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# Renewable Energy Interventions for Sustainable Rural Development: A study on Solar Home System Dissemination in Bangladesh

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***Abstract:*** *Currently, 1.317 billion people worldwide suffer an indigent supply of electricity, of which 99.8% live in rural areas of developing countries. The overall prevalence of electrification in Bangladesh is 60 percent for the nation but much lower for rural areas, at only 42.5 percent. In this regard, the present study aims to examine the potential of off-grid renewable energy technologies like Solar Home System (SHS) to meet the unprecedented demand for electricity and thereby contribute in achieving sustainable rural development. With an extensive literature review, this paper presents an appraisal on the rapid growth and resulting socio-economic benefits and environmental impacts of disseminating SHS in rural communities. The study concludes with an emphasis on multilateral collaboration among the various stakeholders to enhance the sustainability of the SHS program. The study adds value to the existing literature on the impact assessment of rural electrification in a developing country like Bangladesh that sets an impressive example in resilience and innovation in the face of possible climate change adversity*.

***Keywords:*** *Renewable Energy, Sustainable Rural Development, Solar Home System*

## 1. Introduction

Sustainable rural development is one of the major thrust to alleviate global poverty and inequality. Hence the agenda has received considerable global attention especially among the developing nations like Bangladesh, where majority of the population, around 77%, live in rural areas with the prevalence of low electrification rate of 56.8% [1]. Despite the rapid economic growth in Bangladesh (more than 6 percent growth in GDP), per capita availability of electricity of 293 kwh, which is one of the lowest amongst the developing countries [2].

As electrification using grid electricity in rural areas has lagged behind than in urban areas, renewable energy technology, particularly electricity generation from off-grid Solar Home Systems (SHS) stands out to be one of the prospective sources to meet the unprecedented energy demand [3]. Solar Home Systems are small photovoltaic systems that transform solar energy into electricity, which does not require any kind of conventional fuels. The major components of SHS are solar panels, batteries, charge controllers, and some electric appliances (e.g., lamps, small fans, or televisions) which can be operated with minimum training [4].

In Bangladesh, SHS installation program has been implemented by the state-owned Infrastructure Development Company Limited (IDCOL), with technical and financial support from various local and international donor agencies. IDCOL implements the SHS program through a network of 56 partner organizations (POs), mainly Non Government Organizations (NGOs) –including some of the largest in the country. POs of IDCOL utilize their expertise in micro-credit to have greater reach in the rural community for making SHS installations affordable to the users. Till July 2016, more than 4.4 million SHSs have already been

installed in the off-grid rural areas of Bangladesh, thus proving almost 18 million beneficiaries with solar electricity which is around 11% of the total population of Bangladesh [5].

The objective of this study is - to integrate the economic, social and environmental benefits of SHS interventions in addressing the sustainable rural development of the country. The study also identifies the challenges prevailing in this sector that limit the mass adaptation of renewable energy usage.

The paper proceeds in seven stages; first it presents the introductory discussion and dissemination of SHS. Part two specifies the research methodology followed by part three with a brief literature review on the SHS interventions. The conceptual framework representing the scope of the research and subsequent inferences on RE interventions to promote social, economic and environmental developments in Rural Bangladesh have been discussed in the fourth and fifth part of the study. The sixth part highlights the challenges and possible strategic options. Finally, the study concludes with an emphasis on relevant policy formulations and further research in promoting the potential of renewable energy.

## 2. Research Methodology

The present study is intended to fulfill the research objectives by applying an extensive and systematic literature search, conducted at Google Scholar, Research Gate, IEEE, JSTOR, Elsevier and Science Direct platforms to identify existing relevant studies. The pertinent studies have been analyzed on the basis of research concentration and subsequent findings. Both qualitative and quantitative evidences, scrutinized from these literatures, have been appraised to examine the socio-economic benefits and environmental impacts of SHS along with prevailing challenges for the sustainability of the program.

## 3. Literature Review

Renewable energy is generally is collected from resources which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy usually supplies energy in four important areas: electricity generation, air and water heating/cooling, transportation, and rural (off-grid) energy services [6]. Globally, there are an estimated 7.7 million jobs linked with the renewable energy industries, with solar photovoltaics being the largest renewable employer [7].

There is a growing body of literature on the potential, progress status monitoring and impact assessments of SHS dissemination in South Asia, Africa & Latin American countries, particularly in developing nations like Bangladesh. Research papers in renewable studies [8, 9, 10, 11, 12, 13, 14, 15, 16] have analyzed the relationship between access to electricity on enhancing the living standard and economic productivity of the SHS users. These literatures acknowledge that SHS installation in Bangladesh usually gives favorable outcomes for upgrading the living standard of rural households.

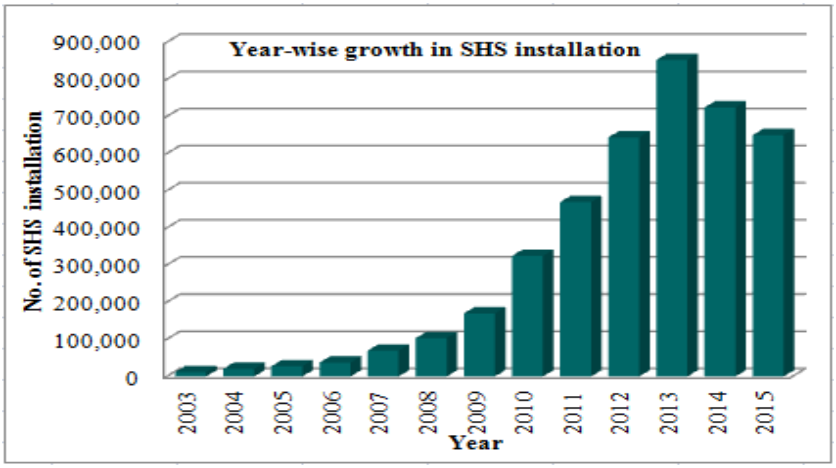


Fig. 1 Year-wise number of SHS installation in Bangladesh by IDCOL

To draw global attention on mitigating the adverse effects of climate change, the environmental benefits of the growing usage of solar energy has also been addressed by many researchers. Adoption of SHS results in the decline of carbon dioxide emissions from kerosene usage and other fossil fuels replacement [9, 12, 15, 16].

The progress scenario and sustainability of SHS programs have been critically reviewed by several researchers as a vital dimension of research in renewable energy. Most of these studies have been conducted in Sub-Saharan Africa and developing Asian countries [17, 18, 19, 20, 21, 22, 23]. The authors in these studies have analyzed the rural electrification programs through solar energy interventions which is the foremost decentralized technology used to improve access to electricity in rural communities. These studies also identified the challenges to the sustainability of solar energy based rural electrification which include lack of awareness, limited trained manpower, high upfront costs of the systems and lack of source of funds. These findings were based on the studies in Bangladesh, Indonesia, Thailand, India, Sri Lanka, the Philippines, Ethiopia and Nigeria.

Despite the significant potential in the commercialization of renewable energy, some prevailing challenges have been identified like affordability and acceptability of the SHS, which create obstacles in the promotion of solar energy technologies.

From the literature review presented above it has been noted that the there is a lack of attention in assessing and integrating the potential of off-grid solar energy in sustainable rural development. This research is intended to fill this gap of present literature on sustainability of solar energy dissemination programs by addressing the remarkable growth of SHSs in a developing country like Bangladesh. By accomplishing the research objective, the present study attempts to unbundle these issues and offer beneficial insights for policy makers and industry stakeholders in formulating pertinent strategies for sustainability and expansion of renewable energy ventures.

## 4. Conceptual Framework

Sustainable Development (SD) can be defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [24]. The concept of sustainable development necessarily includes economic, social and environmental issues. Provision of social services along with a growing economy and clean environment has recently been recognized as the pre-requisite for sustainable development. [26]. Currently, 1.317 billion people worldwide suffer a deprived supply of electricity, of which 99.8% live in rural areas of developing countries like Bangladesh [3]. The prevalent energy crisis demands Government of Bangladesh to develop of a stable and sustainable power supply that will increase electricity access, enhance energy security, improve economic productivity and mitigate climate change. In this respect, implementing renewable energy programs plays a vital role in achieving these goals [25].

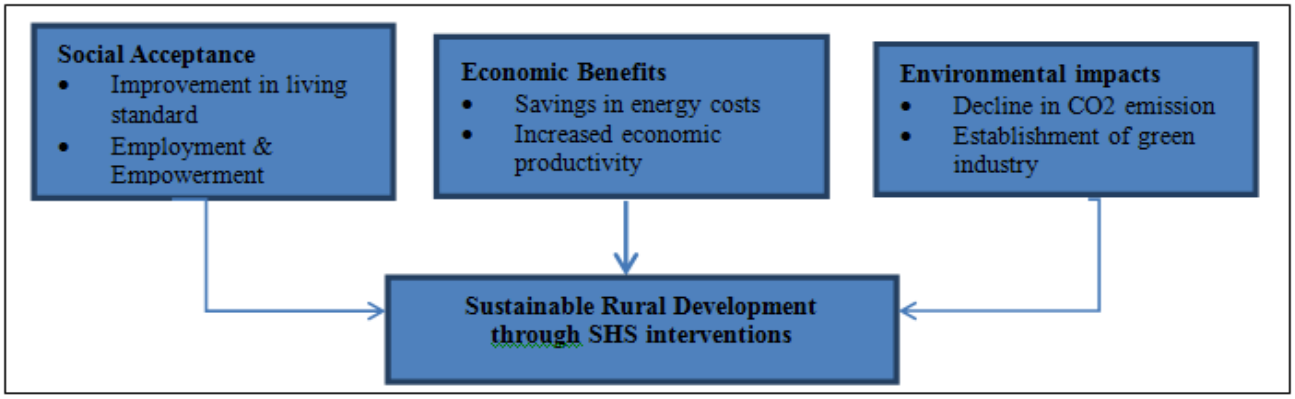


Fig 2. Conceptual Framework of the study

## 5. Sustainable rural development through SHS interventions

### 5.1. Economic Contributions

- **Savings in energy costs**: SHSs have the potential for reducing expenses incurred for lighting facilities, resulting in savings in energy costs and thus ease the strained households' budget.
- **Economic productivity**: In the off-grid rural areas, better lighting conditions from SHSs support rural businesses increase their productivity and income through extended working hours after dark.
- **Access to information**: Enabling the usage of electronic home appliances like mobile phones, televisions and radios increases access to information about market opportunities and prices and assists in emergency situations.
- **Employment generation**: The domestic production of SHS components like solar lamps and charge controllers creates job opportunity for technicians and local youth in solar industries. According to IDCOL, SHS program has provided livelihood to 70,000 people by creating jobs in a green industry [5].

### 5.2. Social Contributions

- **Improved health & safety conditions**: Since SHS is an environmentally sound technology, the increasing adaptation of SHSs in the rural communities reduces harmful in-house air pollution resulting from kerosene vapors, thus contributes in improving health and safety conditions among the most vulnerable groups within the nation.
- **Improved educational opportunities**: Access to solar electricity benefits the students with extended study hours at night and promotes the educational performance in developing countries. Based on Bangladesh, a World Bank case study also revealed the positive correlation between rural electrification and educational enrollment ratios [30].
- **Gender aspects**: Grameen Shakti, leading PO of IDCOL has established village based technology centers to train and empower rural labor force, especially young women to become Renewable Energy Technicians and Entrepreneurs. Inclusion of women to disseminate solar electricity has enhanced their social-economic value in the communities and upholds women empowerment [28].

### 5.3. Environmental contributions

- **Reduction in Greenhouse Gas emission**: For emerging economies, like Bangladesh, SHSs provide cost effective opportunities to adopt low carbon development electrification program without compromising the efforts in continuous developments of living standards. This is evident in the fact that, with the usage of 4.4 million SHSs, the program replaces 242,000 tons of kerosene having an estimated value of USD 300 million per year which is one of the primary sources of greenhouse gas emissions in developing nations [5]. Since about 11% of people in off-grid areas have accepted SHSs, there is a significant potential for even greater diminutions of harmful greenhouse gases.

## 6. Challenges & required Policy implications

Despite the significant potential in the commercialization of solar energy, several research studies have identified a number of constraints in the large scale adaptability of the renewable energy program. This section of the paper presents a discussion on these critical aspects limiting the potential of rapid growth in SHS:

### 6.1. Higher installation cost:

With the prevalence of rural poverty in Bangladesh, disseminating RET needs to address the lower purchasing power of rural customers [4, 11, 14]. One of the major challenges that need urgent attention in this sector is to reduce the high upfront cost of a solar system. Research reveals that, reduction in price by 10% would encourage

61% of non-SHS households to consider adopting SHS [28]. Financial mechanisms should be devised for easy access to loans for installations of SHS in the rural areas.

### 6.2. Lack of awareness about solar energy technology

Renewable energy still constitutes of a small share of Bangladesh's energy generation portfolio. At present, the installed RE generation capacity is [26]. The lack of awareness and acceptance of solar technology necessitates demonstration of it to rural population. An intensive effort on the part of the government and the disseminating organizations is essential to make the benefits of the solar technology known to people through the media and via practical demonstrations [4, 13, 29]

### 6.3. Lack of availability of better quality system components

Research studies revealed that low availability of better quality SHS parts like batteries and charge controllers affects customer's attitude and longevity of the system [3, 9, 12]. Hence, sustainability of the SHS Program also requires the availability of the solar accessories in the remote rural locations so that the users can buy them easily when required.

### 6.4. Low after-sales service support and need for technician training

Customer satisfaction and impact assessment researches [9, 10, 12] revealed that in some cases, SHS users experience the lack of regular and satisfactory maintenance service from the POs. In this regard, training local technicians will yield better results. Moreover trained service personnel can educate the users on the proper usage and maintenance of SHS, which may avoid technician calls and increase system reliability.

### 6.5. Supervision of POs' performance & regulatory affairs

Research studies [9, 12] asserted that lack of integrated efforts from the stakeholders is evident to promote the commercialization of renewable energy. There are problems of management of a decentralized technical system on a one to one basis between service provider on the ground (POs) and the client (household or enterprise). Also, IDCOL should strengthen its quality control and inspections of POs to ensure the quality and benefits of SHS installations. This necessitates a strategic collaboration between the government, IDCOL, POs, component suppliers and the donor agencies to address the sustainability of SHS program.

## 7. Conclusion

Since the instigation of solar power technologies, there has been a notable growth in the adaptation of the SHS for green energy. Based on the inferences on off-grid solar electricity presented in this study, the increased adoption of renewable energy ensures a stable power supply in rural areas that will improve energy access, conditions of living standard, economic growth and climate change mitigation by reducing carbon footprint. This review article has additionally emphasized some of the main issues that must be taken care of to capitalize on the potentials of SHS. In the present-day scenario, when moderating climate change and sustainability are becoming major development issues in the world; solar power highlights itself as a primary solution of green energy. This study concludes with an emphasis on the policy formulation by multilateral cooperation and calls for further research to regulate and streamline the technical, managerial and financing aspects of the program.

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