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Case Study OSMJ

Cost–Benefit Analysis of Solar Energy: A Case Study Dehra Region of Kangra District in Himachal Pradesh

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Abstract

In a crux what we can say about our findings is that solar energy's potential in the area has not been utilized to its optimum level in the Dehra region and the people are not being properly taught about its benefits. No efforts are being put to educate people regarding the various opportunities it holds regarding employment, energy savings, and so on. Solar energy has immense potential to fulfill the energy needs of people across the world and many steps have been taken to promote its use across the world and in India. The Indian government has taken various steps to promote the use of solar energy among the masses. In our study done in Dehra region of Kangra district of Himachal Pradesh, findings show that the use of solar energy in rural areas is confined to lighting purposes only and it is not being used for commercial purposes. Many people in villages here are using solar energy in the form of lights and the panchayats are using solar lights for street lighting along with a few farmers using it for fencing in the fields to protect their crops from the animals. Although solar energy is being utilized still is not used at its full potential. Dehra being a hot region with lots of sunny days in a year holds huge potential for solar energy use. In our study, we found that less than 50% of people included in our survey or sample are using solar energy. As to employment in solar energy, we found not even a single individual that was involved in any work in solar energy indicating that employment in this field from the region is nil.

Keywords: Solar energy, potential, employment, rural areas, villages

INTRODUCTION

Globally, a significant proportion of energy-related carbon dioxide (CO_2) emissions in 2021 can be attributed to the top 10 percent emitters, accounting for almost half of the total emissions. In contrast, the bottom 10 percent of emitters only contribute a mere 0.2 percent [1]. It is worth noting that India, following the United States and China, ranks as the third-largest contributor to CO_2 emissions [2]. India's CO_2 emissions amounted to a staggering 3.9 billion tonnes, representing approximately seven percent of the global emissions [2]. Undoubtedly, energy plays a crucial role in driving economic development. However, it is essential to acknowledge that development pursued at the expense of environmental degradation poses severe risks to humanity. Therefore, the question arises as to how a country should pursue economic development while minimizing environmental harm [3]. This prompts the consideration of which energy sources are beneficial in the long run. Energy can be broadly classified into two categories: non-renewable and renewable. Non-renewable energy sources primarily encompass those derived from fossil fuels. These include coal, oil, and natural gas, which have been extensively used for many years due to their high energy

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density and availability. In India, the principal sources of emissions comprise coal, serving as the primary contributor to CO_2 emissions, and the agricultural sector, ranking second, responsible for substantial methane (CH_4) production from rice paddies and cattle [4]. So, an alternative for fulfilling energy needs is renewable energy resources. Renewable energy sources, encompassing hydro, wind, and solar energy, are clean energy alternatives. They mitigate climate change and pollution due to their sustainable nature. Hydroelectric power harnesses water, while wind and solar energy rely on wind and sunlight, respectively. India heavily relies on coal for approximately 53% of its electricity generation, the study by Spencer et al. (2019) [5] indicates that its coal reserves are projected to be exhausted by the years 2040–2050. Consequently, Indian authorities have set a challenging goal of achieving net zero carbon emissions by 2070 [5]. The current study will center its attention on solar energy due to several factors. Firstly, solar energy is abundantly available, making it a reliable source of power. Additionally, it can be utilized even in cloudy conditions, ensuring a continuous energy supply. Moreover, the Earth absorbs a significantly larger amount of solar energy annually than what is currently utilized by mankind, showcasing its immense potential. Solar systems offer diverse applications, ranging from heating and cooling to natural lighting, power generation, and fuel production. Photovoltaic panels play a crucial role in converting solar radiation into electrical energy, further enhancing the viability of solar energy [6].

Employment Generation in the Renewable Energy Sector

The International Renewable Energy Agency (IRENA) and the International Labour Organisation (ILO) produced a report in September 2022 that stated that 12.7 million people were engaged globally in the sector in 2021, an increase from 12 million in 2020. The report also stated that in a bold energy transformation scenario with front-loaded investments, employment generation in renewable energy may increase to 38.2 million in 2030. More than 80,000 individuals were directly engaged in decentralized renewable energy in India in 2021, largely in solar PV, according to the Powering Jobs Census 2022. Women make up only 21% of the decentralized renewable energy (DRE) sector in India. According to a new and updated report of Council on Energy, Environment and Water (CEEW), NRDC India (Natural Resources Defense Council India) and Skill Council for Green Jobs (SCGJ), “India's Expanding Clean Energy Workforce: Opportunities in The Solar and Wind Energy Sectors,” installing two hundred and eighty GW Solar and one hundred and forty GW Wind capacity can help India achieve its goal of five hundred GW non-fossil electricity generation capacity by 2030 by creating 3.4 million jobs (short-term and long-term). According to a collaborative paper titled “Renewable Energy and Jobs—Annual Review 2022” from the IRENA and ILO India produced 8,63,000 green employment between 2020 and 2021, of which 2,17,000 were in vertical solar photovoltaic and 4,14,000 were in hydropower [7].

Cost–Benefits Analysis of Solar Energy

Himachal Pradesh, with its substantial solar energy potential and average solar radiation of 4.5 to 6.0 KWh/m² per day, offers a viable solution to address rising energy demands and reduce carbon emissions. Several studies have examined the cost–benefit analysis of solar energy in India [8], demonstrated the financial feasibility of solar photovoltaic systems in agriculture, while Dutta et al. [9] identified significant cost savings and economic advantages in industrial applications [10]. Analysed the economic viability of solar power plants in Himachal Pradesh, revealing substantial cost savings in the long term. Additionally, Thakur et al. [11] assessed the environmental impact, emphasizing the reduction in carbon emissions through solar energy adoption in the state. These findings collectively underscore the economic and environmental benefits of solar energy adoption in Himachal Pradesh, making it a promising avenue for sustainable development [11].

Need and Significance of the Study

Need to study various aspects of solar energy arises as many efforts are being made in tackling the problem of climate change through green energy and solar energy has the most potential in the renewable energy sector in mitigating the global warming.

Objectives and Research Methodology

Objectives of the Study

1. To find out the extent to which the solar energy is being used for domestic and commercial purpose in Dehra Gopipur region of Kangra district.
2. To study the cost–benefit analysis in the solar energy sector in the selected region of Himachal Pradesh.
3. To find out the level of employment generation by solar energy in Dehra Gopipur region of Kangra district.

RESEARCH METHODOLOGY

Methodology plays an important role in verifying the findings of the study and also guides the researcher on what the researcher has to do to stay on the right path so that the findings are accurate. This study is focused in Dehra region of Kangra district of Himachal Pradesh.

For the purpose of this study, primary data collected by way of questionnaire, secondary data also used to complement the primary data and then if necessary econometric tools applied to the data as required for further findings. Multistage sampling was used to select the area and the respondents were selected randomly. In total 35 households samples were taken for the purpose of our study and simple statistical methods were used to analyse the data.

Socio-Economic Profile of Respondents

The data collected from Dehra region of Kangra district in Himachal Pradesh through structured questionnaire is used in different villages of Dehra Tehsil. The questionnaire has been divided into two parts; first part covers the socio-economic profile of the respondent and the second part covers the questions covering the objectives of the study. I have taken 35 sample households in total for further research on my topic. Some secondary data has also been used for the research that has been collected from Agriculture Department Office of Dehra.

Family Structure

Family structure explains whether the household under consideration is living in a nuclear or a joint family system. Joint family means that grandparents, parents and children are living together and nuclear family means that only the parents and children are living together not the grandparents. Table 1 represents the ratio of family structure taken in the sample.

Table 1. Type of family.

Family Structure		No of families	Percentage
Joint		13	37.14
Nuclear		22	62.86
Total		35	100

Source: Primary Survey (2023)

The above table represents total selected families are joint and nuclear families. The number of joint families is 13 i.e., 37.14% and the number of nuclear families is 22 i.e., 62.86%. Through this, we can clearly make out that most of the households are living in nuclear families. This has been depicted in the Figure 1 given below.

Demography of Sample Households

This represents the total number of males, females and children in the sample households that we have taken. Males and females here include the persons above 18 years of age, respectively and children include all the girls and boys less than 18 years of age. Table 2 represents the number of males, females and children.

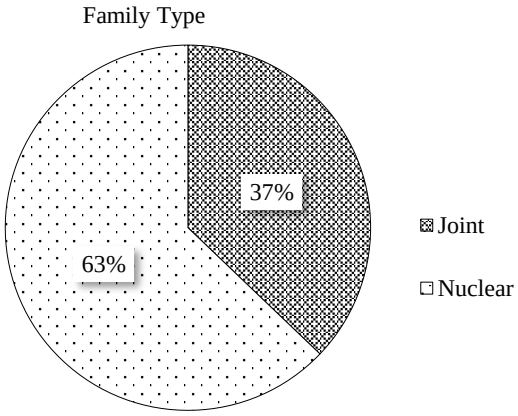

Figure 1. Pie chart depicting types of families included in study.

Table 2. Demographic structure of sample households.

Group of Persons	Number in Figures	Percentage (%) Figure
Males	90	45.45
Females	67	33.84
Children	41	20.71
Total	198	100

Source: Primary Survey (2023)

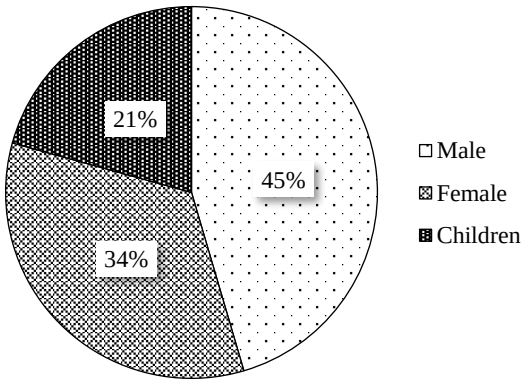

Figure 2. Chart depicting ratio of males, females and children.

Table 2 above tells us that the total number of persons in the sample is 198 and out which the number of males is 90 i.e., 45.45%, the number of females is 67 i.e., 33.84% and the number of children is 41 making it 20.71%. This is also represented by the Figure 2.

Social Category of House Holds

This tells us about the category of the households. The categories majorly can be divided into for namely General, Scheduled Caste (SC), Scheduled Tribe (ST) and Other Backward Classes (OBC). Table 3 represents the total number of social group that are in the sample.

Table 3 shows that out of total 35 samples, the number of households that belong to general category are 24 i.e., 68.57%, number of scheduled caste households are 8 i.e., 22.86%, household belonging to scheduled tribe is zero and number of other backward classes are 3 i.e., 8.57%. This explains that most of the households in the sample are of general category followed by the scheduled castes and at last there were other backward classes that were the least. It is to be noted that there was no household belonging to scheduled tribe category as Dehra region is not a scheduled tribe area. Following Figure 3 also depicts the same information.

Table 3. Social category of households.

Social Group	Number in Figures	Percentage (%) Number
General	24	68.57
Scheduled Caste (SC)	8	22.86
Scheduled Tribe (ST)	0	0
Other Backward Classes (OBC)	3	8.57
Total	35	100

Source: Primary Survey (2023)

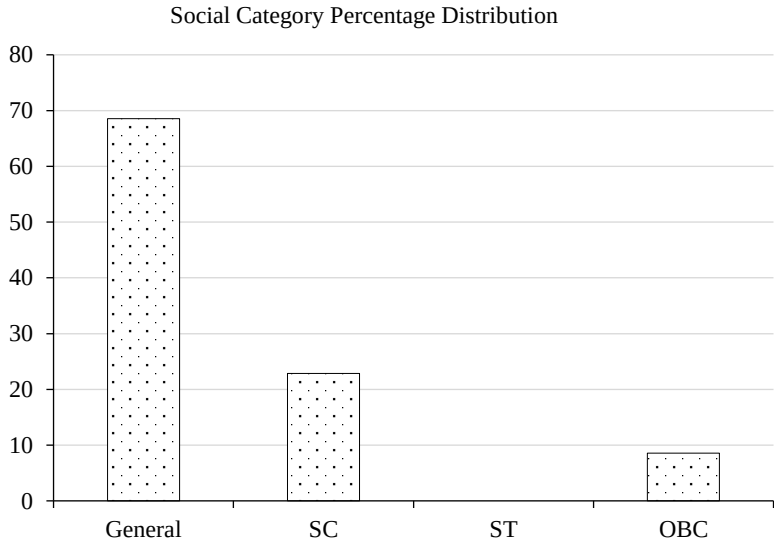

Figure 3. Social category percentage distribution.

Table 4. Occupation status of households.

Occupation	Number in Figures	Percentage (%) Number
Self Employed in Agriculture: Farming	4	11.43
Self Employed in Agriculture: Non-Farming	0	0
Non-Agricultural Enterprise	2	5.71
Regular Wage/Salaried Earner in Agriculture	0	0
Regular Wage/Salaried Earner in Non-Agriculture	9	25.71
Others (Pensioners, Remittance Recipients, etc.)	20	57.15
Total	35	100

Source: Primary Survey (2023)

Occupation refers to the job or profession through which a person earns the livelihood for the family, for example farmer, lawyer, teacher, etc. The occupation here is divided into six fields that are shown in Table 4.

Table 4 shows that a greater number of these households are 20 i.e., 57.15% were pension receivers. The persons that earn regular wages or salaries from non-agricultural enterprise ranks second from highest scale i.e., 9 in numbers and 25.71 in percentage, they are followed by persons that are self-employed in agriculture: farming activities that is 4 that is 11.43% and they are followed by persons involved in non-agriculture enterprise which is 2 that is 5.71% and there were no persons in the sample that works in agriculture: non-farming activities and regular wage or salary earners in agriculture. The column chart in Figure 4 below also depicts the same information.

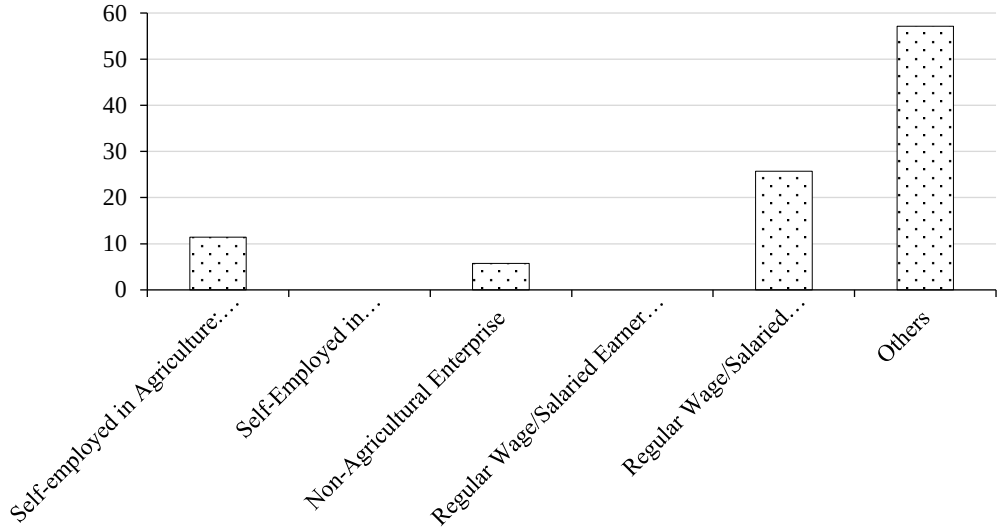

Figure 4. Occupation of households selected.

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Table 5. Annual income details.

Annual Income		Number in Figures	Percentage (%) Numbers
Less than 1 Lakh		12	34.29
1 Lakh–5 Lakh		21	60
5 Lakh–10 Lakh		2	5.71
Total		35	100

Source: Primary Survey (2023)

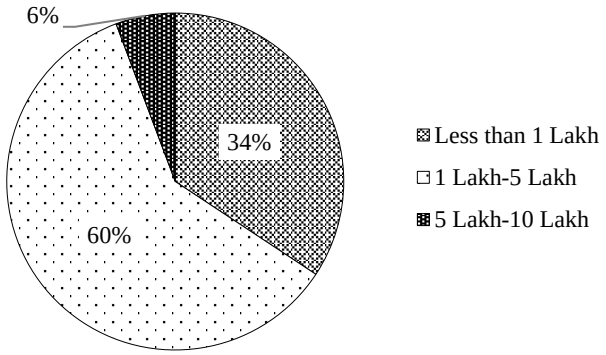

Figure 5. Pie chart depicting income level of different class of people.

Income Levels of the Selected Households

Annual income refers to the total income earned by an individual during the whole year. Here annual income of the whole family of the household is considered in the sample. Annual income of the family here is divided into three heads, the details of which are given in Table 5.

From Table 5, it can be seen that income groups are divided into three, less than 1 lakh, 1 lakh–5 lakh and 5 lakh–10 lakh. As the figures shows that households that have annual income less than 1 lakh are 12 or 34.29%, households that have income between 1 lakh and 5 lakh are 21 or 60% which is highest in number and households that have income between 5 lakh and 10 lakh are only 2 or 5.71% which is lowest. This table also shows that there are very few people in the villages in higher incomes and most of the people have mediocre incomes and some people have very low incomes and these are involved mostly in farming activities or working as wage laborers as shown in Figure 5.

Education Status of Sample Persons

Educated persons in family show about the persons in family those have a formal education and can read and write. This does not include children that are too small to read or write or too small to go to school for a formal education or they are going to school but cannot read and write on their own. Information regarding this is given in Table 6.

Table 6 shows us the number of educated or uneducated persons in the sample. It shows that the total number of educated persons is 169 or 85.35% and the number of uneducated persons is 29 or 14.65%. This makes us clear that most of the persons in the sample were educated and were able to read and write only a very few people were there who were uneducated or were not able to read and write. The Figure 6 below also represents the same figures.

This part completes the socio-economic profile of the households in the sample for the study. Socio-economic profile described the people based on their social status that is education, job type, income, category, etc. Now we will see the analysis of the data based on the objectives of the study.

ANALYSIS OF SOLAR ENERGY USAGE FOR DOMESTIC AND COMMERCIAL PURPOSE IN DEHRA REGION OF KANGRA DISTRICT

Number of Households with Installed Solar Equipment

This head will give us the detailed households that have installed any kind of solar equipment in their house. More clearly it gives us the number that how many households have installed solar equipment and how many households have not installed the same in our sample. Details are given in Table 7.

Table 6. Number of educated persons.

	Number in Figures	Percentage (%) Numbers
Educated	169	85.35
Uneducated	29	14.65
Total	198	100

Source: Primary Survey (2023)

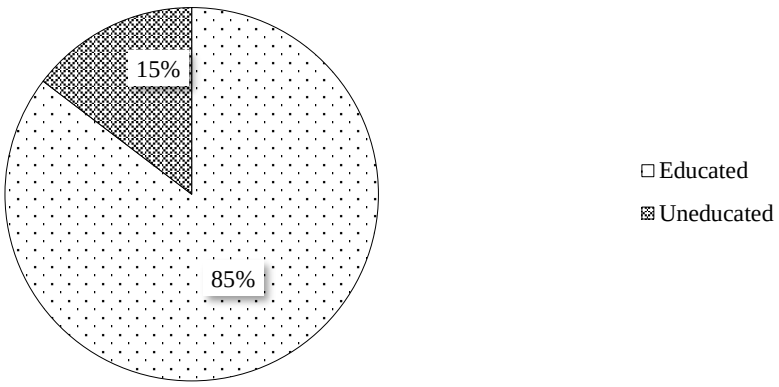

Figure 6. Education status.

Table 7. Installation of solar energy equipment.

	Number in Figures	Percentage (%) Numbers
Households with Installed Solar Equipment	12	34.29
Households without Installed Solar Equipment	23	65.71
Total	35	100

Source: Primary Survey (2023)

Table 8. Details of the households with installed solar equipment.

Household No.	No. of Panels Installed	Cost of Panels Installed (in Rupees)	Energy Generated by the Panel (watt)	Savings after Installation	Installation by Govt. Scheme	Technical Persons Available	Subsidy Received
1	1	0	9w	1	1	1	Fully subsidized
2	1	0	9w	0	1	1	Fully subsidized
3	1	3300	9w	1	0	1	1
4	1	3300	9w	1	0	0	0
5	1	3300	9w	1	1	1	1
6	1	3300	9w	1	1	1	1
7	1	6000	15w	0	0	1	0
8	1	3300	9w	0	1	1	1
9	1	2200	9w	1	1	1	1
10	1	3300	9w	0	0	0	0
11	2	6600	18w	0	0	0	0
12	4	10500	36w	1	1	1	1

Source: Primary survey (2023)
Note:- 0=No; 1= Yes

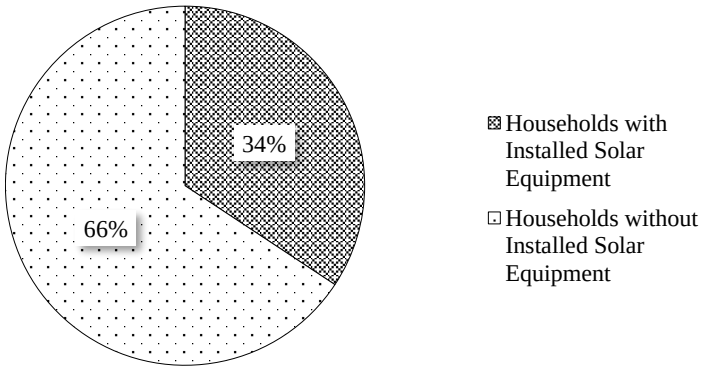

Figure 7. Installation of solar energy equipment.

Table 7 shows that out of the total 35 households, there were 12 households with installed solar equipment, making them 34.29% and there were 23 households with no solar equipment installed making them 65.71%. This shows that very few households had solar equipment installed in their houses making it clear that use of solar energy was done by very few people only. This is also depicted in the Figure 7.

Details Regarding Installations in the Household

As we know from Table 7, there are only 12 households that have installed solar panels in their house, therefore, under this head we will have a look at the details regarding the number of solar panels installed by the household, cost incurred in installation of solar panel, energy generated by the solar panel, are there any savings after installation of solar panel, is there any installation done through the government scheme, are the technical persons needed for the purpose of maintenance of solar equipment available, and did the household receive any subsidy for installing solar panel. This will also give an idea on how much aware the households are after installing the solar equipment. Table 8 shows us the data.

Table 8 shows us that in 12 household, a total of 16 solar panels were found installed. Most of the household have only 1 solar panel installed and one household had 2 solar panels installed and one more had 4 panels installed. Table 8 shows that first two households had to incur zero cost to install solar panel in their house, most of the households with single solar panel had to incur Rs.3300, and

only one household that had four panels installed incurred a cost of Rs.10500. One household with single panel i.e., 7th household incurred a cost of Rs.6000. One household i.e., 8th household incurred a cost of Rs. 3300. It also shows that in most of the houses with a single solar panel, energy generated is 9w, in the household with 2 solar panels, energy generated is 18w and in the household with 4 solar panels, energy generated is 36w. Only in one household i.e., household no. 7, energy generated with single solar panel is 15w. Table 8 also shows that many household deny any savings in power after solar installation but some of the households have agreed to the fact that they have been saving in power expenses since they have installed the solar panels in their house. Table 8 also shows that most of the household have done the installations through the government scheme i.e., more than 50% of households, but still many households deny any role of government schemes in the installations. It also shows that many households agree that the technical persons are easily available for the maintenance of the equipment while three household deny the availability of technical persons for the maintenance. Table 8 shows that the first two household received full subsidy for installing the solar equipment, while some households said that they received subsidy up to some amount while some household deny receiving any subsidy from government for the installation of solar equipment.

Awareness about Various Government Schemes Regarding Solar Installation

This will provide information regarding how many households in our sample are aware about the various schemes offered for the installation of solar equipment in the house. This will simply provide the number of households aware or not aware about the schemes. The data are shown in Table 9.

Table 9 shows us that out of the total 35 households, 20 households i.e., 57.14% were aware about the schemes offered by the government for solar installations and 15 households i.e., 42.86% were unaware about such schemes. This is also represented by the Figure 8.

Details regarding Excess Generation of Power

This head will give us details about excess generation of power after domestic use and is any household selling any excessively generated energy.

Table 9. Awareness about schemes.

	No. in Figures	**Percentage (%) Number**
Awareness about Various Govt. Schemes Regarding Solar Installations	20	57.14
No Awareness about Various Govt. Schemes Regarding Solar Installations	15	42.86
Total	35	100

Source: Primary Source (2023)

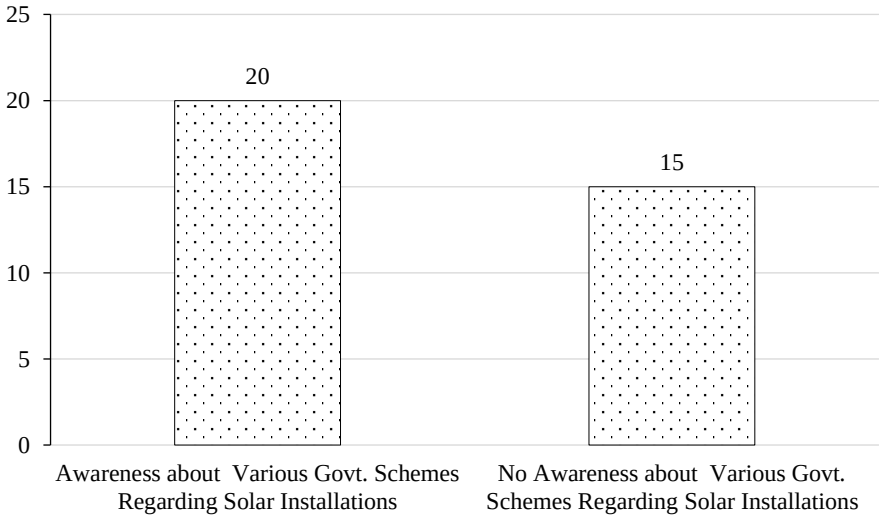

Figure 8. Awareness about various government schemes regarding solar installation.

In our sample, there was no household that was having any excess generation of power after domestic use and therefore, no household was selling any excessively generated power at all.

Any Use of Solar Energy in Farming Activities

Solar energy is also used in farming activities nowadays for solar fencing and other such activities. This head here will provide information if any of the household in our sample is making use of solar energy in farming activities.

In our survey, we found that no household was making any use of solar energy in farming activities.

Payment of Power Charges before and after the Solar Installations

This will give insights about how much power charges of the household change after the solar installations.

In our survey, we found that very few households admitted that they have felt the changes in power charges after the installations of solar equipment, although they told that savings were very small in amounts like from Rs.50 to Rs.100 only. But this change couldn't be felt due to following reasons in the households in the villages as in Himachal Pradesh, electricity up to 125 units is free and in villages there is very less utilization of electricity.

To augment the findings of our study, we also collected some secondary data which was collected from the block agriculture office of Dehra region of Kangra district. In the data, we found that agriculture department was offering solar fencing to the farmers to protect their crops from the animals. Thus in Dehra block, many farmers installed solar fences in their farms in different financial years, the data of which is given below in Table 10.

Table 10 and the Figure 9 shows that in the financial year 2019–20, the number of farmers that installed solar fencing was 15, in the year 2020–21 it was 19, in the financial year 2021–22 the number was 11 and in the financial year 2022–23 the number was only one. It can clearly be seen here that all the farmers received subsidy from the government to install solar fencing. The amount of subsidy received differed but all the farmers received subsidy up to 60%–70% for the installation. Although the thing here to look is that in the financial year 2022–23 only one farmer installed solar fencing.

ANALYSIS OF COST AND BENEFITS OF SOLAR ENERGY IN SELECTED REGION

Here we have done the cost–benefit analysis of the households that have installed the solar panels. Table 11 will give the information in this regard.

In Table 11, we can see that out of the total 12 households that have installed the solar panels only four household agreed to the fact that they have seen the benefits of solar energy in the form of savings in power charges. And they also agreed that they were saving around Rs. 50 to Rs. 100 on a monthly basis and from above table, we can see that household no. 12 is saving around Rs. 500 on monthly basis. The reason for the other households denying savings after solar installations can be attributed to the fact that in Himachal Pradesh, electricity up to 125 units is free and the survey was done at the village level where only few houses consume electricity on a large scale and for most of the households the electricity usage does not cross the bar fixed by the government therefore, people are not counting the benefits received by the solar installations and it becomes difficult to calculate the cost and benefit by the solar installations. Thus for the households with high consumption of electricity it can be said that they are savings around Rs. 500–1000 annually and receiving benefits from the solar energy.

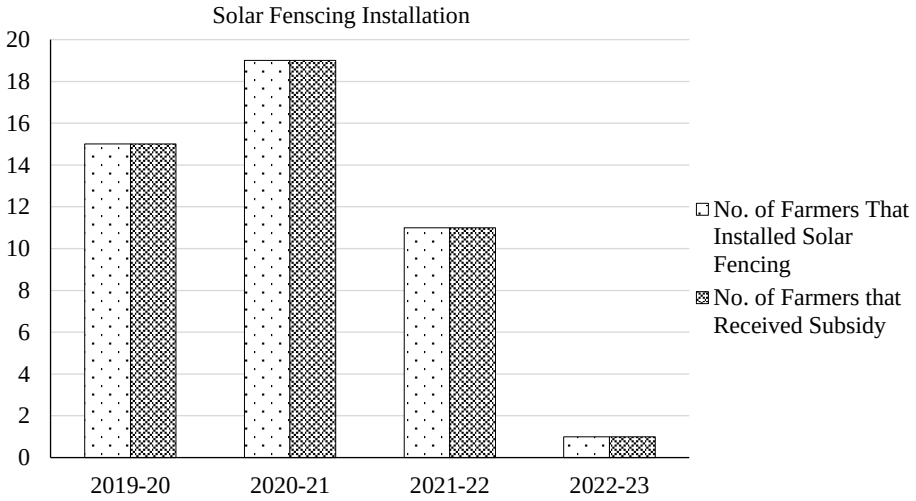

Figure 9. Solar fencing installation.

Table 10. Installation of solar fencing.

Financial Year	No. of Farmers That Installed Solar Fencing	No. of Farmers that Received Subsidy
2019–20	15	15
2020–21	19	19
2021–22	11	11
2022–23	1	1

Source: Agriculture Department Dehra (Dehra)

Table 11. The cost–benefit analysis of the households that have installed the solar panels.

Household No.	No. of Panels Installed	Cost of Panels Installed (in Rs.)	Power Charges Before Installation (Monthly in Rs.)	Power Charges After Installation (Monthly in RS.)	Savings (Monthly in Rs.)
1	1	0	850	750	100
2	1	0	0	0	0
3	1	3300	0	0	0
4	1	3300	0	0	0
5	1	3300	800	750	50
6	1	3300	0	0	0
7	1	6000	0	0	0
8	1	3300	0	0	0
9	1	2200	950	850	100
10	1	3300	0	0	0
11	2	6600	0	0	0
12	4	10500	1200	700	500

Data Source: Primary Survey (2023)
Note: 0 here means respondents were unable to recall any charges as asked

ANALYSIS OF EMPLOYMENT LEVEL IN SOLAR ENERGY SECTOR IN THE SELECTED REGION

Number of family members employed in solar energy, or employment in solar energy here means employed in any field in a solar plant, solar manufacturing, solar installations, etc. In our survey, we found that in our sample of 35 households which includes 198 persons we found no individual were involved in any type of work in solar energy plants. This clearly shows that all the individuals were involved in other professions.

CONCLUSION AND RECOMMENDATIONS

Solar energy has immense potential to fulfil the energy needs of people across the world and many steps have been taken to promote its use across the world and in India. Indian government has taken up various steps to promote the use of solar energy among the masses. In our study done in Dehra region of Kangra district of Himachal Pradesh, findings show that the use of solar energy in rural areas is confined to the lighting purpose only and it is not being used for the commercial purpose. Many people in villages here are using solar energy in form of lights and in villages, the panchayats are using solar lights for street lighting along with few farmers using it for the purpose of fencing in the fields to protect their crops from the animals. Although the solar energy is being utilized still is not used at its full potential. Dehra being a hot region with lots of sunny days in a year holds huge potential for solar energy use. In our study, we found that less than 50% people included in our survey or sample are using solar energy.

As to the employment in solar energy, we found not even a single individual that was involved in any of work in solar energy indicating that employment in this field from the region is nil. As to the awareness of the solar energy schemes related to it, most of the people are aware but they are not using it in daily lifestyle. Many people in our study pointed out that they are not being supported by the local governments in the use of solar energy saying that they are not being told about the benefits they can derive from its usage and where and how they can avail this facility. As to cost and savings of and from solar energy many people who have installed it said they are reaping the benefits from installation of the same while some said that they incurred very huge amount in installing solar equipment and the benefits derived from it are very less or too late in their reversion.

In a crux what we can say about our findings is that the solar energy's potential in the area has not been utilized to its optimum level in Dehra region and the people are not being taught about its benefits in a proper way. No efforts are being put to educate people regarding the various opportunities it holds in regard to employment, energy savings and so on.

While making some suggestions, we would suggest that more projects of public awareness should be taken up by the local authorities while educating people not only on the benefits of solar but also how the topography of the area could be helpful in the long term while using solar energy. Local authorities should also look up to the fact that when someone comes to learn about how they can avail such facilities he should not be returned empty handed rather he should be treated in a due manner. Authorities should also take a step to educate children in schools and colleges about how they can build a career in solar energy or renewable energy. Special lectures from the experts in this field should be arranged, workshops and career counselling lectures should also be arranged so that children can learn about it in the early ages and pursue these kind of profession that is the dire need for green energy programme of the government.

As Dehra is not a mountainous place and is a hot area with a lot of sunny days, local authorities should try and give a proposal to the government and try to set up a solar park in the region so that they can derive the benefits of the solar energy at its best and this will not only fulfil the energy needs but will open many opportunities for employment and learning for the young ones of the region.

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