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THE NON-TAILING SEDIMENT WASTE UTILIZATION STRATEGY AT PTFI DMLZ MINE

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Abstract: Mining in PT. Freeport Indonesia (PTFI) produces tailing and non-tailing sediment waste. The purpose of the study is examining the financial feasibility analysis of managing non-tailings sediment waste through the conversion program of non-tailings sediment waste into concrete products and formulate the strategies of non-tailing sediment conversion program. Quantitative and qualitative methods are combined in this study. Capital budgeting method are used to examine financial feasibility analysis. IFAS, EFAS matrix and SWOT analysis are used for strategies formulation. Results of capital budgeting analysis have yielded a net present value (NPV) at a 9.4% discount rate of Rp12.1 billion for the conversion program of non-tailing waste, Net B/C result is greater than 1, suggesting that the project is viable from a financial standpoint. Sensitivity analysis has also demonstrated that the parameters with more significant influence on project NPV are concrete price, production cost, and sales volume. The non-tailings sediment conversion program is feasible because it provides greater economic, social, and environmental benefits when compared to non-tailings waste management using the landfilling method. The strategies that can be implemented to run the sediment waste utilization program are Strength-Opportunities strategies as follows: first is use a capital strong to access and apply the best technology, secondly increase the use of ready mix concrete made from non-tailing sediment waste for projects that require low Mpa concrete, the third, working with entities inside and outside PTFI to open the market for non-tailing sedimentary waste concrete products, and fourth utilizing good infrastructure and abundant sediment waste and fiber to diversify precast concrete products.

Keywords: aggregates, capital budgeting, financial feasibility analysis, non-tailing waste, strategy, SWOT

Abstrak: *Pertambangan di PT. Freeport Indonesia (PTFI) menghasilkan limbah sedimen tailing dan non-tailing. Tujuan penelitian ini adalah mengkaji kelayakan finansial pengelolaan limbah sedimen non tailing melalui program konversi limbah sedimen non tailing menjadi produk beton pracetak dan merumuskan strategi program konversi sedimen non-tailing. Metode kuantitatif dan kualitatif digunakan dalam penelitian ini. Metode capital budgeting digunakan untuk menganalisis kelayakan finansial. IFAS, matriks EFAS dan analisis SWOT digunakan dalam perumusan strategi. Hasil analisis capital budgeting menghasilkan net present value (NPV) pada tingkat diskonto 9,4% sebesar Rp12,1 miliar untuk program konversi limbah non tailing, hasil Net B/C lebih besar dari 1, menunjukkan bahwa proyek ini layak dari sudut pandang keuangan. Analisis sensitivitas juga menunjukkan bahwa parameter yang paling berpengaruh terhadap NPV adalah harga beton, biaya produksi, dan volume penjualan. Strategi yang bisa dijalankan untuk merealisasikan program pemanfaatan limbah sedimen non-tailing adalah strategi Strength-Opportunities sebagai berikut: pertama memanfaatkan kekuatan modal untuk mengakses dan menerapkan teknologi terbaik dalam pengolahan limbah sedimen non tailing menjadi produk beton berkualitas, kedua meningkatkan penggunaan beton readymix berbahan limbah sedimen non tailing untuk proyek-proyek yang membutuhkan beton Low Mpa, ketiga, bekerja sama dengan entitas di dalam dan di luar PTFI untuk membuka pasar produk beton berbahan limbah sedimen non-tailing, dan keempat memanfaatkan infrastruktur yang baik, limbah sedimen dan serat yang melimpah untuk diversifikasi produk beton pracetak.*

Kata kunci: *agregat, analisis kelayakan finansial, capital budgeting, limbah non-tailing, strategi, SWOT*

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INTRODUCTION

PTFI is a mineral mining company that produces the main product in the form of copper concentrate. In addition to valuable minerals, other results of mining activities are waste rock material and sediment waste derived from processing plants or known as tailings and sediment waste derived from mines known as non-tailing sediment waste. The process of flow of ore and mining materials is shown in Figure 1.

Mineral and metal mining activities can negatively impact the environment, one of the causes is tailings impact. Tailings are waste generated from grinding mining rocks that contain ore material or precious minerals (Sondakh et al. 2015). Mining activities carried out by PTFI have non-tailing sediment waste and produce tailings waste. Non-tailing sedimentation waste comes from upstream mining activities, including open-pit mines and underground mines. High rainfall in upstream areas causes a high rate of erosion that can bring non-tailing sediment waste on the surface into the stream and deposited in the ModADA area. The non-tailing sediment waste that enters the ModADA system contains high sulfide minerals and can produce acidic mine water that can pollute the environment (Taberima et al. 2020). Data on the amount of non-tailing sediment produced in the PTFI highland area can be seen in Figure 2.

In 2018 the Ministry of Environment and Forestry issued a Decree of the Minister of LHK No.594 regarding implementing the tailing management roadmap of PT Freeport Indonesia (PTFI). Its goal is to improve the management of tailings and non-tailings at PTFI. One of the points in the road map is the non-tailing sediment reduction activity of the mining area. Non-tailings sediment collected from deposition ponds (sediment ponds) then disposed of in landfill areas. High rainfall in highland areas causes non-tailing sedimentary waste material in landfill areas to potentially be eroded and carried into the river stream. The potential for landslides in the highlands is very high due to high levels of seismic activity, high rainfall, and landfill areas that tend to contour with steep slopes, steep valleys, and sharp peaks (Rusdinar et al. 2013).

This research was conducted due to the presence of non-tailing sediment waste that can pollute the environment if not managed properly and potential of landslide in landfill area if this waste still disposes in landfill. Innovative research on solid waste management results with newer technologies creates opportunities to use solid waste as an alternative raw material for construction materials and substitutes for materials such as bricks, tiles, aggregates, ceramics, cement, and wood (Asokan et al. 2005).

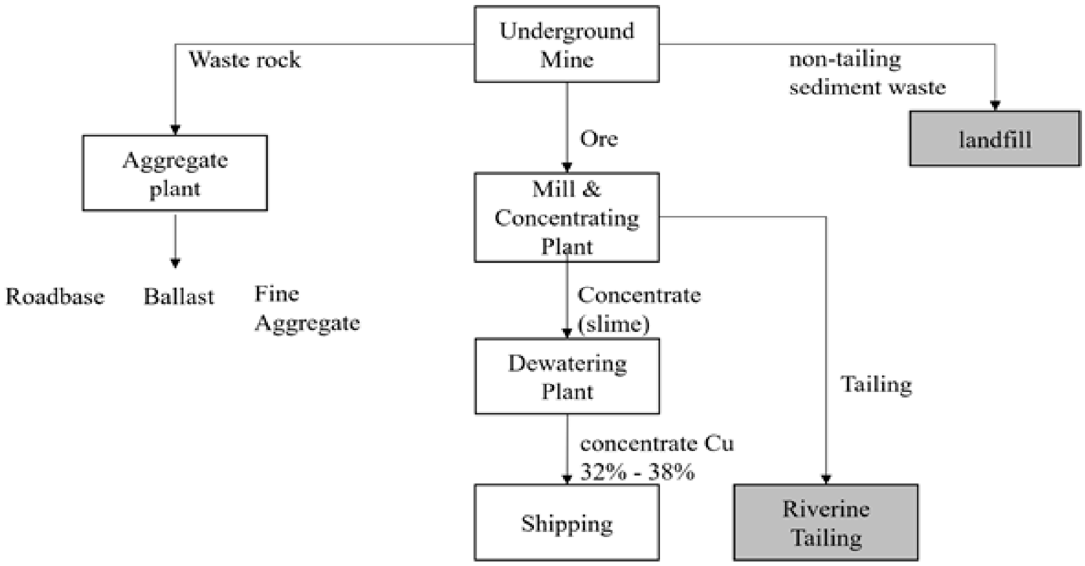

Figure 1. Ore and mining material flow at PTFI

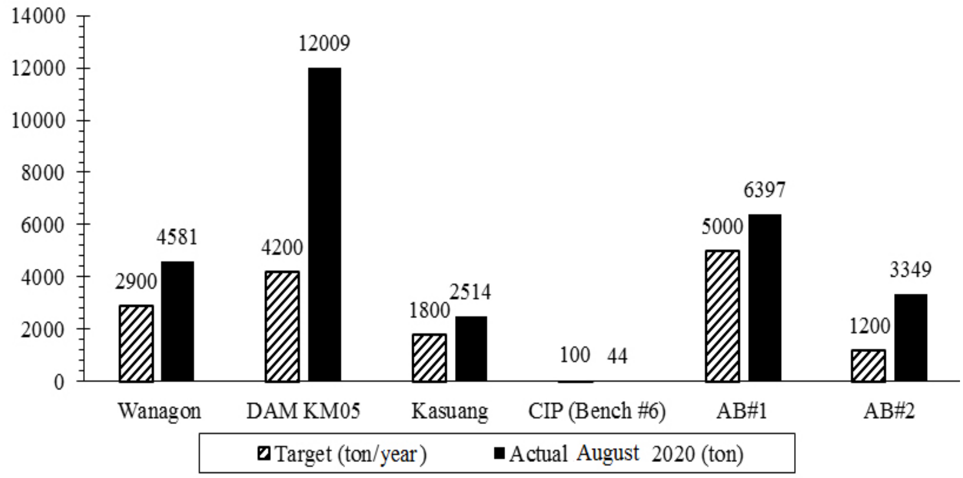

Figure 2. The amount of non-tailing sediment produced in deposition ponds in PTFI highland areas

Research on the utilization of waste as an aggregate material in concrete mixtures has been widely done, among others. Gou et al. (2019) Reviewing the potential utilization of tailings as a substitute for fine aggregates for the complement of cement materials in mortar or concrete and the production of cement clinkers, Ohemeng and Ekolu (2020) Analyze the benefits and costs of natural aggregate production with recycled aggregates derived from concrete waste, Ostrega et al. (2011) Reviewing sustainable development in mining and providing guidelines for mining companies to operate more sustainably, Hahladakis et al. (2020) Formulate strategies in the management and utilization of aggregates derived from construction waste. The study focused on analyzing the financial feasibility of managing non-tailing sediment waste generated at highland by converting non-tailing sediment waste into concrete products and formulating strategies for implementing this waste conversion program.

The general purpose of the study was to utilize non-tailing sediment waste and turn it into value-added products such as concrete. The specific purpose of this research is; Analyze the financial viability of the non-tailing sediment waste conversion program into precast concrete products; Formulate strategies to realize a non-tailings sediment waste conversion program.

Tailing and non-tailing sediment waste have a same physical and chemical properties. Some of advantages of concrete that had been made from tailing are: The quality of concrete reaches 50Mpa and is resistant to the influence of fresh water, rain water, and even acid water. The cost of concrete for roads is half of cost of conventional concrete and material such as gravel and tailing (fine aggregates) does not need to be imported from other places. Safe and environmentally friendly due to leachate concentration from tailing concrete is very low as well as the rest of the stable low-level heavy metals in tailing concrete (Fisonga et al. 2019). Financial benefits in the terms of environmental sustainability is much higher for the tailing agregates in comparison to fines natural aggregates or sand (Mahmood and Elektorowicz, 2016). More over the concrete product that derived from non-tailing sediment waste give the financial benefit because the concrete products are required in the mining development process and for municipal construction. Underground mine need concrete for ground support activity, fix facilities construction, and road maintenance. Timika is the closest city to the mine site which will develop into the provincial capital. The rapid development in Timika has made the city a potential market for precast concrete products. From the purpose of research and literature study, the hypothesis that can be built in this study are, H0: The non-tailings sediment conversion program into concrete products is not viable to run and H1: The non-tailings sediment conversion program into concrete products is viable to run.

The approach taken in solving the problem of potential pollution caused by non-tailings sediment waste in this study is to prove that the non-tailings sediment conversion program provides better economic, social, and environmental benefits when compared to its management non-tailings sediment waste by landfilling, so that the non-tailings sediment waste conversion program is feasible to run. After the feasibility assessment is carried out, analysis of external and internal factors is carried out to formulate the right strategy to implement non-tailings sediment conversion program sustainably.

The expected result of this research is some improvement of non-tailings sediment waste management to prevent potential environmental pollution and with the right strategy, the program for converting non-tailings sediment waste into concrete products can be run sustainably.

METHODS

The research location is in the Common Infrastructure Project (CIP) of PTFI MP72 and the DMLZ mine of PTFI Mimika Regency. The location selection is based on the consideration that CIP includes sedimentation storage facilities in the highlands, aggregate plants, and road facilities leading to the DMLZ underground mine. The study was conducted from July - to December 2020.

This study uses secondary data of company reports, journal and primary data from interview and questionnaire. The determination of respondents for questionnaire is done by purposive sampling. Selected respondents came from the operation, construction, production, and development departments. The respondents' determination is based on the consideration that the respondent knows the operational process thoroughly and plays a role in decision making. Prior compiling the questionnaire, in-depth interviews were conducted to determine a list of external and internal factors. The respondent for in-depth interviews is department head who initiate the waste conversion program.

The method used to analyze data is capital budgeting analysis with Net Present Value (NPV), Net Benefit Cost Ratio (Net B/C), Internal Rate of Return (IRR), Discounted Payback Period (DPP), and Sensitivity analysis tools. Capital budgeting methods with NPV criteria are better to ensure profitability but not liquidity, whereas DPP is superior because it can ensure profitability and liquidity (Bhandari, 2009). The capital budgeting method is the right analytical tool to assess the benefits and risks of a long-term program or project. According to Rigopoulos (2014), capital budgeting is crucial to assess the company's performance and prospects.

Analyze tool for internal and external factor is IFAS and EFAS matrix. The SWOT method is used to formulate a non-tailing waste utilization strategy. This method is used because the SWOT method is valuable and straightforward, especially for preliminary research and the basis for applied and theoretical research. SWOT is one of the most through evaluation methods and can cover various aspects (Kreiner and Wall, 2007).

The hypothesis built on this study are H0: the conversion program of non-tailing sediment waste into concrete products is not viable and H1: the conversion program of non-tailing sediment waste into concrete products is viable. The basis of this hypothesis is research from Lottermoser (2017), which explains that reusing and recycling mining waste creates opportunities to add financial assets, slow down natural resource consumption, reduce waste production, encourage innovation, teach responsibility to the environment, and reduce exposure to contaminated materials to humans and ecology.

Several previous studies on the utilization of waste derived from tailings or construction waste as aggregate substitute materials in concrete mixtures became one of the foundations in establishing a research framework for non-tailing waste utilization strategies. When viewed from theoretical aspects, applying pollution prevention science and technology can help the industry withstand the negative impact of industrial waste on the environment (Rahmawati et al. 2017). The presence of non-tailing sediment waste that can pollute the environment if not managed properly, landslide potential in the landfill area, and the potential benefit of non-tailing sediment waste, prompts PTFI to consider the conversion program of non-tailing sediment waste into concrete products as one of the alternatives to non-tailing waste management. Based on this can be built a research framework in Figure 3.

RESULTS

Non-Tailing Sediment Waste Utilization Process

Drilling, material transport, and blasting activities produce non-tailing sediment waste in the form of sand are carried away by drainage flows in underground mines and then deposited in temporary settling ponds that have been built. Settlement ponds are cleaned regularly, and sediment material resulting from the cleaning of settling ponds is stored temporarily until water content decreases and is ready to be transported to the aggregate plant in the CIP area. The non-tailings sediment waste is then prepared, cleaned of impurities, and sorted until ready to be used as a concrete mix material.

The concrete products from non-tailing sediment waste are safe for human and environment. Leachate concentration from tailings concrete is very low, as well as the rest of the stable low-level heavy metals in tailings concrete. The results of leaching tests on concrete products are shown in Table 1. The concentration of leachate from concrete with a mixture of non-tailings sediment is very low when compared to the quality standard parameters set by the government, and the remaining low content of heavy metals is stable in the concrete. So that the concrete mixture with fine aggregate material derived from non-tailing sediment is safe to use. Wang and Al-Tabbaa (2014), explained that the mobility of heavy metals in cement mixtures will be more stable at pH 9-11.

Feasibility Analysis

The investment costs consist of initial capital for non-tailings sediment waste management, batching plant facilities, and product transportation facilities. The investment costs for the management of non-tailings sediment waste by way of landfilling and conversion into concrete products can be seen in Table 2.

Management of non-tailings sediment waste through a program of converting waste into precast concrete products requires a larger initial investment when compared to the management of non-tailings sediment waste by landfilling. The biggest investment component for these two non-tailings waste management methods is in the provision of heavy equipment. The investment in the conversion program of non-tailings sediment waste into concrete products is greater because it requires additional facilities in the form of a batching plant and more heavy equipment compared to non-tailings waste management by landfilling.

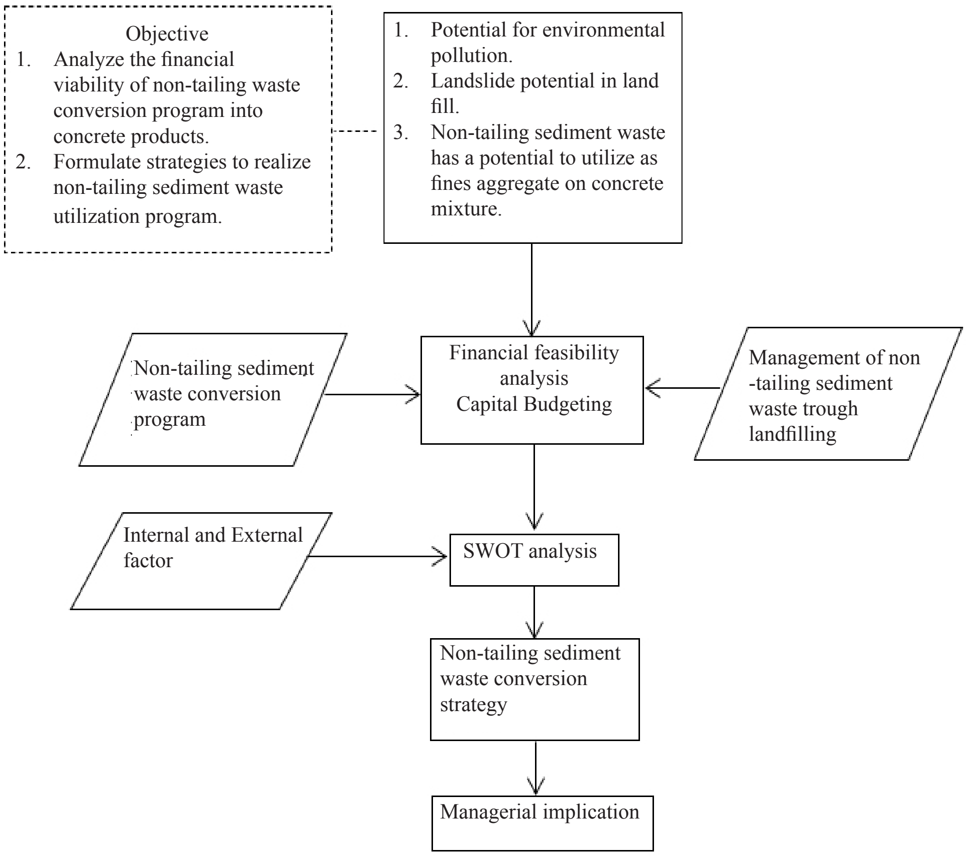

Figure 3. Research framework

Non-tailing sediment waste is a mining waste that can be used for fine aggregate replacement materials or sand in concrete mixtures. Producing 1 m^3 of precast concrete takes 540 kg of fine aggregates derived from non-tailing sediments. To generate cash flow, all non-tailings sediment or as much as 13723 tons/year is used to manufacture precast concrete and readymix concrete. It is assumed that the market absorbs all concrete products. The age of the project used in this analysis is ten years, and the discount rate used is 9.4%. Cash flow results from revenue (benefits), cost components, and predetermined assumptions such as project magnitude, product sales, and discount rates (Auguar et al. 2017). The assumptions in this study are shown in Table 3.

Table 1. Leached test of concrete product from sediment waste

Parameter	Sediment + Cement	Sediment + Cement + Polimer	Convensional concrete
Range of pH	7.83 – 10.05	7.89 – 9.70	7.71 – 9.41
Average pH	8.93	8.91	8.73
Range soluble Cu, mg/L	<0.001-0.059	<0.001 – 0.036	<0.001 – 0.028
Average soluble Cu, mg/L	0.012	0.008	0.004

Table 2. Capital cost of sedimen waste conversion program and landfilling

Capital cost	Waste conversion (Rp)	Landfilling (Rp)
Land	375,000,000	2,500,000,000
Build	750,000,000	150,000,000
WS Truck Mixer	12,352,341,371	-
WS Truck Flatbed	6,194,240,400	-
Mobile batching plan	14,251,954,223	-
Dozer	-	24,190,086,146
Excavator	1,022,104,148	1,022,104,148
Forklift Loader 966	6,838,612,869	6,838,612,869
Truk AT 740	7,242,459,703	7,242,459,703
Offices supplies	64,800,000	40,500,000
Pump and water installation	5,000,000	2,000,000
Electrical installation	2,000,000	5,000,000
Permit	10,000,000	5,000,000
Land certificate	8,000,000	3,000,000
Total	49,116,512,715	41,998,762,867

Table 3. The assumption in calculation

Description	Value	Remark
Investment period	10 years	
Maintenance cost	10% from equipment investment	Excallation 5% /years
Production	Fix	10 years
Depreciation	20% from aquaition price	Straight-line depreciation method
Excallation production cost	5% / years	Assumption
Depreciation years	10 years	PTFI data
Wage increase	5% /years	PTFI data
Discount rate	9,4%	Average discount rate in 2020
Price increase	5% / years	Assumption
1 USD	Rp 13.800	Average exchange rate in 2020

Waste management programs by converting non-tailing sediment waste do not consist cost of handling sediment waste in landfills because all the resulting sediment waste is used as an aggregate material for concrete mixtures. Ohemeng and Ekolu 's research (2020) results show that the cost of handling waste in landfills will reduce if companies use aggregate recycled products. The operational cost of non-tailing sediment waste conversion is shown in Table 4.

Prior to the analysis of cash flow, the stages of the non-tailings sediment management process are identified and the components of management costs are listed and quantified. From the results of the analysis obtained the cost of managing non-tailing sediment waste by landfilling amounting to Rp764,235/ton while for the cost of managing non-tailing sediment waste by conversion was obtained Rp1,851,195/m^3 or equivalent to Rp3,428,138/ton of sediment waste. Although the cost of waste conversion is bigger compared to the method of landfilling, the processing of waste by means of conversion produces concrete products that have added value when compared to landfilling methods. The value of concrete products from conversion program are shown in Table 5.

The income statement in the first year shows a profit. If the calculation using the assumption in Table 6, cash flow for the non-tailing waste conversion program gives a positive NPV value of Rp12,092,993,616. The results of NPV analysis for non-tailing waste conversion programs show that the program is feasible; according to Creemers (2018), the project is categorized as feasible if the NPV result is positive and not feasible if the NPV result is negative.

The results of the Net B/C analysis showed a value of greater than 1 and is an indication that this non-tailings sediment waste conversion program is profitable and feasible to run these results in accordance with Yasri et al. (2020) research that the net value of B / C > 1 in the financial feasibility study of batching plant development in North Sulawesi Province shows that the construction of the batching plant is feasible to run.

The IRR analysis of the non-tailing waste conversion program is 14.87% and more significant than the discount rate used in this analysis which is 9.4%. Investment of non-tailing waste conversion program into precast concrete products is considered feasible to run based on IRR feasibility assessment criteria. This is in line with the results of Abeye's research (2019) that the IRR can be used as a company to take sustainability decisions on a project. If the IRR is higher than the interest rate, the project will experience profits.

Table 4. Operation cost on 2020th of non-tailing sediment waste conversion

Cost	Amount (Rp)
Labour	1,404,000,000
Concrete material	35,750,522,520
Sediment preparation	2,024,065,823
Concrete production	2,345,000,000
Maintenance	4,911,651,271
Fuel	200,000,000
Electric	500,000,000
Depreciation	3,871,455,017
Amortization	2,000,000
Total	51,008,694,632

Table 5. Production capacity

Concrete Products	Amount	unit	Price (Rp)
U Ditch 140x140 X120	2500	ea	3,850,000
Barrier 120 X80x100	4000	ea	1,300,000
Dollos	2500	ea	2,500,000
Concrete pavement	3000	ea	5,500,000
Cover U ditch	2500	ea	1,000,000
concrete wall	3000	ea	2,200,000
concrete ready mix	6172	m^3	1,993,835

Table 6. Income statement on 2020th of non-tailing sediment waste conversion

Income	
Sales	
Ready mix concrete	11,936,596,538
U Ditch 140x140 X120	9,625,000,000
Barrier 120 X80x100	5,200,000,000
Dollos	6,250,000,000
Concrete pavement	16,500,000,000
Cover U ditch	2,500,000,000
Concrete Wall	4,989,600,000
Total Income	57,001,196,538
Expenses	
Production	51,008,694,632
Selling	1,400,000,000
General and administrative	3,000,000
Total expenses	52,411,694,632
Profit	4,589,501,906

The results of the DPP analysis showed that the return on investment of the non-tailings sediment waste conversion program was 7.4, smaller than the investment life that has been set at ten years. Based on the DPP criteria, a non-tailing waste conversion program is feasible to run; according to the results of Bhandari's research (2009), the DPP value smaller than the specified investment life indicates that the project has a high level of profitability and liquidity, so it is feasible. Net benefit cost ratio (Net B/C).

In Figure 4 shows that the line for NPV caused by changes in Price, Sales Volume and production costs is steeper when compared to the NPV line due to investment changes and discount rates. This indicates that a small increase or decrease in selling prices, sales volume, and production costs will lead to major changes in NPV. While on the investment line and discount rate relatively more sloping so that small changes in discount rate and investment do not cause significant changes in NPV.

To determine the maximum change of a variable and its effect on NPV, a calculation of the linear equation obtained for each variable is performed. This calculation is done by finding intercept on the X axis for each linear equation. This intercept on the X-axis indicates that its NPV value is equal to zero, and the maximum change value is still allowed so non-tailing sediment waste conversion program is still viable. The maximum selling price decrease so that this business is still worth running is 5.8%. A decrease in the selling price exceeding 5.8% will cause this business is no longer economical to run. If there is a decrease in the number of sales above 6% then this sediment waste conversion program is no longer profitable. The increase in production costs includes variables that are very sensitive to NPV changes. The maximum acceptable increase in production costs is 6.8%. Investment variables and discount rate variables have less effect on NPV changes compare to selling prices, sales volume, and production costs variable. If there is an increase in investment to the limit of 28.8% this waste conversion program is still worth running. The discount rate variable is a variable that has less effect on changes in NPV, this indicates that the NPV value in this analysis is not sensitive to discount rate changes. The maximum discount rate change that is still acceptable so that the non-tailings sediment waste conversion business is still feasible to run is 71.1% of the initial discount rate value of 9.4% or if the discount rate increases to more than 18.34% then the NPV value will be negative and the non-tailing sediment waste conversion business to precast concrete is not worth running.

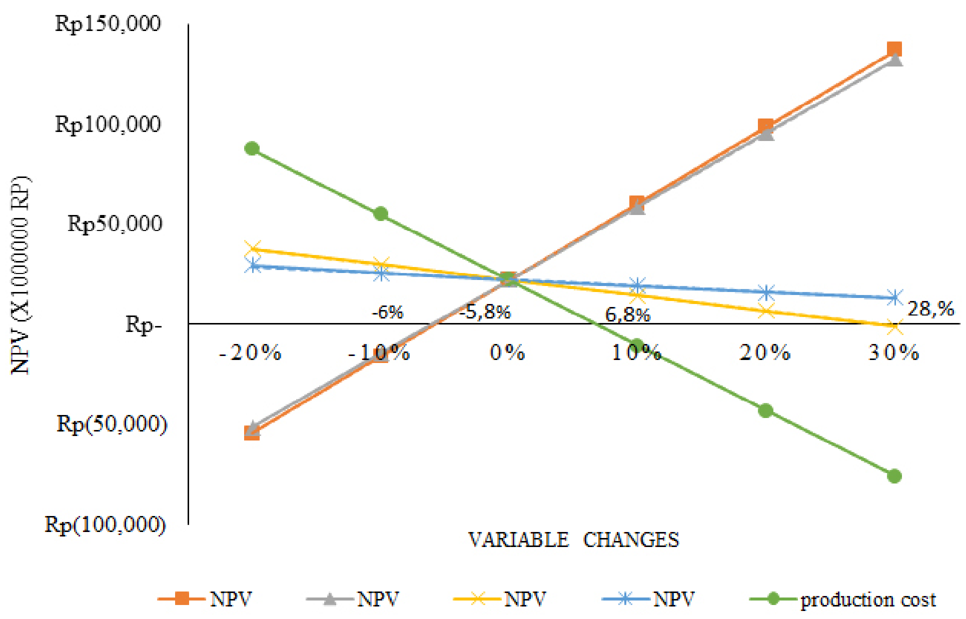

Figure 4. Sensitivity analysis

In addition to providing economic benefits, non-tailing waste conversion programs provide other benefits in environmental and social benefits. The benefit to the environment is a decreased risk of river pollution due to mining acid water and decreased burden of pollution in solids entering the river stream. The total solids collected in the deposition pool during 2020 is 13,729 tons.

Sediment waste management through landfilling have enormous risks such as acid mine water pollution and landslide risk in landfill areas. The risk of landslides in the landfill area can potentially impact villages close to the river flow. If there is no sound mitigation for handling this non-tailing waste, villages around this river flow can be affected by floods and landslides.

High rainfall causes non-tailing waste deposits that come from landfills and enter the river stream. The management of non-tailing sediment waste through landfilling is considered less than optimal because it raises the potential for declining environmental quality such as river water and groundwater around river flows. Kusumastuti's research (2005) explains that less than optimal waste handling shows a tendency towards declining environmental quality and economic losses.

Non-tailings sediment waste treatment programs and diversification of non-tailing sediment processing products provide new employment opportunities. This is an opportunity for the PTFI mining area residents, especially local people, to get jobs. The results of diversification of non-tailing waste products include paving blocks used for road repairs in the city of Tembagapura and dolos, which are used to build stability slope a long riverside. It will prevent erosion and landslides along the river that passes through Tembagapura district and surrounding villages.

Non-tailing sediment waste utilization strategy

Internal and external factors are identified using in-depth interview methods with expert. The expert is department head who initiate a program to use non-tailing sediment waste in the underground mining division. The results of the analysis of internal and external factors are further divided into four categories, namely strength, weakness, opportunity, and threat (Abulebdah and Musharavati, 2016). The results of weight assessment and internal and external factor rating obtained from the questionnaire are then averaged and evaluated using IFAS and EFAS matrix shows on Table 7. and Table 8. In the cartesian diagram (Figure 5), the value x is obtained from the total value of internal factors. In contrast, the value of y is obtained from the difference in the total value of external factors (Tangkas and Trihadiningrum, 2015).

Suppose the EFAS and IFAS analysis results are mapped into the position of organizational strength. In that case, the position is in quadrant I (S-O strategy), which uses the power to get outside opportunities (Rangkuti, 2014). S-O strategies that can be spelled out from the results of external and internal factor analysis for this non-tailing sediment waste utilization program are: Use a capital strong to access and apply the best technology in the treatment of non-tailing sediment waste into quality concrete products; secondly increase the use of readymix concrete made from non-tailing sediment waste for projects that require low Mpa concrete; Collaborate with entities outside and inside PTFI to open the market for non-tailing sedimentary waste concrete products; Utilizing good infrastructure and abundant sediment waste and fiber to diversify precast concrete products.

In addition to the above strategies, preparing an integrated conceptual framework involving related parties in the framework of product development derived from waste is essential because developing products derived from waste requires a significant investment and needs a process of equalizing perception among related parties (Rahmawati, 2018).

Managerial Implication

Based on the analysis results, the managerial implications that management can determine are first to develop a conceptual framework of a unified non-tailing sediment waste utilization program starting from the collection, storage, processing, and generate clear technical procedures in Standard Operating Procedure (SOP) of processing non-tailing sediment waste into precast concrete products. The second managerial implication is to diversify non-tailing sediment waste conversion products such as bricks, paving blocks, dolos (precast concrete for erosion anchoring), barrier concrete, wall concrete, and ditch concrete. The implementation is expected to reduce the amount of non-tailing sediment that must be managed in landfills to impact the company and the environment positively.

CONCLUSION AND RECOMMENDATIONS

Conclusions

Results of capital budgeting analysis have yielded a net present value (NPV) at an 9.4% discount rate of Rp12.1 billion for the conversion program of non-tailing waste, Net B/C result is greater than 1, suggesting that the project is feasible from a financial standpoint. Sensitivity analysis has also demonstrated that the parameters with more significant influence on project NPV are concrete price, production cost, and sales volume. The non-tailings sediment conversion program is feasible because it provides greater economic, social, and environmental benefits when compared to non-tailings waste management using the landfilling method. This conclusion has a conformity with the results of other studies which explain that the use of sediment waste in concrete mixtures will provide economic benefits and benefits related to environmental sustainability.

The implementation of an appropriate strategy is necessary for this program to be sustainable. Based on the results of SWOT analysis, the priority of the strategy of non-tailing sediment waste utilization program that the company can run: first is use a capital strong to access and apply the best technology in the treatment of non-tailing sediment waste into quality concrete products, secondly increase the use of readymix concrete made from non-tailing sediment waste for projects that require low Mpa concrete, the third, working with entities outside PTFI to open the market for non-tailing sedimentary waste concrete products, and fourth utilizing good infrastructure and abundant sediment waste and fiber to diversify precast concrete products.

Recommendations

Based on the results and discussion, the recommendations that can be given is to increase the scope of research on tailings waste and include externality factors in conducting feasibility analysis to obtain more comprehensive results and evaluate social and environmental impacts. The second suggestion is to conduct a sustainability index analysis by considering several dimensions such as man, method, management, environment, money, machine, and market to see the sustainability of sediment waste conversion programs. The advice for companies is to develop tailings waste management trough conversion waste program in highland areas by utilizing the infrastructure built at the underground mine because tailing waste amount is more significant than non-tailing waste.

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