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RESEARCH ARTICLE OPEN ACCESS

Technical and Financial Feasibility Analysis Debris Management Post Earthquake, Tsunami and Liquefaction in Palu City

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ABSTRACT
The handling of the rubble of building ruins is the result of an earthquake, tsunami and liquefaction that hit the city of Palu and its surroundings on September 28, 2018 until now has not been handled, this will cause the area to become a hotbed of various diseases and reduce the appearance and image of the city. The problem is solved by processing the debris. The purpose of the study was to determine the feasibility of debris management in terms of technical and financial aspects. Engineering aspects include unloading, sorting, transporting, processing and selling. The study was conducted in the liquefaction areas of Balaroa and Petobo with a debris volume of 356,680 m3.. Investment feasibility assessment using NPV, IRR, BCR, PP and Sensitivity Analysis parameters. The financing methods used are: equipment purchase contracts and equipment rentals, with an implementation time of 5 years. From the results of the analysis, the financing method using the contract system is more profitable than the other two methods. This can be seen by the difference between benefits and investment reaching Rp. 42,842.78 million, where the investment value of Rp. 11,219.93 million obtained benefits of Rp. 54,062.71 million for a payback period of 1 year. Sensitivity analysis is calculated with a change range of -30% to +30% of NPV. This is due to the large factor changes in technical aspects. From the results of the analysis, it was obtained that a decrease in revenue by 30% caused the heavy equipment purchase method to be unfeasible to implement, for the other two methods feasible to be implemented. While other changes such as investment value, expenditure and interest rates do not have a significant impact on the processing of debris materials.
Keywords: Earthquake, Debris, Technical feasibility analysis, Financial feasibility analysis, Sensitivity

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I. PRELIMINARY

The earthquake, tsunami and liquefaction that hit the city of Palu and its surroundings on September 28 2018 caused the generation of quite large and scattered building construction debris. Construction debris (rubble) from buildings, houses, offices, shops, hotels and bridges destroyed by the earthquake, tsunami and liquefaction made it difficult for disaster victim evacuation, emergency response activities and post-disaster rehabilitation.

Left untreated, building debris can become a breeding ground for various disease carriers such as mosquitoes, flies, and mosquitoes rats and can reduce the appearance and image of the city, therefore waste management. Debris should be an integrated part of the disaster management program. Management of debris during a disaster emergency response is actually the same as managing debris generated from the construction and renovation of residential, office, industrial, road and bridge buildings. The difference is that the amount of debris caused by a disaster is usually very large with a wider scale so that its management becomes more intensive and requires relatively large amounts of heavy equipment, manpower and funds. Therefore, its management requires careful planning, starting from the system of collection, sorting, processing and disposal

Based on data released by (ESC Indonesia 2020), it is estimated that the volume of debris (scattered debris) in Palu and Sigi City is ± 414,464 M3, with details of 57,966 m3 in the zone of unofficial/unapproved landfills and 356,680 m3 in the surface liquefaction zone.

II. LITERATURE REVIEW

Debris is the rubble of collapsed buildings caused by natural disasters and the process of building reconstruction. The definition of debris contained in the report Central Sulawesi Debris Recycling Site Specification ESC Indonesia Version

4 dated 16 June 2020, debris is material arising from buildings and structures damaged by the disaster including structural elements (concrete, bricks etc.), furniture, goods personal and other waste (ESC Indonesia 2020). Evaluation of post-earthquake, tsunami and liquefaction waste management in Palu. The parameters used are estimates of waste generation due to disasters, community participation, and financing (Chandra Putra Parura and Rahardyan 2020)

Investment involves spending investor funds at the present time to obtain greater returns in the future, even though the return from an investment is not necessarily a profit (Suketi 2011). Investments are expenditures made by companies with the expectation that these expenditures will provide benefits or results (benefits) over a period of more than a year. (Syamsudin 2004)

According to (Husnan and Suwarsono 2014) a feasibility study is a study of whether or not an investment project can be implemented successfully. (Gittinger 1986) argues that in analyzing an effective project, one must consider interrelated aspects and jointly determine how the benefits are obtained from a particular investment and consider all of these aspects at each stage of the project planning and planning cycle. Furthermore, according to (Gittinger 1986), there are six aspects in evaluating a project, namely:

1. Technical aspects, namely analysis related to project input (provision) and output (production) in the form of tangible goods and services.
2. Institutional-organizational-managerial aspects, namely analysis related to the establishment of project institutions/agencies that take into account institutional structures, social and cultural patterns that are in a local area or country. Ability and expertise of staff in dealing with project issues.
3. Social aspects, namely analysis that takes into account broader social patterns and habits of the proposed investment. The project must be responsive to adverse social circumstances and environmental impacts.
4. Commercial aspects, namely analysis concerning the marketing plan for the output produced by the project and the plan for providing inputs needed for the continuity and implementation of the project to obtain project equipment and supplies.
5. The financial aspect, namely the analysis relating to the financial effects of a project and is proposed to the projects.
6. Economic aspect, namely analyzing whether the project requires knowledge of whether a proposed project will make a real contribution to economic development as a whole as a whole and whether the contribution is large enough to determine the necessary use of resources.

Based on the aspects described above, the financial aspect is the most dominant aspect in determining the feasibility of a project investment. According to (Sugiyarso G dan F Winarni 2005) investment is an asset used by companies to grow wealth through the distribution of investment returns such as interest, dividends, royalties and rent. And in other words, investment is an asset that the company uses for resources that are expected to be able to bring profits for the future.

There are several main aspects that are studied in the feasibility study of a project including legal aspects, market aspects, financial aspects, management aspects and environmental aspects (Suratman 2001). Several studies regarding financial analysis, for example the financial feasibility analysis of the The Peak Pekanbaru apartment development project (Mathofani and Taufik 2015). Feasibility analysis for the production of paving blocks from coal fly ash waste (Asra, D.A., Bakar, A & Novirani 2015), Analysis of the financial feasibility of the waste management system in Penebel village, Tabanan district (Putri, Dewa Ayu Putu A Garini 2020)

III. RESEARCH METHODS

The research location is located in the administrative area of the city of Palu, Central Sulawesi province, located in 3 sub-districts, namely Balaroa sub-district, Petobo sub-district and Kawatuna sub-district. Geographically the research location is located between 000 54' LS – 000 56' LS and 119050' E - 119056' E. The research location can be seen in the map below:

Figure. 1 Research Locations
Source: Google Earth, 2022Th

The type of data used in this research is secondary data, secondary data consists of: 1). Data on debris generation was obtained from the report (section 3 of "Central Sulawesi Post-Disaster Debris Management Advisory Services: Technical Recommendation", report WMS20.1001-J01); 2). The location of debris waste generation is in the liquefaction area of Balaroa Village and Petobo Village

The data analysis techniques in this study are as follows:

1. Analysis of processing techniques
   In general, the debris treatment system from debris generation to final processing is described as follows:

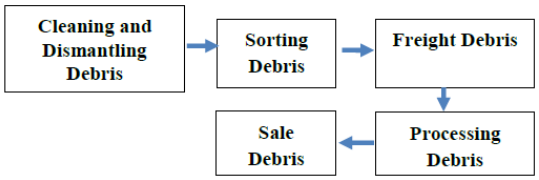

Figure 2. Systematic Debris Processing
Source: World Bank-CSRRP-
Post Disaster Debris Management 2019

2. Equipment purchase cost analysis
   The types of equipment used in debris management are dump trucks, excavators, whell loaders, and stone crushers.
3. Operational and maintenance cost analysis
   Operational and maintenance costs include costs for mobilizing tools, maintaining tools, workers' salaries and processing costs at the site.
4. Analysis of investment calculations
   In this study, the analysis of investment calculations is carried out thoroughly. The method used is:
   a. The Net Present Value (NPV) method is used to see the difference between the value of receipts and the investment value. The Net Present Value method is used to calculate the net (net) value at the present time. According to (Kasmir and Jakfar 2003), Net Present Value or net present value is the difference between the net cash PV and the investment PV over the life of the investment.
   b. The Benefit Cost Ratio (BCR) method is used to evaluate government projects that have a direct impact on society. The comparison value between the aspects of the benefits that will be obtained with the aspects of the costs and losses that will be borne by the investment (Giatman. M 2005)
   c. The Internal Rate of Return (IRR) method is used to calculate the interest rate on income. IRR is an interest rate that shows the net present value (NPV) equal to the total business investment (Pahlevi 2014)
   d. The Payback Period (PP) method is used to calculate how long it will take to return the investment of a project or business. The cash flows used are discounted cash flows on the basis of the interest rate/required rate of return or opportunity cost (Dipohusodo 1996)
   e. Sensitivity analysis determines the extent to which the impact of predetermined investment parameters may change due to situational factors and conditions during the life of the investment The results of these changes have a significant effect on the decisions that have been taken. According to (Borgonovo and Peccati 2004), there are three types of the use of this sensitivity analysis method. Sensitivity analysis is usually used as a medium for evaluating results with a simulation model commonly called a correctness test, as a support for risk analysis or known as a stress test and as an assessor of the level of importance of an input parameter, where these parameters can influence decision making.

IV. RESEARCH RESULT

1. Technical Aspect

In this study, debris volumes were taken at 2 (two) activity locations, namely the Balaroa liquefaction area and the Petobo liquefaction area.

Tabel 1 Debris Volum

Location of Debris	Debris volum (m^3)
Balaroa	230,000
Petobo	126,680

Source: World Bank-CSRRP-
Post Disaster Debris Management 2019

Figure 1 starting from the process of dismantling debris, sorting debris, transporting, processing and selling. The construction heavy equipment used in each stage is as follows:

a. Stages of demolition using excavator heavy equipment
b. The sorting stage uses excavators and dump trucks
c. Stages of transportation using a dump truck
d. The processing stages use a wheel loader and a stone crusher
e. Stages of sales using a dump truck

1.1 Heavy Equipment Financing Structure

The structure of heavy equipment financing according to Minister of Public Works Regulation Number 1 of 2022 concerning guidelines for preparing construction cost estimates consists of definite costs and operational costs. (Litbang PU 2022)

Table 2 Cost of Heavy Equipment

No	Description	Code	Unit	Equipment Operating Cost			
				Dump	Excavator	Whell Loader	Stone Crusher
A.	**EQUIPMENT DESCRIPTION**						
1	Power	Pw	HP	125	138	96	220
2	Capacity	Cp	Ton	10	1	2	60
3	New equipment :						
	a. Economical lifespan	A	Year	5	5	5	5
	b. Working Hours In First Year	W	Hour	2.000	2.000	2.000	2.000
	c. Equipment Price x 1.000.000	B	Rp	360,00	1.960,40	902,40	2.500,00
B.	**EXACT COST PER HOUR OF WORK**						
1	Tool Residual Value x 1.000.000	C	Rp	36	196	90	250
2	Capital Installment Factor	D	-	0	0	0	0
3	Exact Cost per Hour :						
	a. Return of Capital Fee	E	Rp	42.735	232.717	107.123	296.772
	b. Insurance, etc =	F	Rp	360	1.960	902	2.500
	Exact Cost per Hour =(E+F)	**G**	**Rp**	**43.095**	**234.677**	**108.025**	**299.272**
C.	**OPERATING COSTS PER HOUR WORKED**						
1	Fuel	H	Rp	218.750	241.500	168.000	462.000
2	Lubricant	I	Rp	18.750	20.700	14.400	330.000
	Workshop cost	J		3.960	21.564	9.926	78.125
3	Treatment and Maintenance	K	Rp	11.520	62.733	28.877	156.250
4	Operator	L	Rp	35.714	35.714	35.714	35.714
5	Operator Helper	M	Rp	21.429	21.429	21.429	21.429
	Exact Cost per Hour =(H+I+K+L+M)	**P**	**Rp**	**310.123**	**403.640**	**278.346**	**1.083.518**
D.	**TOTAL EQUIPMENT RENTAL COST/HOUR (G+P)**	**S**	**Rp**	**353.218**	**638.317**	**386.371**	**1.382.790**

Source: Calculation analysis results

1.2 Analysis of Work Unit Prices

To calculate the unit price of work, the following data is needed:

1. Cycle Time
   Cycle time is a series of activities of a job and processing operations until reaching a goal or result continues to occur in connection with the manufacture of a product
2. Material Conversion Factor
   The magnitude of the material volume conversion factor depends on the type of material, the condition of the material and the tools used. The material conversion factor can be seen in Tables A.1 and A.2 10 Appendix to Minister of PUPR Regulation No. 1 of 2022 Pages 138-139. The material factor used in this study was 1 (one).
3. Equipment Coefficient Factor
   The equipment coefficient factor is adjusted to the field conditions of the work location. In this study the equipment coefficient refers to difficult conditions.

Table 3 Basic Unit Price of Work

No	Description	Unit	Unit Price (Rp)
1	Debris Disassembly	m^3	9.729,50
2	Transportation of Balaroa debris to landfill	m^3	47.238,74
3	Transportation of Petobo debris to landfill	m^3	30.298,91
4	Debris Processing	m^3	47.320,61

Source: Calculation analysis results

2. Financial Aspect

2.1. Determination of the Number of Equipment

To determine the amount of heavy equipment used, a calculation analysis is carried out by comparing the production capacity of each tool with the available volume of debris.

Table 4 Calculation of Equipment Capacity

No	Description	Number of Equipment		Production Capacity		Time Work (Day)	Production Capacity (M^3/Year)	
		Balaroa	Petobo	Balaroa	Petobo		Balaroa	Petobo
1	Dumptruck	2	1	62	101	330	40.933	33.333
2	Excavator	1	1	973	973	330	320.951	320.951
3	Whell Loader	1		225		330	74.250	
4	Stone Crusher	1		225		330	74.250	

Source: Calculation analysis results

2.2 Debris Processing Time Analysis

Debris management time with the output capacity of the dumptruck that transports debris to the processing site. The capacity of the 3 (three) unit dump trucks is 255 m^3/day, while the debris material to be processed is 356.800 m^3, so that:

Time = volum/capacity
= 356.800 m^3 / 225 m^3
= 1586 days

The time gain mentioned above is added to the equipment maintenance time in a year. The assumption of equipment maintenance time is 30 days per year so the time needed to manage debris is as follows.

Time = 1586 days + (30 x 5)
= 1736 days
= 4,82 Years rounded 5 years

2.3 Debris Processing Financing Methods

There are several types of financing that can be done, but in this study only 3 (three) financing models will be discussed.

1. Third party contract method

This method is carried out by investors by opening tenders to service providers to bid for the debris processing work. In this study, payment agreements with third parties assume 6 stages of payment, 15% down payment and 20% increase in progress.

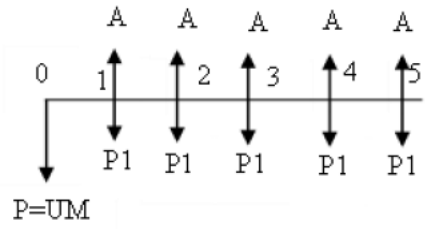

Figure 3. Contract Method Diagram
Source: Calculation analysis results

Information :
UM : Down payment
P1 : Payment
A : Benefit

2. Equipment purchase method

Investing in the purchase of heavy equipment is one of the methods investors can use to carry out debris processing. Purchases of tools are made at the beginning of the work and at the end of the work the tools will be resold. In this method the investor will spend a large enough fund at the beginning of the work so that financial strength will affect the continuity of the work.

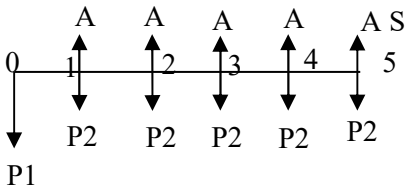

Figure 4.
Heavy Equipment Purchase Method Diagram
Source: Calculation analysis results

Information :
P1 : Payment of heavy equipment
P2 : Payment Operation of month
A : Benefit
S : Heavy equipment sales

3. Equipment rental method

This method is almost the same as the second method, but this third method emphasizes the uniformity of expenses each month during the project period. The initial funding is relatively smaller than the other two methods.

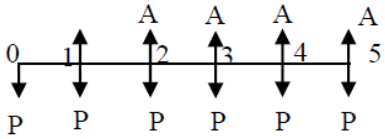

Figure 5.
Heavy Equipment Rental Method Diagram
Source: Calculation analysis results

Information :
P : Payment Operation of month
A : Benefit

2.4 Types of Debris Financing Expenditure General Operational Costs

This fee is incurred monthly as a fixed cost as long as the project activities take place, consisting of land rent, labor salaries, office operations and permits

Table 5 General Operational Costs

No	Description	Unit	Vol	Unit Price Per Month (Rp)	Duration Year	Annual Fees (Rp)
1	*2*	*3*	*4*	*5*	*6*	*7= 4 x 5 x 6*
1	Land Lease	Month	1	10.000.000,00	12,00	120.000.000,00
2	Labor Salaries	Month	1	36.000.000,00	12,00	432.000.000,00
3	Office Operations	Month	1	5.000.000,00	12,00	60.000.000,00
					Overall Price	**612.000.000,00**

Source: Calculation analysis results

Heavy Equipment Operating Costs

Heavy equipment operating costs consist of fuel, maintenance and heavy equipment operator costs

Table 6 Operational Costs of Heavy Equipment

No	Description	Number Of Equipent	Duration (Hour)	Operating Costs Hourly (Rp)	Duration Year	Monthly fees (Rp)
1	*2*	*3*	*4*	*5*	*6*	*6=(3 x 4 x5x6)*
1	Dumptruck 1	3	7	310.122,86	330,00	2.149.151.400,00
2	Excavator 1	2	7	403.639,96	330,00	1.864.816.595,16
3	Whell Loader	1	5	278.346,06	330,00	477.641.834,06
4	Stone Crusher	1	5	1.083.517,86	330,00	1.859.316.642,86
					Overall Price	**6.350.926.472,08**

Source: Calculation analysis results

Purchase of Heavy Equipment

This method provides flexibility for debris managers to use the tool as effectively as possible without any connection with other parties. The heavy equipment can be used during the processing period and will be sold at the end of the project

Table 7 Cost of Purchase of Heavy Equipment

No	Description	Unit	Vol	Unit Price (Rp)	Total Price (Rp)
1	*2*	*3*	*4*	*5*	*6=4 x 5*
1	Dumptruck	Unit	3	360.000.000,00	1.080.000.000,00
2	Excavator	Unit	2	1.960.397.640,00	3.920.795.280,00
3	Whell Loader	Unit	1	902.400.000,00	902.400.000,00
4	Stone Crusher	Unit	1	2.500.000.000,00	2.500.000.000,00
				Overall Price	**8.403.195.280,00**

Source: Calculation analysis results

Heavy Equipment Rental

Rental of heavy equipment will facilitate the initial operation of debris processing, this is because the debris manager does not require high initial costs to provide heavy equipment.

Table 8. Heavy Equipment Rental Fees

No	Description	Unit	Vol	UnitPrice/Day (Rp)	Duration Year	Total Price (Rp)
1	*2*	*3*	*4*	*5*	*6*	*7=4 x 5 x 6*
1	Dumptruck	Unit	3	2.472.526,34	330,00	2.447.801.079,79
2	Excavator	Unit	2	4.468.218,54	330,00	2.949.024.238,58
3	Whell Loader	Unit	1	2.704.599,37	330,00	892.517.791,11
4	Stone Crusher	Unit	1	9.679.530,16	330,00	3.194.244.953,22
					Overall Price	**9.483.588.062,70**

Source: Calculation analysis results

2.5 Contract Method Financing

Debris processing costs for auctions with third parties are prepared based on the standard unit price of work based on PUPR Ministerial Regulation Number 1 of 2022.

Table 9 Financing Contract Method

No	Description	Location	Unit	Volume	Unit Price (Rp)	Total Price (Rp)
1	*2*	*3*	*4*	*5*	*6*	*7=5 x 6*
1	Debris Disassembly	Balaroa	m3	230.000,00	9.729,50	2.237.785.674,88
2	Debris Disassembly	Petobo	m3	126.800,00	9.729,50	1.233.700.972,06
3	Transportation of debris to landfill	Balaroa	m3	230.000,00	47.238,74	10.864.911.133,27
4	Transportation of debris to landfill	Petobo	m3	126.800,00	30.298,91	3.841.901.367,50
5	Debris Processing	Kawatuna	m3	356.800,00	47.320,61	16.883.994.221,65
					Overall Price	**35.062.293.369,36**

Source: Calculation analysis results

2.6 Financing Method for Purchase of Heavy Equipment

The financing for debris management in this method consists of procuring heavy equipment at the beginning of the work, operating costs for heavy equipment and general operating costs. All of this financing is taken into account because the investor will carry out debris processing activities without involving third parties.

Table 10 Financing Purchase Method

No	Description	Unit	Volum	Unit Price (Rp)	Total Price (Rp)
1	*2*	*3*	*4*	*5*	*6=4 x 5*
1	Heavy Equipment Purchase	Set	1	8.403.195.280,00	8.403.195.280,00
2	Machine Operations	Year	5	6.350.926.472,08	31.754.632.360,38
3	General Operations	Year	5	612.000.000,00	3.060.000.000,00
				Overall Price	**43.217.827.640,38**

Source: Calculation analysis results

2.7 Financing Heavy Equipment Rental Method

This method is almost the same as the purchase of heavy equipment, but the difference is that the provision of heavy equipment and heavy equipment operations are carried out by a third party, while the investor acts as a manager.

Table 11 Financing the Leasing Method

No	Description	Unit	Vol	Unit Price (Rp.Million)	Total Price (Rp.Million)
1	*2*	*3*	*4*	*5*	*6=4 x 5*
1	Heavy Equipment Rental	Year	5	2.323,71	11.618,57
2	Machine Operations	Year	5	6.350,93	31.754,63
3	General Operations	Year	5	612,00	3.060,00
				Overall Price	**46.433,20**

Source: Calculation analysis results

2.8 Sales of Debris Products

The product of debris processing in this study is the material for the pile of choice for the implementation of road works or the material for replacing soil improvement, the basis for the selling price of the product is adjusted to the standard price in force in Palu City. The selling price of materials in this study uses the 2022 Palu City Standard Price, namely Rp. 250,000 /m^3

Table 12 Sales prices for Debris Products

No	Debris Production /Year	Unit	Unit Price (Rp)	Total Price (Rp)	Information
1	*2*	*3*	*4*	*5= 2 x 4*	*6*
1	74.250	m^3	250.000,00	18.562.500.000,00	100% Selling Point
2	74.250	m^3	225.000,00	16.706.250.000,00	90% Selling Point
3	74.250	m^3	200.000,00	14.850.000.000,00	80% Selling Point
4	74.250	m^3	175.000,00	12.993.750.000,00	70% Selling Point
5	74.250	m^3	150.000,00	11.137.500.000,00	60% Selling Point
6	74.250	m^3	125.000,00	9.281.250.000,00	50% Selling Point

Source: Calculation analysis results

3. Investment Feasibility Assessment

3.1 Cash flow analysis

Cash flow analysis for each method is described in the table below

Table 13 Contract Method Cash Flow

No	Description	Disbursement Progress	Time (Month)	Payment According to Progress (Rp.Million)	Down Payment Refund (Rp.Million)	Payment Value (Rp.Million)
1	*2*	*3*	*4*	*5*	*6= 15 % x 5*	*7=5-6*
1	Down Payment	15%	1	5.259,34	0,00	5.259,34
2	Payment 1	20%	12	7.012,46	1.051,87	5.960,59
3	Payment 2	40%	24	7.012,46	1.051,87	5.960,59
4	Payment 3	60%	36	7.012,46	1.051,87	5.960,59
5	Payment 4	80%	48	7.012,46	1.051,87	5.960,59
6	Payment 5	100%	60	7.012,46	1.051,87	5.960,59
			Total Price	**40.321,64**	**5.259,34**	**35.062,29**

Source: Calculation analysis results

Table 14 Cash Flow Purchase Method

No	Description	Release (Rp. Million)			Total Price (Rp.Million)
		Purchase of tools	BOP Equipment	BOP Common	
1	*2*	*3*	*4*	*5*	*6=3+4+5*
1	First Year	8.403,20	6.350,93	612,00	15.366,12
2	Second Year		6.350,93	612,00	6.962,93
3	Third Year		6.350,93	612,00	6.962,93
4	Fourth Year		6.350,93	612,00	6.962,93

5	Fifth Year		6.350,93	612,00	6.962,93
Total Price					**43.217,83**

Source: Calculation analysis results

Table 15 Cash Flow Rental Method

No	Description	Release (Rp. Million)			Total Price (Rp.Million)
		Equipment Rental	BOP Equipment	BOP Common	
1	*2*	*3*	*4*	*5*	*6=3+4+5*
1	First Year	2.323,71	6.350,93	612,00	9.286,64
2	Second Year	2.323,71	6.350,93	612,00	9.286,64
3	Third Year	2.323,71	6.350,93	612,00	9.286,64
4	Fourth Year	2.323,71	6.350,93	612,00	9.286,64
5	Fifth Year	2.323,71	6.350,93	612,00	9.286,64
				Total Price	**46.433,20**

Source: Calculation analysis results

3.2 Analysis of Net Present Value

Net Present Value analysis is carried out to determine whether the investment to be carried out has met the feasibility or not. In this study, the investment value at each stage is different. It is adapted to cahflow analysis and the average investment interest rate for the Palu City area for the January – May 2022 period is 9.44%

Table 16 Investment Value of Each Method

No	Financing Methods	Investment (Rp x Million)					
		Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
1	Employment Contract	11.219,93	11.219,93	11.219,93	11.219,93	11.219,93	11.219,93
2	Heavy Equipment Purchase	15.366,12	15.366,12	22.329,05	22.329,05	22.329,05	29.291,97
3	Heavy Equipment Rental	9.286,64	9.286,64	9.286,64	9.286,64	9.286,64	9.286,64

Source: Calculation analysis results

From the data above, the NPV of each financing method can be calculated with 6 (six) alternative income values. Using a spreadsheet program obtained NPV values. Below is a table of NPV values for each financing model

Table 17 NPV Value of Each Method

Year	Contract Method NPV Value					
	Alt.1	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6
0	11.219,93	11.219,93	11.219,93	11.219,93	11.219,93	11.219,93
1	7.342,57	5.486,32	3.630,07	1.773,82	-82,43	-1.938,68
2	19.944,48	16.231,98	12.519,48	8.806,98	5.094,48	1.381,98
3	32.546,39	26.977,64	21.408,89	15.840,14	10.271,39	4.702,64
4	45.148,30	37.723,30	30.298,30	22.873,30	15.448,30	8.023,30
5	54.062,71	45.150,21	36.237,71	27.377,71	18.457,71	9.537,71
NPV	**125.320,47**	**105.423,26**	**85.526,04**	**65.662,27**	**45.760,28**	**25.858,29**

Source: Calculation analysis results

Year	NPV Value of Heavy Equipment Purchase Method					
	Alt.1	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6
0	15.366,12	15.366,12	22.329,05	22.329,05	22.329,05	29.291,97
1	3.196,38	1.340,13	-516,12	-2.372,37	-4.228,62	-6.084,87
2	14.795,95	11.083,45	7.370,95	3.658,45	-54,05	-3.766,55
3	26.395,53	20.826,78	15.258,03	9.689,28	4.120,53	-1.448,22
4	37.995,10	30.570,10	23.145,10	15.720,10	8.295,10	870,10
5	53.590,23	44.677,73	35.765,23	26.905,23	17.985,23	9.065,23
NPV	**111.399,48**	**91.502,27**	**78.567,98**	**58.704,21**	**38.802,22**	**25.863,15**

Source: Calculation analysis results

Year	NPV Value of Heavy Equipment Rental Method					
	Alt.1	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6
0	9.286,64	9.286,64	9.286,64	9.286,64	9.286,64	9.286,64
1	9.275,86	7.419,61	5.563,36	3.707,11	1.850,86	-5,39
2	18.551,72	14.839,22	11.126,72	7.414,22	3.701,72	-10,78
3	27.827,58	22.258,83	16.690,08	11.121,33	5.552,58	-16,17
4	37.103,44	29.678,44	22.253,44	14.828,44	7.403,44	-21,56
5	42.691,80	33.779,30	24.866,80	16.006,80	7.086,80	-1.833,20
NPV	**107.539,83**	**87.642,61**	**67.745,40**	**47.881,63**	**27.979,64**	**8.077,64**

Source: Calculation analysis results

3.3 Analysis of Internal Rate Of Return (IRR)

The calculation of the IRR value is to describe the value of investment feasibility in accordance with the activities carried out. IRR assessment indicators namely

a. If the IRR value ≥ Bank Interest or MARR, it is feasible to build
b. If the IRR value ≤ Bank interest or MARR, it is not easy to build

Table 18 IRR Value of Each Method

Year	Contract Method IRR Value					
	Alt.1	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6
0	-11.220	-11.220	-11.220	-11.220	-11.220	-11.220
1	7.343	5.486	3.630	1.774	-82	-1.939
2	19.944	16.232	12.519	8.807	5.094	1.382
3	32.546	26.978	21.409	15.840	10.271	4.703
4	45.148	37.723	30.298	22.873	15.448	8.023
5	54.063	45.150	36.238	27.378	18.458	9.538
IRR	**137,25**	**117,27**	**96,25**	**73,63**	**48,14**	**16,28**

Source: Calculation analysis results

Year	IRR Value of Heavy Equipment Purchase Method					
	Alt.1	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6
0	-15.366,12	-15.366,12	-22.329,05	-22.329,05	-22.329,05	-29.291,97
1	3.196,38	1.340,13	-516,12	-2.372,37	-4.228,62	-6.084,87
2	14.795,95	11.083,45	7.370,95	3.658,45	-54,05	-3.766,55
3	26.395,53	20.826,78	15.258,03	9.689,28	4.120,53	-1.448,22
4	37.995,10	30.570,10	23.145,10	15.720,10	8.295,10	870,10
5	53.590,23	44.677,73	35.765,23	26.905,23	17.985,23	9.065,23
IRR	**87,25**	**71,01**	**38,82**	**22,73**	**3,15**	**-27,59**

Source: Calculation analysis results

Year	IRR Value of Heavy Equipment Rental Method					
	Alt.1	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6
0	-9.286,64	-9.286,64	-9.286,64	-9.286,64	-9.286,64	-9.286,64
1	9.275,86	7.419,61	5.563,36	3.707,11	1.850,86	-5,39
2	18.551,72	14.839,22	11.126,72	7.414,22	3.701,72	-10,78
3	27.827,58	22.258,83	16.690,08	11.121,33	5.552,58	-16,17
4	37.103,44	29.678,44	22.253,44	14.828,44	7.403,44	-21,56
5	42.691,80	33.779,30	24.866,80	16.006,80	7.086,80	-1.833,20
IRR	**157,03**	**131,75**	**104,62**	**74,18**	**35,86**	

Source: Calculation analysis results

3.4 Analysis of Pay Back Period (PP)

Analysis of the payback period or what is known as the Payback Period is one of the analyzes to calculate how long it takes for an investment to reach the breakeven point

Table 19 PP values for each method

No	Descriptiom	Investment (Rp. Million)	Cash Flow Negative (Rp. Milliom)	Cash Flow Positive (Rp. Milliom)	Payback Periode
		a	b	c	PP
1	Contrack Alternative 1	11.219,93		18.562,50	0,60
2	Contrack Alternative 2	11.219,93		16.706,25	0,67
3	Contrack Alternative 3	11.219,93		14.850,00	0,76
4	Contrack Alternative 4	11.219,93		12.993,75	0,86
5	Contrack Alternative 5	11.219,93	11.137,50	22.275,00	1,01
6	Contrack Alternative 6	11.219,93	9.281,25	18.562,50	1,21
7	Purchase Alternative 1	15.366,12		18.562,50	0,83
8	Purchase Alternative 2	15.366,12		16.706,25	0,92
9	Purchase Alternative 3	22.329,05	14.850,00	29.700,00	1,50
10	Purchase Alternative 4	22.329,05	12.993,75	25.987,50	1,72
11	Purchase Alternative 5	22.329,05	22.275,00	33.412,50	2,00
12	Purchase Alternative 6	29.291,97	27.843,75	37.125,00	3,16
13	Rental Alternative 1	9.286,64		18.562,50	0,50
14	Rental Alternative 2	9.286,64		16.706,25	0,56
15	Rental Alternative 3	9.286,64		14.850,00	0,63
16	Rental Alternative 4	9.286,64		12.993,75	0,71
17	Rental Alternative 5	9.286,64		11.137,50	0,83
18	Rental Alternative 6	9.286,64			

Source: Calculation analysis results

3.5 Benefit Cost Ratio (BCR) Analysis

The Benefit Cost Ratio (BCR) emphasizes the comparative value between the aspects of the benefits to be obtained and the cost aspects

Table 20 BCR values for each method

No	Description	Pemasukan	Pengeluaraan	BCR
1	*2*	*3*	*4*	*5 =3/4*
1	Contrack Alternative 1	89.125,00	35.062,293	2,54
2	Contrack Alternative 2	80.212,50	35.062,293	2,29
3	Contrack Alternative 3	71.300,00	35.062,293	2,03
4	Contrack Alternative 4	62.440,00	35.062,293	1,78
5	Contrack Alternative 5	53.520,00	35.062,293	1,53
6	Contrack Alternative 6	44.600,00	35.062,293	1,27
7	Purchase Alternative 1	89.125,00	43.217,828	2,06
8	Purchase Alternative 2	80.212,50	43.217,828	1,86
9	Purchase Alternative 3	71.300,00	43.217,828	1,65
10	Purchase Alternative 4	62.440,00	43.217,828	1,44
11	Purchase Alternative 5	53.520,00	43.217,828	1,24
12	Purchase Alternative 6	44.600,00	43.217,828	1,03
13	Rental Alternative 1	89.125,00	46.433,204	1,92
14	Rental Alternative 2	80.212,50	46.433,204	1,73
15	Rental Alternative 3	71.300,00	46.433,204	1,54
16	Rental Alternative 4	62.440,00	46.433,204	1,34
17	Rental Alternative 5	53.520,00	46.433,204	1,15
18	Rental Alternative 6	44.600,00	46.433,204	0,96

Source: Calculation analysis results

3.6 Sensitivity Analysis

Sensitivity analysis calculations determine the extent to which the impact of investment parameters has been determined previously due to situational factors and conditions during the life of the investment causing significant changes to the decisions that have been taken (Mangitung, Donny 2013). Investment parameters that require sensitivity

analysis include income (Benefit), expenses (Cost). Sensitivity analysis calculations using the Straus method assumed a range of changes of -30% to +30% of the NPV. This assumption is taken due to the large factor of changes in the technical aspects which include disassembling, sorting, transporting, processing and selling.

Table 21 Sensitivity Analysis

Range	P	NPV-P	Ab	NPV-Ab	Am	NPV-Am	MARR	NPV-MARR
30%	14.585,91	193.363,04	45.580,98	156.269,52	115.862,50	299.573,21	12,27	182.382,08
25%	14.024,92	193.924,04	43.827,87	163.012,77	111.406,25	282.432,51	11,80	184.660,06
20%	13.463,92	194.485,04	42.074,75	169.756,02	106.950,00	265.291,82	11,33	186.982,17
15%	12.902,92	195.046,03	40.321,64	176.499,27	102.493,75	248.151,12	10,86	189.335,41
10%	12.341,93	195.607,03	38.568,52	183.242,52	98.037,50	231.010,42	10,38	191.759,58
5%	11.780,93	196.168,03	36.815,41	189.985,77	93.581,25	213.869,72	9,91	194.202,78
0%	11.219,93	196.729,02	35.062,29	196.729,02	89.125,00	196.729,02	9,44	196.729,02
-5%	10.658,94	197.290,02	33.309,18	203.472,27	84.668,75	179.588,33	8,97	199.262,19
-10%	10.097,94	197.851,02	31.556,06	210.215,52	80.212,50	162.447,63	8,50	201.890,50
-15%	9.536,94	198.412,01	29.802,95	216.958,77	75.756,25	145.306,93	8,02	204.518,81
-20%	8.975,95	198.973,01	28.049,83	223.702,02	71.300,00	128.166,23	7,55	207.244,00
-25%	8.414,95	199.534,01	26.296,72	230.445,28	66.843,75	111.025,53	7,08	209.974,39
-30%	7.853,95	200.095,00	24.543,61	237.188,53	62.387,50	93.884,83	6,61	212.810,73

Source: Calculation analysis results

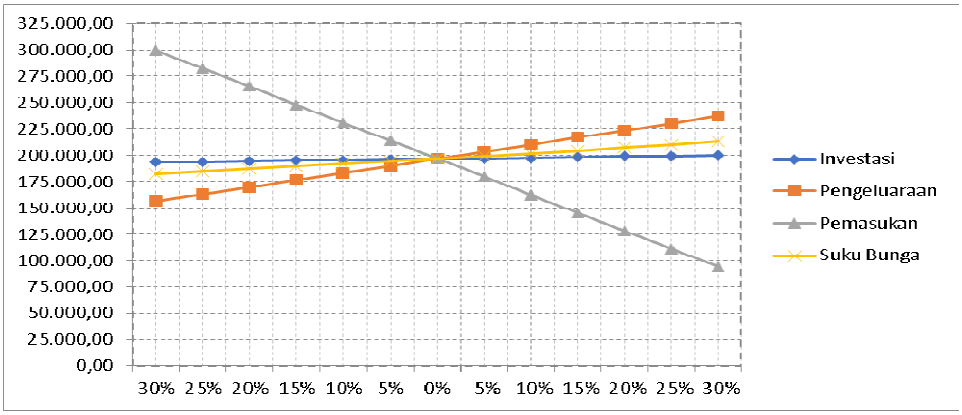

Figure 6 Sensitivity Analysis Graph
Source: Calculation analysis results

Based on the table above, the benefit factor has a considerable impact on the implementation of debris material processing. Under normal conditions for the contract method, the MARR value is 9.44%, the NPV value is 125,320.47, the IRR value is 137.25, the BCR value is 2.54 and the payback period is 1 year.

a. Benefit sensitivity analysis
   If there is a change in the decrease in benefits of 30%, the lowest NPV value is found in the heavy equipment rental method, namely 48,899.32. While the lowest RR value is in the method of purchasing heavy equipment, namely 23.95. For payback period ranging from 1 year-2 years. From this explanation, even though income has decreased by 30%, processing activities are still feasible to carry out with 3 (three) financing methods

b. Investment sensitivity analysis
   From table 4.4 it can be seen that the change in the NPV value decreased by 1.72% - 2.8%. The investment value for the three financing methods ranges from Rp. 9,183.28 million and Rp. 19,841.58 million. The biggest investment value is taken to determine whether this activity is still feasible or not. With a value of Rp. 19,841.58 million, an NPV of 35,667.12 is obtained, the IRR is not recorded and the BCR is 1.12. Based

on this data, it can be concluded that if the investment changes by 30%, then the method of purchasing heavy equipment cannot be implemented. Meanwhile, other methods are still feasible.

c. Interest rate sensitivity analysis

Changes in interest rates play a very important role in the debris material processing work. A change in sensitivity to 30% results in a normal interest rate of 9.44% to 12.72%. For this reason, a re-analysis was carried out on the analysis of NPV, IRR, BCR and PP financing.

Table 22 NPV Value with a 30% Decrease

No	Description	Contrack Methode (Rp.Million)	Equipment Purchase Methods (Rp.Million)	Equipment Rental Methods (Rp.Million)
1	MARR 9.44 %	65.662,27	64.634,09	60.723,31
2	MARR 10 %	58.704,21	58.780,92	55.731,10
3	MARR 12.72	47.881,63	48.204,54	45.556,78

Source: Calculation analysis results

From the table above, it can be seen that even though interest rates have risen to 30%, and the value of benefits has decreased by 30%, the NPV value remains positive, so it can be concluded that changes in interest rates have no impact on the NPV value.

V. DISCUSSION

Assessment of the feasibility of processing debris material using investment calculation analysis, namely the Net Present Value (NPV) method, Benefit Cost Ratio (BCR), Internal Rate of Return (IRR), Payback Period (PP) method and sensitivity analysis. The overall assessment of the implementation method with the investment model can be seen in the following table:

Table 23 Recapitulation of Investment Valuation

No	Description	NPV	IRR	BCR	PP
1	Contrack Alternative 1	125.320,47	137,247	2,542	0,60
2	Contrack Alternative 2	105.423,26	117,265	2,288	0,67
3	Contrack Alternative 3	85.526,04	96,252	2,034	0,76
4	Contrack Alternative 4	65.662,27	73,633	1,781	0,86
5	Contrack Alternative 5	45.760,28	48,140	1,526	1,01
6	Contrack Alternative 6	25.858,29	16,283	1,272	1,21
7	Purchase Alternative 1	111.399,48	87,249	2,062	0,83
8	Purchase Alternative 2	91.502,27	71,014	1,856	0,92
9	Purchase Alternative 3	78.567,98	38,816	1,650	1,50
10	Purchase Alternative 4	58.704,21	22,729	1,445	1,72
11	Purchase Alternative 5	38.802,22	3,154	1,238	2,00
12	Purchase Alternative 6	25.863,15	n/a	1,032	3,16
13	Rental Alternative 1	107.539,83	157,028	1,919	0,50
14	Rental Alternative 2	87.642,61	131,754	1,727	0,56
15	Rental Alternative 3	67.745,40	104,624	1,536	0,63
16	Rental Alternative 4	47.881,63	74,177	1,345	0,71
17	Rental Alternative 5	27.979,64	35,858	1,153	0,83
18	Rental Alternative 6	8.077,64	n/a	0,961	0,00

Source: Calculation analysis results

The selection of the method for debris processing activities is carried out with the right calculation because even though it is feasible, it does not necessarily provide great benefits. Investment is considered successful if the investment value issued is small but generates large benefits. Comparison between the feasibility of investment and the amount of benefits can be seen in the following table:

Table 24 Feasibility Assessment

No	Description	Financing Methods		
		Contrack	Purchase	Rental
1	Technical Analysis	Proper	Proper	Proper
2	Feasibility Analysis	Proper	Proper	Proper
3	Investment Value (x Rp. Million)	11.219,93	15.366,12	9.286,64
4	Expenses (x Rp.Million)	35.062,29	43.217,83	46.433,20
5	Benefits (x Rp. Million)	89.125,00	89.125,00	89.125,00
6	Profit (x Rp. Million)	54.062,71	45.907,17	42.691,80
7	Eligibility assessment (x Rp.Million)	42.842,77	30.541,05	33.405,15

Source: Calculation analysis results

VI. CONCLUSIONS AND RECOMMENDATIONS

1. Conclusion

Based on the results of the technical and financial feasibility analysis of debris material processing on the methods used in carrying out debris material processing activities, the following results are obtained:

1. Based on the results of the analysis of technical aspects including unloading, sorting, transporting, processing and selling meet the requirements to be implemented.
2. Based on the results of the analysis of the financial aspects of the investment feasibility assessment using 4 (four) NPV, IRR, BCR and PP analysis it is declared feasible with 3 (three) financing methods namely the contract method, the purchase method and the leasing method. Selling price with 6 (six) alternatives, namely 100%, 90%, 80%, 70%, 60% and 50%.
   a) The contract method, using an NPV analysis of 125,320.47, an IRR analysis of 137,247, a BCR analysis of 2,542, and a PP analysis of 1.00 is declared feasible
   b) Purchase method, using an NPV analysis of 112,384.26, an IRR analysis of 88,544, a BCR analysis of 2,087 and a PP analysis of 1.00 is declared feasible
   c) The leasing method, using an NPV analysis of 108,557.52, an IRR analysis of 159,790, a BCR analysis of 1,941 and a PP analysis of 1.00 is declared feasible

Based on the results of the sensitivity analysis, debris processing activities are sensitive to changes in sales. With a change in revenue reduction of 30%, the method of purchasing heavy equipment is not feasible to implement. While other changes such as investment value, expenses and interest rates do not have a significant impact on the processing of debris material.

2. Suggestion

From the results of the analysis that has been carried out, several suggestions can be put forward, including:

a. Both private investors and the government are expected to be able to properly process the debris after the earthquake, tsunami and liquefaction in Palu City. This research has not discussed debris ownership and contract law standards for the three financing methods, so further research is needed to discuss this.
b. Enter the difficulty level variable in carrying out the debris demolition work which affects the working time of heavy equipment, operational and maintenance costs.
c. There needs to be further studies and research to develop this research. So that it can be explored further about technical and financial feasibility from various perspectives.

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BIBLIOGRAPHY

[1]. Asra, D.A., Bakar, A & Novirani, D. 2015. "Analisis Kelayakan Usaha Produksi Paving Block Dari Bahan Limbah Fly Ash Batubara." Jurnal Institut Teknologi Nasional 03(2): 363–74.
[2]. Borgonovo, E., and L. Peccati. 2004. "Sensitivity Analysis in Investment Project Evaluation." International Journal of Production Economics 90(1): 17–25.
[3]. Chandra Putra Parura, Tezario, and Benno Rahardyan. 2020. "Evaluation of Post-Earthquake, Tsunami, and Liquefaction Disaster Waste Management in Palu." E3S Web of Conferences 148.
[4]. Dipohusodo, Istimawan. 1996. Manajemen Proyek Dan Konstruksi. Kanisius. Yogyakarta.
[5]. ESC Indonesia. 2020. "Central Sulawesi Debris Recycling Site Specifications." 16 June 2020. Tidak Diterbitkan. Jakarta.
[6]. Giatman. M. 2005. Ekonomi Teknik. PT.RajaGrafindo Persada. Jakarta.
[7]. Gittinger, J. Price. 1986. Analisis Ekonomi Proyek-Proyek Pertanian. Edisi kedua UI Press, Jakarta.
[8]. Husnan, Suad, and Muhammad Suwarsono. 2014. Studi Kelayakan Proyek Bisnis. Edisi kelima UPP STIM YKPN, Yogyakarta.
[9]. Kasmir, and Jakfar. 2003. Studi Kelayakan Bisnis. Kencana Predana Media Grup. Jakarta.
[10]. Litbang PU. 2022. AHSP PERMEN PUPR No. 1 tahun 2022 Analisis Harga Satuan Pekerjaan. Jakarta.
[11]. Mangitung, Donny, M. 2013. Ekonomi Rekayasa Disertai Penyelesaian Dengan Spreadsheet. ed. PT Andi. yogyakarta.
[12]. Mathofani, Anna, and Hendra Taufik. 2015. "Analisa Kelayakan Finansial Proyek Pembangunan Apartemen The Peak Pekanbaru." Jom FTEKNIK 2(1).
[13]. Pahlevi, Reza Widhar. 2014. "Analisis Faktor-Faktor Yang Mempengaruhi Underpricing Saham Pada Penawaran Saham Perdana Di Bursa Efek Indonesia." Jurnal Siasat Bisnis 18(2): 219–32.
[14]. Putri, Dewa Ayu Putu A Garini, dkk. 2020. "Analisis Kelayakan Finansial Sistem Pengelolaan Sampah Di Desa Penebel Kabupaten Tabanan." GANEC SWARA.
[15]. Sugiyarso G dan F Winarni. 2005. Manajemen Keuangan. Media Pressindo, Yogyakarta.
[16]. Suketi, N. A. 2011. "Analisis Perbandingan Return Reksa Dana Dengan Return Benchmark-Nya Berdasarkan Metode Sharpe, Treynor, Jensen Dan M 2 (Studi Pada Reksa Dana Saham, Reksa Dana Pendapatan Tetap Dan Reksa Dana Campuran Periode Tahun 2005-2009)." Thesis Undergraduate, Universitas Diponegoro, Semarang.
[17]. Suratman. 2001. Studi Kelayakan Proyek : Teknik Dan Prosedur Penyusunan Laporan. J & J Learning. Yogyakarta.
[18]. Syamsudin, Lukman. 2004. "Manajemen Keuangan Perusahaan Edisi Terbaru Cetakan Ketujuh." PT. Raja Grafindo Persada, Jakarta.