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RESEARCH ARTICLE

IMPACT ON QUALITY OF LIFE OF RURAL RESIDENTS IN HARYANA AND HIMACHAL PRADESH: SOLAR TECHNOLOGIES INTERVENTIONS

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ABSTRACT

In developing countries the energy problems are both widespread and serious. Lack of access to sufficient and sustainable supplies of energy impacts around 90% of the population of many developing countries. People are compelled to live without regular and good quality electricity supply. The rural population remains dependent on fuels such as animal dung, crop residues, fuel wood and charcoal to cook their daily meals. Without efficient, clean energy, people are undermined in their efforts to engage effectively in productive activities and improve their quality of life (Barnes and Floor, 1996). India is home to the largest rural population in the world with approx. 68.84% of the total population residing in rural areas (Census, 2011). In order to contribute to the overall development in India, access to modern energy and cleaner fuel for rural households is important. There is a need to bridge the access gap by expanding energy systems to meet the energy requirements of the fast growing population and mitigate the threat of climate change. The best possible solution to the energy poverty challenges lies in the shift towards sustainable energy technologies. In the present scenario, the uncontrollable increase in use of non-renewable energies such as fossil fuel, oil, natural gas has led to fluctuation of demand and supply. This negative energy balance for decades has forced India to purchase energy from other countries to fulfill the needs of the entire country. Hence, energy access is an important component of poverty alleviation and an indispensable element of sustainable human development. Government of India has initiated numerous development programmes, focusing on providing sustainable energy solutions to rural communities often deprived of clean and uninterrupted energy supply for their daily energy requirements. The study entitled 'Renewable Energy Options among Rural Households' was conducted in Haryana and Himachal Pradesh states. The outcomes of the study provide a roadmap for future programmes promoting the use of clean, efficient and modern energy technologies, to be implemented more effectively. Findings would further benefit the primary and secondary key stakeholders involved in research and development, formulation of policies and regulations, promoting sale and purchase and provide financial assistance to future energy programmes meant to popularize the use of Renewable Energy Technologies.

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INTRODUCTION

Energy is fundamental to survival of life in any part of the globe. The pervasive nature of energy related activities have vast impact on the environment world over. With the current pattern of energy production, distribution and consumption, the resources will be exhausted much faster that would cause accelerated environmental degradation and slow down the progress dramatically. The energy sector has to play a critical role, especially in developing countries due to the huge investments required to meet the growing energy needs.

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For the present research the categorization of energy resources used is Non-Renewable and Renewable energy resources. Non-renewable Energy Resources refer to those sources of energy that are derived from finite and static stock of energy. They cannot be produced, grown, generated or used on a scale that can sustain its consumption rate. The fossil fuels such as coal, petroleum, natural gas, nuclear power are examples of non-renewable sources of energy. Renewable Energy Resources refer to those resources which are available in abundance, are infinite and environment friendly in nature. These resources include solar, wind, biomass, wave and tidal energy (Varun and Chauhan, 2014).

Energy Access to Rural Households in India

In the rural areas of India, energy access is an important component of poverty alleviation and an indispensable element of change in quality of life of rural residents. Despite the advances in the rural electrification, the number of people lacking access to energy services still remains relatively constant due to the increasing population. Many women and children face incapacitating illness or premature deaths due to dearth of energy services. The reason is that the basic social services such as healthcare are expensive which makes economic development harder to perpetuate. Energy poverty exists when the required infrastructure is not in place for energy delivery, especially electricity. India has transitioned from being the world's seventh-largest energy consumer in 2000 to fourth-largest within a decade and is the fifth largest power generators worldwide. India's energy basket has a mix of all the resources available including renewable energy resources (Pawar and Kaur, 2014). Among the various sectors that use energy, household sector is the largest consumer of energy. Rural Households (HHs) in developing countries are often dependent on the use of traditional biomass resources such as fuel wood, crop residue and dung cakes for activities such as cooking, domestic lighting, water heating, cattle-feed preparation and indoor space heating. It provides for a minimum life-supporting energy service and also represents a high financial cost, negative effects on human health and stress on environmental resources.

There are many impediments to energy access for the rural masses despite the launch of several programmes and policies by the Government that aim to improve quality of life of people living in the remote and rural areas of the country. Some of these barriers are geographically-dispersed villages that are difficult to reach and hence, providing electricity (through conventional electric grid) becomes difficult. There is inadequate focus to explore local energy resources either due to lack of funds, technological know-how and appropriate organization. Adequate financial models to tap resources through Public-Private Partnership (PPP) are inadequate. Private sector investment is not sufficiently facilitated by the Government through an appropriate mix of subsidies and grants; incentives and tariff policies; and risk sharing. Due to low population density and fewer households in rural areas there is high transmission cost along with severe transmission and distribution losses. The lack of facility for domestic connection in initial stages, uncertainty of power, load has impacted the demand for power in rural area due to poor quality and unavailability. Long and cumbersome procedures for getting a connection, distant location of facilities for paying bills and repair affect acceptability of renewable energy resources (Kumar, 2012).

Changes in Quality of Life through Renewable Energy Technologies (RETs)

Several studies have shown that energy access influence the quality of life of people living in rural areas. Rehling (2004) suggested that energy (particularly electricity) is required for meeting the basic needs such as health, education, agriculture, communication, information and other infrastructural services. He further stated that there is a correlation of per capita income with human development context. The United Nations Commission on Sustainable Development (CSD-9) identified renewable and rural energy among the key issues for sustainable development (Chaurey *et al*, 2004).

Traditional solutions often comprise relatively low efficiency and much of the energy output gets wasted due to use of age-old (inefficient) technologies. Therefore, sustainable energy services are seen as a necessity for improving the standard of living, facilitating development and reducing environmental impact. Use of decentralized and small-scale technologies that make use of new, locally available, renewable resources such as sun, biomass, wind, water etc. appear to be the ultimate solution. RETs can provide universal modern energy services which drive development and improve living conditions, particularly in rural communities (Mahapatra and Dasappa, 2012).

As mentioned by Kumar *et al* (2010), to meet the energy requirement for such a fast growing economy, India will require an assured supply of three to four times more energy than the total energy consumed today. RETs are being progressively adopted as an alternative to conventional energy resources to ensure a sustainable future. In India there has been vigorous pursuit of activities related to production, application, research and development, demonstration and awareness for a variety of RETs to be used in different sectors. The benefits of access to clean energy resources for rural areas are many, including reduced deforestation and carbon emissions; improved healthcare services due to reduced consumption of raw water and smoke from open fire cooking; clean energy generated from renewable resources; decreased use and dependency on kerosene, wood and coal; improved agricultural output and access to potable and clean water. Renewable energy sources create a momentum for increasing time available for productive, income generating tasks and wealth creation over time. This can help in poverty reduction in rural communities (Chaurey *et al*, 2004).

METHODOLOGY

The study was conducted in villages/hamlets from four districts of two states, viz-a-viz., Faridabad and Panchkula districts (Haryana); and Hamirpur and Bilaspur districts (Himachal Pradesh). The selection criterion for villages/hamlets for study was the presence of residents using RETs, i.e., either possessing or benefitting from RETs (since two or more than two years). The villages/hamlets from Haryana and HP were selected as the locale of the study because of presence of HHs using similar types of RETs in both the states, there was availability of solar grid in Haryana for electrification of HHs that provided an opportunity to the researcher to understand the effect of electricity on their quality of life. Few hamlets that were close to the border of HP, also benefitted from the solar electrification programme of Haryana. This gave an opportunity to compare the ownership and usage of RETs in both the states. The ex-post facto research design included qualitative analysis and interview of the stakeholders, vis-à-vis., RET users, village representatives and RET programme implementation officers from *Akshay Urja (AU)* shops. Purposive Sampling Technique was used to select the key stakeholders for the study (i.e., RETs programme implementation officials, RET users and village representatives).To get an insight about the location of houses using RETs, community service and facilities, sources of biomass collection etc., resource maps were prepared by involving the village representatives, residents and programme implementation officials (field staff from *AU* shops and local repair technicians). Interview schedules were supplemented with information obtained through informal discussions with residents and village representative. Narratives were recorded during informal discussions with the key

stakeholders (with prior permission). Observation schedule helped to find out information about practices concerning RETs and NRETs. The perception of RET users about the effectiveness of RETs and the resulting change in QoL with respect to RET usage was studied by using two separate rating scales. The QoL Rating Scale covered aspects such as education of children; healthcare; convenience and social life; safety and security; income generation and financial security.

Significance of the Study

Achievement of goals at an individual, community and world level are possible only if access to affordable and reliable energy for rural areas is available. This would help to strengthen jobs, enhance security, provide hygienic food, increase income, help in betterment of health and education. In India, almost 68.84% of the population resides in rural areas (Census Report, 2011). Rural India is a power house of natural energy resources and provides great opportunity for production of renewable energy that can be utilized for the rural households, community at large and improving their built-environment such as schools and health centers. A number of researches have been done on the RETs and QoL focusing on viability of renewable energy for rural people, Government policies and regulations, meeting targets (capacity of RETs installed and coverage of rural areas), measurement of effectiveness and barriers in RET implementation from researcher perspective. There is however, dearth of research study designed to take the overall view of user understand their knowledge about RETs and their perception towards effectiveness of RETs and change in QoL w.r.t its usage.

Hence, a basic assumption to the study is that, to make an effective and efficient renewable energy programme for rural areas, it is necessary to obtain information directly from the rural resident about their needs and expectations from rural development programmes. This study was undertaken to explore in-depth understanding of the parameters that impact the effectiveness of RETs in rural areas and change in dimensions of QoL which the residents (RET users) desired the most to be improved with RETs usage to bring about an overall improvement in their QoL.

RESULTS AND DISCUSSION

The study findings revealed that rural HHs in Haryana and HP used different energy resources including Non-Renewable Energy Technologies (NRETs) and Renewable Energy Technologies (RETs) to fulfill their daily energy requirements.

NRETs used by residents for various HH activities included

- **Biomass-** It primarily comprised of fuelwood (used along with a combination of crop residue and dung cakes).
- **Fossil fuels-** These include LPG, kerosene, coal and candles.
- **Electricity (from conventional grid)** was used to power various electrical and electronic devices owned by rural HHs.

RETs used by residents for various HH activities included

- **Solar-based Technologies- SPV (Solar Photovoltaic) Technologies** such as home lights, lanterns, torch and street lights; **Solar Thermal Technologies** such as solar water heaters (Flat Plate Collector type and Evacuated Tube Collector type), solar cookers (Box type and parabolic type) and **solar grids** (up to 10KW).
- **Biomass-based Technologies-** Rural HHs in Haryana and HP were only using family size biogas plant up to $1m^3$.

A quality of life rating scale was developed and administered to assess the change in quality of life of residents on account of RETs. On the basis of the focused group discussions the change in quality of life of study participants had been expressed under five different dimensions, namely, education of children; healthcare; convenience and social life; safety and security; income generation and financial security**.** These dimensions either brought significant change or insignificant change in the lives of residents (RET users) in selected rural areas. An overview of the five broad dimensions that affected the quality of life of rural residents had been discussed in this section.

Education of Children

Though the availability of facilities and services for educating children were often limited, RETs helped in providing a comfortable and hygienic environment to children at home that was conducive to bring change in overall well-being of children and better performance in school. Change in education could be attributed to (represented in Figure 1 (a) and (b) five sub-factors, namely, increased time for home study, improved academic records, regularity in school, participation in co-curricular activities and access to education services. Most of the schools in the selected rural areas were within walking distance of 1 km while in few places of Panchkula district children had to walk up to 3 km to reach their school. Residents reported that many renowned schools, institutes and polytechnics had started in the recent past near their villages**.** These had better facilities wherein children were taught English, computers, etc. but the advantages of these were enjoyed by well-off children who could enroll in these private institutions. Children who belonged to lower-income families were enrolled in municipal schools because they provided number of incentives such as less fees, books and uniforms. FGD participants who were teachers in schools shared that parental illiteracy or low education was not a barrier in education of children rather education was looked upon as a vehicle for getting jobs in cities break out of their poor financial condition. Hence, most of these parents did whatever was possible to educate their children. The quality of education and infrastructure was an issue in most of the schools and required attention.

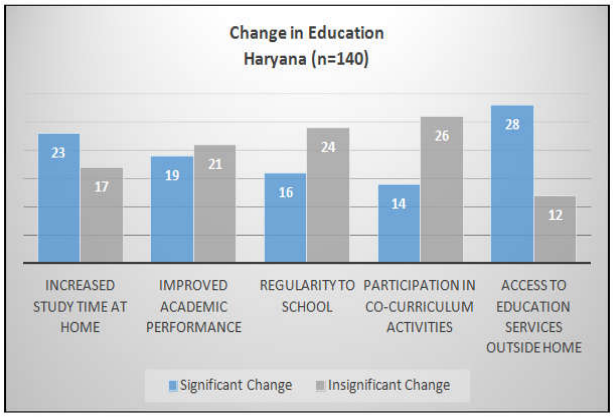

Figure 1 (a)

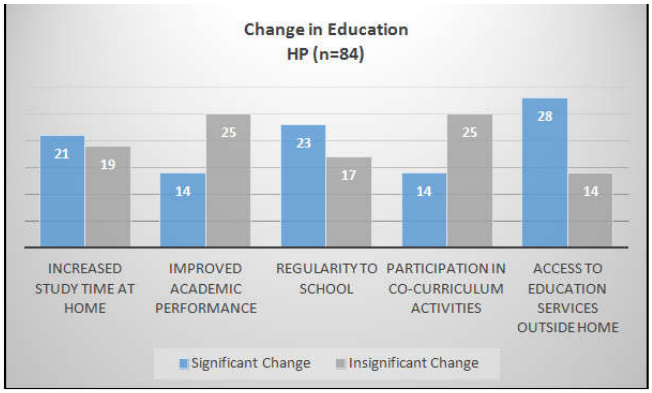

Figure 1 (b)

Figure 1 (a) and (b): Sub-factors Contributing Towards Change in Education of Children w.r.t RETs Usage in Haryana and HP

Study findings revealed that approximately, 28% users in both the states felt an increase in accessibility to educational facilities and services such as stationery shops, internet café, photocopying and tuition centers after the adoption of RETs, especially in late evening hours due to presence of SPV technologies (portable and community RETs such as torch, lantern and streetlights). Some users (14% users from HP and 12% from Haryana) felt that solar streetlights were limited in their village. Participation of children in co-curriculum activities exhibited no change for majority of respondents (26% from Haryana and 25% from HP) as children were occupied in completing their homework and preparing for exams due to limited hours of power supply. Residents of both the states (23% from Haryana and 21% from HP) reported that with the use of RETs, their children now devoted more time for study at home (additional three to four hours/day). The residents shared that before the introduction of SPV technologies and electricity (through solar grid) their children were not able to study after sunset because of poor visibility. They had to study in the light of kerosene lamp or *dibri.* Younger children were unsafe around kerosene lamps and most of the parents had to sit next to them to keep a watch. With the use of RETs (SPV technologies), parents no longer had to keep vigil on children as they were assured of safety when using solar lantern and solar home lights. This provided flexibility to parents to take care of other chores around the house, while their children studied. It was interesting to find that 19% RET users from Haryana and 14% from HP noticed significant improvement in their child's performance w.r.t completion of homework, marks in class test, reading skills and diction, hand-writing skills. All this had been possible with the use of stand-alone SPV technologies and availability of power with the installation of solar grid. They added that children could rest in the afternoon after getting back from school. This helped in improving concentration and they were able to work till late evening in well-lit surroundings.

Healthcare

Study findings revealed that resident of selected villages experienced difficulty in accessing transport and loss of earnings to reach healthcare facilities in the district. Hence, the patients postponed their treatment or just make do with the facilities that were closer but not necessarily cost-effective or even suitable to address their needs. Therefore, it was essential to address accessibility of healthcare facilities, availability of medicines and medical staff, quality and functionality of services and affordability of treatment to improve the present status of healthcare in rural areas. Residents were aware about the importance of eating balanced food and being active in life, to maintain good health**.** FGD with the residents reported the use of home remedies such as tulsi, neem, ginger, elaichi, turmeric powder etc. to get relief from minor ailments. Primary Health Centres (PHCs) were available in selected rural areas. Even though residents were charged only Rs.2/visit, elderly wanted that there should be no charge for them at PHCs as they visited the PHCs more frequently. Many added that even after paying, they were either provided with two type of medicines for all illnesses or referred for treatment at the civil hospital (PGI) in the district. Hence, there was a need for experienced doctors and more staff in PHCs. FGD revealed that residents who could pay, went to local private hospitals that provided better medical care. Women and child health was taken care by the *anganwadi* workers and ASHA (Accredited Social Health Activists) popularly known as *ASHA didi.* They mobilized the community and facilitated them in accessing health related services available at *anganwadi*/PHCs, such as immunisation, Ante Natal Check-up (ANC), Post Natal Check-up, supplementary nutrition, sanitation and other services provided by the Government. They provided essential provisions at the doorstep to inhabitants such as Iron Folic Acid Tablet (IFA), Oral Rehydration Therapy (ORS), Disposable Delivery Kits (DDK), chloroquine, oral pills and condoms.

The change in healthcare services w.r.t RET usage indicated significant improvement in HP. According to an elderly residents of Bilaspur District, HP solar lantern had been helpful in improving healthcare facilities at home as it provided them with ample indoor light to access toilet at night or take medicine etc. without the need for assistance from other family members and was easy to use as well. Figure 2 (a) and (b) depicts that significant percentage of users in Haryana as well as HP experienced substantial improvement in healthcare facilities w.r.t improved availability of medical services in the community (26% from HP and 21% from HP). SPV technologies facilitated better health care services as doctors were available for consultation at the PHCs until late in the evenings. Also, medical shops were open for an additional two to three hours. However, residents in the villages were still dependent on local/uncertified medical practitioners for several illnesses due to lack of education and awareness. Research findings exhibited that 22% users from Haryana and 20% users from HP witnessed positive change in environment due to lesser pollution. They added that use of traditional energy resources such as fuelwood/biomass led to serious health hazards. SPV technologies were recognized as the most helpful RETs to combat kerosene usage for lighting to a great extent. Usage of solar cookers and biogas plants had led to reduced dependence on fuelwood/biomass resulting in decreased women drudgery. In addition, helped women by reducing exposure to indoor air pollution especially in the kitchen. Women added that cooking food in the light of kerosene lamp was unhygienic as often insects fell in cooking vessel and they could not maintain food quality. RETs provided better visibility and greater indoor thermal comfort, relieved from sweat, fight off insects and flies and helped to maintain hygienic surroundings and in turn maintain the quality of food. Improved sanitation in villages of Haryana and HP had been experienced by rural residents with the use of RETs (such as solar lantern, torch and street lights) that had contributed towards better health of inhabitants. They added that prior to the use of RETs many inhabitants would defecate in open spaces adjoining their houses as they avoided going to the forest, due to fear of darkness and wild animals.

Assistance from Government's Total Sanitation Scheme (TSC) had benefited villagers as they had constructed toilets inside their house and fixed LEDs or CFLs and women no longer went outside to defecate in open.

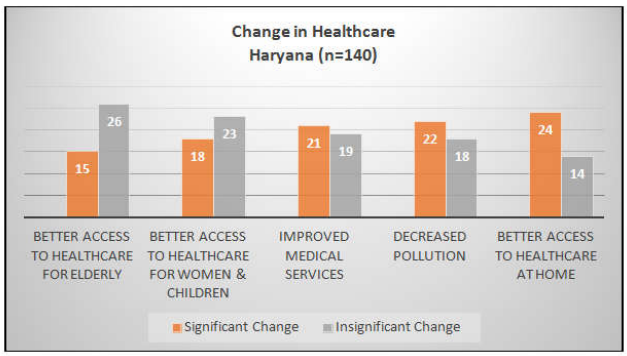

Figure 2 (a)

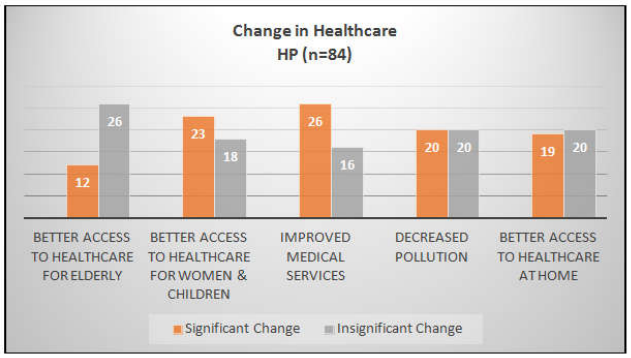

Figure 2 (b)

Figure 2 (a) and (b): Sub-factors Contributing Towards Change in Healthcare w.r.t RET Usage in Haryana and HP

Figure 2 (a) and (b): Sub-factors Contributing Towards Change in Healthcare w.r.t RET Usage in Haryana and HP. Other sub-parameters that contributed towards betterment of healthcare were improvement of healthcare at home experienced by 24% users from Haryana and 19% from HP. Residents felt that the use of RETs had many advantages that included improved visibility, indoor air quality, indoor space cooling and ventilation assisted by SPV technologies. Also, hygienic food and hot water was available with the use of solar thermal technologies and biogas plant. Better access to healthcare facilities for women and children was felt by 23% users from HP and 18% from Haryana. Travelling at night to PHC was easier (in times of emergency). It was easier for local caregivers and ASHA workers. to visit homes at times of need. Also, RETs provided indoor comfort for pregnant women and infants.

Convenience and Social Life

With the adoption of RETs, well-lit HHs resulted in enhanced and motivated surroundings. The change in quality of life w.r.t this dimension was judged on the basis of five broad sub-parameters namely**,** increased leisure time, ease in conducting HH tasks, improved social life, better family relationship and living an active life. As discussed earlier, residents in selected rural areas preferred to remain active as it helped in maintaining good physical health. Also, a good social life brought happiness, helped to keep oneself busy and experience good mental health. Figure 3 (a) and (b) illustrates the contribution of each of these sub-parameters in the lives of rural residents. Study findings revealed that in Haryana majority of residents (29%) found a significant change in the ease to carry out daily household activities. Around 24% residents from Haryana and 25% from HP were happy with the increase in leisure time especially housewives who could now finish the household chores in morning hours and could get additional time to rest in the afternoons. They could now watch their favourite television series, cookery shows, news or indulge in hobbies. Evenings could now be utilized to prepare special dishes for children, spending time with family and taking walk with neighbourhood friends. This gave them a lot of cheer and happiness in life. Many housewives shared that before the use of RETs, their mornings and evenings were extremely busy. All the tasks had to be finished before dawn such as cooking food, shopping for daily supplies (grocery, fruits, vegetables, milk etc.), assisting children to complete their homework, fetching drinking water from nearby sources, collecting fuelwood and fodder, etc. They could not even think about relaxing. One of the resident of Bhagwanpura village, Haryana shared her positive experiences with use of solar cooker. "(The use of parabolic solar cooker had brought a lot of comfort and convenience as ours is joint family. We use it to cook lentils, pulses and rice along with heating water for various household purposes. This had led to decrease in fuelwood usage and collection of fuelwood is no more an everyday task for me.)". A farmer from Morni Block, Haryana shared the positive changes that had come with the installation of solar grid in his village. "(I am a farmer, when I come home from work I am usually very tired but could not rest due to absence of electricity. There was no provision of indoor cooling but solar grid in the village has brought so much comfort. We now have a ceiling fan and after working hard for the day I can sleep comfortably.")

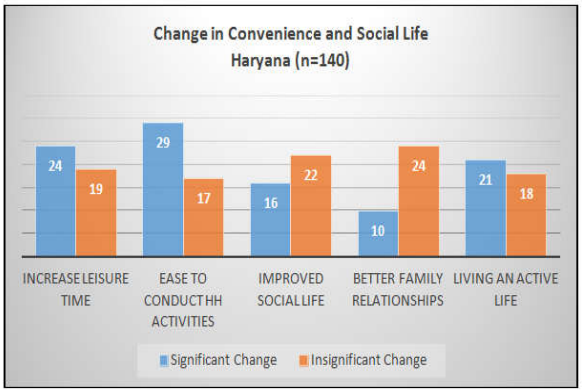

Figure 3 (a)

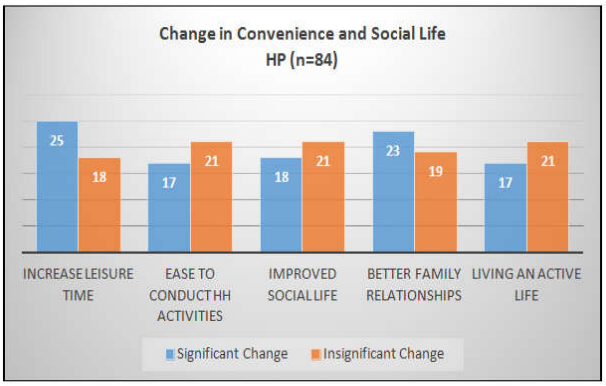

Figure 3 (b)

Figure 3 (a) and (b): Sub-factors Contributing Towards Change in Convenience and Social Life w.r.t RETs Usage in Haryana and HP

Introduction of RETs had enhanced accessibility for the village residents. This was especially felt by residents of Haryana (21%). They shared that the capability to do their own tasks had increase manifolds because facilities including healthcare, restaurants (local dhabas), chemist stores, grocery shops, stationery etc. were accessible and open till late evenings now. This gave independence and enhanced the feeling of worthiness. RETs users from HP (23%) and Haryana (10%) could agree to better family relationships enabled with the use of SPV technologies such as solar home light system. Though there were residents who could not experience any such change in family relationships. This was probably because family members were living away from their hometown for pursuing their studies or jobs in cities. Moreover, residents engaged in services and agriculture work were occupied and spend most of their time outdoors. After returning from work they preferred to have dinner and just take rest. Hence, changing lifestyles and busy daily schedules acted as barriers towards enhancing family bonding.

Residents from HP (18%) and from Haryana (16%) felt that socialization within the community had increased as solar street lights provided amicable environment for residents (especially women) who went for evening walk with neighbours and friends. They even sung bhajans on the way. This was enabled due to RETs as earlier the streets were dark and women felt insecure to go out of their home alone in late evenings. Information concerning personal well-being and community concerns were shared. Communication had improved with mobile phone usage that had been facilitated with the help of battery charging provided in SHS, solar torch and solar grid. Residents shared that they could talk to their relatives and family members living away from home for work. This helped them to stay connected and seek help in times of need or any emergency. SPV technologies assisted in conducting village samiti meetings in the evenings. This allowed better participation of villagers (as working residents were back home from work). Chaupals were well-lit and this made it convenient for everyone in the community to attend the meeting and travel back home safely.

Safety and Security

Streets and by lanes were dark or dimly lit due to lack of infrastructural facilities. Hence, the residents preferred to complete the outdoor tasks until day light was available. Women in general had to face difficulties because they had the responsibility to fetch water, collect fuel and fodder as well as go to fields early morning to attend to the call of nature. They also informed that while coming back from work, a family member had to come to pick them up since, it was pitch dark (especially in winters) and walking uphill alone was scary. For villages situated on hilly terrain, wild animals, reptiles and even poisonous shrubs were an added problem. Many residents had been attacked by monkeys and stray dogs while taking evening walk. Hence, residents usually carried a knife, thick wooden stick or a mashall. They shared that children were not allowed to go out after dark to play and they had been instructed to stay at the tuition center until a family member comes to receive. In villages, electricity supply was erratic, taking advantage of this darkness incidences of thefts were common during late evenings. In HP, it was observed that many residents went for jobs in cities for which they travelled by bus or car to board the train. The journey took one to two hours, so they had to leave as early as 5.00 am from their house, while it was still dark. Bus and car drivers shared that since, they were aware of the way they were able to drive. Many accidents had taken place especially of tourist vehicles, due to darkness. In the recent past, 'glow in dark' sign- tapes had helped to demarcate the road and risk-zones in hilly areas. Safety and security was another important dimension that contributed to the feeling of overall well-being of rural residents. There was high level of satisfaction concerning safety and security in those villages where SPV technologies and solar grid were in use as these directly contributed to the feeling of safety among inhabitants. Respondents residing in hilly terrains informed that attacks by wild animals were very common but with the presence of RETs such incidences had declined to a great extent lately. The use of SPV technologies and installation of solar grid along with street lights can be appreciated for this change in the community, as felt by 26% RET users from Haryana and 23% from HP (refer Figure 4 (a) and (b).

21% RET users from Haryana and 23% from HP felt that well-lit streets also decreased accidents caused due to lesser visibility at night. Residents of Hamirpur district, HP added that the State Government had taken positive steps to increase road safety because roads in hilly areas were vulnerable to accidents. Mostly tourists travelling at night found it difficult to maneuver their vehicles. State Government with the help of HIMURJA had installed solar streetlights along with proper demarcations that were visible at night (glow-sign tapes). This had brought significant change in the lives of professionals who had to travel at odd hours (early morning and late nights) from home (situated on hilly terrains) to their workplace.

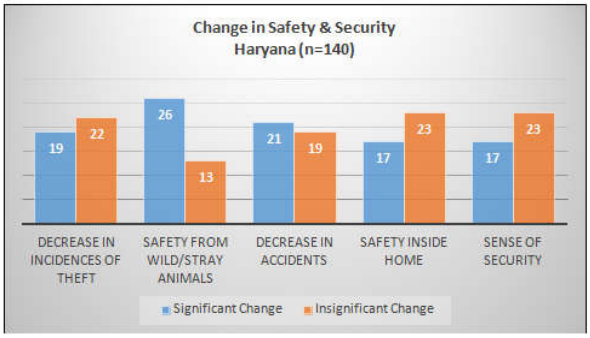

Figure 4 (a)

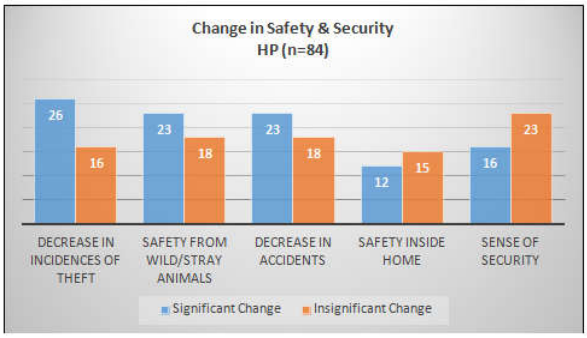

Figure 4 (b)

Figure 4 (a) and (b): Sub-factors Contributing Towards Change in Safety and Security w.r.t RET Usage in Haryana and HP

Study results also indicated decrease in incidences of thefts in selected villages, as reported by 26% respondents in HP and 19% in Haryana. In spite of change in these sub-parameters, residents sought more change in this dimension.

Table 1. Rating of Overall Change in QoL Dimensions of RETs as perceived by Users (Score: 1-100)

Rank	Dimensions	Mean	Subjective Evaluation of QoL Parameters I	Subjective Evaluation of QoL Parameters II
1	Healthcare	66	Above Average	Average
2	Safety and Security	61	Below Average	Below Average
3	Education of Children	60	Below Average	Below Average
4	Income Generation and Financial Security	55	Below Average	Poor
5	Convenience and Social Life	52	Below Average	Poor

Table 2. Frequency Distribution of RET Users (n=224) in Selected States Rating on QoL Index

States	Poor	Below Average	Above Average	Good
HP	11(13)	55(66)	18(21)	0
Haryana	0	86(61)	50(36)	4(3)

Note: Percentages are mentioned in parenthesis

Table 3. State-wise Ranking on the basis of Mean Scores Obtained on QoL Dimensions (n=224)

Dimensions of QoL	Haryana	Himachal Pradesh
	Mean of each parameter	
Education of Children	60.68	58.15
Healthcare	69.39	60.65
Convenience and Social Life	52.18	51.07
Safety and Security	64.32	55.77
Income Generation and Financial Security	59.39	47.20

Almost 23% residents (each) from Haryana and HP could not experience change in the sense of security while 23% RET users from Haryana and 25% from HP felt no change in safety inside home. Many residents suggested that more street lights should be installed in rural areas so that inhabitants felt more secure. The surroundings should be safe for women, children and elderly and providing SPV technologies to low-income HHs at low costs would contribute a lot towards safe and secure surroundings, enhancing the overall quality of life of rural residents. As far as the Government efforts goes State Government of Haryana since 2015 had started providing LED-based SHS at Rs.2000 (actual user share Rs.4500). In HP, three energy-efficient LEDs were provided at just Rs.10 to every electricity user by Bureau of Energy Efficiency (BEE) and Energy Efficiency Services Limited (EESL, a joint venture of public sector companies of Ministry of Power) along with electricity distribution companies.

Income-Generation and Financial Security

Majority of the population in India lives in rural areas and have limited income-generation opportunities. This had resulted in more and more people (especially youth) to migrate to cities in search of better jobs. Rural HHs thus, become solely dependent on the earnings from one family member and desperately in need of productive and remunerative opportunities that rural areas lack. Hence, the need to provide comprehensive support for income-generation was essential. RETs had brought some change w.r.t income-generation and financial security but extended efforts were required in this respect. A school teacher from Hamirpur District, HP shared her happiness with the use of RETs that had facilitated income-generation and better utilization of her time. "(I am a school teacher and take private tuitions in the evening. This had been possible with usage of SPV technologies. Parents felt safe to send their children to study as streets are well-lit unlike before. As an individual I could benefit by keeping myself occupied in the evenings hours along with earning additional income.)" In appreciation of RETs a shopkeeper from Panchkula District (Haryana) shared his experiences, ("I am a shopkeeper at the nearby local market where I have kept a solar lantern and alongside street lights provide ample lighting. This has enabled better sale as the shop is open till late"). Rural residents understood the importance of financial security. They believed that earning money was not only essential to fulfil the daily needs of food, shelter and clothing but also, earned them respect from family members. Financial security was important for respondents who had no ancestral property. Savings were essential for families engaged in agriculture (due to its seasonal nature and risks involved due to dependence on weather conditions) and private service (due to absence of pension after retirement). Elderly members mentioned that they required money to get the HH chores done and care-taking. They reported about the *Sanjay Gandhi Niradhar Yojana*, that provided elderly (females 60 years or above and male 65 years or above) with Rs.100/month if they had no income source. Benefits of concession on bus and train tickets was mentioned by participants either employed or had family member engaged in Government service. They received pension, hence, felt financially secure. Subsidized grocery was provided from village ration shop in rural areas to residents who retired as Government servants or belonged to low socio-economic status. All these schemes supported them to some extent to sustain a reasonably good quality of life.

Study findings highlighted (refer Figure 5 (a) and (b) significant change in regularity of employees at workplace as felt by 33% users (each) from Haryana and HP. Better time management was experienced by 23% RET users from Haryana and 20% from HP. Residents experienced that RETs had facilitated regularity to work as presence of electricity enabled completion of household chores. Hence, they could sleep on time and wake up early for work. Indoor comfort was also enhanced with the presence of fans (either table fan with SHS or ceiling fan powered through solar grids) because of which residents could sleep well and start their day afresh. Users of solar water heaters

informed that they no longer had to get up early in the morning to switch on the electric geyser or immersion rod as hot water was available. Women recalled that before SWH, when there was power cut early morning, heating water for bathing became an additional task along with preparing breakfast, get children ready for school and packing lunch-boxes. Increased productivity and profitability were experienced by residents who possessed shops in local markets or those who operated petty businesses from home (22% from HP and 21% from Haryana).

They could increase the duration of business hours per day and sell products till late in the evening, i.e., an extended one to two hours per day. They worked in such a manner that alternate vocations during evening could be taken up for earning additional income. They shared that RETs facilitated additional hours for doing value addition by pursuing alternative vocation that fetched them additional income. The subsidiary occupation such as opening of small shops, pursuing skills commercially such as beauty parlour, tailoring, etc. were taken up by women and elderly members in the villages during the afternoon and evening hours after their daily chores. This helped to enhance their household income. Even though RETs facilitated the prospects of existing income generation yet in both the states, residents felt no change w.r.t new start-ups by employing RETs. Very few respondents (4% from HP and 3% from Haryana) believed that RETs facilitated them to start new work.

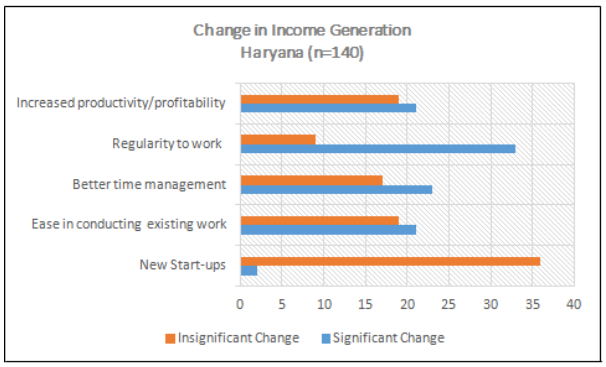

Figure 5 (a)

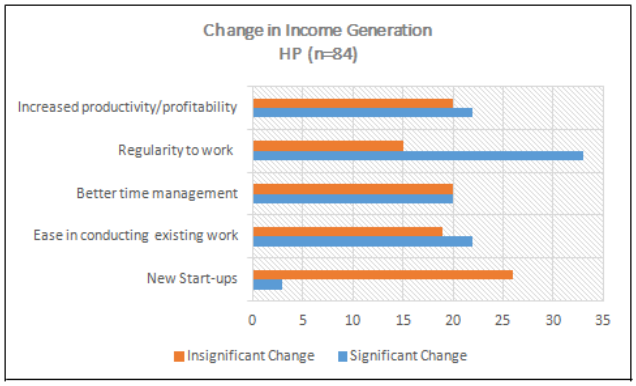

Figure 5 (b)

Figure 5 (a) and (b): Sub-factors Contributing Towards Change in Income-Generation w.r.t RET Usage in Haryana and HP

Residents (particularly residing on low hill in Haryana) shared that though RETs were of great help they could only facilitate in income-generation if support programmes (organized by Government or NGOs) for skill development were available. Rural India had been blessed with abundance of natural resources that formed the basis for major energy projects. Since, development of rural areas by way of integrating RETs required many resources such as manpower, land, transportation facilities, etc. both skilled and unskilled manpower was required. Hence, installation of solar power can help in providing employment to many rural residents. Job creation would lead to income generation, financial security and better adoption of RETs as a result of increased purchasing power and capability to maintain the systems. It was observed that women and young girls were very keen to learn new skills that could help them financially contribute to their family income as well as become self-reliant and more confident of their capabilities. A resident of Samlehri village added, "(Most of the girls in our village got married at a young age and they became full-time housewives. In spite of their willingness towards doing something for self, they could not do so because of lack of facilities. If the Government starts-up women centric schemes to enable skill development, women would participate actively.)"

Conclusion

Change in Quality of Life (QoL) as perceived by RET Users Based on the overall mean scores on the change in quality of life dimensions, 'healthcare' was considered as the best dimension with a mean score of 66 while 'safety and security' and 'education' were perceived as below average. 'Comfort and convenience' and 'income generation' were rated as poor. However, the scores on all the selected QoL dimensions did not vary too much (the range of scores being 52 to 66). The modal scores ranged from 30 to 75. The least modal score was for the dimension 'education of children' and highest modal score was for 'healthcare'. Majority of respondents (61% from Haryana and 66% from HP) perceived the change in QoL as below average. More residents in Haryana (36%) perceived the change as above average as compared to 21% users in HP. About 13% from HP perceived the change as poor whereas none of the users from Haryana state considered it as poor. Only 4% from Haryana considered change in QoL as good while none of the respondents in HP felt it as good. 'Healthcare' dimension was rated above average while other domains including 'safety and security', 'education of children', 'income-generation and financial security' and 'convenience and social life' were rated below average. The state-wise ranking of five QoL dimensions indicated that, change in Haryana state was higher as compared to HP. Dimensions such as 'healthcare', 'education of children' and 'safety and security' scored above 60 while 'income generation and financial security' and 'convenience and social life' had mean scores 59.39 and 52.18. In HP state, only one domain i.e. 'healthcare' scored above 60 while all other dimensions scored below 60, these included 'education of children' (58.15), 'safety and security' (55.77), 'convenience and social life' (51.07) and 'income generation and financial security' (47.20).

The comparative analysis clearly indicated that residents of Haryana felt a better change in their QoL as compared to HP. In HP, better electricity supply and lesser tariffs were available as compared to Haryana. Moreover, RETs were predominantly used to supplement the existing electricity supply which was of good quality and adoption of RETs was a result of energy consciousness among rural residents of HP. In addition, HP state had abundance of natural resources and Government had been trying its best to preserve the same. These included measures such as introduction of LEDs at highly subsidized

prices. In Haryana, the introduction and adoption of RETs was more need-based due to poor power quality in rural areas and the absence of electricity in many hamlets situated in remote locations (Morni block). Hence, RETs served as the sole source of energy for these HHs. Study results revealed that residents of Haryana appreciated the efforts of the Government as RETs had been a ray of hope for them, since, conducting many HH activities was difficult without access to electricity and paucity of resources.

Association of Change in Quality of Life with Sample Characteristics

The association of user perception of change in quality of life with their socio-economic characteristics revealed high association at 1% level of significance with education. Graduates and professionals had better knowledge about use, operation and maintenance of RETs that resulted in positive changes in their quality of life. Occupation, income and family size were associated with change in quality of life at 5% level of significance. Service class respondent gave preference to RETs because of their busy schedule and responsibility to fulfil the needs of their family with limited financial resources. Housewives had monotonous HH tasks and were probably not very ambitious. Self-employed respondents and agriculturists associated change with increased profitability and new start-ups which was probably not up to their expectations. Low-income HHs were dependent on traditional NRETs which were low cost, readily available and familiar.

Also, since they had received some RETs free of cost under various schemes their importance was not much realized by the recipients. High-income respondents expected more change since, RETs were one of most expensive durables and expectations with their performance were high. RETs were able to fulfil the energy needs of smaller families than joint families, due to less family members.

IMPLICATIONS OF THE STUDY

The penetration of RETs is picking up and a perceptible improvement in the quality of life of RET users would take its due course after usage of these technologies for a significant period of time, due to their novel nature as compared to the familiar and well-established conventional technologies. It was not possible to draw out the importance of NRETs from the lives of rural residents. Hence, rural energy programmes should integrate improvement of existent NRETs by providing awareness towards energy-efficient practices and importance of energy conservation. Furthermore, introduction of RETs was essential so that rural residents could enhance their quality of life by supplementing and complementing RETs with the NRETs particularly biomass technologies. The findings of the study brought forth a number of implications. To ensure the sustainability of energy supply and sustainable economic development in rural areas, the Government needs to intensify implementation of RETs and energy efficiency programs. In addition, the existing research and development centers, and technology development institutions should be further strengthened to support the shift towards increasing the use of RETs. Human resource development, transfer of knowledge and technical know-how should be focused for project development, management, monitoring and evaluation. Accreditation of RETs through preparation of standards and codes of practices, maintenance manuals for efficient usage, life cycle costing and cost-benefit analysis tools should be undertaken on urgent priority. Sustainability of RETs through training programmes and better infrastructure is necessary.

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