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Modeling of Operational Costs (Tipping Fee) and Inscentives to Improve Solid Waste Management Services in Indonesia

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ABSTRACT

Waste management needs in each region are increasing every day as a result of population growth. However, this is not supported by the ability of each region to process its own waste, so it uses a third party and pays a number of tipping fees charged to the regional budget. This tipping fee is paid to third parties in order to transport waste from one area to another. One ideal step that can be done is to do schematic calculations related to tipping fees that are adjusted to the characteristics of waste in Indonesia. To maximize the scheme, the government offers investors who want to participate so that they are able to repress the regional budget. The government in this case also estimates the total costs that will be before, during and after operations using life cycle cost analysis. The entire activity resulted in a mass decision-making decision guide for waste management in Indonesia. Local governments are expected to be able to conduct financing independently without relying on the available budget by performing tipping fees in a life cycle cost analysis.

KEYWORDS

Tipping fee, Incentives, Solid Waste Management

1 Introduction

According to Indonesian regulation on solid waste management, solid waste problems are a national problem that must be carried out thoroughly from the initial process to the final process that is influenced by various factors and the government has the task To ensure the implementation of good solid waste management with financing and incentives, whether originating from a state budget or a regional budget [1]. There are several factors that cause solid waste problems as national issues including an increase in uneven population growth, gross domestic product growth (GDP), and a population consumption pattern that causes Increased volume, diversity of types, and characteristics of solid waste itself [2]. The relevant ministry stated that the national solid waste amount reaches 175.000 tonnes per day and if calculated annually to 64 million tonnes per year with the presentation of and characteristics of solid waste of 50% organic, 15% plastic, 10% paper, and 25% other solid waste [3]. State leaders undertake an agreement to jointly address the world's problems relating to poverty, gaps, and the environment in order to ensure sustainable consumption and production patterns by reducing Waste production through prevention, reduction, reuse [4]. According to the relevant ministry, there are several provinces that have not done budget calculations relating to solid waste and the use of national budgets for solid waste issues of only 1.1%, so for facilities and infrastructures and management units has not been well facilitated [5]. Indonesia has a solid waste with a lot of amount and potential when managed properly. Therefore, the government needs to do a scheme of cooperation with the private sector to tackle this national problem, so it does not impact the losses in the later days.

Identify of problems is there must be a reference to the cost of solid waste management in order to continue to serve the needs of the community broadly and thoroughly. In addition, community participation is needed in solid waste management efforts ranging from the selection of solid waste, sorting at baseline, and household recycling efforts, thereby generating additional revenue from increased value added.

Research objective is development of models for operational costs and incentives in improving solid waste management in Indonesia, development of investment feasibility model for operational cost and incentives to improve solid waste management in Indonesia, and identify how the relationship of the model for operational costs and incentives in the improvement of solid waste management in Indonesia.

2. Literature Reviews

Solid waste is all solid waste sourced from human and animal activities in the form of normal solids and disposed of due to undesirable solid waste or reusable by the owner. The source can be derived from residential, commercial, institutional, construction and demolition, urban services, waste management units, industry, and agriculture [6]. The current solid waste treatment paradigm is still referring to the old paradigm where solid waste processing is the collection, transport, and disposal. [7]. Currently, solid waste management pattern is still carried out consist of several ways with the transport and the disposal of solid waste of 69%, solid waste

burial by 10%, the posting and recycling of solid waste by 7%, burning solid waste By 5%, solid waste disposal to the river by 3%, and solid waste management by 7% [8].

3. Research Methods

This research uses a benchmarking method that can be defined as a benchmark for measuring something, from a quality aspect or a value that is both of the same size. [9]. As a follow up to the benchmarking activities, in this research conducted a mathematical calculation of life cycle cost Analysis (LCC) which is an economic assessment of an object, system or facility, considering all the significant cost of ownership of economic life, which is stated to be equal to the dollar/euro [10]. If you have done mathematical calculations on Life Cycle Cost Analysis, then in the next process is done by using expert validation so as to produce a recommendation of solid waste management fee [11]

4. Data and General Review

Indonesia is located between 6°04'30 " north latitude and 11°00' 36" south latitude and between 94°58'21" to 141°01'10" east longitude [12].

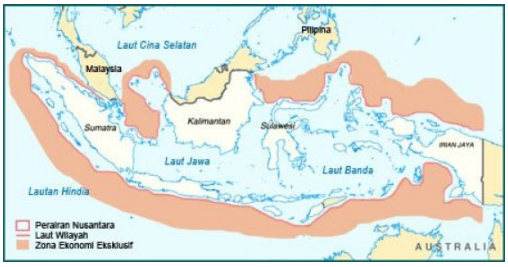

Figure 1. Maps of Indonesia [13]

Indonesian population projection 2010 – 2035, the population of Indonesia is 261,890,900 with a percentage of people living in West Java province with a percentage of 18.31%, East Java province with a percentage of 15.10%, and the province of Center Java A percentage of 13.15%. [14]

Figure 2. Indonesian Population Projection [15]

In the record, in 2016 the number of solid timmonth waste in Indonesia reaches 65.2 million per year with a population of 261,115,456 inhabitants. It was then reprojected so that in 2025, the number of solid accumulation waste would reach 5,928,386 tonnes per year with a population of 284,829,000. [3]

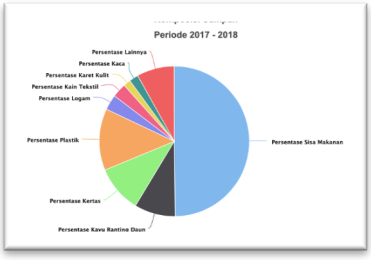

Figure 3. Solid Waste Composition in Indonesia [16]

Solid waste with the largest number of donors comes from households, traditional markets, and business centres. The importance of solid waste management from the initial form will greatly affect the amount of solid waste when arriving at the shelter.

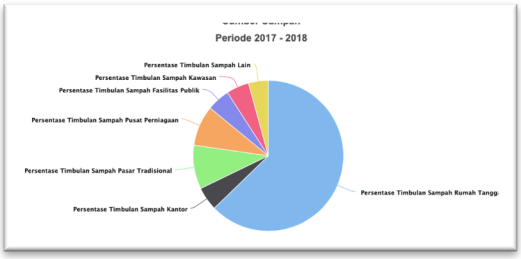

Figure 4. Solid Waste Sources in Indonesia [17]

Indonesia has had the final processing place (TPA) of solid waste with an area of about 2,927 ha with a solid waste shelter capacity of 33,317,193 m^3/year. For that capacity, it is actually enough to accommodate the amount of solid waste that goes to the final processing place (TPA) of solid waste as much as 19,638,697 m^3/year. But the unfortunate thing is that the spread is not good. [18].

The city of Surabaya is one of the successful city in its solid waste management. With its excellent solid waste management, in the year 2019, the city of Surabaya received an award from the Ministry of Environment and Forestry. In addition to the management of its solid waste, the city of Surabaya also able to produce energy from solid waste of 1-2 MW and Target 11 MW in the year 2031. Within the budget of 474.9 billion rupiah, it covers the construction of solid waste management facilities with 3R technology (reduce, reuse, recycle), solid waste transport from temporary end management (TPA) place to the final management site (TPA) Solid waste, and community involvement in cleanliness [19].

Figure 5. The Best Solid Waste Management Role Model in Indonesia [20]

There are at least six regulations governing the management of solid waste in Indonesia including Undang-undang No. 18 Tahun 2008 about Pengelolaan Sampah, Peraturan Pemerintah Republik Indonesia No. 81 Tahun 2012 tentang Pengelolaan Sampah Rumah Tangga dan Sampah Sejenis Sampah Rumah Tangga, Peraturan Menteri No. 13 Tahun 2012 tentang Pedoman Pelaksanaa *Reduce*, *Reuse*, dan *Recycle* Melalui Bank Sampah, Peraturan Menteri No. P.59/Menlhk/Setjen/Kum.1/7/2016 tentang Baku Mutu Lindi Bagi Usaha dan/atau Kegiatan Tempat Pemrosesan Akhir Sampah, Pedoman Pelaksanaa Surat Edaran Menteri LHK Nomor : SE.1/MenLHK/PSLB3/PLB.0/1/2018 tentang Kerja Bersama Untuk Peningkatan Penanganan Smapah Dalam Rangka Hari Peduli Sampah 2018, dan Surat Edaran Nomor: SE.1/MenLHK/PSLB3/PLB.0/1/2018 tentang Kerja Bersama Kerja Bersama Untuk Peningkatan Penanganan Smapah Dalam Rangka Hari Peduli Sampah 2018 [17].

Indonesia has enormous potential in the aspect of the writing process and recycling solid waste with the condition of processing can be done well from the source. With a percentage of 60%, organic is able to be converted into compost or other energy sources such as biogas, compost and electricity. Then with a percentage of 14%, plastic is able to be converted into electrical energy and mix asphalt even tiles with good management. And lastly, with a 9% percentage of paper can be turned into raw material for the production of the next paper [21].

Figure 6. Value Engineering System on Solid Waste [22]

Function Analysis System Technique (FAST) Diagam or technical diagram of system function analysis is an engineering in the form of diagrams depicting the relationship of each function, product, process, and service with basic questions how and why [23].

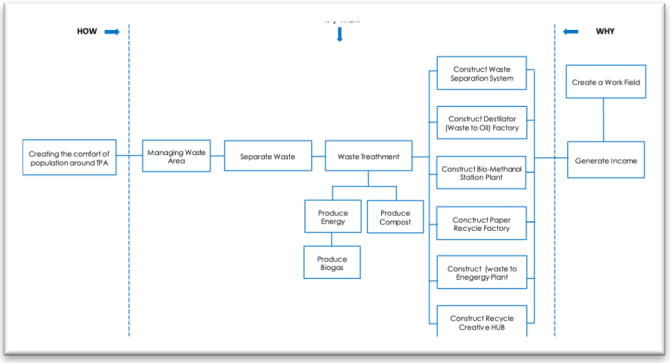

Figure 6. Function Analysis System Technique (FAST) Diagam [24]

A pilot project can be done well with a lot of things in consideration of the definition of project needs, the selection of the members who will be followed, making a pilot plan and a cycle of the project, making Project communication flows, conducting pilot projects, and evaluating the implementation of the pilot project itself [25]

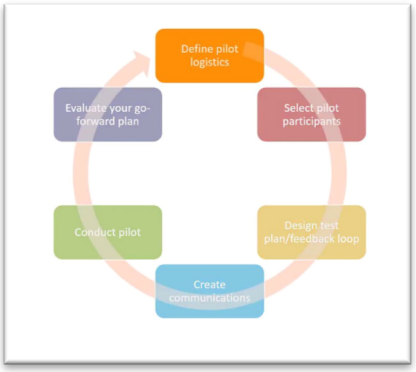

Figure 6. Six Steps For Implementing A Success Pilot [26]

DKI Jakarta as the capital of the Republic of Indonesia has a land area 662.33 km^2 and ocean 6, 977.5 km^2 [27]. The population of DKI Jakarta in 2019 reaches 10.9 million people with an increase in population from the previous year reaching 0.73%. The data is divided into females of 5.3 million people and male population of 5.2 million. Compared to its land area, DKI Jakarta is a fat province where the density reaches 19,516 population/km square [28].

Figure 7. Maps of DKI Jakarta [29]

Jakarta's population doubled from 4.5 million in 1970 to more than 10 million in 2017, while the Jabodetabek population has grown from 8.2 million to more than 30 million over the same period of time. The growth rate of this area far exceeds the government's estimate and the national average, as much as 1% from 2000 to 2010, compared with a 3.6% increase in the Jakarta area [30].

Tahun	Jumlah Populasi	Tingkat Pertumbuhan (%)	Pertumbuhan
2030	11,310,000	9.71	1,223,000
2025	11,034,000	11.43	1,291,000
2020	10,645,000	5.98	638,000
2017	10,374,200	3.26	337,000
2015	10,177,900	7.20	693,000
2010	9,640,400	7.14	642,000

Tabel 1. Indonesia Population Growth Projection (Million Inhabitants) [31]

Bantar Gebang Integrated Garbage Disposal (TPST) that began in operation in 1989 is located in RT 002 RW 005 Ciketing Udik Village, Cikiwul village, and Sumur Batu village Bantar Gebang subdistrict, Bekasi City 17153. Integrated garbage Disposal (TPST) Bantar Gebang has an area of 110.3 Ha with an effective area of 81.91% or about 90.35 Ha and the rest with extensive facilities and infrastructures such as entrance, Office Road, and processing installation Lindi amounted to 19.95% or about 19.95 Ha [32].
The amount of solid waste in DKI Jakarta in 2014 as much as 7,147.36 tons per day. The highest area with solid waste production per day is in West Jakarta administrative City with a total production of 1574.92 tonnes with the amount of solid waste of 1111.68 tons and the amount of solid waste is not carried out by 19.78 tons [33].

Tahun	Produksi per Hari	Terangkut per Hari	Sisa
2014	7,147.36	6,491.75	665.61
2013	6,513.85	5,636.90	876.95
2012	6,356.88	6,004.20	352.68
2011	5,597.87	4,986.31	611.56

Tabel 2. Garbage Production Data 2010-2014 [34]

In the year 2011, Integrated Garbage Disposal (TPST) Bantar Gebang received solid waste with an average amount of weight of solid waste reaches 5172.84 tons per day. In 2012 it experienced an increase in the average weight of waste in the Bantar Gebang's Integrated Garbage Disposal (TPST) which reached 5263.30 tonnes per day [35].

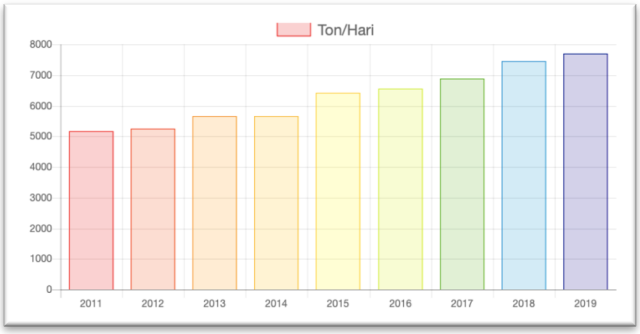

Figure 8. Solid waste production Data based on weight in integrated garbage disposal (TPST) Bantargebang [36]

5. Results And Discussion

This benchmarking activity is done in countries that are able to answer the problem of solid waste such as Sweden, Singapore, Austria, Japan, and South Korea. These countries are chosen to see how solid waste is produced and how to process solid waste done, so it can be applied and implemented in Indonesia which in this case DKI Jakarta as a pilot project Model.

No	Nations	Types Of Solid Waste Treatment
1	Indonesia	Sanitry Landfill
2	Singapore	Waste to Energy
	Austria	
	South Korea	
	Japan	
	Sweden	

Tabel 3. Garbage Production Data 2010-2014 [37]

Management of solid waste of the region independently prioritizes the principle that solid waste management must be managed in solid waste sources. The concept of solid waste management area offered is the integrated infrastructure concept that we named "JAWARA" (Jakarta Waste Management Area). In this area there is a waste separation system (including Ecojos Junior/Tomra)),

Plastic solid waste management (pyrolysis machine converting waste), paper solid Waste management (paper recycle system), organic solid waste management (Bio Methanisation plant), solid waste combustion (incinirator), and recycle creative hub.

Unit	Land Needs	Input		Output	
		Types	Volume	Types	Volume
Waste Separation System (Include Ecojos Junior/Tomra)	195.000 m^2	All of Type	10.000 ton/day	Solid Waste by Type	10.000 ton/day

Tabel 4. Solid Waste Separation Equipment Specification Estimation

Unit	Land Needs	Input		Output	
		Types	Volume	Types	Volume
Pyrolysis Machine Converting Waste	18.900 m^2	Plastic	1.350 ton/day	Diesel/Solar Fuel	22.500 L/day

Tabel 5. Pyrolysis Machine Converting Waste Equipment Specification Estimation

Unit	Land Needs	Input		Output	
		Types	Volume	Types	Volume
Bio-Meth Plant	302.400 m^2	Organic	5.400 ton/day	Biogas, Compost, Electricity	810.000 m^3/day, 900 ton/day, 63.000 kWh/day

Tabel 5. Bio Methanisation Plant Equipment Specification Estimation

Unit	Land Needs	Input		Output	
		Types	Volume	Types	Volume
Paper Recycle System	78.000 m^2	Paper	1.500 ton/day	Paper raw Materials	1.350 ton/day

Tabel 6. Paper Recycle System Equipment Specification Estimation

Unit	Land Needs	Input		Output	
		Types	Volume	Types	Volume
Waste to Energy Plant	150.000 m^2	All of Type	1.695 ton/day	Electricity	98.113 kWh

Tabel 7. Waste to Energy Equipment Specification Estimation

Unit	Land Needs	Input		Output	
		Types	Volume	Types	Volume
Recycle Creative Hub	1.500 m^2	Recycled Solid Waste	120 ton/day	Handicraft, Training Softskill, Training Hardskill, Exhibition	20 units, 1 act, 12 act, 4 act

Tabel 8. Recycle Creative Hub Equipment Specification Estimation

Initial cost (IC) is the initial cost incurred in the Life Cycle Cost Analysis (LCCA). In a development, Initial Cost (IC) is the initial cost of development. Operational & Maintenance (OM) is a cost that each year is issued in a Life Cycle Cost Analysis (LCCA). In a development, Operational & Maintenance (OM) is a routine cost of development. Revenue is a cost generated annually in a Life Cycle Cost Analysis (LCCA). In a development, Revenue is a cost produced by a development [10].

No	Item	IC	OM	Revenue
1	*Waste Separation System* (Termasuk *Ecojos Junior /Tomra*)	Rp 239.715.000.000,00	Rp 109.176.000.000,00	Rp -
2	*Pyrolysis Machine Converting Waste*	Rp 262.890.000.000,00	Rp 19.440.000.000,00	Rp 299.497.500.000,00
3	*Bio Methanisation Plant*	Rp 3.412.800.000.000,00	Rp 540.000.000.000,00	Rp 30.659.265.000.000,00
4	*Paper Recycle System*	Rp 364.750.000.000,00	Rp 42.450.000.000,00	Rp 492.750.000.000,00
5	*Incinirator (Waste to Energy Plant)*	Rp 936.000.000.000,00	Rp 12.995.000.000,00	Rp 988.979.040.000,00
6	*Recycle Creative Hub*	Rp 10.000.000.000,00	Rp 102.360.000.000,00	Rp 214.800.000.000,00
		Rp 5.226.155.000.000,00	Rp 826.421.000.000,00	Rp 32.655.291.540.000,00

Figure 9. The Cost of Capital Expenditure (CAPEX), Operational Expenditure (OPEX), and Revenue

Based on the results of the calculation of cash flow conducted on the scheme with the government 80% and private 20%, government 70% and private 30%, government 60% and private 40%, government 60% and private 40%, and government 70% and private 30%. the estimated sales increase by 5% per year compared with the previous year. In addition, the cost of operating expenses is estimated to increase operating expenses by 10% per year compared to the previous year. From the financial analysis that has been done, both the cash flow calculation, Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period, and Profitability Index (PI) with the cost scheme as follows government 80% private 20%, government 70% private 30%, government 60% private 40%, government 40% private 60%, government 30% private 70%, and government 20% private 80%. Here's a resume related to the financial feasibility analysis that has been done.

Skenario	Split IC		Split OM		WACC	IRR	NPV	PP	RPC
	Swasta	Pemerintah	Swasta	Pemerintah					
1	80%	20%	0%	20%	51,00%	62,50%	negatif	5 tahun 38 hari	432%
2	70%	30%	70%	30%	29,00%	44,62%	negatif	5 tahun 55 hari	430%
3	60%	40%	60%	40%	19,50%	37,59%	negatif	5 tahun 75 hari	427%
4	40%	60%	40%	60%	13,00%	33,11%	positif	5 tahun 122 hari	423%
5	30%	70%	30%	70%	12,43%	32,71%	positif	5 tahun 150 hari	421%
6	20%	80%	20%	80%	12,75%	32,89%	positif	5 tahun 183 hari	418%

Figure 10. Financial Feasibility Analysis For All Schemes

Because of the large amount of investment needed for this project, it is necessary to have a good cooperation scheme between the Government and the business entity. In the implementation of investment in this garbage processing system, it is advisable to apply the scheme of government cooperation and business entity

(KPBU) or commonly known as the Public Private Partnership (PPP) scheme with the Build-Operate-Transfer (BOT) system.
Based on the table above can be known that the financing scheme that is done will be better when using the share of government 40% and private share 60% then will get WACC 13.00%, IRR 33.11% with the estimated Payback Period in the 5th year More than 122 days and has an RPC (Repaymentt Capacity) of 423% assuming the loan can be paid to third parties with a ratio of 423%.

6. Conclusion

1. How is the modelling of operational costs (tipping fee) and incentives to improve solid waste management in Indonesia?
This benchmarking activity is done in countries that are able to answer the problem of solid waste such as Sweden, Singapore, Austria, Japan, and South Korea. These countries are chosen to see how solid waste is produced and how to process solid waste done, so it can be applied and implemented in Indonesia which in this case DKI Jakarta as a pilot project Model.
2. How are investment feasibility modeling from operating costs (tipping fee) and incentives to improve solid waste management in Indonesia?
Based on the table above can be known that the financing scheme that is done will be better when using the share of government 40% and private share 60% then will get WACC 13.00%, IRR 33.11% with the estimated Payback Period in the 5th year More than 122 days and has an RPC (Repaymentt Capacity) of 423% assuming the loan can be paid to third parties with a ratio of 423%.
3. How is the modelling influence of operational costs (tipping fee) and incentives to improve solid waste management in Indonesia?
Solid waste management Model with waste to energy method The conclusion is worth the investment with the scheme that has been simulated before.

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