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A Non-Market Valuation Approach to Environmental Cost-Benefit Analysis for Sanitary Landfill Project Appraisal

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Abstract: Extensive non-engineered landfilling practice in developing countries has raised environmental concerns, but operating a sanitary landfill appears infeasible due to financial incapability. This study aims to determine the feasibility of a sanitary landfill project by including its environmental values into the project appraisal while simultaneously applying three policy-relevant methods—non-market valuation, benefits transfer, and cost-benefit analysis—in two study areas in Peninsular Malaysia. The non-market valuation study used choice modeling, a questionnaire-based technique, to elicit willingness to pay among 624 households toward the environmental attributes of the sanitary landfill. Their responses resulted in the monetary values of the environmental attributes by referring to implicit prices of leachate discharge, bad odor, disease vector and view. The implicit prices of bad odor (RM2.29 per month) and view (RM3.59 per month) in the two study areas were transferable and used as a proxy of additional solid waste disposal payment in environmental cost-benefit analysis. Positive net present value offers empirical evidence of the feasibility of the sanitary landfill project. The findings show that the inclusion of environmental values in project appraisals increases the chances of implementing sanitary landfills, providing a new approach to address the environmental concerns in developing countries. Future research should consider the external costs along with the external benefits to allow for a comprehensive comparison between environmental values in environmental cost-benefit analysis.

Keywords: non-market valuation; choice modeling; cost-benefit analysis; sanitary landfill; externalities

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1. Introduction

Solid waste disposal is infamously known as an environmentally noxious activity. This circulated claim is not entirely wrong since environmental issues are linked to the externalities of landfilling activities. Externalities could be positive or negative, represented by the unaccounted gain or loss of human well-being [1]. Regarding landfilling activity, negative externalities due to gas emission and leachate discharge affect the community's welfare [2]. Due to environmental concerns, developed countries have started adopting sanitary landfills as engineered landfills equipped with provisions (e.g., cover soil, leachate treatment system and gas emission system) to minimize the negative externalities from landfilling activity [3,4]. Due to higher costs, sanitary landfills are not a popular choice in developing countries, despite the burgeoning solid waste generation for disposal [5]. Extensive non-engineered landfilling practices increase the negative landfilling externalities of ground pollution, water pollution and nuisances originating from foul odor and breeding pests [2].

The importance of adopting sanitary landfill as final solid waste disposal not only involves its mitigative measures against negative externalities but also its key role in the circular economy concept, an alternative to economic growth that promotes resource cycling to reduce the use of natural resources and solid waste production in line with sustainable development [6]. When implementing sanitary landfills, the extracted landfill gases from solid waste decomposition are renewable energy sources for power generation and can minimize the dependency on coal extraction. Meanwhile, solid waste processing and transformation prior to final disposal prolong the product lifecycle. It also shows that the option of post-closure landfill mining increases resource circulation, with the recovery of perspective materials [7–9]. These practices have been used in Europe and the United States since the beginning of the 20th century to support the circular economy [10]. Unlike developing countries, sanitary landfills are still in the infancy phase, and the closest attempt to support the circular economy, in the sense of solid waste management, is the informal recycling of solid waste through waste pickers [10,11].

At a glance, operating sanitary landfills in developing countries appears infeasible. With income being a constraint, the costs of a sanitary landfill will exceed the amount people are currently paying for solid waste disposal. From another viewpoint, feasibility is only measured according to technical and operational aspects, overlooking environmental aspects despite solid waste disposal generating environmental concerns. As far it goes in practice, project onset only requires environmental assessment to address corrective measures for any likelihood of environmental damage. This norm in project appraisal could underestimate a project's worth, leading to infeasibility. The inclusion of environmental elements in project appraisal could increase the chances of implementing sanitary landfills for a better environment.

The need for this study is based on abolishing barriers to achieving better solid waste disposal in developing countries. Increases in material production and consumption mainly due to urbanization and the rise of economic activities accelerate waste generation, demanding better solid waste disposal facilities [12]. Unfortunately, many sanitary landfill projects often end up unprofitable or only half completed. This results in recurrent cases of the landfilling impacts that originally prompted mitigation and highlights the importance of finding alternatives for sanitary landfill projects. This study intends to help solve the dilemma by incorporating environmental elements into sanitary landfill project appraisal to test whether they increase project feasibility.

This study quantifies the positive externality of sanitary landfills by alleviating adverse landfilling impacts like leachate, bad odor, disease and view. These are the environmental values of the sanitary landfill that will be used in the cost-benefit analysis (CBA). Illustrating the CBA for a sanitary landfill project that appears feasible on paper and in practice is not a straightforward process that requires a combination of methods in parallel with a new approach for project appraisal.

This study aims to determine the feasibility of sanitary landfill projects by including transferable environmental values from non-market valuation studies in the CBA. Overall, the goal is to provide empirical evidence showing the influence of the environmental values of sanitary landfills on project feasibility as an alternative to making sanitary landfill projects possible amid financial constraints, as commonly happens in developing countries. This study is significant for the non-market valuation literature in two ways. First, this is the first study to interpret the positive externality of sanitary landfills described by environmental values as incorporated into a CBA. Second, it suggests the use of policy-relevant methods as a new approach to project appraisal.

1.1. Background of the Study

Non-market valuation is synonymous with economic policy to allocate economic value for non-market goods and services where market prices are not observable. Numerous non-market valuation studies estimate solid waste management values from various aspects, as shown in Table 1, especially in developing countries, which underscores the interest in improving solid waste management. The findings of the studies are significant in assisting with solid waste management policy decisions and are presumably used to support policy assessment for domestic use. However, in the non-market valuation literature, there are infrequent discussions about utilizing the findings in project appraisal. The closest attempt to utilize the empirical findings from a non-market valuation of solid waste management was by [13], who used the findings to estimate external cost, the monetary term of the negative externality of landfills in Japan, and to calculate the social costs in the form of the sum of the private costs and external costs. The results displayed the influence of the external costs in yielding higher social costs. The commendable results of [13] were discussed in [14], recommending a broad application of the approach by [13] with a more careful manner to elicit values that correctly represent those of the community.

Table 1. Previous related studies.

Methods	Previous Related Studies	Scope
Non-Market Valuation	Ko et al. (2020)	Solid waste management
	Gabreeyosus and Berhanu (2019)	Solid waste management
	Czajkowski et al. (2014)	Recycling
	Li et al. (2014)	Waste to energy incinerator
	Khee and Jamal (2011)	Solid waste disposal
	Ku et al. (2009)	Solid waste management
	Jamal (2007)	Solid waste management
	Jin et al. (2005)	Solid waste management
	Sasao (2004)	Solid waste management
Cost-Benefit Analysis	Begum et al. (2006)	Solid waste disposal
	Dobraja et al. (2015)	Waste to energy incinerator
	Zhou et al. (2014)	Landfill mining
	Mutavchi (2012)	Solid waste management
	Kumar et al. (2004)	Landfill
	Yedla and Parikh (2001)	Landfill
	Chong et al. (2005)	Sanitary landfill
	Liu, Zhang and Wang (2020)	Recycling project

Concerning the increasing cases of negative externality from landfilling activities in developing countries, proper solid waste disposal becomes a prerequisite to reverse the impacts. However, it is not uncommon to hear of failed sanitary landfill projects in developing countries. The authors of [15] relate such failures to excluding externalities during project appraisal by stressing that private costs and benefits alone do not reflect the project's true worth. This statement parallels the study confirming externalities and the need to internalize them by implementing appropriate policy instruments [16]. This requires developing policy assessment tools to enhance the empirical basis of policy decisions [14]. Broad applications of non-market valuation of solid waste management studies show the reliability of the methods used, and deliberation of the study outcomes as a part of a policy assessment tool is appropriate. Recent studies [17–19] suggest incorporating non-market values into policy decisions so that policymakers can come up with more informed and fair social choices to formulate successful policies.

Using non-market values in solid waste management policy decisions can achieve comprehensive project appraisal, where the current norm only weighs the prices of technical and operational aspects, with attempts to include relevant environmental aspects with an observable price, such as the cost of landfill gas emissions [20], the cost of space reclamation [21], the cost of preventing pollution [22], the price of recycled waste material [23], and the costs associated with pollution reduction [24]. This approach ignores non-market values due to their unobserved prices, which may seem inconsequential. For instance, a sanitary landfill provides significant environmental benefits to the local community from the treatment of leachate discharge, reduced bad odor, controlled disease vectors, and improved view. However, the prices of these benefits are unobservable due to their qualitative nature; benefits are assigned as zero, and consequently, they are not included in any decision-making process in the policy context. A solution to this problem involves defining the benefits in monetary terms, giving non-market valuation the quality characteristics of privately consumed goods and services defined by price.

Real practice often ignores non-market values during project appraisal, undermining the non-market value results [25]. Along with this, directly using the non-market values in project appraisal seems abrupt without a policy-relevant validation process; transferring suitable values is more credible. To only consider accurate non-market values in project appraisal, this study proposes an alternative to improve the findings by using benefit transfer (BT) as a means to use transferable non-market valuation results in CBA. BT has several uses in the non-market valuation literature [15,26–29], but incorporating the findings into policy or project appraisals has not yet been addressed. In the case of SWM, the authors of [15] transferred non-market values concerning SWM improvement from relevant studies by means of BT to establish suitable reference values.

Ref. [30] stated that decision-makers are increasingly using BT to estimate values suitable for use in CBA. CBA is an empirical analysis of a project to assess its effects on social welfare by comparing the costs against the benefits. CBA seeks to translate the comparison of the monetized costs and benefits into the net present value (NPV). Positive NPV indicates the social benefits outweigh the social costs, thereby justifying the implementation of the assessed project [31]. For this reason, CBA outcomes are usually used in project development to evaluate the proposed initiatives to know if the project is drifting toward success or failure, though it is rarely used as the sole decision criterion [32].

The standard practice of CBA is for policymakers (e.g., the government) to apply a top-down approach, with guidance to identify and measure the costs and benefits of the assessed policies or projects for the public [31]. In this one-way approach, inputs from the public are not assessed. Hence, it is unknown whether the policies or the projects are meeting public needs. Therefore, this study provides information from the public on a sanitary landfill project by including transferable non-market values of the sanitary landfill. The literature has shown that participation fosters trust among stakeholders, yielding an increase in understanding among them, and indirectly improves the integration of broader societal goals in the policy process [33–36]

1.2. Conceptual Framework of Environmental Cost-Benefit Analysis

Figure 1 illustrates the conceptual framework of an environmental CBA rendition with the inclusion of transferable non-market elements. The first step is to quantify the non-market values of a sanitary landfill through welfare measurement of an individual at the level of his/her utility, which depicts the willingness to pay or willingness to accept. The welfare measurement in this study focuses on measuring an individual's willingness to pay for the environmental values of a sanitary landfill. This study suggests using BT as a bridge toward using only suitable non-market values in CBA. BT was carried out to compare the non-market values of a population living nearby the policy site and a population living some distance away from the policy site. Using comparable non-market values of a sanitary landfill as a component in the environmental CBA as well as the market values from technical and operational aspects provides a comprehensive comparison between costs and benefits. The hope is that the framework can deliver a more engaging analysis to determine project feasibility in light of limited financial capability.

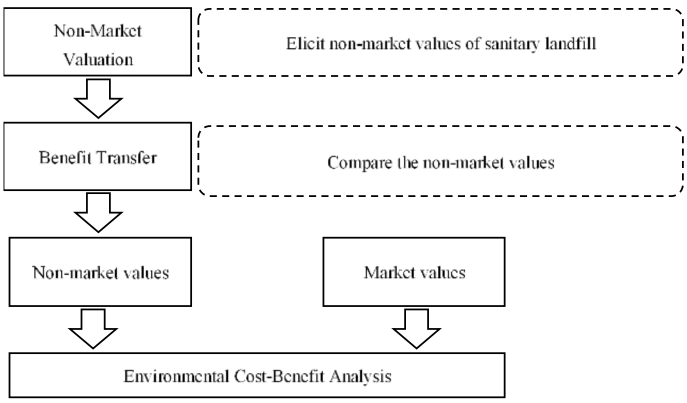

Figure 1. Conceptual Framework for the Environmental Cost-Benefit Analysis.

2. Materials and Methods

This section will explain the process employed to answer whether the estimated non-market values of the sanitary landfill would be meaningful to determine project feasibility. This requires the simultaneous use of three policy-relevant methods: non-market valuation, BT, and CBA, as illustrated in Figure 2. Below is a discussion of the methodological flow in this study.

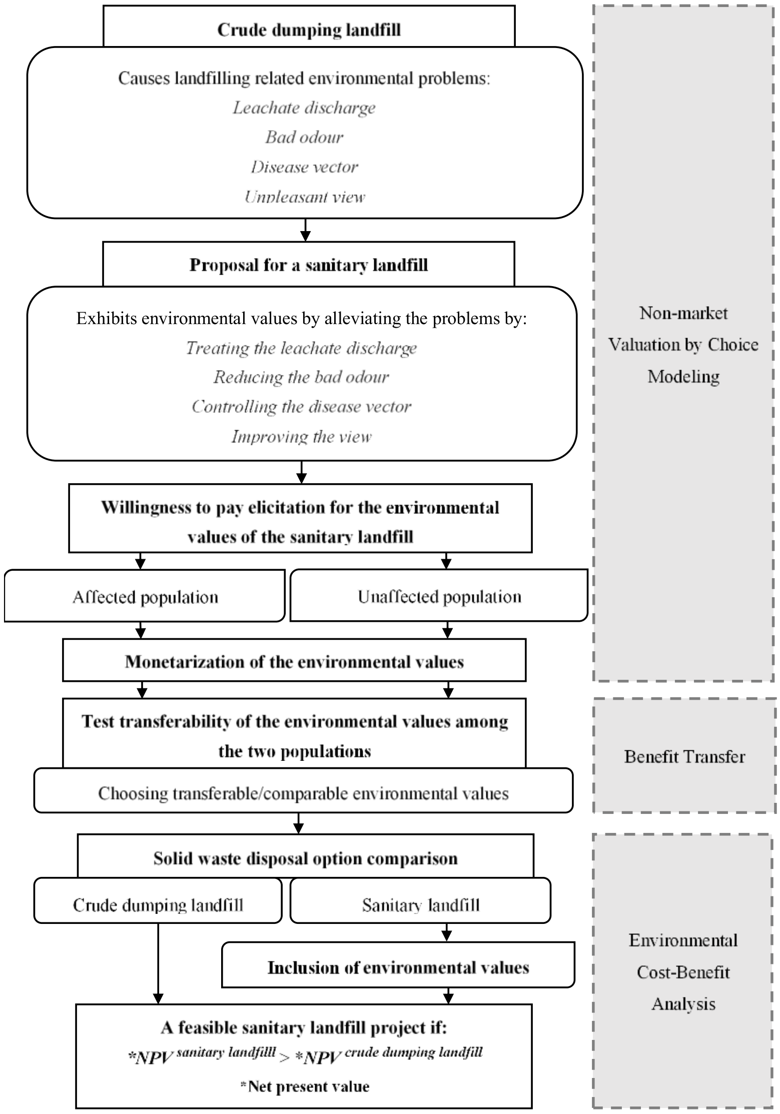

Figure 2. Methodological Workflow of the Study.

2.1. Non-Market Valuation by Choice Modeling

The study on which the non-market valuation part of this paper is based was carried out in the neighboring districts of Kota Bharu and Bachok, Peninsular Malaysia. These districts were chosen due to their mutual use of a "crude dumping" landfill located in Bachok; the proposed sanitary landfill would accommodate solid waste disposal service for the households in both districts. Currently, the landfilling activities cause a nuisance for the households residing close to the landfill. The difference in distance of these districts to the landfill allows this study to capture differences in the preferences for the proposed sanitary landfill among the affected populations in Bachok and unaffected populations in Kota Bharu.

Non-market valuation comprises several techniques, such as choice modeling, the contingent valuation method, the travel cost method, the hedonic pricing method and the averting behavior method, to allocate economic value for non-market goods and services. This study used choice modeling (CM), a reputable survey-based technique that has been touted as being particularly suitable for BT, since it allows differences in environmental quality and socioeconomic characteristics, as shown by [29].

Conducting a CM questionnaire survey requires focus group sessions for representatives from local households and solid waste management service providers to (i) gauge environmental problems from the "crude dumping" landfilling practice, (ii) identify provisions in sanitary landfill to mitigate the landfilling impacts, and (iii) identify the attributes that best describe the sanitary landfill. As a result of these sessions, four environmental attributes—leachate discharge, bad odor, disease vector and view—were chosen, as defined in Table 2. Each attribute was set at level one to describe the status quo at the "crude dumping" landfill: untreated leachate discharge, strong bad odor, uncontrolled disease vector and unpleasant view. The higher levels of each attribute indicate improvements, describing the environmental benefits of the sanitary landfill. Monetary attributes were established in the form of an additional solid waste disposal fee to enable welfare measurement of each environmental attribute.

Table 2. Attributes and levels for sanitary landfill.

Attribute	Definition	Levels
Leachate	Discharge of toxic liquid formed from degraded waste and rainwater	1: Untreated discharge *(Status Quo)* 2: Half-treated discharge 3: Fully treated discharge
Bad odor	Presence of bad odor due to disposed waste in the landfill	1: Strong *(Status Quo)* 2: Distinct 3: Weak 4: No odor
Disease vector	Breeding of vectors (e.g., rats, mosquitoes, flies) in the landfill	1: Uncontrolled *(Status Quo)* 2: Controlled
View	Aesthetic surrounding of the landfill	1: Unpleasant *(Status Quo)* 2: Pleasant
Additional fee	Additional fee for sanitary landfill incorporated into annual assessment payment	1: No payment *(Status Quo)* 2: RM3 per month 3: RM5 per month 4: RM7 per month

Combinations of attribute and levels were assigned to the questionnaire using fractional factorial design. Each choice set consisted of a three-way choice: Alternative A and Alternative B for sanitary landfill, which was the combination of levels from all the attributes that suit the balance and orthogonal elements, and the status quo at the "crude dumping" landfill.

Data collection was undertaken using stratified-random sampling through house-to-house questionnaires distributed among 624 households in Kota Bharu and Bachok. From the choice set responses, Multinomial Logit and Nested Logit regressions were estimated individually for the samples in Kota Bharu and Bachok. The ratio of the respondents from Kota Bharu to the respondents from Bachok was 3:1, equivalent to the ratio of the actual population in Kota Bharu to the population in Bachok.

The Multinomial Logit model specification for CM relies on Lancaster's theory of value and random utility theory, characterizing utility function into two parts of choice probability: the observable component (V) and the error term (ε), representing unobservable components of the respondent's choice [37]. Therefore, the specification assumes that the utility of an individual i for an alternative n depends on environmental attributes (X):

$$U_{in} = V(X_{in}) + \varepsilon(X_{in}) = \beta X_{in} + \varepsilon_{in} \tag{1}$$

where the probability that individual i will choose alternative n over alternative k is given by

$$P(n|C) = \text{Prob}\{V_{in} + \varepsilon_{in} > V_{ik} + \varepsilon_{ik},\ all\ j \in C\} \tag{2}$$

where C is the complete choice set. The estimation of Equation (2) requires an assumption that the error terms are independently and identically distributed (IID), which results in the property of independence of irrelevant alternatives (IIA). The IIA states that the probability of two alternatives being selected is entirely unaffected by introducing or removing any other alternatives. When there is a violation of the IIA property, a Nested Logit regression can relax the assumption by explaining the respondents' choices using a decision tree. An individual may choose one branch (category) of the decision tree and then determine a specific alternative from the chosen branch. Each branch allows for correlations among error terms within subsets of alternatives. Equation (3) is the probability of an individual choosing the ath alternative in branch b:

$$P_{ab} = P(a|b)P(b) \tag{3}$$

P(b) is the probability that the individual chooses the bth branch. where P(a|b) is the probability of the individual choosing the ath alternative as conditional on choosing the bth branch. This study postulates that respondents made their decision between three solid waste disposal alternatives as a sequence of a two-level process. On the first level, respondents were assumed to choose between two branches, either supporting sanitary landfill or not supporting sanitary landfills. On the second level, conditional on supporting sanitary landfill, they were assumed to choose within a nest between the two sanitary landfill alternatives, "Alternative One" or "Alternative Two", presented in each choice set.

Welfare measurement is made possible by the marginal change of any environmental attribute from the estimation of Equation (1). It can be expressed as the ratio in coefficients, usually known as implicit prices. In this study, implicit prices are the marginal rate of substitution between the coefficient of the environmental attributes, βx, and the coefficient of the monetary attribute, βm, as shown in Equation (4). The implicit price of an environmental attribute reflects an individual's willingness to pay for an additional unit of the attribute, ceteris paribus.

$$Implicit\ price = \frac{-\beta_x}{\beta_m} \tag{4}$$

The implicit prices of each attribute were obtained from individual Multinomial Logit and Nested Logit models from the two samples to show differences in willingness to pay among affected and unaffected populations. The estimation of the implicit prices represents the environmental values of the sanitary landfill, as elicited from individuals.

2.2. Benefit Transfer

To investigate the transferability of the environmental values between affected and unaffected populations, this study tested the transferability of the implicit prices in Kota Bharu and Bachok. This study used overlapping confidence intervals to test the equality of implicit prices across models for Kota Bharu and Bachok. The implicit prices were estimated using the application of Krinsky and Robb bootstrapping simulation of the 1000 draws technique. This technique yielded more profound standard error values than the standard deviation based on linear approximation [38]. This statement is supported by findings of [39], where the mean and standard deviations derived from the bootstrapping simulation of 1000 draws were better than the results of a linear approximation. This study found that linear approximation provides inaccurate standard deviation estimates, since the implicit prices were non-linear functions of the estimated coefficients.

The transferability of the implicit prices could be decided in terms of the confidence interval, showing the importance of estimating profound standard deviation values. The 95% confidence interval of the implicit prices was calculated based on the following formula:

$$Confidence\ Interval = Implicit\ Price\ \pm Z * \frac{sd}{\sqrt{n}} \tag{5}$$

where Z equals 1.96, sd is the standard deviation and n is the sample size. The test hypothesis to assess whether the implicit prices in Kota Bharu were statistically different from the implicit prices in Bachok was as follows:

H0: IPKB = IPB

H1: IPKB = IPB

where IP_{KB} refers to the estimated implicit prices for Kota Bharu and IP_{B} refers to the implicit prices estimated for Bachok. The decision on the transferability of the implicit prices was made based on two considerations. First, it only applied for significant implicit prices, and second, when the implicit price for Kota Bharu fell between the confidence interval for the implicit price in Bachok, it meant that the implicit price in Kota Bharu was statistically similar to the implicit price in Bachok and vice versa.

2.3. Environmental Cost-Benefit Analysis

This study illustrated an environmental CBA for two SW disposal alternatives: the crude dumping landfill (status quo) and the proposed sanitary landfill. To engage in environmental CBA, the transferable implicit prices in Kota Bharu and Bachok were used to represent the environmental values of the sanitary landfill. In addition to the aim of the standard CBA practice to assess the feasibility of the SW disposal options from net present value estimation, the environmental CBA injects a new dimension by examining the influence of environmental values of the sanitary landfill on project feasibility.

The net present values for both SW disposal options were the comparisons of the summation of the present value benefit to the present value cost, where both are the discounted real-time benefits/costs determined using the following equations:

$$Present\ Value\ Benefit = \sum_{t=0}^{T} \frac{B_t}{(1+r)^t} \tag{6}$$

$$Present\ Value\ Cost = \sum_{t=0}^{T} \frac{C_t}{(1+r)^t} \tag{7}$$

where Bt are the benefits of the solid waste disposal option and Ct are the costs of the solid waste disposal option in time t, and r is the social discount rate. For project appraisal, net present value must yield a positive value, showing that the total discounted benefits exceed the total discounted costs.

$$Net\ Present\ Value = \sum_{t=0}^{T} Present\ Value\ Benefit - \sum_{t=0}^{T} Present\ Value\ Cost \tag{8}$$

$$= \sum_{t=0}^{T} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{T} \frac{C_t}{(1+r)^t} \tag{9}$$

$$= \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t} \tag{10}$$

The net present values for both solid waste disposal options were estimated using Equations (11) and (12) for 25 years of the lifespan of both options.

$$NPV^{L} = \sum_{T=25} \frac{B_t^L - C_t^L}{(1+r)^t} \tag{11}$$

$$NPV^{SL} = \sum_{T=25} \frac{B_t^{SL} - C_t^{SL}}{(1+r)^t} + \sum_{T=25} \frac{D_t^{SL} - E_t^{SL}}{(1+r)^t} \tag{12}$$

NPVL and NPVSL represent net present value formulas for the crude dumping landfill and the sanitary landfill. The net present value formula for the sanitary landfill was extended, with the inclusion of environmental values of the sanitary landfill captured by $D_t - E_t$ in time t, with r as the social discount rate. Along with net present value calculation, the benefit-cost ratio was calculated by dividing the present value benefit by the present value cost (from Equations (6) and (7)) to summarize the relationship between the associated costs and benefits of the sanitary landfill. A benefit-cost ratio value of greater than one means this is a desirable option.

3. Results

This section will discuss the results to answer whether the environmental values of the sanitary landfill would be meaningful to determine project feasibility. The results from non-market valuation, BT and environmental CBA will be discussed.

3.1. Environmental Values of a Sanitary Landfill

From the non-market valuation study, the respondents gave encouraging and positive feedback in answering the choice set questions. As shown in Figure 3, 89% favored sanitary landfill alternatives over the status quo option, indirectly showing their agreement to pay toward improvement in environmental attributes of the sanitary landfill. Meanwhile, 11% chose the status quo options when answering the choice set questions, showing their disagreement with implementing a sanitary landfill. 34% chose to disagree with these responses due to the inability to pay the mentioned prices in the choice sets, though they supported the sanitary landfill. Meanwhile, others did not support sanitary landfills based on their perceptions that solid waste disposal cannot be improved. It is not their responsibility to pay for the sanitary landfill, their disagreement with the options given, and feelings of indifference toward solid waste disposal. These results showed that the respondents did not arbitrarily answer the choice set questions, but they took an in-depth reasoning process when answering.

Table 3 shows the results for the estimation of Multinomial Logit and Nested Logit models from the responses to the choice set questions. The coefficients for the environmental attributes are significant at the 1% level, and all had the expected signs. Positive coefficient signs for leachate, bad odor, disease vector, and view depicted demand for improvements in these attributes when respondents chose between alternatives for sanitary landfill. The significance of the additional solid waste management fee coefficient is important to avoid a meaningless interpretation of willingness to pay. The explanatory power of the Nested Logit models with rho-squared of 43% and 64% are higher than the Multinomial Logit models, implying a better explanation of the choices made by the respondents.

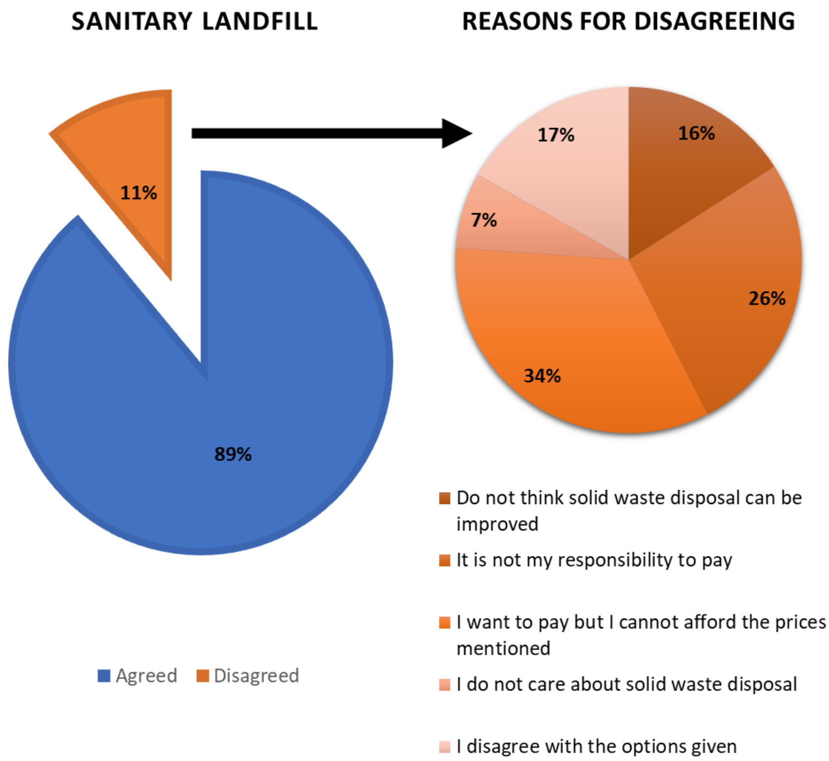

Figure 3. Agreement/Disagreement with Sanitary landfill and the Reasons for Disagreeing.

Table 3. The resulats of Multinomial Logit models and Nested Logit models.

Variables	Multinomial Logit		Nested Logit	
	Kota Bharu	Bachok	Kota Bharu	Bachok
Leachate discharge	0.313 *** (0.042)	0.675 *** (0.091)	0.342 *** (0.044))	0.675 *** (0.092)
Bad odor	0.267 *** (0.036)	0.421 *** (0.076)	0.320 *** (0.040)	0.421 *** (0.076)
Disease vector	1.382 *** (0.081)	1.963 *** (0.204)	1.593 *** (0.096)	1.972 *** (0.205)
View	0.464 *** (0.073)	0.661 *** (0.149)	0.555 *** (0.080)	0.661 *** (0.150)
Additional solid waste management fee	−0.109 *** (0.014)	−0.184 *** (0.029)	−0.120 *** (0.015)	−0.185 *** (0.029)
Inclusive value parameters				
Improvement			0.368 *** (0.110)	1.195 (1.942)
No improvement (fixed parameters)			1	1
Summary Statistics				
Log likelihood	−1502.589	−268.232	−1403.218	−283.919
Pseudo-R^2	0.13	0.33	0.43	0.64
Iterations completed	6	31	26	11
Observations	1872	572	1872	572

Note: Significant at 5% level, *** Significant at 1% level.

The implicit prices for each environmental attribute were estimated using Equation (4) in the preceding text from the regressed models. Table 4 shows the implicit prices for each environmental attribute in Kota Bharu and Bachok, estimated from the Multinomial Logit and Nested Logit models. Slightly higher willingness to pay is shown among respondents from Kota Bharu compared to those from Bachok. The implicit prices placed for leachate discharge, bad odor and view are within the range of implicit prices obtained in previous SWM evaluations in Malaysia, below RM5 per month [40,41]. Disease vector has significantly higher implicit price estimates compared to other environmental attributes. The marginal effect for each disease vector unit improvement has a range of additional fees, between RM12.08 and RM12.59 per month. This result suggests that when the propagation of the disease vector is controlled in a sanitary landfill, the households are better off by RM12.08 and RM12.59 per month.

Table 4. Implicit prices for the environmental attributes of sanitary landfills measured in RM per month.

Attribute	Multinomial Logit Model		Nested Logit Model	
	Kota Bharu	Bachok	Kota Bharu	Bachok
Leachate discharge	2.87	3.66	2.87	3.65
Bad odor	2.44	2.29	2.68	2.28
Disease vector	12.63	10.66	13.33	10.67
View	4.24	3.59	4.64	3.58

3.2. Transferability of the Environmental Values of the Sanitary Landfill

The implicit price results from the non-market valuation study refer to the environmental values of the sanitary landfill. BT captures transferable implicit prices between Kota Bharu and Bachok on the ground to assess if the implicit prices between affected and unaffected populations from "crude dumping" landfilling practice in Bachok were statistically similar.

Based on Table 5, the implicit prices of bad odor and view were transferable in the MNL models. The implicit price of bad odor (RM2.29) in Bachok was in the confidence interval of the bad odor implicit price (2.00, 2.87) in Kota Bharu. Similarly, the implicit price of view (RM3.59) in Bachok was in the confidence interval of the view implicit price (3.36, 5.11) in Kota Bharu. The implicit prices of bad odor and view were significant at the 1% level for Kota Bharu and Bachok. Meanwhile, the implicit prices derived from the Nested Logit models were not significant, thus prohibiting their transferability.

Table 5. Transferability of the implicit prices measured in RM per month.

Attribute	Extended Multinomial Logit Model		Nested LogitModel	
	Kota Bharu	Bachok	Kota Bharu	Bachok
Leachate discharge	2.87 *** (2.34, 3.40)	3.66 *** (3.54, 3.78)	2.87 *** (2.85, 2.89)	3.65 *** (3.64, 3.65)
Bad odor	2.44 *** (2.00, 2.87)	2.29 *** (2.21, 2.37)	2.68 (−1.74, 7.09)	2.28 (0.13, 4.43)
Disease vector	12.63 *** (10.92, 14.35)	10.66 *** (10.37,10.96)	13.33 (11.37,15.29)	10.67 *** (10.32, 11.02)
View	4.24 *** (3.36, 5.11)	3.59 *** (3.44, 3.74)	4.64 (1.50, 7.78)	3.58 (−10.47,17.63)

Note: Significant at 5% level, *** Significant at 1% level.

The results illustrate that household willingness to pay comprises the transferable implicit prices of bad odor (RM2.29 per month) and view (RM3.59 per month). The accumulation of the implicit prices on a yearly basis resulting in the willingness to pay an amount of RM70.56 per household. This would mean that households need to pay RM70.56 per year on top of current solid waste management fees for sanitary landfill implementation.

3.3. Environmental Cost-Benefit Analysis for the Sanitary Landfill

The transferable implicit prices obtained in the BT study represent the environmental values of the sanitary landfill. Incorporation of the environmental values must be aggregated following the projection of the CBA to assess the feasibility of two solid waste disposal options—"crude dumping" landfill (status quo) and sanitary landfill—with a 25-year lifespan. Hence, the formula for the aggregated environmental values is as follows:

$$\begin{aligned}\text{Aggregated environmental values} \\ &= \text{Number households} \times \text{Proportion of willingness to pay sample} \\ &\times \text{transferable implicit prices}\end{aligned} \tag{13}$$

The number of households was obtained from information about the local population [42]. The proportion of the willingness to pay sample represents the respondents who agreed to pay for the sanitary landfill in the non-market valuation study, and the transferable implicit price was the yearly amount of RM70.56 per household. The aggregated environmental values were interpreted as the additional payment of a solid waste disposal fee to implement the sanitary landfill to identify costs and benefits.

3.3.1. Identified Costs and Benefits

Table 6 shows the identified benefits and costs for both solid waste disposal options: the "crude dumping" landfill (base case) and the sanitary landfill. The total cost for the crude dumping landfill includes a one-off land cost for a new landfill site, the cost of 25 years of operation and the cost of 25 years of rental of the machinery. The operation cost was estimated based on the operation cost for solid waste disposal by crude dumping, which is RM35 per ton SW disposed of, and information about the local population [42]. Meanwhile, the total benefit of the crude dumping landfill comprises the revenues from yearly SW disposal fees paid by the households for 25 years. On average, each household would be paying RM62 per year for solid waste disposal.

Table 6. Identified costs and benefits of the sanitary landfill.

Crude Dumping Landfill (Status Quo)		Sanitary Landfill	
	Year		**Year**
Costs		**Costs**	
Land cost	0	Capital cost	0
Operation cost	1 to 25	Operation cost	1 to 24
Machine rental	1 to 25	Closure cost	25
Benefits		**Benefits**	
Revenues from solid waste disposal fee	0 to 25	Revenues from solid waste disposal fee	0 to 25
		Additional payment for solid waste disposal fee	0 to 25

The total costs and benefits of the sanitary landfill follow the requirements to build a new sanitary landfill facility with a capacity sufficient to accommodate solid waste disposal demand for a population of 500,000 with a lifespan of 25 years. The total costs associated with the sanitary landfill would be capital cost, operation cost and closure cost (the cost of closing the landfill after lifespan expiration). This study used comprehensive one-off capital costs and the closure costs provided by [43]. The capital cost of the sanitary landfill included costs for land, an Environmental Impact Assessment report and construction. The closure cost of the sanitary landfill comprises the costs for final landfill cover, vegetation and monitoring for environmental protection [43]. The operation cost was estimated based on the operation cost for a sanitary landfill in Malaysia, RM50 per ton of solid waste disposal, and local population information [42,44]. The total benefit for the sanitary landfill comprises the revenues from the solid waste disposal fee plus the additional payment for the solid waste disposal fee.

3.3.2. Estimation of Net Present Values

By referring to the identified cost and benefit information in Table 6, the net present values of the projection of the crude dumping landfill (status quo) and sanitary landfill for the next 25 years were estimated with two social discount rates, r of 5% and 10%, based on Equations (11) and (12), respectively. These discount rates were chosen because they were between the range of the social discount rate used in developing and developed countries, from 3% to 15% [45]. The overall calculation of the net present values for both SW disposal options is shown in Table 7.

Table 7. Net present values for crude dumping landfill and sanitary landfill.

	Discount Rate	
	5%	**10%**
Crude dumping landfill		
Net Present Value	−16,604,762	−10,089,451
Benefit-Cost Ratio	0.82	0.83
Sanitary landfill		
Net Present Value	50,264,040	32,618,078
Benefit-Cost Ratio	1.50	1.50

The net present values for the crude dumping landfill (status quo) yielded negative values for the discount rates of both 5% and 10%. This reflected the infeasible implementation of the crude dumping landfill for the next 25 years. Despite its lower costs compared to the sanitary landfill, the stagnant allocation of the solid waste disposal fee could not cover the total costs for the crude dumping landfill. Population growth over the years would create increasing demand for solid waste disposal, in parallel with the increasing total cost for solid waste disposal. To illustrate, the net present value for the crude dumping landfill estimation only used a fixed annual cost for the rental of machinery (RM1,600,000/year) for simplicity. However, the cost would be higher, with more machinery required to flatten the solid waste in the landfill in the real situation. This will lead to inefficient use of land and the tendency for solid waste spillage into nearby waterways or land, thus triggering a far greater nuisance for the environment and public health.

The net present values for the sanitary landfill yield positive values for the discount rates of both 5% and 10%. The inclusion of the environmental values of the sanitary landfill, captured by the additional solid waste disposal fee, makes the implementation economically feasible for the next 25 years. In other words, when the additional solid waste disposal fee is charged at RM70.56/household/year, compared to the current fee of RM62/household/year, the total benefit of the sanitary landfill outweighs the total cost.

The benefit-cost ratio was also calculated by dividing present value benefit by present value cost (from Equations (6) and (7)), to summarize the relationship between the associated costs and benefits of the SW disposal options. A benefit-cost ratio value greater than one means this is a desirable option. The results of the benefit-cost ratio are consistent with the net present values for the sanitary landfill and the crude dumping landfill, showing the sanitary landfill is a desirable solid waste disposal option compared to the crude dumping landfill.

4. Discussions

This section will respectively summarize the results of the non-market valuation, BT and environmental CBA and discuss implications of the results with regard to solid waste management policy change.

4.1. Environmental Values from Non-Market Valuation

A majority of the respondents (89%) agreed with the sanitary landfill project as seen from their positive responses to assign monetary values to the qualitative nature of the environmental values of the sanitary landfill, including propagation of disease vector, reduction of bad odor, treatment of leachate discharge and pleasant view. These environmental values are frequently overlooked due to the unobservable price. In common practice, stakeholders identify the externalities of the project or policy and suggested mitigation measures without quantifying the value of environmental impacts. This practice does not estimate the external costs/benefits and results in the non-contribution of the net social costs/benefits of the project or policy. Focusing on the external benefits, the monetarization of the environmental values in this study will have implications for maximizing net social benefit, thus providing information that can be used routinely for a comprehensive policy or project decision-making.

The results are realistic, with the rise of environmental concerns among the public. There have been cases of opposition toward sustainably driven solid waste disposal facility projects due to environmental concerns [40]. It seems ironic for the public to oppose such projects, but implementing a new solid waste disposal concept, at least in developing countries, can lead to public fear regarding project failure and distrust issues [49–51]. The anxiety regarding project failure can become a threat and result in unwillingness to pay for the services offered. Hence, this study highlights the environmental values of the sanitary landfill, which is an improved condition from the status quo of local solid waste disposal. Public understanding of the external benefits offered by the sanitary landfill will elevate the willingness to pay in addition to the current fees for services offered [52].

However, there are concerns that the valuation results do not reflect real behavior. Moreover, environmental values are a subjective topic that not everyone fully understands [52]. Therefore, information on the agreement/disagreement regarding the sanitary landfill is substantial to solicit an answer as to why people disagree that is as close as possible to actual behavior. This will give ideas to the stakeholders for the initiatives that should be taken to improve public agreement [40].

4.2. Transferable Environmental Values

This study used transferable monetized environmental values among the populations in Kota Bharu and Bachok to ensure comparable values for paying communities as a proxy to propose the required additional solid waste disposal fee for the sanitary landfill implementation. From the BT results, the additional annual fee would be RM70.56 per household. With a biannual payment of RM35.28, it should not be burdensome for households to pay.

A sanitary landfill is a public solid waste disposal facility with non-excludability and non-rivalry characteristics, allowing all to enjoy the benefits of the sanitary landfill [46–48]. Therefore, the additional solid waste disposal fee should be a fixed flat rate across the households in Kota Bharu and Bachok. Moreover, a direct solid waste management fee is unavailable where the fee is absorbed into a local tax imposed based on the value of a residential property. Despite differences in the amount paid for the local tax across the households, the fixed payment mechanism for the sanitary landfill unveils the purpose of the additional fee charged. This is a prelude to a ‘pay as you throw’ policy, an efficient solid waste disposal charge imposed in developed countries. Currently, it is not yet suitable as a payment scheme in most developing countries due to unavailable information on the actual volume of solid waste generated by households [49].

4.3. Environmental Cost-Benefit Analysis

Environmental CBA in this study showed that the inclusion of environmental values for sanitary landfill projects has implications for project feasibility for the next 25 years. The practice of current crude dumping landfills shows an infeasible implementation for the next 25 years. These outcomes can minimize the doubt regarding project uncertainty since high expenditure on sanitary landfills has been the main cause of delayed projects. Moreover, will the public be willing to pay for an expensive solid waste disposal facility? The results showed that the public’s price on the sanitary landfill’s environmental values exceeds its high expenditure. The sanitary landfill promotes environmental protection, but it is a more economically feasible solid waste disposal option compared to the current disposal practice.

The engaging results of the environmental CBA showed the possibility of its use for actual sanitary landfill projects. The environmental CBA delineates a clear and well-described procedure so that the engaged stakeholders of the sanitary landfill project can follow the procedures with good understanding, to make the goals achievable and cost-effective. The elements in the environmental CBA should match the local demographic, which might necessitate an in-depth analysis of the costs and benefits.

With the price that the public put on the environmental values, sanitary landfill projects in developing countries can turn over a new leaf, despite the number of issues related to insufficient funds and lack enforcement of solid waste management policies [53]. Public readiness to pay for sanitary landfill projects is a big milestone, as the public are stakeholders, along with the government, local municipality, service providers, and other actors [49]. Their engagement to pay for the environmental benefits provided by the sanitary landfill is paralleled with a noticeable increase in the interest in proper solid waste management among households in a large number of developing countries [53]. Many are quickly embracing the principle of sustainable solid waste management, which does not always require high-end solutions; people can voluntarily participate in separating solid waste at the source, informally recycling solid waste and reusing bags for groceries [10,54,55]. The big picture already has supported the circularity of resources, which is a crucial element in the circular economy concept.

5. Conclusions

This study was inspired to seek feasibility for a sanitary landfill project by incorporating environmental values into project appraisal through a case study using three policy-relevant methods (non-market valuation, BT and CBA) in two districts in Peninsular Malaysia. The results show the inclusion of the environmental values in project appraisal increase the chances of implementing sanitary landfill. This shows the importance of quantifying in monetary terms the environmental benefits offered by sanitary landfills and then incorporating them efficiently into the decision-making process through cost and benefit comparisons.

This study provides examples for policymakers on using environmental values to compare the costs and benefits associated with a project. Private costs and benefits alone could not reflect the true social worth of the project, owing to the externalities involved, which can cause project undervaluation. This study captured the external benefits of the sanitary landfill in the project appraisal, which were taken into consideration for social benefit estimation and consequently increased the feasibility of the sanitary landfill project. This gives a new hope toward sustainable solid waste disposal in developing countries.

Solid waste management in most developing countries is largely focused on the improvement of solid waste collection and disregards the end cycle of solid waste by relying on disposal in improper landfills or open dumps. This has resulted in environmental degradation along with a lack of consideration of product lifecycle, which has circular economy opportunities. On the other hand, sanitary landfills offer environmental protection with efficient landfilling practice and give opportunities for circular economy practices with renewable energy sources, inducing solid waste transformation and recovery of materials after landfill closure. This offers developing countries a shift from the environmentally invasive practice of solid waste disposal toward a more sustainable approach. With the multiple benefits of sanitary landfills, the transition toward sustainable solid waste disposal in developing countries is necessary, but there are uncertainties and risks when replacing the existing solid waste disposal methods. Addressing these uncertainties requires an effective approach to gain a good understanding and address any potential threats during the implementation of the sanitary landfill project.

It is noteworthy to acknowledge the limitations of the approach used in this study. This study is useful to facilitate decisions on project feasibility when insufficient funds are an issue. It may not be necessary for countries when willingness to pay for solid waste disposal is already high. The environmental CBA focuses only on assessing the influence of external benefits toward project feasibility. Hence, the environmental CBA was adapted with basic elements of costs and benefits. It might exclude in-depth analysis of the marketable costs and benefits, for instance, economic indicators such as the inflation rate, GDP per capita, or bank loan interest rate.

For future research, along with in-depth analysis on the marketable elements in the environmental CBA, the scope of the study should not be limited to quantifying the external benefits of the sanitary landfill. The consideration of the external costs of the landfill will yield a comprehensive comparison between the environmental values. This will require a non-market valuation study for both positive and negative externalities. This will provide a comprehensive analysis prior to project implementation to give better insights into project feasibility.

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