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TECHNO-ECONOMIC ANALYSIS OF PRODUCTION ECO-BRICK PAVING BLOCK-BASED PLASTIC WASTE AS AN ALTERNATIVE FOR SCHOOL FACILITIES AND INFRASTRUCTURE DEVELOPMENT TO SUPPORT SUSTAINABLE DEVELOPMENT GOALS (SDGS)

SYUKRI INDRA[1]*, R. SITI PUPU FAUZIAH[1], RADIF KHOTAMIR RUSLI[1], ADI RAHMANNUR IBNU[1,2], ABDUL KHOLIK[1], MUHAMMAD RENDI RAMDHANI[1], IRMAN SUHERMAN[1], IMAM ABDUL AZIZ[1]

[1]Universitas Djuanda, Jl. Tol Ciawi No. 1 Bogor West Java Indonesia 16720
[2]University of Birmingham, Edgbaston, Birmingham, B152TT United Kingdom
*Corresponding Author: syukri.indra@unida.ac.id

Abstract

This research aims to analyse the economic feasibility of fabricating plastic waste into eco-brick paving blocks which can be used as an alternative in building facilities and infrastructure in schools. The research method used is to carry out analysis to inform the production potential of valuable materials from plastic waste including gross profit, internal rate of return, payback period, net value, and so on. The results of this study show that the cumulative net present value divided by the total investment cost value is negative. It stagnated until the 3rd year. However, after the 4th year to the 20th year, conditions changed to become favourable and increased. In the 4th year, income increases and reaches the payback period (PBP). PBB can be achieved only in a short time, namely in the 3rd year and the income earned tends to increase until the 20th year. This shows that the project to produce eco-brick paving blocks made from plastic waste is very prospective. At a more affordable price, eco brick paving blocks are an alternative for constructing school facilities and infrastructure, houses, buildings, and so on. To ensure project feasibility, the project is estimated from ideal to worst-case conditions in production, including labor, sales, raw materials, utilities, as well as external conditions (i.e. taxes and subsidiaries). And this study also supports current issues in sustainable development goals (SDGs).

Keywords: Eco-bricks, Economic analysis, Paving blocks, Plastic waste, School facilities and infrastructure.

1. Introduction

Eco-brick paving block based on plastic waste is an alternative for schools in building infrastructure at a more affordable cost. Complete infrastructure will have a very positive impact on schools. Thus, the learning process can run well and education can be implemented optimally. Educational facilities are facilities to support the process of teaching and learning activities, for example, buildings, classrooms, tables, chairs, and so on, while educational infrastructure is facilities that support the achievement of school activities. Thus, they are carried out optimally, such as in the school field/yard [1-2]. The completeness of educational facilities is one factor in attracting students' interest in participating in the educational process at a school [3-4]. Much research has been carried out regarding techno-economics (Table 1).

Table 1. Summary of research on techno-economic analysis.

No.	Title	Ref.
1	Techno-economic assessment of coal to SNG power plant in Kalimantan	[5]
2	Techno-economic analysis on the production of zinc sulfide nanoparticles by microwave irradiation method	[6]
3	Techno-economic evaluation of hyaluronic acid production through extraction method using yellowfin tuna eyeball	[7]
4	Computational bibliometric analysis on publication of techno-economic education	[8]
5	Techno-economic evaluation of gold nanoparticles using banana peel (*musa paradisiaca*)	[9]
6	Techno-economic analysis of the business potential of recycling lithium-ion batteries using hydrometallurgical methods	[10]
7	Domestic waste (eggshells and banana peels particles) as sustainable and renewable resources for improving resin-based brakepad performance	[11]
8	Computational bibliometric analysis on publication of techno-economic education	[12]
9	Techno-economic feasibility study of low-cost and portable home-made spectrophotometer for analyzing solution concentration	[13]

This research aims to analyze the economic feasibility of fabricating plastic waste into eco-brick paving blocks which can be used as an alternative in building facilities and infrastructure in schools. The novelty in this research is the economic analysis of the production of eco-brick paving blocks made from plastic waste, the use of eco-brick paving blocks as an alternative for building infrastructure in schools, and the fabrication of plastic waste into eco-brick paving blocks. This study also supports current issues in sustainable development goals (SDGs), as reported elsewhere [14-18].

2. Theoretical Production of Eco-brick Paving Block-Based Plastic Waste

Eco-brick paving blocks are a contemporary alternative that can be applied to building outdoor floors. Paving blocks are a type of concrete paving used for paving road surfaces that consists of solid, unreinforced concrete and has various shapes, sizes, and colors to suit the needs and desires of the architect. This type of paving block is made from a mixture of polyethylene (PE), bottom ash (BA) plastic, and sand for aggregate. Polyethylene plastic is a thermoplastic that has flexible and pliable properties due to its long C chain structure so it does not crack, break, or bend easily [19]. This eco-brick paving block can be an alternative for educational institutions (schools) as a building material at a more affordable cost and has strong durability.

Making paving blocks so main ingredient is plastic waste which is burned and melted and then processed in several stages [20]. Making paving blocks consists of two ways, namely by using human power (manual) and by using machines [21]. The work procedures in making eco-brick paving blocks are: (i) the material preparation stage includes plastic waste (PE), bottom ash (BA) and sand, (ii) chopping the cleaned plastic waste and smoothing the bottom ash, (iii) weighing the plastic waste and ba according to measure, (iv) the mixing stage of all ingredients, (v) the paving block printing stage, (vi) pressing using a press for 2 minutes, and (vii) the drying stage is assisted by dousing it with water to speed up drying. The flow chart for making eco-brick paving blocks is shown in Fig.1.

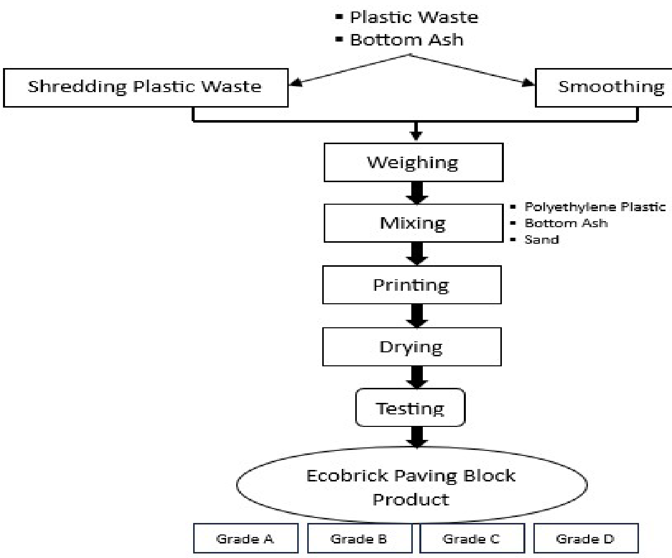

Fig. 1. The flow of making eco-brick paving blocks.

3. Research Method

We analyzed the manufacture of eco-brick paving blocks and calculated operational costs and sales estimates. The prices of materials in this study were taken from the average commercial price of products available on online shopping websites to guarantee the latest prices for each type of material. Then the data is calculated using simple mathematical analysis. In confirming the economic evaluation in this research, several parameters were used including CNPV (cumulative net present value), GPM (gross profit margin), PBP (payback period), BEP (break-even point), BEC (business email compromise), IRR (internal rate return), ROI (return on investment), and PI (profitability index). In evaluating feasibility, various conditions are tested including changes in raw materials, sales capacity, labor conditions, interest rates, etc. Detailed information for the calculation is explained elsewhere [22-23).

4. Results and Discussion

The economic evaluation related to the operational costs of making paving blocks includes a comprehensive analysis of the various cost components involved in the production process. The operational costs calculated include the price of materials, equipment prices, utilities, and employee salaries, and the calculation of total production and sales per year. The raw material used consists of three main ingredients, namely: (i) plastic waste pellets with a price of 0.19 and 4800 kg/h so the total price is $ 906.52, (ii) bottom ash with a price of 0.08 and 5000 kg/h so the total price is $ 424.93, and iii) sand at a price of 0.22 and 600 kg/h then the total price is $ 132.20. Total cost/day $ 1,463.65 and total cost/year $ 439,093.69.

The total price of tools for making paving blocks from plastic waste is $ 84.82 with the following details : (i) press machine (making hollow brick maker aks-Ha26cm) with a price per unit of $ 11.33 which amounts to 1 unit, (ii) Iron stirrer with a price per unit of $ 0.19 which amounts to 1 unit, (iii) burning and mixing drums price per unit $ 10.39 which amounts to 2 units so the total price is $ 20.77, (iv) digital scale with a price per unit of $ 9.95 which amounts to 1 unit, (v) cement spoon with a price per unit of $ 2.10 which amounts to 3 units so the total price is $ 6.29, (vi) wood ponder with a price per unit of $ 5.04 which amounts to 2 units so the total price is $ 10.07, (vii) stove with a price per unit of $ 19.01 which amounts to 1 unit, (viii) sieve with a price per unit of $ 5.19 which amounts to 1 unit, and (ix) bucket with a price per unit of $ 0.50 which amounts to 4 units so the total price is $ 2.01.

Total production of paving blocks from plastic waste is 10,000 pcs per day, 200,000 pcs per month with a working period of 20 days, 2,400,000 pcs per year with a production price per pc of $ 0.20. So sales of $0.22 per piece produce annual income of $528,801. Calculations that have been carried out, for utilities, namely in the form of a press machine, the costs are $ 4.38 per day and $ 1,051.56 per year, while employee costs for 7 people are $ 157.38 per day and $ 12,727 per year with an estimated working day of 20 days per month. The estimated production of paving blocks per day is 10,000 pcs with a production cost per pc of IDR 3,226.57. For the calculation of total production, it is calculated within one year, the results obtained are 2,400,000 paving blocks per year with a selling price of $ 0,22 per piece. Thus, total sales per year are $ 528.801. Total manufacturing cost of making paving blocks from plastic waste are $ 487,488.81 with seven components, namely: (i) raw materials $ 439,093.69, (ii) utilites $ 1,051.56, (iii) loan Interest 7%, (iv) operating labor $ 1,888.57, (v) labor-related cost $ 1,265.34, (vi) capital related cost $ 7,173.57, and (vii) sales related cost $ 37,016.07.

Manufacturing cost is the total amount of all the resources needed to make a product, in this case, paving blocks made from plastic waste. Manufacturing costs in making paving blocks include raw materials, utilities, loan interest, labor-related costs, capital-related costs, and sales-related costs. After carrying out the calculations, the result was a total product cost (TPC) of $ 487,488.81.

The calculation results from the economic evaluation illustrate the data that paving blocks from plastic waste have very good prospects as an alternative for building facilities and infrastructure in schools. Paving blocks made from plastic waste are stronger than ordinary paving blocks. Various benefits for the environment, efficiency from an economic perspective, and support from government policy, the use of this material can be the right alternative for realizing sustainable development in the educational environment. This is a challenge that can be overcome through research, outreach, and good collaboration between government, schools, and industry. Table 2 is an overview of the prospects for paving blocks from plastic waste:

Table 2. Summary of making paving blocks from plastic waste.

Fixed Cost	Parameter	Cost
Component	Capital related cost	7,173.57
	Depreciation	616.71
	Total fixed cost	7,790.29
	Raw material	439,093.69
Variable Cost	Utilities	1,051.56
	Operating labor (OL)	1,888.57
	Labor related cost	1,265.35
	Sales related cost	37,016.07
	Total variable cost	480,315.24
	Sales	528,801
% Profit Estimated	Manufacturing cost	487,488.81
	Investment	6,610.33
	Profit	0.08
	Profit to Sales	6.25
	Unit	2.400.000
BEP	Fixed cost	7,790.29
	Variable cost	480,315.24
	Sales	528,801
	BEP	385611,907
	Percent Profit on Sales	**0,078**
	Return on Investment	**6,698**
	Pay out time	**0,147**

Table 2 the BEP is obtained at 385,611.90. This shows that with operational costs, the bep between sales volume and profitability is 3.8 years. This means that producers return on investment in the 3rd year, and in the 4th year and so on they will get higher profits. This is something that has prospects for development, considering that the basic material for making paving blocks from plastic waste can be provided at low cost or can even be obtained for free. Thus, making paving blocks from plastic waste can be more economical compared to conventional materials. This can certainly be an alternative and reduce construction costs for school infrastructure, such as building parking areas, sports fields, classrooms, etc.

Economic evaluation requires the existence of ideal conditions. Thus, it can be used as a benchmark for a product or project. The ideal conditions by analyzing the relationship between CNPV/TIC and age (years) are shown in Fig.2.

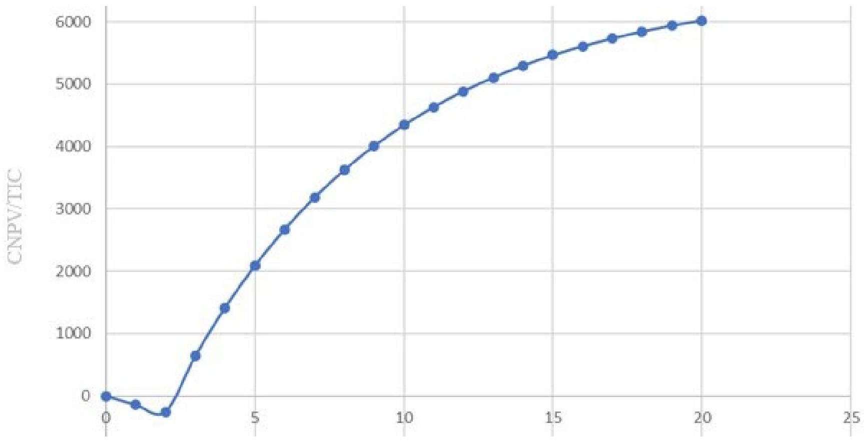

Fig. 2. Curve of ideal conditions for cnpv/tic to a lifetime (year) for making paving blocks from plastic waste.

The curve in Fig. 2 shows a negative CNPV/TIC value. The CNPV/TIC value stagnated until the 3rd year. However, after the 4th year to the 20th year, conditions changed to become favorable and increased. In the 4th year, income increases and reaches the payback period (PBB). PBB can be achieved only in a short time, namely in the 3rd year and the income earned tends to increase until the 20th year. This shows that the project to produce eco-brick paving blocks made from plastic waste is very prospective. Schools can implement efficiency in procuring school infrastructure by starting with careful planning. Thus, they can obtain good quality facilities at relatively cheaper prices. At a more affordable price, eco-brick paving blocks are an alternative for constructing school facilities and infrastructure, houses, buildings, etc.

5. Conclusion

After analysis, data was obtained that the cnpv/tic value was negative. The CNPV/TIC value stagnated until the 3rd year. However, after the 4th year to the 20th year, conditions changed to become favorable and increased. In the 4th year, income increases and reaches the payback period (PBB). PBB can be achieved only in a short time, namely in the 3rd year and the income earned tends to increase until the 20th year. This shows that the project to produce eco-brick paving blocks made from plastic waste is very prospective. At a more affordable price, eco brick paving blocks are an alternative for constructing school facilities and infrastructure, houses, buildings, and so on. To ensure project feasibility, the project is estimated from ideal to worst-case conditions in production, including labor, sales, raw materials, utilities, as well as external conditions (i.e. taxes and subsidiaries).

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