Renewable Energy for Development: Assessing Impact of Solar Technology Transfer in Sitio Kiito, Barangay Can-ayan, Malaybalay City, Bukidnon

Joan M. Recente
Bukidnon State University
ORCID No. 0000-0001-6104-0610
joan_monteros@buksu.edu.ph

Jiemalyn B. Paulican
Bukidnon State University
ORCID No. 0000-0002-2336-9711
jbpaulican@buksu.edu.ph

Carina Joane V. Barroso
Bukidnon State University
ORCID No. 0000-0002-7418-9390
carinajoane_barroso@buksu.edu.ph

Richard Alboroto
Texas Tech University
0000-0003-1981-0479

Rolando Y. Casas
San Isidro College
ORCID No. 0009-0002-8136-8810
rcasas@sic.edu.ph

Abstract

This study evaluated the impact of a solar-powered electrical system project in Sitio Kiito, Barangay Can-ayan, Malaybalay City. A qualitative research design, specifically an intrinsic case study approach was employed to comprehensively understand the impact of solar technology transfer. The project has transformed the community, benefiting 10 out of 27 households and nearly 100 residents. Key changes include enhanced educational opportunities, economic growth, and improved living conditions, with social interactions and community cohesion increasing due to reliable lighting. The project also empowered residents by providing technical skills, fostering self-reliance and ownership of their energy resources. However, sustaining the project presents challenges, such as technical difficulties and financial constraints. Despite initial training, residents struggle with complex repairs, highlighting the need for ongoing technical support and a reliable supply of spare parts. Financial constraints also pose significant challenges, with the community's limited resources impacting their ability to manage maintenance and repairs. The study underscores

the importance of community engagement, continuous technical support, and financial planning in the long-term success of renewable energy projects. By addressing these challenges, future initiatives can promote sustainable development and provide clean energy solutions in rural areas. The findings offer valuable insights for policymakers and stakeholders aiming to advance renewable energy projects, contributing to enhanced sustainability and community development.

Keywords: *Solar technology transfer, key changes, challenges*

Introduction

The absence of electricity hinders significant development in an area. Development refers to the process of improving the quality of life and economic well-being of people typically through efforts to increase economic growth, reduce poverty, and enhance social and cultural progress. It encompasses a range of activities, policies, and programs aimed at achieving sustainable improvements in health, education, infrastructure, and other key areas that contribute to overall human well-being (Todaro & Smith, 2015). To bridge this energy access gap, providing a sustainable and independent source of electricity through renewable energy is essential. This can be achieved by implementing extension activities, particularly the establishment of off-grid solar-powered electrical systems.

Solar-powered electrical systems are one of the numerous means of promoting renewable energy use vis-a-vis sustainable development in rural areas, addressing the growing demand for energy within the community. Studies on renewable energy highlight its potential to drive sustainable development in rural areas, improve living standards, and promote economic growth (Bhattacharyya, 2013; Timilsina et al., 2015). Specifically, the transformative impact of off-grid solar-powered electrical systems reveals significant benefits for economic development, environmental sustainability, and social well-being in remote and underserved regions.

Internationally, a study on Kibumba Island in Tanzania highlighted how solar-powered mini-grids supported local development by enabling small businesses to operate more efficiently and extending working hours beyond daylight (Werner et al., 2012). Shahsavari and Akbari (2018) emphasized the environmental sustainability impact of solar energy as the best solution to energy poverty. Solar energy can reduce GHG emissions and indoor air pollution by substituting kerosene for lighting and firewood for cooking. This claim is further supported by Feron (2016), who noted that access to electricity in remote areas improves living conditions by providing better lighting, enhancing educational opportunities, and enabling access to information through electronic devices. This can lead to improved literacy rates and better overall educational outcomes.

While solar-powered electrical systems offer substantial advantages for economic development, environmental sustainability, and social well-being, the study of Rai et al. (2020) emphasized that related studies often focus on general outcomes without delving into individual, household and community-level changes resulting from such interventions. Hong and Abe (2012) also revealed that the sustainability of renewable energy projects, such as solar rural electrification, is a concern due to technically and financially weak recipients and users of the projects.

The electrical energy access gap in the community of Sitio Kiito of Barangay Can-ayan, Malaybalay City, positions it as an excellent candidate for the implementation of the College of Technology of Bukidnon State University's extension project on solar-powered electrical systems. Sitio Kiito, a remote area in Barangay Can-ayan, represents a peaceful yet challenging lifestyle for its approximately 20 households with primarily depend on farming for survival. Their daily routine starts at dawn and ends at sunset, as Kiito lacks electricity due to its considerable distance from the barangay center. For years, Sitio Kiito has lacked basic electricity services that limits them to development opportunities. This living condition prompted the installation of the off-grid solar-powered electrical system project that commenced in 2016. It distributed solar-powered energy to selected households in Sitio Kiito, and concluded in 2022. The project implementors followed it up by conducting capability development activities such as electrical troubleshooting and maintenance.

In this context, the study aimed to comprehensively assess the impact of the solar technology transfer on Sitio Kiito by evaluating the key changes attributed to the project and the challenges encountered by residents in implementing and sustaining it. By focusing on specific outcomes of the project and identifying obstacles faced in maintaining the benefits of solar technology, this research sought to provide valuable insights for the design and execution of future renewable energy initiatives, thereby enhancing sustainability and community development.

Objectives

The study aimed to assess the impact of the solar-powered electrical system project on the community of Sitio Kiito, Barangay Can-ayan, Malaybalay City.

Specifically, the study aimed to:

1. Uncover the key changes within the community resulting from the transfer of solar technology, and
2. Identify the challenges encountered during the implementation and sustainability of the project.

Theoretical Framework

This study is anchored in the theory of change (ToC), a conceptual framework that elucidates how change occurs and the steps required to achieve desired outcomes. ToC is essential for understanding the pathways of change and identifying the necessary conditions for success in social interventions and programs. According to Weiss (1995), the theory of change involves "a systematic and cumulative study of the links between activities, outcomes, and contexts of the initiative." This framework enables a structured exploration of the interconnected pathways of change by outlining the sequence of inputs, activities, outputs, outcomes, and impacts.

ToC is particularly useful in this context as it provides a clear roadmap for understanding the complex dynamics of solar technology transfer and its impact on the Sitio Kiito community. It helps delineate the steps involved, from the initial installation of solar panels to long-term changes in community life, and ensures that the study captures the full scope of the project's influence.

A. *Inputs* represent the resources that form the foundation of the intervention. In this study, inputs include the installation of solar panels, technology transfer, funding, and community engagement initiatives. These inputs are essential for kickstarting the project and setting the stage for subsequent activities. The quality and availability of these inputs, as highlighted by Connell and Kubisch (1998), determine the project's potential success.

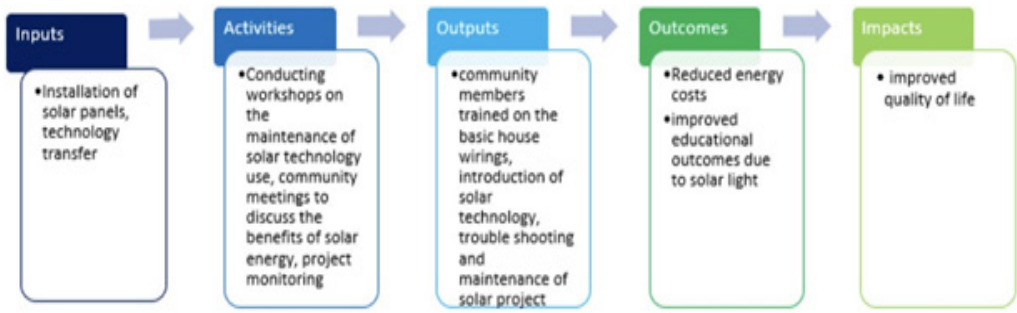
B. Activities describe the concrete actions taken to implement the intervention. In this case, they involved conducting workshops on solar technology maintenance, community meetings to discuss the benefits of solar energy, and ongoing project monitoring. These activities transformed the inputs into functional systems that can be utilized by the community. As Patton (2015) notes, activities are the processes that convert inputs into outputs, reflecting the project's ability to foster initial changes.

C. Outputs represent the immediate, measurable results of these activities. In this study, outputs included community members being trained on solar technology, troubleshooting, and basic wiring. Outputs also included the installation of solar technology in homes, leading to increased awareness and capacity for maintaining the system. As Hatry (1999) suggests, these outputs serve as tangible evidence of the project's implementation and initial success.

D. Outcomes reflect the medium-term effects that arise from the outputs. In this context, outcomes included reduced energy costs for households and improved educational outcomes due to better lighting from solar technology. Outcomes indicate deeper, more sustained changes in the community, marking the transition from immediate results to longer-term benefits (Kusek & Rist, 2004)

E. Impacts are the long-term changes brought about by the outcomes. These include improved quality of life, characterized by enhanced security, sustained energy savings, and broader community cohesion through the collective benefits of solar energy. Impacts also extend to environmental benefits, such as reduced carbon emissions, which contribute to sustainable development. Rossi et al. (2004) emphasize that impacts represent the broad, lasting changes that reflect the project's ultimate goals.

Figure 1
A Schematic Diagram Showing the Concepts Considered in the Study



Feedbacking on the Challenges Encountered on the Off-Grid Solar-Powered Electrical System

Figure 1 represents the ToC pathway, showing the flow from Inputs (installation of solar panels, technology transfer), through Activities (workshops, community meetings), to Outputs (trained community members, installed solar systems), followed by Outcomes (reduced energy costs, improved educational outcomes), and culminating in Impacts (improved quality of life). This flow demonstrates how each stage builds on the previous one to drive lasting change in the community.

Furthermore, feedback on the challenges encountered in sustaining the off-grid solar-powered electrical system is a crucial aspect of the study. Challenges such as maintenance issues or lack of technical knowledge will be examined through community stakeholder feedback. Understanding these challenges is vital for developing strategies that ensure the sustainability of the solar project in the long run.

By applying the ToC framework, this study systematically assessed how solar technology transfer contributed to community development, allowing for a comprehensive analysis of key changes at each stage and providing insights into the project's overall effectiveness and sustainability.

Methodology

Research Design

This study employed a qualitative research design, specifically an intrinsic case study approach, to comprehensively understand the impact of the solar technology transfer in Sitio Kiito, Barangay Can-ayan, Malaybalay City, Bukidnon. A case study approach was ideal for this investigation as it provided an in-depth, multi-faceted understanding of complex issues within real-life contexts (Crowe et al., 2011). An intrinsic case study was appropriate because the focus was on the specific project of solar technology transfer, which held a unique interest due to its context and implementation. This approach allowed for a detailed exploration of how the project affected various aspects of the community's daily lives.

While the case study method was appropriate for this research, certain limitations must be acknowledged. The primary limitation lies in the generalizability of the findings, as the study focused on a single community. Additionally, the purposive sampling of 10 out of 27 households, while effective for gathering targeted insights, may not fully capture the diversity of experiences within the entire community. Future research would benefit from increasing the sample size to encompass a broader range of experiences and insights. Furthermore, this study specifically examined the unique circumstances and outcomes of implementing the solar technology transfer in Sitio Kiito, focusing on how it influenced residents' daily lives. The emphasis was placed on understanding the real-life context in which these changes occurred and the interconnected nature of their impacts, providing valuable insights into the project's effects within this specific setting.

Sample and Data Collection

In this study, participants were purposively selected based on specific criteria to ensure a diverse representation of the community and project implementers. The study involved two distinct types of respondents. The first group consisted of project implementers, including the project leader and extensionists. The inclusion criteria for this group were: a) active involvement in the project from 2016 to 2022, b) current employment as regular faculty at the College of Technologies, and c) willingness to participate in the study. These respondents were purposively selected to provide comprehensive insights into the project implementation process. This group was also involved to determine the activities conducted and included document analysis of reports submitted by the project implementers.

The second group comprised stakeholders, categorized as either direct or indirect beneficiaries. Direct beneficiaries are residents who have directly received benefits from the project, while indirect beneficiaries include barangay officials, residents who have not received solar panels or lights, and similar stakeholders. The inclusion criteria for this group included: a) residency in Sitio Kiito, Barangay Can-ayan from 2015 to the present, b) equal representation across genders, c) having received direct or indirect benefits from the project, and d) willingness to participate in the study. This group served to validate the reports of the implementers and determine the impact of the project on the community.

Purposive sampling allowed the researchers to deliberately choose participants due to the qualities they possess, ensuring the collection of rich, relevant data. This non-random technique enabled the researchers to set specific criteria to select participants who are knowledgeable and experienced with the solar technology transfer project (Bernard, 2002). The number of participants was determined using the principle of data saturation, which occurs when no new information or themes are observed in the data (Urquhart, 2013).

To gather rich, qualitative data, the study utilized in-depth interviews with participants directly involved with or affected by the solar technology transfer project. These interviews provided a comprehensive understanding of the changes brought about by the project, covering various dimensions of the residents' lives. The interviews were guided by outcome mapping questions from Wilson-Grau et al. (2012), which are designed to identify and understand key changes, effects, and the significance of these changes in the lives of the project recipients. Sample questions included: "What are the key changes attributed to the transfer of solar technology in Sitio Kiito, Barangay Can-ayan?" This question aimed to identify the actors involved, the time and place of occurrence, and the specific changes observed. Another key question was, "What are the challenges encountered in sustaining the Off-grid Solar-Powered Electrical System Project?" This question sought to explore the implications of these changes on the community's development objectives and overall quality of life.

The case study method was utilized to delve deeply into the project's impact within the real-life context of Sitio Kiito. Proper protocol in gathering data was observed, with the researchers securing a list of potential participants from local community leaders and obtaining their contact details. Participants were contacted via phone or in person, and their contact details were kept secure and confidential.

Before conducting the study, the interview guide, which utilized standardized questions from the outcomes harvesting guide, was evaluated by a qualitative research expert, and specific feedback was incorporated into the revised interview protocol. Pre-recorded interviews and reports were also reviewed to gain a better understanding of the project's impact. Subsequently, participants were interviewed to validate the initial assessment. They first received an orientation on the study's purpose and methodology, and informed consent was obtained. Interviews were scheduled at convenient times to ensure maximum participation. The researchers conducted the interviews in local dialects to facilitate full and accurate expression. With participants' consent, interviews were audio-recorded for precise data capture and transcribed verbatim for thorough analysis.

Research Locale

The study focused on Sitio Kiito in Barangay Can-ayan, located in the western part of Malaybalay. Barangay Can-ayan is approximately 7 kilometers from the urban center of Malaybalay. The barangay comprises five (5) puroks and eight (8) sitios, covering a total land area of 13,090 hectares. Of this, 10,189 hectares are classified as forest land, while the remaining 2,228.24 hectares are classified as alienable and disposable.

Sitio Kiito is one of the remotest sitios in Barangay Can-ayan. The community consists of 20 households with a population of approximately 150 people, most of whom depend on farming for their livelihood. Their daily routines begin at sunrise and continue until sunset. Kiito is one of the few sitios within Can-ayan that lacks access to electricity, primarily due to its considerable distance from the center of the barangay.

The absence of electricity in Sitio Kiito is a significant challenge for its residents. The Barangay Local Government Unit has highlighted the need for electricity in their Barangay Development Plan. While the community longs for a stable electricity supply, the implementation of solar energy solutions has been identified as one of the best options due to the logistical difficulties of extending the main power grid to this remote area. As the lone sitio without electricity, the residents of Kiito have been actively requesting assistance from the local government to address this issue and provide sustainable electricity solutions.

Data Analysis

An inductive content analysis was conducted with the research team to ensure rigor and reliability. Audio data were meticulously transcribed and supplemented with detailed field notes to create a comprehensive dataset. Transcripts were independently reviewed by three researchers to identify and correct any errors and ensure the accuracy of participants' statements. Participants were also engaged in validating the transcripts, thus enhancing data credibility.

Utilizing Lodico et al. (2010) "bottom-up" inductive approach, the analysis followed a specific-to-general pattern to derive meaning from the collected data. This systematic method involved organizing the data and extracting significant statements that encapsulated core meanings. These statements were meticulously categorized and developed into broader themes.

The themes were progressively refined and condensed into codes, providing a structured and detailed breakdown of the researched case. This iterative coding process ensured the analysis remained grounded in the data, capturing the nuanced impact of the solar technology transfer.

The final results were presented through a comprehensive narrative, supported by tables, and discussion materials, offering a holistic view of the findings. This inductive approach facilitated a deep understanding of the solar technology transfer's impact, ensuring the analysis was contextually rich and reflective of the participants' lived experiences.

Data Validity

Data validity was ensured through several rigorous methods as outlined in Patton (2002) and Shenton (2004). First, participants were involved in member checking to verify the accuracy of their statements in the transcripts and field notes. Second, the entire data collection process was meticulously documented, with audio recordings and field notes preserved as evidence. Third, the transcript data, field notes, and analysis results were reviewed and discussed with an expert in qualitative research to ensure methodological soundness. Finally, the research findings were validated by cross-referencing participant feedback and comparing them with reports submitted by the extension project, thereby enhancing the credibility and reliability of the study.

Ethical Considerations

This study adhered to stringent ethical guidelines as set forth by the University Research Ethics Committee, ensuring the protection of participants' rights and well-being throughout the research process. Informed consent was obtained from all participants after they were thoroughly briefed on the study's purpose, procedures, potential benefits, and risks. For participants unable to read, oral consent was secured in the presence of an impartial witness. Confidentiality and anonymity were strictly maintained through the use of pseudonyms and secure handling of sensitive information, ensuring that participants' identities were protected in all public reports and data presentations.

Inclusivity and fairness were central to the research design, with careful attention given to gender balance and the equitable representation of all demographic groups, including marginalized and vulnerable populations. The consent process was adapted to reflect the socio-cultural dynamics of the rural community, respecting local norms and addressing potential barriers to participation. This approach helped to foster trust and ensure that the study was accessible to all segments of the community.

Risks to participants were minimized by proactively identifying potential emotional or social issues, and appropriate support resources were made available as needed. Participation was entirely voluntary, and participants were informed of their right to withdraw at any time without consequence. Where possible, the study aimed to provide direct benefits to participants by offering findings that could positively contribute to their community's development.

Transparency was maintained throughout the research, with findings shared with participants in an accessible format as a form of feedback and appreciation for their involvement. All research activities were conducted in compliance with local, national, and international ethical standards, and the study was reviewed and approved by an institutional review board where necessary, ensuring the integrity and ethical rigor of the research.

Results and Discussion

Key Changes from Solar Technology Transfer

The Solar Powered Electrical System project at Sitio Kiito in Barangay Can-ayan, Malaybalay City, has brought about a profound transformation within the community. Since its installation, the project has directly benefited 10 out of 27 households, impacting nearly 100 residents. This study has captured the ripple effects of this technology transfer through the lens of the Theory of Change, highlighting the narratives of key informants who experienced these changes firsthand.

The central theme emerging from the key informants' voices is that the solar power has sparked and illuminated a community-wide transformation. This theme is further unpacked into detailed sub- themes, each drawn meticulously from the informants' verbatim statements, providing a vivid portrayal of the changes observed by extensionists and experienced by the residents.

Solar Spark: Igniting Community Transformation

The Solar Powered Electrical System project in Sitio Kiito has sparked a transformative journey for the community, fulfilling their long-held dream of accessing electricity. Informants vividly articulated the project's significant impact on various aspects of their lives, initiating substantial positive changes in education, communication, security, economic activities, and social interactions. One informant expressed,

> *"Dako kaau ug tabang ang Solar sa among Lugar, Dugay na namo gihangyo nga unta naa mi suga"* (The solar project is a great help to our place; we have long asked to have electricity) - Informant 7.

> Another shared, *"Grabe amo kalipay nga nihayag na among lugar, daghan kaau mahimo kung naay suga"* (We are extremely happy that our place is now illuminated; there is so much we can do with electricity) - Informant 6.

These statements underscore the multifaceted benefits of solar technology reflected into sub- themes, illustrating the profound and far-reaching effects on the community's overall well-being and quality of life. The voices of the informants reveal a clear narrative of transformation, with solar power not just illuminating their homes but also expanding their opportunities and aspirations.

Sub-themes 1: Bright Minds: Illuminating Education and Empowerment

The transformation from darkness to light has significantly shifted Sitio Kiito's future generation, enhancing educational opportunities and empowering students. The installation of solar lighting has enabled students to extend their study hours into the night, markedly improving their academic potential. A study conducted by Valdez and Cuadra (2022) observed that the Solar Power project encouraged learning after dark. This observation is verified by an informant who shared,

> *"...usahay kanang mag study mi ngitngit kayo kay maggamit lang mi lampara. Karon na naa na ang solar, dako kaayo syag tabang sa amoa mga kabatan-unan kay makastudy nami kay hayag na man jud sya. Palongon ra dayon ang solar mga 8pm or 9pm sa gabie"* (Sometimes, when we studied, it was very dark because we only used lamps. Now that we have solar power, it greatly helps us youth because we can study since it's really bright. We just turn off the solar lights at around 8pm or 9pm) -Informant 8.

> Another informant emphasized, *"Wala man mi documento pero kami ngpamatuod nga nakahuman ang among mga bata tungod sa Solar. Dali ra sa mga bata magkahuman sa ila assignment ug nakatabang nga makahuman sila ug skwela"* (We do not have documents, but we can attest that our children graduated because of solar power. It made it easier for the children to complete their assignments and helped them finish their schooling) -Informant 6.

These testimonials highlight the transformative impact of solar lighting on education. The ability to study longer into the night has empowered the youth, fostering a brighter future through improved academic performance. The critical role of lighting in education is well-documented. Sovacool and Drupady (2012) assert that rural electrification directly impacts educational outcomes by providing students with the necessary environment to excel academically. This is supported by Khandker, Barnes, and Samad (2012), who found that access to reliable lighting increases study hours, resulting in better school performance and higher academic achievement.

Moreover, the impact of solar lighting extends beyond academic performance, influencing the overall learning environment. Bensch, Kluve, and Peters (2011) found that students in rural areas with access to electricity showed significant improvements in literacy and numeracy skills compared to their peers without such access. The availability of light in the evening allows students to complete homework, engage in reading, and prepare for exams, contributing to a more holistic educational experience.

The experiences of Sitio Kiito's residents underscore the transformative power of solar technology in education. As the informants succinctly noted, the ability to study longer hours at night has been a game-changer for the youth, setting them on a path to academic success and personal growth. This aligns with global findings that highlight the importance of access to electricity in improving educational outcomes and fostering sustainable development in rural communities.

Sub-theme 2: Radiant Connections: Empowering Communication and Social Interaction

The introduction of solar power in Sitio Kiito has significantly empowered residents' communication and social interactions, as reflected in their statements.

> *"Tungod sa Solar makatapok ang mga residente ug gabii"* (Because of the solar power,
> we can gather at night) - Informant 4.

> *"Pinaagi sa Solar magtapok mi while gahulat sa among gicharge nga radio ug cellphone"* (Through the solar power, we gather while waiting for our radios and cell phones to charge) - Informant 7.

The installation of solar power has facilitated community gatherings in the evenings, fostering stronger social bonds and enhancing communication among residents. This change has revived a sense of community that was previously hampered by the lack of electricity. The ability to charge electronic devices such as radios and cellphones has further strengthened connections, enabling residents to stay informed and maintain contact with the outside world.

Existing literature supports these observations. According to Samad et al. (2013), access to electricity in rural areas significantly enhances social interactions and community cohesion. Electrification allows for extended social activities, which strengthens communal ties and improves overall quality of life. Similarly, a study by Winther et al. (2017) found that rural electrification projects lead to increased social capital, as communities with access to electricity can organize more social events and maintain better communication networks. Moreover, the ability to charge mobile phones has critical implications for connectivity and communication. As noted by Blumenstock, Eagle, and Fafchamps (2016), mobile phone access in rural areas improves communication, facilitates information dissemination, and supports social networks. This is particularly important in remote communities like Sitio Kiito, where traditional communication infrastructure is often lacking.

The experiences of Sitio Kiito residents illustrate the transformative power of solar technology in enhancing communication and social interaction. The statements from informants highlight how solar power has brought about a vibrant community life, breaking the isolation that once characterized their evenings. This aligns with broader findings on the social benefits of rural electrification, demonstrating that access to electricity not only improves individual well-being but also fosters stronger, more connected communities.

Sub-theme 3: Shining Security: Enhancing Safety and Well-being

A newfound sense of safety has transformed nightly routines and alleviated longstanding anxieties about darkness. One extensionist noted,

> *"Sa akong pag-interview sa mga residente, nafeel gyud sa mga tawo nga safe ang palibot katong naa na ang Solar"* (In my interviews with residents, they really felt that the surroundings were safer once the solar lights were installed)- Informant 2.

Another informant added, *"Dili lang pud pag-ubos sa kawat ang naaddress sa Solar, kundi ang seguridad sa mga bata. Sa una daghan gakadisgrasya—madagma, mapandol tungod sa kangitngit. Nigamay ang kaso sa disgrasya after matransfer ang Solar"* (Solar not only reduced theft but also enhanced children's safety. Before, many accidents happened—people tripping and falling in the dark. The number of accidents decreased after the solar lights were installed) - Informant 3.

Residents echoed these sentiments, highlighting the practical benefits of the solar lights. One resident stated, *"...dako na jud ug tabang karon na niabot na ang Solar. Ang mga CVO, mga kagawad maayo na ilang pagbantay-bantay kay naa man suga"* (The solar lights are a big help. Now, the community watchmen can patrol more effectively because there is light) (Informant 8).

Another mentioned, *"Sa una daghan mi kawat murag muabot ug 20 ka kaso pagabii kay walay makita. Pag-naa na ang solar ni-ubos amo kawat nga kaso to 2 na lang"* (Before, we had around 20 theft cases per night because it was too dark to see anything. Since the solar lights were installed, theft cases have dropped to just two) - Informant 7.

"Kampanti gyud mi nga naay suga, makatulog ka ug imo gyud mabati nga safe ka." (We are really confident now that there is light; you can sleep and truly feel safe)- Informant 6

The presence of reliable illumination throughout the night has not only deterred potential threats but also provided residents with peace of mind. The brightening of previously dark and potentially perilous areas has reduced fears and allowed for safer evening activities. The impact of solar lighting extends beyond mere visibility; it transforms the daily life and habits of the community. Parents feel more comfortable allowing their children to play outside later in the evening, and communal areas are now safe gathering spots after sunset. The ability to move freely without fear has improved overall community morale and well-being.

This enhancement in security aligns with findings by Kirubi et al. (2009), which indicate that improved lighting from solar projects can significantly enhance safety in rural areas. Their study demonstrated that solar-powered illumination not only deters crime but also promotes a sense of security, contributing to the overall mental health and quality of life in rural communities. The radiant glow of solar lights has resonated deeply within Sitio Kiito, instilling a newfound confidence among its residents. This shift is not just about physical safety but also about the psychological comfort that comes with knowing one's environment is secure. Informants' observations reflect a broader sentiment shared across the community, where the enhanced lighting has become a symbol of reassurance—a shining security blanket for its residents.

Sub-theme: Economic Radiance: Boosting Productivity and Income

The introduction of solar technology in Sitio Kiito has not only illuminated homes but also significantly boosted the local economy. A study by Valdez and Cuadra (2022) highlighted how

solar power has supported small-scale businesses such as the production of duyan (hammocks). This observation is echoed by extensionists who noted,

> *"Dako ug tabang sa Solar kay nakita namo nga makahimo na sila ug duyan taman alas 9pm, ug mabaligya dayon nila pagkaugma"* (Solar power is a great help because we see that they can now make hammocks until 9 pm, and they can sell them the next day) -Informant 3.

Another extensionist mentioned, *"In our interview, residents confirmed nga maka-overtime sila ug himo ug duyan ug makaincrease sa ila income"* (In our interview, residents confirmed that they can now work overtime making hammocks, which increases their income) - Informant 5.

Residents also shared their experiences, verifying the economic impact of solar lighting. One informant said, *"Tungod sa Solar makatapok mi ug matabangan ug himo ug duyan, usahay dili na namo mabantayan nga ngitngit na"* (Because of the solar lights, we can gather and help each other make hammocks, sometimes we don't even notice that it's already dark) - Informant 6.

Another resident observed, *"Sa una amo income sa paghimo ug duyan muabot ra ug 1,000 pesos kay isa ra amo mahimo, katong naa na ang solar, makahuman mi ug duha ka duyan, dako na amo kita"* (Before, our income from making hammocks was only around 1,000 pesos because we could only make one. Since the solar lights were installed, we can finish two hammocks, and our earnings have increased) -Informant 7.

Beyond increasing income, solar panels have also decreased household expenses. As Informant 4 shared, *"Sa una wala pa ang solar mugasto mi ug Php 300.00 para sa kerosene, karon nga naa na ang solar tunga ang nawala nga expenses"* (Before we had solar power, we spent Php 300.00 on kerosene. Now that we have solar power, those expenses have been cut in half).

The availability of reliable solar lighting has extended working hours for local artisans and business owners, leading to increased productivity and income. This economic boost has positively impacted the community, demonstrating the powerful economic benefits of solar technology. This observation is consistent with findings from the International Renewable Energy Agency (IRENA, 2016), which reports that solar power can enhance economic activities by providing reliable energy.

In terms of the empowerment through enhancing Knowledge and Skills, the extension project not only has physical benefits but also a significant boost to the residents' knowledge and skills, particularly in maintaining and utilizing solar technology for household use. As shared by

> Informant 7, *"... wla naapil amo balay nga natagaan ug solar, pero nakaapil mi sa training nga nakahatag ug kaalam ug kahibalo ug unsaon pag-atiman sa mga solar panel apil unsaon mgtan-aw sa mga problema. Tungod sa solar panel ngpalit mi ug amoa para sa amo balay"* (We are not a recipient of the solar panels but we

participated in trainings on how to maintain the solar panels and troubleshoot issues enhancing our knowledge and skills. Because of this, we bought our own solar panels for our house).

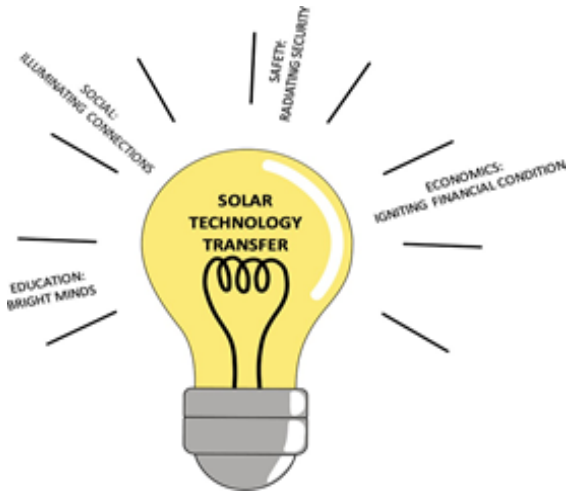
This statement highlights the dual impact of the solar technology transfer: providing immediate energy solutions and fostering a sense of ownership and capability among the residents. The training provided has led to a deeper understanding of solar technology, reducing dependency on external assistance for maintenance and repairs. Moreover, the skill development associated with solar technology maintenance has broader implications for community development. It fosters a culture of continuous learning and adaptation, equipping residents with the tools needed to handle future technological advancements. This empowerment through knowledge aligns with findings from other studies that emphasize the importance of skill-building in the successful implementation of renewable energy projects (Bhattacharyya, 2013; Sovacool & Drupady, 2012).

Solar Spark

The Solar Powered Electrical System project has emerged as a transformative force in the lives of the residents and the broader community of Sitio Kiito. Over three years of benefiting from the project, the spark of change has illuminated various aspects of the residents' lives, particularly in education, social connections, safety, and economics. These facets are vividly represented as rays of light emanating from the installation of solar panels, symbolizing the multifaceted impact of the project.

Figure 2 illustrates how informants view the extension project in terms of its significance in improving their quality of life. Much like a bulb emitting light, the project has had widespread and profound effects on their way of living. The qualitative data collected through interviews and focus groups reveal a consistent narrative of transformation across multiple dimensions of life in Sitio Kiito.

Figure 2
Solar Spark Key Changes



The solar technology transfer project in Sitio Kiito stands as a testament to the power of renewable energy in driving positive change. The qualitative insights from community members provide a rich narrative of transformation, illustrating how such projects can illuminate the path toward a brighter and more sustainable future. This case study exemplifies how targeted interventions, supported by active community involvement, can achieve substantial and lasting improvements in quality of life. Through their testimonies, community members vividly describe the far-reaching impacts of the project, highlighting the importance of sustainable energy solutions in fostering development and enhancing well-being.

Challenges Encountered to Sustain the Off-grid Solar-Powered Electrical System Project

Sustaining the off-grid solar-powered electrical system project in Sitio Kitio, Barangay Can- ayan, has presented several challenges, reflecting common issues faced in renewable energy projects in rural areas. This section discusses the key challenges encountered on technical difficulties and financial constraints.

Technical Challenges

One of the primary challenges has been maintaining the technical infrastructure. Despite the initial training provided by the Bukidnon State University's Electronics Technology Department, residents occasionally struggle with more complex repairs and maintenance tasks. As Sovacool et al. (2015) highlight, local capacity-building is essential, but ongoing technical support is often necessary to address issues that arise beyond the community's expertise. Periodic failures of solar panels, inverters, or batteries can disrupt the energy supply and diminish the community's confidence in the system. Therefore, establishing a reliable mechanism for technical support and spare parts supply remains crucial.

Financial Constraints

Financial sustainability poses another significant challenge. While the initial installation was funded by Bukidnon State University, long-term financial planning for maintenance, repairs, and eventual replacements is necessary. The community's limited financial resources mean that unexpected costs can severely impact their ability to sustain the project. As noted by Pachauri et al. (2012), financial mechanisms such as micro-financing, subsidies, or community savings programs are vital to support the ongoing costs associated with renewable energy systems. However, the lack of access to such financial instruments in Sitio Kitio has made it challenging to ensure the project's longevity.

Lessons Learned, Opportunities and Recommendations

The implementation of the solar technology transfer project in Sitio Kiito offers valuable lessons and actionable insights that are critical for ensuring the sustainability and scalability of similar initiatives, particularly in rural or low-income communities.

1. Community Engagement and Capacity Building. A key lesson from the project is the essential

role of community engagement and capacity building in ensuring the long-term success of renewable energy systems. Training residents in the maintenance and troubleshooting of the solar systems empowered them to take ownership and manage the technology independently. This local empowerment, fostered through targeted capacity-building programs, builds a sense of responsibility and ownership that helps to sustain the project long after its initial implementation. However, the project also highlighted the importance of ongoing technical support and the availability of spare parts, as residents occasionally struggled with more complex maintenance tasks. To ensure continued sustainability, local governments must allocate resources from the barangay to the provincial level to provide regular technical assistance and ensure access to necessary parts.

Recommendation: Communities in similar contexts should prioritize the establishment of ongoing technical support systems, either through partnerships with local technical schools or through government support. Additionally, regular refresher training should be organized to update community members on new maintenance techniques or potential issues that may arise. Partnering with local suppliers to ensure an affordable and steady supply of replacement parts is also crucial.

2. Financial Planning and Sustainability. Another critical insight from the project is the importance of sound financial planning in maintaining renewable energy systems. While the initial funding covered the installation costs, the community's limited financial capacity posed challenges in covering the ongoing costs of maintenance and repair. Without a clear financial plan, communities may struggle to maintain such systems over time, leading to a decline in their functionality. To address these challenges, financial mechanisms such as micro-financing, subsidies, or community-led savings programs can provide essential support for the long-term upkeep of solar systems.

Recommendation: Develop community-driven financial models to support maintenance and repairs. For instance, community savings groups can pool resources for common maintenance needs, while micro-financing options could help individual households cover repair costs. Local governments could explore subsidies or grants specifically aimed at supporting the upkeep of renewable energy systems in rural areas. Engaging external partners, such as NGOs or private sector companies, to offer financial solutions or provide grants could also be an effective strategy for ensuring financial sustainability.

3. Strengthening Technical and Financial Sustainability. To ensure long-term success, future initiatives should focus on creating integrated solutions that address both technical and financial sustainability. This includes establishing local technical support networks and developing financial mechanisms that alleviate the burden of ongoing maintenance costs. Furthermore, future research and monitoring efforts should adopt a longitudinal approach, tracking the evolution of the project's benefits and challenges over time. This approach will provide more robust insights into how renewable energy systems can be made sustainable in the long run and how they continue to benefit communities as they evolve.

Recommendation: Communities and stakeholders should focus on building partnerships with local and international organizations to provide both technical support and financial assistance. For instance, partnerships with renewable energy companies can help in offering maintenance

services at subsidized rates, while collaborations with financial institutions can create accessible micro-financing models for rural communities. Future projects should also include provisions for continuous monitoring and evaluation, ensuring that both successes and challenges are documented and addressed in a timely manner.

The project in Sitio Kiito highlights the importance of comprehensive planning that integrates community engagement, technical capacity building, and financial planning. By addressing these elements, renewable energy projects in resource-limited communities can become more sustainable, ensuring long-term benefits for the community.

Conclusion

The solar technology transfer project has transformed the community of Sitio Kiito, bringing significant benefits to individuals, households, and the community as a whole. Key improvements include enhanced educational opportunities, economic growth, and improved living conditions. Additionally, residents have gained valuable technical skills, fostering self-reliance and ownership of their energy resources. The project has also increased social interactions and community cohesion due to reliable lighting. However, sustaining the project presents challenges, such as technical issues and financial constraints. Addressing these challenges requires ongoing technical support, community-based financing, and inclusive decision-making. This study provides valuable insights for policymakers and stakeholders aiming to advance renewable energy projects, highlighting the importance of sustainable solutions and community involvement in achieving lasting improvements in quality of life.

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