

27-04-2026

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To cite this article: Anggraini, A., Arahman, H. N., Nisa, K., Fasari, F., Rosa, K. V., & Warmansyah, I. (2026). The effectiveness of rocket stoves in reducing household waste in Danau Baru Village. *Priviet Social Sciences Journal*, 6(4), 539–549. <https://doi.org/10.55942/pssj.v6i4.1660>

To link to this article: <https://doi.org/10.55942/pssj.v6i4.1660>



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The effectiveness of rocket stoves in reducing household waste in Danau Baru Village

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Received 21 February 2026

Revised 11 March 2026

Accepted 27 April 2026

ABSTRACT

This study examines the issue of waste management in Danau Baru Village, which does not yet have a waste disposal site, resulting in the community still disposing of waste into the river, and tests the rocket stove as a contextually appropriate technological solution. Using a Participatory Action Research (PAR) approach, the study was conducted through participatory diagnosis, planning, implementation, observation-evaluation, and reflection with the active involvement of the community. Data were collected through participatory observation, semi-structured interviews, documentation, and field notes, then analyzed qualitatively. The results show that participatory rocket stoves are relevant and have gained initial social acceptance, but their sustainability is highly dependent on changes in sorting behavior, consistency of use, and institutional strengthening and assistance. Therefore, this technology is best positioned as a transitional solution towards a sustainable community-based waste management system.

Keywords: Rural waste management; rocket stove; participatory action research; appropriate technology; community participation; the value of cleanliness in Islam; sustainable development goals.

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RESEARCH & PUBLISHING



1. INTRODUCTION

Waste management remains a fundamental problem in many rural areas that lack adequate final disposal facilities and structured waste services. In such contexts, communities are often left with limited options, leading to the emergence of informal and environmentally harmful practices. Studies such as [Aroge et al. \(2025\)](#) and [Mihai \(2018\)](#) highlight that the absence of proper infrastructure significantly shapes disposal behavior, often resulting in open dumping, burning, or disposal into nearby water bodies. In Danau Baru Village, located in Sungai Rotan Subdistrict, Muara Enim Regency, these limitations are clearly reflected in the community's reliance on the river as a primary disposal site for household waste. This practice, while practical in the absence of alternatives, poses serious risks, including water pollution, public health threats, and long-term ecosystem degradation. Consequently, there is a pressing need for solutions that are not only technically effective but also simple, accessible, and adaptable to local conditions.

Previous studies have explored various approaches to rural waste management, including the application of appropriate technologies designed to operate within resource-constrained environments. Among these, rocket stoves have gained attention as a more efficient and relatively low-emission combustion method compared to traditional open burning. Research by [Kerdsuwan et al. \(2015\)](#), [Kohli et al. \(2024\)](#), [Kumar et al. \(2018\)](#), [Mihai et al. \(2019\)](#), [Viljoen et al. \(2021\)](#), and [Ingram et al. \(2022\)](#) demonstrates that such technologies can improve combustion efficiency, reduce visible smoke, and contribute to better waste volume reduction. However, most of these studies tend to focus primarily on technical performance and environmental outcomes, with limited attention to the broader social context in which these technologies are implemented.

Based on this gap, this study offers an integrative approach that connects appropriate technology, Islamic values, and the principles of sustainable development within a single conceptual framework. Logically, religious values that emphasize the importance of cleanliness and environmental responsibility play a role in shaping community awareness and behavior ([Kelly, 2005](#); [Mallory, 2024](#); [Matz, 2024](#)). This awareness then encourages active participation in waste management, including the acceptance and use of technologies such as rocket stoves. Furthermore, the adoption of such technology contributes to reducing waste volume, improving environmental quality, and supporting the achievement of sustainable development goals, particularly those related to environmental sustainability and community well-being ([Kohli et al., 2024](#); [Kerdsuwan et al., 2015](#); [Aroge et al., 2025](#)).

Thus, the research questions of this study are: (1) what are the conditions of waste management in Danau Baru Village; and (2) how is the rocket stove implemented as a community-based waste management solution. This study aims to analyze waste issues, evaluate the application of rocket stove technology, and formulate a model integrating technical aspects, religious values, and sustainability.

The contributions of this study lie in two main aspects. Theoretically, this study develops a conceptual framework linking Islamic values, community behavior, and technology adoption in the context of rural waste management. Practically, this study offers a simple, low-cost, and easily replicable solution model for villages that do not yet have an adequate waste management system.

2. METHOD

This study employs the Participatory Action Research (PAR) approach, which emphasizes the active involvement of community members in all stages of the research process, including problem identification, planning, implementation, and evaluation. PAR is particularly relevant in community-based development contexts because it positions participants not merely as research subjects, but as co-creators of knowledge and solutions. This approach fosters a sense of ownership, increases the relevance of interventions, and enhances the sustainability of outcomes. As highlighted by [Ingram et al. \(2022\)](#), effective community engagement strategies are essential in ensuring that interventions align with local needs and realities. Similarly, [Kelly \(2005\)](#) emphasizes that participatory approaches strengthen community capacity and improve the effectiveness of interventions by integrating local knowledge into the research process.

More recent discussions by [Mallory \(2024\)](#) and [Matz \(2024\)](#) further reinforce that PAR enables iterative learning and adaptive problem-solving through continuous cycles of action and reflection.

The study involved 18 participants drawn from the local community, representing a range of household backgrounds and experiences related to waste management practices. The selection of participants aimed to ensure inclusivity and representation of those directly affected by the identified issues. Rural waste management challenges, such as limited infrastructure, low awareness, and reliance on informal disposal methods, have been widely documented in previous studies. For instance, [Aroge et al. \(2025\)](#) highlight that inadequate waste disposal practices are closely linked to health risks and environmental degradation in rapidly growing communities. Similarly, research by [Kumar et al. \(2018\)](#) and [Viljoen et al. \(2021\)](#) shows that rural areas often face systemic challenges, including lack of formal waste collection systems and low adoption of sustainable waste practices.

Operationally, this research followed the PAR cycle, with each stage conducted over an average of four days to allow sufficient time for engagement, implementation, and reflection. The first stage, diagnosis, involved identifying key issues related to waste management through direct observation, semi-structured interviews, and group discussions. This stage revealed common practices such as open dumping and backyard burning, which have been associated with environmental pollution and health hazards. Studies such as [Mihai \(2018\)](#) and [Mihai et al. \(2019\)](#) emphasize that such practices contribute significantly to air pollution and ecological damage in rural settings.

The second stage, planning, focused on co-developing practical and context-appropriate solutions with the community. In this study, the primary intervention involved designing a rocket stove model as an eco-friendly waste utilization technology, alongside a community outreach strategy to promote its adoption. The use of locally adaptable technologies is supported by [Kerdsuwan et al. \(2015\)](#), who highlight the importance of sustainable and community-based waste solutions. Additionally, [Kohli et al. \(2024\)](#) emphasize that effective rural waste management requires integrating technological innovation with community participation and awareness-building.

The implementation stage involved the practical application of the designed rocket stove technology within the community. Participants were actively engaged in constructing, testing, and using the technology, ensuring that they gained hands-on experience and practical understanding. This participatory implementation approach aligns with PAR principles, where learning occurs through action and direct involvement. Observations were conducted during this phase to assess both the technical performance of the technology and the level of community acceptance.

Following implementation, the evaluation stage assessed the effectiveness of the intervention in addressing the identified waste management issues. This included evaluating the functionality of the rocket stove, its usability, and its potential to reduce waste accumulation and harmful disposal practices. Community responses were also gathered to understand perceptions, challenges, and levels of satisfaction with the intervention. Previous research, such as that by [Aroge et al. \(2025\)](#), underscores the importance of combining technical evaluation with community feedback to ensure that solutions are both effective and socially acceptable (See [Figure 1](#)).



Figure 1. Rocket Stove Implementation Planning Scheme

The third stage, namely the action or implementation phase, was carried out through the collaborative creation and demonstration of rocket stoves with community members, accompanied by practical education on waste sorting and reduction. This stage emphasized hands-on participation, where residents were not only introduced to the concept of rocket stove technology but were also directly involved in its construction using locally available materials. The participatory nature of this process allowed community members to better understand the functionality, benefits, and maintenance of the technology. In addition, educational sessions were integrated into the activities to raise awareness about proper waste segregation, distinguishing between organic and non-organic waste, and promoting reduction practices at the household level. This approach aligns with findings from [Kohli et al. \(2024\)](#), which highlight that community engagement combined with practical demonstration is essential for improving waste management behaviors in rural settings.

Furthermore, the implementation stage also addressed behavioral aspects of waste management. Participants were encouraged to reflect on their existing practices, such as open dumping or burning, and to consider more sustainable alternatives. Studies such as [Aroge et al. \(2025\)](#) emphasize that raising awareness and providing practical solutions can significantly influence community attitudes toward waste management. By integrating technical demonstration with educational outreach, this stage aimed to create both knowledge and behavioral change simultaneously.

The fourth stage, observation and evaluation, was conducted by systematically monitoring the use of rocket stoves, gathering feedback from community members, and assessing initial changes in waste management practices. Observations focused on how frequently and effectively the rocket stoves were used, the types of waste utilized, and any operational challenges encountered by participants. In addition, informal interviews and group discussions were conducted to capture community perceptions, satisfaction levels, and suggestions for improvement. This stage is crucial in determining whether the intervention is not only technically functional but also socially acceptable and practically applicable.

Evaluation also included identifying early behavioral shifts, such as reduced reliance on open burning or indiscriminate dumping, and increased awareness of waste sorting practices. Research by [Mihai \(2018\)](#) and [Viljoen et al. \(2021\)](#) indicates that monitoring community adoption and behavioral change is essential in assessing the effectiveness of rural waste management interventions. By combining direct observation with community feedback, this study was able to capture both measurable outcomes and experiential insights.

The fifth stage, reflection, involved a participatory analysis of the results together with the community to identify areas for improvement and to explore strategies for program sustainability. Reflection sessions were conducted in a collaborative manner, encouraging participants to share their

experiences, challenges, and perceived benefits of using rocket stoves. This stage allowed the research team and the community to jointly evaluate what aspects of the program were successful and which areas required further refinement.

Through this reflective process, several key insights emerged, including the importance of continuous support, the need for simple maintenance guidelines, and the potential for expanding the initiative to other households. Reflection also served as a platform for reinforcing learning, as participants revisited key concepts related to waste management and sustainable practices. According to [Mallory \(2024\)](#), reflection is a critical component of participatory action research, as it transforms practical experiences into actionable knowledge and supports long-term behavioral change.

Moreover, this stage contributed to strengthening community ownership of the program. By involving participants in the evaluation and decision-making process, the intervention became more aligned with local needs and capacities. This participatory reflection fosters a sense of responsibility and commitment, which is essential for ensuring the continuity of the initiative beyond the research period.

The integration of action, observation, and reflection stages within the PAR framework ensures that the intervention is iterative, adaptive, and grounded in real community experiences. The process not only facilitates the introduction of appropriate technology but also promotes sustainable behavioral change, laying the foundation for improved waste management practices and long-term environmental benefits at the community level (See [Figure 2](#)).



Figure 2. Participatory Waste Management Activities

The research subjects consisted of selected target households and community leaders who were directly involved in the implementation of the activities. These participants were chosen to represent both the primary users of the rocket stove technology and key local figures who influence community decision-making and collective behavior. Their involvement ensured that the data collected reflected both practical experiences at the household level and broader social perspectives within the community.

Data collection was carried out using multiple qualitative techniques to ensure depth and reliability. Participatory observation was used to capture real-time interactions, usage patterns, and behavioral changes during the implementation process. Semi-structured interviews allowed participants to express their experiences, perceptions, and challenges in a more flexible and in-depth manner. In addition, activity documentation such as photographs, process records, and written reports provided supporting evidence of program implementation. Field notes were also maintained to record contextual details, spontaneous observations, and reflections during each stage of the research.

Data analysis was conducted qualitatively through a systematic process of data reduction, data presentation, and reflective conclusion drawing. This approach enabled the researchers to identify key patterns, evaluate the effectiveness of rocket stove implementation, and generate insights relevant to community-based waste management practices.

3. RESULT

3.1. Waste Management Conditions in Danau Baru Village

Observations indicate that Danau Baru Village does not yet have a designated landfill site or a structured, formal waste management system. In the absence of such infrastructure, the majority of households rely on informal and environmentally risky disposal methods, most notably by discarding waste directly into the river. This practice has persisted over time and has gradually become normalized within the community. Rather than being driven solely by a lack of environmental awareness, this behavior reflects a rational and adaptive response to structural limitations particularly the absence of accessible, affordable, and reliable waste management services.

Field observations show that household waste in the village consists of a mix of organic and inorganic materials, including food scraps, plastic packaging, paper, and other domestic refuse. Without a system for sorting or collection, these waste streams are combined and disposed of in a single flow, often ending up in nearby waterways. The river, therefore, functions not only as a natural resource for daily needs such as washing and irrigation but also as an informal waste disposal channel. Over time, this dual function has contributed to declining water quality and increased environmental pressure on the surrounding ecosystem.

Interviews with residents reveal that the decision to dispose of waste in the river is strongly influenced by practicality and convenience. Many households lack access to waste bins, collection services, or designated disposal sites. As a result, throwing waste into the river is perceived as the most immediate and low-effort solution. In addition, there are limited economic incentives or regulatory mechanisms to encourage alternative practices. This situation aligns with findings from previous studies, such as [Aroge et al. \(2025\)](#), which highlight that inadequate infrastructure often shapes waste disposal behavior more significantly than individual awareness or attitudes.

Another important factor is the persistence of long-standing habits and social norms. In Danau Baru Village, waste disposal practices have been passed down across generations, reinforcing the perception that such methods are acceptable and even routine. Behavioral change, therefore, cannot be achieved solely through information campaigns but requires structural support and viable alternatives. Research by [Kumar et al. \(2018\)](#) suggests that without accessible systems for waste collection and processing, communities are likely to continue using familiar disposal methods, even when they are environmentally harmful.

The environmental implications of these practices are significant. Accumulation of waste in the river contributes to water pollution, disrupts aquatic ecosystems, and increases the risk of flooding due to blocked waterways. In addition, the decomposition of organic waste combined with the presence of plastics and other non-biodegradable materials creates long-term environmental degradation. Studies such as [Mihai et al. \(2019\)](#) and [Viljoen et al. \(2021\)](#) emphasize that improper waste disposal in rural areas is closely linked to both environmental and public health risks, including water contamination and exposure to hazardous substances.

Health concerns are also evident in the local context. Residents who rely on river water for certain daily activities may be exposed to pollutants, increasing the risk of waterborne diseases. However, awareness of these risks varies among community members, and in many cases, immediate practical needs take precedence over long-term health considerations. This reflects a broader challenge in rural waste management, where economic and infrastructural constraints often outweigh environmental and health concerns in shaping daily behavior.

Institutionally, the absence of a structured waste management system suggests limited coordination between local authorities and community stakeholders. There is little evidence of formal policies, regular waste collection schedules, or designated disposal areas. This gap highlights the need for integrated approaches that combine infrastructure development, community engagement, and policy support. As noted by [Kohli et al. \(2024\)](#), effective rural waste management requires a combination of technological solutions, institutional frameworks, and active community participation.

Despite these challenges, there are also emerging opportunities for improvement. Community members have expressed openness to alternative waste management solutions, particularly those that are practical, low-cost, and aligned with local conditions. This suggests that interventions such as decentralized waste processing, community-based initiatives, or simple technologies (e.g., composting or waste-to-energy solutions) may be viable if properly introduced and supported. The willingness of the community to engage in participatory activities provides a strong foundation for implementing such approaches.

3.2. Implementation of Rocket Stoves as a Solution

The implementation of rocket stoves in the community was carried out using a participatory approach that actively involved residents at every stage of the process, including socialization, construction, and testing. This approach was intentionally designed to ensure that the technology introduced was not perceived as an external solution imposed on the community, but rather as a collectively developed and locally owned initiative. During the socialization phase, residents were introduced to the concept of rocket stoves, including their function, benefits, and potential role in addressing household waste challenges. These sessions also served as a platform for dialogue, allowing participants to express their concerns, ask questions, and relate the technology to their daily experiences with waste management.

The construction phase emphasized hands-on involvement, where community members directly participated in building the rocket stoves using locally available and affordable materials. This not only reduced implementation costs but also ensured that the technology could be easily replicated without dependence on external resources. Participants learned about the structural design of the stove, including airflow mechanisms and combustion chambers, which are essential for achieving efficient burning. By engaging in the construction process, residents developed a sense of ownership and technical understanding, increasing the likelihood of sustained use.

Testing and initial usage of the rocket stoves were conducted collaboratively, with participants experimenting with different types of household waste, particularly non-biodegradable dry materials such as paper, cardboard, and certain plastics. Compared to traditional open burning practices, the rocket stove demonstrated a more controlled combustion process. This control is achieved through improved airflow and higher combustion temperatures, which result in more efficient burning and reduced visible smoke. Technically, this contributes to a reduction in the overall volume of household waste, addressing one of the key challenges faced by the community in the absence of formal waste management systems.

In addition to reducing waste volume, the rocket stove also offers environmental advantages. Controlled combustion minimizes the release of harmful pollutants compared to uncontrolled open burning, which is commonly practiced in rural areas. While it does not eliminate emissions entirely, the improved efficiency represents a step toward more environmentally responsible waste handling. This aligns with broader findings in rural waste management studies, where simple, low-cost technologies can play a significant role in mitigating environmental impacts when more advanced infrastructure is unavailable.

Initial monitoring of the implementation indicates a generally positive response from the community. Residents expressed interest and willingness to adopt the technology, citing several key advantages. First, the low cost of materials and construction makes the rocket stove financially accessible, even for households with limited income. Second, the simplicity of the design allows for easy replication, meaning that households can build additional units independently if needed. Third, the technology is compatible with local conditions, both in terms of available resources and existing practices related to waste disposal and cooking.

This positive response suggests that the community's acceptance of the rocket stove goes beyond mere compliance with an introduced program. Instead, it reflects an early stage of social acceptance, where residents begin to recognize the practical value of the technology in addressing their daily challenges. Social acceptance is a critical factor in the success of community-based interventions, as it influences not only initial adoption but also long-term sustainability. When community members perceive a solution as useful,

relevant, and manageable within their context, they are more likely to integrate it into their routine practices.

The participatory nature of the implementation process contributes significantly to this acceptance. By involving residents in decision-making, construction, and testing, the program fosters a sense of agency and empowerment. Participants are not passive recipients but active contributors, which strengthens their commitment to maintaining and improving the technology. This also creates opportunities for peer learning, where knowledge and skills are shared among community members, further supporting the diffusion of the innovation.

However, it is important to note that this stage represents an initial phase of adoption. While early responses are encouraging, sustained use will depend on continued support, monitoring, and adaptation. Challenges such as maintenance, consistency of use, and integration with other waste management practices may emerge over time. Therefore, ongoing engagement with the community is essential to ensure that the benefits of the rocket stove are maintained and that any issues are addressed collaboratively (See Figure 3).



Figure 3. Inauguration and Implementation of Rocket Stoves in Danau Baru Village

However, the effectiveness of this technology remains contingent on consistent usage, waste sorting practices, and sustained community engagement. Without these supporting factors, there is a risk that the technology will not be used optimally beyond the initial implementation phase.

4. DISCUSSION

The findings demonstrate that the absence of formal waste infrastructure in Danau Baru Village is not merely a technical limitation, but rather the result of complex interactions between limited service provision, the practical rationality of residents, and long-standing behavioral patterns. In everyday practice, households adopt disposal methods that are the most accessible, low-cost, and time-efficient within their context. As a result, practices such as disposing waste into rivers or open burning persist, not necessarily due to a lack of awareness, but because they represent the most feasible options available.

This observation supports prior studies, including Aroge et al. (2025), Kerdsuwan et al. (2015), Kohli et al. (2024), Kumar et al. (2018), Mihai (2018), Mihai et al. (2019), and Viljoen et al. (2021), which consistently highlight that environmentally harmful behaviors in rural areas often persist due to the absence of viable and affordable alternatives rather than simple ignorance. These studies emphasize that infrastructure gaps and limited institutional support play a central role in shaping community behavior.

Therefore, interventions that focus solely on providing facilities or introducing technology without understanding the lived realities and decision-making logic of residents risk being ineffective or unsustainable. In this context, behavior-based approaches that consider local habits, socio-economic

conditions, and cultural norms become equally important as technical solutions. A locally grounded strategy one that integrates community participation, practical feasibility, and contextual relevance offers a more promising pathway for achieving sustainable improvements in rural waste management practices.

We agree that appropriate technology based on participation—such as rocket stoves—is relevant because it bridges the gap between waste reduction needs and available local capacity. Our findings are consistent with the appropriate technology literature, which emphasizes that adoption rates increase when communities are involved from the planning and testing stages (Aroge et al., 2025; Kohli et al., 2024; F. C. Mihai, 2018). The positive community response in this study can be interpreted as an early indication of social acceptability. However, we note that initial acceptance is often situational and does not necessarily lead to regular use. Previous studies have shown that many community innovations fail to continue after the project phase due to weak maintenance mechanisms, incentives, and social ownership.

Therefore, we emphasize that the sustainability of implementation is highly dependent on consistent behavioral change in waste sorting, routine use of technology, and strengthening local institutions. This argument is supported by studies on environmental behavior transition that place continuous assistance as a key factor in the successful adoption of household technology (Aroge et al., 2025; Kohli et al., 2024; F. C. Mihai, 2018). Without integration into daily domestic practices and without a systematic assistance scheme, there is a real risk that rocket stoves will only remain at the demonstration stage. In other words, the main challenge ahead is no longer proving technical feasibility, but rather institutionalizing practices so that this technology truly transforms into a part of a well-established community-based waste management system.

4.1. Implications

The implications of this study confirm that waste management interventions in villages without TPS must prioritize solutions that are contextual, low-cost, and community-based. In such settings, approaches that align with local habits and resource availability are more likely to be adopted and sustained. Rocket stoves show strong potential as a realistic transitional technology, helping to reduce the common practice of disposing waste into rivers while offering a practical alternative that can be implemented at the household level. In addition, their use creates entry points for environmental education, particularly in promoting awareness of waste sorting and responsible disposal practices.

However, achieving long-term sustainability requires more than technological introduction. Strong village-level policy support is needed to legitimize and encourage adoption, alongside continuous education on waste segregation. Furthermore, a structured and ongoing mentoring system is essential to ensure that the use of rocket stoves becomes embedded within a broader, community-based waste management framework rather than remaining a short-term intervention, but a lasting collective community habit.

5. CONCLUSION

The waste management problem in Danau Baru Village stems from a combination of limited formal services, the practical rationality of residents, and deep-rooted habits, which cannot be adequately addressed through technical approaches alone. The implementation of participatory rocket stoves has proven to be a relevant contextual solution and has gained initial social acceptance because they are inexpensive, easy to replicate, and suited to local conditions. However, the findings also emphasize that long-term success is highly dependent on changes in waste sorting behavior, consistency of use, and institutional strengthening and sustainable mentoring. Thus, rocket stoves are best positioned as a transitional technology that effectively reduces the practice of dumping waste into rivers, but they require village policy support and community-based institutionalization in order to develop into a truly established and sustainable waste management system, supported by continuous evaluation, community engagement, and adaptive local innovation strategies.

Ethical Approval

This research was conducted in accordance with the principles of social research ethics. This study did not require formal ethical committee approval because it did not involve medical intervention or sensitive data, but the entire research process still referred to applicable research ethics standards, including respect for the privacy and dignity of participants.

Informed Consent Statement

All participants were given an explanation of the research objectives and procedures prior to data collection. Consent was obtained voluntarily from participants, with assurances of confidentiality and the freedom to withdraw at any time without consequences.

Authors' Contributions

AA and HNA contributed to conceptualization. AA and HNA contributed to methodology. AA, HNA, and KN contributed to validation. AA, HNA, and KN contributed to formal analysis. AA contributed to resources. AA and HNA contributed to writing – original draft preparation. KN, FF, and KVR contributed to writing – review and editing. IW contributed to supervision.

Disclosure Statement

The author declares that there are no conflicts of interest, whether financial, personal, or professional, that could influence the results of this study.

Data Availability Statement

The data used in this study are available from the corresponding author upon reasonable request, taking into account the privacy of participants.

Funding

This research did not receive external funding.

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