International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Impact of Solar Street Lights on Wellbeing of Rural Communities in North-Eastern Region of India

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Abstract: **About 366** ***Solar LED Street Lights were installed in four villages of Golaghat district of Assam using Corporate Social Responsibility funds of Numaligarh Refinery Limited (NRL). After a year of installations, assessment of impacts was conducted. NRL, TERI and the villages worked in close coordination to maintain the functionality of the installed street lights. This initiative impacted positively on the overall well-being of the villages. Easy movement during evening hours and rainy days, reduced elephant attacks and snake bite incidents, improved sense of security among women and children, contribution towards power for all, and savings on conventional electricity were the prominent benefits of the Solar LED Street Lights. A strong sense of ownership among the community towards the security of the Solar Street Lights was observed during the investigation. Considering the benefits of the Solar Street Lights on the community, similar initiatives may be replicated for other villages as well.***

Keywords: Solar Street Lights, Rural, Wellbeing

1. Introduction

India has already achieved the target of power for all by providing electricity connection to almost 100% of the rural households [1]. The next level of rural electrification is to provide electricity for improving quality of life such as providing street lights. Many initiatives are already in place by the state government agencies to provide street lights to the Indian villages. In India 1,131 villages are fully electrified. Provision of street lights based on conventional electricity in all these villages would enhance the electricity demand by manifolds. One of the option of illuminating village streets without increasing electricity load is Solar Street Lights. The Numaligarh Refinery Limited (NRL) with The Energy and Resources Institute (TERI) as implementation partner installed Solar Street Lights in four villages of Golaghat district of Assam.

About 366 Solar LED Street Lights were installed in four villages. Review of literature indicates that the peer reviewed papers documenting the impacts of the Solar Street Lights are almost negligible. After a year of installations, an impact assessment study was conducted in the month of March 2020, primarily to understand the impact of solar street lights on well-being of rural community. The present paper shares the findings on impact of Solar Street Lights on the wellbeing of the rural communities.

a) Study area

The state of Assam holds significant share in world tea market and produces more than half of the tea produced in India [2]. The state has huge forest share of about 35% of its total geographical area. As per the recent Economic Survey of Assam, the status of power is not satisfactory in the state as there is a gap between generation and demand. Presently, there are 33 districts in the state.

Agriculture, tea plantations and daily wages are the main source of livelihood in both villages. Women in the villages majorly engage in household work and weaving activities.

All the four study villages have household numbers ranging between 400 and 800 in numbers. Two among the four villages were partially electrified about 25 years back while the other two villages were electrified partially in the years 2016-17. However, all the villages were fully electrified in the first quarter of the year 2020. Power cuts are regular but are not for very long durations. Although, the villages were established about 40 to 50 years back, no street lights were ever installed. The Solar Street Lights were installed in the month of March 2019.

b) Institutional model

Three institutions were involved in the execution of the initiative. The cost of the systems and installations were covered under the Corporate Social Responsibility (CSR) fund of the NRL. The Energy and Resources Institute (TERI) is the implementation and the knowledge partner. The Institute conducted scoping study to understand the technology needs, identified appropriate technology; identified technology supplier based on institute's bidding protocol, and then finally supervised the installation of technology. The technology supplier installed the Solar Street Lights with three years of warranty period. In case of observation of any fault in the systems, the village coordinators call the technology supplier. The houses are located adjacent to the village street. The Solar Street Lights are installed in the main street with the spacing to cover the entire village street. The villagers use the quality illumination in the streets while commuting after twilight. Illumination is also received in the house premises adjacent to the Street Lights. The figure 2 illustrates the interaction structure among all the key stakeholders.

c) Technology

TERI conducted an assessment for technical feasibility for Solar Street Lights. The duration of sunny hours and availability of space were indicative of suitability of the technology in the village locations. Based on the street length, the numbers of solar Street Lights were decided. The

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spacing was estimated in such a manner that no dark patch remains after the dusk hours.

The Solar Street Light comprises of one light (luminary), one battery of lithium Ferrous-phosphate ($LiFePO_4$) attached with fixture on the top of Hot Dip Galvenised Octagonal pole. The solar panel capacity is 100 W with battery configuration as 12V48Ah. The luminary capacity is 24 W. The system is provided with battery storage backup sufficient to operate the light for 16-18 hours daily. There is automatic ON/OFF time switch for dusk to dawn operation and overcharge / deep discharge prevention cut-off with LED indicators.

2. Review of Literature

The initial cost of a solar Street Light ranges between INR 9000 to INR 50000 depending on the wattage of the system which generally ranges from 9 W to 60 W [3]. The initial cost of Solar Street Light is higher than that of the conventional street light. Kiong in 2014 conducted an economic analysis of the solar powered LED street light and mercury vapour street light for 25 years life cycle [4]. Kiong concluded that the cost effectiveness of the solar street light is equivalent to 18.22% of cost savings in compare to the mercury vapour street light system. Velaga and Kumar (2012) conducted a techno-economic evaluation of solar street lights for rural India. Their results of economic evaluation indicated that although the initial cost of installation of intelligent systems such as solar street lights appears to be higher but they are economically more beneficial in long run [5].

The government of India launched many schemes to improve road connectivity to rural areas such as Pradhan Mantri Gram Sadak Yojana (PMGSY). The successful introduction of street lights in rural areas is able to enhance the transport system [6]. Government through its different initiatives is also promoting Solar Street Lights. For example, Philips after winning two major separate LED solar street lighting contracts for UPNEDA (Uttar Pradesh New and Renewable Energy Development Agency) and MANIREDA (Manipur Renewable Energy Development Agency) installed 76,000 solar LED street lights across 800 villages in Uttar Pradesh and across the main areas of the state capital, towns and villages of Manipur. The technology used in Uttar Pradesh is a 12W, 1200 lumen LED luminaire with IP66, high efficiency PWM (Pulse Width Modulation) charger of more than 96% efficiency and integrated LED driver offering a 5-yr manufacturing warranty. In Manipur, Philips provided 43W, 3500 lumen Solar LED Street Lighting System [7].

The authors further searched for the literature on impact of solar street lights, especially on the rural communities using the databases subscribed by TERI. However, there seemed to be a major dearth of literature on the impact of Solar Street Lights in the scholarly databases. However, literatures are available in scattered form in the non-peer reviewed literature space. Thus, the present paper provides the analysis of the primary information on impact of solar street light on rural communities.

3. Methodology

Majorly qualitative methods were used to assess the impact and effectiveness of project management structure. The tools used were Focused Group Discussions (FGD), Individual Questionnaires and Key Person's Interviews (KPI). Details of the assessment tools used are provided at table 1. A four layered assessment method was followed.

1) Layer 1
The assessment in each village started with interaction with the village coordinators and village leaders. The interaction gave the overview of functionality of the systems, the institutional model and impact from the perspective of leaders.

2) Layer 2
At next level, FGD was conducted with the group comprising of men, women and children. Each group comprised of minimum 10 members. The primary objective of the FGD was to gauge the perception of the users on various aspects associated with Solar Street Lights. One FGD was conducted in each village.

3) Layer 3
Post FGD, a walk across the village streets were conducted by the surveyors. During the walk, each Solar Street Light was observed for its functionality.

4) Layer 4
After taking the walk, the surveyors went to the households to fill the individual questionnaires. The individual's perception was mapped. In total, 120 individual questionnaires were filled for the study across four villages. 30 respondents were interviewed randomly from each village to complete the individual questionnaires.

4. Results

For the Individual questionnaires, 51% of the respondents were adult females and 49% were adult males. The responses are presented in the figure 2.

a) Ease in walking during evening hours and rainy days
About 96% of the respondents mentioned that they find it easy to walk during evening and night hours in the village street. The ease in walking during evening and night hours is due to better illumination. About 88% of the respondents mention that their movements during evening hours in rainy days have become much easier. This is a great boon for the rainy days. The functional duration of the Solar Street Lights during rainy days were reduced due to reduced sunlight hours. However, the Solar Street Lights functioned for 5-6 hours each day and even more during the rainy season. 5-6 hours are generally enough to cover the waking hours after dusk.

b) Reduced elephant, tiger, jackal, fox and snake attacks
Almost 94% of the respondents mentioned that elephant attacks have reduced in the villages after installation of Solar Street Lights. The respondents mentioned that nowadays elephants enter the village but passes by the streets without halting in the village. Thus, the damages caused by

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elephants are negligible now. Similar is the case with tigers, jackals and foxes. Before installation of the Solar Street Lights, the incidences of spotting of these animals were more frequent. However, after installation of the Solar Street Lights, such incidences of spotting of wild animals have reduced drastically. The incidences of snake bites have reduced in the villages, says about 94% of the respondents. The reason is better illumination in the roads. Prior to installation of Solar Street Lights, the snakes or other reptiles were not visible in the village streets and unknowingly stepping on them would result in reptile attacks. Due to better illumination in the streets, the reptile attacks have reduced in the villages.

c) Sense of security felt by females

A gender strengthening dimension is observed as an impact of the Solar Street Lights. 90 % of the respondents said that women feel safe to walk during evening and night. Prior to installation of Solar Street Lights, women were hesitant to walk alone in the streets. Now, the women are able to go by themselves to the nearby grocery shops alone after dusk. 86% of the respondents mention that women now walk in the streets without being accompanied by any male member during the evening hours. Solar street lights have helped the young girl students as they now go for their tuition classes in the evening without any fear, alone.

d) Reduced theft incidents

The theft incidences in both the villages have reduced, says about 90% of the respondents. A direct correlation is difficult to establish between installation of Solar Street Lights and reduced incidences of theft in the villages.

e) Enhanced liveliness

About 22% of the respondents mentioned that there is no difference felt in the frequency of social gatherings outside household premises after installation of Solar Street Lights. However, 78% of the respondents mentioned that the frequency of informal social gatherings outside the household premises has increased after installation of Solar Street Lights. Informal social gatherings enhance the liveliness of the villages.

f) Source of quality illumination during power cuts

The Solar Street Lights are now the source of quality illumination in the villages during power cuts in evening hours. Thus, in case of power cuts many times the inhabitants depend on the light received from the Solar Street Lights. The light from the Solar Street Lights also illuminates the premises of the adjacent households. Thus, during power cuts, the families gather outside their houses sometimes to sit under the light.

g) Feeling of security for children

Three respondents mentioned that they feel safe about their children now. The respondents elaborated that earlier they rarely allowed their kids to play outside during evening hours. However, after installation of Solar Street Lights they allow their kids to play outside during evening hours as there is reduced fear of snake and animal attack.

In all, the overall quality of the villages has improved due to installation of Solar Street Lights. The figure 3 shows the various dimensions of wellbeing among the inhabitants of the villages perceived due to installation of Solar Street Lights.

Table 2 categorizes few quotes documented during the field survey. The sense of wellbeing, security and pride are evident from the remarks made by the users.

5. Discussions

The benefits perceived by the inhabitants are provided in the result section. However, there are few broader benefits of the Solar Street Lights as well. Hon'ble Prime Minister, on 5th January, 2015 launched the Street Lighting National Programme (SLNP) to replace 1.34 crore conventional street lights with energy efficient LED street lights by March, 2019 [8]. SLNP is being implemented by Energy Efficiency Services Limited (EESL), a joint venture company of Public Sector Undertakings (PSUs) under the Ministry of Power. Till date, EESL has installed over 92 lakh LED street lights in 29 States/UTs. The Solar Street Lights installed in the study villages contributes to the overall objective of the SLNP by illuminating streets using solar energy and conserving the conventional electricity.

There are other advantages of using Solar Street Lights over the conventional street lights. The average daily electricity consumption of one conventional street light with 24W LED luminary (specification of the used in the study villages) is around 0.29 kWh for operating 12 hours[1]. Similarly, the electricity consumption for one street light with 24W luminary for operating 325 days (eliminating non sunny and rainy days) in a year will be about 2808kWh. Thus, 366 Conventional LED street lights would have used about 1,027,728 kWh of electricity in a year. The initiative is able to save 1,027,728 kWh of electricity in a year.

The other advantage observed is wireless installation. The wireless installation is able to provide much more aesthetics to the street lights. The day to day operations of Solar Street Lights are easy as they come with automatic ON OFF mechanism. In addition, as they operate with solar energy, no regular operation cost is associated with solar street lights. Figure 4 provides the broader benefits of the Solar Street Lights.

The Solar Street Lights are provided with automatic switch on / off facility. The Solar street Lights switch on automatically with the dusk, the diminishing rays of sun. These Solar Street Lights remain functional till the dawn, with the first sun ray. The Solar Street Lights are functional throughout the night in the study villages. The best part with the automatic ON/OFF system is that no human resource is required to take care of the daily operation of switch on and off. Again, the Solar Street Lights are able to adjust with the changing day and night duration due to change in season. Complete community support was observed in the study villages during the time of installation and thereafter. The issues of reduced functioning hours of 4-5 solar street lights were due to shade from adjacent tree canopies. Whenever

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such issues were observed, the community pruned their trees without any delay.

6. Conclusion and Policy Implication

The Numaligarh Refinery Limited (NRL) with The Energy and Resources Institute (TERI) as implementation partner installed Solar Street Lights in four villages of Golaghat district of Assam. These street lights are designed to switch on automatically with reducing sunlight and automatically switch off when sunlight falls on the solar panels. Thus, the street lights provide light from evening till first few sun rays fall on the solar panel in morning, i.e, from dusk to dawn. On an average the Street Lights illuminate the area almost 10 -12 hours during evening and night time. 366 Solar Street Lights are installed in four villages.

"Our Village looks developed after installation of Solar Street Lights", says a respondent from one of the study village. Elephant attacks were frequent in these villages. The major relief felt by the villagers is reduced movement of elephants in the villages. Movement after sunset is much safer with reduced tiger attacks and reduced fear of snake bites. Women now feel much safer to step out during evening hours. The mobility of women during evening hours has significantly increased. Social gatherings during evening hours increased in the villages making the evenings much livelier. Movements became much easier during raining season because of the Street Lights.

With the passage of time two major challenges may come up; (i) security of Solar Street Lights and (ii) maintenance of Solar Street Lights. For sustenance of any technology at field level, it is important to create a formal structure at village level to perform the functions such as security of the street lights, checking of functionality of the street lights on periodic basic, and interacting with the technology provider. The villagers themselves prune trees if they find that the shade is covering the solar panel. NRL, TERI and the villages work in close coordination to maintain functionality of the installed Street Lights. NRL used its CSR funds to cover the system, installation and maintenance cost. Solar Street Lights have edge over the conventional street lights as daily monitoring for switch on and off is not required and it uses the resource available in abundance, the sunlight. "People from other villages now come to see our village during evening time", mentions one of the respondent. A sense of pride and safety is now associated with the Solar Street Lights. In broader terms, the Solar Street Lights are able to save conventional electricity. The initiative may be considered as to have high impact on the well-being of the villagers and thus, may be replicated in other villages as well.

7. Acknowledgement

We would like to express our sincere appreciation to Numaligarh Refinery Limited (NRL) for providing financial support to carry out the installation of Solar Street Lights in the villages of Assam. We are especially thankful to Mr Rajkamal Saikia, Chief Manager (CSR), NRL and Mr D. Choudhury, CGM (HR) I/C, NRL for providing indispensable support. We are also grateful to the programme Director and Director, REL Division, TERI for providing guidance during the course of project execution.

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Author Profile

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Table

Table 1: Details of the assessment tools used

Tool	Individual Questionnaire	Functionality check	FGD	KPI
Structure	Structured	Structured	Semi structured	Semi structured
Respondent	Individuals	None	Group	Village leaders, NRL coordinators
Technique	Surveyors asked the questions	Observation	Surveyors are the moderator	Interview
Aspects	(i) functionality and impact of Solar	functionality of all	(i) overall functionality and	(i) functionality and

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covered	Street Lights, (ii) scaling of impact, (iii) documentation of perspectives, (iv) willingness to pay towards maintenance fund	Solar Street Lights	impact of Solar Street Lights, (ii) functionality of project management structure at village level	impact of Solar Street Lights (ii) project management structure

Table 2: Categorization of the quotes received during the field survey

Well being	Safety	Sense of pride
"Movements during rainy season have become very easy now." "We can easily walk during evening hours." "The village has become very lively after installation of solar street lights." "Walking during evening hours is a pleasure now." "Social gatherings are very frequent during evening hours in the village."	"Women feel safe to walk during evening hours." "Nowadays women move in the streets in evening hours without any fear." "The elephant attacks has reduced drastically now." "The tiger attacks are not there in village now." "We can see snakes or other reptiles crawling in the streets during evening hours." "Nowadays parents feel safe for their kids when they play outside during evening hours." The theft incidents have reduced in the village.	"Our village looks developed now." "The people from other villages have started visiting our villages."

Figures

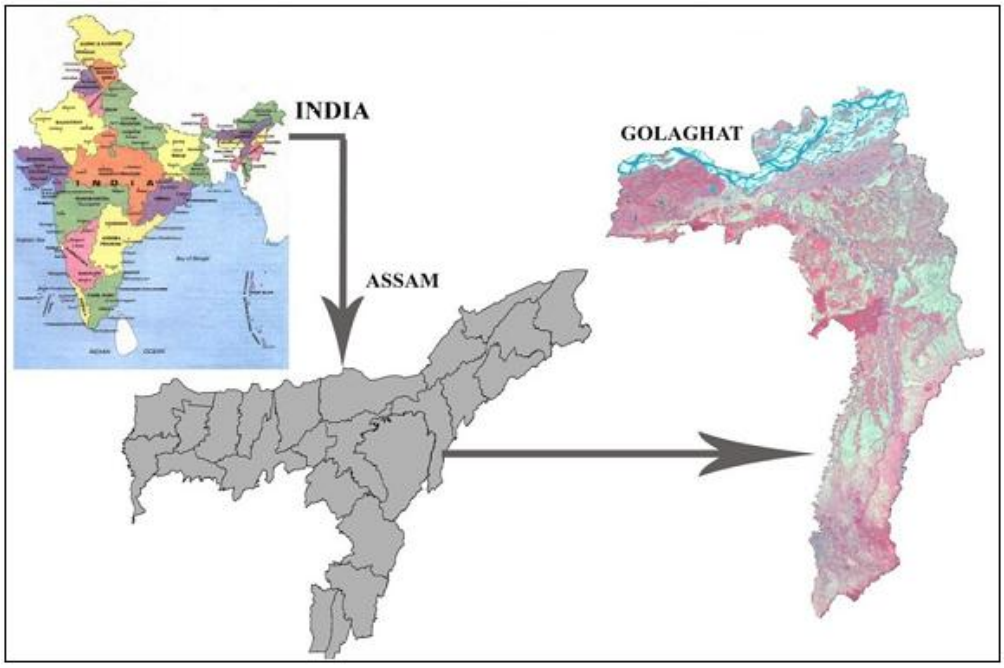

Figure 1: Location map of Golaghat district of Assam
Source: [3]

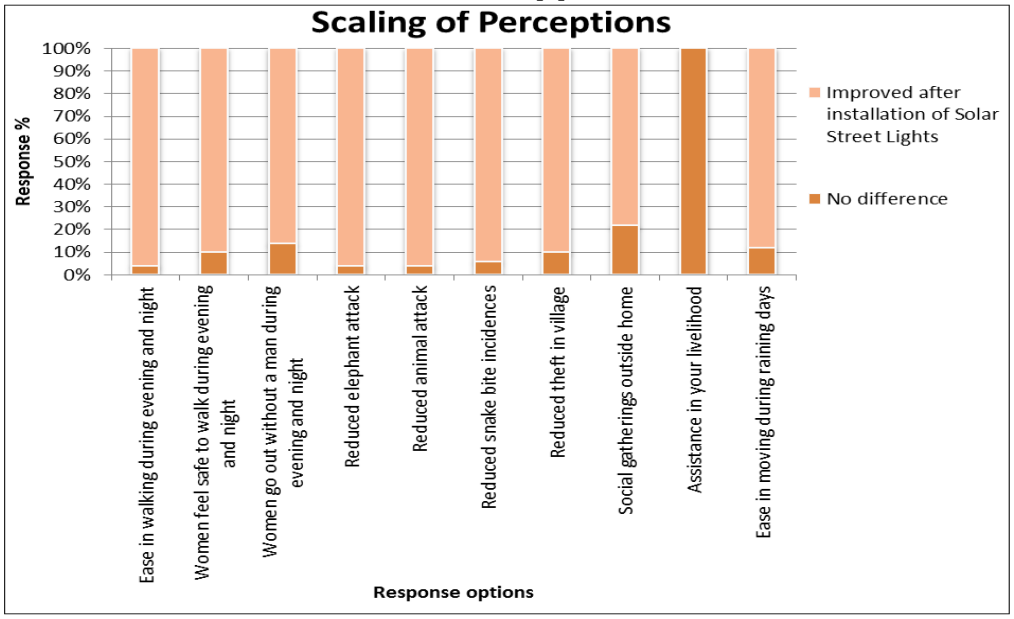

Figure 2: Scaling of perceptions

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Figure 3: Perceived dimensions of wellbeing due to installation of Solar Street Lights by the inhabitants

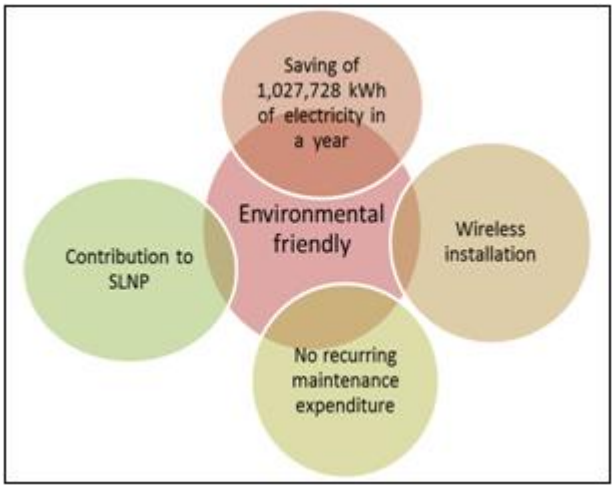

Figure 4: Broader benefits of Solar Street Lights

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