Economic Analysis on the Use of Clove Leaf Essential Oil Waste for Making Non-Burning Interlock Bricks

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Abstract. The production of essential oil from clove leaves in Samigaluh, Yogyakarta, generates waste that is slow to decompose and accumulates, posing environmental challenges. The disposal of this waste into rivers threatens aquatic habitats and exacerbates pollution in local communities. In collaboration with the Adi IAI Foundation, a study was conducted to explore the potential use of clove leave essential oil waste in the production of non-burning interlock bricks. This research aims to evaluate the economic viability of utilizing clove leaf waste as a raw material in brick manufacturing. The study involved analyzing the cost-benefit structure of using waste material compared to traditional brick making methods. Factors such as production costs, material availability, environmental impact reduction, and potential market demand were evaluated. Findings from this economic analysis show promising results, indicating a reduction in both raw material costs and environmental pollution. The utilization of clove leaf waste not only addresses a significant environmental concern but also offers an economically sustainable alternative for local industries. The integration of clove leaf essential oil waste into brick-making processes could serve as a viable waste management strategy while supporting environmentally sustainable economic development. Policymakers should encourage similar eco-friendly innovations in other waste-producing industries

1 Introduction

The production of clove leaf essential oil in Samigaluh, Yogyakarta, generates a significant amount of waste. This waste is produced by several small home-based essential oil industries, which process dried clove leaves, collected from naturally fallen or pruned clove plants, into essential oil. Processing clove leaves into essential oil leaves blackish brown waste. This waste cannot be decomposed immediately, accumulating due to the continuous production process. It is estimated that one home essential oil industry accumulates one ton of waste per month. From observations, it is known that this waste has polluted the environment and there are several home industries dumping waste into the river. Research states that clove essential

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oil processing waste must be managed immediately because the waste solids can pollute environmental water and make it unfit for use [1].

The research is conducted with CV. Bata Interlock Adi IAI (Adi IAI Foundation), which specialized in non-burning interlock bricks. These bricks do not require traditional adhesives such as cement for installation; instead, they are designed to interlock with one another. Initially, the company produced interlock bricks from ordinary clay, then developed to innovate and research mixed raw materials including from waste. The proximity of the interlock brick production site to the essential oil industries in Samigaluh presents a logistical advantage for utilizing the waste material in brick production.

Discussions with the research team from the Universitas Muhammadiyah Yogyakarta agreed to research interlock brick production using mixed raw materials with waste essential oils from clove leaves. The study was carried out in several aspects, and in this research, it is an economic study. The study covers multiple aspects, including cost assessments, technical feasibility, and market viability. The waste-based interlock bricks offer potential environmental benefits by reducing pollution, while also presenting an economically viable alternative to traditional materials. Furthermore, the research seeks to identify the most technically feasible and economically profitable composition for the interlock bricks using this waste. The study is expected to provide a sustainable solution for both the waste management problems of essential oil producers and the demand for eco-friendly construction materials. By incorporating clove leaf essential oil waste into brick manufacturing, this approach aligns with circular economic principles, reducing environmental harm and offering cost-effective building materials. Future policy recommendations will encourage further innovations in waste utilization across other industries.

2 Methods

2.1 Interlock Brick Production Process with Mixed Waste Materials

The production process for interlock bricks made from a mixture of essential oil waste from clove leaves follows the general flow or stages of the interlock brick production process at the Adi IAI Foundation which has been used previously:

a) Loading and Hauling: the required materials are distributed from the source to the raw material warehouse closest to the building location according to needs.
b) Storage: materials are collected around the production area to make it easier and easier closer if it is used.
c) Milling: the material is smoothed using a Hammer Mill Machine which was designed by the Adi IAI Foundation itself
d) Sieving: material that is already fine is sifted to make it cleaner without gravel interfering with the mixing process.
e) Mixing: mixing raw materials using a Mortar Mixer designed by the Adi IAI Foundation
f) Pressing: materials that have been mixed evenly are printed using an Interlock Brick Molding designed by the Adi IAI Foundation
g) Drying: the printed interlock bricks are then dried using condensation or air drying (drying without sunlight)

The composition of the mixture is the most urgent thing in the production process of interlock bricks made from clove leaf essential oil waste. This study focuses on how to find a mixture composition that is technically and economically feasible. If the previous production process used clay as the main raw material, in this study the clay raw material was replaced with essential oil waste from clove leaves. Technical research carried out by

the civil engineering team finally found the best composition according to civil engineering rules. The composition is: essential oil waste 4 kg, clay 1 kg, cement 1 kg, and sand 1 kg. Total mixed material: 7 kg, produces 4 interlock bricks according to the capacity of the molding equipment.

2.2 Economic Analysis of Interlock Brick Production Made from Essential Oil Waste from Clove Leaves

Economic analysis is carried out by calculating total production costs, including explicit and implicit costs. Explicit costs include raw materials, labor, equipment depreciation, electricity, and other costs. Meanwhile, implicit costs include labor costs in the family and interest on own capital. Interlock brick production is calculated in units, the price of interlock bricks is the local price (excluding delivery costs). The amount of production times the price is revenue (production value). Income is calculated from revenue minus explicit production costs. Income is calculated per day and then converted per month (assuming 25 working days/month). Profit is calculated from revenue minus implicit costs of production. Cost, income, and profit analysis are used to calculate the feasibility of an interlock brick production business made from waste essential oil from clove leaves.

2.3 Economic Analysis Formula

The analysis calculates production costs, revenue, income, profits, and business feasibility. The calculation of production costs uses the Sukartawi concept, which is used by [2], [3], [4], [5], and [6]

2.3.1 Total Cost calculated by the formula:

$$TC = TEC + TIC \tag{1}$$

where, *TC* was Total Cost (IDR); *TEC* was Total Explicit Cost (IDR); and *TIC* was Total Implicit Cost (IDR)

2.3.2 Total Revenue calculated by the formula

$$TR = P \; x \; Q \tag{2}$$

where, *TR* was Total Revenue (IDR); *P* was Price per unit product (IDR) ; and *Q* was Total product (unit).

2.3.3 Net Revenue (Income) calculated by formula:

$$NR = TR - TEC \tag{3}$$

where, *NR* was Net Revenue (IDR); *TR* was Total Revenue and *TEC* was Total Explicit Cost (IDR).

2.3.4 Profit calculated by the formula

$$\pi = TR - TC \tag{4}$$

where, π was Profit (IDR); *TR* was Total Revenue (IDR) and *TC* was Total Cost (IDR)

2.3.5 Break Event Point (BEP)

$$BEP\ on\ Price = \frac{Explicit\ Cost}{Production\ Total} \quad (5)$$

$$BEP\ on\ Production = \frac{Explicit\ Costs}{Price} \quad (6)$$

2.3.6 Feasibility Analysis

The feasibility of industry used three criteria: RC ratio analyses, and capital productivity analyses.

1) R/C Ratio Analyses

$$RC\ Ratio = \frac{Total\ Revenue}{Total\ Cost} \quad (7)$$

Criteria
R/C > 1: business is feasible
R/C = 1: business is break even
R/C < 1: business is not feasible

2) Capital Productivity Analyses

$$CP = \frac{TR\text{-}RVOF\text{-}FLC}{TEC} x\ 100\% \quad (8)$$

where, *CP* was Capital Productivity; *TR* was Total Revenue; *FLC* was Family Labor's Cost; *TEC* was Total Explicit Cost; and *RVOF* was Rent Value of Own Factory
Criteria:
CP > Bank Interest Rate, business is feasible
CP < Bank Interest Rate, business is not feasible

3 Result and Discussion

3.1 Management of Waste Essential Oil from Clove Leaves

The accumulation of clove leaf essential oil processing waste is evidence of low community participation in handling waste or rubbish, according to research [7]. Individuals in the household should be directed to the discipline of sorting waste so that waste is easier to manage. Unfortunately, in Indonesia, the behavior of sorting waste is not accompanied by a strict control policy. There are no serious sanctions for individual violations of littering. Disciplined individual behavior in sorting waste should be strictly implemented and regulated, as in Beijing, China. The discipline of waste sorting behavior (WSB) has been integrated with the household waste management regulations (NEMAR) policy. The research results show a positive relationship between WSB and NEMAR. High fines are highly effective in increasing discipline in sorting waste (WSB). Propaganda, publications, and training have significantly increased citizens' discipline in sorting waste [8].

Companies or industries that dispose of waste must be strictly regulated and supervised. In Indonesia, these regulations already exist but violations are proven by the high production of hazardous waste[9]. It is time for producer responsibility to be extended (EPR) to waste matters accompanied by the formation of producer responsibility organizations (PRO). The research results in Jordan show that legal instruments are the most vital component of EPR. The most preferred PRO alternative is profiting orientation. This means that managing waste should also bring profits to producers [10].

Solid waste (biosolids) from industry as the main material, substitute material, or as a mixture has been widely used. Some of these studies include research using pumice waste as a building block for lightweight concrete [11]; The utilization of biosolid waste and fly ash as a brick mixture [12]; Utilization of rice husk waste and fly ash for red bricks (burnt bricks) [13]; Utilization of clove leaf waste for briquettes [14], Utilization of oil palm waste (SBE) for bricks [15]; and research on the use of agricultural waste and natural waste into bricks without burning [16].

The amount of research on the use of solid waste to make bricks, both burnt and non-burnt bricks, has encouraged the Adi IAI Foundation's innovation in the production of burnt-free interlock bricks. Interlock brick production, which previously relied on clay, has developed with several trials of mixed materials or substitutions. One interesting material to study is the essential oil waste from clove leaves, which is abundant in Samigaluh.

The research began with the initial orientation of replacing the main material of clay with essential oil waste from clove leaves. The main reason is that clay has become very popular for making bricks. So far, clay bricks are identical to burnt bricks with a reddish color. Even though they are burned, the ecological effects of burned bricks are still lower than their socio-economic effects, according to the results of research in Indonesia [17] and research in Russia [18]. Non-fired interlock bricks made from clay have the appearance of original earth color like raw baked clay bricks (have not undergone the firing process).

The appearance of a color resembling the color of soil makes the quality of the non-burnt clay interlock bricks produced by the Adi IAI Foundation sometimes questionable. People are doubtful about non-burning interlock bricks, especially their water resistance. Even though previous tests of Adi IAI non-burnt interlock bricks had a compressive strength of 60 - 90 kg/cm², equivalent to SNI standard K125 concrete, they were still unable to convince the public. The essential oil waste from clove leaves produces non-burnt interlock bricks that are darker in color, resembling pressed concrete in general, which is made from a mixture of sand and cement.

If in other research on the use of waste for briquettes and concrete material what is generally sought is the formula for changing sand or cement [19], then the Adi IAI Foundation is experimenting with increasing the amount of waste as much as possible, starting from 10%, 20%, 30%, 40% until a formula is found that is still technically test worthy by 80 %. Experiment Adi IAI Foundation found the following effective formula in Table 1.

Table 1. Main Material Formula for Adi IAI Foundation Interlock Bricks

No	Mixed Ingredients	weight (kg)	%
1.	Clove Leaf Essential Oil Waste	50	80
2.	Sand	3	5
3.	Clay	4	7
4.	Cement	5	8
	Total Materials	62	100
	Interlock Brick Production: 14 pieces		
	Brick weight per piece (wet)	4.4	
	Brick dimensions: 25 cm (about 9.84 in) x 12.5 cm (about 4.92 in) x 10 cm (about 3.94 in)		

Table 4 describes a production process with one mixing process according to the capacity of the Adi IAI Foundation machine. 62 kg of mixed materials can produce 14 pieces of interlock brick. From the formula in Table 1, it can be explained that the proportion of essential oil waste material from clove leaves is 50 kg out of 62 kg (80%) of mixed materials. This proportion shows that the essential oil waste from clove leaves has succeeded in substituting more than 90 % of clay. The weight of the interlock bricks after press molding per brick is 4.4 kg. After drying, the average weight of interlock bricks is 4 kg per piece. In

one day, the mixing process to the molding press can be repeated 30 times, so that in one day 420 interlock bricks can be produced.

The color of interlock bricks from waste essential oil from clove leaves which tends to be black, similar to pressed concrete made from sand and cement, turns out to be more attractive and convincing to consumers. The demand for non-burnt interlock bricks from clove leaf essential waste has increased. Installation of interlock bricks that do not require adhesive and are installed like interlocking Legos. After becoming a wall, the majority is not plastered so that it displays its original color. This interlocking technique can make installation easier, faster, and resistant to vibration and shaking [20]. Interlock bricks provide a decorative effect to the building. The difference in dark color of interlock bricks from waste essential oils can be an alternative color combination for buildings.

3.2 Economic Analysis of Interlock Brick Production

The economic analysis of interlock brick production from essential oil waste at the Adi IAI Foundation is to calculate production costs, benefits, and business profits. This calculation is made from daily production converted in one month (for 25 effective working days).

3.2.1 Explicit Costs and Break Event Point

From table 2 it is explained that the total explicit cost of the interlock brick production process made from the main raw material of essential oil waste from clove leaves at the Adi IAI Foundation is (IDR) 2,258,400 per day. Conversion of the production process in one month (assumption: 25 effective days) explicit cost is IDR 56,460,000 per month. The proportion of clove leaf waste costs is the largest (66.42%) of the total production costs. Depreciation costs are calculated by production tools or machines and factory buildings. The value of the machine is IDR 300,000,000 with an economic life of 20 years and a residual value of IDR 20,000,000 so the depreciation is IDR 1,160,000 per month. The factory building price is IDR 200,000,000 with an economic life of 50 years and a residual value of IDR 20,000,000 so the depreciation is IDR 300,000 per month.

Table 2. Cost and BEP of Intrelock Brick Production in Adi IAI Foundation

No	Explicit Cost	Costs per day (IDR)			Costs per month* (IDR)	%
		unit	price	amount		
1.	Clove Leaf Waste (kg)	1500	1,000	1,500,000	37,500,000	66.42
2.	Sand (kg)	90	500	50,000	1,250,000	2.21
3.	Clay (kg)	120	2,000	140,000	6,000,000	10.63
4.	Cement (kg)	150	1,500	150,000	3,750,000	6.64
6.	Elektric Power (token)			50,000	1,250,000	2.21
7.	External Labor (men)	2	100,000	200,000	5,000,000	8.86
8.	Additional costs			10,000	250,000	0.44
8.	Tools Depreciation			46,400	1,160,000	2.05
9.	Building Depreciation			12,000	300,000	0.53
Total Explicit Costs				**2,158,400**	**56,460,000**	**100**
11.	Production total Interlock Brick (pieces)			**420**	**10,500**	
12.	Production rate failed (rejected): 1 %			4,2	105	
13.	Net Production (pieces)				**10,395**	
14.	**Break Event Point** on Price (IDR)				**5,432**	

The production quantity of interlock bricks is 420 pieces per day, then in 25 days the effective production quantity is 10,500 pieces. Assuming a production failure rate (rejected) of 1%, the net production of interlock bricks is 10,350 pieces. With a total explicit cost of IDR 56,460,000, the Break Event Point on Price is IDR 5,432 per piece. For production to

be profitable, it is recommended that interlock bricks be sold at a price of >IDR 5,432 per piece. To make calculations easier, the recommended price is IDR 5,500 per piece.

At the Soft Launching stage, Adi IAI interlock bricks are sold at IDR 4,000 per piece. This price is set based on using free waste essential oil from clove leaves, not buying from the essential oil factory in Samigaluh. This economic analysis was made to anticipate increases in waste prices. Essential oil producers will be interested in collecting the waste and selling it at the same price as the clay used to make bricks. If the price remains at IDR 4,000, the monthly production capacity must be increased to over 14,115 pieces. This is impossible because the engine capacity is limited. Increasing interlock brick production means increasing the amount of input including raw materials, labor, and other additional costs.

3.2.2 Benefit, Profit and Business Feasibility of Interlock Brick

To calculate the benefit, profit, and feasibility of the interlock brick business, the implicit costs of family labor, factory rental value, and interest value of own capital must be calculated. Family labor costs are calculated from the use of family labor involved in the production process per day, then the costs are converted into 25 effective days. The factory rental value is the conversion value if the factory land is rented by another business. The value of capital itself is the total amount of explicit costs crossed with the lowest loan interest rate in force in Samigaluh at the time the research took place. Revenue is the amount crossed with the price of interlock bricks. The benefit is revenue minus explicit costs. Profit is the benefit minus the total explicit and implicit costs. Business feasibility is calculated from the RC Ratio and capital productivity.

From Table 3, the total production costs for the Adi IAI interlock brick business are IDR 58,960,000 per month. With a brick-selling price of IDR 5,500, there is still a benefit of IDR 465,000 per month. But if we calculate implicit costs, the interlock brick business at Adi IAI loses IDR – 2,035,000. Adi IAI's interlock brick business is not feasible if seen from BCR analysis but is feasible if analyzed by capital productivity. Based on these results, the following business steps are needed: 1) increase the production capacity to be larger with a production capability of 1,000,000 pieces per day; 2) increase the selling price of interlock bricks by promoting interlock bricks as art items, not as ordinary materials. If the selling price is more than IDR 6,000,000 then BCR: 1.05 > 1 (feasible business) and there will be a profit of IDR 3,140,000 per month.

Table 3. Benefit, Profit and Business Feasibility of Interlock Brick per month

No	Component	IDR	Information
1.	Explicit Costs	**56,460,000**	
2.	Implicit Costs (Family Workers)	2,500,000	
3.	Total Costs	58,960,000	
4.	Total Production (net) pieces	10,350	Price: IDR 5,500 per piece
5.	Revenue	56,925,000	
6	Benefits	465,000	
7.	Profits	-2,035,000	(minus = not profitable)
8.	BCR	0,96	< 1 = not feasible business
9.	Rent of Own factory	1,000,000	
10.	Bank Interest Rates	1 %	Rate of KUR BRI (= 6 %/year)
11.	Capital Productivity	94 %	CP>Bank Interest Rate = feasible

4 Conclusions and Recommendations

Essential oil waste from clove leaves can be used to make interlocked bricks. So far, interlock bricks have been made from clay. The use of this waste can substitute up to 90% of clay. This condition is ecologically beneficial because continuous excavation of clay can damage the environment. Utilizing waste is profitable because waste thrown away carelessly pollutes the environment, water, and air. Physical studies have proven that interlock bricks made from essential oil waste from clove leaves comply with civil engineering requirements, which are equivalent to K125 concrete. However, from economic studies, interlock brick production at the Adi IAI Foundation is not yet profitable and not feasible. There are several recommended steps, namely increasing machine capacity or increasing the selling price of interlock bricks by promoting them as materials that have artistic value.

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