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THE APPLICATION OF CHOICE MODELLING FOR A SANITARY LANDFILL IN KOTA BHARU, KELANTAN, MALAYSIA

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Abstract

Environmental impacts from poor landfilling practices have long been a concern in Kota Bharu, a densely populated city in Peninsular Malaysia. Addressing this issue requires a sustainable disposal solution, such as a sanitary landfill. However, such a project can fail without understanding household demand. This study examined households' willingness to pay for a sanitary landfill using a survey-based method known as Choice Modelling. This method was employed to determine households' willingness to pay for the environmental benefits of a sanitary landfill, characterized by attributes like controlled leachate discharge, reduced bad odour, reduced disease vectors, and pleasing views. The results indicated a positive willingness to pay for each attribute, ranging from RM2.37 to RM12.08 per month. This information aids policymakers in making decisions that align with household demands, thereby minimizing opposition and enhancing project feasibility.

Keywords: Non-Market Valuation, Choice Modelling, Sanitary Landfill, Solid Waste Disposal

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INTRODUCTION

The twentieth century saw a rapid increase in solid waste (SW) generation due to population growth and greater consumerism, particularly in developing countries experiencing unprecedented economic development (Yaacob, et. al, 2019; Bowan, et al., 2020). This has led to poor solid waste management (SWM), with infrequent SW collection and excessive demand for SW disposal, exacerbating environmental issues due to the inefficient disposal activities (Haron et al., 2023). Landfilling, the most common disposal method, often remains unattended, causing problems like gas emission, leachate discharge, and land use issues (Edwards et al., 2018; Martinez-Sanchez et al., 2017; Sahariah et al., 2015; Suandi, et. al, 2023). Sustainable SW disposal methods, such as sanitary landfills or incineration, and SW reduction approaches like recycling and composting are essential (Shekdar, 2009). Different nations have varying SW disposal schemes based on land availability, expertise, and financial capacity. Developed countries have optimal schemes for SW reduction, unlike developing countries where sustainable SW disposal is hindered by resource and capacity constraints (World Bank, 2012; Anik, et al., 2018). A holistic SW disposal facility with SW reduction technologies is often infeasible in developing countries, making sanitary landfills a more viable option (Rodic and Wilson, 2017). Gradual implementation, adapting to available resources, local SW composition, and creating public awareness are key (Subhasish, et al., 2019).

In Malaysia, over 90% of SW is landfilled (Kamaruddin, et al., 2017; Fauziah and Agamuthu, 2010). The reliance on landfilling for waste disposal leads to significant space constraints, health problems, and environmental issues (Shakil et al., 2023). There are 166 operating landfills, 92% of which lack a clear operational concept, often being mere "dump sites" (NSWMD, 2018; Kamaruddin, et al., 2017). The outdated SW disposal method struggles to accommodate the increasing SW generation rate, which grows by 18% every three years, necessitating the development of SWM policies (Zainu and Songip, 2017; NSWMD, 2018). The Solid Waste Management and Public Cleansing Act (Act 672) promotes sustainable SWM by implementing SW reduction strategies and advancing disposal methods. Post-enactment, 14 sanitary landfills, four incinerators, and the shutdown of 135 dump sites have been achieved (NSWMD, 2018). Despite Act 672's progress, only 8% of operating landfills are sanitary due to high construction and operational costs, ranging from RM128 million to RM198 million for 20 years. Public opposition to SW disposal facility projects, especially incinerators, further hinders implementation (Khee and Othman, 2011).

These challenges jeopardize SW disposal quality, resulting in poorly managed landfills and dump sites. Addressing these issues requires an approach to alleviate the situation. Non-market valuation, a technique to assess public willingness to pay (WTP) for goods or services, is increasingly used in SWM, especially in developing countries, to measure preferences for SWM from various aspects. Non-market valuation studies support the need to enhance the SWM scheme as evidenced by the increasing number of recent non-market valuation studies, including those by Huynth et al. (2023) and Rahman and Bohara (2022). Moreover, the non-market valuation studies are aligned with the need to improve the SWM scheme. Proposing a sanitary landfill to support sustainable SWM policy requires eliciting the value of the landfill's disposal service and its indirect environmental benefits. This involves WTP elicitation among households likely to benefit from the SW disposal service.

The Necessity of a Sanitary Landfill in Kota Bharu, Kelantan

The focus of this study was Kota Bharu, located in the northeast of Peninsula Malaysia. Undesirable impacts from solid waste (SW) disposal have long been a concern, necessitating the execution of a sanitary landfill. Since 1976, landfilling in Kota Bharu has harmed the environment and caused health hazards to nearby residents and SWM workers. The current Beris Lalang landfill has led to river and groundwater pollution and vector-borne diseases. Leachate from degraded SW mixes with rainwater, contaminating nearby rivers and groundwater. Landfilling also increases the breeding of disease vectors like flies and mosquitoes, spreading diseases such as Malaria, Dengue, and Leptospirosis (Nazri et al., 2012).

Efforts to implement basic sanitary landfill requirements have been discontinued due to financial constraints and a lack of expertise. The local authority, facing excessive SW generation and financial limitations, resorted to crude dumping methods. This has exacerbated environmental problems at Beris Lalang, jeopardizing public health. Given the financial constraints and lack of household demand data, the study aimed to investigate household preferences and their willingness to pay (WTP) for a sanitary landfill using a non-market valuation technique called Choice Modelling (CM). This survey-based method will gauge household demand for the environmental benefits offered by a sanitary landfill, focusing on attributes like leachate discharge, odour intensity, disease vectors, and aesthetics.

Understanding household WTP for improved environmental attributes will help policymakers design SWM policies that align with public preferences and support sustainable landfill projects. This information is crucial to avoid public discontent and potential project failure when implementing improved SW disposal policies in the future.

MATERIALS AND METHOD

Choice Modelling (CM) is a survey-based methodology by presenting the respondents with alternatives for a sanitary landfill. Each choice is a bundle of attributes differentiated by varying attribute levels. The respondents were asked to choose their most preferred alternative. By including a monetary feature in the form of an additional SWM fee as one of the attributes, WTP estimates could be obtained from the marginal value estimates from a probabilistic choice model for changes in attribute levels (Hanley et al., 2005).

CM relies for its theoretical basis on Lancaster's theory of value and random utility theory (RUT) characterising utility function into two parts of choice probability, namely observable component (V) and error term (ε), representing unobservable components on the choice of the respondent (Manski, 1977). This assumes the utility of an individual ***j*** for an option ***c*** depends on environmental attribute (**X**):

$$U_{jc} = V\left(X_{jc}\right) + \varepsilon\left(X_{jc}\right) = \beta X_{jc} + \varepsilon_{jc} \quad (1)$$

The chance that individual ***j*** will pick option ***c*** over option ***k*** is:

$$P(c|C) = \text{Prob}\left\{V_{jc} + \varepsilon_{jc} > V_{jk} + \varepsilon_{jk},\ all\, j \in C\right\} \quad (2)$$

Where **C** is the entire choice set. Approximation of Equation (2) needs assumption over the distribution of the error terms. The assumption is that the error terms are independently and identically distributed (IID), leading to the property of independence of irrelevant alternatives (IIA). According to the IIA, the likelihood of choosing between two alternatives remains unchanged regardless of the introduction or elimination of other options. This implies that the probability of choosing alternative ***c*** is given by:

$$\text{P}rob(c) = \frac{exp^{uv_c}}{\sum_{j\in C} exp^{uv_k}} \quad (3)$$

Where $V_c = V(X_c)$ is the indirect utility function, X_c is a vector of the attributes and ***u*** is a scale parameter which is inversely proportional to the standard deviation of the error distribution assumed to be equal to 1 (implying constant error variance). Equation (3) is estimated by means of a Multinomial Logit (MNL) regression with assumption that the choices must obey the rule of the IIA property which can be tested by using a procedure suggested by Hausman and McFadden (1984).

The most basic form of indirect utility function, V_c as in terms of Equation (1) is as follows:

$$V_c = ASC + \sum \beta_q Z_q \quad (4)$$

Where ***ASC*** is an alternative specific constant, ***β*** is a coefficient and ***Z*** are attributes in the choice set. ***ASC*** captures the unexplained effect of systematic variations of the choices of respondents, reflecting the differences in the error terms. It is possible to include other variables into the utility function by interacting with the variables either with the $\boldsymbol{ASC}$ or with any of the attributes of the choice set as follows:

$$V_c = ASC + \sum\gamma_l ASC * S_l + \sum\beta_q Z_q \quad (5)$$

Where $\boldsymbol{S_l}$ indicates the sociocultural variable for the $\boldsymbol{l}$th individual. The estimation of Equation (1) can be used for implicit prices estimation. Basically, implicit prices are the marginal rate of substitution between the coefficients of the environmental attributes, $\boldsymbol{\beta_x}$ and the coefficient of the monetary attribute, $\boldsymbol{\beta_m}$ as shown in Equation (6). The implicit price of an environmental attribute reveals the WTP of individuals for an additional unit of the attribute. Estimates of the implicit prices can be used for better comprehension of the monetary values of the attributes.

$$Implicit\ price = \frac{-\beta_x}{\beta_m} \quad (6)$$

Techniques in Choice Modelling

Table 1: Attributes and levels for a 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 discharged
Bad odour	Presence of bad odour due to disposed waste in the landfill	1: Strong *(Status Quo)* 2: Distinct 3: Weak 4: No odour
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: Non-pleasing *(Status Quo)* 2: Pleasing
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

CM is a questionnaire-based method with eight compulsory steps. First, a valuation scenario and welfare change criterion were defined to familiarize respondents with the good or service, ensuring their true WTP. The scenario included four aspects: landfill conditions (comparing Beris Lalang landfill with the proposed sanitary landfill), the need for additional payment, the payment method, and glossaries of attributes.

Next, in-depth literature reviews and focus groups identified relevant attributes. Two focus groups, including local authority officers and household representatives from Kota Bharu, identified three environmental attributes (leachate, bad odour, and disease vectors) to describe the sanitary landfill's benefits, along with levels indicating attribute improvement. The monetary attribute was an additional SWM fee currently included in the annual assessment payment.

In a subsequent session, the attribute identification and levels were revised. "Leachate" was simplified to "toxic liquid" for data collection purpose for easier comprehension among respondents. An additional environmental attribute, "view," was added, with specific levels defined. The final attributes included four environmental (leachate, bad odour, disease vectors, and view) and one monetary (additional fee) attributes. Higher attribute levels indicate better environmental problem mitigation, as shown in Table 1.

The third step was the experimental design and choice set construction. The experimental design created combinations of attributes with varying levels into alternatives for the sanitary landfill. These alternatives were assigned into choice set questions, each with three options: Alternative One (Sanitary Landfill), Alternative Two (Sanitary Landfill), and the Status Quo (Current Condition). The status quo represented the Beris Lalang landfill with "Level one" attributes: untreated leachate discharge, strong bad odour, uncontrolled disease vectors, non-pleasing view, and no additional SWM fee. The study used the standard L^{MN} design to generate 48 choice sets with varying attribute combinations. Table 2 provides an example of these choice set questions where respondents select their preferred alternative.

Table 2: An example of choice set questions

	30km from Kota Bharu	***50 km from Kota Bharu***	
	CURRENT LANDFILL	**SANITARY LANDFILL**	
		ALTERNATIVE 1	**ALTERNATIVE 2**
Leachate	Untreated discharge	Untreated discharge	Untreated discharge
Bad odour	Strong	Strong	Weak
Disease vectors	Uncontrolled	Controlled	Uncontrolled
View	Non-pleasing	Pleasing	Pleasing

	30km from Kota Bharu	***50 km from Kota Bharu***	
Additional fee	No payment	RM5 per month	RM5 per month
CHOICE			

Table 3: The variables for the models

Variable		**Definitions**
ASC_0	Alternative specific constant for status quo	1= Status quo *(Current landfill)* 0= Improved alternatives *(Sanitary landfill)*
ASC_1	Alternative specific constant for sanitary landfill	1= Improved alternatives *(Sanitary landfill)* 0= Status quo *(Current landfill*
DD_1	District Kota Bharu	1= Respondents from Kota Bharu 0= Respondents from Bachok
LC	Leachate discharge	1= Improved *(Half and fully treated)* 0= Status quo *(Untreated)*
OD	Intensity of bad odour	1= Improved *(No odour, weak and distinct)* 0 = Status quo *(Strong)*
DI	Propagation of disease vectors	1= Improved *(Controlled)* 0= Status quo *(Uncontrolled)*
VI	View	1= Improved *(Pleasant)* 0= Status quo *(Unpleasant)*
FEE	Additional fee for sanitary landfill	Monthly fee
INC	Household income (ratio data)	
FAM	Number of household members (ratio data)	
DIS	Distance from the current landfill	1= Above 20 km 0= Below or equal to 20 km
EMP	Employment	1= Employed 0= Unemployed
HOM	House ownership	1= Self-owned 0= Others
ALAND	Aware of problems in landfill	1= Aware 0= Unaware
APAY	Aware of SWM fee	1= Aware 0= Unaware

The fourth step involved designing the questionnaire, which included choice set questions, the valuation scenario, and questions on knowledge and socio-demographic background. A pre-test with 60 respondents assessed comprehension before the actual survey, which was conducted with 624 respondents. To avoid cognitive burden, each respondent answered only four choice set questions. The 48 choice sets were divided into four blocks, with each block containing 156 respondents. Each respondent in a block was presented with a specific set of four choice sets, ensuring coverage of all 48 sets across the sample.

Data from the questionnaire survey was used for descriptive analysis, modelling, and WTP estimations. The models measured respondents' preferences for the three SW disposal options: Alternative One (Sanitary Landfill), Alternative Two (Sanitary Landfill), and Current Condition (Status Quo). The models were estimated using MNL, with theoretical backgrounds explained in subsequent equations. WTP calculations were made in terms of implicit prices from the estimated models, considering socio-cultural factors. These calculations indicated the marginal rate of substitution (MRS) between each environmental attribute and the monetary attribute.

The Research Areas and Sampling

The research focused on Kota Bharu, the state capital of Kelantan with a population of 314,964, and the adjacent town of Bachok, which has one-third of Kota Bharu's population. These areas were selected because they both used the current "crude dumping" disposal site in Bachok, allowing the study to describe variations in household preferences for the projected sanitary landfill. The sanitary landfill served both areas and had a buffer zone from residential areas. The sampling followed the choice set blocking, with 624 respondents divided into four blocks, stratified by economic activities and population density. Each block had 156 respondents randomly selected from 12 pre-planned residential areas, using the rule of "every third house approached." This sample size was based on recommendations that a block should have at least 50 respondents and previous studies on SWM in Malaysia. Target respondents were household heads or family representatives aged over 18. The survey, conducted over two months, involved eight trained enumerators. They were trained to approach and assist respondents without bias and used diagrams of the current and proposed landfills to reduce respondents' cognitive load when answering CM questions.

RESULTS AND DISCUSSION

Table 4 shows the analysed data concerning the socio-demographic backgrounds of the respondents. The mean age of the respondents interviewed was 42 years old with a balanced gender composition. They were mostly self-employed, proving that they had a strong mercantile culture. Some 74 % of the respondents self-owned their house with an average household having five members. Majority of them live 20 kilometres away from the current landfill site. The mean household income was RM2674.07 which was below the state mean income.

Choice Modelling

The results from the CM revealed the demand of the households for the proposed sanitary landfill project in terms of their preferred environmental benefits of the sanitary landfill along with their WTP and what factors influenced their decisions. The results provided information in two ways, namely for the policy makers to make decisions that align with households' demand and to address triggering factors that caused an increase or decrease in WTP. For the purpose, the estimated models explained the preferences of the respondents for three different SW disposal options which were Alternative One for Sanitary Landfill, Alternative Two for Sanitary Landfill and the Current Condition (Status Quo).

Table 4: Socio demographic profile of the respondents

Variables		**Total respondents =624**	
		Mean	**%**
Age		42	
Gender	Male		46.6
	Female		53.4
House-ownership	Self-owned		74
	Rented		25
	Parents' house		1
Employment	Government/private sector		31.6
	Self-employed		38.1
	Not employed		30.4
Distance from landfill	Below 10km		10.4
	10km to 20 km		14.6
	Above 20 km		75
Household size		5	
Household income		RM 2674.07	

Table 5: The results of Multinomial Logit models

Variable	Basic MNL	MNL with socio-cultural factors
ASC_0	-0.690***	-9.5397***
	(0.121)	(2.1820)
ASC_1	-	-
ASC_1DD1	-	-
LC	0.382***	0.3810***
	(0.037)	(0.0369)
OD	0.274***	0.2912***
	(0.0314)	(0.0320)
DI	1.447***	1.4823***
	(0.072)	(0.0734)
VI	0.481***	0.4873***
	(0.064)	(0.0646
FEE	-0.116***	-0.1227***
	(0.012)	(0.0124)
ASC_0INC	-	-0.00083***
		(0.98D-04)
ASC_0FAM	-	0.1666***
		(0.0330)
ASC_0DIS	-	3.0860***
		(0.7039)
ASC_0EMP	-	-0.7634***
		(0.2649)
ASC_0HOM	-	0.3785**
		(0.1855)
ASC_0ALAND	-	0.7420***
		(0.1817)
ASC_0APAY	-	-0.01744
		(0.18932)
Log likelihood	-1868.390	-1739.246
Pseudo-R^2	0.16	0.22
Iterations completed	6	10
Observations	2496	2496

Note: MNL=Multinomial Logit
: Parentheses indicate the standard errors of the respective coefficients. *Significant at 10 % level ** Significant at 5 % level *** Significant at 1 % level.

Basic Multinomial Model

Column I in Table 5 displays the results for the model. The attributes encompass significant coefficients at the 1 % level with the expected signs. The environmental attributes had positive signs, depicting that improvements in these attributes might lead to positive utility among the respondents. The coefficient value for ***DI*** was the highest in comparison to the coefficients of the other environmental attributes (***LC***, ***OD***, ***VI***). This implies the most demanded environmental benefits of sanitary landfill by the respondents are controlled propagation of the disease vector. Meanwhile, the monetary attribute, ***FEE*** had a negative sign, suggesting a decline in utility as the additional fee was raised for sanitary landfill.

The Hausman and McFadden test showed that this model estimation violated the IIA assumptions at the 1 % level indicating a biased estimation. This may be explained from the literature, whereby the inconsistency of the MNL model with respect to the IIA is a frequent outcome in CM due to situations where some alternatives are qualitatively like others or there are heterogeneous preferences among the respondents (Mogas, et al., 2006; Jamal, et al., 2004; Hanley, et al., 2002).

Extended Multinomial Models

Column II in Table 5 shows the results of the extended MNL model with socio-cultural factors. All the environmental attributes and socio-cultural interacted variables were significant except for ASC_0****APAY*** in explaining the choices of the respondents. The Hausman and McFadden test also showed IIA violation from this model estimation at the 1 % level, similar to the basic MNL model.

The environmental attributes have positive signs depicting demand for improvements in these attributes. The results of the socio-cultural interacted variables showed that the respondents with lower income, larger household size, a greater distance from the landfill site, unemployment, homeowners and familiar with the problems in the landfill tended to choose the status quo. This draws attention to the fact that when there is house ownership and familiarity about landfill problems, this leads to the tendency to opt for the status quo. Perhaps, the fact that they actually have to pay an additional amount in the annual assessment for the sanitary landfill discourages them to opt for sanitary landfill alternatives. In addition, familiarity makes an individual more cautious due to their anticipation of the effectiveness of the sanitary landfill.

Implicit Prices

The estimations of implicit prices from the extended MNL with socio-cultural factors is as shown in Table 6. The implicit prices in the model did not differ significantly which was consistent with the outcomes observed by Jamal (2007) who noted the little effect on the estimates of implicit prices due to heterogeneity of preference among respondents. The implicit price for the disease vector was significantly higher with RM12.08. This result suggested that when the propagation of disease vectors was controlled through provisions in the sanitary landfill (e.g., provision of cover soil mitigates breeding of rats, flies and mosquitoes), the households would be made better-off by RM12.08. This result was also significantly higher compared to previous SWM evaluations in Malaysia (Khee and Jamal, 2011 and Jamal, 2007). However, a high implicit price placed for controlling the disease vector was not surprising since it matched the situation where landfilling activities in Beris Lalang landfill has escalated the breeding of vectors, thus risking disease dispersion among landfill workers and the nearby households.

Table 6: Implicit prices in MNL model with socio-cultural factors

Attribute	**MNL with socio-cultural factors (RM per month)**
LC	RM3.11
OD	RM2.37
DI	RM12.08
VI	RM3.97

Note: MNL=Multinomial Logit, LC=leachate, OD=bad odour, DI=disease vector, VI=View

CONCLUSIONS

This study has implemented a non-market valuation technique, CM to gather demand side information for a circumstance of improving SW disposal into a sanitary landfill. The economic value of the sanitary landfill was described by the environmental attributes of leachate discharge, intensity of bad odour, vector-borne diseases and the view. A monetary attribute, additional SWM fee was included for welfare estimation for the improvement of given environmental attributes. This study was carried out on 624 households representing households that would benefit from the SW disposal service. The SWM fee (including SW disposal fee) would be paid through a yearly annual assessment payment to the local authority. The WTP for the sanitary landfill would be an increase in SWM fee described on a monthly basis.

The outcomes of the study indicate a positive WTP for improvement of leachate discharge, intensity of bad odour and the view ranging from RM2.37 monthly to RM3.97 monthly. The attribute for vector-borne disease has a high outcome of WTP (RM12.08 monthly) surpassing the WTP results for non-monetary attributes in other relatable SWM studies in Malaysia.

This study aimed to assist SWM policymakers in reducing the inequality of SW disposal across Malaysia, addressing financial disparities among state governments. While fast-developing states have adopted sanitary landfills, this study provides insights into household demand for improved SW disposal in the northeastern state of Kelantan. The implicit prices for the sanitary landfill are comparable to those in other states, indicating a consistent WTP for improved facilities nationwide. Effective policy implementation requires public, state, and federal commitment.

A sanitary landfill includes provisions like daily cover soil, bunds, drainage, and leachate treatment systems to minimize environmental and health impacts. The study highlighted household demand for minimizing disease vector problems, emphasizing the need for daily cover soil to prevent vector propagation (e.g., rats, mosquitoes, and flies). According to the Ministry of Housing and Local Government guidelines, a Level 2 sanitary landfill requires sufficient cover soil to alleviate this issue.

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