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Evaluating solar waste management practices in rural communities of Western Uganda Kakanju Sub- County

Ounyesiga Living[1], Stephen Ndubuisi Nnamchi[2], Mustafa M. Mundu[3], Afam Uzorka[4], Musa Bawa M. Bawa[5], Omuna Daniel[6]

[1] *Department of Physical Sciences, SONAS, Kampala International University, P.O. Box 20000, Kampala, Uganda, living.ounyesiga@kiu.ac.ug, ORCID: https://orcid.org/0000-0003-1444-510X*
[2] *Department of Mechanical Engineering, SEAS, Kampala International University, P.O. Box 20000, Kampala, Uganda, stephennnamchi@kiu.ac.ug, ORCID: https://orcid.org/0000-0002-6368-2913*
[3] *Department of Electrical, Telecom and Computer Engineering, SEAS, Kampala International University, P.O. Box 20000, Kampala, Uganda, mundu.mustafah@kiu.ac.ug, ORCID: https://orcid.org/0000-0003-1345-9999*
[4] *Department of Physical Sciences, SONAS, Kampala International University, P.O. Box 20000, Kampala, Uganda, afamuzorka@kiu.ac.ug, ORCID: https://orcid.org/0000-0003-4653-1619*
[5] *Department of Physical Sciences, SONAS, Kampala International University, P.O. Box 20000, Kampala, Uganda, musabawa@kiu.ac.ug, ORCID: https://orcid.org/0000-0002-0360-4526*
[6] *Department of Biological and Sciences, SONAS, Kampala International University, P.O. Box 20000, Kampala, Uganda, daniel.omuna@kiu.ac.ug, ORCID: https://orcid.org/0000-0003-2084-3606*

Corresponding Author: Ounyesiga. Living, living.ounyesiga@kiu.ac.ug

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Abstract

Despite the potential for clean energy access, the quick adoption of solar energy in rural areas has resulted in a rising problem with solar photovoltaic (PV) waste management that is not well addressed. A location where solar technologies are increasingly being used for small businesses, irrigation, and home illumination, Kakanju Sub- County, Bushenyi District, Western Uganda, is the site of this study's evaluation of solar waste management techniques. Data were gathered from 80 solar-using houses in five parishes using proportionate stratified random sampling. The questionnaires covered demographics, awareness, handling, and disposal of solar waste. The findings indicate that although while 88.8% of respondents are aware of solar waste, unsafe disposal methods such as burning and outdoor storage continue because of a lack of official recycling facilities, poor infrastructure, and a lack of technical expertise. The most often broken parts are batteries and panels, although just 3.8% of users take advantage of recycling services. Even though 93.8% of people tried recycling, 86.3% were unhappy with the way things are now disposed of. There is environmental consciousness, but actual effects are still mostly invisible. The absence of collection facilities, technical know-how, and well-defined rules are major obstacles. The necessity of policy enforcement, education, and incentive take-back programs is emphasized in community-driven suggestions. The results highlight how urgently integrated, locally tailored methods are needed in Uganda's expanding off-grid solar industry to guarantee safe, sustainable solar waste disposal and avoid future health and environmental hazards.

Nomenclature

N_a	Households in parish
N	Total households
n	Total sample size
n_a	Sample size per parish

1.0 Introduction

Concerns over solar waste have grown as a result of the increased use of solar energy worldwide, particularly in rural regions with inadequate disposal facilities. The increasing use of solar systems in Western Uganda's Kakanju Sub-County is now accompanied with difficulties in handling end-of-life components. For safer, more sustainable solar waste management, this study looks at local trash practices, finds gaps, and investigates community-driven solutions.

Globally**,** Bajagain et al., 2020 explored the growing use of hazardous metals in solar photovoltaics, its environmental risks, waste management, recovery efforts, and regulations, including leaching tests and waste classification in different countries. Piedrahita et al., 2025 examined the design and construction of a solar-powered garbage collector for environmentally friendly waste disposal in rural areas, evaluating current waste management techniques and case studies. Vinti & Vaccari, 2022 explored solid waste management in rural LMICs, highlighting common practices, sustainable solutions, and potential benefits such as improved social, environmental, health conditions, and reduced climate change impact. Zaman, 2023 explored rural solid waste management in Bangladesh, finding 41.9% of respondents participate, mainly in pits or lowlands. It recommends local governments coordinate policies with citizens for improved practices.

Shi et al., 2024 highlighted the importance of resilience, scalability, and innovation in rural energy communities, highlighting the need for policy support and community involvement for sustainable growth. Nagawa, 2022 discussed waste-to-energy techniques in Uganda, recommending UK policies and a Public-Private Partnership for low-income countries, highlighting areas for further study due to rising global waste generation. Shapna & Hossain, 2025 highlighted solar home systems as a viable alternative to fossil fuel-dependent grids in Bangladesh, providing basic lighting and enhancing social safety. However, adverse weather conditions affect performance, necessitating strategies for improvement. Akinyele employed the Criteria Importance through Inter-criteria Correlation (CRITIC) - Preference Ranking Organization METHODOLOGY (PROMETHEE) approach to evaluate the sustainability of solar PV microgrids in rural Nigeria. Al Zaabi & Ghosh, 2024 used a quantitative modelling framework to predict future PV waste generation in key markets, emphasizing the need for alternative EoL management options like repair, reuse, and recycling to prevent resource loss and environmental contamination. Ghosh et al., 2023 analyzed the potential of a waste management system for three solar power plants in Bangladesh, focusing on recycled materials post-plant end-of-life. The results reveal recoverable copper, aluminum, silicon, plastic, and glass from the proposed plants, suggesting that a successful waste management system can maximize solar power benefits while minimizing environmental harm.

Sharma et al., 2024 compared landfilling of end-of-life crystalline silicon panels with recycling, revealing that recycling can reduce environmental impacts by up to 70%. The study also shows lower carbon footprint values for recycling compared to landfilling, emphasizing the importance of sustainable panel management. The "Solar-Powered Solid Waste Management System Using IoT" addresses the growing issue of overflowed bins in urban areas. The system uses solar energy to segregate waste into wet, dry, and metallic categories, monitors dustbins, and updates real-time data for administrators via an Android application (Ansah et al., 2022).

Andrei et al., 2020 examines a grid-tied photovoltaic power plant for waste sorting, focusing on technical and environmental factors. The system, simulated using PVsyst software, achieves an 85% performance ratio, reducing carbon emissions by 858.7 tons over 30 years. In Africa**,** Nsefu & PalangwaMutale, 2021 examined the negative effects of solar PV energy on waste management, highlighting moderate adoption influenced by political environment, economic situation, technological advancement, and climate change, and proposing a Strategic Framework. Sub-Saharan Africa's electricity access rate is 42%, with household-scale off-grid solar (OGS) products being a key tool. However, the growing waste poses environmental risks due to decentralized market, short product lifetimes, affordability constraints, lack of local technical expertise, and poor usage habits (Kinally et al., 2022).

Madonsela et al., 2024 assessed indigenous waste management practices in rural South Africa using the Analytic Hierarchy Process, revealing environmental sustainability as the top priority, composting as the most important sub-criteria, and waste trading as economically effective. Teshome et al., 2022 found that plastics are the dominant type of solid waste in Kebridehar city, with age and distance from the town center having significant effects. The majority (76.2%) are unaware of environmental and health impacts. Kinally et al., 2024 evaluated the life cycle of solar home systems in Malawi, focusing on lead pollution from informal lead-acid battery recycling. Low efficiency restricts electricity delivery, and formal recycling solutions impose significant burdens. Kenya, like many Global South countries, has a strong general waste policy but lacks specific regulations for off-grid solar electronic waste management.

Awareness of hazardous components is lacking, and infrastructure is inadequate. Enforcement challenges and corruption culture hinder the development of effective policies for sustainable off-grid solar e-waste management, despite the increasing use of off-grid solar systems (Mugendi et al., 2024).

Solar Photovoltaics (PV) is a promising energy solution, but its short lifespan poses a hazardous waste problem. By 2050, 1.8 million tonnes of PV waste are expected, highlighting the need for sustainable waste management strategies and technological advancements (Ndalloka et al., 2024). In Uganda, Kizza et al., 2024 investigated the use of solar and wind energy in Uganda's Bushenyi District, highlighting its potential socioeconomic benefits and potential for economic development. This study demonstrates an extreme absence of infrastructure for managing solar waste, public knowledge, and policy enforcement, despite the rapid growth of Kakanju Sub-county's solar energy utilization. Formal recycling or disposal facilities are still hard to find, and hazardous practices like burning and burying continue because there are no other options, despite growing awareness of solar components and environmental concerns.

Furthermore, most consumers are unaware of how improper waste management might affect their long-term health and the environment. This project aims to identify knowledge and infrastructure gaps, evaluate the current state of solar waste management in rural Western Uganda, and offer sustainable, community-driven approaches to treating solar components that have outlived their useful lives.

1.1 The life and recycling process of Solar PV system components

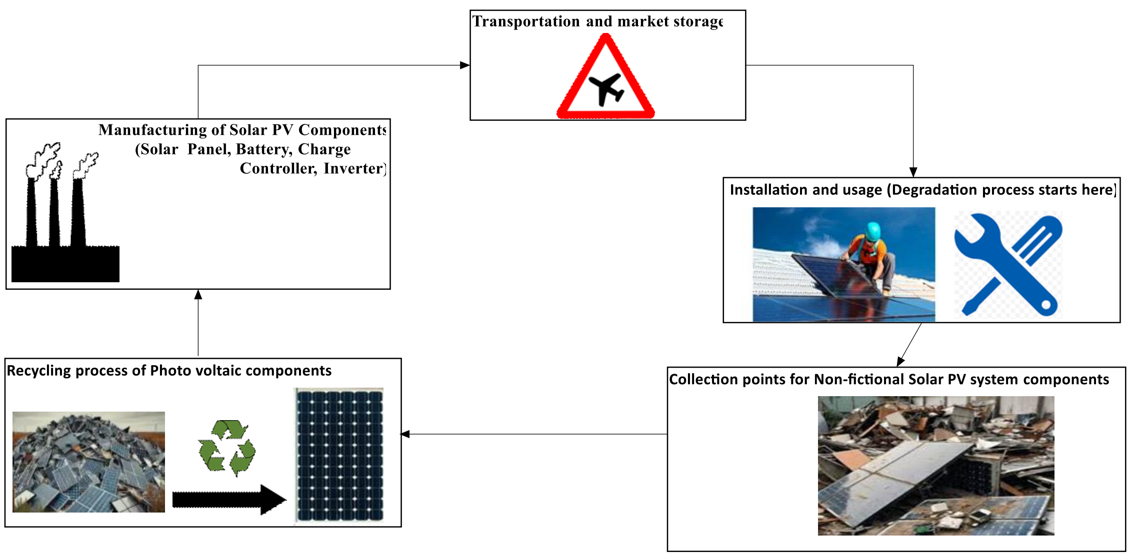

Figure 1. life and recycling process of Solar PV system components

Source: Present study 2025

Figure 1 demonstrates the proposed full lifecycle of solar PV components from manufacturing, transportation, installation and degradation, to collection of faulty parts and their eventual recycling as explain in subsections below.

1.1.1 Manufacturing of Solar PV Components

During this phase, a number of essential solar PV system components are produced, such as inverters, charge controllers, batteries, and solar panels. Raw materials like silicon, metals, glass, and polymers are used to make these parts. Energy-intensive, precision engineering is needed to ensure durability and efficiency in the production process (Saad, 2024, Al Mahdi et al., 2024). The performance and longevity of the overall solar system are greatly influenced by the caliber of the components made at this point.

1.1.2 Market and storage of solar PV system components

Following the production phase, solar PV parts like inverters, charge controllers, batteries, and solar panels are sold in the market. This covers both official and informal channels, such as hardware stores, retail establishments, solar energy firms, and internet platforms. Customer's individuals, organizations, and businesses can choose from a variety of brands and models in the market according to factors including cost, energy requirements, and quality (Hansen, 2024). The presence of knowledgeable sellers who can provide advice, consumer awareness, pricing, and availability all affect how effective the market stage is. To guarantee that the appropriate components are delivered to end users in a timely and convenient way, this step is crucial.

1.1.3 Installation

After the components are acquired, engineers or technicians install them at the designated locations. Charge controllers and inverters are integrated to control and convert electricity, and solar panels are positioned to collect sunlight and link to batteries for energy storage. Safe and effective system operation is ensured by proper installation. Determining the system's long-term functionality and user happiness depends heavily on this step (Aboagye et al., 2011).

1.1.4 Collection Points for Non-Functioning solar PV system Components

As solar components age, sustain damage, or are exposed to the elements, they may deteriorate or cease to function. Designated collection stations are set up to accept these non-functioning components rather than disposing of them inappropriately. These facilities act as drop-off points for customers to return outdated or damaged equipment (Ndallokaet al., 2024). Collection sites are essential for protecting the environment and making it easier to manage solar waste properly.

1.1.5 Recycling Process of Solar Photovoltaic System Components

Recycling the gathered solar PV trash is the last step. Valuable elements like silicon, glass, copper, and aluminum are removed and repurposed in new production through sophisticated methods. This eliminates pollution in the environment, encourages a circular economy, and lessens the need for new raw resources. By completing the cycle of solar energy, efficient recycling not only lowers waste but also promotes sustainability (Preet & Smith, 2024).

2.0 Methods and materials

2.2 Study area

The study was conducted in the five parishes of Kabaare, Kakanju, Katunga, Kitojo, Mazinga, and Rushinya, which make up Kakanju Sub County, which is situated in Bushenyi District, Western Uganda. In Bushenyi District, which has coordinates of 0°32′S 30°11′E, it borders Bumbaire, Bushenyi-ishaka Tc, Katerera, Katunguru, Kichwamba, Kyabugimbi, Kyamuhunga, Kyeizoba, Nyabubare, and Ryeru, among other sub-counties. In Kakanju Sub County, Bushenyi District, solar power utilization has increased and been widely adopted, with a concentration on both institutional and residential illumination. Basic solar-powered lighting, sophisticated irrigation water pumping systems, and finance options for small enterprises like hair salons and phone charging are among the initiatives.

2.3 Methodology

In this study, solar waste management techniques in Kakanju Sub-county, Bushenyi District, Western Uganda, were evaluated using an equal stratified random sampling technique. Kabaare, Kakanju, Katunga, Kitojo, Mazinga, and Rushinya are the five parishes that make up the study region. These were selected because of their increasing use on solar energy for irrigation systems, home lights, and small-scale enterprises like phone charging stations and salons. Based on the number of households with solar systems, a total sample size of 80 households was calculated and allocated proportionately throughout the parishes using equation 1. Structured questionnaires were given to chosen household members as part of the data collection process in order to capture both quantitative and qualitative data. The questionnaire included about respondent demographics, solar system types, solar waste knowledge and management, storage and disposal methods, perceived health and environmental effects, difficulties encountered, and suggestions from the community. The data was analyzed using descriptive statistics, such as frequency distributions and percentages, and the results were tabulated to allow for a clear understanding of the sub-county's solar waste practices and related issues.

2.4 Proportionate Stratified Random Sampling Technique

Table 1 demonstrates how respondents were chosen from five parishes in Kakanju Sub-county using a proportionate stratified random sampling technique. For each parish, the total number of households and the number of households that used solar power were initially determined. Out of the 80 sampled households, a comparable sample size was established based on the percentage of solar users in each parish in relation to the overall number of solar users (2,797 households). As an illustration, Kitijo gave the smallest sample (10 houses) and Katunga, with the greatest number of solar users (691), the largest sample (20 households). This strategy made sure that every parish was fairly represented based on how much solar energy they used.

Table 1. Sample Distribution Table

S/#	Parish	Total solar User house holds	Sample Households
1	Kabaare	645	18
2	Rushinya	510	15
3	Katunga	691	20
4	Kakanju	609	17
5	Kitijo	342	10
Total		2797	80

$$n_a = \left(\frac{N_a}{N}\right) \times n \qquad (1)$$

Where n_a is sample size per parish, N_a is households in parish, N total households, n is the total sample size

2.5 Validity and reliability of the questionnaires

To ensure content validity, the structured questionnaire was examined by three specialists with backgrounds in environmental management and renewable energy prior to the main data collection. A pilot study was conducted with 10 households from a nearby parish that were not included in the final sample. The questionnaire structure was enhanced, ambiguities were addressed, and response possibilities were updated based on comments from the pilot study. Cronbach's alpha was used to evaluate the questionnaire's reliability, and the instrument's overall internal consistency coefficient of 0.82 revealed satisfactory reliability. The only version of the questionnaire used to collect data was the updated and confirmed version.

3.0 Results and discussion

Table 2. Demographic Characteristics of Respondents

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	56	70.0
	Female	24	30.0
Age group	21-30	33	41.3
	31-40	39	48.8
	41-50	3	3.8
	51 and above	5	6.3
Education Level	No formal	4	5.0
	Primary	9	11.3
	Secondary	15	18.8
	Diploma	17	21.3
	Bachelor's	29	36.3
	Masters	5	6.3
	Ph.D.	1	1.3
Primary occupation	Farmer	14	17.5
	Teacher	35	43.8
	Health worker	16	20.0
	Unemployed	8	10.0
	Others	7	8.8
Household Size	1-3	39	48.8
	4-6	34	42.5
	7-9	5	6.3
	9 and above	2	2.5

The respondents' demographic details are displayed in Table 2 for each of the following five variables: gender, age group, education level, primary occupation, and household size. Males made up 70% of the respondents, while women made up 30%. The respondents' age groups were 31–40 years old (48.8%), 21–30 years old (41.3%), and educated (36.3%) with a bachelor's degree, 1.3% with a doctorate, and 5.0% with no formal education. Primary Occupation: Teachers made up the largest group (43.8%), followed by farmers (17.5%) and health professionals (20%). Household Size: 42.5% lived in households with four or six people, while nearly half (48.8%) lived in households with one or three people.

Table 3. Solar Energy System Information

Item	Category	Frequency	Percentage (%)
Type of Solar System	Basic	78	97.5
	Advanced	2	2.5
Number of years using system	less than 1	35	43.8
	1-2	22	27.5
	3-5	17	21.3
	5 and above	6	7.5
Supplier/Installer	Government	7	8.8
	Family member	26	32.5
	Local technician	5	6.3
	Company/vendor staff	3	3.8
	Self	39	48.8
Functional status of the solar system	Working	78	97.5
	Not Working	2	2.5

The main attributes pertaining to respondents' use of solar energy systems are summarized in Table 3. Only a small percentage (2.5%) employ sophisticated solar systems, while the vast majority (97.5%) use basic ones, suggesting that high-capacity solar technologies are not widely adopted in the studied area. The majority of homes (43.8%) have had their systems for less than a year, indicating a recent adoption of solar technology. A comparatively recent trend of solar adoption is highlighted by the lesser percentage (27.5%) who have utilized the systems for one to two years, followed by 21.3% for three to five years, and just 7.5% for more than five years. Nearly half (48.8%) of the respondents installed the system themselves, with family members coming in second (32.5%). Government (8.8%), local technicians (6.3%), and vendor staff (3.8%) made smaller contributions, suggesting that there was little official assistance for installation. Last but not least, 97.5% of systems are reported to be operational, and only 2.5% are found to be non-functional, indicating a high operational success rate (Singh & Sharma, 2025; Hansen et al., 2022). This suggests that the systems' functionality is generally dependable.

Table 4. Solar Waste Awareness

Item	Category	Frequency	Percentage (%)
Aware of solar waste	Yes	71	88.8
	No	9	11.3
Knows components that become waste	Panel	66	39.1
	Charge controllers	23	13.6
	Inverter	21	12.4
	Battery	59	34.9
Heard of Solar Waste Effects in environment	Yes	43	53.8
	No	37	46.3
Source of Information on solar wastes	Radio/TV	32	40.0
	NGO	9	11.3
	Company/vendor staff	21	26.3
	None	18	22.5

The respondents' awareness and understanding of solar waste is demonstrated in Table 4. While a small amount (11.3%) did not know about solar waste, the vast majority (88.8%) did. Solar panels were the most commonly identified component when questioned about solar waste (39.1%), followed by batteries (34.9%), charge controllers (13.6%), and inverters (12.4%). This suggests that end users primarily identify parts that are visible or regularly replaced. With 53.8% of respondents having heard of the environmental effects of solar waste and 46.3% not, awareness of these effects was comparatively balanced. This suggests a knowledge gap that could influence appropriate disposal procedures. More structured public awareness campaigns on solar waste management are needed, as evidenced by the fact that radio and television were the primary information sources (40.0%), followed by corporate or vendor staff (26.3%), non-governmental organizations (11.3%), and no source at all (22.5%).

Table 5. Solar Waste Generation & Handling

Item	Category	Frequency	Percentage (%)
Has Faulty Solar Parts?	Yes	33	41.3
	No	47	58.8
Type of Faulty Component	Panel	18	22.5
	Inverter	11	13.8
	Charge controllers	15	18.8
	Battery	36	45.0
Disposal Method Used	Return to vendor	2	2.5
	Keep stored	8	10.0
	Burn/bury	21	26.3
	Recycling center	3	3.8
	Local collection point	1	1.3
	Drop at e-waste site /Rubbish Collection site	45	56.3
Duration Stored Before Disposal	Days	68	85.0
	Months	7	8.8
	Years	5	6.3
Reason for Chosen Disposal Method	Costs	11	13.8
	No Alternative	69	86.3

Table 5 shows statistics on how users generate and manage solar waste. Of the respondents, a sizable percentage (41.3%) reported having defective solar components. Batteries were the most often damaged component (45%), followed by solar panels (22.5%), charge controllers (18.8%), and inverters (13.8%). The majority (56.3%) disposed of defective parts at e-waste or garbage collection facilities, whereas 26.3% employed risky techniques like burning or burying. It was just 3.8% who used recycling centers, 2.5% who returned things to merchants, and 1.3% who used local collection locations. The majority of customers (85%) kept defective items for a few days before discarding them, although others kept them for months (8.8%) or even years (6.3%). There is a notable lack of understanding and infrastructure about solar waste, as seen by the fact that just 13.8% of respondents indicated cost as the primary factor in their method choice, but 86.3% noted the absence of alternative disposal options (Ali et al., 2024).

Table 6. Storage and Disposal Practices

Item	Category	Frequency	Percentage (%)
Storage Location	Inside	23	28.8
	Outside	57	71.3
Safety Measures Taken	Labelled	13	16.3
	Covered	67	83.8
Recycling Attempted	Yes	75	93.8
	No	5	6.3
Access to Collection Centers	Yes	3	3.8
	No	77	96.3
Satisfaction with Current Practices	Satisfied	11	13.8
	Not Satisfied	69	86.3

Table 6 presents details on how users manage the disposal and storage of defective solar components. Compared to 28.8% who keep their solar waste within, the majority (71.3%) store it outdoors, potentially exposing it to environmental hazards. As for safety, 83.8% of respondents said they covered the rubbish, but only 16.3% labeled the objects, suggesting that safe handling procedures were not being followed too strictly. The fact that 93.8% of respondents have tried to recycle solar waste in spite of the difficulties indicates a great desire to handle it correctly. 96.3% of respondents did not have access to authorized collection centers, while only 3.8% said they did. Given that only 13.8% of respondents were satisfied with the way solar waste is currently managed, 86.3% of respondents indicated unhappiness with current methods, which is likely exacerbated by this lack of infrastructure (Saad et al., 2024; Xu et al., 2018). The information generally points to significant gaps in user satisfaction, safe storage, and availability to disposal services. Tables 5 and 6 show statutes and infrastructure deficiencies that are similar to studies presented by Hansen et al., 2022, Adediran & Abdulkarim, 2012 where insufficient regulations and shoddy collection systems compromise the safe management of solar waste. The high rate of damage to batteries (45%) and panels (22.5%) is consistent with research showing that short product lifespans and subpar components hasten the accumulation of trash in off-grid markets. Similarly, just 3.8% of users visited collection sites despite 93.8% of users attempting recycling, highlighting a structural gap between environmental awareness and available services a problem that has also been reported throughout Sub-Saharan Africa Badza et al., 2024.

Table 7. Environmental and Health Perceptions

Item	Category	Frequency	Percentage (%)
Believes Solar Waste is Harmful	Yes	42	52.5
	No	38	47.5
Perceived Effects	Air Pollution,	29	36.3
	Soil	38	47.5
	Impact	13	16.3
Impact Observed in Household/Area	Yes	23	28.8
	No	57	71.3

The opinions of the community about the impacts of solar waste on the environment and human health can be observed in Table 7. Just over half of the respondents (52.5%) think solar waste is bad, but a sizable minority (47.5%) disagree, showing that opinions on the matter are not entirely in agreement. The most frequently reported adverse effects are soil contamination (47.5%), air pollution (36.3%), and overall environmental or health impact (16.3%). Despite these worries, the majority of respondents (71.3%) have not noticed any real environmental or health impacts in their homes or communities, while only 28.8% have. This implies that even if people are becoming more conscious of the possible dangers of solar waste, most community members still have little to no firsthand experience with its effects (Janmaimool et al,2024; MacNaughton et al., 2016,).

Table 8. Challenges in Solar Waste Management

Item	Category	Frequency	Percentage (%)
Key Challenges Faced	Lack of awareness	13	16.3
	No disposal centers	19	23.8
	No recycling companies	36	45.0
	High cost of safe disposal	3	3.8
	Lack of technical skills	9	11.3

Table 8 lists the main difficulties in handling solar waste. The absence of recycling businesses was mentioned by 45.0% of respondents as the biggest obstacle, indicating a serious weakness in the waste management system. The lack of disposal facilities (23.8%) and ignorance (16.3%) come next, suggesting that treating solar waste properly is hampered by both informational and logistical issues. A small percentage (3.8%) mentioned the high expense of safe disposal as a limiting issue, while lack of technical knowledge (11.3%) also leads to inappropriate disposal techniques (Kadam et al., 2023). Overall, the data points to a number of structural, financial, and instructional issues that need to be resolved in order to enhance community solar waste management.

Table 9. Community Recommendations for Improvement

Item	Category	Frequency	Percentage (%)
	Community Education on proper disposal	49	35.5

Suggested Action for solar waste disposal	Collection Centers	30	21.7
	Government/NGO Support	20	14.5
	Incentives for returning damaged solar equipment	12	8.7
	Regulation Enforcement	9	6.5
	Access to Recycling	13	9.4
	Clear Disposal Guidelines	5	3.6
Willing to Participate in Disposal Programs	Yes	78	56.5
	No	2	1.4
Willing to Pay for Safe Disposal	Yes	36	45.0
	No	44	31.9

Table 9 lists suggestions made by the community to enhance solar waste disposal procedures. A significant need to increase knowledge and encourage safe handling is evident from the fact that 35.5% of respondents endorsed community education on proper disposal as the most suggested course of action. The need for organized processes and institutional involvement is highlighted by other important recommendations, such as creating collecting centers (21.7%) and improving government or NGO assistance (14.5%). The desire for both practical and policy-level interventions is reflected in other proposals, which include the following: clear disposal rules (3.6%), incentives for returning damaged equipment (8.7%), regulation enforcement (6.5%), and access to recycling services (9.4%). The community is also quite willing to participate in proper disposal activities; 45.0% of respondents say they are willing to pay for safe disposal, and 56.5% say they are willing to participate in disposal programs (Almulhim, 2022). Strong community interest and the possibility of successful solar waste treatment are indicated by this, assuming that the necessary support and enabling structures are in place.

4.0 Conclusion

The study reveals a significant disconnect between rural communities' readiness to handle solar photovoltaic (PV) waste sustainably and the increasing use of solar technology. Even though 88.8% of users in Kakanju Sub-county are aware of solar waste, unsafe disposal methods including burning, landfilling, and outdoor storage are still common since there are no official recycling facilities, inadequate infrastructure, and a lack of technical expertise. Despite being the most frequently discarded parts, batteries and solar panels are only recycled by 3.8% of households, indicating a serious shortage of convenient and trustworthy disposal solutions. User satisfaction with current practices is still quite low, despite the fact that over half of users said they would be happy to participate in safe disposal programs as well as 93% of users attempted recycling in some capacity. This preparedness implies that adoption might be high if vendor-supported return programs or coordinated recycling were put into place. This suggests a glaring misalignment between awareness and practical waste management machinery.

The study encourages the immediate establishment of community-based collection centers, formalized recycling frameworks, and public-private partnerships to invest in regional waste management solutions in order to protect the environment and public health, particularly in Uganda's growing off-grid solar industry. Additionally, clear government regulations regarding solar items that have reached the end of their useful lives, training for solar specialists, public education campaigns, and the implementation of take-back incentives can all significantly increase participation and compliance. Sustainability will need bolstering enforcement systems and incorporating solar waste management into current environmental policy frameworks. Ultimately, a multi-stakeholder strategy based on infrastructure development, policy change, capacity training, and community participation is needed to achieve safe, inclusive, and efficient solar waste management in rural Uganda.

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