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Techno-Economic Feasibility Analysis of Eco Product Production from Waste Fabric Materials to Support Sustainable Development Goals (SDGs)

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ABSTRACT

This study evaluates the techno-economic feasibility of producing eco-products from waste fabric materials to support sustainable development. We conducted a long-horizon feasibility assessment using commercial price data, defined production capacity and labor needs, selected appropriate machinery, and estimated cash flows to compute gross profit margin, internal rate of return, payback period, net present value, and break-even point. Results: The analysis indicated that the project is technically workable and economically attractive, with investment recovery occurring within an early operating window and profitability sustained across the planning horizon. Reasoning: These outcomes arise because waste fabric provides low-cost inputs, the process relies on simple equipment and skills, and value addition through design and quality control increases marketability. Impact: The study informs decision makers about scaling circular textile initiatives, guiding investors, producers, and local communities toward environmentally responsible enterprises while advancing sustainable consumption and responsible production in urban and rural contexts globally. This study supports Sustainable Development Goals (SDGs).

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1. INTRODUCTION

Fabric waste poses significant environmental challenges as it is an inorganic material that does not decompose easily and cannot be composted or reprocessed. If incinerated, fabric waste releases harmful smoke and toxic gases that endanger both the environment and human health [1]. In 2020, fabric waste ranked sixth among the largest waste types, contributing around five percent of the total waste. The COVID-19 pandemic further exacerbated the issue by increasing the production of disposable cloth masks, which contributed additional fabric residue to the waste stream [2].

Several industries have begun processing fabric waste into new products, including fashion and furniture items. Beyond these applications, patchwork fabrics also have the potential to be developed into household items such as bags, doormats, and other decorative goods. These products, termed "eco-products" in this study, cater to the preferences of both traditional and modern consumers [3].

Tables 1 and 2 highlight several previous techno-economic studies. These studies support the relevance of transforming textile waste into value-added products. These works cover a variety of approaches, such as eco-printing, biorefineries, textile wastewater treatment, and recycling for sound barriers and energy generation.

Table 1. List some previous related research regarding waste management.

No	Topic	Ref
1	Utilization of plastic packaging waste and fabric scraps as a form of economic creativity in Sidodadi Village, Sekampung, Lampung	[4]
2	Techno-economic analysis and ecoprint development (blue ocean strategy approach to Ecoprint Tapak Patera)	[5]
3	Innovative biorefineries for cleaner waste textile management towards the circular economy, from the perspective of techno-economic analysis	[6]
4	Techno-economic analysis of textile dye bath wastewater treatment by integrated membrane processes under the zero liquid discharge approach	[7]
5	Economic and environmental benefits of using textile waste for the production of thermal energy	[8]
6	Waste management in the fashion and textile industry, relating to recent advances and trends, life-cycle assessment, and circular economy	[9]

Table 2. Previous studies on techno-economic analysis.

No	Title	Ref
1	Integrating learning media for language and literacy development: Educational impact and economic evaluation of recycled paper production	[10]
2	Techno-economic analysis of sawdust-based trash cans and their contribution to Indonesia's green tourism policy and the SDGs	[11]
3	Techno-economic analysis of solar panel production from recycled plastic waste as a sustainable energy source for supporting digital learning in schools based on Sustainable Development Goals (SDGs) and science-technology integration	[12]
4	Techno-economic evaluation of gold nanoparticles using banana peel (*Musa Paradisiaca*)	[13]
5	Techno-economic feasibility of educational board game production from agro-industrial waste	[14]
6	Optimal design and techno-economic analysis for corncob particles briquettes	[15]
7	Economic evaluation of different fuels in the production of La_2NiO_4 particles using a sol-gel combustion	[16]
8	Techno-economic evaluation of biodiesel production from edible oil waste	[17]
9	Techno-economic evaluation of dysprosium-doped cobalt ferrites nanoparticles	[18]

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Table 2 (continue). Previous studies on techno-economic analysis.

No	Title	Ref
10	Techno-economic analysis of the business potential of recycling lithium-ion batteries	[19]
11	Computational bibliometric analysis on publication of techno-economic education	[20]
12	Techno-economic feasibility and bibliometric review of integrated waste processing installations	[21]
13	Techno-economic and bibliometric analysis of wet organic waste ecoenzymes production	[22]
14	Techno-economic analysis of production ecobrick from plastic waste	[23]
15	Alternative energy options for a Thai durian farm: Feasibility study and experiments for the combination of solar photovoltaics and repurposed lithium-ion batteries	[24]

This study aims to analyze the techno-economic feasibility of producing eco products from fabric waste using a detailed set of economic indicators and modeling tools. The novelty lies in applying a project-scale techno-economic evaluation specifically to patchwork-based household products, an area rarely explored in previous research. The findings contribute directly to Sustainable Development Goals (SDGs) on responsible consumption and production by promoting fabric waste valorization, supporting local production systems, and encouraging scalable green entrepreneurship through informed decision-making.

2. LITERATURE REVIEW

Figure 1 illustrates the complete process of converting waste fabric scraps into eco products through a structured production workflow. The transformation process begins with sorting the fabric waste by type, color, and size, followed by cleaning and washing to prepare the material for reuse. After preprocessing, the design phase determines the appropriate pattern based on the type of product to be created. The waste fabric is then cut, sewn, and assembled into finished items such as bags or decorative goods. The production concludes with quality checks, labeling, and final packaging before distribution.

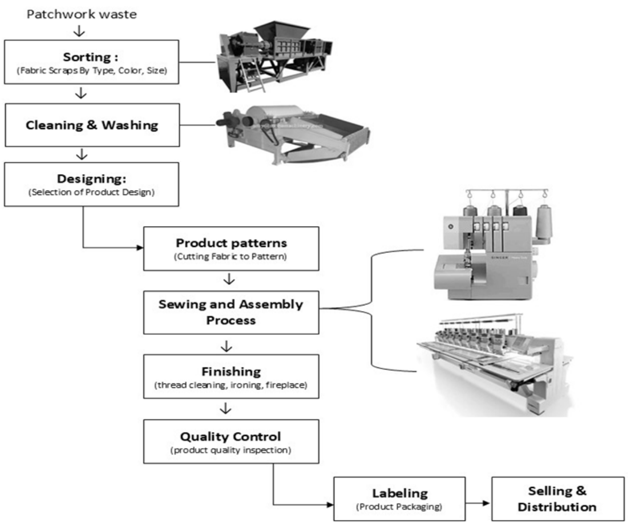

Figure 1. Production of Eco-product from waste fabric materials.

This systematic approach ensures that even heterogeneous fabric waste can be managed effectively and converted into valuable items. The inclusion of design and labeling stages enhances product appeal and market readiness. From a sustainability perspective, this model directly aligns with SDGs, especially SDG 12, which promotes responsible consumption and

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production by reducing textile waste through upcycling and reuse. Moreover, by involving local labor in creative and income-generating activities, the model also supports SDG 8 on inclusive economic growth and decent work, especially in marginalized or informal communities.

3. METHODS

This study employs a techno-economic feasibility approach to evaluate the production of eco-products from waste fabric scraps. The analysis covers both technical and financial aspects to assess whether the project is viable for long-term implementation. The key components analyzed include raw material identification and cost structure, estimation of production capacity, selection of appropriate technology and equipment, and the labor requirements for a scalable small-industry model.

From an economic perspective, the feasibility study incorporates various financial tools and indicators such as gross profit margin (GPM), cumulative net present value (CNPV), internal rate of return (IRR), payback period (PBP), return on investment (ROI), and break-even point (BEP). These indicators are analyzed under the assumption of a 20-year project duration using real market prices for raw materials and equipment. Additional calculations, such as the CNPV to Total Investment Cost (TIC) ratio, are included to evaluate long-term value generation and investment recovery [25–26].

4. RESULTS AND DISCUSSION

4.1. Assumptions and Inputs

Table 3 presents the key assumptions used in this techno-economic feasibility study. These assumptions serve as the foundation for modeling projected costs, revenue, and investment recovery. The analysis assumes a project lifetime of 20 years with a production capacity of 1,560 units per year and two production cycles per day. The commercial price of materials and equipment was adopted, and other auxiliary costs (such as instrumentation and electrical components) were excluded. Financial assumptions include a bank interest rate of 4.5%, annual income tax of 22%, and an exchange rate of IDR 16,270 per USD. These standardized assumptions are consistent with techno-economic models used in similar studies on waste valorization and green product development [27-28].

Table 3. Calculation of Raw Material Costs.

No	Raw Material	Requirements per Small Scale Production (Kg/Hour)	Unit	Requirements per Large Scale Production (×1000)	Price (USD)
a	Fabric Scraps	10	Kg	1000	1.106
b	Zipper	50	Unit	5000	1.383
c	Buttons	50	Unit	5000	0.461
d	Sewing Thread	20	Roll	2000	0.430
e	Ribbon/Lace/Rope	100	Unit	10000	3.073
	Total Price / Day				**6.453**
	Price / Year				**1,935.841**

4.2. Cost Analysis

Table 4 provides a detailed calculation of raw materials needed per production cycle. To produce 100 units per cycle, components such as fabric scraps, zippers, buttons, sewing thread, and ribbons are required. The total daily cost of these materials amounts to USD

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6.453, leading to an estimated annual raw material cost of USD 1,935.841. This figure forms the basis of the variable cost structure.

Table 5 lists the required machinery, including fabric shredders, overlock sewing machines, embroidery machines, labeling machines, and fabric washing machines. The total capital investment for these tools is USD 10,770. The simplicity and affordability of the equipment suggest that the production model is well-suited for small to medium-sized enterprises. This mirrors findings from previous studies on low-barrier entry technologies for sustainable textile reuse [29-30].

Table 4. Calculation of Equipment Components.

Name of Tool	Unit Price (USD)	Quantity	Total Price (USD)
Fabric Shredder	553.10	3	1,659
Sewing Overlock Machine	338.00	10	3,380
Embroidery Machine	460.91	5	2,305
Labeling Machine	76.82	5	384
Fabric Washing Machine	3,042.04	1	3,042
Total			**10,770**

Table 5. Factors for Estimating Production Costs.

Parameters	Cost (USD)
Capital Related Cost	75,494
Depreciation	6,333
Total Fixed Cost	81,827
Raw Material	1,935,841
Utilities	900
Operating Labor (OL)	24,336
Labor Related Cost	7,301
Sales Related Cost	164,546
Total Variable Cost	2,132,924
Sales	2,350,664
Manufacturing Cost	2,208,418
Investment	67,884
Profit	0.06
Profit to Sales	2.10
Unit	450,000
Break-Even Point (BEP)	169,110.97
Percent Profit on Sales	6.05%
Return on Investment	2.25
Pay Out Time	0.43

4.3. Economic Evaluation

The project's feasibility was evaluated using a range of economic indicators. Total capital-related costs were calculated at USD 75,494, while fixed costs, including depreciation, amounted to USD 81,827. The total variable costs, dominated by raw materials and labor, reached USD 2,132,924. Annual sales were projected at USD 2,350,664, with manufacturing costs of USD 2,208,418.

Using this data, the following indicators were derived: a profit margin of approximately 6%, return on investment (ROI) of 2.25, and a payback period (PBP) of approximately 0.43 years. Although the textual summary of the paper states a PBP of over three years, the actual table calculation indicates a much shorter recovery time. This discrepancy may stem from

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conservative modeling in narrative form versus direct numerical computation. Similar payback periods have been observed in circular economy projects utilizing textile and agricultural waste [31,32].

4.4. Interpretation of CNPV Curve

Figure 2 illustrates the CNPV/TIC curve over the 20-year project lifespan. The x-axis represents the number of years, while the y-axis reflects the ratio of cumulative net present value to total investment cost. During the initial phase (years 0 to 3), the curve is negative, indicating that investment exceeds generated revenue, marking the payback period. From year 3 onward, the curve trends upward rapidly, signifying that the project begins to generate profit.

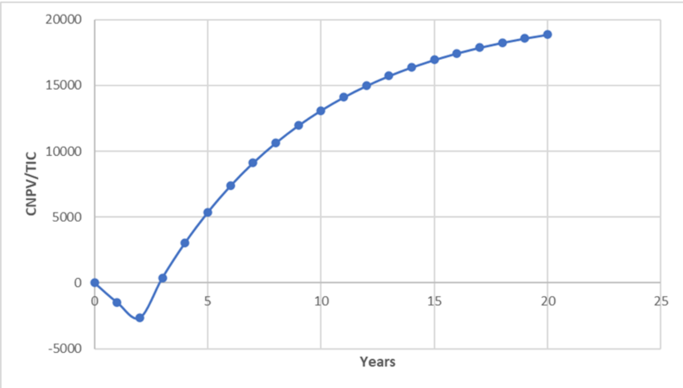

Figure 1. Ideal conditions for CNPV/TIC regarding life time (years).

This pattern is consistent with the expected investment trajectory for small-scale green technologies, where moderate startup costs are offset by growing cash flow in mid- to long-term projections [33]. The model confirms financial viability while also contributing to SDG 12 by reducing waste and SDG 8 through employment creation in sustainable industries.

4.5. Relevance to Sustainable Development Goals (SDGs)

The findings of this study directly support the achievement of several SDGs, particularly SDG 12: Responsible Consumption and Production and SDG 8: Decent Work and Economic Growth.

From the perspective of SDG 12, the project demonstrates a practical strategy for reducing textile waste through upcycling. The utilization of fabric scraps (often discarded or incinerated) into value-added eco-products represents a shift from linear to circular production models. By designing a low-cost and low-tech manufacturing process, this study contributes to minimizing environmental impact, optimizing resource efficiency, and promoting sustainable patterns of consumption. The technical feasibility confirmed in this research validates the scalability of this model for community-based or industrial initiatives that prioritize environmental responsibility.

In line with SDG 8, the proposed business model also creates economic opportunities by fostering entrepreneurship and supporting micro-enterprises. The reliance on relatively simple machinery and modest capital investment makes it accessible to small producers, including those in rural or informal sectors. Moreover, the labor requirements outlined in the cost structure highlight the potential for local job creation in waste collection, fabric sorting, sewing, and product distribution.

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Beyond these two primary SDGs, the study's implications may extend to SDG 9 (Industry, Innovation and Infrastructure) by promoting innovation in sustainable manufacturing practices, and SDG 11 (Sustainable Cities and Communities) through localized production that addresses urban waste challenges.

The alignment with these global goals reinforces the broader value of this research (not only in economic terms but also in its contribution to long-term environmental sustainability, community development, and green innovation ecosystems).

This study adds new information regarding SDGs as reported elsewhere (**Table 6**).

Table 6. Previous studies on SDGs.

No	Title	Ref
1	Dataset on the number of schools, teachers, and students in Sulawesi, Indonesia	[34]
2	A bibliometric insight into materials research trends and innovation	[35]
3	Techno-economic analysis of sawdust-based trash cans	[36]
4	Education on diversification of food using infographic	[37]
5	Sustainable packaging: Bioplastics as a low-carbon future step	[38]
6	Enhancing innovative thinking through a theory-based instructional model	[39]
7	Environmentally friendly packaging and zero waste interest	[40]
8	HIRADC for workplace safety in manufacturing	[41]
9	Enhancing job satisfaction through HRIS and communication	[42]
10	Analysis of student's awareness of sustainable diet	[43]
11	Professional readiness in vocational education	[44]
12	Smart learning as transformative impact of technology	[45]
13	Sustainable development goals (SDGs) in science education: Definition, literature review, and bibliometric analysis	[46]
14	Optimizing lemon commodities and community empowerment	[47]
15	Integrating generative AI-based multimodal learning	[48]
16	Application of Mediterranean diet patterns on sustainability	[49]
17	Definition and role of sustainable materials	[50]
18	Safe food treatment technology	[51]
19	Wet organic waste ecoenzymes for environmental conservation	[52]
20	Techno-economic analysis of production ecobrick	[53]
21	Self-efficacy on affective learning outcomes	[54]
22	School feeding program and SDGs in education	[55]
23	Physical adaptation of college students in high-altitude training	[56]
24	Enhancing occupational identity and self-efficacy	[57]

5. CONCLUSION

The techno-economic feasibility analysis of eco product manufacturing from processed fabric waste confirms that the project is both technically and economically viable. The analysis shows that production using recycled textile materials can be carried out using simple equipment and affordable raw materials, making the model accessible and replicable for small-scale enterprises. From a technical perspective, the production process is straightforward and requires minimal complexity. Economically, the projected return on investment and short payback period (supported by profitability indicators) demonstrate the project's financial attractiveness. The CNPV/TIC curve further confirms that the project transitions to a profitable phase after the third year, with steadily increasing returns throughout the 20-year horizon. This business model provides a realistic solution for addressing textile waste management while generating economic value. Its alignment with SDGs (particularly SDG 12 on responsible production and SDG 8 on decent work) underscores its potential impact for promoting circular economy practices, local employment, and sustainable entrepreneurship.

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7. 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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