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Article

Social Benefits of Solar Home Systems and User Satisfaction: Experience of Rural Bangladesh

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RESUMO

A energia solar também pode ser utilizada pelos indivíduos como uma solução híbrida – isto é, uma solução que combina a rede e a energia solar – para fornecer um fornecimento constante de electricidade em caso de corte de energia. Este estudo teve como objetivo explorar o modo de compra do sistema solar doméstico (SHS), o estado de utilização diária, os impactos do SHS e o nível de satisfação dos residentes da comunidade no subdistrito de Singair, no distrito de Manikganj, no Bangladesh. Um total de 120 agregados familiares utilizadores de sistemas solares domésticos foram selecionados aleatoriamente e inquiridos através de um questionário semiestruturado. Este estudo revelou que as famílias têm adquirido SHS com o seu rendimento directo, empréstimos de ONG e bancos, e emprestado dinheiro de familiares e vizinhos. Os sistemas são amplamente utilizados pelos agregados familiares utilizadores (>5 horas/dia por 53% dos agregados familiares). Os resultados destacaram vários benefícios relatados dos SHSs na área de estudo, incluindo melhorias na educação das crianças (96%), produtividade familiar (84%), nível de vida (84%), comunicação (82%), entretenimento (76%) e serviços sociais. Além disso, este estudo explorou um elevado nível de satisfação em relação à utilização, aceitação e eficácia dos sistemas solares domésticos na área de estudo. Este estudo centrou-se principalmente nos benefícios sociais e na satisfação dos utilizadores dos sistemas solares domésticos. A investigação futura poderá centrar-se em benefícios socioeconómicos e ambientais abrangentes, bem como na satisfação dos utilizadores com base na procura.
Palavras-chave: iluminação, crise energética, energia renovável, energia solar, sistema solar doméstico, satisfação do utilizador

ABSTRACT

Solar energy may also be used by individuals as a hybrid solution—that is, one that combines grid and solar power—to provide a steady supply of electricity in the event of a power outage. This study aimed explore the mode of solar home system (SHS) purchasing, daily usage status, impacts of SHS and satisfaction level of community dwellers in Singair sub-district of Manikganj district in Bangladesh. A total of 120 solar home system user households were randomly selected and surveyed using a semi-structured questionnaire. This study revealed that households have been purchasing SHSs with their direct income, loans from NGOs and banks, and borrowed money from relatives and neighbours. The systems are widely used by the user households (>5 hours/day by 53% households). Results highlighted several reported benefits of SHSs in the study area, including improvements in children's education (96%), household productivity (84%), living standard (84%), communication (82%), entertainment (76%), and social interactions (62%). Besides, this study explored a high level of satisfaction regarding the use, acceptance, and effectiveness of solar home systems in the study area. This study mainly focused on the social benefits and user satisfaction of solar home systems. Future research can focus on comprehensive social-economic-environmental benefits as well as demand based user satisfaction.
Keywords: lighting, power crisis, renewable energy, solar energy, solar home system, user satisfaction.

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Introduction

The environment and the subsurface of the earth are sources of energy. This energy is regarding as the primary factor influencing the continuous advancement of the economy and the well-being of the populace in developing countries, including Bangladesh (Brkić, 2021; Huq, 2018; Siddik and Zaman, 2021). Nonetheless, new energy efficiency and grid systems are leading to a change in the global energy systems. Two types of energy sources can be distinguished based on their capacity for regeneration, i.e., non-renewable and renewable. Sources of energy that never run out due to human activity are known as renewable energy sources (Siddik et al., 2021). Renewable energy sources are regarded as the practical alternatives for electrifying remote or rural areas in developing nations, regardless of people's access to grid connections (Khandker et al., 2014; Uddin et al., 2023).

Bangladesh is a developing country, and the people of many districts have been facing severe electricity shortages as a result of the increasing trend of energy demand and gas-based power plants, as well as system losses, misuse, and corruption in the power sector (Haque and Rahman, 2010; Huq, 2018). Besides, Bangladesh is one of the most severe disaster-prone Asian countries and home to different sorts of disasters, including cyclones, riverbank erosions, floods, lightning, landslides, storm surges, etc. (Hasan et al., 2018; Moniruzzaman et al., 2013, 2014, 2019; Rahman et al., 2015; Siddik et al., 2014, 2024; Siddik and Islam, 2024a; Siddik and Moniruzzaman, 2013). These disasters also damage the power infrastructure and disrupt the energy generation and supply systems in the affected regions for hours to days (Moniruzzaman et al., 2014; Shahid, 2012; Siddik and Islam, 2024b; TBS Report, 2024). Nonetheless, it is also proved that the amount of energy used in homes for things like lighting, heating, and cooling depends on where such regions are located geographically (Siddik et al., 2022). Numerous power plants have been installed and connected to the national power grid to address the power crisis, but they are insufficient to meet the increasing demand (Islam et al., 2014). Uddin et al. (2023) claimed that in addition to being a viable option for families without electricity, solar energy may also be used by individuals as a hybrid solution—that is, one that combines grid and solar power—to provide a steady supply of electricity in the event of a power outage. The percentage of renewable energy in the nation's ultimate energy consumption in 2020 was 3.49%. By 2030, Bangladesh wants to generate 10% of its total electricity from renewable sources (GED, 2022).

Several scholars carried out studies on solar energy in Bangladesh. Amongst them, Haque and Rahman (2010) emphasized the reasons for the power shortage and its possible solutions in Bangladesh. Saim and Khan (2021) investigated problems and benefits of SHSs in Bangladesh's coastal island. Uddin et al. (2023) explore the underlined causes of purchasing the solar home systems. They also highlighted the impacts of solar power on economic, employment, environmental, educational, and nutritional outcomes. Rana and Moniruzzaman (2024) focused on the identification of suitable regions for the solar power plants. Sarker et al. (2020) focused on the social and environmental impacts as well as the financial viability of solar home systems in areas not connected to electricity supply areas. Hoque and Das (2013) conducted research on the current status of SHSs and photovoltaic micro utilities. They also suggested a model for the expansion of village electrification. Aziz et al. (2009) addressed the strategies of marketing as well as financing of SHSs in Bangladesh. Huq (2018) studied about the surge of SHSs and its benefit for ensuring sustainable livelihood in five coastal sub-districts of Bangladesh. They found that SHSs have a positive impact on all types of livelihood capitals among the user community. But authors could hardly find studies regarding the mode of solar home system (SHS) purchasing and their daily usage status, social impacts of SHSs, and satisfaction of the user community. Therefore, in this paper we explored the mode of solar home system (SHS) purchasing and their daily usage status in Singair sub-district of Manikganj district in Bangladesh. We also tried to investigate the social impacts of SHS in the study area and to analyze the satisfaction level of community dwellers in the study area.

Materials and Methods

Study Area

Singair sub-district of Manikganj district was purposefully selected for this study. The study area is comprised of 11 lowest administrative units called unions. The total area of the sub-district is about 217.56 sq. km. The sub-district is bordered to the north by the Dhamrai sub-district of Dhaka district, to the south by the Nobabganj sub-district of Dhaka district, to the east by the Keraniganj sub-district and Savar sub-district of Dhaka district, and to the west by the Mankganj Sadar sub-district. With 287451 inhabitants in total, it has a population density of 1300 people per sq. km. It is also noted that about 46.20% percent of its population are literate (BBS, 2015).

Statistical analysis

Primary and secondary data are used to carry out this study. A total of 120 solar home system user households were randomly selected and surveyed. For gathering household information, we used a semi-structured household questionnaire. Before finalizing the questionnaire, we conducted a pilot survey with 10 households in the study area. Due to the fact that over 50% of the people living in the study area are illiterate or have low levels of education, we conducted household surveys in Bengali. The households were asked about their solar home system supplier, about the impacts of solar home systems, and their level of satisfaction for using the solar home system in Bengali. They also answered these questions in Bengali and then translated into English. We have used secondary information mainly from journal articles and published reports. We also collected unpublished information sheets from the offices of the three solar home system suppliers in the study area, namely, Grameen Shakti, Aava Development Society, and Jagoroni Chokra Foundation.

Data Analysis

The raw data (primary and secondary) has been checked and cleaned for a comprehensive and effective analysis. At the desk, the initial round of data verification was completed. But following the survey's completion, field cross-checking was used for the second and final round of data verification. A combination of Microsoft Excel 10 and SPSS software (17.0) was used to handle and analyze the collected field data. We mainly used descriptive statistics in order to comprehend the respondents' general characteristics—such as gender, age, and income sources—as well as details regarding the impacts of the solar home system and their degree of satisfaction with its use in the study area.

Results

Profile of the Respondents

In this study, a total of 120 randomly selected families were contacted for the survey. Table 1 shows key characteristics of the respondent, including gender and age distribution as well as their source of income. About 61% of the respondents were male, and the rest were female. The age distribution of the respondents showed that almost 55% of them were older than 35 years. There is more experience within this age group. Only 17% of the respondents, meanwhile, were in the under-25 year age group. The result reveals a wide variety of sources of income, with a fairly even allocation of farming, service, and business. The largest category (25%) in the results, farming, shows how important agriculture is to the respondents' lives. This can point to a population that is mostly from a rural or semi-rural area and makes their living from farming. Nonetheless, over 23% of the participants generate their income from jobs or salaried employment. This is a large amount, indicating that respondents generally have steady work as a source of income. In the same way, 23% of respondents make

their income through business activities. It indicates a significant presence of entrepreneurs and maybe a wide range of economic activity in the neighbourhood. A sizeable percentage of respondents (23%) did not engage in any activities that generated income. This might apply to pensioners, students, stay-at-home parents, or jobless people.

Table 1: Key characteristics of the respondents

Variables	Measurement	Percentage
Gender distribution	Male	61
	Female	39
Age distribution	<25 yrs	17
	26-35 yrs	28
	36-45 yrs	41
	>45 yrs	14
Income sources of respondents	Service	23
	Farming	25
	Business	23
	House rent	3
	Others	3
	Not involve in income generation	23

Source: Field work, 2024

Mode of Solar Home System Purchasing

Purchasing capability acts as one of the crucial aspects of solar home system promotional strategy (Aziz et al., 2009). According to this study, the majority of households (68.3%) invested their income to purchase solar home systems (Figure 1). It indicates that these households had financial solvency as well as a high degree of confidence and belief in the return of investing in solar home systems. Furthermore, non-governmental organizations assist people financing new solar home systems. Approximately 23.3% of households had taken loans from NGOs and purchased SHS, highlighting the critical role of non-governmental organizations in encouraging solar energy adoption. According to Hoque and Das (2013), loans from non-governmental organizations (NGOs) are a common occurrence in the countryside of Bangladesh. They observed that people with limited incomes wish to take out a loan from an NGO to purchase a SHS. However, a lesser number of households had taken loans from a bank (5.8%), relatives and neighbours (1.7%), or other sources (0.8%).

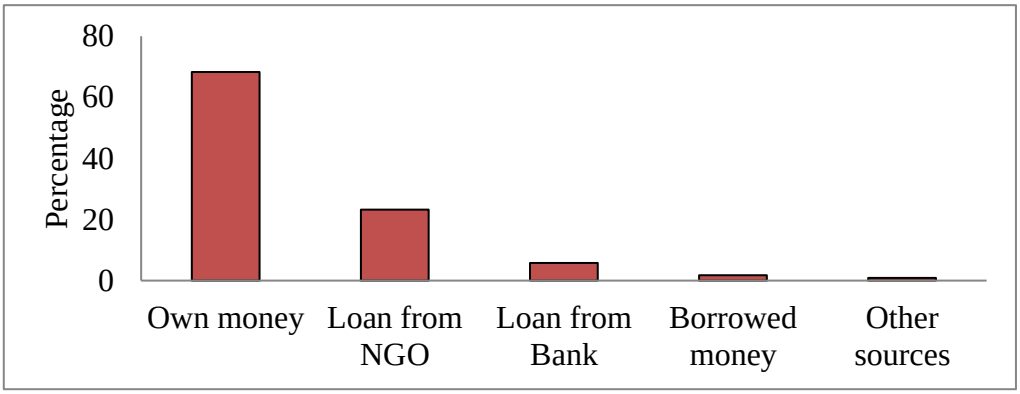

Figure 1: Mode of solar home systems purchasing. Source: Field work, 2024

Usage Years of Solar Home Systems

Figure 2 shows that most of the surveyed households have been using SHS for the last 2-3 years. But a sizable percentage of the household—32%—has only been using SHS for a short time—less than two years. Maybe they are the new SHS users. Only 7% of the households, nonetheless, have been utilizing SHS for more than four years. This may point to the need to concentrate on the long-term viability of solar household systems, including upkeep plans, user education, and support systems within the community to guarantee that systems continue to operate and provide benefits over time. Siddik et al. (2018) reported that solar panel repair is a challenge for households using solar home systems.

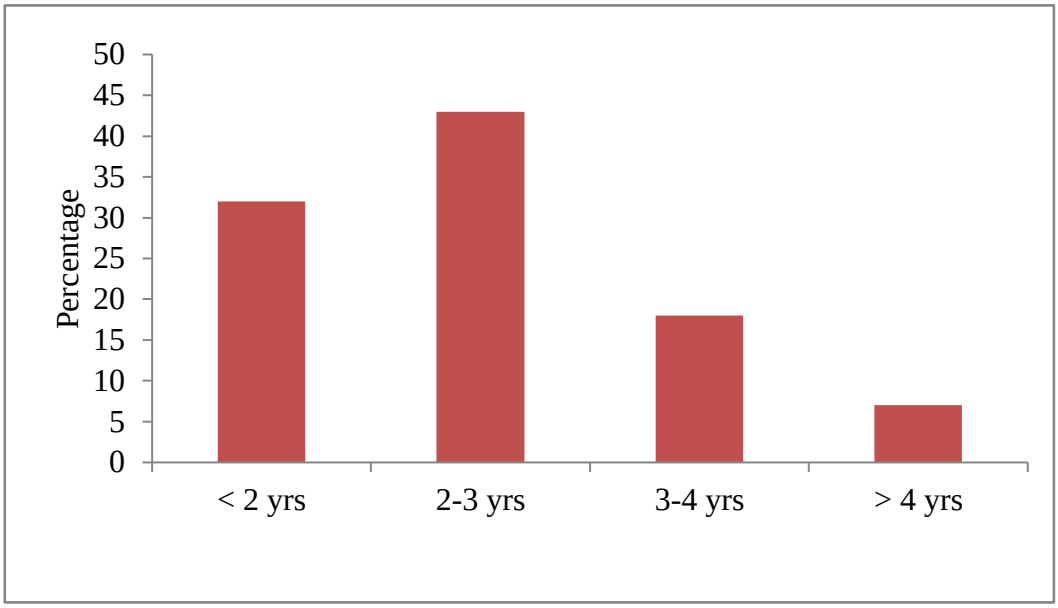

Figure 2: Usage years of solar home systems. Source: Field work, 2024

Daily Usage (hours) of Solar Home Systems

The majority of households (53%) have been using their solar systems for more than five hours every day (Table 2). This suggests that households rely heavily on solar power, potentially for a wider variety of domestic tasks, including watching TV, and more intensive lighting requirements. It implies that these respondents' everyday lives are significantly impacted by solar systems. But a moderate percentage (29%) has been using three to five hours per day. Basic requirements like lighting, using some appliances, and charging electronics might all be covered by this consumption. It implies a moderating dependence on solar power. Only 18% of the households, meanwhile, reported using their solar home systems for fewer than three hours per day. This can be a sign of low energy requirements or a dependence on alternate energy sources. It could also be a reflection of consumption patterns in which solar energy is only required for certain activities, like charging gadgets or lighting.

Table 2: Daily usage (hours) of solar home systems

Daily usage (hours)	Percentage
< 3 hrs	18
3-5 hrs	29
>5 hrs	53

Source: Field work, 2024

Social Benefits of Solar Home Systems

There are several benefits of solar home system inclusion at the household level. The benefits may be categorized as lighting, entertainment, and mobile phone charging. This study revealed that most of the respondents reported about home lighting benefits. About 96% of respondents stated that the solar home system can prolong the study hours of school-aged students (Table 3). This means it has positive impacts on student's education. According to the World Bank (2017), more favourable lighting circumstances contribute to improved educational environments and higher academic achievement. Similarly, according to the IEA (2017), having access to consistent lighting enhances student's ability to learn at night, and this is critical for academic achievement. Studies conducted by Mishra and Behera (2016) and Uddin et al. (2023) confirmed the results. They found that solar power increased student's study hours in their respective study areas. Moreover, Diallo and Moussa (2020) found that solar home systems can increase on an average 1.79 years of household education.

Table 3: Benefits of solar home systems (multiple responses)

	Benefits	Percentage
Home lighting	Prolong study hours for school-aged children at night	96
	More hours for household work at night	84
	Improve household environment at night	84
	More friends and relatives can visit at night	62
	Charging mobile phone	82
	More entertainment (TV-DVD) at night	76

Source: Field work, 2024

In this study, about 84% of the respondents reported about the prolonged household activity hours at night (Table 3). Completing household tasks might have incentives beyond everyday life (Tepper et al., 2022). Making it possible to accomplish household activities over prolonged periods of time indicates a considerable increase in total household production. It suggests that the presence of light can aid in more effective time management as well as task completeness, which is especially advantageous in families when daylight hours are consumed by other responsibilities (IRENA, 2017; World Bank, 2017).

Results also indicated that having solar home systems can improve the overall household environment. About 84% of the respondents reported this benefit (Table 3). It indicates an improved quality of life. Enhanced lighting circumstances can help to create a safer, healthier environment for living, lowering accidents and offering an overall feeling of comfort (IEA, 2017; WHO, 2018). Similarly, Uddin et al. (2023) explored that solar power offers instant advantages, such as more hours for work and home life, as well as prolonged study hours for school-aged children. Mishra and Behera (2016) found that solar power enhanced the living environment of households and increased student's study hours. Results also included the benefit of extended social life. About 62% of the respondents reported that solar power improves their social life by enabling social interactions with friends and relatives.

Charging mobile phones was identified as one of the key benefits of solar home systems by about 82% of the respondents (Table 3). Mobile phone charging is essential for preserving communication, getting information, and utilizing a range of digital applications. This advantage demonstrates how solar home systems, particularly in off-grid locations or electricity crisis situations, may aid in closing the digital gap (Kabir et al., 2017).

About 76% of the respondents reported that solar home systems provide easier access to entertainment, particularly household TV and DVD watching (Table 3). Such entertainment opportunities can improve dwellers psychological health and knowledge on different issues. Similarly, Wagner et al. (2021) found an increasing trend of TV watching time with the families having solar power. Moreover, Kabir et al. (2017) found that easier access to such particulars can link community members to the global village.

User Satisfaction

Figure 3 shows the level of satisfaction of the consumers regarding the use, acceptance, and effectiveness of solar home systems in Singair sub-district. Results show that about 74.2% of the households are satisfied with their solar home systems. The degree of satisfaction suggests that the majority of users believe the systems suit their needs adequately. A modest but considerable percentage of households (13.3%) are highly satisfied with their solar home systems. This group may experience exceptional performance and dependability, as well as strong customer service and perceived value for money. A small percentage of households (5%) are moderately satisfied, indicating minor concerns or unmet desired outcomes. This group may suffer occasional problems with performance or believe that some features of the system may need to be improved. Approximately 5% and 2.5% of households are dissatisfied or highly dissatisfied with their SHS. This suggests more serious difficulties, such as recurrent malfunctions, inadequate performance, or a lack of assistance. Addressing the problems of these households is critical to increasing overall satisfaction.

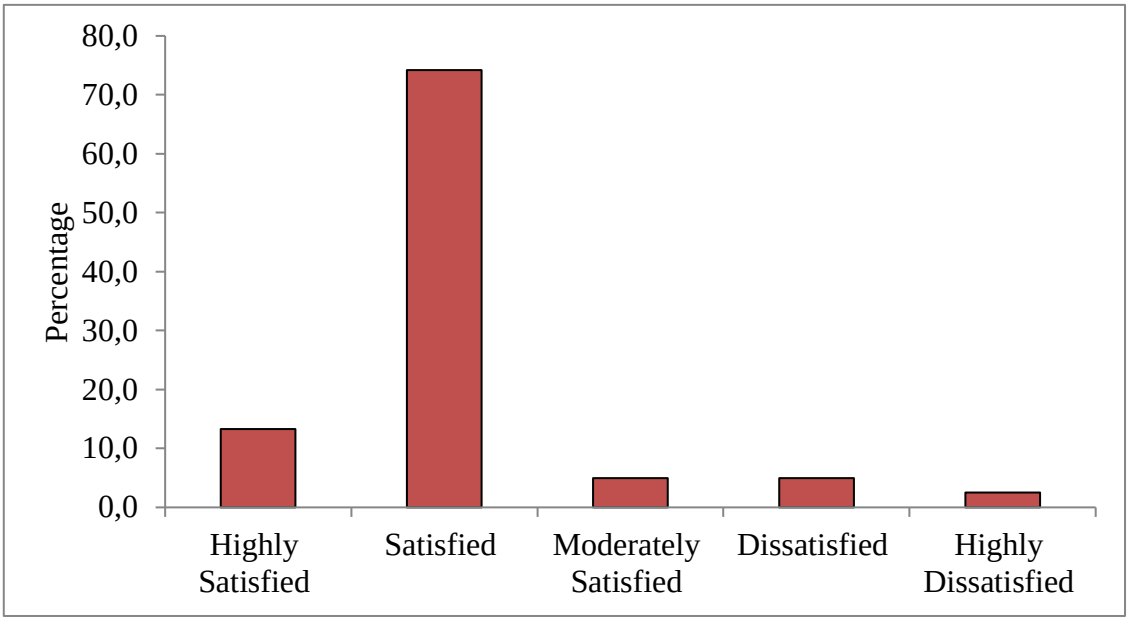

Figure 3: Level of satisfaction of the consumers regarding the use, acceptance and effectiveness of solar home system in the study area.Source: Field work, 2024

Conclusions

This study explored that about 68.3% of the surveyed households purchased solar home systems with their family income, followed by loans or borrowed money from NGOs, banks, neighbours, or relatives. Community dwellers have been using these systems for a period ranging from less than two years to more than four years. More than fifty percent of the households have been using solar home systems for more than five hours a day. However, households' daily usage rate varies from less than three to more than five hours per day. Several benefits of solar home systems have been highlighted in this study, with particular attention to improvements

in children's education, household productivity, living standards, communication, entertainment, and social interactions. However, future studies can focus on the broader economic-social-environmental consequences of the solar home system. This study explored a high level of satisfaction (satisfied: 74.2% and highly satisfied: 13.3%) regarding the use, acceptance, and effectiveness of solar home systems in the study area. It indicates that solar home systems fulfil the needs and expectations of the user community. Future research can focus on demand-based user satisfaction.

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Author contribution

Conceptualization, S.B. and M.M.; methodology, S.B.; formal analysis, S.B., M.A.H.K., and M.A.S.; investigation, S.B., M.A.H.K., and M.A.S.; writing—original draft preparation, S.B., M.M., M.A.H.K., and M.A.S.; writing—review and editing, S.B., M.M., M.A.H.K., and M.A.S. All authors have read and agreed to the published version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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