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Techno-Economic Analysis of Production Ecobrick from Plastic Waste to Support Sustainable Development Goals (SDGS)

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ABSTRACT

This research aims to analyze the techno-economics of plastic waste into ecobrick products from a Collaborative Governance perspective. The research method used is to carry out an economic feasibility analysis of ecobrick production from plastic waste over 20 years, by carrying out an analysis from various points of view. The research results show that the production of ecobricks from plastic waste is economically feasible if it is produced for 20 years. This is proven by the technical analysis of the conversion of 135 tons of plastic waste per year to produce 90,000 ecobricks with a total production cost per bottle of USD 0.308 at a selling price of 0.617. However, when production started, there were quite large losses due to equipment and raw materials, reaching negative values of -1000. Even so, in the third year, there was a relatively stable increase until it reached an increase in cumulative net profit every year. Thus, analytical calculations show the potential for significant profits by achieving the break-even point (BEP). However, fluctuations in raw material prices and operational costs can affect profitability, so there is a need for collaborative governance involvement from the government sector in policies on the use of plastic waste and providing financial assistance to the community as waste producers and the private sector as producers. Therefore, this research will have an impact on the government's goal of achieving environmental cleanliness by creating ecobricks and creating profit opportunities for the community and entrepreneurs/private parties. This study also supports current issues in the Sustainable Development Goals (SDGs).

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1. INTRODUCTION

Plastic waste is the remaining waste from the increasing daily use of plastic (Sarkingobur & Tukur, 2025). Plastic waste is an inseparable part of modern life, resulting from various human activities in the household, commercial, and industrial sectors. Therefore, as long as humans still use plastic, this waste will continue to be produced.

Ecobricks are a method of utilizing plastic waste by filling empty plastic bottles with plastic waste until it is solid. This reduces the amount of plastic waste that ends up in landfills and helps reduce the negative impact of plastic on the environment (Mihai *et al*., 2021; Jain *et al*., 2021). Ecobrick manufacturing can also be analyzed through economic and environmental approaches (Wardani & Khotimah, 2021). Many techno-economic analyses have been conducted by researchers to understand the benefits and challenges of eco-bricks (see **Table 1**).

Table 1. Previous studies on research relating to ecobrick production.

Title	Reference
Reimagining plastics in the built environment: Ecobricks at the Ridge, Cape Town	(Brunette *et al*., 2021)
Indonesian policy and research toward 70% reduction of marine plastic pollution by 2025. Marine Policy	Kristianto & Widya, 2021)
Management of plastic waste: A sustainable approac	Kumari *et al*., 2024)
A novel vermiculite/vegetable polyurethane resin-composite for thermal insulation eco-brick production.	Rabello & da Conceicao Riberiro, 2021)
Socialization of the manufacture of eco-brick as a solution to management of plastic waste in Nagari Tanjung Betung, Pasaman	(Syukri & Fauziah, 2022)
Adoption of eco-bricks for housing: The case of Yelwa, Nigeria.	Udike *et al*., 2022)
Thermal and mechanical shock testing of a brick wall and a polystyrene wall	(Khechekhouche *et al*., 2023)

Based on previous studies on managing plastic (Nandiyanto *et al*,m 2023; Sridevi *et al*., 2024; Pebrianti & Salamah, 2021; Soegoto *et al*., 2021; Setyani *et al*., 2023), this research aims to analyze the techno-economics of making eco-bricks from plastic waste. The main innovations from this research include (i) preserving the environment through recycling plastic waste, (ii) using ecobricks as environmentally friendly building materials, (iii) assessing the prospects of the ecobrick industry in plastic waste management, and (iv) evaluating the potential for applying ecobrick technology on an industrial scale to reduce the carbon footprint in the construction sector (Haque, 2019; Haque & Islam, 2021).

This research also emphasized the application of this method to simple construction projects, such as retaining walls or non-structural structures in the development of rural communities, which do not require expensive materials. Additionally, this study showed the development of the eco-brick industry in increasing local economic value and providing a sustainable solution for plastic waste management (Adiyanto *et al*., 2022; Akinwumi *et al*., 2022). This study highlights additional strategies supporting sustainable development goals (SDGs), including managing plastic waste, promoting eco-bricks as a solution, and fostering ecological intentions among youth to repurpose waste. It also emphasizes the role of zero-waste practices, like turning plastic waste into art, in achieving SDGs through recycling and sustainable waste management (Kristianto & Widya, 2021; Karyono *et al*., 2024).

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2. METHODS

The approach used in this research includes economic analysis over 20 years to assess the feasibility of production using plastic waste materials. Some of the parameters explained include gross profit margin (GPM), investment return rate (IRR), break-even point (BEP), and other financial parameters. The data used was obtained from the average product prices available on various online shopping sites, which were then analyzed using simple mathematical calculations. This method allows clearer projections regarding business potential, labor costs, raw material purchasing costs, and interest rates. This economic assessment is reinforced by the evaluation of various scenarios, including changes in raw material prices and market fluctuations, which helps mitigate possible risks. Additionally, the use of sensitivity analysis provides additional insight into how changes in certain variables may affect economic outcomes. Further information about the details of these calculations has been explained in other parts of this study (Wahyudin *et al*., 2023).

3. RESULTS AND DISCUSSION

The process of producing eco-bricks from plastic waste is shown in **Figure 1**. Making eco-bricks involves five main stages, starting from collecting plastic waste to forming eco-bricks that are ready to be used as environmentally friendly building materials or other creative materials. The stages in making eco-bricks are first collecting plastic waste and separating it according to the type of plastic, then washing the plastic until it is clean, and drying it in the sun. The next stage is the stage of chopping or cutting the paper using a chopping machine. After the cutting or chopping stage, the next stage is filling the bottles that have been cleaned. The compaction was carried out manually using a wooden stick. Once completed, the final stage is checking and weighing to determine whether the product is successful or whether there are still improvements.

Figure 1. Process flow diagram of the ecobrick production from plastic waste.

The economic analysis was based on these assumptions: (i) exchange rate of 1 USD = Rp. 16,500; (ii) used paper costs of Rp. 500/pcs and glue Rp. 20,000/kg; (iii) equipment prices based on commercial online rates; (iv) total investment including direct, indirect, and start-up costs; (v) projected production costs from project inception; (vi) labor wages of Rp. 52,051,314.71 per production cycle; and (vii) the operating period of 20 years (**Tables 2, 3, and 4**).

A techno-economic analysis of opportunities for commercialization of the use of plastic waste for ecobrick production has been presented. In addition to **Figure 2**, which explains the CNPV/TIC, **Table 5** provides a summary of the results of the techno-economic analysis.

Figure 2 shows the CNPV/TIC curve over time. A decrease in income in the first to second years was due to initial investment costs such as equipment and purchasing land for eco-brick

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production. Over the past two years, CNPV/TIC was below 0, with a loss of around 4%. However, in the third year, there was an increase in income, which indicated a payback period (PBP). CNPV/TIC growth continued to increase significantly until the 20th year, showing that eco-brick production from plastic waste is a profitable project with a payback period of only around 2 years, making it very suitable for industrial production. In addition, this project can contribute to reducing useless plastic waste, preserving the environment, and optimizing economic benefits.

Table 2. Price of equipment and the process condition.

No	Tool Name	Unit Price (USD)	Amount	Total Price
1	Push wood	USD. 0.61	20	USD. 12,34
2	Shredding machine	USD. 413.68	3	USD. 1.241,04
3	Scissors	USD. 0.92	20	USD. 18,52
		Total		USD. 1.271,91

Table 3. Total capital investment.

No	Component Direct Cost	Factor	Price (IDR)
1	Component Direct Cost	Factor	Price (IDR)
	Tools costs	1.000	54,350,000.00
	Transportation costs	0.100	5,435,000.00
	Freight insurance	0.007	380,450.00
	Transportation to the location	0.050	2,717,500.00
	Equipment installation costs	0.550	29,892,500.00
2	Instrumentation	0.300	16,305,000.00
3	Piping	0.500	27,175,000.00
4	Electrical	0.500	27,175,000.00
5	Utilities	0.400	21,740,000.00
6	Building cost	0.700	38,045,000.00
7	Insulation	0.060	3,261,000.00
8	Painting, fireproofing, and safety	0.050	2,717,500.00
9	Yard Improvement	0.080	4,348,000.00
10	Environmental	0.700	38,045,000.00
12	Land	0.080	4,348,000.00
Direct Cost			**275,934,950.00**
Indirect Cost			
1	Technician and supervision	0.100	5,435,000.00
2	Contractors fee	0.150	8,152,500.00
3	Contingency	0.100	5,435,000.00
Indirect Cost			**19,022,500.00**
Starting Up Fee			
1	Off-site facilities	0.200	**10,870,000.00**
2	Plant strart-up	0.070	**3,804,500.00**
3	Working capital	0.200	**10,870,000.00**
Starting Up Fee			**25,544,500.00**
Fixed Capital Investment (FCI)			**294,957,450.00**
Working Capital Investment (WCI)			**52,051,314.71**
Total Capital Invesment (TCI)			**347,008,764.71**

Tourism, markets, and households often produce large amounts of plastic waste, which, if not managed properly, can damage the environment. However, through various waste management programs, this plastic can be processed into more useful products, such as eco-bricks. Techno-economic analysis shows that the use of plastic waste for ecobrick production

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has very promising potential. The results of analyses such as CNPV/TIC show a positive upward trend over 20 years, indicating that this project has the potential to be economically profitable. Other economic analyses, such as gross profit margin, rate of return on investment, break-even point (BEP), and profit-to-sales percentage, also show favorable results for ecobrick production from plastic waste. This study adds new information relating to the analysis in techno-economical analysis, as reported elsewhere (Elia *et al.*, 2023; Ragadhita & Nandiyanto, 2022; Wangsupphaphol *et al.*, 2024; Maratussolihah *et al.*, 2022; Nurdina *et al.*, 2022).

Table 4. The factor for estimating manufacturing cost.

No	Total Lifetime	Factor 20 years	Price (IDR)
1	Raw Materials		90,000,000.00
2	Utilities		33,750,000.00
3	Loan Interest	7% of the loan	-
4	Operating Labor		12,000,000.00
5	Labor-related cost		
	a. Payroll overhead	30% of labor	3,600,000.00
	b. Supervisory, misc. labor	25% of labor	3,000,000.00
	c. Laboratory charges	12% of labor	1,440,000.00
6	Capital-related cost		
	a. maintenance	6% of labor	720,000.00
	b. Operating supplies	15% of maintenance	108,000.00
	c. Environmental	15% of (equipment)	3,090,000.00
	d. Depreciation	10% of (FCI)	29,495,745.00
	e. Local taxes, insurance	4% of (FCI)	11,798,298.00
	f. Plant overhead cost	100% of (OL)	294,957,450.00
7	Sales-related cost		
	a. Packaging	1% of sales	9,000,000.00
	b. Administration	2% of sales	18,000,000.00
	c. Distribution and marketing	2% of sales	18,000,000.00
	d. Research and development	1% of sales	9,000,000.00
	e. Patents and royalties	1% of sales	9,000,000.00
Total Product Cost (TPC)			**546,959,493.00**

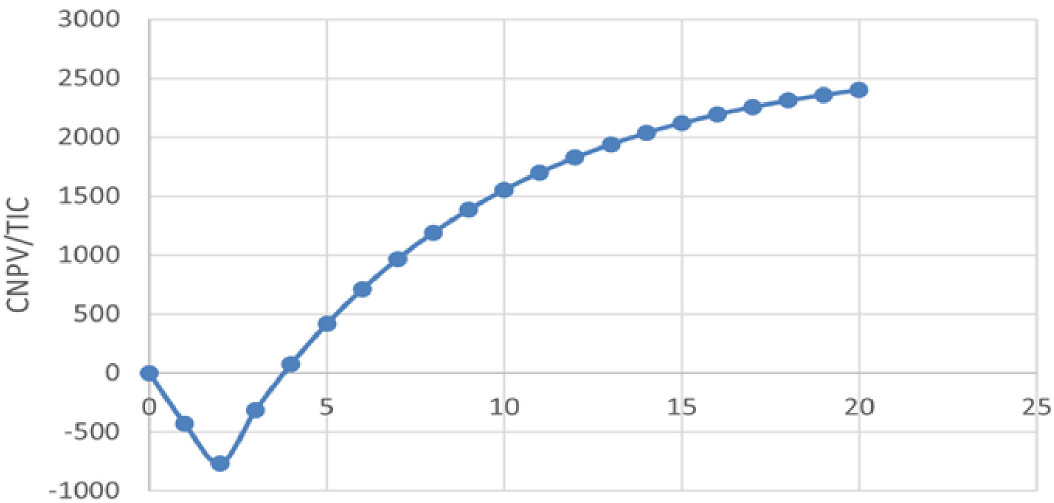

Figure 2. CNPV/TIC with various economic evaluation parameters in the ideal condition.

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Table 5. Summary of techno-economic analysis.

Component	Parameter	Price (IDR)
Fixed Cost	Loan Interest	
	Capital Related Cost	340,169,493.00
	Fixed cost+Depresiasi	
	Depreciation	29,495,745.00
	Fixed Cost less depreciation	
	Total Fixed Cost	369,665,238.00
Variable Cost	Raw material	90,000,000.00
	Utilities	33,750,000.00
	Operating Labor (OL)	12,000,000.00
	Labor Related Cost	8,040,000.00
	Sales Related Cost	63,000,000.00
	Total Variable Cost	206,790,000.00
% Profit Estimated	Sales	900,000,000.00
	Manufacturing Cost	546,959,493.00
	Investment	316,153,950.00
	Profit	0.39
	Profit to Sales	1.12
BEP	Unit	90000
	Fixed Cost	369,665,238.00
	Variable cost	206,790,000.00
	Variable cost	0.00
	Sales	900,000,000.00
	Sales	0.00
	BEP	47993.92885
	Percent Profit on Sales	0.39226723
	Return on Investment	1.196920122
	Pay Out Time	0.77105751

4. CONCLUSION

Based on the economic analysis carried out, ecobrick production from plastic waste shows very good prospects. Utilizing plastic waste as raw material for ecobrick production, an economic analysis was carried out over 20 years to generate potential profits from this project. Some of the indicators calculated in this analysis include gross profit margin, rate of return on investment, BEP, and percentage of profit to sales. This research has a positive impact on the government's goal of creating a cleaner environment and creating profit opportunities for communities and entrepreneurs. Suggestions for further research include discussing the analysis of collaborative support from the government, private sector, and society.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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