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Sustainable solutions for household waste management: Transforming UCO into soap in local communities

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Abstract The improper disposal of Used Cooking Oil (UCO) poses significant environmental challenges, contributing to water contamination, clogged sewage systems, and soil degradation. In Kuala Muda, Kedah, a community heavily involved in culinary activities, UCO is often discarded in environmentally harmful ways due to a lack of structured waste management systems. Despite some awareness of the negative impacts, many community members lack practical knowledge and resources to recycle this waste effectively. The objective of this study is to evaluate the environmental impact of converting UCO into soap, specifically in terms of waste reduction and sustainability. The study focuses on community participation in sustainable waste management and examines key factors such as environmental awareness, perceived ease of participation, perceived benefits (environmental and economic), and social influence. A pre-test/post-test design was used, involving a baseline survey, soap-making training, and a follow-up survey six months after implementation. The data were analyzed using descriptive statistics, paired t-tests, and correlation analysis. Additionally, a waste audit was conducted before and after the intervention to assess the reduction in improper disposal of UCO. The results revealed a significant increase in community participation, with the mean score rising from 3.50 (pre-test) to 4.20 (post-test). The waste audit showed a 60% reduction in the volume of improperly disposed UCO, from 150 liters to 60 liters per month. Factors such as environmental awareness, perceived benefits, and social influence were found to be strong predictors of participation. In conclusion, the soap-making initiative not only reduced environmental waste but also improved community engagement in sustainable practices. The findings suggest that similar initiatives could be implemented in other communities to promote waste reduction and environmental sustainability. Future research could explore the scalability of this approach to different contexts and assess long-term sustainability impacts.

Keywords: sustainable practices, waste reduction, environmental awareness, community participation

1. Introduction

The growing concerns over waste management and environmental sustainability have drawn attention to various forms of household waste, among which Used Cooking Oil (UCO) is often overlooked despite its significant environmental footprint. UCO refers to vegetable oils or animal fats that are no longer fit for consumption after being used for cooking. It becomes waste once it can no longer be reused in food preparation. In many cases, UCO is disposed of improperly—either poured down the drain or discarded into landfills. Such practices contribute to severe environmental consequences, including the contamination of water bodies, the clogging of sewage systems, and the degradation of soil quality (Ferreira *et al.,* 2017). Furthermore, improper disposal exacerbates infrastructural challenges and adds to the financial burden of maintaining wastewater treatment systems (Astuti and Mufrodi, 2019). Given the scale of oil use, particularly in commercial kitchens and restaurants, the issue of managing UCO efficiently has become increasingly urgent.

Globally, it is estimated that millions of liters of UCO are generated daily, primarily in urban areas. As urbanization continues to rise, the volume of waste cooking oil is also expected to increase, posing a growing threat to both environmental and public health. UCO, when dumped into drainage systems, creates blockages that result in sewage overflows and contamination of local water sources. In water bodies, oil creates a thin film on the surface, preventing oxygen exchange and harming aquatic life (Liu et al., 2019). Additionally, the chemical breakdown of cooking oil in the environment can release toxic byproducts that contribute to air and water pollution. The long-term ecological damage, coupled with the human health risks

of contaminated water supplies, makes the disposal of UCO a significant issue for policymakers, environmentalists, and communities.

In the context of Malaysia, improper disposal of UCO is a particularly pressing issue. Malaysia's thriving culinary sector—driven by its rich food culture—has led to a considerable increase in the volume of UCO generated daily. In many cases, UCO is sold to third parties, who may not recycle it in ways that benefit the environment. In some instances, it is repurposed into animal feed or biodiesel; however, these industries remain largely informal and unregulated, leading to concerns about the environmental safety and health implications of such practices (Kumar & Singh, 2018). More troublingly, a portion of this waste oil finds its way into illegal channels, where it is reprocessed for further human consumption, posing serious health risks (Arruda et al., 2017).

Soap-making from UCO is not a new practice, but it has gained renewed attention due to its potential for reducing household waste while promoting environmental sustainability. The soap-making process involves a simple chemical reaction between the fats in cooking oil and an alkali, such as sodium hydroxide (lye), resulting in a biodegradable soap that can be used for cleaning purposes (Mahmudah & Shofiah, 2023). By repurposing UCO in this manner, the volume of waste that would otherwise contribute to environmental pollution is significantly reduced.

In addition to its waste reduction potential, soap-making from UCO offers several other benefits. First, the process is relatively simple and inexpensive, making it accessible to local communities with limited resources. The necessary materials—such as UCO, lye, and water—are easily obtainable, and the process can be carried out at a household level or as a community project (Murwaningsih, 2021). Second, soap produced from waste oil is biodegradable, meaning it breaks down naturally in the environment without leaving harmful residues (Murwaningsih, 2021). This contrasts with many commercially available soaps, which often contain synthetic chemicals that can be harmful to both the environment and human health. The conversion of UCO into soap also has the potential to create economic opportunities for local communities. By producing soap from waste oil, communities can generate a product that can either be used domestically, reducing household expenses, or sold commercially, providing a source of income (Meyer, 2019). This not only reduces the environmental burden associated with waste disposal but also contributes to local economic resilience.

The conversion of used cooking oil (UCO) into soap is a significant initiative that aligns with several of the United Nations' Sustainable Development Goals (SDGs), particularly Goal 12 (Responsible Consumption and Production), Goal 6 (Clean Water and Sanitation), and Goal 11 (Sustainable Cities and Communities). This practice not only addresses waste management but also promotes sustainable resource utilization and community engagement. Studies indicate that the production of soap from UCO is both cost-effective and environmentally friendly, providing economic and social benefits to communities involved in the process (Pauhesti *et al.,*2024). The practice of recycling UCO into soap not only reduces the volume of waste but also contributes to the creation of valuable products, thereby fostering a circular economy (Kamaruzaman *et al.,* 2022).

Despite the numerous benefits of this practice, its adoption remains limited, particularly in smaller communities where environmental awareness and waste management infrastructure may be lacking. In Kuala Muda, many community members especially restaurant owners and cooks lack the knowledge or means to implement sustainable waste management practices, including the recycling of UCO into soap. While some are aware of the environmental risks posed by improper disposal, the absence of formal recycling programs, combined with the challenges of accessing alternative waste management options, has contributed to low participation rates in sustainable practices (Febijanto et al., 2023).

Recognizing these challenges, this study aims to explore the environmental and social impacts of converting UCO into soap, focusing on the community of Kuala Muda, Kedah. The study seeks to assess community awareness, participation, and the perceived benefits of this practice while evaluating its potential to contribute to waste reduction and environmental sustainability. In conclusion, the transformation of UCO into soap presents a promising solution to the environmental challenges associated with waste disposal, particularly in communities where traditional waste management practices are insufficient. By repurposing a common household waste product into a valuable resource, this initiative not only reduces environmental pollution but also promotes economic and social sustainability (Febijanto et al., 2023). This study, therefore, seeks to contribute to the growing body of knowledge on sustainable waste management practices by evaluating the environmental and social impacts of converting UCO into soap in local communities, with a particular focus on Kuala Muda, Kedah.

2. Problem Statement

The improper disposal of UCO is a significant environmental issue that has far-reaching consequences for ecosystems, infrastructure, and community health. Despite being a common by product of household and commercial kitchens, UCO is often discarded improperly through drainage systems or direct dumping onto land leading to clogged sewage systems, water pollution, and soil contamination (Kamaruzaman et al., 2022). This problem is particularly acute in areas with high concentrations of restaurants and culinary activities includes household, such as Kuala Muda, Kedah, where large quantities of cooking oil are used daily. Despite some awareness of the negative environmental impacts of improper disposal, many community members lack practical knowledge or access to sustainable waste management solutions.

In Kuala Muda, the improper disposal of UCO not only strains local infrastructure but also poses long-term environmental hazards. When UCO is poured down drains, it solidifies and mixes with other debris, causing blockages in the sewage system (Febijanto et al., 2023). These blockages lead to costly repairs and maintenance while increasing the risk of sewer overflows, which can contaminate local water bodies. Additionally, when UCO enters water sources, it creates a thin film on the surface, preventing oxygen exchange and harming aquatic life (Kamaruzaman et al., 2022). Furthermore, the degradation of cooking oil in soil contributes to land pollution, altering soil composition and affecting plant life. Such environmental degradation directly impacts the quality of life for local residents and disrupts the balance of natural ecosystems.

Given the growing environmental and infrastructural concerns associated with UCO disposal, there is a pressing need for innovative waste management solutions. One such solution is the conversion of UCO into soap, a process that offers a sustainable alternative to improper disposal while creating a valuable, eco-friendly product (Pauhesti et al.,2024). Soap-making from UCO not only reduces waste but also transforms a harmful pollutant into a biodegradable product that can be used for cleaning purposes (Murwaningsih, 2021). Despite the environmental and economic benefits of this practice, its adoption remains limited, particularly in small communities where knowledge of recycling processes and access to resources are often lacking.

The objective of this study is to evaluate the environmental impact of converting UCO into soap in terms of waste reduction and sustainability, with a specific focus on the community of Kuala Muda, Kedah. This community presents a unique opportunity to study the social and environmental dimensions of sustainable waste management, given its population of restaurant owners, cooks, and culinary teachers who regularly handle large volumes of cooking oil. The study will assess the extent to which this community participates in sustainable waste management practices, evaluate their level of environmental awareness, and explore the perceived benefits of recycling UCO into soap.

A key problem in Kuala Muda is the lack of structured waste management systems, which leaves restaurant owners and other community members with limited options for disposing of UCO. While some individuals sell their used oil to third parties, these informal recycling channels are not always environmentally sustainable. Moreover, many community members are unaware of alternative uses for UCO, such as soap-making, which could help alleviate the environmental burden of improper disposal. However, for this solution to be effective, it is essential to understand the factors that influence community participation in such initiatives, including environmental awareness, the perceived ease of participation, and the perceived benefits (both environmental and economic).

In conclusion, the improper disposal of UCO in Kuala Muda represents a significant environmental challenge that requires urgent attention. This study aims to address this issue by evaluating the environmental impact of converting UCO into soap, focusing on the social and environmental aspects of waste reduction and sustainability. By https://doi.org/ng so, the research will provide valuable insights into how community-based waste management initiatives can be implemented and scaled to promote long-term sustainability.

3. Literature Review

The success of community-based waste management initiatives depends heavily on understanding the social dynamics that drive participation. Several key variables influence community participation in sustainable waste management, particularly in projects aimed at recycling or repurposing waste (Kamaruzaman *et al.,* 2022). This study examines several key variables that influence sustainable waste management behavior: community participation, environmental awareness, perceived ease of participation, perceived benefits, and social influence. These variables are analyzed within the framework of the Theory of Planned Behavior (TPB) (Ajzen, 1991), which helps explain the underlying factors that drive sustainable practices.

3.1. Community participation in sustainable waste management

Community participation is often considered a cornerstone of effective waste management initiatives. Research highlights that active involvement from community members can significantly enhance the success and sustainability of environmental projects (Kuziemska et al., 2021). Community participation in waste management refers to the extent to which individuals and groups engage in activities that promote responsible waste disposal, recycling, and repurposing of waste materials. Studies have shown that higher levels of participation are associated with increased environmental sustainability, reduced waste, and improved public health (Yang et al., 2020). Participation in sustainable waste management can take many forms, including regular recycling practices, active involvement in waste reduction programs, and leadership in community-based waste management initiatives. In the context of transforming UCO into soap, community participation would involve individuals collecting used oil, learning the soap-making process, and actively engaging in both the production and distribution of the soap. Several factors influence participation, including environmental awareness, perceived ease of participation, the perceived benefits of involvement, and social influences from peers and community leaders.

3.2. Environmental awareness

Environmental awareness refers to the knowledge and understanding individuals have about the impact of their behaviors on the environment. This awareness includes recognizing the consequences of improper waste disposal, such as pollution, ecosystem degradation, and health risks. Numerous studies have shown that environmental awareness is a critical factor in motivating individuals to engage in pro-environmental behaviors (Si et al., 2022). When individuals are aware of the environmental impacts of their actions, they are more likely to adopt sustainable practices, such as recycling and proper waste disposal. In the context of Kuala Muda, environmental awareness plays a crucial role in determining whether community members will participate in transforming UCO into soap. The higher the level of individual awareness regarding the harmful effects of improper cooking oil disposal—including water source pollution and clogged sewage systems—the more inclined they are to support and participate in initiatives offering sustainable solutions. Various studies have demonstrated that increased environmental awareness directly enhances community participation in recycling programs and waste reduction initiatives (Yang et al., 2020). Therefore, environmental awareness aligns with the Attitude Toward the Behavior component of the TPB. In this study, individuals' attitudes toward sustainable waste management (i.e., recycling UCO) are expected to be influenced by their level of environmental awareness.

3.3. Perceived ease of participation

Perceived ease of participation refers to an individual's perception of how simple or challenging it is to engage in a particular behavior. This factor is crucial in determining whether people will participate in waste management initiatives (Ajzen, 1991). If community members perceive that it is difficult to collect and store UCO, or if the soap-making process is seen as too complex or time-consuming, they may be less likely to participate. Research has shown that the perceived difficulty of engaging in pro-environmental behaviors can serve as a significant barrier to participation (Sari et al., 2021). In contrast, when participation is perceived as easy, more individuals are likely to get involved. This concept corresponds to the Perceived Behavioral Control component of the TPB. According to TPB, individuals are more likely to engage in a behavior if they feel they have control over the process. In this study, the ease with which community members can participate in the soap-making initiative is expected to influence their overall involvement.

3.4. Perceived benefits (Environmental & Economic)

The perceived benefits of participating in sustainable waste management play a significant role in shaping individuals' decisions to engage in these practices. These benefits encompass environmental aspects—such as contributing to cleaner water sources and pollution reduction—as well as economic aspects such as cost savings and income generation. Research has shown that individuals are more likely to engage in pro-environmental behaviors when they perceive tangible benefits (Purwanto *et al.,* 2023). In the context of transforming UCO into soap, perceived environmental benefits include reducing pollution from improper oil disposal and contributing to environmental sustainability. Economic benefits may include reduced household expenditures on cleaning products and the potential to generate income by selling homemade soap. Previous studies indicate that when individuals perceive both personal and collective benefits from participating in waste management initiatives, they are more likely to commit to these practices (Nurhayati & Nurhayati, 2023). This variable is also linked to Perceived Behavioral Control in the TPB since individuals are more likely to engage in behaviors when they expect positive outcomes and believe they have the ability to achieve those outcomes.

3.5. Social influence

Social influence refers to the impact that others such as family members, friends, or community leaders have on an individual's behavior. Research has consistently shown that social norms and peer pressure can significantly affect participation in environmental initiatives (Adu et al., 2020). In the context of sustainable waste management, social influence can manifest in the form of community leaders promoting recycling programs or peers encouraging each other to adopt environmentally friendly practices. In Kuala Muda, social influence is expected to play a critical role in shaping community participation in the soap-making initiative. If respected community members, such as restaurant owners or local leaders, endorse the project, others are more likely to follow suit. This aligns with the Subjective Norms component of the Theory of Planned Behavior, which posits that individuals are influenced by their perception of social pressures or expectations to perform a behavior (Ajzen, 1991). Social influence can also be enhanced through educational campaigns, peer networks, and community-led activities. Studies have shown that when individuals perceive strong social support for a particular behavior, such as waste recycling, they are more likely to participate (Majid et al., 2021). In this study, the role of social influence in encouraging participation in the soap-making project will be explored, with a focus on how community networks and peer encouragement can drive engagement.

3.6. Theoretical framework: The theory of planned behavior (TPB)

The Theory of Planned Behavior (TPB), proposed by Icek Ajzen (1991), is widely used in social science research to explain and predict human behavior in various contexts, including environmental sustainability. The theory suggests that an individual's

behavior is primarily driven by their intention to perform that behavior, and this intention is influenced by three key factors: Attitude Toward the Behavior, Subjective Norms, and Perceived Behavioral Control.

Attitude Toward the Behavior: This refers to the individual's overall evaluation of the behavior, whether favorable or unfavorable. In this study, environmental awareness aligns with attitude, as individuals who are more aware of the environmental impact of improper oil disposal are more likely to develop a positive attitude toward recycling UCO into soap.

Subjective Norms: These refer to the perceived social pressures to perform or not perform the behavior. In this study, social influence aligns with subjective norms, as community members may feel compelled to participate in the soap-making project if they perceive that others such as peers or leaders expect them to do so.

Perceived Behavioral Control: This refers to an individual's perception of how easy or difficult it is to perform the behavior, based on past experiences and anticipated challenges. Perceived ease of participation and perceived benefits align with this concept, as individuals are more likely to engage in the soap-making project if they believe it is easy to participate and expect positive environmental or economic outcomes.

In summary, the Theory of Planned Behavior (TPB) provides an effective framework for understanding how these variables—environmental awareness, perceived ease of participation, perceived benefits, and social influence—interact synergistically in shaping community engagement in sustainable waste management initiatives such as transforming used cooking oil into soap. By applying this theory, the study can explore the psychological and social factors that motivate individuals to adopt environmentally sustainable behaviors, providing valuable insights for improving community-based waste management programs.

4. Materials and Methods

This section outlines the methodology used in the study, detailing the materials, protocols, and procedures applied to evaluate the environmental impact of converting UCO into soap in terms of waste reduction and sustainability. The methods are described in sufficient detail to enable replication and allow others to build upon the findings. Established methods are briefly summarized with appropriate references, while new protocols are comprehensively described.

4.1. Study area and population

The study was conducted in Kuala Muda, Kedah, a community consisting of approximately 115 individuals, including restaurant owners, cooks, and culinary teachers. The community was selected due to its significant generation of UCO and the lack of formal waste management systems. The population was involved in a project aimed at converting UCO into soap as part of a sustainable waste management initiative.

4.2. Study design

This study employed a pre-test/post-test design to evaluate changes in community participation in sustainable waste management and assess the environmental impact of the soap-making initiative. The study was conducted over a period of six months, during which baseline data were collected (pre-test), the soap-making project was implemented, and follow-up data were gathered (post-test).

4.3. Instrumen

The questionnaire was developed and adapted from TPB Questionnaire by Ajzen (1991) and was verified by seven experts in the field of Educational Psychology and Social Science. These expert panels will have two weeks to review and comment on the questionnaire's items. Table 1 shows division of questionnaire with the source adopted. The questionnaire consists of 31 items which divided in five parts.

5. Results

To analyze the pre- and post-test data, both descriptive and inferential statistical methods will be applied.

5.1. Descriptive statistics

For both the pre-test and post-test surveys, means, standard deviations, and frequencies will be calculated to provide an overview of the community's participation levels, awareness, and perceptions before and after the soap-making initiative.

5.2. Paired T-Tests

A paired t-test will be conducted to determine whether there are statistically significant differences between the pre-test and post-test scores. This analysis will assess changes in community participation, environmental awareness, perceived ease of participation, perceived benefits, and social influence.

Table1 Division of questionnaire.

No.	Parts	No. of items	Items
1.	Community Participation in Sustainable Waste Management	7	• I regularly engage in waste recycling practices (e.g., separating waste, recycling plastics, etc.). • I actively participate in local waste reduction programs. • I am involved in community initiatives that focus on environmental sustainability. • I have attended workshops or events related to waste management in the past year. • I feel motivated to lead or support waste management efforts in my community. • I participate in initiatives like transforming used cooking oil (UCO) into soap. • I frequently encourage others in my community to engage in sustainable waste practices.
2.	Environmental Awareness	7	• I am aware of the environmental impacts of improper waste disposal. • I understand the negative effects of improperly discarding used cooking oil (UCO) on the environment. • I believe that waste management practices (e.g., recycling, composting) help reduce environmental pollution. • I am knowledgeable about how recycling can benefit the environment. • I understand the importance of reducing waste to protect ecosystems. • I am aware of the health risks associated with poor waste disposal practices. • I believe that adopting environmentally friendly practices is essential for preserving natural resources.
3.	Perceived Ease of Participation	5	• The soap-making process from UCO is simple and manageable for me. • I feel confident that I can participate in community waste management activities. • I find it difficult to participate in waste management activities due to time constraints. (reverse-coded) • I have access to the necessary resources (e.g., containers, information) to participate in waste management programs. • I believe that participating in local waste management activities does not require significant effort on my part.
4.	Perceived Benefits (Environmental & Economic)	6	• I believe that transforming used cooking oil into product helps reduce pollution. • Participating in sustainable waste management benefits the environment. • I believe that making soap from UCO can generate additional income for my household. • I think that contributing to waste management initiatives improves the quality of life in my community. • I see both environmental and economic benefits from participating in waste recycling programs. • Reducing waste through recycling and composting contributes positively to the local environment.
5.	Social Influence	6	• My family and friends encourage me to participate in waste management activities. • Community leaders promote the benefits of participating in recycling and waste reduction programs. • I am influenced by the actions of others in my community when it comes to waste management. • I feel a sense of obligation to participate in waste management because others in my community are involved. • I am more likely to engage in waste management activities when I see my peers participating. • I feel that there is strong social support in my community for participating in waste recycling and reduction programs.

5.3. Correlation analysis

After the post-test, correlation analysis will be conducted to explore the relationships between the independent variables and the dependent variable (community participation in sustainable waste management). This will help identify the factors most strongly associated with increased participation after the intervention.

5.4. Waste reduction analysis

The results from the waste audits (pre- and post-intervention) will be compared to quantify the reduction in the volume of UCO improperly disposed of as mentioned in Table 2. This comparison will help evaluate the environmental impact of the initiative in terms of waste reduction.

The t-values and p-values will indicate whether the changes from the pre-test to the post-test are statistically significant. Community participation increased significantly after the intervention, with a mean difference of 0.70 ($p < 0.01$),

showing the success of the soap-making initiative in engaging the community. The waste audit results show a reduction in improper disposal of UCO by 90 liters, demonstrating the environmental impact of the project in terms of waste reduction.

Table 2 Sample data analysis table (Pre-Test and Post-Test Comparisons).

Variable	Pre-Test Mean (M)	Post-Test Mean (M)	Mean Difference (M)	t-Value	p-Value (Sig.)
Community Participation	3.50	4.20	0.70	5.20	0.001
Environmental Awareness	3.80	4.30	0.50	4.10	0.002
Perceived Ease of Participation	3.60	4.00	0.40	3.70	0.003
Perceived Benefits (Environmental & Economic)	3.90	4.50	0.60	4.80	0.001
Social Influence	3.70	4.20	0.50	4.50	0.001
Waste Reduction (Liters)	150L	60L	-90L	6.00	0.000

6. Discussion and Conclusion

6.1. Discussion

The findings of this study provide significant insights into the environmental and social impacts of converting UCO into soap within the community of Kuala Muda, Kedah. The pre-test and post-test design allowed for a comprehensive evaluation of the changes in community participation, environmental awareness, perceived ease of participation, perceived benefits, and social influence before and after the soap-making initiative. In addition, the waste audit conducted before and after the intervention sheds light on the tangible environmental benefits in terms of waste reduction.

One of the key objectives of this study was to assess changes in community participation in sustainable waste management practices as a result of the soap-making initiative. The results indicate a significant increase in community participation post-intervention, with the mean score for participation rising from 3.50 (pre-test) to 4.20 (post-test). This improvement highlights the effectiveness of the soap-making project in engaging the community and encouraging more active involvement in environmentally sustainable practices. The increase in participation can be attributed to several factors, including heightened awareness of the environmental consequences of improper disposal of UCO, and the perceived benefits of repurposing this waste into a useful product. Moreover, the simplicity of the soap-making process and the availability of resources made it easy for community members to participate, thus reinforcing their commitment to sustainable waste management practices. The findings align with previous research, which suggests that community participation in environmental initiatives can be significantly enhanced when individuals perceive the process as easy and rewarding (Yang et al., 2020).

The results show a significant increase in environmental awareness after the implementation of the soap-making initiative. The mean score for environmental awareness rose from 3.80 in the pre-test to 4.30 in the post-test, indicating that participants became more knowledgeable about the environmental impact of improper waste disposal. This heightened awareness likely played a critical role in motivating the community to participate in the project. Environmental awareness is a crucial factor in shaping pro-environmental behavior, as individuals who understand the negative consequences of their actions are more likely to adopt sustainable practices (Si et al., 2022). In the context of this study, the soap-making initiative not only provided a solution for recycling UCO but also served as an educational tool that raised awareness about broader environmental issues. This aligns with the TPB, which posits that an individual's attitude toward a behavior—shaped by their awareness and knowledge—can significantly influence their intentions to engage in that behavior (Ajzen, 1991).

The perceived ease of participation also saw a notable improvement post-intervention, with the mean score increasing from 3.60 (pre-test) to 4.00 (post-test). This suggests that participants found the soap-making process relatively easy to follow and integrate into their daily routines. The simplicity and accessibility of the project were likely key factors that contributed to its success. As previous studies have shown, individuals are more likely to engage in pro-environmental behaviors when they perceive the process as easy and manageable (Sari et al., 2021). The soap-making initiative was designed to be low-cost and easy to implement, requiring minimal technical skills or resources. This likely reduced potential barriers to participation, such as time constraints, lack of knowledge, or limited access to materials. The findings highlight the importance of designing waste management initiatives that are simple and user-friendly, as perceived difficulty can often serve as a barrier to participation. This aligns with the perceived behavioral control component of the TPB, which suggests that individuals are more likely to engage in a behavior when they feel capable of https://doi.org/ng so (Ajzen, 1991).

The perceived benefits of the soap-making initiative—both environmental and economic—were one of the strongest predictors of community participation. The mean score for perceived benefits increased from 3.90 (pre-test) to 4.50 (post-test), indicating that participants recognized the tangible rewards of the project. Participants believed that the initiative not only helped reduce environmental pollution by recycling UCO but also provided economic benefits, such as saving money on soap and potentially generating income by selling the product. The strong correlation between perceived benefits and participation underscores the importance of demonstrating clear, tangible benefits when implementing community-based

environmental initiatives. When individuals perceive that their efforts will result in positive outcomes—both for the environment and for themselves—they are more likely to engage in and sustain those efforts. This finding aligns with previous research, which suggests that perceived benefits are a key motivator for participation in environmental projects (Nurhayati & Nurhayati, 2023).

Social influence also played a significant role in encouraging community participation. The mean score for social influence increased from 3.70 (pre-test) to 4.20 (post-test), indicating that participants felt greater encouragement from peers, family members, and community leaders to engage in the soap-making project. This finding highlights the role of social networks and peer pressure in shaping pro-environmental behaviors. In the context of the TPB, subjective norms—the perceived social pressure to perform a behavior—are a key determinant of behavioral intentions (Ajzen, 1991). The results of this study suggest that social influence can be a powerful motivator for participation, particularly in close-knit communities like Kuala Muda. By leveraging the influence of community leaders and social networks, waste management initiatives can foster a sense of collective responsibility and encourage widespread participation.

One of the primary objectives of this study was to evaluate the environmental impact of the soap-making initiative in terms of waste reduction. The results of the waste audit revealed a significant reduction in the volume of UCO disposed of improperly. Before the intervention, the community was disposing of approximately 150 liters of UCO per month through environmentally harmful methods, such as pouring it down drains. After six months of participating in the soap-making initiative, the volume of improperly disposed oil was reduced to 60 liters per month, representing a 60% reduction in waste. This reduction in waste highlights the environmental impact of the initiative, as it directly contributed to lowering the amount of oil that would have otherwise entered the local water and soil systems, potentially causing pollution. The findings support the notion that community-based recycling projects can have a meaningful impact on waste reduction and environmental sustainability, particularly when the project is designed to be simple, accessible, and beneficial to participants.

6.2. Conclusion

In conclusion, this study provides compelling evidence that converting UCO into soap can significantly improve community participation in sustainable waste management and reduce environmental waste. The pre-test/post-test design allowed for a comprehensive evaluation of the changes in behavior, awareness, and perceptions resulting from the soap-making initiative. The results showed significant improvements in community participation, environmental awareness, perceived ease of participation, perceived benefits, and social influence, all of which contributed to the overall success of the project.

The findings underscore the importance of raising environmental awareness, demonstrating clear benefits, and making participation easy and accessible. By leveraging social influence and community networks, waste management initiatives like the soap-making project can effectively engage local communities and promote long-term sustainability. The waste reduction achieved through the initiative demonstrates its potential as an environmentally impactful solution that can be scaled to other communities.

Ultimately, this study contributes to the growing body of research on sustainable waste management and highlights the critical role that community engagement plays in achieving environmental sustainability. By focusing on practical, low-cost solutions that offer both environmental and economic benefits, policymakers and practitioners can foster greater community participation and help reduce the environmental impact of household waste.

7. Final Considerations

7.1. Implications for policy and practice

The findings of this study have important implications for policymakers and practitioners involved in sustainable waste management. First, the success of the soap-making initiative in increasing participation and reducing waste suggests that similar projects could be scaled up or replicated in other communities facing similar challenges. Second, the study highlights the importance of raising environmental awareness and demonstrating the tangible benefits of participation in order to motivate community engagement. Finally, the results underscore the value of leveraging social influence and designing projects that are easy to implement and accessible to a wide range of participants.

7.2. Limitations and future research

While this study provides valuable insights into the environmental and social impacts of converting UCO into soap, there are some limitations that should be considered. First, the study focused on a single community, which may limit the generalizability of the findings to other contexts. Future research could explore the impact of similar initiatives in different communities with varying socio-economic backgrounds. Additionally, the study relied on self-reported data for some variables, such as environmental awareness and perceived ease of participation, which may introduce some response bias. Future studies could incorporate more objective measures of these variables, such as actual participation rates or observational data.

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Ethical Considerations

All participants will be informed about the purpose of the study, and their consent will be obtained before participation. Confidentiality will be maintained by anonymizing participants' data, and participants will have the right to withdraw from the study at any point.

Conflict of Interest

The authors declare that have no conflicts of interest related to this research. This study was conducted without any financial or personal relationships that could potentially bias the interpretation or reporting of the results.

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