EVALUATION OF THE SOCIAL AND ECONOMIC IMPACT OF SOLAR HOME ENERGY USAGE IN JURU AND MUGORORE CELLS, BUGESERA DISTRICT

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For Sustainable Village Foundation

January 10th , 2025

List of Acronyms

ES	Executive Secretary
FGD	Focus Group Discussion
IRB	Institutional Review Board
KII	Key Informant Interview
NST2	National Strategy for Transformation 2
PV	Photovoltaic
SEDO	Social Economic and Development Officer
SHS	Solar Home System
SVF	Sustainable Village Foundation

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Executive Summary

This assessment evaluates the impact of the Solar Home Systems (SHS) project implemented by the Sustainable Village Foundation (SVF) in Bugesera District, Rwanda. A total of 203 households were surveyed to understand the social, economic, and technical challenges of the intervention.

This study revealed that SHS project has positively impacted surveyed households, which were predominantly female led (55.2%) with an average size of 4.6 members, exceeding national averages. The Solar Home Systems (SHS) project has significantly improved children's education, with 77.3% reporting better academic performance, and enhanced safety for 97% of respondents by reducing theft and wild animal threats. Economically, SHS has lowered energy expenses and enabled 64.5% of households to invest savings in income-generating activities, with 64% reporting increased income. Socially, reliable lighting has fostered stronger community cohesion through evening interactions. However, challenges remain, including limited system capacity and dissatisfaction with technical support among those facing issues.

The recommendations emphasize enhancing repair services through local centers and regular maintenance, expanding system capacity to support larger appliances and small businesses, and scaling up the intervention to other communities to address electricity challenges and align with Rwanda's NST2 goals of improving access to clean energy and education for all.

The SHS project has delivered substantial benefits in education, safety, and economic empowerment, demonstrating its potential for scalability. Addressing current challenges and expanding the initiative to new regions will further enhance its impact, supporting national development goals and improving the quality of life for underserved communities.

1. Introduction

1.1. Study objectives

The aim of this study was to evaluate the social and economic impact of home solar energy usage in Juru and Mugorore cells, Juru sector, Bugesera District. In this evaluation, our emphasis was on the following objectives:

1. To assess the economic impact, including household savings, income generation, and overall social well-being of households living in Juru and Mugorore cells.
2. To identify the barriers and motivations for adopting and using home solar energy systems in rural settings.
3. To explore technical problems and challenges related to the small solar home systems distributed in the projects of the Sustainable Villages Foundation in Juru and Mugorore cells.

1.2. Background

Solar energy emerged as a vital renewable energy source that offered a sustainable and environmentally friendly solution to the energy crisis faced by many underdeveloped countries. Access to reliable electricity remained a significant challenge for millions of people, particularly in rural areas where grid extension was often economically unfeasible. Traditional energy sources, such as kerosene and firewood, were still widely used in these regions, despite being costly, hazardous to health, and environmentally damaging. Solar energy, with its potential to provide clean and affordable electricity, presented a transformative opportunity for improving the quality of life in these communities. However, the uptake of solar energy by households remained slow due to various challenges, including high costs, lack of awareness, limited access to financing, and insufficient technical support.

In Juru and Mugorore cells from Bugesera District, where grid electricity was inaccessible for all households living in that cell, the Sustainable Village Foundation launched a transformative home solar system intervention in 2021. This initiative aimed to bridge the energy gap by providing “small solar home systems” featuring a 10W photovoltaic (PV) panel, a lithium-ion battery, three lights, and a radio. Over 700 households benefited from this installation, which sought to lessen dependence on traditional, harmful fuel sources and improve socio-economic conditions within the community.

However, despite the progress, limited information existed on the social and economic impact of these solar systems on local households, as well as on the technological challenges faced by residents in adopting and maintaining solar technology in a rural context. The study, therefore, evaluated the intervention's effect on household well-being in Juru and Mugorore, shedding light on the broader impacts of solar energy in rural settings and identifying technological barriers that influenced the long-term sustainability and accessibility of solar energy solutions in these communities.

2. Methodology

2.1. Description of the Study

This study evaluated the social and economic impact of home solar energy usage in the population living in Juru and Mugorore cells of Bugesera District, Rwanda. The focus was on households that received home solar energy systems from the Sustainable Village Foundation, which has operated in the district since 2021. The data collection methods included structured household surveys administered using the Kobo Collect mobile application for the first objective and Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) for the second objective

2.2. Study design

The study employed a mixed-methods approach, combining quantitative and qualitative data collection techniques to ensure a comprehensive evaluation of the intervention. Quantitative data was collected through structured surveys, while qualitative data was obtained via interviews and FGDs.

2.3. Study population and sampling

The study targeted households from Juru and Mugorore cells that adopted home solar energy systems through the intervention by the Sustainable Village Foundation. Surveys were conducted with household heads or their representatives (e.g., spouse). KIIs were held with local leaders of Juru and Cyirabo villages and Executive Secretary of the cell of Mugorore and Socio-Economic Development Officer (SEDO) of Juru cell. FGDs were conducted with community members who benefited from the solar energy intervention.

2.4. Sampling Strategy

Systematic sampling was used for selecting households, ensuring a representative and manageable sample size. Every second household was planned to be selected for participation but due to the absence of every second of the household this study took the third one or fourth. Purposive sampling was used in selecting KIIs and FGDs participants, with four KIIs conducted with local leaders (Two village leaders and two cells' leaders and two FGDs involving seven participants each.

2.5. Sample size

The sample size was calculated to achieve a 95% confidence level with a margin of error of ±5%, standard for social science research. The formula used Population size(N), Z-value for a 95% confidence level is 1.96, Estimated population proportion (0.5) and the Margin of error is 0.05)

$$n = \frac{N \cdot Z^2 \cdot p \cdot (1-p)}{Z^2 \cdot p \cdot (1-p) + (N-1) \cdot e^2}$$

n = required sample size
N= population size
Z = Z-value (1.96 for a 95% confidence level)
p = estimated population proportion (commonly 0.5, as it maximizes the required sample size)
e = margin of error (0.05 for ±5%)

2.6. Inclusion and Exclusion Criteria

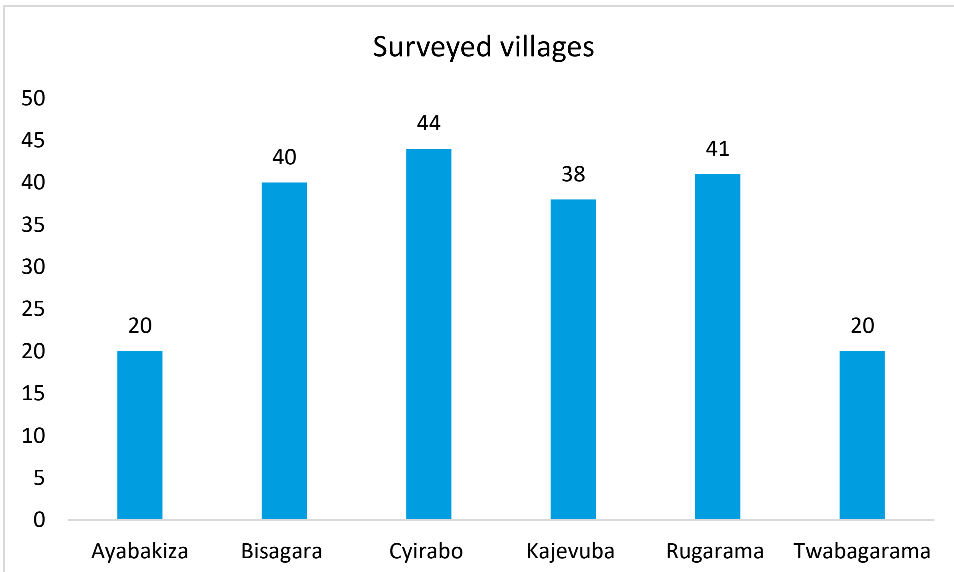
Households that received home solar systems from the Sustainable Village Foundation were included while households that did not receive home solar systems from the foundation were excluded from this study.

2.7. Data Collection Methods

2.7.1. Quantitative Data Collection

Structured household surveys were conducted with 203 systematically selected households to gather comprehensive data on various aspects of solar energy adoption and its impacts. Figure 1 depicts the distribution of interviewed households by villages. Enumerators were thoroughly trained to ensure high-quality data collection, and the questionnaire underwent pre-testing to confirm its clarity and reliability for accurate and effective data gathering. The surveys captured information on income, exploring how access to solar energy influenced income generation and savings for households. Data on expenditure highlighted changes in household energy-related costs, showcasing potential savings from using solar energy compared to traditional fuels. The surveys also examined energy usage, noting a shift from reliance on traditional fuels to solar energy, which indicated a transformation in the community's energy consumption habits.

Figure 1: Covered villages



2.7.2. Qualitative Data Collection

Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) were conducted to complement quantitative data collection by exploring community perspectives, experiences, and social dynamics surrounding solar energy adoption, insights into the barriers, challenges, and recommendations for future initiatives.

A. Key Informant Interviews (KIIs)

The discussions were conducted with the Executive Secretary, the Social and Economic Development Officer (SEDO), and village leaders to gather insights from key stakeholders about the adoption and impact of solar energy in their community. These individuals were chosen because of their leadership roles and comprehensive understanding of local socio-economic conditions. They provided valuable perspectives on how solar energy initiatives have influenced community development, including the perceived benefits and any limitations encountered.

B. Focus Group Discussions (FGDs)

To gather in-depth qualitative data, we conducted two Focus Group Discussions (FGDs), each comprising 7 participants from all the villages that made up the cell that have an intervention. This group size ensured diverse perspectives while maintaining a manageable discussion dynamic that encouraged active participation from all members. This Focus group discussion focused on community-level impacts, collective challenges, and recommendations for scaling up solar energy adoption. The discussion from the FGDs focused on three key areas: community level impact, collective challenges and recommendation for scaling up the interventions in the other community. Participants shared their experiences and insights on how the adoption of solar energy had affected their households and community, emphasizing changes in socio-economic conditions, energy reliability, and overall quality of life. The FGDs explored common barriers faced by the community in adopting and maintaining solar energy systems, including technological, financial, and logistical issues, Participants provided practical suggestions and strategies to improve the adoption and sustainability of solar energy systems in the community, considering both the local context and broader scalability.

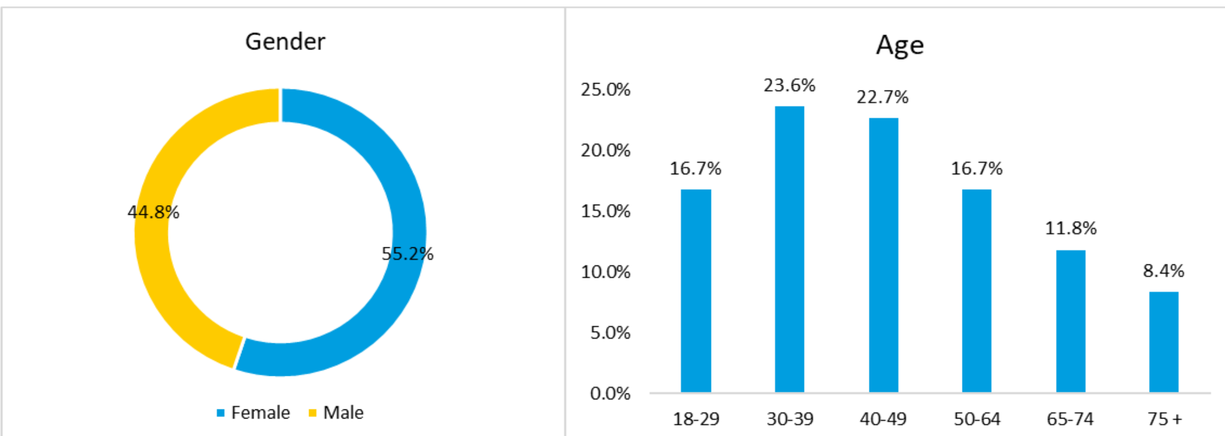
3. Results and Discussion

3.1. Respondent demographics

3.1.1. General demographics

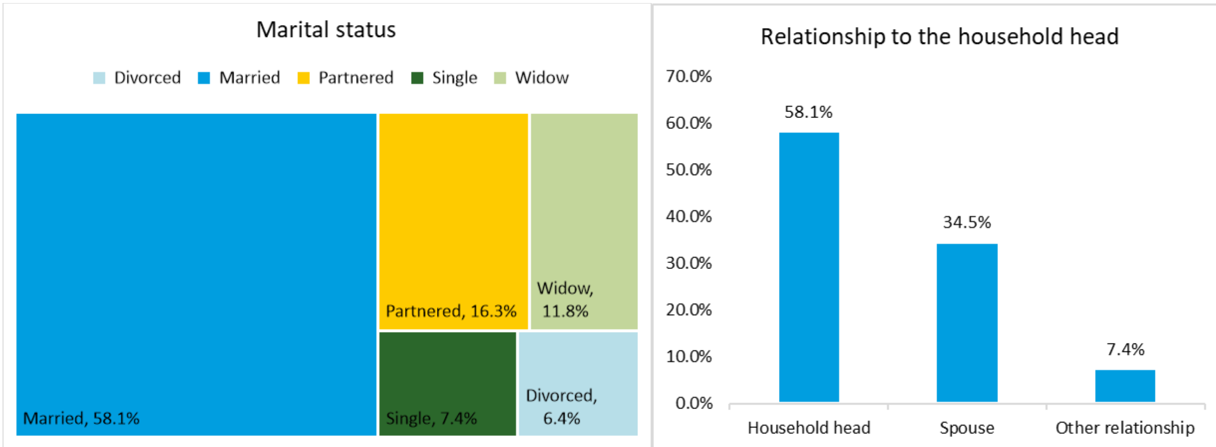
In this assessment, 203 households who benefited from the electrification project implemented by SVF were interviewed. Female respondents accounted for 55.2% of the respondents whereas males accounted for 44.8%. Half of the respondents were aged 30-49 years old, and 16.7% of the respondents were under the age of 30 (Figure 2).

Figure 2: Gender and age of respondents



Additionally, many survey respondents were married (58.1%) followed by those cohabitating at 16.3%, widows at 11.8%, single at 7.4%, and divorced at 6.4% (Figure 3). Most respondents interviewed were either household heads or their responses, which enhances the validity and accuracy of the data collected as data was being directly collected from project beneficiaries.

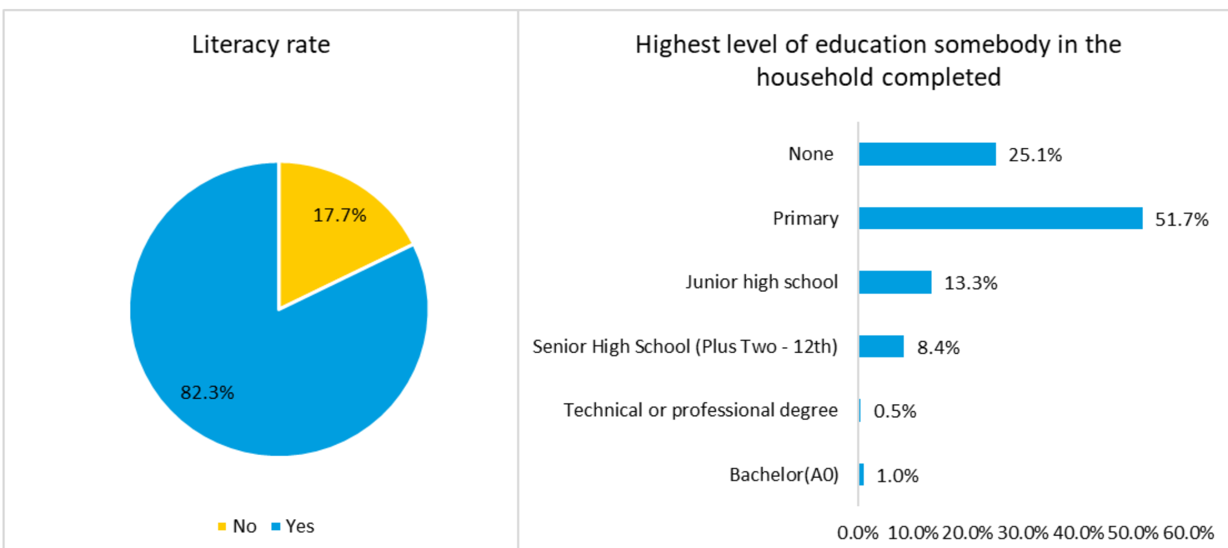
Figure 3: Respondent's marital status and their relationship to the household head



3.1.2. Education

Most (82.3%) respondents were literate; however, surveyed households have limited education as only 8.4% of households have someone who completed secondary education (high school) (Figure 4). Half of the respondents have only attained primary education.

Figure 4: Household's level of education



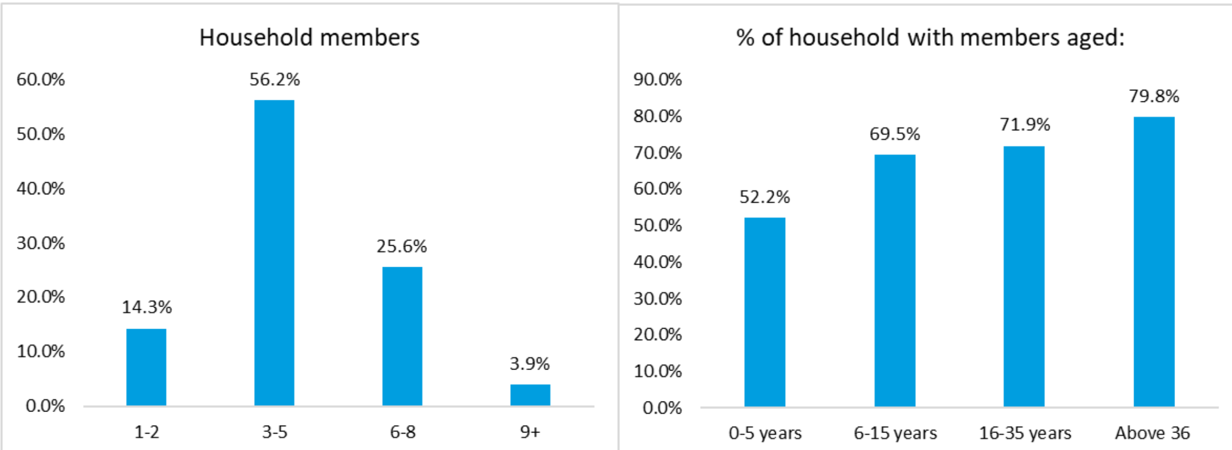
3.1.3. Household members

The average member size for the surveyed households was 4.6 members, which is relatively above the national average of 4.0 and Bugesera's of 3.9.[1] Half of the households have 3-5 members whereas a quarter of households have 6-8 members, 14.3% have 1-2 members

[1] NISR, Population and Housing Census - Main Indicators Report, 2022

and only 3.9% have more than 9 household members. Additionally, 52.2% of households have children under the age of 5, 69.5% have children aged 16-35, 71.9% of households have members aged 16-35 whereas 79.8% have members aged above 36 years (Figure 5).

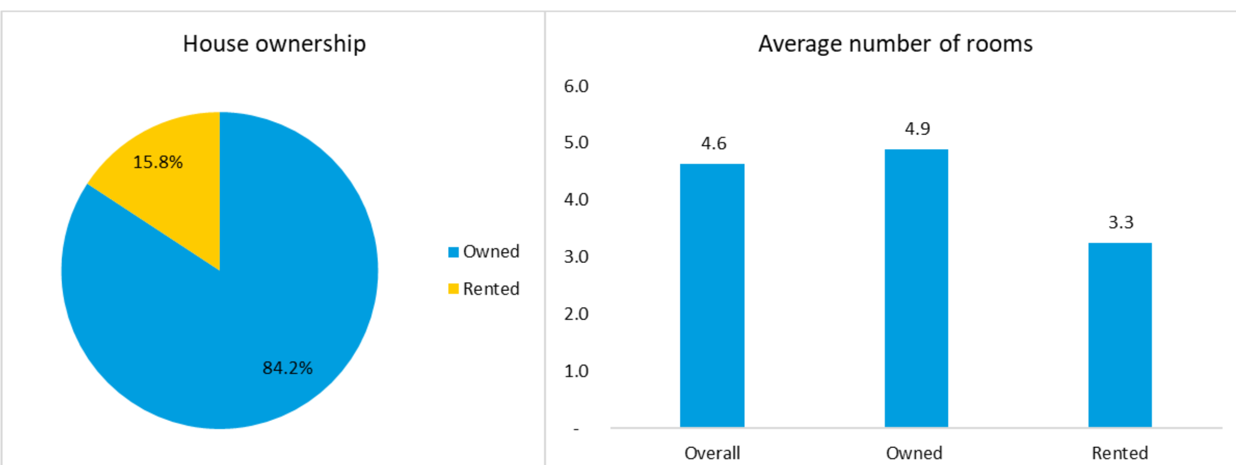
Figure 5: Household member size and their age



3.1.4. House ownership status and size

Most project beneficiaries are the owners of houses they live in. Tenants account for 15.8% of the surveyed households. The average number of rooms for all surveyed households is 4.6, and owners have bigger houses with an average size of 4.9 whereas the average room size for tenants is 3.3.

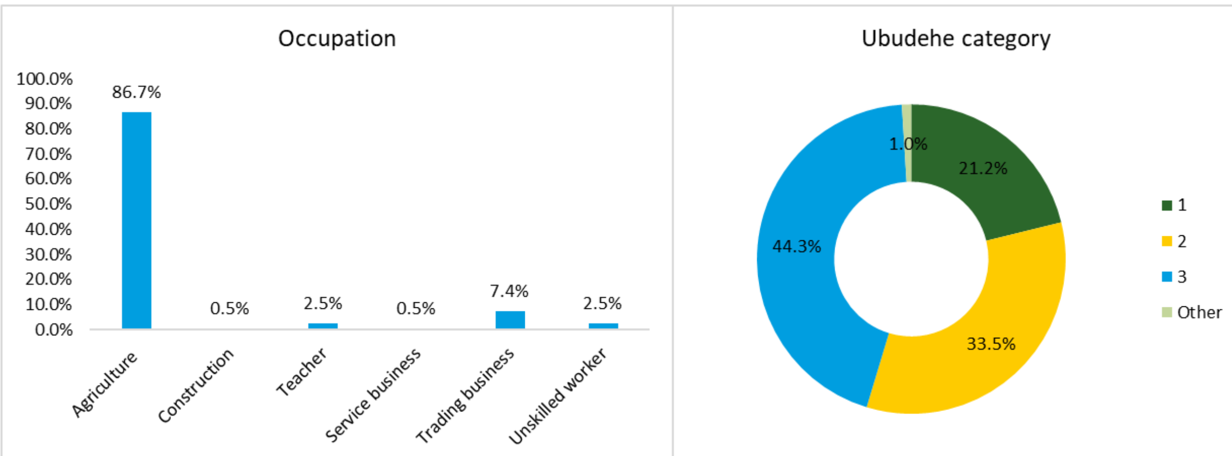
Figure 6: House ownership status and average number of rooms



3.1.5. Occupation and socio-economic status

Agriculture serves as the primary source of income for the interviewed households, with 86.7% engaged in the sector, highlighting the minimal presence of off-farm activities within this community. Regarding wealth status, 21.2% of households fall under Ubudehe category 1, 33.5% under category 2, and 44.3% under category 3 (Figure 7).

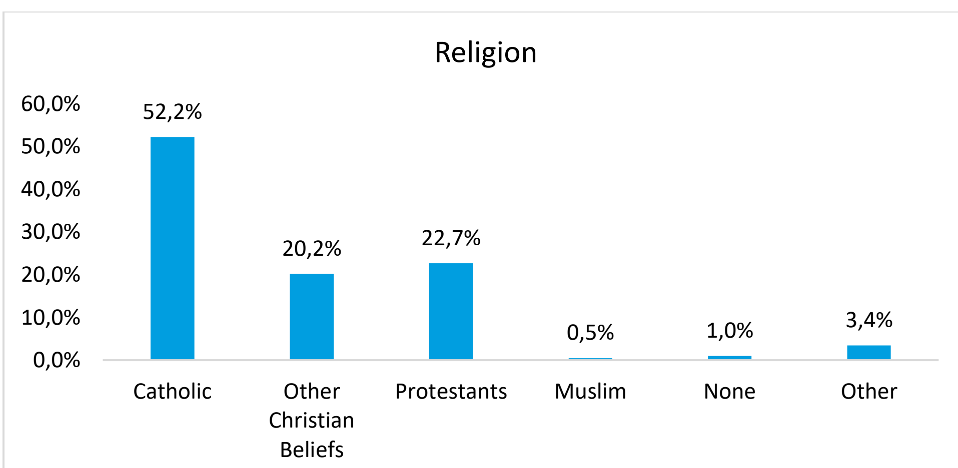
Figure 7: Household's occupation and socio-economic status



3.1.6. Household religion

Catholicism is the most popular region in the community, followed by protestants and other Christian beliefs. Muslims accounted for 0.5% of the surveyed households (Figure 8).

Figure 8: Household religion

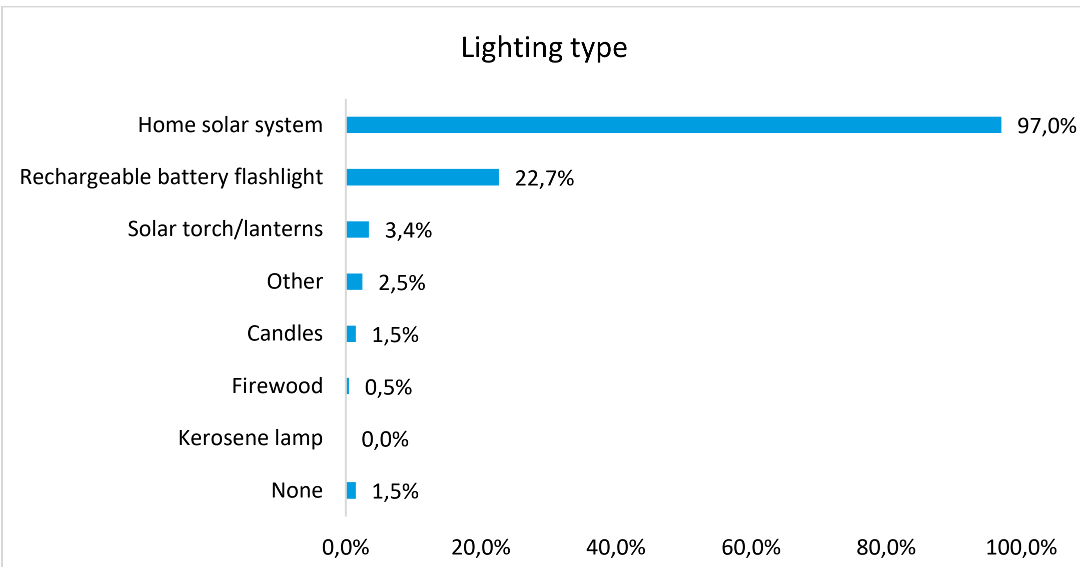


3.2. Access to electricity

3.2.1. Sources of lighting

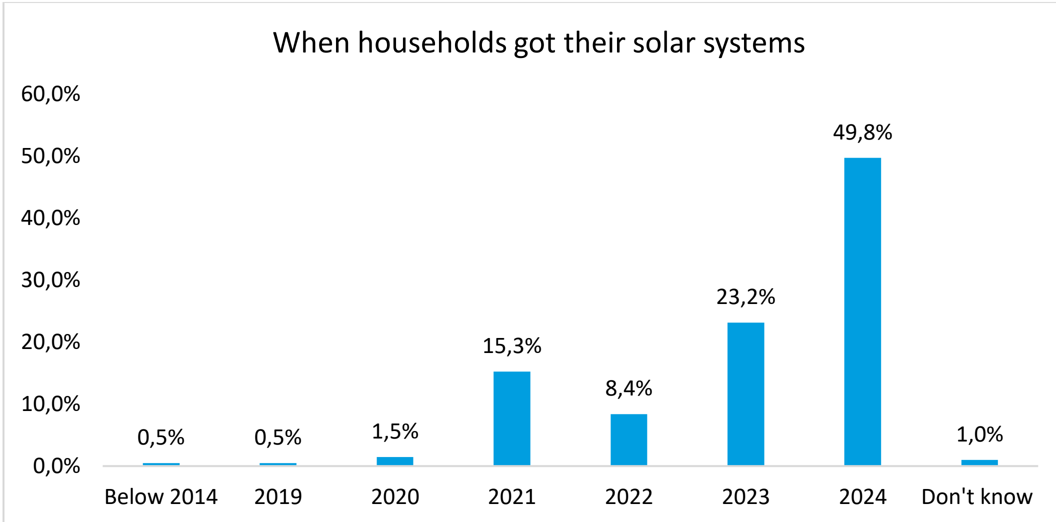
Survey results indicate that home solar systems are the dominant source of lighting, used by 97.0% of respondents, showcasing widespread adoption of this renewable energy solution. Rechargeable battery flashlights are the second most common option, utilized by 22.7%, followed by solar torches or lanterns at 3.4%. Traditional lighting methods, such as candles (1.5%) and firewood (0.5%), are minimally used, while kerosene lamps are entirely absent. A small proportion of respondents (2.5%) rely on other unspecified lighting types, and 1.5% reported having no access to lighting (Figure 9).

Figure 9: Lighting sources



In terms of when households acquired solar systems, most households (49.8%) installed solar systems in 2024. The second largest group (23.2%) adopted solar in 2023, followed by 15.3% in 2021 and 8.4% in 2022. Very few households acquired solar systems prior to 2020, with 1.5% in 2020, 0.5% in 2019, and 0.5% before 2014. Additionally, 1% of respondents were uncertain about when they installed their systems (Figure 10).

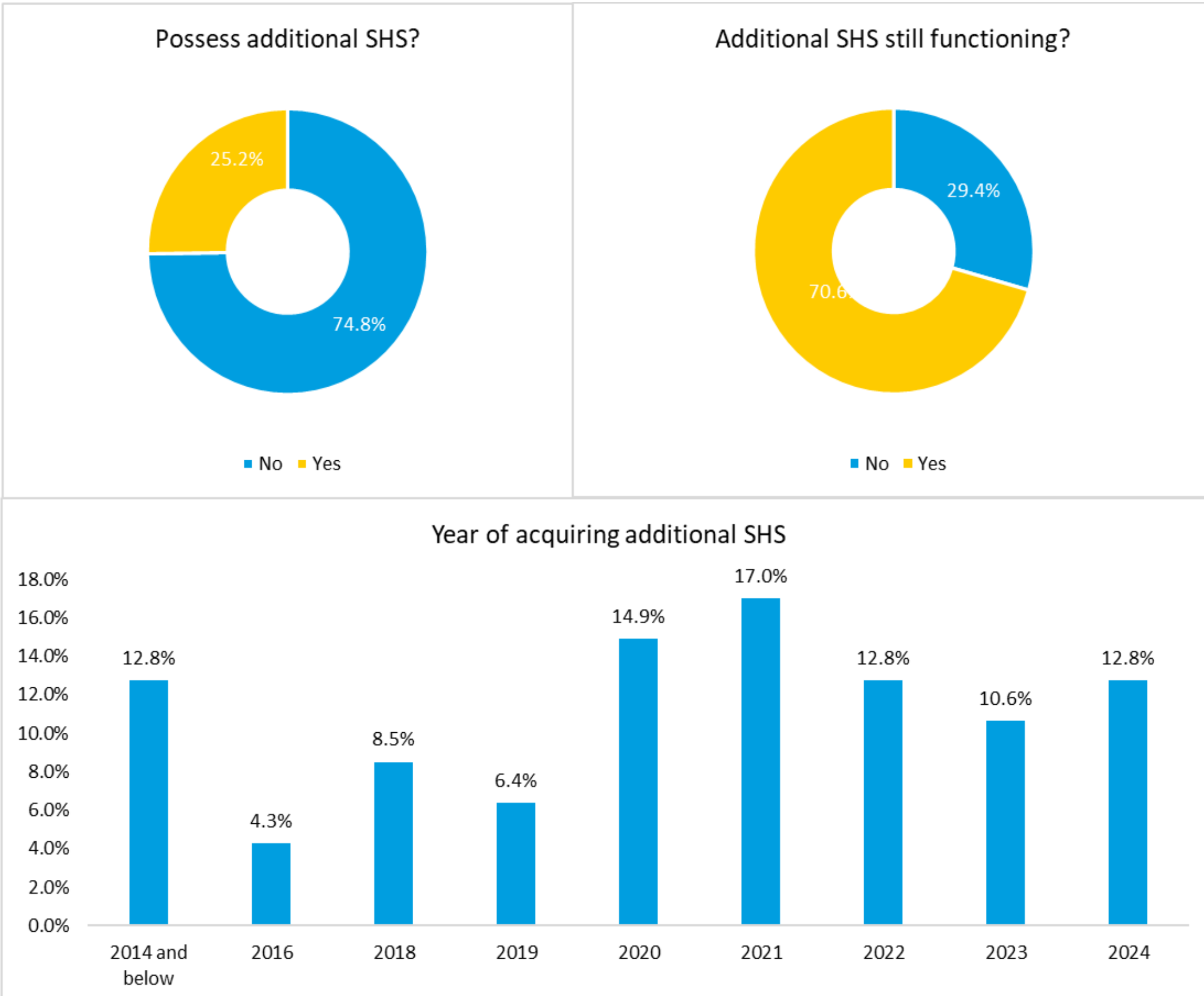
Figure 10: Year of acquiring solar systems



3.2.2. Possession of additional solar home systems

Approximately 25.2% of households possess additional SHS, while 74.8% do not. This suggests that a quarter of the households invested in supplementary solar systems, potentially to meet increasing energy needs. Among those with additional SHS, 70.6% report their systems are still functioning, while 29.4% are not. The timeline of additional SHS adoption shows a peak in 2021, with 17% of households acquiring additional systems that year, followed by 14.9% in 2020. In recent years, 2023 and 2024 saw moderate adoption rates at 10.6% and 12.8%, respectively (Figure 11).

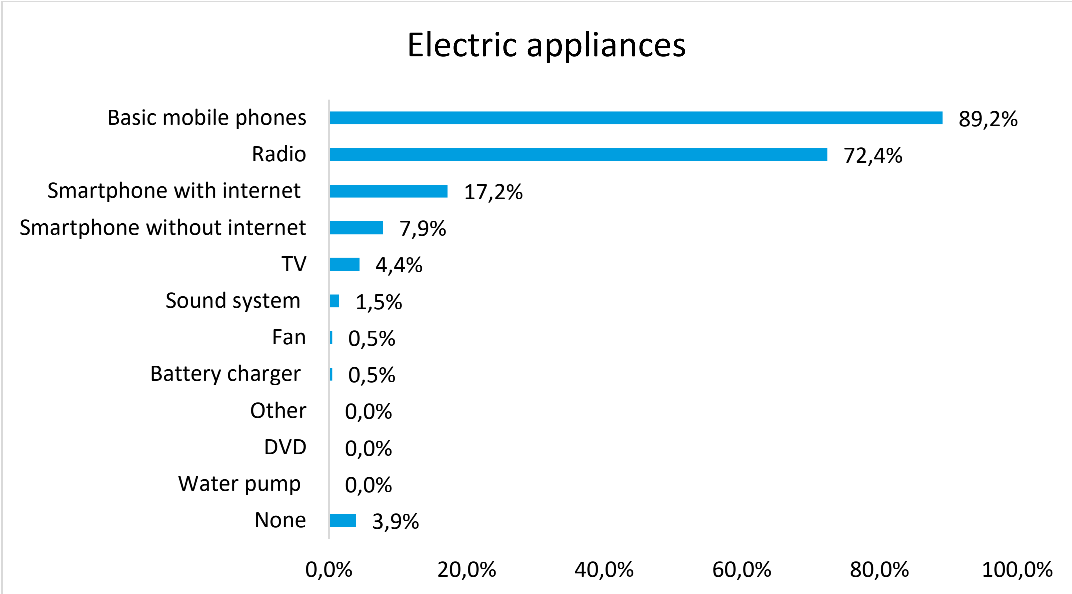
Figure 11: Whether households possess an additional SHS and when they got them



3.2.3. Electric appliances owned

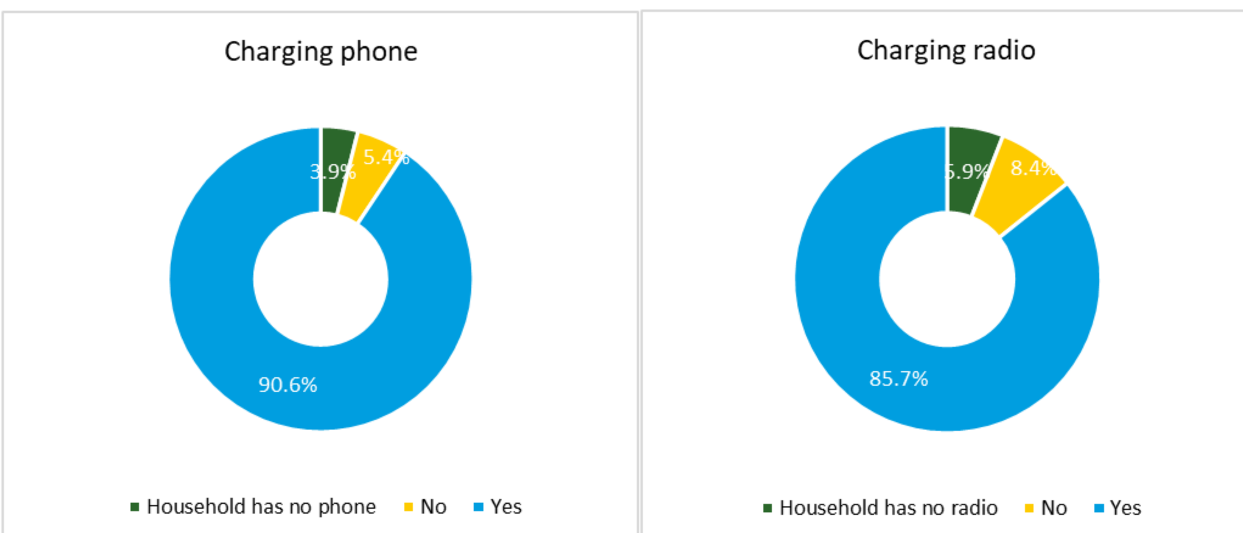
Basic mobile phones are the most owned device, with 89.2% of households possessing one, followed by radios at 72.4%. Smartphones with internet access are owned by 17.2% of households, while 7.9% own smartphones without internet. Less commonly owned appliances include TVs (4.4%), sound systems (1.5%), fans (0.5%), and battery chargers (0.5%). Other devices such as DVD players and water pumps are absent from ownership. A small percentage of households (3.9%) reported owning no electric appliances (Figure 12).

Figure 12: Electric appliances owned by households



The graph below depicts the ability of households to charge phones and radios using their solar systems. For charging phones, 90.6% of households can use their solar systems for this purpose, while 5.4% cannot, and 3.9% of households do not own a phone. Similarly, 85.7% of households can charge radios using their solar systems, 8.4% cannot, and 5.9% of households do not own a radio (Figure 13).

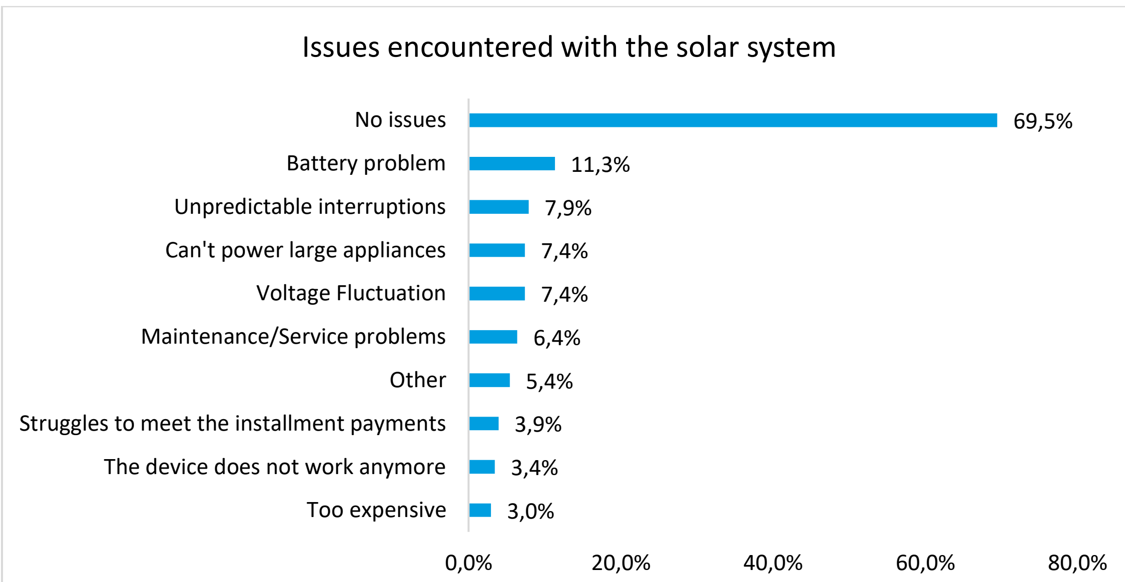
Figure 13: Whether households can charge phone or radios



3.2.4. Issues faced with the solar system

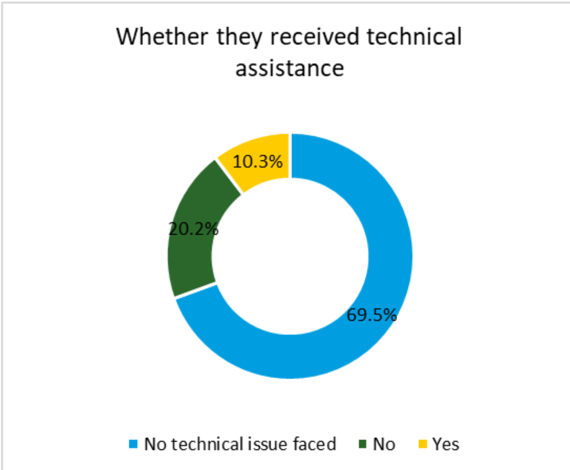
Figure 14 highlights that most respondents (69.5%) reported no issues with their solar systems, indicating high reliability and user satisfaction. Among those experiencing problems, the most common issue was battery-related (11.3%), followed by unpredictable interruptions (7.9%), inability to power large appliances (7.4%), and voltage fluctuations (7.4%), reflecting technical limitations. Maintenance and service problems were reported by 6.4% of users, while 5.4% mentioned other unspecified issues. Financial challenges were also noted, with 3.9% struggling to meet installment payments and 3.0% finding the system too expensive. Additionally, 3.4% reported that their system no longer works. Overall, while most users are satisfied, the issues reported suggest a mix of technical and financial barriers.

Figure 14: Issues that users face with the solar system



Survey results indicate that 69.5% of households reported facing no technical issues, while 20.2% faced issues but did not receive technical assistance, and only 10.3% received assistance. Among those who received assistance, 47.6% were dissatisfied, while a slightly higher percentage (52.4%) were satisfied (Figure 15). These findings indicate that while most households do not face technical issues, the provision and quality of technical assistance need improvement, as a significant portion of those who received help were dissatisfied.

Figure 15: Technical assistance and level of satisfaction



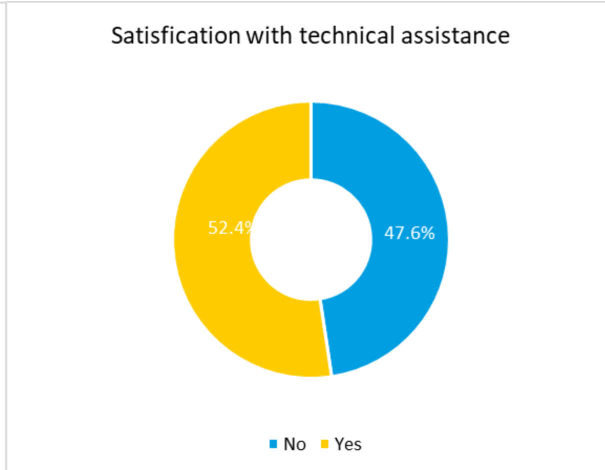
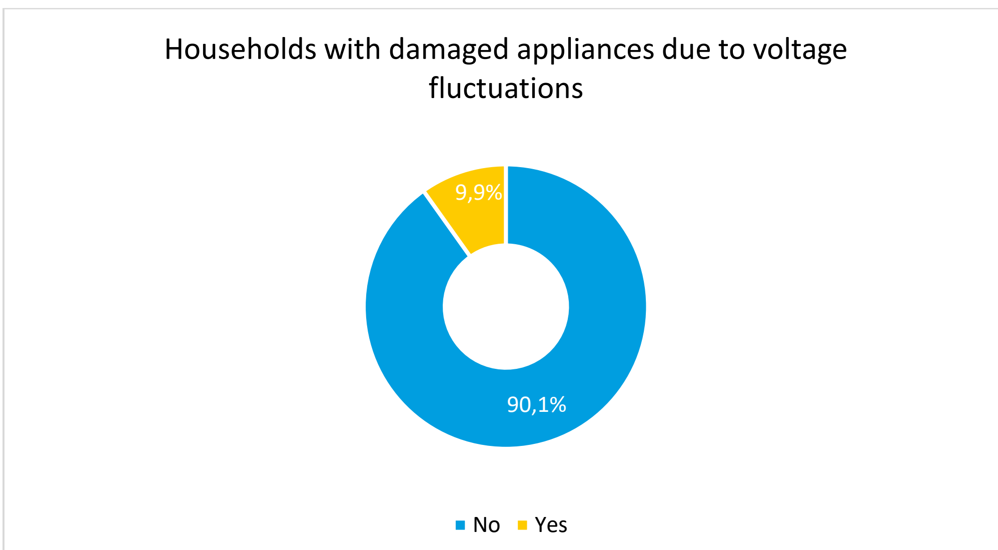


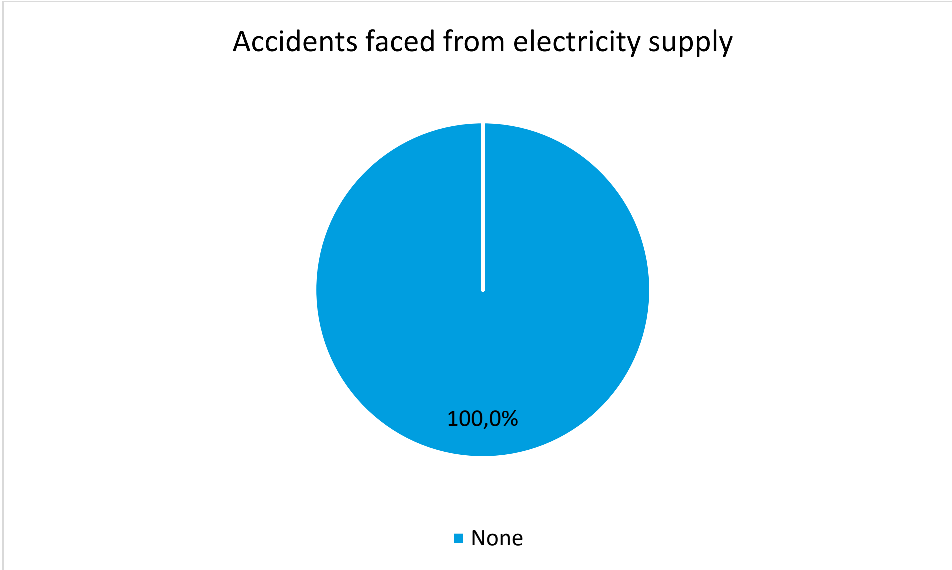
Figure 16 illustrates the percentage of households that have experienced appliance damage due to voltage fluctuations. A significant majority (90.1%) of households reported no damage, indicating that their appliances have not been affected. However, 9.9% of households experienced such damage, highlighting a notable issue for a minority.

Figure 16: Households with damaged appliances due to voltage going up and down



Survey results reveal an overwhelmingly positive safety outcome from electricity supply, as 100% of households reported experiencing no accidents (Figure 17). This perfect safety record highlights the reliability and safety improvements brought about by solar home energy, reducing the risks traditionally associated with other energy sources like kerosene lamps. These findings underscore the added benefit of clean energy solutions—not only are they cost-effective and sustainable, but they also enhance household safety.

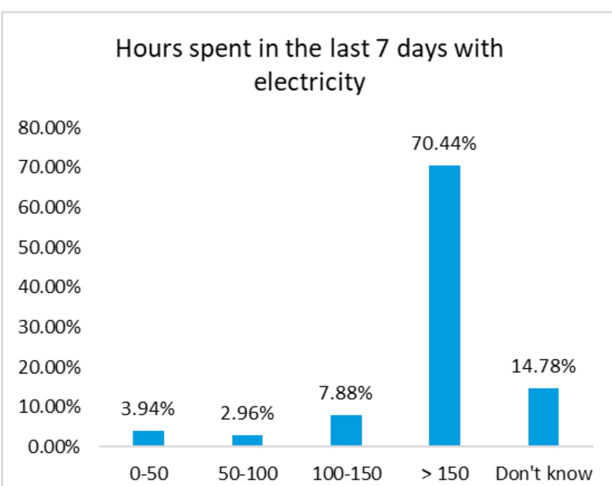
Figure 17: Whether households faced accidents from electricity supply

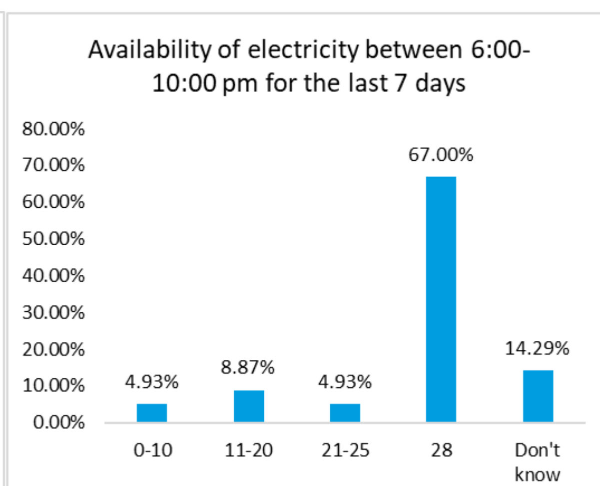


3.2.5. Availability of electricity

The average number of hours that households spent in the last 7 days with electricity was 154.3 hours, with 70.44% of respondents reporting above 150 hours of electricity in the past 7 days. Smaller proportions of the households reported being with electricity for 0-50 hours (3.94%), 50-100 hours (2.96%), and 100-150 hours (7.88%). Additionally, 14.78% of respondents were unsure about the number of hours they spent with electricity (Figure 18). Moreover, most households (67%) had full electricity during these evening hours (28 hours over seven days). However, 14.29% were uncertain, and others reported limited availability: 11-20 hours (8.87%), 0-10 hours (4.93%), and 21-25 hours (4.93%). These findings underscore the importance of solar systems in addressing energy access gaps.

Figure 18: Hours spent in the last 7 days without electricity

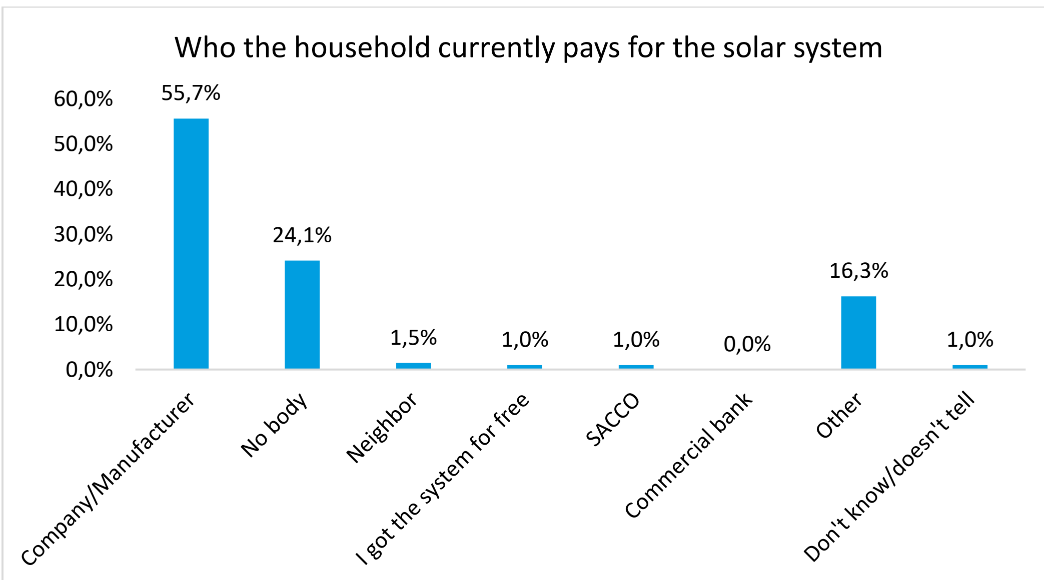




3.2.6. Who the households currently pay for the solar system

Most households (55.7%) pay the company or manufacturer directly, while 24.1% report not paying anyone, indicating they might already own the system outright or have other arrangements. Smaller percentages involve alternative arrangements: 16.3% listed "Other," 1.5% pay a neighbor, 1.0% obtained the system for free, and 1.0% either paid through a SACCO (Savings and Credit Cooperative) or are unsure/did not disclose (Figure 19). The data highlights that most households have a direct relationship with the company or manufacturer, with fewer utilizing intermediaries or alternate methods for acquiring or maintaining solar systems.

Figure 19: Who the household pays for the solar system

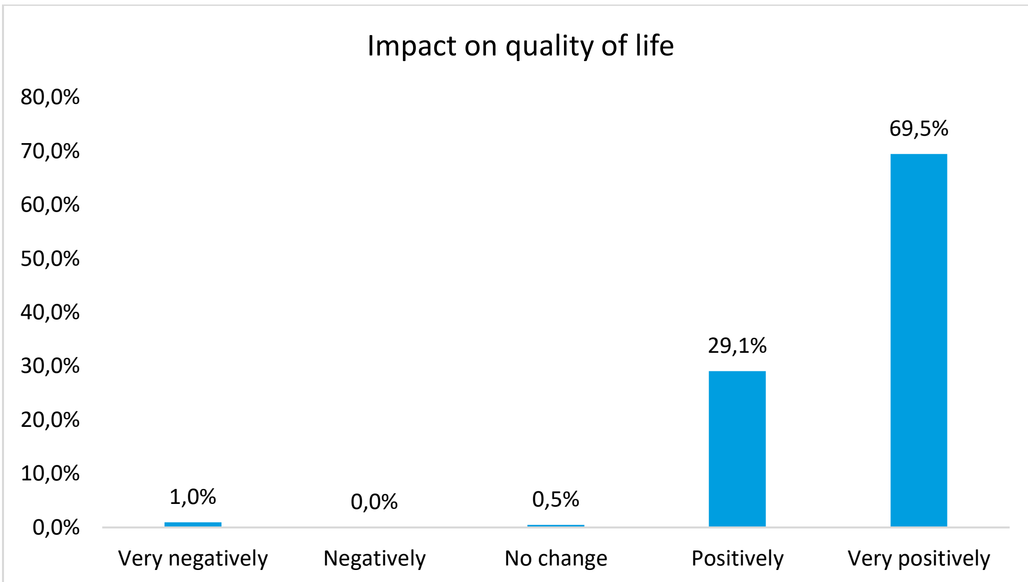


3.3. Social impact of solar home energy

3.3.1. Overall impact

A significant majority, 69.5%, of interviewed households reported that solar home energy has had a "very positive" impact, while 29.1% described the impact as "positive." Only a small fraction, 0.5%, indicated "no change," and minimal negative impacts were recorded, with 1.0% reporting a "very negative" effect and none reporting a "negative" effect (Figure 20). Overall, the data highlights the overwhelmingly positive perception of the system in improving household quality of life This finding aligns with qualitative survey responses, where participants noted that the introduction of home solar systems has significantly improved social life in Juru and Mugorore cells, particularly in education, safety, and community gatherings.

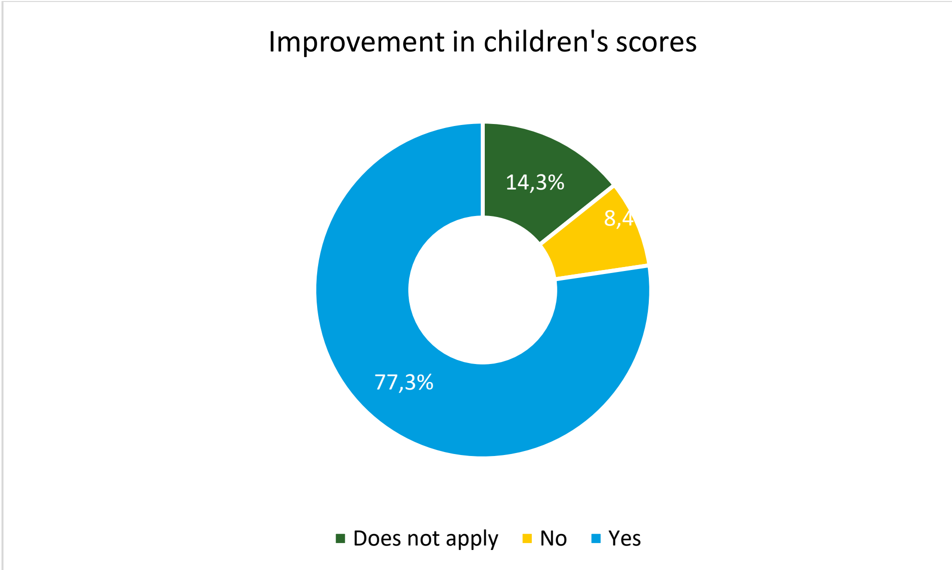
Figure 20: Impact of installing SHS on household's quality of life



3.3.2. Education

Figure 19 highlights the impact of solar home systems (SHS) on children's academic performance, with 77.3% of respondents reporting an improvement in scores due to the system. While 8.4% stated there was no improvement, 14.3% noted that the question was not applicable as they do not have children (Figure 21). This data underscores the substantial positive influence of the energy system on educational outcomes, primarily by providing reliable lighting for evening study and creating a conducive learning environment. These findings align with qualitative survey responses, where participants emphasized the transformative impact of SHS on education. Parents reported that children now have consistent access to lighting, eliminating the challenges of poor visibility or reliance on costly kerosene lamps, resulting in noticeable academic improvements. One parent shared, “Our child, who was once ranked 10th, now comes 2nd in their class because of the lighting.” By enabling consistent study time, SHS has opened better opportunities for children's academic success.

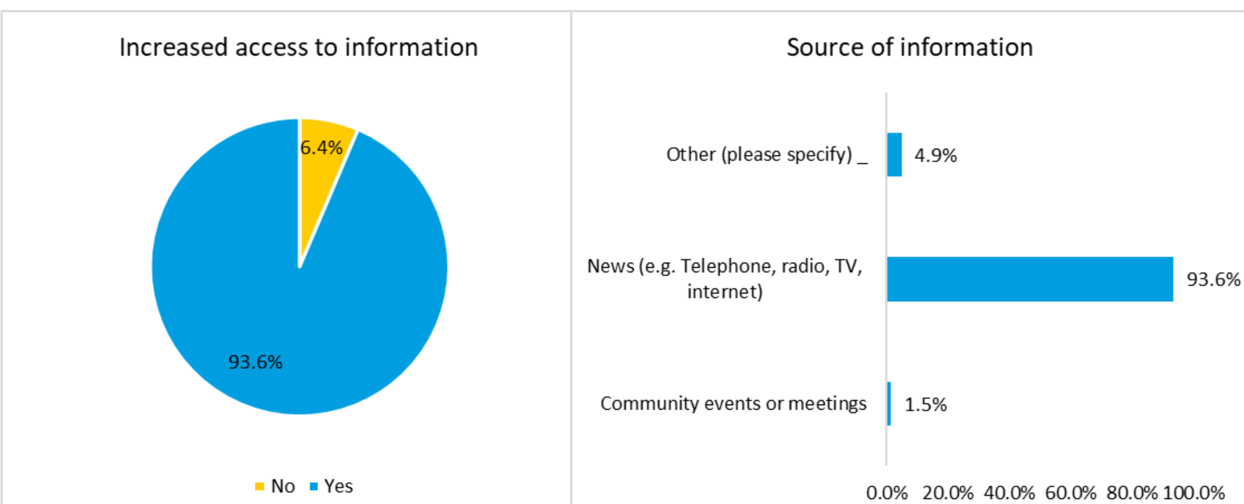
Figure 21: Impact of the SHS on children's school performance



3.3.3. Access to information

Most respondents, 93.6%, indicated that SHS increased their access to information. The chart on the left shows that the primary source of this information was through news platforms, such as telephone, radio, TV, and the internet, which accounted for the largest share (93.6%). Community events or meetings and "other" unspecified sources contributed minimally to information access (Figure 22). This highlights that SHS facilitates improved connectivity and information dissemination, predominantly via electronic and digital media.

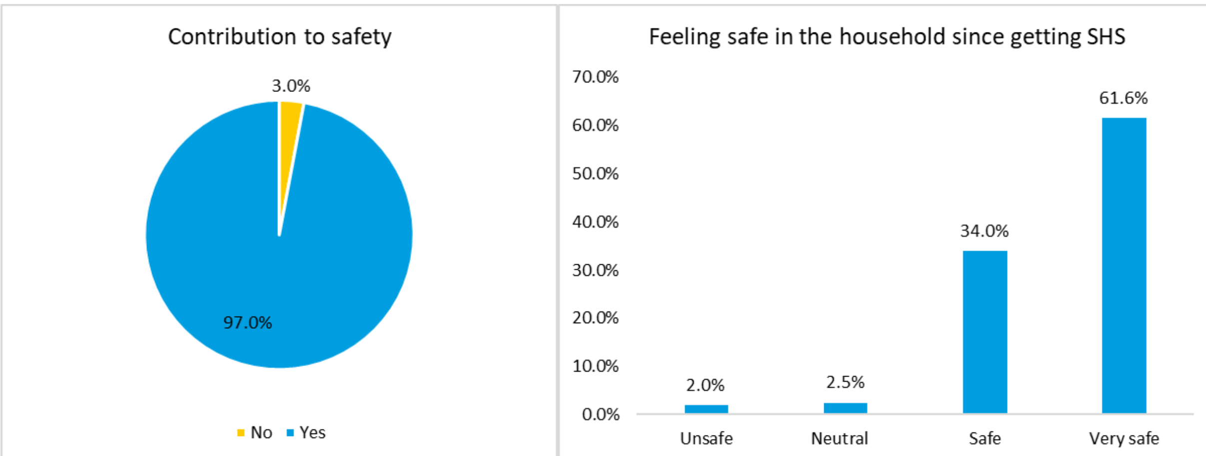
Figure 22: Impact on accessing information



3.3.4. Safety

Figure 23 demonstrates the significant impact of Solar Home Systems (SHS) on enhancing safety, with 97% of respondents reporting improved safety due to SHS, while only 3% did not perceive any contribution. Additionally, the bar chart highlights that 61.6% of respondents feel "very safe" and 34% feel "safe" since acquiring SHS, compared to only 2% who feel "unsafe" and 2.5% who remain neutral. This overwhelming positive response indicates that SHS has fostered a secure living environment for most beneficiaries.

Figure 23: Impact of the SHS on safety



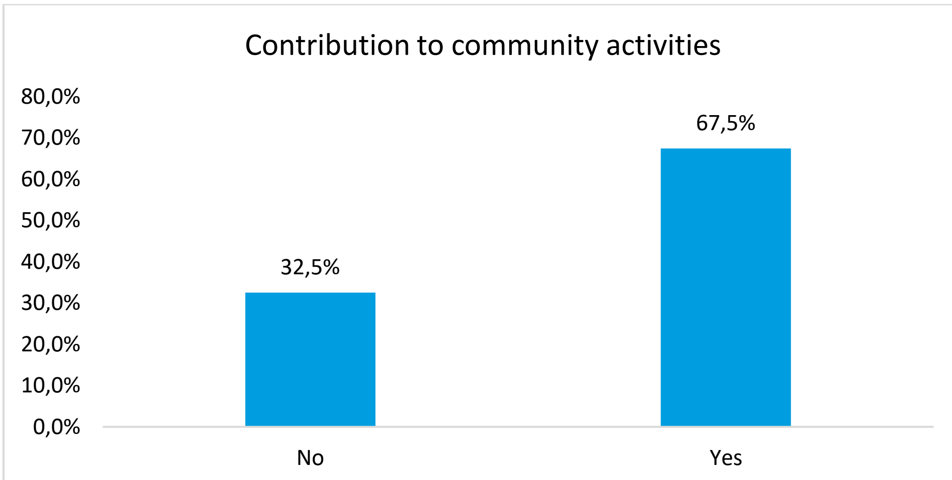
Qualitative insights provide context to these findings, emphasizing the transformative role of Solar home system lighting. Respondents highlighted how solar lights have prevented criminals and reduced theft by illuminating previously dark areas. One participant noted, “Thieves have decreased significantly since the villages are lit up by home solar system power,”. Beyond theft prevention, solar lighting has also enhanced safety from wild animal threats. A focus group participant from Mugorore cell shared, stated that “There used to be wild animals that could attack people or livestock at night, but now, outdoor lights have stopped that.” Another respondent from Juru cell emphasized the increased sense of security, stating, “With solar energy, thieves have decreased significantly because they know they can be spotted.” These qualitative insights align with the quantitative data, highlighting SHS’s pivotal role in creating safer communities by improving visibility and deterring potential threats

3.3.5. Community activities

The majority (67.5%) of households reported that home solar energy has contributed to community activities and initiatives, highlighting its role in fostering social cohesion. Solar lighting has transformed evening social interactions by providing reliable illumination, which was previously hindered by darkness that kept people isolated in their homes after sunset.

With well-lit outdoor spaces, neighbors can now gather to converse and participate in communal activities, strengthening bonds within the community. This impact was strongly described by one respondent: “With outdoor lighting, people gather in the evenings to talk and interact. It feels like the community has come alive again.” These qualitative insights align with the quantitative findings, emphasizing the role of solar energy in renewing community life and promoting stronger social connections.

Figure 24: Impact on community activities



3.4. Economic impact of solar home energy

3.4.1. Impact on household expenditure

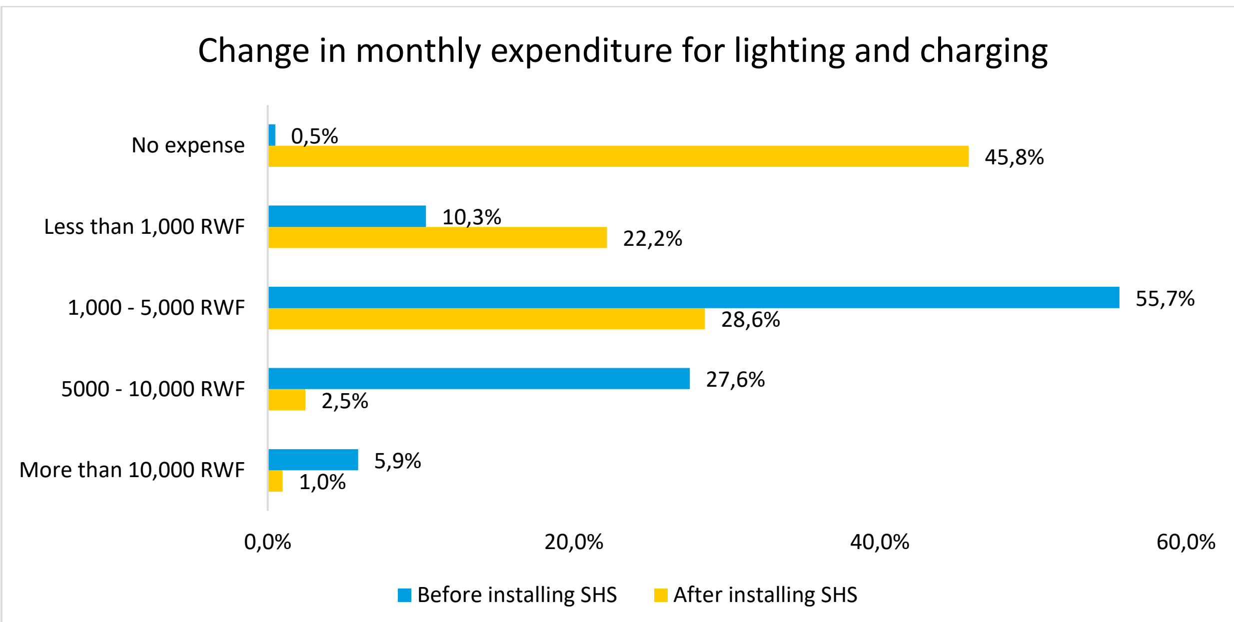
Before installing SHS, most households (55.7%) spent between 1,000 and 5,000 RWF monthly on lighting and charging phones and radios, while 27.6% spent 5,000 to 10,000 RWF, and 5.9% spent more than 10,000 RWF. Only 0.5% of households had no expense for these utilities prior to installing SHS. Installing the SHS led to a significant shift in expenditure patterns. Nearly half of the households (45.8%) reported no expenses, while those spending less than 1,000 RWF rose from 10.3% to 22.2% after installing SHS. Expenditures in higher spending categories dropped sharply, with only 28.6% spending 1,000 to 5,000 RWF, 2.5% spending 5,000 to 10,000 RWF, and just 1% spending more than 10,000 RWF after installing SHS. While SHS helped households reduce expenses on lighting and charging electric appliances, some spending on these items persists, highlighting the system’s limitations in fully meeting household energy needs.

Qualitative data supported the quantitative result, showing how before the intervention, households relied on traditional energy sources such as batteries, and candles, spending up to 9,000–10,000 RWF monthly. These expenses, driven by inefficient and environmentally harmful options, constrained household budgets.

After the installation of SHS, households experienced reductions in energy costs, with some spending as little as 750 RWF monthly per household. This cost saving enabled resource reallocation toward essential needs and productive investments. One village leader highlighted the economic effects from the use of SHS, stating that, “Now that amount goes back to the business. If they spent 6,000 RWF on batteries charging, the 5,250 RWF saved can be used to buy a chicken or school uniforms” Another participant shared that savings were used to “buy livestock and fertilizers” (FGD: Participant M5, Mugorore cell).

Both quantitative and qualitative data show that SHS impacted household economies by reducing expenditures on batteries, and candles for lighting, allowing families to save money and redirect it toward other household investments.

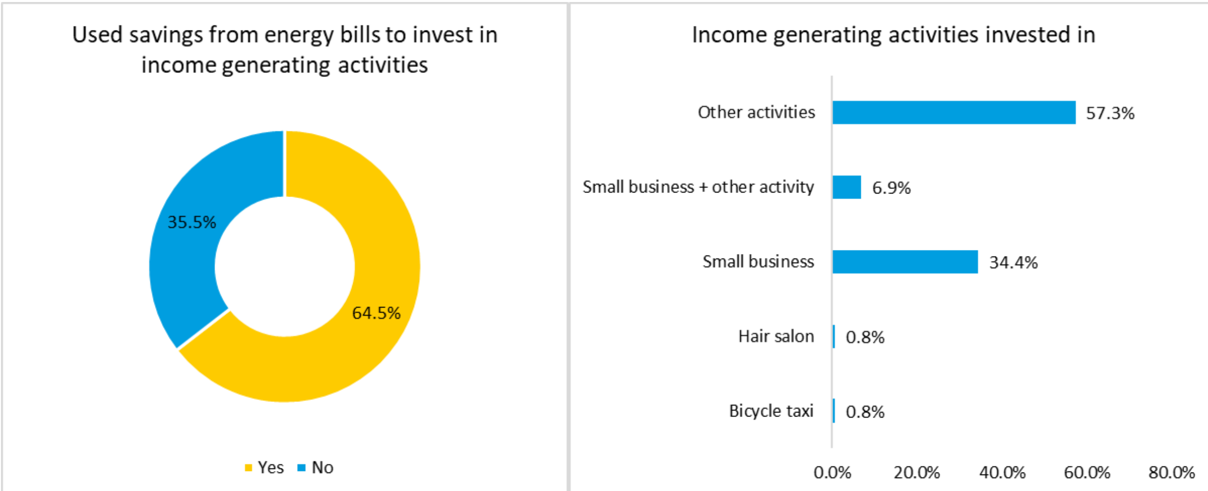
Figure 25: Change in monthly energy expenditure



3.4.2. Investing in income generating activities

Figure 26 depicts that 35.5% of households did not reinvest their savings, while 64.5% directed these savings toward income-generating ventures. Among those who invested, the largest share (57.3%) engaged in "Other activities,", which were primarily crop or livestock farming. This was followed by 34.4% who started or expanded small businesses. A smaller portion (6.9%) combined small business investments with other activities, while only 0.8% each invested in hair salons or provision of transport services in the community by using bicycle . This demonstrates that for a significant portion of households, the savings from reduced energy costs opened opportunities for economic activities, with a focus on diversification and small business development.

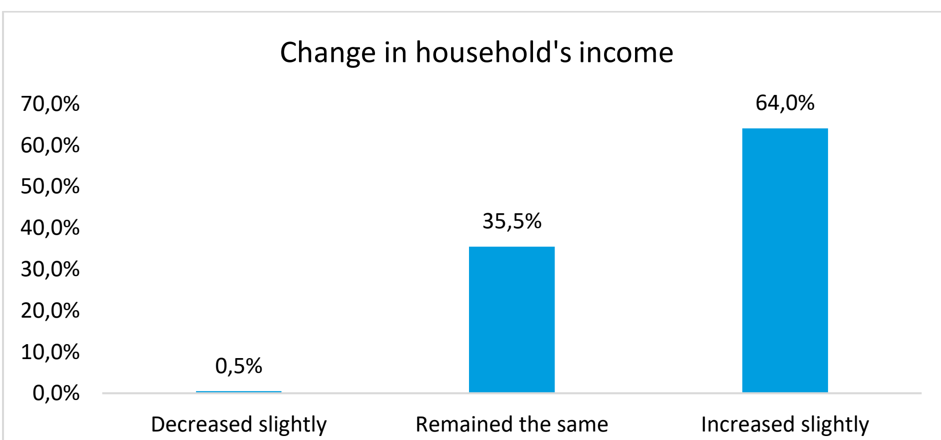
Figure 26: Types of economic activities invested in due to energy savings



3.4.3. Change in household's income

Figure 27 portrays the changes in household income following the installation of solar home systems (SHS). A majority of households (64.0%) reported a slight increase in their income, likely due to savings on energy costs and potential reinvestment into income-generating activities. Meanwhile, 35.5% of households experienced no change in their income levels, suggesting that the financial benefits of SHS did not directly impact all households equally. Only a very small percentage (0.5%) reported a slight decrease in income. These findings highlight the positive economic impact of SHS for most households, with a significant portion experiencing improved financial well-being.

Figure 27: Change in household's income after installing SHS

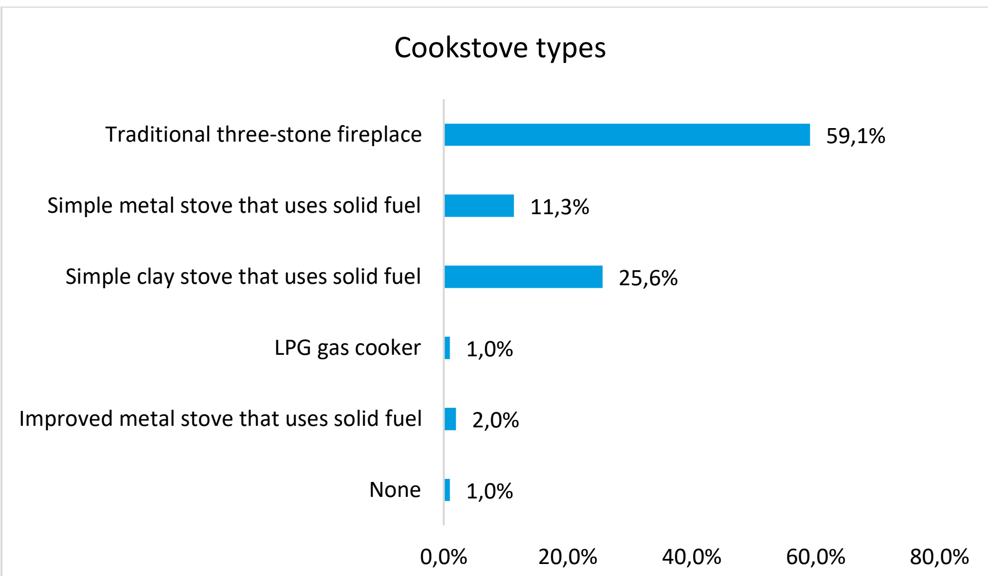


3.5. Access to cooking energy

3.5.1. Types of cookstoves used

The traditional three-stone fireplace remains the most widely used cooking method, accounting for 59.1% of households, emphasizing its deep cultural roots and accessibility. Meanwhile, 25.6% of households have adopted simple clay stoves, which offer slightly improved efficiency and reduced fuel use compared to traditional methods. A smaller portion, 11.3%, use simple metal stoves that rely on solid fuel. Modern alternatives like LPG gas cookers and improved metal stoves are rare, each representing only 1% to 2% of households, highlighting the limited penetration of cleaner cooking technologies. These figures suggest an opportunity for targeted interventions to promote safer and more efficient cooking solutions, which could significantly impact health, time, and environmental conservation.

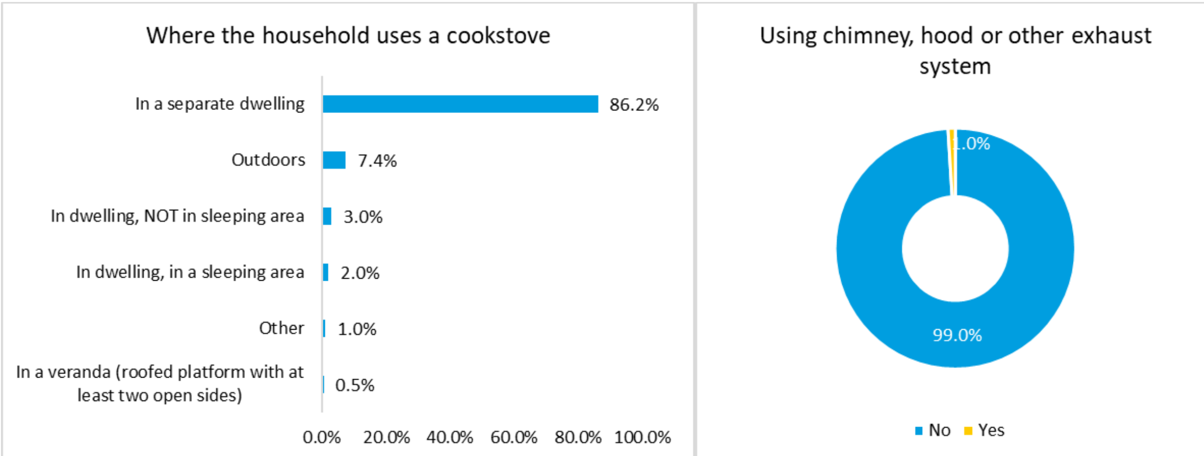
Figure 28: Cookstoves used by the households



3.5.2. Where the stoves are used

The data reveals that 86.2% of households cook in a separate dwelling, underscoring an effort to isolate cooking activities—possibly to mitigate smoke exposure within living areas. Outdoor cooking accounts for 7.4%, and a small portion still cooks inside the main dwelling, either outside sleeping areas (3%) or within them (2%), raising potential health concerns. Only 0.5% use a veranda with at least two open sides. Alarmingly, 99% of households do not use any chimney, hood, or other exhaust system (Figure 29), signifying a critical gap in addressing indoor air pollution. This highlights an urgent need for awareness and access to ventilation solutions to improve household air quality and health outcomes.

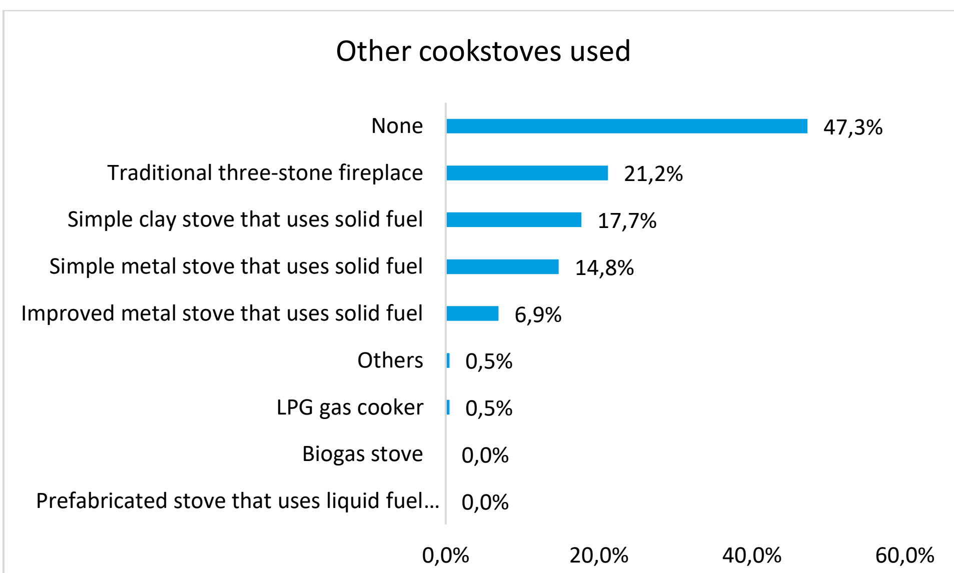
Figure 29: Where the cookstove is used and types of exhaust system utilized



3.5.3. Other cookstoves utilized and types of fuels utilized

Notably, 47.3% of respondents reported not using any additional cookstoves, indicating reliance on primary cooking solutions. Traditional three-stone fireplaces remain a prevalent alternative cooking solution, utilized by 21.2% of households, reflecting a continued dependence on conventional methods. Similarly, 17.7% and 14.8% use simple clay and metal stoves, respectively, both relying on solid fuel. Improved metal stoves, used by 6.9%, represent a shift toward efficiency but remain underutilized. Advanced options like LPG gas cookers and biogas stoves are nearly absent, accounting for a mere 0.5% each.

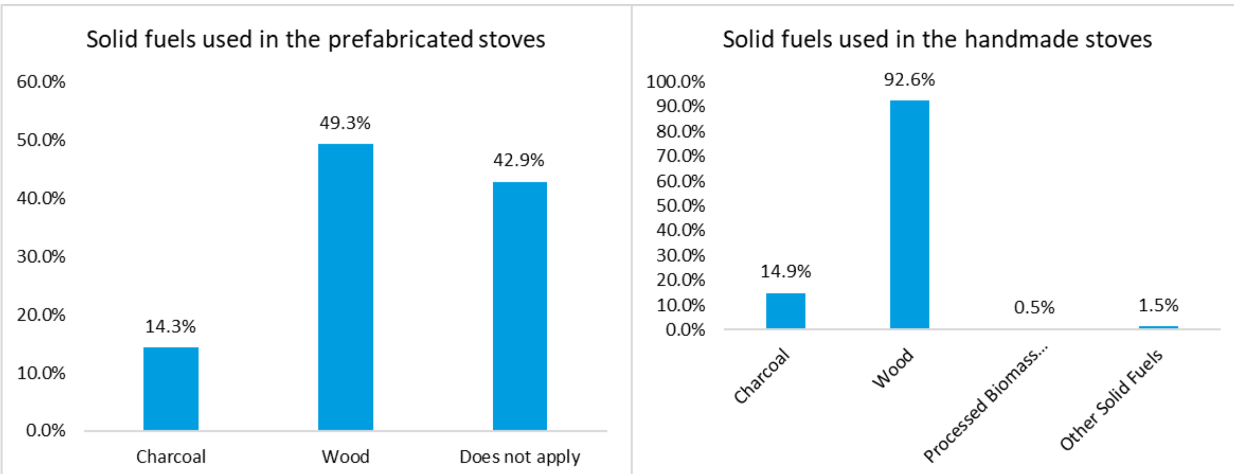
Figure 30: Other cookstoves utilized by households



For prefabricated stoves, wood emerges as the dominant fuel, used by 49.3% of respondents, while charcoal accounts for a smaller share at 14.3%. Notably, 42.9%

indicated "does not apply," likely reflecting households that do not use prefabricated stoves. In contrast, handmade stoves show a heavy reliance on wood, with an overwhelming 92.6% of respondents using it, while charcoal use is minimal at 14.9%. Processed biomass and other solid fuels are almost negligible, at 0.5% and 1.5% respectively, underscoring the predominance of traditional wood-based fuels. These patterns suggest a need for diversifying into more sustainable or efficient fuel types with targeted interventions.

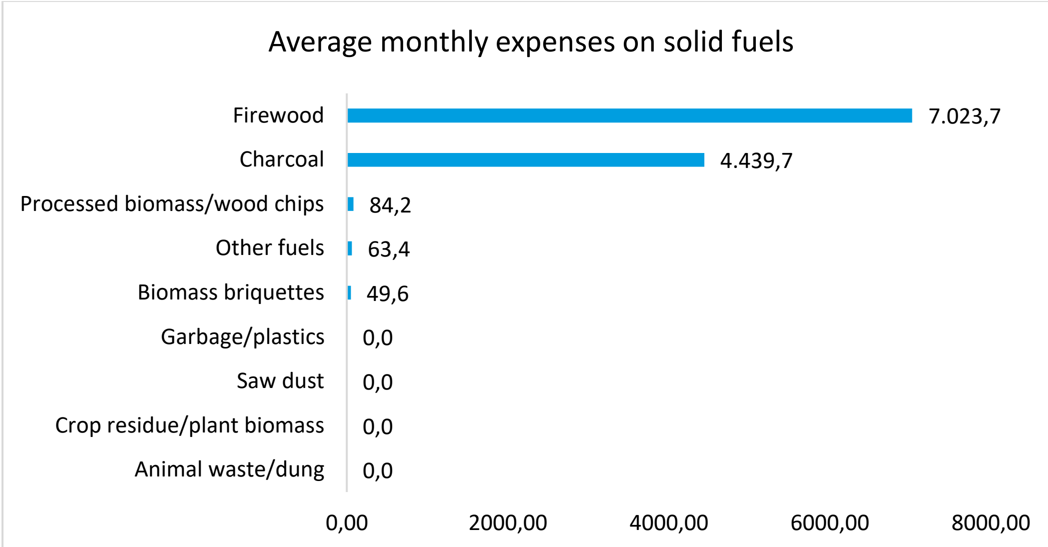
Figure 31: Types of solid fuels used



3.5.4. Cooking energy monthly expenditures

Figure 32 showcases household monthly expenditure on solid fuels in Rwandan Francs (RWF). Firewood has the highest monthly average expense of 7,023.7 RWF, followed by charcoal at 4,439.7 RWF. In stark contrast, processed biomass, biomass briquettes, and other fuels barely register, with costs under 100 RWF (Figure 32). Notably, options like garbage, sawdust, crop residues, and animal waste are entirely absent from the expense list, underscoring their non-utilization. This snapshot reveals a strong dependence on traditional biomass fuels, while alternative or unconventional fuels remain largely explored in household cooking energy consumption practices.

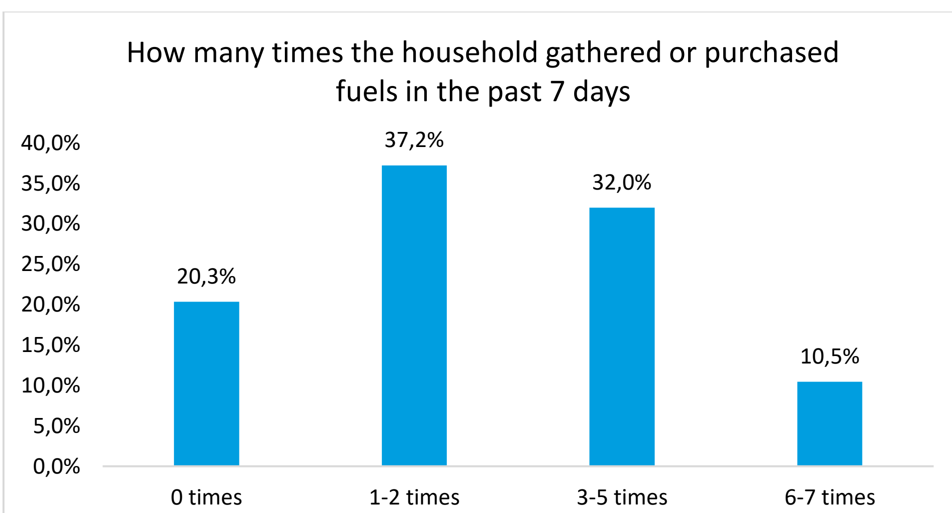
Figure 32: Average monthly cooking energy expenditure



3.5.5. Time spent gathering or purchasing fuels for the main cookstove

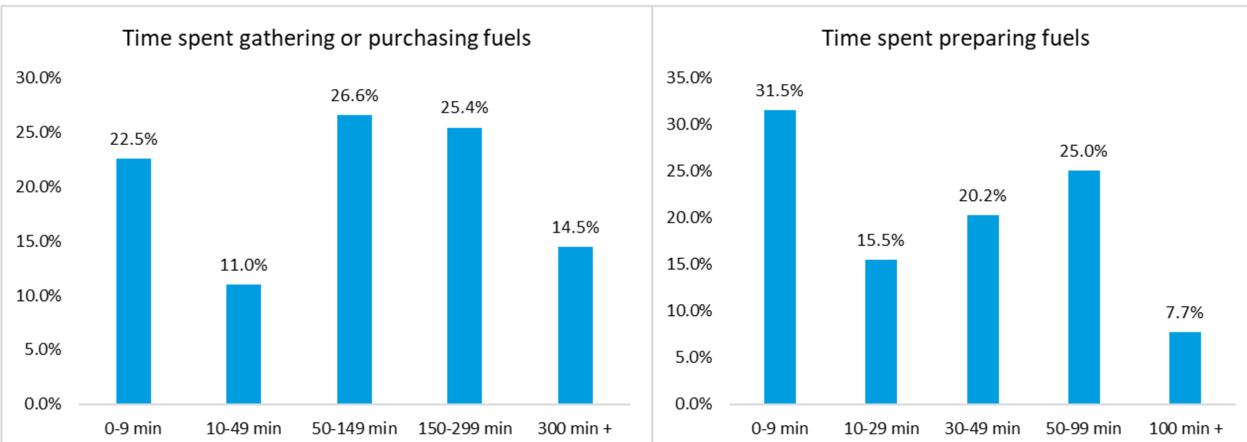
On average, households spent 2.38 times a week gathering or purchasing solid fuels for the main cookstove. The frequency of 1-2 times a week had the highest percentage of 37.2%, followed by the frequency of 3-5 times at 32.0%. Additionally, 10.5% of households collected or purchased fuels 6-7 times (nearly daily), potentially indicating high demand, limited storage capacity, or irregular access. About one-fifth of the households did not gather or purchase fuel during the past week, possibly indicating access to alternative energy sources or no immediate need for fuel. This data highlights varying patterns of fuel acquisition, which could be influenced by factors like energy availability, household size, or reliance on traditional fuels.

Figure 33: Frequency of collecting or purchasing fuels



For gathering or purchasing fuels for the main cookstove, households spent 167 minutes on average. Most households (26.6%) spent 50–149 minutes daily, followed closely by 25.4% of households that spent 150–299 minutes. Meanwhile, 22.5% spent less than 10 minutes, and 14.5% spent over 300 minutes (Figure 34). On the other hand, households spent 39 minutes on average preparing fuels for the main cookstove. The data shows that the largest group (31.5%) spent 0–9 minutes daily preparing fuels, while 25.0% spent 50–99 minutes. Another 20.2% spent 30–49 minutes, and only 7.7% spent over 100 minutes (Figure 34). These findings shed light on how households spend substantial time gathering and preparing fuels, suggesting a need for targeted cooking interventions to promote safer and more efficient cooking solutions that require less time for fuel collection or purchasing and preparation.

Figure 34: Time spent gathering, purchasing or preparing fuels per day in the past 7 days



4. Recommendations

Drawing from the findings of both quantitative and qualitative analyses, the following are recommendations regarding the home solar system intervention implemented by the Sustainable Village Foundation in Bugesera District:

4.1. Enhancing accessibility of repair services to the community

To improve access to repair services, the Foundation should establish local repair centers staffed with skilled technicians to provide timely maintenance support and conduct regular community visits to prevent system failures and extend the lifespan of solar systems. This approach will address delays in technical support and dissatisfaction among beneficiaries, ensuring prompt assistance and implementing regular follow-ups to resolve user concerns effectively. This approach will save beneficiaries both time and money by eliminating the need to travel to Kigali for technical assistance.

4.2. Expanding solar system capacity in the community

Introducing higher-capacity solar systems compared to the existing HSS will support appliances such as refrigerators, televisions, and business equipment, enabling small enterprises like hair salons, and charging stations to operate more efficiently. This will boost the beneficiaries' economic growth and enhance the social well-being of the community.

4.3. Expanding solar interventions to other communities

The home solar system project has greatly enhanced children's education in beneficiary households while also improving community safety. Expanding this initiative to other communities would amplify its positive impact by addressing electricity challenges in Bugesera and other regions of Rwanda. This expansion would not only support social and economic development but also contribute to the 2nd National Strategy for Transformation (NST2), specifically by improving the quality of education (Goal No. 9) and advancing the goal of ensuring access to clean water and electricity for all Rwandans.

4.4. Promoting Cleaner Cooking Solutions

To promote cleaner cooking solutions, it is crucial to focus on raising awareness about the health, environmental, and economic benefits of transitioning to improved cookstoves and sustainable fuel alternatives. Programs should prioritize the distribution of affordable and efficient cooking technologies, such as improved biomass stoves and biogas systems, while providing subsidies or financial incentives to ensure accessibility for low-income households. Additionally, integrating behavior change campaigns and community training can help shift cultural preferences toward modern cooking methods.

5. Conclusion

The assessment highlights the transformative impact of the home solar system (SHS) project implemented by the Sustainable Village Foundation in Bugesera District. The study reveals that SHS adoption has significantly improved household quality of life by enhancing children's education, increasing community safety, and fostering social interactions. Economically, households have benefited from reduced energy costs and reinvestment opportunities, with many reporting increased income levels. Despite these positive outcomes, challenges persist in accessing reliable repair services and addressing the limited capacity of current systems for powering larger appliances and supporting small businesses. Overall, the project demonstrates a strong potential for scalability to other communities, aligning with Rwanda's 2nd National Strategy for Transformation (NST2) goals of improving education quality and ensuring access to clean energy. To maximize its impact, the study recommends expanding repair services, introducing higher-capacity systems, and extending the intervention to additional regions to address broader electricity challenges and enhance socio-economic outcomes.