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Cost Analysis of Construction Cost Planning for Landfill Site

Nurhayati Junaedi[1*], Ridho Bayuaji[2], Alfred Jonathan Susilo[3]

[1,3]Doctoral Program in Civil Engineering,
Tarumanagara University,
Jakarta, Indonesia 11440

[2] Civil Engineering, Department of Civil Infrastructure Engineering,
Sepuluh November Institute of Technology,
Surabaya, Indonesia 60116

nurhayati.328182009@stu.untar.ac.id, bayuaji@ce.its.ac.id, alfred@ft.untar.ac.id,

*Correspondence: nurhayati.328182009@stu.untar.ac.id

Abstract — *Accurate construction cost planning is essential to ensure project success, as inaccurate estimates may lead to delays, cost overruns, and reduced quality. Landfill construction, which is more complex than many other infrastructure projects, includes several components such as landfill work, leachate treatment facilities, and supporting infrastructure. The purpose of this study is to determine the major cost factors that have a major impact on the overall cost of building landfill sites. With the aid of SPSS software, a regression analysis was carried out using cost data from six landfill projects in Java Island that were completed between 2013 and 2018. With a Sig value of 0.000 (<0.05) and a very strong correlation (Pearson Correlation 0.991, within the 0.8–1.0 interval), the results show that landfill work (X3) significantly affects total costs (Y). Leachate treatment facilities (X4) are another crucial element in a number of situations, but landfill work (X3) consistently represents the largest portion of construction costs, according to proportion analysis. These results demonstrate the growing significance of environmental facilities and point to landfill work as the main factor influencing landfill construction costs. The study offers contractors and federal and local governments useful information for creating more precise cost estimates, maximizing budgetary allotments, and enhancing planning and development efficiency for landfill projects.*

Keywords: *Landfill construction; Cost estimation; Regression analysis; Infrastructure planning; Construction management; Waste management*

I. INTRODUCTION

There is a condition of inconsistency between cost estimates at the planning stage and the implementation stage which is often found in a construction project. Inaccurate cost estimates result in significant cost changes during the implementation stage so that cost estimates play an important role at the beginning of construction project planning. Cost estimates are carried out in order to determine the amount of funds that must be prepared in a construction project plan. Cost estimates that are less detailed result in the data being less reliable where inaccurate cost estimates have a negative impact on the project such as cost overruns, delays in work completion, and so on (Dapu et al., 2016). Work results that are not in accordance with what is desired due to inaccurate cost estimates cannot be used as a guideline in project management (Asiyanto et al., 2005). The quality of a cost estimate is related to the accuracy and completeness of its elements depending on the availability of data and information, the techniques or methods used, the skills and experience of the estimator, the purpose of using the cost estimate (Soeharto, 1997).

In estimating a construction cost for landfill site construction is usually more complex compared to general infrastructure projects because landfill sites have different designs and technologies (such as controlled and sanitary landfill systems) and the existence of supporting facilities that are part of one operating system at the landfill site. This results in more costs that must be prepared. The preparation of cost estimates for landfill site construction requires a long process until a detailed planning document is compiled, including the calculation of the Budget Plan and Construction Costs starting from the preparation work to the landfill closure work.

Research on factors in determining cost estimates for landfill site projects is still limited. There is a study by Pivato et al (2018) which states that the most influential cost factor in estimating the cost of landfill construction in Northern Italy is the leachate treatment plant work. This study did not use a significant model for costs and did not produce a mathematical model for estimating the cost of landfill construction.

Estimation is an assessment of all elements of a project or business based on an agreement on the scope of work (Perrot, Melvin W., 2004). Cost estimation is the art of estimating the amount of costs that may be required for an activity based on information available

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at that time (Soeharto 1997). Project planning activities including cost estimation are factors that greatly influence the occurrence of cost and budget overruns (Ceylan 2008). Cost estimation can be used for several purposes, such as determining the economic feasibility of a project, evaluating project alternatives, planning the project budget, and providing initial project costs and controlling the project schedule (AACE 1992).

Inadequate scope changes at the planning stage led to major changes and rework on construction projects that can reduce project efficiency (Memon, AH; Rahman, IA; Azis, AAA 2012). The biggest factor causing budget overruns is incomplete and inaccurate cost estimates at the beginning of the project, so it can be said that cost estimates that are increasingly in line with cost realization in the field have a positive effect on efficiency (Ali, AS; Kamaruzzaman, SN, 2010).

Types of cost estimates seen from the completeness of data and project stages, cost estimates can be divided into 3 (three) types (Asiyanto et al., 2005), namely:

a. Initial Estimate is a cost estimate at the planning stage. At this stage, the project design does not exist yet, only an idea. Cost estimates are provided for feasibility study purposes. Estimates are calculated roughly based on price information from similar projects per unit of production capacity or per unit of function or per unit of area.
b. Semi Detailed Estimate, this estimate is at the conceptual engineering stage. The cost estimate can be calculated in detail because the basic design of the project already exists. The cost estimate results at this stage can be used as a basis for consideration to prepare the funds needed for the project, therefore it is often referred to as a budget estimate for the owner.
c. Definitive Estimate, this estimate is at the detailed engineering stage, where all the information needed for implementation is complete. Cost estimates can be calculated in detail because construction drawings already exist. Several things are considered in this estimate, including construction methods, project site conditions, initial work to be done, use of labor resources, tools and materials and subcontractors according to existing specifications and project implementation time.
d. The level of accuracy in cost estimation is important, especially in the early stages of estimation (Barrie, Donald S., Paulson Jr., Boyd C., 1984),

The level of accuracy is the level of measurement or calculation that varies from the actual value that occurs. There are several methods used in data processing to compile cost estimates, namely: (PMI, 2017 PMBOK Sixth Edition 2017). Expert Judgment or from experts can be obtained historical information based on their experience, especially for similar projects.

Referring to Law Number 18 of 2008 concerning Waste Management, it is stated that waste is the remains of daily human activities and/or natural processes in solid form. Waste is something that is no longer used, not used, not liked or something that is thrown away that comes from human activities and does not occur by itself (Chandra, Budiman 2006). Waste Management is a systematic, comprehensive, and sustainable activity that includes waste reduction and handling. Alfiandra (2009) describes in simple terms the stages of the process of activities in waste management, namely Collection, Transportation and Final Waste Disposal.

Based on Law No. 18/2008, the landfill disposal site is a place to process and return waste to the environmental media in a way that is safe for humans and the environment. According to Azwar, AH (1996) there are 3 requirements that must be met in building a landfill site, namely not being built close to drinking water sources or other water sources used by humans such as bathing, washing, toilets and so on. The distance that is often used as a guideline is more than 200 meters from the water source, not being built in a place that often floods and being built in a place far from human settlements, namely around 2 km from residential areas, and less than 15 km from the sea.

In the Regulation of the Minister of Public Works Number 3 of 2013, it is stated that there are several types of final waste disposal sites based on how they are managed, including the following:

a. Open Dumping Site
   Open Dumping or what is called open disposal is the process of piling up waste in a landfill disposal site without going through a periodic compaction and closing process (Minister of Public Works Regulation Number 3 of 2013). Open dumping is a simple disposal method where waste is only spread in a location, left open without security and abandoned after the location is full.
b. Controlled Landfill Site
   In the Regulation of the Minister of Public Works Number 3 of 2013, Controlled Landfill is a method of waste accumulation in a waste disposal area, by compacting and covering with topsoil at least once every seven days. This method is an intermediate method, before being able to apply the Sanitary Landfill method.
c. Sanitary Landfill Site
   According to the Regulation of the Minister of Public Works Number 3 of 2013, Sanitary Landfill is a method of storing waste in a final waste disposal area that is prepared and operated systematically, by spreading and compacting waste in the waste storage area and covering the waste every day.

According to UNEP (2005), several main factors that influence landfill construction costs are land area and topography, landfill capacity and age, type of processing system and technology used, availability of local materials and labor, environmental aspects and government regulations, location accessibility to transportation systems and utility networks, and hydrological and geotechnical conditions.

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II. METHODS

The approach used in determining construction costs that have the greatest influence on the construction of a landfill site refers to the budget and cost plans that have been prepared in the Detail Engineering Design document for the construction of the landfill site. The analysis method used in this study is the statistic analysis with SPSS software. The data used in this study are secondary data obtained from the budget and cost plan for the landfill site construction project on the island of Java. Data collection was carried out on the island of Java because the largest population and waste generation are on the island of Java, so it is hoped that by using this data it can represent landfills in other areas in Indonesia.

The following is the research process flow carried out in the scheme which can be seen in Figure 1. The data used in this study are secondary data from the construction cost plan for the construction of 6 landfill site on Java Island from 2013 to 2018 with funding sources from the central government budget. Data on TPA development planning costs on Java Island can be seen in Table 1.

The research variables consist of dependent variables (Y) and independent variables (X). The dependent variable (Y) in this study is the total cost of the work, while the independent variables (X) are components of the work costs consisting of 7 X variables or types of costs in each data of the Budget Plan and Cost of the landfill site construction project, namely:

a. X1: preparation work
b. X2: occupational Safety and Health Management System cost
c. X3: landfill work
d. X4: leachate treatment plant work
e. X5: operational road work
f. X6: soil wall work
g. X7: monitoring well work

From the cost components in each budget and cost plan for landfill site construction, a statistical analysis will be carried out to determine the costs that are closely related to the overall costs in landfill site construction.

a. Time Value Influence. Each data calculation of the landfill site construction cost plan is first equalized in value according to inflation to the price in the last year of landfill site construction in 2021.
b. Regression Model. A model in statistical calculation methods used to analyse the relationship between one dependent variable and a series of other or independent variables, such as data on the cost component variables of landfill site construction (from X1 to X7) as the cost per sub-item of work and the Y variable as the total cost of the work.

The analytical methods used include the cost significance model (CSM), regression analysis using SPSS software, and a review of relevant literature. The resulting model focuses on estimating the costs of the conceptual phase of landfill construction and is expected to serve as a tool for local governments in budget planning and waste management systems

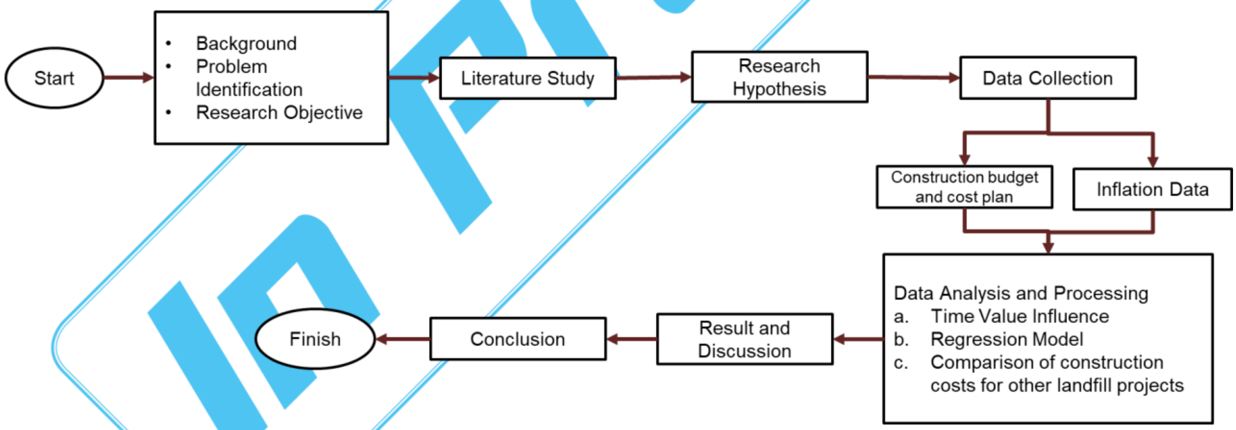

Figure 1. Research process flow

Table 1. Data on Planning Costs for Landfill Construction on Java Island

No	Cost	Cost (Rp)	Year	Location
1	Landfill Construction 1	10,222,687,065.89	2013	Purworejo Regency
2	Landfill Construction 2	29,105,765,518.75	2015	Nganjuk Regency
3	Landfill Construction 3	10,928,458,203.65	2016	Pati Regency
4	Landfill Construction 4	6,667,588,795.71	2016	Wonogiri Regency
5	Landfill Construction 5	23,440,032,793.79	2018	Kediri Regency
6	Landfill Construction 6	20.767.012.417,44	2018	Kabupaten Regency

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Table 2. The Influence of Time Value on Construction Cost Variables

Description	X1 Preparation work	X2 Occupational Safety and Health Management System cost	X3 Landfill work	X4 Leachate treatment plant work
Landfill Construction 1	171,646,362.71	96,276,832.02	11,778,363,053.35	7,833,743,048.95
Landfill Construction 2	305,342,658.58	1,083,109,123.07	25,860,991,766.76	12,248,925,776.85
Landfill Construction 3	247,083,215.81	134,246,977.77	8,305,825,073.24	1,795,501,218.92
Landfill Construction 4	20,318,994.02	57,416,551.29	2,563,218,467.75	3,291,283,801.42
Landfill Construction 5	163,919,012.95	781,084,817.75	16,699,938,105.21	1,384,705,857.09
Landfill Construction 6	105,702,554.32	468,047,008.11	8,431,283,998.69	4,199,872,541.68

Description	X5 Operational road work	X6 Soil wall work	X7 Monitoring well work	Y TOTAL
Landfill Construction 1	203,188,683.11	1,017,539,512.13	8,259,674.60	21,109,017,166.86
Landfill Construction 2	3,097,740,570.22	2,258,536,815.45	27,164,102.81	44,881,810,813.75
Landfill Construction 3	2,796,864,401.33	168,995,761.90	9,378,920.47	13,457,895,569.45
Landfill Construction 4	1,530,462,916.28	743,203,566.02	4,925,816.73	8,210,830,113.51
Landfill Construction 5	1,894,370,400.13	5,591,091,168.26	69,783,890.57	26,584,893,251.95
Landfill Construction 6	2,160,517,441.99	276,633,322.02	10,085,479.22	15,652,142,346.03

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III. RESULT AND DISCUSSION

3.1 Time Value

Time value is used to calculate the effect of time on the price of each work item. The price of work in the year of implementation is adjusted to the price in the year to be projected by taking into account the inflation factor. Each data for calculating the budget plan for each TPA construction location is adjusted to the price inflation factor in the last year of TPA construction in 2021, so that the total work value data is converted according to the basic inflation price up to 2021. The following are the calculation results using the time value which can be seen in Table 2.

3.2 Statistical Analysis (with SPSS)

Statistical analysis using SPSS software in the context of quantitative research of the construction cost plan component data.

3.2.1 Normality Test with Shapiro-Wilk

The Shapiro-Wilk test is an effective and valid normality test method, especially for small samples (less than 50). The following is the data from the normality test assessment results with Shapiro-Wilk which can be seen in Table 3.

Table 3. Results of Normality Test with Shapiro-Wilk

Description	Shapiro-Wilk Statistic	df	Sig.
Preparation work	.984	6	.969
Occupational Safety and Health Management System cost	.934	6	.612
Landfill work	.944	6	.688
Leachate treatment plant work	.879	6	.266
Operational road work	.938	6	.647
Soil wall work	.881	6	.274
Monitoring well work	.954	6	.776
TOTAL	.906	6	.410

The Shapiro-Wilk data normality test was conducted based on the comparison guideline of its probability value with the significance value (α = 0.05). The requirement for data to be called normal is if the probability or p > 0.05. It is known that the significant value of all cost variables X1-X7 is more than 0.05. This indicates that the data is normally distributed.

3.2.2 Correlation Test (Pearson)

Correlation tests to measure the closeness and direction of the relationship between two or more variables so that it helps in determining whether there is a significant relationship between the variables being studied. The following are the results of data analysis using the correlation test (Pearson) can be seen in the Tabel 4.

Table 4. Correlation Test Results (Pearson)

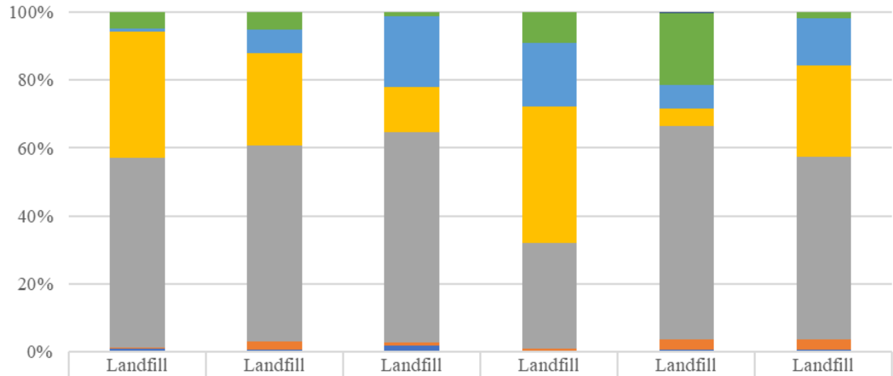
	Y	X1	X2	X3	X4
Pearson correlation (R)	1	0.524	-0,264	0,991*	0,745
Sig (2 tailed)		0.286	0.613	0,000	0,089
N	6	6	6	6	6

	Y	X5	X6	X7
Pearson correlation (R)	1	0,620	-0,198	-0,270
Sig (2 tailed)		0,189	0,707	0,605
N	6	6	6	6

Based on the table above, variable X3 (landfill work) has a Sig value < 0.05, meaning that variable X3 has a correlation/relationship with variable Y, with a very strong degree of correlation (the Pearson Correlation value is in the interval 0.8 – 1.0).

3.3 Analysis For Landfill Site Construction Costs

Based on the proportion of cost components X1-X7 to the total cost Y for landfill site construction at 6 landfill site locations in Java Island, it can be seen that landfill costs (X3) are always the largest proportion of the total cost at the 5 existing locations (Landfill Construction 1,2,3,5,6) with a value of >50% of the total cost (Y), except at Landfill Location 4 where the largest is the leachate processing installation cost component (X4) which reaches 40.08% of the total landfill cost (Y). The percentage proportion of cost components per Landfill Site Construction Location can be seen more completely in Figure 2.



	Landfill Construction 1	Landfill Construction 2	Landfill Construction 3	Landfill Construction 4	Landfill Construction 5	Landfill Construction 6
X7 Monitoring well work	0.04%	0.06%	0.07%	0.06%	0.26%	0.06%
X6 Soil wall work	4.82%	5.03%	1.26%	9.05%	21.03%	1.77%
X5 Operational road work	0.96%	6.90%	20.78%	18.64%	7.13%	13.80%
X4 Leachate treatment plant work	37.11%	27.29%	13.34%	40.08%	5.21%	26.83%
X3 Landfill work	55.80%	57.62%	61.72%	31.22%	62.82%	53.87%
X2 Occupational Safety and Health Management System cost	0.46%	2.41%	1.00%	0.70%	2.94%	2.99%
X1 Preparation work	0.81%	0.68%	1.84%	0.25%	0.62%	0.68%

Figure 2. Proportion of Landfill Construction Costs at Six Landfill Site Construction Locations

As a comparison of the construction cost plan for a landfill site, three data were obtained regarding the budget plan and costs for landfill site construction planning outside Java. From these data, the order of the percentage of the largest construction cost components and the influence on the total cost for landfill site construction was obtained, namely:

1. Landfill site development planning in Rejang Lebong Regency in 2020, where the three largest components of work costs to the total landfill site development costs in sequence are Leachate treatment plant work (X4) of 28.83%, Landfill work (X3) of 28.14% and Operational road work (X5) of 14.51%.
2. Planning for the construction of a landfill site in Kepahiang Regency in 2020, where the three largest percentages of all components of the landfill site construction work costs are the Leachate treatment plant work (X4) of 42.74%, Landfill work (X3) of 38.13% and Operational road work (X5) of 11.39%.
3. Planning for the construction of a landfill site in Mempawah Regency in 2021, where the three components of the work costs with the largest percentage of the total costs are the cost of Landfill work (X3) of 77.23%, the cost of Operational road work (X5) of 9.02% and the cost of the Leachate treatment plant work (X4) of 5.31%.

From the three types of cost plans for landfill site construction outside Java, it can be seen that the costs for landfill work and leachate treatment plant work always have the highest cost portion of the total construction costs for the landfill site. This is similar to the results of the analysis in this study where the costs for landfill work is the costs that have the greatest influence on the total construction costs for the landfill site.

IV. CONCLUSION

Based on the analysis, landfill work (X3) has a significant and very strong correlation with the total construction cost (Y), making it the key cost component that most determines the overall expenditure for landfill site development. In most landfill sites in Java, landfill work consistently accounts for more than half of the total cost, while outside Java, both landfill work (X3) and leachate treatment plant (X4) dominate the cost structure, with their proportions varying by location. Thus, landfill work can be concluded as the primary driver of landfill construction costs, supported by the leachate treatment plant as a secondary but still substantial component. The results of this study can be a consideration for the owners of the work budget in the Central Government/Local Government and contractors in preparing construction cost budget plans to be more precise in estimating the construction costs of landfill site development.

However, this study is limited to data from selected landfill sites in Java and a few cases outside Java, so the findings may not fully represent variations in cost structures across other regions of Indonesia. In addition, external factors such as local regulations, land characteristics, and technology choices were not deeply examined in this analysis.

For future research, it is recommended to expand the dataset by including more landfill projects from diverse regions and to incorporate additional influencing factors such as geological conditions, environmental standards, and innovation in waste treatment technologies. Such an approach would provide a more comprehensive understanding of the determinants of landfill construction costs and strengthen the basis for cost planning and policy formulation.

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