

Analysis of the Impact of Construction and Demolition Waste Project in Surabaya on Socio-Economics and the Environment

Michella Beatrix^{1✉}, Gede Sarya², Nurani Hartatik³

^{1, 2, 3} Department of Civil Engineering, Faculty of Engineering, University of 17 Agustus 1945 Surabaya, Indonesia

Informasi Artikel

Riwayat Artikel

Diserahkan : 08-11-2023

Direvisi : 15-11-2023

Diterima : 17-11-2023

Kata Kunci:

Limbah; Limbah
Konstruksi dan
Pembongkaran; C&DW

Keywords :

Waste, Construction and
Demolition Waste, C&DW

Corresponding Author :

Michella Beatrix

Department of Civil Engineering, Faculty of Engineering, University of 17 Agustus 1945 Surabaya
Jl. Semolowaru 45 Surabaya, East Java, Indonesia

Email: michella@untag-sby.ac.id

ABSTRAK

Pekerjaan konstruksi dan pembongkaran berkontribusi dalam menghasilkan limbah. Limbah yang dihasilkan tersebut dapat memberikan dampak terhadap faktor sosial, ekonomi dan lingkungan. Penelitian ini bertujuan untuk mengukur besarnya dampak limbah konstruksi dan pembongkaran yang terjadi pada proyek di kota Surabaya terhadap faktor sosial, ekonomi dan lingkungan dengan menggunakan metode Partial Least Square (PLS) dengan bantuan software SmartPLS 4.0. Model Struktural dalam penelitian ini memiliki goodness of fit yang baik, yang berarti model struktural dapat menjelaskan keragaman data penelitian yang sangat besar. Dimana, semakin tinggi limbah konstruksi dan bongkaran, semakin besar dampaknya. Hasil yang diperoleh adalah besarnya dampak dari limbah konstruksi dan pembongkaran terhadap faktor sosial sebesar 28,5%, faktor ekonomi 39,9%, dan dampak yang terbesar adalah 52,6% terhadap faktor lingkungan.

ABSTRACT

Construction and demolition works contribute to waste generation. The waste generated can impact social, economic, and environmental factors. This study aims to measure the impact of construction and demolition waste in projects in Surabaya on social, economic, and environmental factors using the Partial Least Square (PLS) method with the help of SmartPLS 4.0 software. The Structural Model in this study has a good goodness of fit, which means that the structural model can explain the enormous diversity of research data. The higher the construction and demolition waste, the more significant the impact. The results are the impact of construction and demolition waste on social factors is 28.5%, on economic factors is 39.9%, and the most significant effect is 52.6% on environmental factors.

INTRODUCTION

Economic growth, population increase, and demand for urban development have positively contributed to the growth of construction activities and increased waste generation (Shukor et al., 2021). The primary mechanism for infrastructure development for urban expansion and its role in environmental degradation is part of the construction industry; on the contrary, 35% of the energy consumed and 40% of the carbon dioxide released into the earth's atmosphere are

also the result of the construction industry (Luangcharoenrat et al., 2019). The United Nations Environment Programme (UNEP) also reports this, which explains that development and construction activities consume 36% of global energy and produce 40%-50% of CO₂ emissions (Tafesse & Abegaz, 2019). Thus, the construction industry is mentioned as a contributor to global CO₂ emissions. Given the increasing population, the solution to reduce construction activities cannot be done, so another solution is to reduce the negative impacts that can be caused on the environment (Maier, 2021). Research by Tafesse et al. (2022) found that waste generated from construction activities is a challenge for almost all construction projects, with only 57.14% of construction companies recording and measuring the volume of construction waste (Tafesse et al., 2022). A World Economic Forum (WEF) study showed that dumped waste reaches 75% (Maurya, 2022).

Large amounts of waste come from constructing and demolishing existing buildings (Borrachero et al., 2022). Some researchers explain, that construction activities such as renovation and demolition (roads, bridges, subway overpasses, and building extensions) inevitably generate waste (Sembiring, 2018). Dadhich et al. (2022) expressed a similar opinion: Construction and demolition waste is generated from building, renovating, repairing, and demolishing residential, industrial, and large buildings such as roads, bridges, and dams (Dadhich et al., 2022).

Waste management is now a significant focus of the European Union and the rest of the world, be it architects, engineering, and construction, i.e. as in some cases material reuse and recycling to reduce resource and energy consumption and environmental emissions (Schützenhofer et al., 2022). According to Sembiring (2018) that in Indonesia, the use of reused materials in Indonesia is still not optimal because the Indonesian construction industry has not made this an important issue that can support a better environment. Instead, Indonesia is still more concerned with developing building materials technology that supports practical, compact, economical, and environmentally friendly construction solutions (Sembiring, 2018).

Material resources are the most critical resources needed in increasing construction development in growing cities in Indonesia, in addition to the resources of money, equipment, methods, and labor (Thoengsal & Tumpu, 2022). Surabaya is Indonesia's second-largest city, contributing significantly to the country's economy. The construction sector in Surabaya City continues to increase, and many construction projects characterize this. Construction projects that have great potential to carry are the housing, hospitality, and road sectors. With the development of this construction project, the potential to generate waste is enormous.

The results of research by Allo & Bhaskara (2022) by conducting a questionnaire analysis of material waste using the Bayes theorem shows that the defect and waiting indicators are indicators that cause the most dominant material damage with a confidence value of 100% for each indicator, where the source of waste during the production process is significantly influenced by the variables of tools/machines, work methods, materials, labor, and environment (Allo & Bhaskara, 2022). Based on the research of Putra & Wiguna (2019), the three most significant factors that cause waste in building projects in Surabaya City are the owners making design changes when construction is already underway, incompetent planners, and miscommunication in design planning (Putra & Wiguna, 2019).

Waste generated can have economic, social, and environmental impacts. Waste material is one of the factors that affect project costs. One of the factors that cause project costs to increase is material waste (Rachman & Tenriajeng, 2019); this is similar to what was conveyed by Putra & Wiguna (2019) state that one of the factors that cause project costs to exceed the budget is waste, which is the result of work but does not add to the work progress (Putra & Wiguna, 2019). Research by Tafesse et al. (2022) revealed construction waste can have major impacts in the form of cost overruns, environmental pollution due to the disposal of chemicals and other materials, decreased profits and failure of construction companies, excessive consumption of raw materials leading to resource depletion, and risks to public health and safety (Tafesse et al., 2022).

Waste from construction and demolition is considered high volume compared to others and causes environmental and social problems (Luangcharoenrat et al., 2019). Construction waste, particularly material waste, is one of the major problems in construction projects and has essential socio-economic and environmental implications for the country (Ting et al., 2022). Therefore, this study uses the Partial Least Square method to analyze the impact of construction and demolition waste on socio-economics and the environment aspects.

RESEARCH METHOD

Data Collection

This research uses a survey method that takes samples from the population and uses questionnaires as a data collection tool. The data used in this study is primary data, which is the perception of respondents' assessment of construction and demolition waste indicators on social, economic, and environmental. The perception of data was obtained from a questionnaire addressed to contractor companies that have and are working on projects in Surabaya, be it building, road, or bridge projects, with respondents being project managers, site managers, site engineering and supervisors. Questionnaire measurement in this study is a variable indicator using a Likert Scale between 1 to 5. The questionnaires were distributed directly to construction companies and projects with the sampling method used being the random sampling method. Based on distributing questionnaires, 97 questionnaires were analyzed using the Partial Least Square (PLS) way with the SmartPLS 4.0 program.

Research Hypotheses

This research measures the impact of construction and demolition waste (C&DW) on the socio-economic, and environmental. Thus, the independent variables in this study are C&DW, while the dependent variables in this study are social, economic, and environmental. Based on the literature study on social, economic, and environmental, the relationship model for this research is to confirm that C&DW impacts social, economic, and environmental. The relationship between these variables is illustrated in Figure 1.

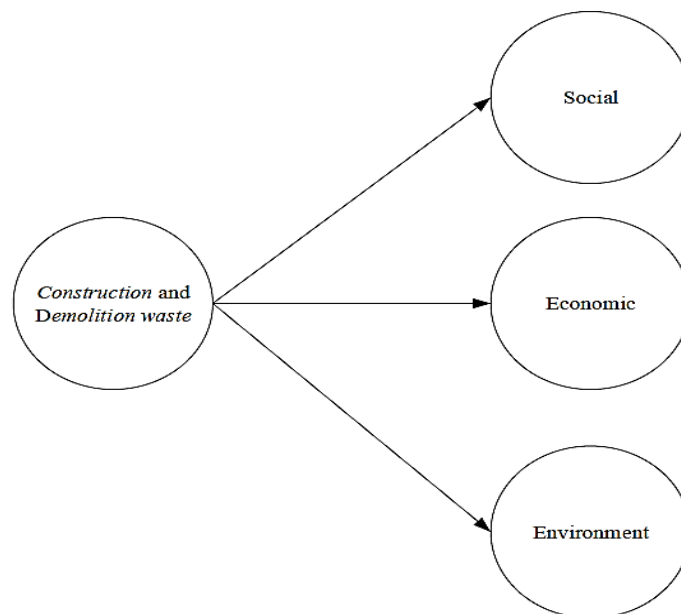


Figure 1. Illustration of Relationship Between Variables

The hypotheses of this study were formulated based on the illustration of the relationship between the variables shown in Figure 1, namely the impact of construction and demolition waste on socio-economic and environmental conditions as follows:

Hypothesis 1: Construction and demolition waste affects the economy

Hypothesis 2: Construction and demolition waste affects the environment

Hypothesis 3: Construction and demolition waste affect the Social

Partial Least Square (PLS)

This research uses the Partial Least Square (PLS) method, which includes evaluating the outer model or measurement model, evaluating the inner model or structural model, then testing the hypothesis. In the first order stage, the latent variables measuring C&DW, in this case, the design, material, workforce, tools, methods, procurement, and external factors through the indicators that form them, followed by the second order. In the second order stage, C&DW were measured through the latent variables that include it. Measurement indicators were obtained through a literature review of various related studies. The indicators in this study are reflective, where the size of each indicator is said to be high if it correlates more than 0.5 with the variable to be measured.

The next step is to evaluate the inner model that is able to describe the relationship between latent variables based on substantive theory. The evaluation is carried out using R-Square for the dependent variable, Stone-Geisser Q-square test for predictive relevance and t-test and significance of the structural path parameter coefficients. In assessing the model with PLS, starting with R-Square for each dependent latent variable. Changes in the R-Square value can be used to assess the effect of independent latent variables on the dependent latent variable whether it has a substantive effect.

To answer the hypothesis that has been made, an analytical method in the form of a t-test is used by determining the level of significance, namely the value of the path coefficient or inner model shown by the T-Statistic value must be above 1.96 for a two-tailed hypothesis.

Indicator of Variables

The variables in measuring C&DW are divided into several factors that cause it. These factors are design, materials, manpower, tools, methods, procurement, and external factors through a literature review of various related studies. Indicators measuring social variables in this study consist of Public health and safety risks, Traffic congestion, Diseases associated with high levels of air pollutants, Flooding due to blockage by waste debris, Disputes between parties involved in construction, Loss of reputation and conflict with the community (Tafesse et al., 2022). Indicators measuring economic variables in this study consist of Project cost overruns, Reduced profits and failures of construction companies, Delays in project time (time overrun), Expenditures for waste disposal, Transportation costs for transporting waste, Reducing the GDP contribution of construction companies, Increasing the price of raw materials. , and Reduced productivity of crops (Tafesse et al., 2022). Indicators measuring environmental variables in this study consist of Environmental pollution by disposal of chemicals and other materials, Excessive consumption of raw materials and resource depletion, Soil pollution by chemicals and other materials, Reduction in the sustainability of the construction sector, Generating waste that causes water pollution, Use of land to dispose of waste, Influence on biodiversity and environmental damage, Adverse impact on the welfare of communities that are disposed of waste, Emission of greenhouse gases into the atmosphere causing climate change, Increased illegal disposal of waste, and Dust generation around the project (Tafesse et al., 2022).

RESULT AND DISCUSSION

In testing the hypothesis of this study with PLS analysis, the smartpls 4.0 program was used to create a structural model to visualize the relationship between the variables of this study, which is presented in Figure 2.

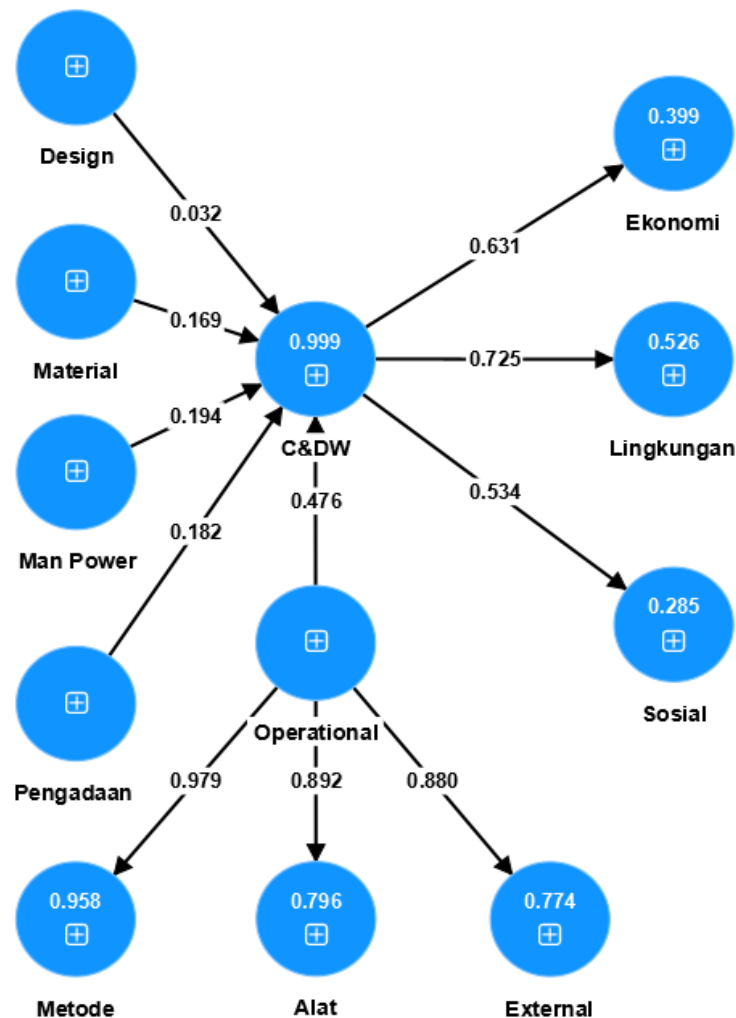


Figure 2. Structural Model of the Relationship Between the Variables with the SmartPLS 4.0 program

Outer Model Evaluation

The first outer model evaluation is to measure convergent validity, which is by examining the value of each outer loading; where the outer loading value > 0.70 , then convergent validity can be fulfilled. Based on the processing results, it is known that all indicators have an outer loading value of more than 0.70, so it can be concluded that these indicators have convergent validity and can be used for further analysis.

The second evaluation of the outer model is discriminant validity, where the measurement of discriminant validity uses the cross-loading value. Variable indicators can fulfill discriminant validity if the cross-loading value of the indicator on the variable is the largest compared to other variables. Based on the cross-loading on the results of this study, each indicator that composes each variable in this study has the greatest loading value on the variable it forms, so it can be concluded that each indicator on each variable in this study has met discriminant validity. Variables with good validity values if the AVE value > 0.5 . The results of the analysis in the research that has been carried out obtained an AVE value of more than 0.5, as shown in Table 1.

The last evaluation of the outer model is composite reliability, namely by testing the reliability value of indicators on a variable. The variable fulfills reliability if the composite reliability value > 0.70 . The following is the composite reliability value of each research variable:

Table 1. Average Variance Extracted (AVE) & Composite Reliability

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Tools	0.959	0.959	0.966	0,803
Design	0.912	0.917	0.929	0,619
Economic	0.880	0.893	0.906	0,581
External	0.915	0.922	0.933	0,666
Environment	0.963	0.965	0.968	0,753
Manpower	0.963	0.968	0.968	0,732
Material	0.964	0.966	0.968	0,735
Method	0.974	0.975	0.976	0,732
Operational	0.980	0.980	0.981	0,667
Procurement	0.945	0.948	0.954	0,699
Social	0.882	0.900	0.910	0,628

Table 1. Shows the composite reliability value of each variable in this study > 0.7, so it can be concluded that each variable has fulfilled the expected reliability criteria.

Inner Model Evaluation (Structural Model)

The first evaluation of the inner model is the R-squared value. R-Square shows the proportion of the effects of exogenous (independent) variables on endogenous (dependent) variables. Based on data processing with SmartPLS 4.0, the R-Square value is as follows:

Table 2. R-Square Value

	R-square
Economic	0.399
Environment	0.526
Social	0.285

Based on Table 2, the R-Square value for the Economic Variable is 0.399, which means that the percentage of data diversity in the economic variable that can be explained by the C&DW variable is 39.9%, or in other words, it can be concluded that the C&DW variable can have an impact of 39.9% on the Economic Factor. The R-Square value for the Environment is 0.526, which means that the percentage of data diversity in the time variable that can be explained by the C&DW variable is 52.6% or in other words, it can be concluded that the C&DW variable can have an impact of 52.6% on environmental factors. The R-Square value for the social factor is 0.285, which means that the percentage of data diversity in social variables can be explained by the C&DW variable is 28.5%, or in other words, it means that the C&DW variable can have an influence of 28.5% on social factors.

The goodness of fit assessment in the PLS model is known from the Q^2 value, the higher the Q^2 value, the more the model can be said to be a fit with the data. From Table 2., the Q^2 value can be calculated as follows:

$$Q^2 = 1 - (1 - 0.399) \times (1 - 0.526) \times (1 - 0.285) \\ = 0,796$$

From the calculation results, it is found that the Q^2 value is 0.796, meaning that the amount of diversity from the research data that can be explained by the structural model is 79.6%. 20.4% is explained by other variables that are not contained in the structural model or outside the model. Thus, the structural model in this study has good goodness of fit.

Hypothesis Test

The following is the path coefficient value and t-statistic value in the inner model, If the t-statistic value > 1.96, the research hypothesis is accepted.

Table 3. Results of Path Coefficient and t-count

Hypotesis	Impact	Path Coefficient	t-statistic	P-Values	Results
H1	<i>C&DW</i> → Economic	0.631	12.221	0.000	Accepted
H2	<i>C&DW</i> → Environmet	0.725	15.914	0.000	Accepted
H3	<i>C&DW</i> → Social	0.534	8.489	0.000	Accepted

Based on Table 3, the path coefficient value of the impact of the C&DW variable on the Economy is 0.631 with a t-statistic of 12.221, higher than the t-table value of 1.96; this shows that there is a significant positive effect between C&DW on the Economy or it can be explained that the higher the C&DW, the higher the impact on economic factors. The considerable value is 0.000, smaller than the 5% alpha level. Based on these results, the first hypothesis of this study can be accepted.

The path coefficient value of the impact of the C&DW variable on the Environment is 0.725 with a t-statistic of 15.914, which is higher than the t-table value of 1.96; this shows that there is a significant positive effect between C&DW on the Environment or it can be explained that the higher the C&DW that occurs, the higher the impact on Environmental factors. The significant value of 0.000 < 5% alpha level; thus the second hypothesis of this study can be accepted.

The path coefficient value of the impact of the C&DW variable on Social is 0.534 with a t-statistic of 8.489, which is higher than the t-table value of 1.96; thus, there is a significant positive impact between C&DW on Social, or it can be explained that the higher the C&DW that occurs, the higher the impact on Environmental factors. The significant value, which is 0.000 < 5% alpha level; thus the third hypothesis of this study can be accepted.

CONCLUSION AND RECOMMENDATION

Conclusion

Based on the analysis results using the partial least square method using the Smart PLS 4.0 program, the structural model in the research has good goodness of fit, which means that the structural model can explain the enormous diversity of research data. So, this research concludes that construction and demolition waste have social, economic, and environmental impacts. The higher the construction and demolition waste, the more significant its impact. The magnitude of the impact that construction and demolition waste has on social factors is 28.5%, on economic factors is 39.9%, and the most significant effect is 52.6% on environmental factors.

Recommendation

Suggestions that can be given for further research are Research to measure whether contractor companies in Surabaya have carried out 3R (reuse, reduce, and recycle) efforts to anticipate the impact of construction and demolition waste and measure the amount of waste for each material produced from construction and demolition waste projects in Surabaya

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