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COLLABORATIVE GOVERNANCE IN WASTE MANAGEMENT WITH A TECHNO-ECONOMIC FEASIBILITY STUDY PERSPECTIVE OF ORGANIC COMPOST FERTILIZER PRODUCTION BASED ON LIVESTOCK BONE WASTE

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Abstract

This research evaluates the feasibility of a techno-economic based small and medium production business regarding organic compost fertilizer from livestock bone waste. This can be done with the government in Bogor city because Bogor city has regional regulation number 6 of 2019 concerning waste management. The research method used is content analysis and economic evaluation using fundamental economics such as gross profit margin, payback period, and net value. The data used in this analysis is from official e-commerce with complete descriptions such as prices, components, brands, and specifications of equipment and raw materials. Ideally, the calculations are carried out with production simulations for the next 20 years. The results of the economic evaluation analysis show that this project is feasible for small and medium-scale industries because the tools used are still simple and commercially available in e-commerce. The evaluation showed positive results in all parameters, indicating that this production plant has promising profit potential. This research impacts the understanding of waste management practices. It contributes information and knowledge from the economic aspects of compost production. It supports collaborative governance between the government and the private sector in Bogor city regarding sustainable waste management.

Keywords: Collaborative governance, Livestock bone waste, Organic compost fertilizer, Techno-economic feasibility, Waste management.

1. Introduction

Many previous studies have shown the effectiveness of current waste recycling. This usually applies to the efficacy of machines, community empowerment, and turning waste into compost or other valuable goods [1-3]. However, there needs to be more information regarding the economic evaluation of the feasibility of commercial-scale processing of recycled livestock bones. In previous research, we collaborated with the government, private sector, and communities in managing plastic waste. Some literature examines the recycling of organic waste from livestock bones into organic fertilizer for social purposes and profit or socio-entrepreneurship [4-6]. This is the novelty of this research.

This organic compost fertilizer from livestock bones is intended to be applied collaboratively between the government, private sector, and communities [7]. This collaboration pattern is community participation [8]. Thus, this organic fertilizer has the potential to be used for social and profit purposes in developed or developing countries where chemical fertilizers are challenging to access and expensive. Livestock bones were selected because this waste is no longer used and is thrown away for free in temporary storage areas. Apart from that, the advantages of this animal bone are that it is pure phosphorus, calcium, magnesium, iron, and zinc, it is suitable for plants, it can improve soil fertility [9, 10]. This research used content analysis and economic evaluation methods to make organic compost from livestock bones. The analysis described using observations on the charts and tabulations available on these observations is called content analysis, which is supported by scientific references in the field [11]. There are many research regarding techno-economic analysis, presented in Table 1.

Table 1. Previous studies regarding techno-economic analysis.

No.	Title	Ref.
1	Techno-economic assessment of coal to SNG power plant in Kalimantan	[12]
2	Techno-economic analysis on the production of zinc sulfide nanoparticles by microwave irradiation method	[13]
3	Techno-economic evaluation of hyaluronic acid production through extraction method using yellowfin tuna eyeball	[14]
4	Computational bibliometric analysis on publication of techno-economic education	[15]
5	Techno-economic evaluation of gold nanoparticles using banana peel (musa paradisiaca)	[16]
6	Techno-economic analysis of the business potential of recycling lithium-ion batteries using hydrometallurgical methods	[17]
7	Domestic waste (eggshells and banana peels particles) as sustainable and renewable resources for improving resin-based brakepad performance: Bibliometric literature review, techno-economic analysis, dual-sized reinforcing experiments, to comparison with commercial product	[18]
8	Techno-economic analysis and environmental impact assessment of energy recovery from municipal solid waste (MSW) in Brazil	[19]
9	Techno-economic feasibility study of low-cost and portable home-made spectrophotometer for analysing solution concentration	[20]

Several economic evaluation indicators, such as gross profit margin (GPM), internal rate of return (IRR), payback period (PBP), cumulative net present value (CNPV), break-even point (BEP), and profitability index (PI), are calculated to support the economic evaluation [21]. Data, including raw materials prices, components, and equipment specifications, are taken from available e-commerce sites to support this financial analysis.

This research is vital because it has four benefits. The first benefit is understanding the possibility of producing organic compost fertilizer made from livestock bone waste, which has low production costs [22]. This can help decide whether the scale-up process is possible and provide appropriate recommendations on maximizing this recycling project. The second benefit is when the process of each recycling stage is feasible in medium or larger-scale production. Organic compost fertilizer made from livestock bone waste has now been used as an alternative fertilizer in agriculture that is more environmentally friendly in developed and developing countries [22]. The third benefit is providing sales value and profit for the private economy and society, including economic growth, poverty reduction, and the availability of job vacancies. The fourth benefit is reducing the volume of waste and protecting the environment with this recycling. This is due to the analysis in the feasibility study, where, in detail, all calculations are carried out under ideal conditions produced over the next twenty years. Even large-scale development processes must be analysed more deeply and continuously. Other variables can and must be added.

These variables, such as labour conditions, weather, equipment prices, raw materials, utilities, and environmental dynamics, such as competitors, taxation, and subsidies, are significant for producing sustainable and well-adapted results. This analysis can inspire researchers or other readers to conduct more profound and comprehensive investigations, enabling them to create a factory with larger-scale production. In addition, this research is equipped with a collaborative model for waste management by recycling organic waste. This aims to enable readers to understand well and provide further development. This study also supports current issues in sustainable development goals (SDGs), as reported elsewhere [23-27]. One aspect of this research is related to the 12th goal of the SDGs, Responsible Consumption and Production. Because most waste is generated from household consumption, reducing waste through this research is important.

2. Method

The research method used is content analysis in charts and tables, which provides in-depth and comprehensive results and discussion [28]. Economic evaluation using a feasibility study, which consists of several financial indicators, such as GPM, IRR, PBP, CNPV, BEP, and sales-to-investment ratio, is also used. The systematic process used in this research is shown in Fig. 1.

To support the analysis in this research, data on prices of raw materials and equipment required were taken prices from official e-commerce sites that are well known for their credibility [29]. Each calculation is carried out in ideal conditions by simulating and predicting production over the next 20 years, assuming that global economic conditions are not experiencing inflation or deflation [30].

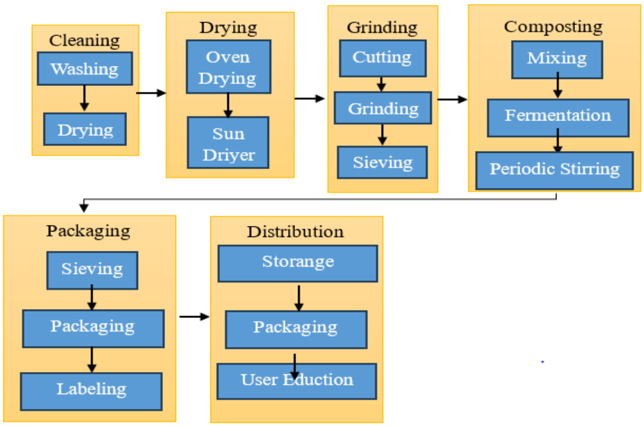

Fig. 1. Flowchart of the process for making organic fertilizer from animal bone waste.

3. Results and Discussion

In Table 2, the total equipment needed to make organic compost is 7,025.60 USD, the most expensive being the bone-crushing machine, which equals 2,934.43 USD. The total daily costs for these raw materials reach 7,654.82 USD, if calculated in one year, the total costs can reach 2,296,447.34 USD. These details show that livestock bone waste is the most critical component. This dominates the cost of raw materials in producing this organic compost fertilizer. Apart from that, using cleaning agents and water is also necessary to ensure the cleanliness and quality of raw materials before further processing and with additional organic materials such as vegetables, dirt, and others. This can help enrich the nutritional content in the compost produced, it is more plentiful and of better quality. We calculate the total daily utility costs for producing organic compost made from livestock bone waste at 22.05 USD. This calculation is using various equipment with different electrical power. These overall utility costs are essential for estimating daily operational costs, the economic feasibility of this project can be assessed. By looking at the relatively low operational costs with the material capacity used and the selling price used, this product can be profitable in terms of profit.

The total capital required for the investment in the project to produce organic compost fertilizer made from livestock bone waste is 44,856.41 USD. This investment capital consists of two main components: Direct and indirect costs. This total investment has feasibility if seen from the profit margin, which is quite significant in terms of return on investment (ROI), which is high, and the PBP, which is relatively short. This shows that this investment can return capital in a brief time, this can attract investors and is a guarantee that this project has long-term potential.

As detailed, the manufacturing costs for producing organic compost fertilizer from livestock bone waste amount to 2,562,131.92 USD. This is high but still measurable and can be managed well. Looking at the enormous profits, efficiency in using raw materials and labour is essential. Here, maintenance and depreciation costs are also exceptionally high. This is because the equipment can be used in the long term.

Table 2. Equipment calculation.

Tool name	Price (USD)	Amount	Total price (USD)
Bone container	35.15	1	35.15
Cutting machine	104.85	1	104.85
Washing machine	545.39	1	545.39
Oven	715.03	1	715.03
Drying place	97.78	1	97.78
Grinding machine	2,934.43	1	2,934.43
Sifter machine	1,347.82	1	1,347.82
Mixer machine	180.30	1	180.30
Composting place	488.91	1	488.91
Packaging container	48.89	1	48.89
Labelling tool	502.60	1	502.60
Gloves	4.89	5	24.45
Total			7,025.60

The feasibility of producing this organic compost fertilizer because, with a daily capacity, it can produce 3200 kg/day (960,000 kg/year) with a compost price of 2.91 USD/kg. The annual income is 2,562,131.92. The production of organic compost fertilizer has a total Fixed Cost of 49,351.19 USD, a total Variable Cost of 2,516,593.52 USD, and a total manufacturing cost of 2,562,131.92 USD. With the estimated annual income, this can produce a profit margin. This is positive, with BEP, there are 171,573.1707 units with a profit percentage on sales of 8.26%. ROI is 6.05%, and the PBP is 0.16 years. Investing in organic compost fertilizer can quickly return the initial capital. Figure 2 shows the CNPV curve against total investment cost (TIC) in a factory producing organic compost fertilizer made from livestock bone waste for 20 years. This curve shows the cumulative change in the net present value of the total investment cost in various production capacities. This curve describes the profitability of the project in the long term, the CNPV value at the beginning of the first and second years is negative, which means that the number is negative due to the significant initial costs associated with factory construction, procurement, and product marketing. However, the following year, with an increase in production capacity, the value of CNPV began to increase significantly in terms of business profits. It continues to grow for the next 20 years, assuming it is not influenced by inflation and deflation.

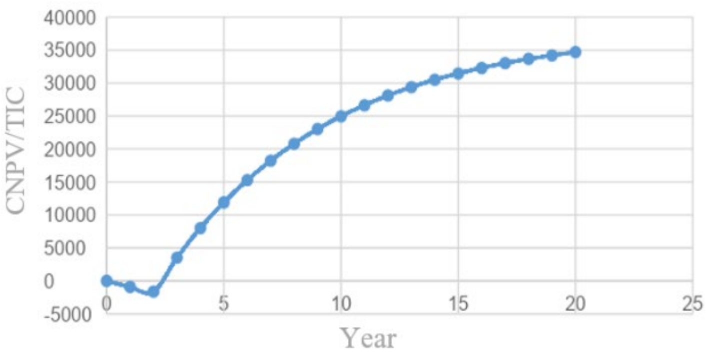

Fig. 2. CNPV/TIC curve.

4. Conclusion

Calculation of feasibility study on the production of organic compost fertilizer made from waste bones, livestock animals have positive viability and have good profitability even in the long term for the next twenty years, even though at the beginning of the development year, they have not shown positive progress, but that is normal because they are still in the development and marketing period. Because with total investment costs incurred amounting to 44,856.41 USD and manufacturing costs amounting to 2,562,131.92 USD, the prospects for this business can generate an annual income of 2,792,727.27 USD. Thus showing a good profit margin. Therefore, to realize this significantly, the government must conduct collaborative governance with the private sector and the community. This collaboration model could be an excellent solution to waste management, which is a problem in every big city in Indonesia. The city of Bogor has regional regulations that regulate waste management. Our findings, waste recycling has yet to be implemented significantly and comprehensively in all villages. Therefore, with collaboration and the results of this service study, it can be a recommendation for the Bogor city government that this recycling can benefit all parties.

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