirement of repair arrangement at local level (49.09%), followed by need to increase battery backup (43.64%) are the major one (Table 4.5).

Table 4.5: Suggestions on Solar Light

Sl. No.	Suggestions	% of HHs
1	Increased battery back up	43.64
2	Need repairing arrangement at local level	49.09
3	Damage in CFL Light due to power fluctuation need to be checked	1.82

Source: Field survey

4.3 Glass Roof Tiles

The use of glass roof tiles had also brought some changes in the lifestyle of the beneficiary households. About 88 percent households had mentioned that use of glass roof tiles have reduced the darkness hours in house during day time which had given them feeling of increase in standard in living (Table 4.6 and Fig 4.3). Not only use of kerosene had reduced but also electricity bill got reduced. The only one beneficiary household has made a suggestion that more number of tiles should be given to install in all four corners of the house (Table 4.7).

Table 4.6: Benefit of glass roof tiles

Sl. No.	Benefits	% of HHs
1	Reduce darkness hours during day time	87.50
2	Reduce electricity bill thus saving	62.50
3	Reduce dependence on electricity	62.50
4	Reduce uses of Kerosene	75.00
5	Better lifestyle/livelihood	87.50
6	Increase study hours children	25.00

Source: Field survey

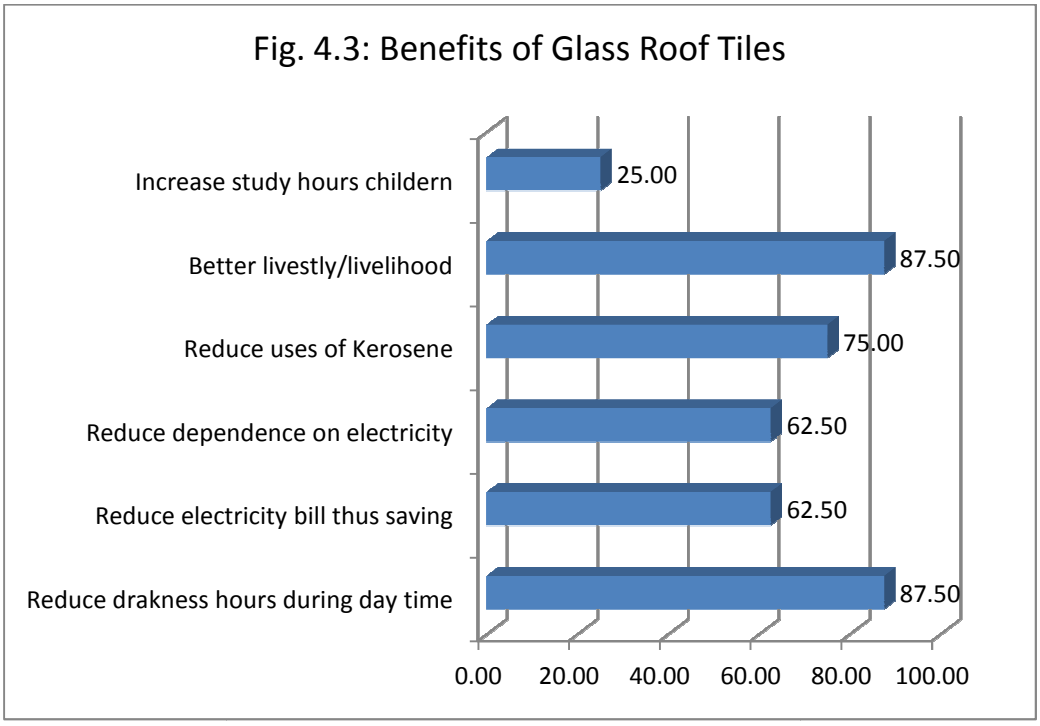


Table 4.7: Suggestion on Glass Roof Tiles

Sl. No.	Suggestions	No. of HH	% of HHs
1	More number of tiles should be given to install in all four corner of the house	1	12.50

Source: Field survey

4.4 Biogas Plant

The details on benefits experienced by use of biogas plant by beneficiary households are presented in Table 4.8 and Fig 4.4.

Table 4.8: Benefits of biogas plant

Sl. No.	Benefits (n=9)	% of HHs
1	Reduced the fuel collection and preparation time	88.89
2	Reduce dependence on wood/kerosene	100.00
3	Reduce cooking hrs.	100.00
4	Reduce the blackness of roof and outer side of utensils	77.78
5	Time saved in fetching wood/kerosene	66.67
6	Better lifestyle and livelihood	77.78
7	Better use in rainy season as wood and other material get wet	88.89
8	Cheaper than LPG cylinder	100.00
9	Reduced use of wood	88.89
10	Increase in study hours of children	11.11
11	Reduction in weeds and thus cost on weeding reduced	55.56
12	Increase in income from agriculture due to use of FYM	55.56
13	Easy to use pressure cooker	66.67
14	Advantages in using biogas spent slurry as compared to FYM	100.00

Source: Field survey data.

All beneficiary households had mentioned that biogas was found cheaper than LPG, reduction in cooing hours, advantage in use of biogas slurry for FYM as compared to FYM prepared by conventional method and reduction in dependence on wood/kerosene. More than 88 percent households mentioned that it has reduced/saved fuel wood collection and preparation time, better use in rainy season (as wood and other material got wet) which saves cooking time and wood. The other major benefits

reported by beneficiary households were reduction in blackness of roof and outer side of utensils resulted in better lifestyle and livelihood, reduction in weeds and thus cost on weeding has reduced and income from agriculture has increased, easy to use pressure cooker for cooking the rice and dal, time saved in fetching wood/kerosene. The biogas beneficiary has faced some problems in operation and use of same. It can be seen from the Table 4.9 that about 22 percent households had faced choke-up problem, followed by lack of supply chain for components and spare pates in rural locations, repair and maintenance is difficult, required more space to install and in some cases mosquito problem was also noted.

Fig. 4.4: Benifits of Biogas

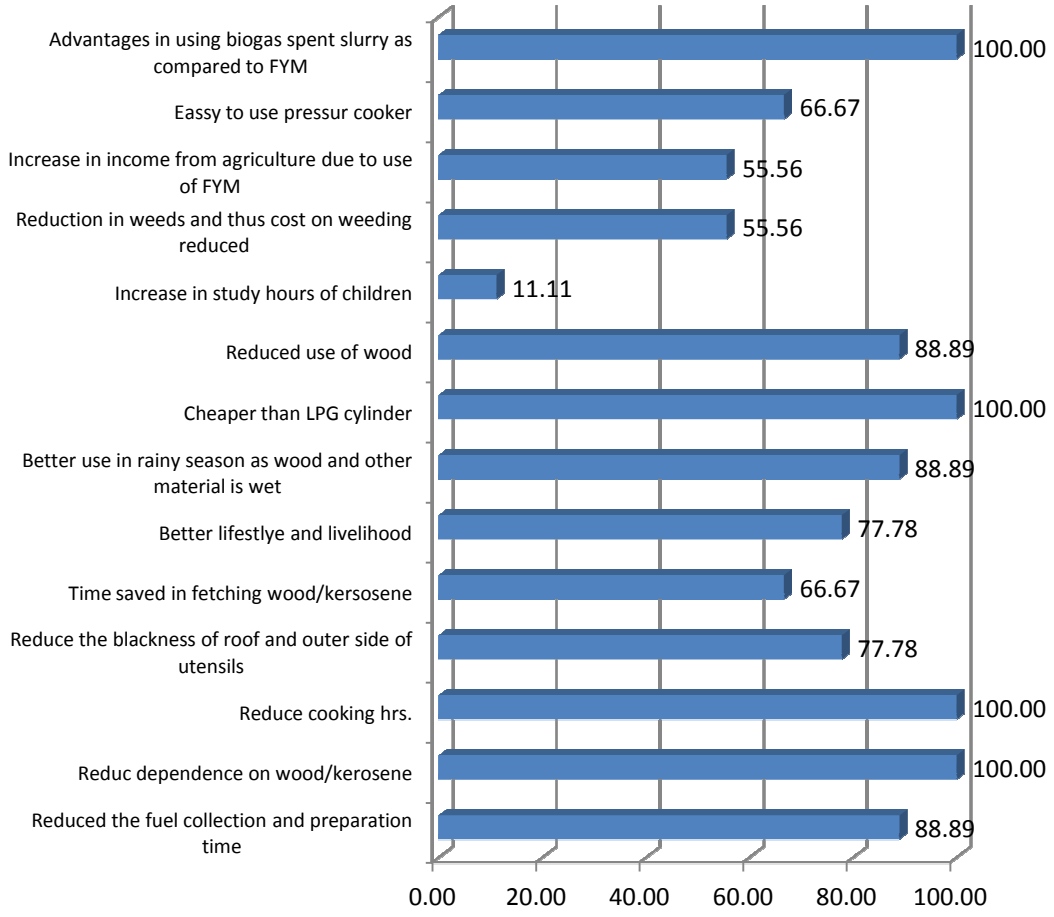


Table 4.9: Constraints in Use of Biogas plant

Sl. No.	Constraints	Biogas plant % of HHs (n=9)
1	Required more space to install (n=1)	11.11
2	Repair and maintenance is difficult	11.11
3	Choke up is main problem (n=2)	22.22
4	Water availability during summer is inadequate thus effect on plant (n=1)	11.11
5	Lack of supply chain for components and spare parts in rural area (n=1)	11.11
6	Mosquito problem (n=1)	11.11
7	Bad odor/smell (n=1)	0.00

Source: Field survey data.

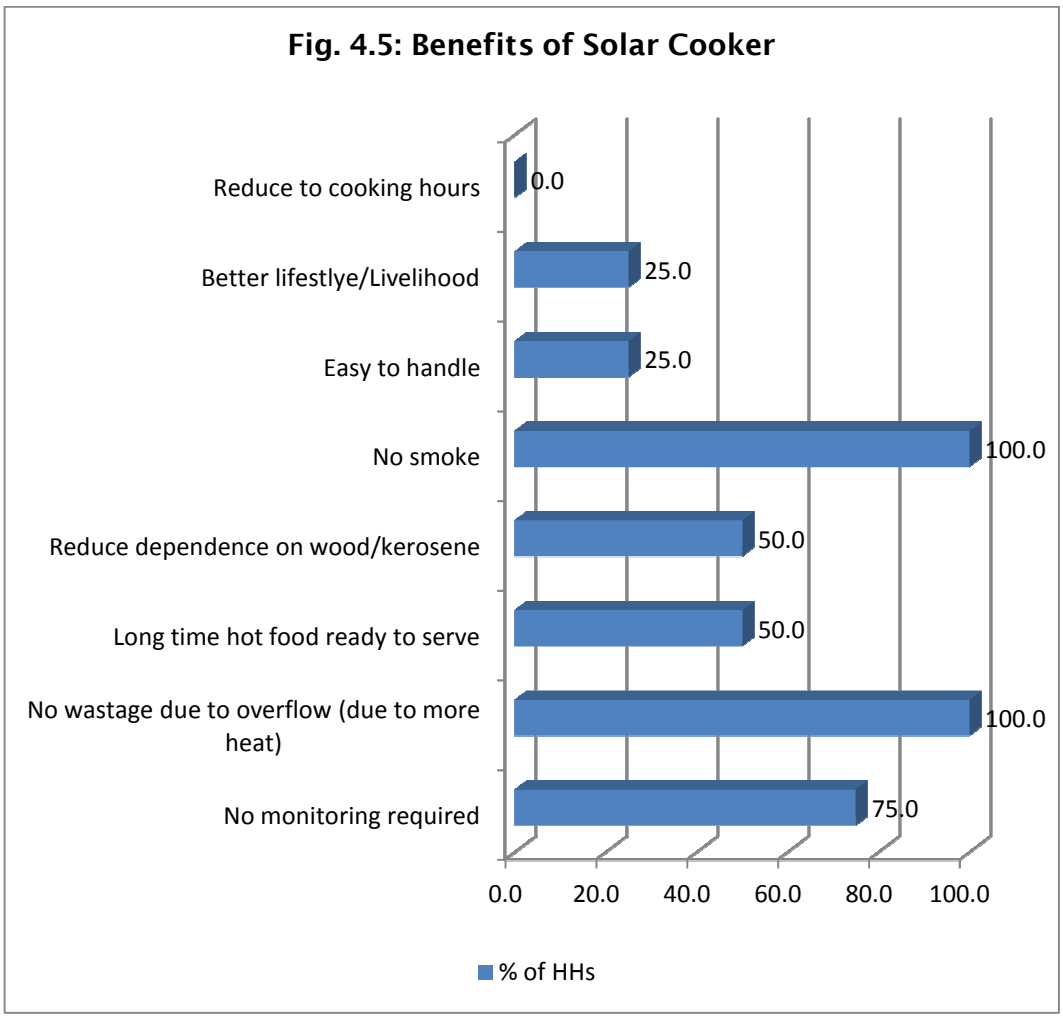
5.5 Solar Cooker

Among the various benefits experienced in use of solar cooker by beneficiary households, no wastage due to overflow (due to more heat as generally happen in case of conventional cooker) and no smoke were major one opined by all of them (Table 4.10 and Fig. 4.5). More than 75 percent of households had mentioned that as there is no wastage due to more heat (as generally it happens in case of conventional cooker), no monitoring is required. About half of the households mentioned that we could keep hot food available for long time as well as dependence on wood and kerosene was reduced and it is very easy to handle. However, no benefit in reduction in cooking hours was recorded.

Table 4.10: Benefits of Solar Cooker

Sl. No.	Benefits (n=4)	Solar Cooker % of HHs
1	No monitoring required	75.0
2	No wastage due to overflow (due to more heat)	100.0
3	Long time hot food ready to serve	50.0
4	Reduce dependence on wood/kerosene	50.0
5	No smoke	100.0
6	Easy to handle	25.0
7	Better lifestyle/Livelihood	25.0
8	Reduce to cooking hours	0.0

Source: Field survey data.



The major and only constraint faced by the 25 percent beneficiary households was solar cooker takes more time during rainy and winter seasons. It is obvious because solar cooker decency on sun ray during rainy season affects due to cloudy weather and during winter, low temperature takes more time to cook food in solar cooker.

Table 4.11: Constraints in use of solar cooker

Sl. No.	Constraints	% of HHs
1	More time taken during rainy and winter seasons	25.0

Source: Field survey

5.5 Solar Dryer

The major benefit of solar dryer experienced by users was no inspection required and no change in taste, colour of material (Table 4.12 and Fig. 4.6). Around half of the beneficiary households mentioned that in case of solar dryer, other benefits were reduction in losses during drying though bird/animal/handling wastage, reduction in drying time and important one was dust free drying of material. The only constraint faced by half of the selected households was solar dryer net got damaged during its use, which needs to be repaired /replaced by the agency in time (Table 4.13).

Table 4.12: Benefits of solar dryer

Sl. No.	Benefits (n=2)	% of HHs
1	No inspection required	100.00
2	Reduce losses in drying though bird/animal/handling wastage	50.00
3	No change in taste and color	100.00
4	Reduce drying time	50.00
5	Dust free drying of material	50.00

Source: Field survey

Fig. 4.6: Benefits of Solar Dryer

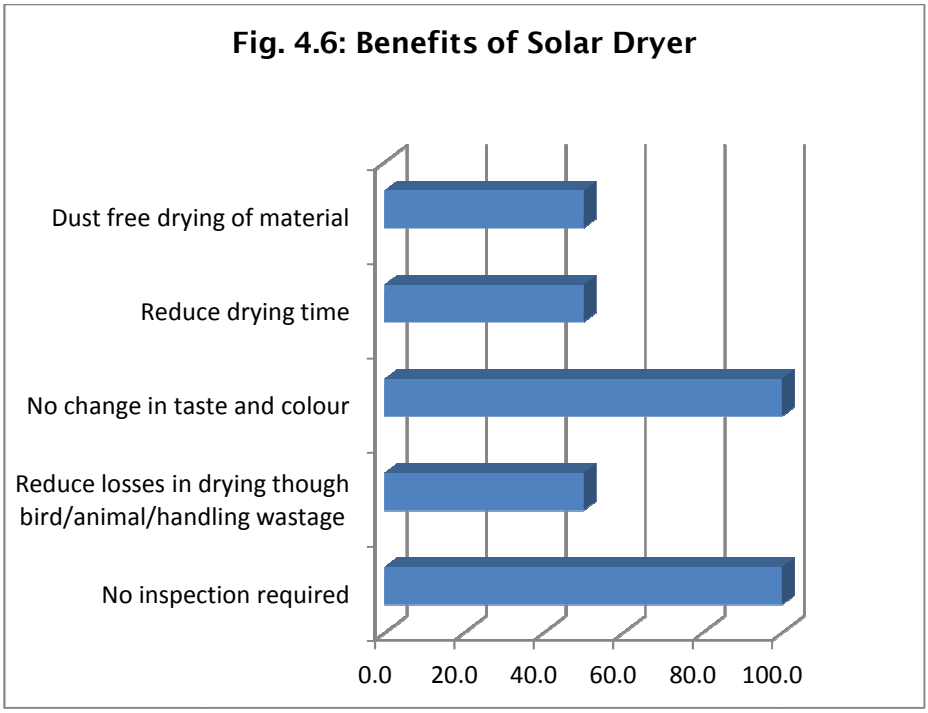


Table 4.13: Constraints in use of solar dryer

Sl. No.	Constraints	% of HHs
1	Net got damaged (n=1)	50.00

Source: Field survey data.

4.5 General Suggestions to Improve working of the RE technologies

All the beneficiary households were asked to give their suggestions on improvement of RE technologies, whether same household has used or not used all RE technologies. Thus, we got responses from the household who had not used the technology may be because of this or any other reason. The highest number of households have suggested that battery quality of solar light need to be improved (16.2 percent hh), followed by opinion to make available more side feeding stove as it is better than top feeding cook stove (Table 4.14). Stabilizer should be provided with light (due to fluctuation in electric voltage charging to light not possible). Instead of LED, HLS should be provided (battery backup is more in HLS than led). More number of glass roof tiles should be provided and weight of ceramic cook stove need to be reduced.

Table 4.14: Suggestion to improve working of the RE technologies

Sl. No.	Suggestions	% of HHs
1	Improved battery quality	16.2
2	Make available Side feeding stove as it is better than top feeding cook stove	10.5
3	Due to fluctuation in voltage electric charging to solar light not possible, thus stabilizer is required	1.0
4	Provided home light (HLS) instead of LED because HLS Battery backup is more than LED	1.0
5	Provided more number of glass roof tiles	1.0
6	Weight of ceramic cook stove should be reduce	1.0

Source: Field survey data.

The agency should take into account the suggestion made by the beneficiary household and if work on the possible suggestions, the households would realized more impact and benefits of RE technologies.

4.6 Non-Beneficiary Preference and Causes of their Exclusion

The non-beneficiary households were asked about their level of awareness and preferences for various solar renewable technologies available in their villages. Their choice pattern and willingness to pay is presented in Table 4.15.

Table 4.15: Interest to Use Renewable Technologies by Non-beneficiary HHs (N=42)

Sr. No.	Particulars	BCS-Ceramic Liner	BCS-Top Feeding	BCS-Side Feeding	Solar Light-LED	Solar Light-CFL	Solar Light-HLS	Biogas Plant	Solar Cooker	Solar Dryer	Glass Roof Tiles
1	Source of information (% of HHs):										
	Own	0.0	0.0	19.0	0.0	2.4	16.7	9.5	0.0	0.0	19.0
	Fellow Farmers	0.0	0.0	21.4	0.0	9.5	4.8	0.0	0.0	0.0	21.4
	Village level worker	0.0	0.0	4.8	2.4	2.4	9.5	0.0	0.0	0.0	4.8
	NGOs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SPRERI Personnel	0.0	0.0	28.6	4.8	4.8	16.7	2.4	0.0	0.0	28.6
	News paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TV/Radio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NABARD awareness programme	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sarpanch	0.0	0.0	2.4	0.0	0.0	2.4	0.0	0.0	0.0	2.4
2	% of HHs interested to purchase	0.0	0.0	76.2	7.1	19.0	50.0	11.9	0.0	0.0	76.2
3	No. of unit to purchase (per HH)	0.0	0.0	0.8	0.1	0.2	0.5	0.1	0.0	0.0	0.8
4	Willingness to Pay(Rs./unit):										
	a) With Subsidy	0.0	0.0	212.5	1000	1000	871.4	5000.0	0.0	0.0	212.5
	% of HH Purchase with subsidy	0.0	0.0	76.2	7.1	19.0	50.0	11.9	0.0	0.0	76.2
	b) Without Subsidy	0.0	0.0	247.4	1500	1250	922.2	7500.0	0.0	0.0	247.4
	% of HH Purchase without	0.0	0.0	45.2	7.1	19.0	21.4	4.8	0.0	0.0	45.2

Source: Field Survey

Majority of them revealed their preferences for sided fitted biogas stove and glass roof tiles (76.2% each), solar light-HLS (50%) and biogas plant (11.9%). The major sources of information for them were SPRERI personnel and fellow farmers. There were no major differences between willingness to pay with subsidy and without subsidy for various instruments except bio gas plants and solar lights. The non-beneficiaries' willingness to pay with subsidy and without subsidy for bio gas plants was Rs 5000 and Rs7500 respectively.

As far as the causes of exclusion of rural households are concerned, about 54.8 per cent non-beneficiaries expressed that they were not aware about the benefits of solar instruments (Table 4.16). About 52.4 per cent non-beneficiaries expressed that the financial constraints were the major constraint for them that prevented them in buying those instruments. Since these instruments were available on limited basis for a short period of time, many rural families failed to arrange money at the time of availability. Thus, about 23.8 per cent non-beneficiaries could not purchase solar instruments because of limited stock. Majority of them requested to make arrangements to have sufficient stock of these instruments at local level, so that these families can purchase at their convenient time.

Table 4.16: Exclusion from the Programme

Sr. No.		% of HHs
1	Not Aware about the technology	54.76
2	Financial Constraint	52.38
3	Limited Stock with SPRERI	23.81
4	Biogas- Stringent criteria (no animals, etc.)	4.76
5	Biogas- Small family size, no need	0.00
6	First come first serve basis of SPRERI	11.90

Source: Field survey

The next chapter presents the concluding remarks and policy suggestions.

CHAPTER V

Conclusions and Policy Suggestions

5.1 Background:

India has a vast availability of renewable energy resources, and it has one of the largest programs in the world for deploying renewable energy products and systems. The role of new and renewable energy has been assuming increasing significance in recent times in India with the growing concern for the country's energy security. The Power generation from renewable sources is on the rise in India, with the share of renewable energy in the country's total energy mix rising from 7.8% in FY08 to 12.3% in FY13. India's renewable installed capacity has reached 35.49 GW, as of February 29, 2015. The Cumulative grid tied wind power capacity has reached 22644 MW's, while solar grid tied power capacity has reached 3382mw's. Also during the month of February 2015, wind power, contributed largest share of new installed power capacity, while small hydro power ranked in a close second. How India develops will have widespread implications for global energy markets. The renewable energy sources in India are, a) Wind energy; b) Solar energy; c) Biomass, and d) Small hydro.

SPRERI continues its research and development in renewable energy technologies. Many renewable energy devices and systems developed at SPRERI are now manufactured by selected industries for meeting requirements of the end users. The manufacturing and marketing rights of the SPRERITECH improved biomass cook stoves have been transferred to three firms. These cook stoves are now available commercially in three different models to meet the requirements for domestic as well as community/small commercial applications. The Institute continued working actively in five selected tribal villages of Chota Udaipur/Vadodara and Dahod districts for the fifth consecutive year to study the impact of

introducing useful renewable energy technologies such as biogas plants, improved biomass cook stoves, solar lantern, provision of the natural sun light into the tribal homes etc. on the socio-economic life of the communities. The major devices that SPRERI has provided to tribal households in Gujarat are: Biomass Cook Stove – Ceramic liner; Biomass Cook Stove – Air Insulated- Top feeding; Biomass Cook Stove – Air Insulated - Side feeding; Solar Lantern LED; Solar Light CFL; Solar Light HLS; Biogas Plant; Solar Cooker; Solar Dryer; Glass Roof Tiles; Biomass Cookstove - Dhabha size; Biomass Cookstove -Community size; and Solar Water Heater

The present study was undertaken to find out the answer to the questions such as whether or not the selected renewable energy devices used by the beneficiary households had any impact on the various socio-economic parameters?. Whether or not the selected households adopted the technology devices and are they still using the same? What are the benefits realized by the beneficiary households while using these devices? What is the rate of willingness to pay for particular device by beneficiary households as compared to its present value? What are the suggestions of users for improvement in these selected devices? What is the demand and willingness to pay by non beneficiary households for these technology devices.

The specific objectives of the study were as follows:

1) To analyse the extent of adoption of renewable energy technologies in selected tribal villages of Gujarat.
2) To analyse the impacts of renewable energy technologies on selected tribal villagers of Gujarat.
3) To suggest the measures to raise the adoption level of renewable energy technologies in selected tribal areas of Gujarat.

5.2 Methodology

The study is based on the primary data collected from the two selected tribal districts in Gujarat, where RE devices were set up by the agency, i.e. Dahod and Vadodara/Chhota Udaipur. There were two villages (Simal Faliya, Raysingpura/Oliamba) from Chhota Udaipur taluka of Chhota Udaipur/Vadodara district and total three villages from Dahod district [i.e. two villages (Chilakota, Chaidiya) from Limkheda taluka and one village (Dageria) from Zalod taluka] covered under the scheme (see, Map 1.1). The study covered the total ten RE devices, viz. (a) Improved Biomass Cook Stove – Ceramic liner, (b) Improved Biomass Cook Stove – Air Insulated- Top feeding, (c) Improved Biomass Cook Stove – Air Insulated - Side feeding, (d) Solar Light LED, (e) Solar Light CFL, (f) Solar Light HLS, (g) Biogas Plant, (h) Solar Cooker, (i) Solar Dryer, (j) Glass Roof Tiles. The village-wise RE devices-wise list of beneficiary was obtained from the SPRERI. As per the proportion of RE devices set up on subsidy rate in respective village, the 20 percent of total beneficiary households for selected RE device in that village were drawn as a sample selected beneficiary households for the study. The data were collected on 166 RE devices from the selected 105 beneficiary households from these five villages. In order to get some idea about demand and feedback on these RE devices from non-users, the data was collected from 42 non-beneficiary households (25 percent of total number of beneficiary units) from same villages. Besides formal survey through filling up of schedules, informal group discussions with beneficiaries and non-beneficiaries were also held. The conscious efforts have been also made to get the views of women and non-beneficiary households. The required data have been collected by canvassing a pre-designed and pre-tested schedule during the period from January to February 2015. The due care was taken in selecting beneficiary households in order to avoid the effect of one device on other. The simple tabular analysis was carried out to know the change in various parameters related to livelihood in the selected villages.

5.3 Socio-Economic Profile

- The major devices that SPRERI has provided to tribal households were solar lantern, biomass cook stove, glass roof tiles, biogas plant, solar cooker and solar dryer. Out of 887 devices set up in six villages of two districts (Dahod and Chhota Udaipur), about 31 per cent were solar lantern, 26.4 per cent were ceramic liner biomass cook stove, 23 per cent are air insulated biomass cook stove, 9.8 per cent are glass roof tiles and only 5 per cent are biogas plant.
- The average age of head of a beneficiary household was 45.4 years while that of non-beneficiary households was 41.3 years. About 93.3 per cent of heads of beneficiary households and 100 per cent heads of non-beneficiary households were male. The majority of both beneficiary (94.3%) and non-beneficiary households (100%) were dependent on agriculture as their main occupation. However, dairy sector was identified as their source of subsidiary occupation in both groups. The average farming experience of heads of beneficiary and non-beneficiary households was found 20.6 years and 20.1 years, respectively. The average years of education of heads of beneficiary households and non-beneficiary households were 7.2 years and 5.2 years, respectively. Thus, beneficiary household heads were relatively younger and more educated than non beneficiary heads.
- The caste composition of our sample beneficiaries revealed that, the proportion of ST population was the highest among the sample selected households (96.2 per cent for beneficiary HHs and 83.3 per cent for non-beneficiary HHs). Whereas, the proportion of SC population was as low as 3.8 per cent in case of beneficiary HHs and as high as 16.7 per cent in case of non-beneficiary HHs. The OBCs and General categories HHs were not found among sample households. The proportion of BPL HHs were more among non-

beneficiaries (50.0%) compared to beneficiaries (41.0%). The majority of beneficiary households comprising of 58.1 per cent were above poverty line (APL) ration card holders.

- The average family size of a beneficiary household was smaller (5.5) than that of non-beneficiary households (6.3). The analysis of age composition of beneficiary and non-beneficiary households reveals that male members of beneficiary households were more aged (28.0 yrs) compared to non-beneficiary households(26.4 yrs), whereas female members were almost same aged (27.4 yrs) for both the categories. The beneficiary households enjoyed better status over non-beneficiary households in term of education since the average numbers of education was higher for their members (7.3 years for male and 4.5 years for females) compared to that in non-beneficiary households (4.9 years for male and 3.4 years for females).
- About 54 per cent male members of both beneficiary households and non-beneficiary households were working in agriculture sector. However, slightly more female members in non-beneficiary category (55.3%) were engaged in agriculture sector compared to about 53.5 per cent female members of beneficiary households. Overall, the dependency rate (% non working members) was found more in case of beneficiary households (41.7% male and 43.2% females) compared to that in non-beneficiary households (38.0% male and 39.8% females).
- The livestock was found the major subsidiary source of income and employment for the sample HHs. Since agriculture in the both districts is highly risky venture depending on vagaries of rainfall, livestock holding provides the main platform for risk sharing. The livestock holding by beneficiary and non-beneficiary HHs was mainly consist of cows and buffalos. The average number of cows held by a beneficiary and a non-beneficiary HH was 1.85 and 1.10,

respectively. The average number of buffalos held by beneficiary and a non-beneficiary HH was 1.37 and 0.81, respectively. The average number of goats held by a beneficiary and a non-beneficiary HH was 1.03 and 0.29, respectively. The average number of poultry birds held by a beneficiary was 0.5 while no poultry bird was reared by non-beneficiary HH. Thus, the beneficiary households were found to hold more livestock and poultry compared to that by non-beneficiary households.

- The average amount of livestock products and income generated from them was more in case of beneficiary households compared to non-beneficiary households. The average annual income generated from livestock products was found about Rs 36430/- from cow and Rs 58305/- from buffalos in case of beneficiary households. Whereas in case of non-beneficiary households, the average amount of income generated from cow and buffalos was Rs 16860/- and Rs 19065/-, respectively.
- The net sown area (NSA) and gross cropped area (GCA) of a beneficiary household was found to be 3.54 acre and 5.68 acre, respectively which imply that the cropping intensity was 160.6 per cent. On the other hand, the net sown area (NSA) and gross cropped area (GCA) of a non-beneficiary household was 3.21 acre and 4.10 acre, respectively which imply that the cropping intensity for non-beneficiary households was 127.8 per cent. Thus, the agricultural lands had been utilized more intensively by the beneficiary farmers.
- The size of available own area for cultivation for beneficiary households and non-beneficiary households was 3.43 acre and 3.13 acre, respectively. The size of operational holding for beneficiary households and non-beneficiary households was 3.54 acre and 3.21 acre, respectively. It may be noted that the proportions of leased-out land was nil in case of both category of our sample farmers.

The average size of leased-in land for beneficiary households and non-beneficiary households was 1.57 acre and 1.75 acre respectively. In case of beneficiary farmers, the term of lease-in land for about 71.4 per cent of HHs was share cropping and for remaining 28.6 per cent HHs, it was fixed rent in cash. On the other hand, the term of lease-in case of non-beneficiary households was equally distributed (50% each) between share cropping and fixed rent in cash. It can be further noted that the area under irrigation for beneficiary households and non-beneficiary households was 51.1 per cent and 45.2 per cent of total operated area, respectively. In case of beneficiary households, the irrigated area for the categories of marginal farmers, small farmers, semi-medium farmers and medium farmers was 70.0 per cent, 62.2 per cent, 49.6 per cent and 25.6 per cent, respectively. There was no farmer from large farm holdings size in our sample.

- As far as different sources of irrigation are concerned, as high as 63.9 per cent of total operated area of beneficiary farmers was irrigated by open well or dug wells followed by tube wells (24.5%), usually energized by electricity and/or diesel. Canal and tank and other source of irrigation were minor contributors to irrigation coverage in the study regions as their joint contribution is about 2.1 per cent in the case of our beneficiary households. The area irrigated through canals and check dams was nil for both categories of sample households.
- The cropping pattern of the sample household (HH) shows that the distribution of area under different crops and under different crop groups. The GCA per HH of a beneficiary household and non-beneficiary household was estimated to be 5.68 acre and 4.10 acre, respectively. Overall, the per-HH area under *Kharif* and *Rabi* crops cultivated by a beneficiary household was 3.72 acre and 1.90 acre,

respectively. The per-HH area under *Kharif* and *Rabi* crops cultivated by a non-beneficiary household was 2.70 acre and 1.39 acre, respectively. The area under summer crops was meager in case of both categories. The share of kharif crop and rabi crop in GCA was 65.49 per cent and 33.45 per cent respectively for beneficiary households. The same for non-beneficiary households was 65.85 per cent and 33.90 per cent respectively.

- Among various *Kharif* crops, the area under cereals such as maize and paddy, pulses such as urad/black gram and oilseeds such as cotton, groundnut and soybean constituted the major proportion of total kharif area for both beneficiary and non-beneficiary households.
- Among various *Rabi* crops, the area under maize, wheat, cotton, groundnut, tur, gram and vegetables constituted the major proportion of total rabi area for both beneficiary and non-beneficiary households. The 51.5 per cent of total area under *Kharif* crops of beneficiary households was provided with protective irrigation whereas corresponding figure was 55.1 per cent for non-beneficiary households, which implies that the level of production risk induced by rainfall variability was quite high in the study areas.
- It was observed that non-beneficiary households were better off than beneficiary households in terms of having number houses and cattle sheds. However, beneficiary households had better position in terms of having two wheeler and four wheeler, tractors and other agricultural implements and infrastructures. About 92.4 per cent beneficiary households had houses (kuchha/pucca) against 95.2 per cent of non-beneficiary households.
- The numbers of kuccha houses were slightly more in case of non-beneficiary households, whereas the number of pucca houses were more in case of beneficiary households. About 11.4 per cent

beneficiary households had pucca houses against 9.5 per cent of non-beneficiary households. As regards kuchha houses, about 81.0 per cent beneficiary households had kuchha houses against 85.7 per cent of non-beneficiary households. However, the number of cattle sheds was more in case of non –beneficiary households (0.79) compared to 0.66 number of cattle sheds of beneficiary households.

- On an average, a beneficiary household (HH) had 0.38 number of TV connection and 0.03 number of Local Cable connection. They have paid Rs 203.33 per month for Local Cable connection. On contrary, a non-beneficiary had 0.14 number of TV connections. Non beneficiary households did not have any local cable connection. The beneficiary households had 0.30 number of Dish TV connection for which they paid Rs 177.0 per month. On the other hand, the non-beneficiary households had 0.12 number of Dish TV connection per HH for which they paid Rs 260.0 per month.
- The beneficiary households had used 4.6 number of cylinders per annum for which they had paid Rs 434/-. On the other hand, the non-beneficiary households had used 3.0 number of cylinders per annum for which they paid Rs 427/-. Almost every beneficiary household had mobile phones where as corresponding figure was about 69 per cent for non-beneficiary households.
- The beneficiary HHs had succeeded to avail more credit compared to non-beneficiary HHs. A beneficiary HH had availed Rs. 9062/- of credit loans from various commercial banks and cooperatives as against of Rs. 48857/- of institutional loans by a beneficiary HH. Borrowings from informal sources such as landlord, employers and traders-cum-money lenders which are generally very costly were not found to prevail in study areas. As far as the purpose of borrowing is concerned, crop cultivation, tractor purchase, land reclamation

and purchase of agricultural implements and livestock were the major purposes for which loans were taken.

- In case of beneficiary households, about 13.3 per cent of households were taken loans for agricultural crop growing purpose, 6.7 per cent of them resorted loans for the purchase of agricultural implements and livestock, among others. However, in case of non-beneficiary households, about 11.9 per cent of households were taken loans for agricultural crop growing by whereas none of them resorted for loans for purchase of purchase of agricultural implements and livestock. The average rate of interest paid was found slightly higher for beneficiary households (6.56%) compared to non-beneficiary households (5.1%).
- The per-household consumption of food and non-food items by the beneficiaries and non-beneficiaries were found to be reasonable in the study areas. The beneficiaries had enjoyed better status with regard to consumption of different food and non-food items over non-beneficiary households. They had spent more on most items compared to that by non-beneficiary HHs. Among different kinds of food items consumed by beneficiary households, major proportion of expenditure was on rice, wheat, maize, tur, cotton and groundnut oils, milk and ghee for both categories of households.
- Among non-food items, the annual expenses on education, clothes, Fuel & electricity, medical expenses and loan repayment accounted major proportion of total household spending by the sample HHs. Except few exceptions, there were no much differences observed between beneficiary and non-beneficiary HHs with respect to monthly and annual consumption pattern. Beneficiaries were found to spend more on rice (Rs. 453.9 per month) compared to non-beneficiaries (Rs 386.4 per month). The amount spent on loan

repayment was Rs 17651.0 per annum by a beneficiary household against Rs 9532.1 by a non-beneficiary household.

- The non-beneficiary households were more affected on migration front. About 42.9 per cent of non-beneficiary HHs as against 18.1 per cent of beneficiary HHs had some members migrated out to get wage employment and income. Out of households having migrated members, about 83.3 per cent of non-beneficiary HHs as against 73.37 per cent of beneficiary HHs had some members migrated out every year. About 16.7 per cent of non-beneficiary HHs and 26.3 per cent of beneficiary HHs had migrated out during bad monsoon years. The duration of migration was much higher for non-beneficiary households (129.7 days) compared to 85 days for beneficiary households. However, the non-beneficiary migrants earned better wages (Rs 245.5 by males and Rs 242.5 by females) than beneficiary migrants (Rs 235.5 by males and Rs 234.4 by females). The majority of migrant workers were engaged in labour intensive works.
- The majority of sample migrant households had to migrate out for earning wages since they were not economically sound. About 84.2 per cent of beneficiary households cited the motive to earn wages as a major cause of migration, whereas about 55.6 per cent of non-beneficiary households cited that their family had to migrate out since they were not economically sound. About 22.2 per cent of non-beneficiary households expressed that they wanted to migrate out since they were not having any work and they were free of their traditional agricultural works which is mainly seasonal in nature.

5.4 Impact of RE Technology Devices

- It was observed that all the beneficiary households were using the renewable energy devices set up at subsidized cost by the SPRERI. The other agencies working in selected study area on renewable energy devices were SADGURU and GUJAGRO. The maximum numbers of devices set up among these households were biomass cook stove- ceramic liner, followed by solar lantern CFL and biomass cook stove-air insulated-side feeding. Solar dryer was the least preferred device in selected study area.
- The devices were set up at very high subsidized rate by the SPRERI. The amount paid by the beneficiary households after subsidy amount was ranging from 15 to 20 percent in case of cook stove, 24 to 27 percent in case of solar lantern, around 16 percent in case of biogas, 11 percent in glass roof tiles and about 7 percent in case of solar dryer.
- The SPRERI personnel were the major source of information about these devices, followed by village level workers, fellow farmers as well as information received/collected by him on his own. It was very strange to note here that no other agency including NABARD, Newspaper, TV/Radio as well as NGOs working in study area had extension/renewable technology dissemination programme.
- Among the sources of information for various devices, village level workers had played important role in disseminating the information about the devices to the various households. Most of the village workers identified by the implementing distributing agency were the first user of the device as they work as contact hub for any demand request for any device by any villager. They also hold the stock of devices as desired by the agency in order to minimize the time lag as well as hassle in meeting with agency person for same.

- Biomass Cook Stove and Domestic Chulha: It was observed that almost all the selected households are using improved Biomass Cook Stove and preferred same due its mobility (TABLE 3.3 and Figures 3.1 to 3.4). However, in case of improved BCS Top Feeding, most of the households reported that it is very tedious/cumbersome to cook rotla on top feeding cook stove as every time one need to remove the fry pan. Thus, these households are still using domestic chulha for the purpose of rotla making and hot water purpose whereas BCS-TF is mostly used for preparation of tea, rice, sabji, dal, etc. The rotla is main item in food and therefore beneficiary households had kept both BCS-TF and domestic Chula in use.
- Wood fuel requirement for cooking was found almost fifty per cent less in case of BCS than domestic chulha. In case of agri waste and dung cake also, the requirement was found less in BCS than its counterpart. The need of Kerosene was also reduced to about half level in BCS. Therefore, costs of fuel item were found to be higher in case of domestic chulha than BCS. Despite of half reduction of requirement of wood for BCS, the time for collection of wood had recorded marginal decline in BCS than domestic. This may be due to the fact that time for search, collection of wood as well as preparing wood suitable for cooking purpose has done together by beneficiary households for both kinds of chulha and therefore, they could not separate it into two.
- The cooking time requirement during day as well as night time was found less in case of BCS than domestic chulha. The saved time was used on field. The expenditure on health was found relatively similar in both the cases. The beneficiary households were asked about their willingness to pay for BCS, and it was observed that they are willing to pay around Rs. 350/- per unit.

- Some of the households were not using the cook stove, mainly BCS-CL (2.1% HHs) and BCS-AITF (6.3% HHs). These devices were not used for about 3 months. The reason towards same was mentioned that these households' requirement was less and thus they did not use it regularly. Training was provided by the agency and maintenance back up was also provided as and when required. No equipment was transferred to other person and all were in use with selected households.
- Solar Lights: The selected houses were of mixed in nature, i.e. compact and spacious. The average number of rooms in selected households was around two having maximum windows as well as direction of house towards east-west. The adequate ventilation in house was observed in case of 49 percent houses. More than 40 percent houses of solar light beneficiary households were with mangalore roof whereas around 25 percent households were with *desi* roof. About half of the selected households had good ventilation, however during the rainy and cloudy days, they had made some arrangements to reduce the darkness. The use of solar light followed by kerosene and GEB electricity were the prominent source to reduce darkness in the house. After availability of solar light, it has been used heavily to reduce the darkness in the house. Thus, it must have saved the expenditure on kerosene.
- Except one each in LED and CFL, all other LED and CFL as well as HLS units were in use at the time of survey. All the light units were charged for about 6 hours by solar recharge system, whereas supportive recharge was also provided by electric supply to some CFL and HLS units to the extent of 2.67 and 1.0 hour respectively. More than 86 percent of beneficiary households had done recharge every day. About 90.0 per cent beneficiary households of LED and 93.3 per cent beneficiary households of HLS had to recharge their

solar light system every day. About 36 percent and 16 percent beneficiary households of LED and CFL respectively mentioned that they themselves repaired the units, as and when they had faced problem in same. About 48 percent CFL users, more than 63 percent LED and HLS users recorded that agency had provided them maintenance backup. No unit of solar light was transferred and all were with beneficiary household.

- Before solar light system situation, selected beneficiary households were used to have light for about 6 hours in a day, mostly through GEB electric supply and through use of kerosene. Whereas after use of lantern, total light hours had increased to around 8 hours and major source was lantern, supported by GEB supply and also use of kerosene. However, significant decline in use of kerosene has been noticed, i.e. from around 3.8 liters per month to around 0.8-1.0 lit per month. Thus expenditure on kerosene has reduced by about two third of cost incurred earlier. The impact could be also seen in total electricity bill, which declined from Rs. 289/- per month to less than Rs. 252/- per month. The increase in studying hours of their children was another positive feature of use of lantern. HLS system was first choice of children for studying followed by CFL, whereas households having LED experienced relatively less studying hours.
- In case of total working hours on the field, it was observed that there was increase in numbers of working hours on the field after having availability of lantern with beneficiary household. During the night hours, beneficiary households had used the lantern on field to complete some works. On the response to willingness to pay, beneficiary households opined that they would pay around Rs. 350-600/- extra than the subsidy amount paid by them to the agency. Thus, despite of having numbers of benefits from the lanterns, the willingness to pay amount seems to be lower.

- Glass Roof Tiles: The houses of beneficiary household of glass roof tiles were with average two rooms and adequate ventilation. The average height of the house was about 16 feet and 75 percent houses were with mangalore roof whereas 25 percent households were with *desi* roof. In order to reduce the darkness in house, besides use of glass roof tiles, use of kerosene and grid electric supply were the prominent sources. The details on glass roof tiles used indicated that half of the beneficiary households had used one tile whereas remaining had used two tiles and no one had faced any problem. Training and maintenance facility was provided by the agency and all the units were with beneficiary households. The selected beneficiary households mentioned that they are willing to pay Rs. 50/- for one tile and Rs. 100/- for two tiles with subsidy and Rs. 103/- for one tile and Rs. 150/- for two tiles without any subsidy.
- Before glass roof tiles, total light hours in beneficiary households due to use of GEB supply and use of kerosene were found around 6.3 hours, which had reduced to around 3.5 hours after use of glass roof tiles. Due to reduction in use of kerosene, the expenditure on same had reduced to one third of earlier one, i.e. from Rs. 45/month to Rs. 15/month.
- Biogas Plant: The constructed biogas unit size was of 3 by 3 meter having capacity of 2 meter cubm gas/day capacity and of animal waste based units. The feeding pipe was of PVC with small slurry dragging area. The water and dung requirement ratio suggested to be used was as 5 parts of dung and 2 part of water. Every day around 23 kg dung was used for slurry making, thus requirement of 9-10 liters of water for same. The selected biogas beneficiary households had used to prepared slurry every day by spending about half an hour and thus no requirement of additional labour

was mentioned by the beneficiary households. The slurry was prepared by sometime by male, female and even children of these households as per their availability and engagements.

- The digested slurry was used mainly for FYM purpose, as well as for making vermin compost. The use of used slurry for FYM was preferred most because of the fact that dragged slurry has no seed of weed or any unwanted crop and thus results in no problem of weeds after use of FYM of slurry made. The less expenditure on control of weeds thus benefits the beneficiary households during crop cultivation.
- The agency had provided the training to all the beneficiary households on operation and use of biogas plant. Some of beneficiary households had faced problem in operation and they themselves had solved the same. One biogas plant was found non-working because of pipe was broken and same was informed to the agency for maintenance backup. The gas was used by beneficiary households for their uses and no one had shared to other nearby household. All the households had mentioned that they would continue with the present biogas systems and their willingness to pay for biogas plant was upto the extent of Rs. 5000/- only.
- About 67 percent households had mentioned that they would like to go for toilet linked biogas plant, whereas remaining households mentioned that they have adequate availability of dung and thus not to prefer for same.
- The drastic decline in cooking time was noticed after use of biogas, i.e. from almost 2 hours to 1 hour/day. Thus half of the cooking time was reduced because of use of biogas. The time spent on field also increased after biogas use which may be due to time saved in cooking. In case of time of study hours of children, surprisingly no change was noticed.

- Solar Cooker: The both conventional and solar cooker was used for preparation of rice and dal only mostly on every day afternoon. The use of conventional cooker was found throughout the year, whereas solar cooker was used mainly in winter and summer season. Because during the rainy season, non availability of adequate and high intensity sun rays due to cloudy weather results in non use of solar cooker by beneficiary households. The cooking time required in solar cooker was found one and half times higher than the conventional cooker. No problem was faced by the beneficiary households in use of solar cooker. Also all of them mentioned that no change in food taste was realized by them in food cooked in solar cooker. The households opined to pay Rs. 813 per solar cooker as compared to Rs. 750/- per cooker paid by them as subsidy amount for getting the same. The training on use of cooker was provided by the agency and as no problem was faced by the users, no maintenance back was provided. All the cooker were found to be used by the beneficiary households themselves and no one transferred to other.
- Solar Dryer: The weight of the solar dryer was of 0.5 to 1.0 kg and it was found that solar dryer was mostly used for drying vegetables sometime every day or on alternative day. It was used heavily during summer followed by winter season, while during rainy season, it was used rarely.
- The use of solar dryer had impact on saving time in drying the vegetables with no change in food taste. The agency had provided training on use of solar dryer and no one had faced any problem in use of same. All solar dryer were used by beneficiary households and no one had transferred unit. Without subsidy, the beneficiary households mentioned their willingness to pay was Rs. 150/ per unit.

5.5 Benefits & Constraints

- More than 93 percent beneficiary households opined that use of biomass cook stove helped them in reduction of use of wood followed by reduction in indoor air pollution and use of kerosene (more than 84 percent hh). More than 70 percent of households mentioned that due to use of BCS, not only cooking time has reduced but also suffocation in kitchen and female hard work had reduced significantly. The other major benefits of BCS cited by the beneficiary households were reduction in time of wood collection, better cleanliness of kitchen and thus may be better livelihood/ better family life.
- In case of top feeding BCS, feeding of wood from top generally disturb the cooking thus results in more cooking time or less preference of unit for cooking. Also cutting of wood in small pieces which is requirement of top feeding cook stove was major constraints faced by beneficiary household. The major food items of selected beneficiary households was rotla (chapatti) which can be cooked properly on BCS, for which they have to use domestic chulha is another constraint faced by the beneficiary households. This is one of the reasons why beneficiaries wanted more side feeding BCS. However, beneficiary HHs faced problem in moving the cook whenever necessary due to breakage of handle in BCS. About 4 per cent HHs of side feeding BCS raised this issue.
- About 93 percent households opined that the use of solar lantern has benefited by reduction the use of kerosene heavily, followed by reduction in darkness in the house (87.27 percent hh), reduced the dependency on GEB supply (about 69.09 percent hh) and also reduced the electricity bills. Due to use of the solar lantern, inside house pollution due to use of kerosene for lighting has reduced (69.09 percent hh), which resulted in better lifestyle/livelihood

(49.09 per cent hh). Besides, reduction in cooking hours, reduction in fire incidents and health hazards, more time for field work (by using lantern on field during night time) are some of the benefits experienced by the beneficiary households.

- There were some of the constraints reported during the survey time by the beneficiary households in the use of solar light. The major constraint experienced by the more than 52 percent of beneficiary household was low battery backup, followed by frequent battery problem (41.82 percent) and low intensity of LED lights. Besides, some of the households have reported that problem in charging of battery, no availability of no local repair expert were some of the problems faced by them.
- Among the suggestions given by the beneficiary households, majority of households opined that requirement of repair arrangement at local level (49.09%), followed by need to increase battery backup (43.64%) are the major one.
- The use of glass roof tiles had also brought some positive changes in the lifestyle of the beneficiary households. About 88 percent households had mentioned that use of glass roof tiles have reduced the darkness hours in house during day time which had given them feeling of increase in standard in living. Not only use of kerosene had reduced but also electricity bill got reduced. The only one beneficiary household has made a suggestion that more number of tiles should be given to install in all four corners of the house.
- All beneficiary households had mentioned that biogas was found cheaper than LPG, reduction in cooking hours, advantage in use of biogas slurry for FYM as compared to FYM prepared by conventional method and reduction in dependence on wood/kerosene. More than 88 percent households mentioned that it has reduced/saved fuel wood collection and preparation time, better use in rainy season (as

wood and other material got wet) which saves cooking time and wood. The other major benefits reported by beneficiary households were reduction in blackness of roof and outer side of utensils resulted in better lifestyle and livelihood, reduction in weeds and thus cost on weeding has reduced and income from agriculture has increased, easy to use pressure cooker for cooking the rice and dal, time saved in fetching wood/kerosene. The biogas beneficiary has faced some problems in operation and use of same. About 22 percent households had faced choke-up problem, followed by lack of supply chain for components and spare parts in rural locations, repair and maintenance is difficult and required more space to install was also noted.

- Among the various benefits experienced in use of solar cooker by beneficiary households, no wastage due to overflow (due to more heat) and no smoke were major one opined by all of them. More than 75 percent of households had mentioned that as there is no wastage due to more heat (as generally it happens in case of conventional cooker), no monitoring is required. About half of the households mentioned that we could keep hot food available for long time as well as dependence on wood and kerosene was reduced and it is very easy to handle. However, no benefit in reduction in cooking hours was recorded.
- The major and only constraint faced by the 25 percent beneficiary households was solar cooker takes more time during rainy and winter seasons. It is obvious because solar cooker decency on sun ray during rainy season affects due to cloudy weather and during winter, low temperature takes more time to cook food in solar cooker.
- The major benefit of solar dryer experienced by users was no inspection required and no change in taste and colour of material.

Around half of the beneficiary households mentioned that in case of solar dryer, other benefits were reduction in losses during drying though bird/animal/handling wastage, reduction in drying time and important one was dust free drying of material. The only constraint faced by half of the selected households was net got damaged during its use, which needs to be repaired/replaced by the agency in time.

- All the beneficiary households were asked to give their suggestions on improvement of RE technologies, whether same household has used or not used all RE technologies. Thus, we got responses from the household who had not used the technology may be because of this or any other reason. The highest number of households have suggested that battery quality of solar lantern need to be improved (16.2 percent hh), followed by opinion to make available more side feeding stove as it is better than top feeding cook stove. Stabilizer should be provided with lantern (due to fluctuation in electric voltage charging to lantern not possible). Instead of LED, HLS should be provided (battery backup is more in HLS than led). More number of glass roof tiles should be provided and weight of ceramic cook stove need to be reduced.
- The non-beneficiary households were asked about their level of awareness and preferences for various solar renewable technologies available in their villages. Majority of them revealed their preferences for sided feeding biomass stove and glass roof tiles (76.2% each), solar lantern-HLS (50%) and biogas plant (11.9%). The major sources of information for them were SPRERI personnel and fellow farmers. There were no major differences between willingness to pay with subsidy and without subsidy for various devices except bio gas plants and solar lanterns. The non-

beneficiaries' willingness to pay with subsidy and without subsidy for bio gas plants was Rs. 5000 and Rs. 7500 respectively.

- As far as the causes of exclusion of rural households are concerned, about 54.8 per cent non-beneficiaries expressed that they were not aware about the benefits of solar devices. About 52.4 per cent non-beneficiaries expressed that the financial constraints were the major constraint for them that prevented them in buying those devices. Since these devices were available on limited basis for a short period of time, many rural families failed to arrange money at the time of availability. Thus, about 23.8 per cent non-beneficiaries could not purchase solar devices because of limited stock. Majority of them requested to make arrangements to have sufficient stock of these devices at local level, so that these families can purchase at their convenient time.

5.6 Policy Suggestions:

The study brought out following policy suggestions for policy makers:

- There is high demand for some of SPRERI's devices such as Solar Lantern HLS, Glass Roof Tiles, Side feeded Biomass Cook Stove and Biogas Plant in survey areas, but due to short supply of these devices, some households could not be benefited with same. Therefore, these solar devices should be made available in adequate number by the agency, if needed by having collaboration with private agencies.
- There is also a need to make these devices available in adequate number with local coordinators/service points. This

will help in enabling the rural people to purchase the item/s at their own financial convenience.

- Since these devices are highly subsidized and has demand, normally people close to local authority thus got the benefit, which should be avoided.
- The agency should take into account the suggestions made by the beneficiary household (e.g. Top Feeding Stove, Solar light-battery, etc) and should work on the possible corrections in the devices so that households would realize more impact and benefits of RE technologies.
- More awareness among rural women about important RE device as well as handling of these devices need to be made since devices are mostly handled by women and thus mishandled very often cause damage to the system/device. In some cases, it was observed that women could not start plugging the charger (Solar Lantern-HLS) because of fear of electricity.
- One of the reasons of low adoption of some devices was the unavailability of effective service points at local level. The unavailability of spare parts/accessories of these devices in local market, sometime delay in repairing of the devices, long procedure in getting the damaged devices repaired [1] and quality of the service provided have been the major constraints in generating confidence among rural people. These constraints should be addressed by the service provider in a timely manner.

[1] If any device gets damaged, as per instructions given to user by agency, they deposit the same with Sarpanch/Local coordinator. Then local coordinator informs to SPRRI personnel. SPRERI personnel visit the vilage as per their convenience/programme. Sometimes, it takes more than couple of months time address the issue.

- There is a need to train the local people to repair the systems in effective manner. The quality training should be provided to the local coordinator/service provider since they are found not to have sound knowledge about repairing of the devices.
- In case of Bio-gas plant, the technical problems were found to continue for a long period in Simal Faliya, causing spread of negative impression/rumors about the system and partial abandon of the system. Thus, the technical faults should be corrected within a reasonable time period.
- The number of solar cookers set up was found very less due to less adoptability. It can be mainly help in boiling the foods. In some cases, the users have never used such devices since it took much time and its use was not preferred/liked by rural women. Thus, agency should make some improvement in same.
- Solar Dryer was also not found that much useful for rural households. It was not found to be effective in saving time, though it was found effective in maintaining the taste and colour of the dried food better and cleaner compared to open drying.
- It is suggested to check the design of these two products (Solar cooker and Solar Dryer) so as to raise the level of efficiency. It is the only way to promote these devices.
- Frequent problems in battery of Solar Lantern HLS were observed in some study villages. Thus, it is necessary to undertake proper quality checks on these products before distributing them and the supplier of the battery should be cautioned about the technical faults.

- Efforts should be made by Government, NGOS and related organization to increase awareness among the people to use renewable energy devices.
- Efforts should be also be made by Government to make available these devices at commercial basis at lowest possible rate so the opportunity cost of same would enhance use of RE devices.

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Annexure I

Village-wise Distribution of Instruments

Sr. No.	Particulars	Vadodara			Dahod				Grand Total
		Simal Faliya	Oliamba/ Rayansinghpura	Total	Dageria	Chediya	Chilakota	Total	
1	Biomass Cook Stove – Ceramic liner	71	0	71	49	55	60	164	235
2	Biomass Cook Stove – Air Insulator- Top feeding	10	15	25	15	0	39	54	79
3	Biomass Cook Stove – Air Insulator- Side feeding	20	10	30	45	0	50	95	125
4	Solar Lantern LED	14	0	14	9	5	27	41	55
5	Solar Lantern CFL	39	10	49	33	0	62	95	144
6	Solar Lantern HLS	42	8	50	1	0	24	25	75
7	Biogas Plant	4	6	10	5	3	26	34	44
8	Solar Cooker	0	2	2	2	0	15	17	19
9	Solar Dryer	0	0	0	0	0	12	12	12
10	Glass Roof Tiles	0	2	2	16	0	23	39	41
11	Biomass Cookstove - Dhabha size	2	0	2	3	1	2	6	8
12	Biomass Cookstove - Community size	0	0	0	0	0	1	1	1
13	Solar Water Heater	0	0	0	0	0	1	1	1
	Total	202	53	255	178	64	342	584	839