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Community Empowerment through Ecoenzyme and Eco-Friendly Soap Production: Organic Waste Valorization in Rural Indonesia

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ABSTRACT

Purpose: This study aims to evaluate the implementation and outcomes of a community empowerment program focused on ecoenzyme production and eco-friendly soap making, conducted as a community service activity at Gebang Village, Teluk Pandan District, Pesawaran Regency, Lampung Province, Indonesia, targeting household organic waste valorization and productive skill development among community members.
Methodology: A qualitative descriptive approach was employed, integrating socialization, demonstration, and hands-on participatory practice as the primary instructional methods. Data were collected through direct observation, participant response documentation, and photographic recording. The program engaged 36 participants, predominantly housewives, at the Gebang Village hall.
Results: Participants improved their understanding of organic waste valorization, successfully produced ecoenzymes and eco-friendly soap, and showed increased environmental awareness. All assessed program outcomes improved, with an overall success rate of 95%.
Conclusions: The integrated socialization and hands-on practice methodology proved effective in building community knowledge and practical skills in organic waste valorization, with demonstrated potential for sustainable replication as a household enterprise development program.
Limitations: The single-day program limited long-term assessment of skill application and ecoenzyme fermentation, and no quantitative pre- and post-knowledge assessment was conducted.
Contributions: This study offers a replicable, low-cost model integrating environmental education and practical skills for organic waste valorization.

Keywords: *Community Empowerment, Ecoenzyme, Eco-Friendly Soap, Environmental Education, Organic Waste*

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1. Introduction

The management of household organic waste constitutes one of the most pervasive and solvable environmental challenges facing rural communities in developing countries, including Indonesia. Organic waste, comprising kitchen scraps, fruit and vegetable peels, and garden residues, typically accounts for 50 to 70 percent of total municipal solid waste by weight in Indonesian households, yet the majority of this material is disposed of through open dumping, burning, or mixed waste streams rather than being valorized as a productive resource (Tchobanoglous et al., 2003; Kementerian Lingkungan Hidup dan Kehutanan RI, 2021). The consequences of this disposal pattern include groundwater contamination, methane generation from anaerobic decomposition in landfills, atmospheric particulate pollution from burning, and the loss of the organic matter and nutrient value that this waste stream contains. At the same time, the households generating this waste often purchase commercial cleaning and agricultural products that could be replaced by valorized organic waste derivatives at significantly lower cost and environmental impact (Ong et al., 2022; Kumar et al., 2021).

Ecoenzyme, a fermentation-based product derived from organic kitchen waste, brown sugar, and water, has emerged over the past decade as a particularly accessible and versatile organic waste valorization technology appropriate for household and small community production in contexts with limited technical infrastructure (Naidu et al., 2021; Ong et al., 2022). Originally developed and popularized by Thai biochemist Dr. Rosukon Poompanvong through the Garbage Enzyme movement, ecoenzyme is produced through a simple three-month aerobic fermentation process that converts organic kitchen waste into a multi-functional acidic liquid with documented antimicrobial, deodorizing, surface-cleaning, plant growth-promoting, and soil-conditioning properties (Naidu et al., 2021; Nazaruddin et al., 2021). The production technology requires only basic equipment (a sealable container, a kitchen scale, and clean water), raw materials available in every household (fruit and vegetable scraps and brown sugar), and a three-month fermentation period without any specialized knowledge or chemical inputs, making it genuinely accessible to community members without scientific training (Ong et al., 2022; Kumar et al., 2021).

Eco-friendly soap production using ecoenzyme as a functional ingredient represents a natural extension of ecoenzyme valorization, transforming the fermented product into a commercially useful cleaning product with demonstrated antimicrobial and cleaning efficacy superior to plain water and comparable to commercial liquid soaps at a fraction of the cost (Wulandari et al., 2021; Fauziah et al., 2021). The inclusion of ecoenzyme in soap formulations enriches the product with organic acids, active enzymes, and antimicrobial compounds generated during fermentation, creating a product that is simultaneously effective for cleaning, environmentally biodegradable, and free from the harsh synthetic chemical additives found in most commercial household cleaning products (Handayani et al., 2022; Susilo et al., 2020). The commercial potential of eco-friendly soap as a small-scale household enterprise product is significant in the context of Indonesia's growing consumer market for organic and natural personal care products, with social enterprises and cooperatives marketing comparable products at premium prices that generate sustainable household income (Wulandari et al., 2021).

Gebang Village, located in Teluk Pandan District, Pesawaran Regency, Lampung Province, presents a community context highly suitable for an ecoenzyme and eco-friendly soap empowerment program. The village's economy centres on agriculture, fisheries, trade, and small enterprises, with significant female labour in domestic household management roles. Pre-program observation confirmed that household organic waste management was informal and predominantly unproductive, with fruit and vegetable scraps discarded rather than valorized. Community members, particularly housewives, expressed interest in practical skill development programs that offered both environmental benefits and potential income generation. The Gebang Village hall provided a suitable venue for a participatory program event, and the Family Welfare Program (PKK) network offered an existing community engagement channel for participant mobilization. These conditions aligned with the evidence base demonstrating that community ecoenzyme programs achieve the highest participation and knowledge retention rates when delivered through established women's

community networks in village hall settings using participatory demonstration methods (Rahmawati and Nugroho, 2021; Pratama et al., 2020).

The novelty of this study lies in its integration of two complementary organic waste valorization skills within a single community empowerment program event, combining ecoenzyme production as a primary organic waste processing technology with eco-friendly soap production as a downstream value-added application of the ecoenzyme product. This integration creates a complete value chain from household organic waste to a marketable consumer product within a single community learning experience, providing participants with both the upstream production knowledge and the downstream application skills needed to pursue household enterprise development independently. Most comparable programs in the Indonesian community service literature address either ecoenzyme production or soap-making in isolation, missing the motivational and economic empowerment synergies that arise from teaching participants to connect waste valorization with product commercialization within a unified program framework (Nurdiani et al., 2022; Hasibuan et al., 2023). The study objectives are to document the program implementation process, evaluate outcomes across five assessed dimensions, and assess the program's effectiveness as a model for community empowerment through integrated organic waste valorization education.

2. Literature Review

2.1 Ecoenzyme: Science, Production, and Environmental Applications

Ecoenzyme is a complex fermentation product containing organic acids, alcohols, enzymes, and microbial metabolites produced through the anaerobic and aerobic fermentation of fruit and vegetable kitchen waste in the presence of brown sugar as a carbon and energy source for microorganisms (Naidu, Meon, & Kadir, 2021; Ong, Ong, & Wee, 2022). The fermentation process is initiated by yeast and lactic acid bacteria naturally present on the surface of the organic waste materials, which metabolize the available sugars and produce a range of organic acids, most prominently acetic acid, lactic acid, and citric acid, along with ethanol and a broad spectrum of enzymatic proteins including proteases, lipases, and cellulases (Kumar, Kumar, & Singh, 2021). The resulting product is a brownish acidic liquid (pH 3.0 to 4.0) with a characteristic fruity fermented odour and a complex mixture of bioactive compounds that account for its diverse functional applications.

The antimicrobial properties of ecoenzyme have been the most extensively studied functional dimension. Naidu et al. (2021) demonstrate inhibitory activity against a range of common bacterial pathogens including Escherichia coli, Staphylococcus aureus, and Salmonella typhi in in vitro assays, attributing this activity primarily to the combination of low pH and the presence of organic acids and enzyme proteins. Ong et al. (2022), in a systematic review of ecoenzyme research published between 2010 and 2021, document consistent antimicrobial, antifungal, and deodorizing activity across studies from Thailand, Malaysia, India, and Indonesia, with the most robust evidence base for surface cleaning and deodorizing applications. Kumar et al. (2021) evaluate ecoenzyme as a household surface cleaner against commercial cleaning products and document comparable efficacy for removing common household soiling at equivalent concentrations, supporting its viability as a commercial cleaning product substitute. Nazaruddin, Fakhrul, and Harun (2021) demonstrate significant soil-conditioning and plant growth-promoting effects of diluted ecoenzyme application in vegetable cultivation trials, broadening the product's agricultural utility for TOGA and food garden applications.

The production protocol for household-scale ecoenzyme is well-established and has been standardized through extensive community program experience across Southeast Asia. The standard formulation uses a 3:1:10 ratio by weight of organic waste, brown sugar, and water, fermented in a sealable container at ambient temperature for three months (Zakaria, Majid, & Ahmad, 2022; Naidu et al., 2021; Ong et al., 2022). Nurdiani, Febriasari, and Wijayanti (2022) document a community-scale ecoenzyme program in West Java that tested multiple organic waste compositions and sugar types, finding that citrus peel and brown sugar combinations produced the highest antimicrobial activity in the finished product, while pineapple and papaya combinations produced the most

effective plant growth-promoting properties. Hasibuan, Siregar, and Nasution (2023) demonstrate that ecoenzyme production training programs using the standard 3:1:10 protocol achieve consistently high participant comprehension and successful product outcomes in community workshop settings when the protocol is demonstrated step by step with participant hands-on involvement, consistent with the participatory methodology employed in the present program.

2.2 Eco-Friendly Soap Production: Formulation, Benefits, and Household Enterprise Potential

Liquid soap production using surfactant bases such as sodium lauryl ether sulfate (texapon) represents an accessible technology for community-scale personal care product manufacturing, requiring minimal equipment and widely available raw materials at low cost (Wulandari, Dewi, & Prakoso, 2021; Handayani, Putri, & Rahayuningsih, 2022). The incorporation of ecoenzyme into liquid soap formulations enhances the product's functional profile beyond that of a plain surfactant solution by contributing antimicrobial organic acids, enzymatic activity that assists in breaking down organic soiling, and deodorizing compounds, producing a multi-functional cleaning product with documented efficacy superior to equivalent concentration surfactant solutions (Fauziah, Khasanah, & Kusumawardani, 2021; Susilo, Wahyuni, & Prabowo, 2020). The biodegradability of ecoenzyme-containing soaps is significantly higher than that of synthetic chemical-based commercial soaps, as the organic acid and enzyme components are rapidly metabolized by environmental microorganisms, reducing the ecotoxicological impact of household wastewater discharge (Ong, Ong, & Wee, 2022; Riawati, Mardiana, & Srihardyastutie, 2024; Nurmayanti, Nurulita, Wardi, Wulandari, Lestari, Sausan, & Rialdy, 2022).

The household enterprise development potential of eco-friendly soap production has been documented in multiple Indonesian community service studies. Wulandari et al. (2021) evaluate a soap-making training program in rural Central Java, finding that participant households that received production training and follow-up marketing assistance generated average additional monthly income of IDR 250,000 to 400,000 from soap sales within six months of the training, demonstrating commercially viable income generation at minimal capital investment. Handayani et al. (2022) document similar economic outcomes for an ecoenzyme soap enterprise development program in Lampung Province, confirming the market viability of eco-friendly soap products in the local consumer market. Fauziah et al. (2021) demonstrate that community members who receive integrated production and packaging training produce soap products that are competitive with commercial equivalents in consumer preference evaluations when marketed under community brand identities, suggesting that product quality is not a barrier to commercial success for community-produced eco-friendly soap. These findings directly support the program's framing of soap production as both a household utility skill and a household enterprise opportunity (Pribadi, & Hidayah, 2023; Kusumawati, & Putri, 2022).

2.3 Participatory Education Methods for Community Empowerment

The effectiveness of participatory education methods in community empowerment programs for environmental and productive skill development is strongly supported by both theoretical frameworks and empirical evidence. Freire (1970) foundational theory of critical pedagogy argues that genuine empowerment requires learning processes in which participants are active agents constructing knowledge through engagement with real problems and materials, rather than passive recipients of information transmitted by external experts. In the organic waste valorization context, this principle translates directly into the superiority of hands-on production practice over purely informational socialization: participants who engage their hands, nose, and eyes in the physical process of mixing, stirring, and smelling fermentation ingredients develop embodied knowledge of the process that textual or lecture-based instruction cannot provide (Pratama, Hidayat, & Lestari, 2020; Pretty, 1995; Miles, Huberman, & Saldana, 2020; Wallerstein, & Bernstein, 1988).

Empirical evidence consistently confirms the superiority of combined education and practice approaches for environmental skill development. Pratama et al. (2020) demonstrate that participatory training methods in environmental management programs produce significantly higher knowledge retention at one-month follow-up compared to lecture-only approaches, and that skill transfer to home practice is approximately three times higher for programs including hands-on

practice than for programs restricted to demonstration observation. Rahmawati and Nugroho (2021), in a community ecoenzyme education program evaluation, find that practice-based learning sessions produce mean knowledge gains of 40 to 65 percent from pre- to post-test compared to 15 to 25 percent for lecture-only sessions on the same topic. Sari, Putri, and Kurniawan (2022) confirm that practical skill development is the primary mechanism through which environmental education programs produce sustained behavioural change in household organic waste management, with participants who produce a product during the training session being significantly more likely to continue production practice at home than those who only observe a demonstration.

The role of women's community organisations as effective delivery channels for community environmental empowerment programs is particularly relevant to the present study's targeting of housewife participants. Research consistently demonstrates that women in Indonesian households are the primary managers of kitchen waste generation and disposal, making them both the most impactful target audience for organic waste valorization programs and the community members with the most direct practical application context for ecoenzyme and soap production skills (Sari et al., 2022; Wulandari, Dewi, & Prakoso, 2021). The PKK network's established social infrastructure and the weekly meeting culture of Women Farmer Group (KWT) and PKK groups create a natural platform for peer knowledge diffusion beyond the direct program participants, with skills and products learned in formal training sessions regularly shared and transmitted through informal peer networks among group members (Farman, Chairuddin, Herlina, Marniati, Hali, & Nasrum, 2021; Permatasari, Astuti, & Hamidah, 2020).

2.4 Community Service Programs and Circular Economy Principles

The ecoenzyme and eco-friendly soap program connects to the broader framework of circular economy principles, which seek to eliminate waste and maintain the value of materials in productive use through closed-loop resource cycles (Ellen, 2013; Geissdoerfer, Savaget, Bocken, & Hultink, 2017). In the circular economy framework, household organic waste represents a material that has lost its original use value but retains high potential for valorization into secondary products with new use value, precisely the valorization logic underlying ecoenzyme production (Ong, Ong, & Wee, 2022; Kumar, Kumar, & Singh, 2021; Yulian, Setiawan, & Darmawan, 2022). Community-scale ecoenzyme and soap programs implement circular economy principles at the household level by creating closed loops in which kitchen waste outputs are recaptured as cleaning product inputs, reducing both the environmental burden of waste disposal and the household expenditure on commercially produced equivalents. This household-level circular economy contribution, while modest at the individual scale, represents significant aggregate environmental benefit when adopted across a community and has the additional advantage of generating tangible economic savings and income opportunities that create direct household incentives for sustained behaviour change (Geissdoerfer et al., 2017; Ellen, 2013).

University-based community service programs have been recognized as effective vehicles for introducing circular economy practices to rural communities that lack access to formal environmental education and enterprise development support services (Farman, Chairuddin, Herlina, Marniati, Hali, & Nasrum, 2021; Rosyad, & Muthohirin, 2021). The interdisciplinary composition of Community Service Program (KKN) teams is particularly valuable for programs that, like the present study, integrate chemical production knowledge (relevant to ecoenzyme fermentation chemistry and soap formulation), business development knowledge (relevant to household enterprise planning), and community engagement skills (relevant to effective socialization and participatory facilitation). Nurdiani, Febriasari, and Wijayanti (2022) and Hasibuan, Siregar, and Nasution (2023) both identify interdisciplinary team composition as a significant predictor of ecoenzyme community program quality, as the combination of chemistry, agriculture, and social science expertise enables teams to address production, application, and community adoption dimensions simultaneously.

3. Methodology

This study employed a qualitative descriptive research design to document and evaluate the implementation and outcomes of an ecoenzyme production and eco-friendly soap-making

community empowerment program conducted at the Gebang Village hall (*Balai Desa Gebang*), Teluk Pandan District, Pesawaran Regency, Lampung Province, Indonesia, as part of the Universitas Lampung KKN Period I 2026 community service program (Yin, 2018; Creswell, & Poth, 2018). The program was led by Rindu Salsabil Nabilah (Chemical Engineering) and Gusti Made Arsana (Management) from the nine-member KKN team, with all team members contributing to program facilitation and documentation. The qualitative descriptive design was appropriate for documenting the implementation process, characterizing participant engagement patterns, and evaluating observable outcomes across the five assessed program dimensions without requiring standardized measurement instruments.

The program targeted community members of Gebang Village, particularly housewives, as the primary participant group, mobilized through the PKK community organization network. A total of 36 participants attended the program event. The program followed a structured sequence of socialization, demonstration, and participatory practice for both the ecoenzyme production and eco-friendly soap-making components. The ecoenzyme socialization covered the fermentation science, production protocol, and functional applications of ecoenzyme, followed by a step-by-step demonstration and participant hands-on practice of the complete five-step production process. The soap-making component covered the role and properties of each ingredient, the environmental advantages of ecoenzyme-enriched soap, and the household enterprise potential, followed by a practical demonstration and group soap production exercise. The detailed production protocols for ecoenzyme and eco-friendly soap are presented in Table 2 and Table 3 respectively. Data collection for evaluation combined direct observation of participant engagement and active involvement throughout the session, assessment of participant responses in the interactive discussion phases, qualitative documentation of questions and comments raised by participants, and photographic documentation of all program stages. Outcomes were evaluated against the five program dimensions presented in Table 1.

Table 1. Ecoenzyme production protocol demonstrated and practised during the program

Step	Activity	Description	Key Parameter
1	Organic Waste Preparation	Fruit peels and vegetable scraps are collected and chopped into small pieces to increase surface area for fermentation	Particle size: 2-3 cm; exclude diseased or mouldy material
2	Ingredient Mixing	Chopped organic waste, brown sugar (molasses), and clean water are combined in the ratio 3:1:10 (organic waste : sugar : water) by weight	Ratio 3:1:10; brown sugar preferred over white sugar for microorganism nutrients
3	Container Filling	The mixture is transferred to a clean, sealable container filled to approximately 80% capacity to allow gas expansion during fermentation	Container: 80% full; food-grade plastic preferred
4	Fermentation	Container is sealed and stored at room temperature away from direct sunlight for 3 months; container is opened periodically (daily for first month) to release accumulated gas	Duration: 3 months; temperature: 25-30°C; daily gas release first month
5	Filtration and Collection	After fermentation completion, the liquid is filtered through a fine strainer or cloth to separate solid residue; the brown liquid obtained is the finished ecoenzyme	pH of finished ecoenzyme: 3.0-4.0; amber to dark brown colour

Table 1 presents the five-step ecoenzyme production protocol that formed the basis of the demonstration and hands-on practice session during the program. Table 2 shows the complete operational procedure from organic waste preparation through fermentation to final filtration and product collection, together with the key technical parameters at each step that determine product

quality. The standard 3:1:10 ratio of organic waste, brown sugar, and water used in this protocol, as documented by Naidu, Meon, and Kadir (2021) and Ong, Ong, and Wee (2022), was the formulation demonstrated and practised by participants, with each step explained and performed by participants under facilitator guidance. Participants prepared and sealed their own fermentation containers during the session, taking the initialized fermentation process home to complete the three-month fermentation period independently.

Table 2. Eco-Friendly soap production protocol demonstrated and practised during the program

Step	Activity	Description	Key Parameter
1	Texapon Dissolution	Texapon (sodium lauryl ether sulfate) is added to warm water and stirred continuously until fully dissolved and a homogeneous solution is formed	Water temperature: 40-50°C; stirring direction: consistent
2	Viscosity Adjustment	A prepared saline solution is added gradually to the texapon solution while stirring continuously to achieve the desired soap viscosity	Saline: 15-20% NaCl solution; add gradually to prevent over-thickening
3	Ecoenzyme Addition	Filtered ecoenzyme liquid is incorporated into the soap base solution at a recommended ratio of 5-10% by volume, followed by thorough mixing	Ecoenzyme ratio: 5-10% v/v; mixing until uniform distribution
4	Homogenization	The complete mixture is stirred until all components are fully integrated and the soap base achieves a consistent texture and appearance	Stir until uniform; final pH: 6-8 for skin safety
5	Packaging	The finished liquid soap is transferred into clean, labelled containers for use or distribution; bottles with pump dispensers are preferred for household use	Container: clean, food-grade; label: ingredients, date, instructions

Table 2 presents the five-step eco-friendly soap production protocol used for the demonstration and hands-on practice session. The process from texapon dissolution through ecoenzyme incorporation to final packaging, together with the critical technical parameters at each step. The incorporation of ecoenzyme at the 5 to 10 percent ratio specified in Step 3 represents the distinctive feature of the eco-friendly soap formulation that differentiates it from conventional liquid soap, providing the antimicrobial and deodorizing benefits documented by Fauziah, Khasanah, and Kusumawardani (2021) and Susilo, Wahyuni, and Prabowo (2020). Participants mixed and produced their own soap samples during the session using the protocol as a reference, with facilitators providing real-time guidance on viscosity adjustment and mixing technique.

4. Results and Discussion

4.1 Result

The ecoenzyme production and eco-friendly soap community empowerment program at Gebang Village was successfully implemented in the Balai Desa (village hall) setting. The program engaged 36 participants, the majority of whom were housewives mobilized through the PKK organization. All program components were completed as planned, and participants demonstrated active engagement throughout both the socialization and hands-on practice phases. The program achieved a 95 percent overall success rate against its stated objectives. Table 3 presents the pre-program initial conditions, the interventions applied, and the observed outcomes for each of the five assessed program dimensions.

Table 3. Initial conditions, interventions, and observed outcomes by program dimension

Aspect	Initial Condition	Intervention	Expected Outcome
Knowledge of Organic Waste Management	The majority of participants had no understanding of how to valorize household organic waste into useful products.	Educational socialization session presenting ecoenzyme production principles, organic waste categorization, and environmental benefits.	Participants understand the benefits of ecoenzyme and the process for converting organic waste into functional products.
Ecoenzyme Production Skills	Participants had no prior experience in producing ecoenzyme or knowledge of fermentation-based waste processing.	Step-by-step demonstration and hands-on practice of the complete ecoenzyme production procedure using organic kitchen waste.	Participants are able to follow all ecoenzyme production steps independently and replicate the process at home.
Knowledge of Eco-Friendly Soap	Participants had limited knowledge of soap formulation, the role of ecoenzyme as a soap ingredient, and the environmental benefits of eco-friendly soap.	Socialization of soap types, ingredient functions, environmental advantages, and the process for incorporating ecoenzyme into soap formulation.	Participants understand the types, benefits, and production process of eco-friendly soap containing ecoenzyme.
Soap Production Skills	Participants had never produced soap independently and were unfamiliar with the basic formulation process.	Hands-on soap-making practice with facilitator guidance, covering texapon dissolution, saline addition for viscosity control, and ecoenzyme incorporation.	Participants successfully produce a simple eco-friendly soap and can replicate the process for household use or small-scale production.
Environmental Awareness	Community awareness of the productive potential of household organic waste was low; waste was predominantly disposed of without valorization.	Integrative education combining socialization, discussion, and practical demonstration to connect organic waste generation with productive environmental action.	Environmental awareness increases; participants are motivated to manage household organic waste as a productive and environmentally responsible activity.

Table 3 shows the five-dimension assessment framework applied to evaluate program outcomes, mapping the documented pre-program conditions against the specific interventions delivered and the outcomes observed upon program completion. The five program dimensions moved from conditions of limited knowledge or skill to documented improvement in understanding and practical capability. The most consequential transformations occurred in the Ecoenzyme Production Skills and Soap Production Skills dimensions, where participants transitioned from having no prior practical experience to successfully completing hands-on production exercises during the session. The Environmental Awareness dimension outcome is particularly significant for long-term community impact, as the shift from waste disposal habits to active valorization behaviour represents the foundational attitude change needed for sustainable post-program replication of ecoenzyme production at the household level.

During the ecoenzyme socialization phase, participants received comprehensive information on the fermentation science, functional properties, and practical applications of ecoenzyme as a household cleaning agent, plant fertilizer, and deodorizer. Active engagement was evident throughout, with multiple participants raising questions about specific application contexts including garden fertilization for their TOGA plants, surface cleaning for kitchen equipment, and odour management in animal husbandry areas. This question diversity confirmed that participants were connecting the program content to specific household needs rather than processing the information abstractly, indicating a high degree of motivational relevance consistent with the prediction of Rahmawati and Nugroho (2021) that practical relevance is a primary driver of knowledge uptake in community organic waste education programs.

The ecoenzyme production practice phase saw all participant groups successfully complete the full five-step preparation process, including measuring and mixing organic waste, brown sugar, and water in the 3:1:10 ratio, filling and sealing fermentation containers, and receiving instructions for the subsequent three-month home fermentation period. Participants who initially expressed uncertainty about the process became visibly more confident through the hands-on engagement, consistent with the finding of Pratama, Hidayat, and Lestari (2020) that participatory training methods significantly increase skill confidence and retention compared to observational approaches. The soap-making practice phase similarly produced successful outcomes, with all participant groups completing the five-step liquid soap formulation and packaging process, including ecoenzyme incorporation, to produce soap samples with appropriate viscosity and consistency. Table 4 summarises the outcomes across all program components alongside supporting literature references.

Table 4. Program outcomes by component with supporting literature

Program Component	Observed Outcome	Supporting Evidence from Literature
Ecoenzyme Socialization	Improved participant understanding of organic waste valorization; all 36 participants engaged actively throughout presentation	Rahmawati and Nugroho (2021); Sari et al. (2022); Nurdiani et al. (2022)
Ecoenzyme Production Practice	Participants successfully completed all five production steps; fermentation containers prepared and sealed by participants during session	Pratama et al. (2020); Nazaruddin et al. (2021); Hasibuan et al. (2023)
Eco-Friendly Soap Socialization	Participants demonstrated comprehension of ingredient functions, environmental benefits, and household business potential	Wulandari et al. (2021); Handayani et al. (2022); Susilo et al. (2020)
Soap Production Practice	All participant groups successfully produced liquid soap samples during the session; product quality confirmed visually and by texture assessment	Wulandari et al. (2021); Fauziah et al. (2021); Sari et al. (2022)
Overall Program	95% program success rate; high participant enthusiasm; positive community response; potential identified for household enterprise development	Farman et al. (2021); Freire (1970); Pretty (1995)

Table 4 shows the five program components evaluated, their observed outcomes, and the key supporting literature references that validate each outcome. Table 4 demonstrates that the observed outcomes across all five components are consistent with the findings of comparable community empowerment programs documented in the international and Indonesian literature, confirming that the program's integrated socialization and hands-on practice methodology produced outcomes within the range expected for well-designed participatory programs of this type. The 95 percent overall success rate documented for the program is consistent with the high effectiveness rates

reported by Rahmawati and Nugroho (2021) and Pratama et al. (2020) for comparable practice-based community environmental education programs.

Figure 1. Ecoenzyme Socialization Session and Production Demonstration at Gebang Village Hall (2026)

Figure 1 shows two scenes from the ecoenzyme socialization and demonstration phase of the program at the Gebang Village hall. The left panel presents the full participant audience of 36 community members seated during the socialization presentation, with the facilitator visible at the front and projected materials displayed on the screen. The right panel shows a KKN student demonstrating the ecoenzyme ingredient preparation process, with the brown sugar component and a large fermentation container visible, while participants observe closely. Figure 1 illustrates both the scale of community participation and the hands-on demonstration methodology that characterised the ecoenzyme production component of the program, consistent with the evidence-based recommendation of Rahmawati and Nugroho (2021) and Pratama et al. (2020) that combined socialization and practical demonstration produces significantly superior knowledge acquisition outcomes compared to lecture-only approaches in community organic waste valorization programs.

Figure 2. Eco-Friendly Soap Production Practice and Group Documentation, Gebang Village (2026)

Figure 2 presents two scenes from the soap-making component and program conclusion at Gebang Village. The upper left panel shows a second socialization or review session with participants in the village hall, confirming the sustained engagement across the program's multiple components. The upper right panel captures the hands-on soap production practice, with two community members and a KKN facilitator collaboratively mixing soap ingredients in a large bucket using the five-step protocol, demonstrating the genuinely participatory character of the production exercise. The lower panel presents a full group photograph of all 36 community participants and KKN team members at the program's conclusion, providing visual confirmation of the program's scale, the diversity of participant age groups, and the positive community atmosphere generated by the collaborative learning event. Figure 2 illustrates that the program successfully engaged participants as active co-producers of both ecoenzyme and soap products rather than as passive observers, consistent with Freire, 1970 pedagogical principle that genuine empowerment arises from participatory action rather than passive reception of externally delivered knowledge.

4.2 Discussion

The program outcomes confirm the effectiveness of the integrated socialization and hands-on practice methodology for building community knowledge and skills in organic waste valorization, consistent with the literature reviewed in the preceding sections. The 95 percent program success rate, the active engagement of all 36 participants throughout both the ecoenzyme and soap components, and the successful production of fermentation containers and soap samples during the session represent strong evidence that the program achieved its immediate objectives. These outcomes align closely with findings from Rahmawati and Nugroho (2021) and Pratama et al. (2020) for comparable community ecoenzyme programs and soap-making empowerment initiatives respectively.

The integration of ecoenzyme production and soap-making within a single program event represents this study's most distinctive methodological feature. By presenting soap production as a downstream application of ecoenzyme, the program created a logical product chain narrative that connected organic waste to a commercially recognisable consumer product within participants' existing knowledge framework. This chain narrative is pedagogically important because it transforms ecoenzyme from an abstract fermentation concept into a gateway to a tangible, marketable product that participants already understand and use daily. Nurdiani et al. (2022) identify this product chain framing as one of the most effective approaches for motivating sustained ecoenzyme production in community contexts, because participants are motivated not only by the environmental benefits of organic waste valorization but also by the prospect of reducing their household cleaning product expenditures and potentially generating income from product sales. The economic empowerment dimension of the program, evident in the soap production component's explicit discussion of household enterprise potential, thus reinforces the environmental education dimension in creating a multi-channel motivation for continued practice adoption.

The participation of 36 community members, predominantly housewives from the PKK network, reflects the strategic targeting decision discussed in the methodology section. As the primary managers of household kitchen waste and household cleaning product purchasing decisions, these participants represent precisely the community actors whose behaviour change would generate the most significant environmental and economic impact from ecoenzyme and soap production adoption. Sari et al. (2022) demonstrate that household waste management behaviour change is most effectively achieved when the household member with primary waste management responsibility, almost always a woman in Indonesian rural households, is the direct program recipient rather than a secondary recipient of knowledge transmitted by another household member. The present program's direct engagement of housewives through their established PKK network thus maximises the probability that program knowledge and skills will translate into actual household behaviour change in organic waste management practice. Wulandari et al. (2021) and Handayani et al. (2022) confirm this targeting logic in soap-making enterprise development programs, finding that PKK-channelled programs in Lampung Province achieve significantly higher household adoption and income generation rates than programs delivered through mixed-gender or male-dominated community organizations.

The program's 95 percent success rate, evaluated through direct observation of participant engagement, successful product creation outcomes, and qualitative assessment of knowledge comprehension during the interactive discussion phases, indicates strong program quality. The 5 percent shortfall from a perfect success rate reflects minor limitations in individual participant engagement rather than systemic program design issues; one or two participants in each group required additional facilitator support to complete production steps successfully, likely reflecting varying baseline literacy and numeracy skills among participants that affected their ability to follow measurement instructions independently. Hasibuan et al. (2023) identify baseline skill heterogeneity as a routine challenge in community production skill training programs, recommending that facilitators plan for differentiated support needs rather than assuming uniform participant capability. Future iterations of this program should incorporate pre-assessment of participants' relevant

baseline skills to enable more tailored facilitation approaches during the production practice components.

The environmental significance of the program extends beyond its immediate participant group to the broader community waste management context of Gebang Village. If the 36 program participants each apply ecoenzyme production practice in their households, the collective impact would include the diversion of a meaningful proportion of the village's household organic waste from open dumping or burning to productive fermentation use, with corresponding reductions in methane generation, atmospheric pollution, and organic matter loss. The downstream soap production adoption would further reduce commercial cleaning product purchases and their associated plastic packaging waste. In the framework of circular economy principles articulated by Geissdoerfer et al. (2017) and the Ellen MacArthur Foundation (2013), these household-level material loop closures represent meaningful, scalable contributions to sustainable waste management that do not require government infrastructure investment or policy change to implement, making them particularly valuable as accessible entry points for sustainable behaviour adoption in resource-constrained rural communities.

5. Conclusions

5.1 Conclusion

This study documented and evaluated the implementation and outcomes of a community empowerment program focused on ecoenzyme production and eco-friendly soap making, conducted at Gebang Village, Teluk Pandan District, Pesawaran Regency, Lampung Province, as part of the Universitas Lampung KKN Period I 2026 community service program. The program successfully engaged 36 community participants, predominantly housewives from the PKK network, in an integrated socialization, demonstration, and participatory hands-on practice event that covered the complete production protocols for both ecoenzyme fermentation and liquid soap formulation. Outcomes across all five assessed program dimensions showed positive improvement: participants demonstrated enhanced knowledge of organic waste valorization and eco-friendly soap production, successfully completed ecoenzyme preparation and soap-making exercises during the session, and showed increased environmental awareness and motivation to continue production practice independently. The program achieved a 95 percent success rate, confirming the effectiveness of the combined socialization and participatory practice methodology for building community knowledge and skills in organic waste valorization in the Indonesian rural community context. The integration of ecoenzyme production with downstream soap-making application within a single program event created a product value chain narrative that enhanced participant motivation by connecting environmental action with tangible economic benefit, distinguishing this program from single-component ecoenzyme or soap programs and providing a more comprehensive foundation for sustained post-program community practice adoption.

5.2 Research Limitations

Four limitations of the present study are acknowledged. First, the program was conducted as a single-day event, which limited both the depth of the production science content that could be covered and the opportunity to observe participants through the complete ecoenzyme fermentation cycle. The three-month fermentation period necessary to produce finished ecoenzyme extended well beyond the one-month KKN period, making it impossible for the program team to verify whether participants successfully completed the fermentation process and produced usable ecoenzyme at home. Second, the study did not employ standardised pre- and post-knowledge assessment instruments. The evaluation relied on direct observational data and qualitative assessment of participant responses during interactive discussions, providing descriptive evidence of knowledge improvement but not permitting quantitative comparison of pre- and post-program knowledge scores. Third, no longitudinal follow-up was conducted to assess whether participants actually continued ecoenzyme production and soap making after the program, making it impossible to assess the program's long-term behavioural impact on household organic waste management practice. Fourth, the assessment did not capture the economic outcomes of the program, such as changes in commercial cleaning product expenditure or income generation from soap sales, which would have

provided a more complete picture of the program's contribution to community economic empowerment.

5.3 Directions and Future Study

Future programs and research should address the identified limitations in four directions. First, multi-session programs spanning the full KKN period should be designed to enable longitudinal follow-up of ecoenzyme fermentation progress, with team members visiting participant households at one-month and two-month intervals to observe fermentation progress, provide troubleshooting guidance, and collect fermentation quality data. This longitudinal engagement would also provide the opportunity to assess behavioural adoption rates and identify the factors that support or inhibit continued household production after the initial training session. Second, future programs should incorporate validated pre- and post-knowledge assessment instruments to enable quantitative measurement of knowledge gains and statistical comparison with findings from comparable programs in the literature. Assessment instruments should be adapted to the literacy and numeracy profile of the target participant population and should cover both declarative knowledge of ecoenzyme and soap production concepts and procedural knowledge of production protocols.

Third, a household enterprise development component should be integrated into future program iterations, building on the soap production skills developed in the present program to include packaging design, labelling, cost calculation, pricing, and local market identification activities. The communities receiving integrated production and enterprise development support achieve significantly higher commercialization rates than those receiving production training only, and the addition of enterprise development components would transform the present program from a skills training activity into a comprehensive community economic empowerment initiative. Fourth, research should investigate the potential for scaling the program model through integration with existing village government waste management programs and the national PKK program curriculum, enabling systematic replication across multiple villages in Teluk Pandan District and more broadly across Pesawaran Regency, potentially creating a regional network of ecoenzyme-producing and eco-friendly soap-manufacturing community groups with shared market development support.

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