Environment, Development and Sustainability (2023) 25:12395–12417
https://doi.org/10.1007/s10668-022-02572-4

Solid waste management program in developing countries: contingent valuation methodology versus choice experiment

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Received: 21 September 2021 / Accepted: 11 July 2022 / Published online: 4 August 2022

Abstract

The willingness to pay by households in Vietnam to improve collection and processing services linked to source-separated municipal solid waste (MSW) is investigated in this research. This study contributes to the current literature by comparing welfare benefits derived from contingent valuation methodology and choice experiments for changes to waste service provision. The respondents were also stratified, for the first time, into households with/without previously sorted waste and across urbanization grades. Our results return broadly consistent willingness to pay estimates across the two methodologies and offers evidence that MSW sustainable management—a priority need in developing countries—may be addressed by positively enticing residents into a new fee-for-service program, but only where social benefits from such engagement are made clear. Interestingly, residents in lower urbanization grades, and those who have not previously sorted waste, reveal higher WTP values. Our results suggest that respondents are most interested in a wider selection of separated material options (i.e., recycled, organic and residual) as well as the potential for CO_2 emission reductions associated with new waste management programs. We argue that the application of both stated preference techniques widens the set of policy input factors available to government officials and ensures useful evidence for structuring future engagement programs to address those who retain a preference for the status quo.

Keywords Disposal · Mekong river delta · Source separation · Strategic actions · Willingness to pay

1 Introduction

Governments worldwide are grappling with solid waste management, particularly in rapidly developing countries like Vietnam. Unsuccessful waste management is associated with negative environmental impacts including greenhouse gas emissions, land and water

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contamination, odor, landscape deterioration and noise, and human health concerns such as fire hazard and disease (Ghanbari et al., 2012). Effective waste management could reduce these negative impacts, but it would most likely come at a high cost to society for improved infrastructure, modern collection/sorting systems, and increased public awareness campaigns. Developing countries may struggle to afford these increased costs, limiting their range of policy alternatives. However, if the public is willing/able to pay for improved municipal solid waste (MSW) management the revenue may enable investments to avoid amenity losses, human health risks, etc. (Pearce & Howarth, 2000).

Reconciling the needs of waste producers with those of the waste managers is critical for achieving policy objectives. To that end, stated preference techniques play an important role in estimating both the willingness to pay (WTP) for a change to an environmental state and key attributes for successful waste management policies (Ko et al., 2020). Waste management services are frequently under- or non-priced, making it challenging to obtain economic benefit estimates from market prices (Anaman & Jair, 2000). Further, social preferences for waste services are not homogenous across individuals and therefore policymakers need to adopt targeted instruments with appropriate incentives based on evidence (Massarutto et al., 2019). These characteristics also support the selection and application of stated preference techniques—making them quite common, as detailed below. Stated preference techniques also enable the benefit transfer of WTP estimates beyond original study sites (Hanley et al., 1998a). This can be important for developing countries if budget/time constraints make repeated valuation surveys at sites of interest impractical (Damigos et al., 2016), and where a high level of precision may not be required (Rosenberger & Loomis, 2001).

Household preferences for waste scheme management have been researched widely via elicitation approaches such as choice experiments (Lee et. al, 2017) and contingent valuation methods in developed contexts (Kipperberg & Larson, 2012). Yet studies of stated preferences for waste management in developing countries remain limited (Ko et al., 2020). This is despite a recognition of the need for this work nearly two decades ago, especially via preference choice sets to identify the attributes of effective waste management systems (Jin et al., 2006a, 2006b), and applications of discrete choice experiments aimed at identifying the value provided by waste-sorting services (Nainggolan et al., 2019a; b). This motivates our study of waste management preferences using both contingent valuation methods (CVM) and choice experiment (CE) techniques to examine individual (private) drivers of willingness to pay for a specific change to the environmental state, as well as the key (public) policy attributes that might incentivize wider adoption by less-supportive individuals in the Mekong River Delta region of Vietnam as a case study.

2 Study site background

The Mekong River Delta (MRD) has experienced a significant economic expansion in recent years which has increased solid waste output. Migratory movement from rural to urban regions between 2009 and 2018 was caused by low and unstable regional earnings. Climate change has impacted rice and other production in rural areas of the MRD, while the rapid development of industry and services in urban areas of the six major MRD provinces/cities has created an imbalance in regional income distribution. Rapid population expansion has depleted natural resources such as water, electricity, and raw materials to fulfill production and consumption demands; negatively impacting the environment. As a result, the amount of MSW created in metropolitan areas is rapidly increasing.

MSW from urban areas accounts for more than half of all waste generated in Vietnam, growing from 32,000 tons per day in 2014 to 37,000 tons per day in 2019 (Ministry of Natural Resources & Environment of Vietnam, 2016, 2020). In 2020, the total daily volume of solid waste created in MRD regions was around 14,000 tons. By contrast, the volume of solid waste collected by government services each day is 9800 tons or roughly 70% of the volume created (Ministry of Natural Resources & Environment of Vietnam, 2020). Therefore, waste service infrastructure, financial investment, and human resources in the MRD region have not kept pace with output growth. Further, in many MRD districts waste collection, transportation, and treatment operations are disconnected from one another, particularly at the municipal level where public/private interaction is highest. Poor implementation of waste services is also driving environmental and public health issues. In recent years environmental deterioration, particularly in landfills, has been a significant source of concern. A program to improve municipal solid waste (MSW) collection and treatment is therefore critical.

An issue is the public cost of such change, and limited privately provided revenues. The present monthly rate for current MSW collection and treatment services of around US$0.86 per household is substantially lower than the service operating costs (Ministry of Natural Resources & Environment of Vietnam, 2020), limiting government investment unless private individuals are willing to pay more for the service in future. Increased pressure on government policy-makers to identify an appropriate MSW management solution has come from a recent *National Strategy on Integrated Solid Waste Management: 2025–2050* approved by the Vietnamese Prime Minister in Decision No. 2149/QD-TTg. The strategy sets specific objectives that, by 2025, 90% of all urban solid waste will be collected and treated according to national standards with 85% of all MSW to be recycled, reused, energy-recovered, or converted to organic fertilizer. This objective necessitates the implementation of a more sophisticated waste management system with different integrated solutions in the MRD. A focus of that change is the source separation of waste materials.

Source separation is the segregation of different types of solid waste (organics, plastics, paper, non-recyclables) at the location where they are generated (household or business). The number and types of categories into which wastes are divided usually depend on the collection system used and their final destination/use (Moh, 2017). Advantages of source separation include (World Bank, 2018):

(i) Economic: organic and recycled waste components in Vietnam account for about 60–65% and 22–26% of solid waste, respectively. Organic components in residential solid waste can be used to supply raw materials for fertilizer products in conjunction with the source separation of materials (e.g., composting bins or separate green waste collection). Recyclable components such as plastic, glass, nylon, metal, and rubber can also be removed at source to save money on incinerator operation costs while also increasing total landfill space for residential solid waste.

(ii) Environmental: lowering the volume of organic and harmful materials (e.g., oils, paints, and chemicals) through source separation reduces negative environmental effects such as smells, leachate, and soil, groundwater or surface water contamination.

(iii) Social: Solid waste source separation also raises public awareness about environmental conservation. Increased awareness, and the development of positive environmental habits, can lead to increased social benefits.

In order to successfully accomplish a source separation initiative, private households must be incentivized to change their behavior (i.e., separate waste materials) and contribute to public waste service funding so that the government can update their equipment, processes, and employee skills. As a result, we are interested in knowing what factors will encourage behavioral change in the separation of waste, and if households would be willing to cover the additional costs of upgraded services where the fee paid in the future will obviously be higher than current fees, and especially in the case of a developing country where this study will provide a useful base to compare with other developing contexts (Padilla & Trujillo, 2018).

Both the requirement for increased revenue in support of changes to MSW management in the MRD and the complex set of treatment criteria established under the new national strategy link well with our adoption of stated preference techniques. Further, it is highly likely that there will be a diverse set of preferences spread across the population spanning high acceptance of the need for environmental change to those who prefer the status quo. Identifying these different groups and their potential drivers is a key advantage of stated preference techniques. Finally, recent reductions in oil prices highlight volatility in waste recycling markets and a need for governments to be prepared to invest locally to address future instability (Ko et al., 2020). Our study of MSW using stated preference techniques is therefore timely given a narrow focus on these issues in developing countries since 2006. In support of that view, we begin with a review of the relevant literature in this field.

3 Literature review

As stated above, solid waste management preferences are hard to assess since they often have no market value and must be estimated using non-market valuation approaches. A willingness to pay (WTP) for additional services that may change an environmental state is the underlying premise of these approaches (Bateman et al., 2002). Optimal waste management systems ensure that society gains net maximum benefits from proper disposal (Garrod & Willis, 1998), and stated preference techniques are commonly used to elicit people's WTP to establish those economic benefits (Jin et al., 2006a, 2006b). The two most commonly applied techniques in the MSW literature are contingent valuation methods (CVM) and choice experiments (CE). These techniques share a common random utility theory basis allowing for direct comparison (i.e., the bid values) and are based on an assumption that peoples' behavior in a hypothetical market can indicate their genuine intentions for environmental products (Hanley et al., 1998b), even with very little data (Diafas, 2016).

Both Damigos et al. (2016) and Ko et al. (2020) provide helpful summaries of applications of CVM and CE techniques in the study of solid waste management. Both summaries indicate that CVM techniques (see Aadland & Caplan, 2006; Yusuf et al., 2007; Gillespie & Bennett, 2013; Ferreira & Maques, 2015; Maimoun et al., 2016) are more commonly applied over CE—mainly due to the complexities associated with CE design and implementation. However, despite these issues, many studies employ CM to determine the MSW program characteristics for which people are willing to pay (see Othman, 2007; Adeoti & Obidi, 2010; Czajkowski et al., 2013; Yuan & Yabe, 2015; Fukuda et al., 2018; Tarfasa & Brouwer, 2018). In a seminal study, Adamowicz et al. (1998) show that CE techniques may be beneficial over CVM in some contexts where they completely explain the tradeoffs between attribute qualities. CE techniques can also be used to eliminate bias and other issues that might arise in surveys that include only "agree" or "disagree" questions (Ready et al., 1996). Specific to MSW contexts, the capacity for CE to identify key attributes of MSW programs that appeal to people is a necessary foundation for suggesting legislation or program reforms to improve the efficacy of waste management services (Pearce et al., 2006).

By contrast, CVM surveys focus on recognizing the gains or losses from an environmental change using a limited set of commodity features (Diamond & Hausman, 1994; Stevens et al., 2000) where it may be appropriate to use an open-ended WTP question format. Where multiple attributes are connected to an environmental change, applications of CVM may be inappropriate (Jin et al., 2018). Further, in developing contexts where market distortions complicate shadow pricing exercises (Arrow, 2001), and literacy rates are low, personal interviews using CVM approaches may provide a more appropriate elicitation method (Johnston et al., 2017). Recognizing the pros and cons of these techniques this study employs both CVM and CE approaches to (i) assess MRD household willingness to pay for improved solid waste management programs to reduce the government's total financial burden in the Mekong Delta and (ii) identify key policy attributes that will inform future MSW policy design and implementation to increase engagement across a wider sample of the MRD population. These are useful contributions in this growing literature, where we will also compare estimated welfare differences—as suggested by Boxall et al. (1996)—as important possible drivers of differences between the two modeled results.

There has been an increase in the number of studies using the CE method to evaluate various attributes of sorted-waste management programs (Das et al., 2008). Some studies, such as Othman (2002), Jin et al., (2006a, 2006b), and Karousakis and Birol (2008) have used CE methods to evaluate solid waste management programs. However, it is necessary to clearly define the attributes of the waste management program being studied. Past studies have often focused on the attributes associated with the phases of a waste management system including: (i) monetary attributes or the fee that people pay for the improvement of the quality of services (Fukuda et al., 2018; Karousakis & Birol, 2008; Othman, 2007; Sakata, 2007; Tarfasa & Brouwer, 2018); (ii) the amount people may receive for contributing to an improvement in the quality of solid waste management services (Yuan & Yabe, 2015); (iii) waste collection periods (; Fukuda et al., 2018; Karousakis & Birol, 2008; Yuan & Yabe, 2015); (iv) the availability of equipment to support waste classification (Fukuda et al., 2018; Tarfasa & Brouwer, 2018; Yuan & Yabe, 2015) or final waste treatment (Fukuda et al., 2018; Othman, 2007); and/or (v) improved recycling methods as an incentive to change behavior (Sakata, 2007). However, in developing countries, the number of solid waste classification types is often lower than that of studies conducted in developed countries where solid waste might be classified into one of five (Czajkowski et al., 2014a, 2014b) or as many as 11 categories (Sakata, 2007).

Therefore, when designing a CE survey the key attributes and levels must be carefully identified and examined (Pearce et al., 2006) with the number of attributes proportional to the number of observations in the study (Bateman et al., 2002); that is, the larger the number of observations, the greater the number of attributes that can be included. However, to avoid complex choice sets for respondents, the number of attributes should be limited to no more than four or five attributes (Pearce et al., 2000; Hanley et al., 2002). Willis and Garrod (1999) argue that solid waste management strategies should address public concerns about sustainable use of resources as well as reduce the amount of solid waste that needs to be disposed of in landfills. This suggests four attributes related to a household's MSW reduction program: reducing the amount of solid waste that needs to be treated, reducing the amount of CO2 emitted from solid waste treatment, the number of types of solid waste classified, and the monthly fee for MSW management.

Further, while contemplating environmental action, psychological considerations should also be taken into account. This broad term refers to an individual's personality and perceptual qualities as they relate to their behavior. Intrinsic incentives to engage in change such as behavioral gratification (De Young, 1986) and threats to welfare from environmental problems (Baldassare & Katz, 1992) are examples. A study should also consider any contextual factors, personal capacities, attitudinal factors, and habitual factors (Soderholm, 2013) as key elements that influence environmental behavior. Finally, drivers of individual attitudes and motives for change could stem from technical-organizational circumstances (external factors), socio-demographic factors (e.g., age, gender, income), and socio-psychological variables (Miafodzyeva & Brandt, 2013).

4 Research methodology

4.1 Survey instrument design

For both the CVM and CE survey instruments our design process began with a thorough scan of the available literature, and initial discussions/focus groups with both waste management experts and local resident groups. This information was then used to establish requisite framing information to be added into each survey, as well as final attribute and payment card details. In each case, the penultimate survey designs were pretested with 20 randomly selected households to calibrate the validity of the format, comprehension of the information included, and the effectiveness of any bias management tools employed.

In the final iteration of the CVM survey, respondents were first introduced to the proposed MSW program and told that it would aim to reduce landfill solid waste by supporting management methods such as waste avoidance and reduction (e.g., recycling, reusing), where some further detail about how this would work in practice via source separation was also offered. A cheap talk script as an *ex-ante* bias correction was also shown to the respondents to remind them to consider budget constraints and state an amount as if the payment was real. The respondent was then asked if they would be willing to pay for the proposed program using closed-ended questions comprising five possible monthly payment bid values: VND20,000, VD50,000, VND80,000, VND110,000, and VND130,000 (which were equivalent to US$[1]0.87/month, US$2.18/month, US$3.49/month, US$4.81/month, and US$5.68/month). The close-ended question format was chosen because of its significant benefits over other forms. In fact, this type of question is much easier for respondents to answer as they can focus on the question rather than the framing issues (Whitehead, 2006). These bid values were based on additional discussions with local waste managers and public officials from urban joint-stock companies as the local authority managing waste in every province in Vietnam, and reflect the range of expected low and high-cost changes. Finally, respondents were asked to provide some social demographic characteristics and their perceptions and benefits of MSW programs. The commonly used model to estimate utility functions in CVM method is the Logit model. This model is based on limited assumptions and is popular due to the simplicity of estimations.

By contrast, the CE survey instrument included more detail about the proposed program attributes and how changes to the environment might alter under different levels of

[1] US$1 was equal to 22,890 Vietnamese Dong (VND) on June 30th, 2021.

Table 1 Description of different version options in the CE questionnaire

Categories	Option A	Option B	Option C
Rate of MSW being recycled	Reduced 10% 	Reduce 5% 	**Do not** choose both A and B (Status quo)
The rate of CO_2 emissions is reduced	Reduced 15% 	Reduce 15% 	
Number of types of classified MSW	Recycling and remaining 	Non-classified 	
Fees for solid waste management service	US$0.87/month	US$2.18/month	
Please **tick only 1** of the 3 options	☐	☐	☐

those attributes. When designing a CE survey both the key attributes and their relevant levels must be carefully developed and tested (Pearce et al., 2006). The total number of attributes that can be taken into account is proportional to the number of study observations (Bateman et al., 2002); that is, the more data gathered, the higher the number of attributes that can be included. However, to avoid complicated choice sets for respondents the number of attributes should be limited (Hanley et al., 2002)—typically to six attributes/levels at most, inclusive of the payment option. Based on the discussions and focus groups outlined above we settled on four attributes for the study (with levels in parentheses):

1. The percentage of solid waste recycled (0%, 5%, 10% and 15%) through the new program
2. The rate of CO_2 emission reductions (0%, 5%, 10% and 15%) achieved
3. The number of MSW separation classes on offer (unsorted, recycled + residual, or recycled + organic + residual) through provided bins, and
4. The monthly fee for MSW management service (US$0.86/month, US$2.14/month, US$3.43/month, US$4.71/month, and US$5.57/month).

Consistent with the literature, when investigating households' preferences for waste separation these four attributes may differ according to specific local conditions (e.g., payment fee and the number of MSW sorting classes) (Czajkowski et al., 2014a, 2014b). These attributes have been widely, and successfully, used in different contexts. Therefore, their application for waste sorting in this study is deemed appropriate. Naturally though, the attribute levels employed by our study differ from those of others to accommodate local MRD household preferences for emission rate reductions, levels of waste recycled, and sorted-waste classifications based on our pilot program data (i.e., consistent with the government-provided bin classes).

Following the pretesting phase, an orthogonal combination approach was used to create 25 alternative survey versions using the four attributes/levels detailed above. These options were then incorporated into five final different survey versions (see Table 1 for an example choice set), and each household was provided with one of those five survey

Table 2 The proportion of willingness to pay for improved MSW management services

Bid (US$/month)	Total of observations	Willing to pay		Unwilling to pay	
		No. of respondents	Proportion (%)	No. of respondents	Proportion (%)
0.87	78	74	94.87	4	5.12
2.18	76	59	77.63	17	22.36
3.49	72	47	65.27	25	34.72
4.81	78	42	53.84	36	46.15
5.68	76	30	39.47	46	60.52
Total	380	252	66.31	128	33.68

Source: Survey data, 2020

versions. Each package corresponded to a set of choices, and each question had three options. Option A and option B were hypothetical solid waste management service quality improvement plans defined by the four criteria above, with varying levels the attributes. Option C was the status quo option, where an individual saw no need to increase the current MSW management service quality.

4.2 Data collection

Once finalized, the two survey instruments were implemented among a stratified sample of the population. Following Jin et al. (2018) and Contu and Mourato (2020) we administered both surveys to each household. This was done so that we could compare welfare estimates, contribute to the ongoing examination of comparability between the two approaches in the literature (see for example Lehtonen et al., 2003), and highlight better how each can inform program or policy decision-making processes in developing contexts (Boxall et al., 1996). In order to avoid bias when presented to respondents with CVM and CE on the same day, each scenario was carefully explained to the respondents (Boxall et al., 1996).

The final data (380 observations) for our study were gathered by conducting direct interviews with local residents in three of the biggest MRD cities: Can Tho (urban grade 1–146 responses), Long Xuyen (urban grade 2–120 responses), and Ca Mau (urban grade 3–114 responses). According to the Ministry of Natural Resources and Environment of Vietnam (2016), urbanization is a critical reason for sharp recent solid waste increases; but where differing levels of urbanization will drive different sources of waste and separation requirements. Thus, in urban settings within developing countries, the use of stratified samples is common (see for example Chaudhry et al., 2007) and, for our purposes, useful as the results of this study may in future be applied to the rest of the Mekong River Delta region.

4.3 Data analysis

The CVM survey instrument used in this study is based on random utility theory as detailed by Luce (1959) and McFadden, 1974), which states that the indirect utility function as a vector of a households' use of a resource (V) follows the form:

$$V(p,\ q_i, M, \varepsilon) \tag{1}$$

where p is the price vector, q is the number of goods, M is income, and ε is a random error. For simplicity, we can remove the price vector from the indirect utility function and assume that any change in an environmental good will be at the expense of a households' capacity to perform MSW source separation. Accordingly, when classifying and separating their MSW, the utility of a household will be:

$$V(q_0,\ M + t_k, \varepsilon) \geq V(q_0,\ M, \varepsilon) \tag{2}$$

In the CVM scenario, the bid or cost of the program arose from our earlier discussions with experts and residents. The probability that a household chooses to answer "Yes" with the *bid* t_k is:

$$\Pr[\text{Yes}] = \Pr[V(q_0,\ M + t_k, \varepsilon_1) \geq V(q_0,\ M, \varepsilon_0)] \tag{3}$$

$$\text{If we assume that the utility function is linear}: v\left(q_i,\ M\right) + \varepsilon_i, \tag{4}$$

then it is possible to write the probability formula (3) for the option "Yes" as:

$$\Pr[\text{Yes}] = \Pr[v\left(q_0,\ M + t_k,\right) - v\left(q_0,\ M\right) + \varepsilon_1 - \varepsilon_0 \geq 0]. \tag{5}$$

The household will select "Yes" when the total utility changes, $\Delta U = v(q_0,\ M + t_k,)$—$v(q_0,\ M)$, and the difference in error, $\eta = \varepsilon_1 - \varepsilon_0$, is greater than 0. The subsequent probability is:

$$\Pr[\text{Yes}] = \Pr[\eta \geq -\Delta U]. \tag{6}$$

Based on the theory of probability, we have:

$$\Pr[\text{Yes}] = \Pr[\eta \geq -\Delta U] = 1 - F_\eta(-\Delta U), \tag{7}$$

where F_η is the cumulative density function (CDF) of η. If $F(x)$ has a symmetrical distribution then $F(x) = 1$—$F(-x)$. If we assume that η has a symmetrical distribution we can write:

$$\Pr[\text{Yes}] = F_\eta(\Delta U). \tag{8}$$

Based on probability theory, the maximum likelihood estimation approach was employed to determine the cumulative density function (CDF) and then the values of the corresponding coefficients. A parametric method is employed to estimate willingness to pay mean and median based on the coefficient of bid and other variables related to attitudes and other households' socioeconomic characteristics. This research used the Logit model, which is one of the approaches commonly used to estimate the cumulative density function when the random error has a normal distribution, to estimate the coefficients of these variables. The Logit model is presented as follows:

$$P_i = F\left(x_i'\beta\right) = \frac{e^{x_i'\beta}}{1 + e^{x_i'\beta}} \quad (9)$$

$$\text{where } x_i'\beta = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 d_1 + \beta_4 x_3 + \beta_5 d_2 + \beta_6 d_3 + \beta_7 d_4 + \beta_8 d_5 \quad (10)$$

The dependent variable (Y) is the probability of agreeing to pay for the increased MSW management service fee. This variable holds two values: $Y=1$ if the respondent agrees to pay, and $Y=0$ if the respondent does not agree to pay. The independent variables include the bid (X1), which is the monthly fee per household for increased MSW management services. These fees are suggested based on rates for unsubsidized MSW services from the government and local experts. The variable age (X2) is the respondent's age (in years). The variable male (D_1) is a dummy variable that holds two values: $D_1=1$ if the respondent's gender is male, and $D_1=0$ if the respondent's gender is female. Edu (X3) is the respondent's years in school (in years). It is expected that respondents with higher educational attainment tend to understand the benefits of increased MSW management services and the environmental harm from solid waste. Therefore, they may tend to pay higher for any program changes. Income D_2 (dummy variable) holds two values: $D_2=1$, if the respondent's monthly income is US$385.44 or more (this is the level of a deduction for taxpayers based on Law No. 26/2012/QH13 issued by the National Assembly of the Socialist Republic of Vietnam on November 22, 2012), and $D_2=0$ when lower than US$385.44. In this case, the demand theory for environmental goods assumes that the higher the income, the better the demand for environmental quality (Lewis & Tietenberg, 2019). The non-classified variable (D_3—dummy variable) takes two values: $D_3=1$, if the respondent does not recycle the MSW by classifying it, and $D_3=0$ otherwise. Finally, we also classify by type of urban setting, which differs with respect to population size and density, rates of non-agricultural labor, and architectural or infrastructure amenities (where type 1 > type 2 > type 3). The variable Urbantype2 (D_4—dummy variable) again takes two values: $D_4=1$, if the respondent is in urban city type 2, and $D_4=0$, if otherwise. Finally, Urbantype3 (D_5—dummy variable) has two values: $D_5=1$, if the respondent is in urban city type 3, and $D_5=0$ if otherwise.

The CE approach is based on the multi-criteria utility theory of Lancaster (1966) combined with the random utility theory of Thurstone (1927). Random utility theory states that an individual consumer's utility consists of observable and unobservable parts. The observable (measurable) portion of an individual's utility is based on their evaluation of the product attributes. The unobservable portion is random and depends on the individual's preferences. The utility function of an individual i when consuming product j is:

$$U_{ij} = V_{ij} + e_{ij} = V\left(Z_{ij}, S_i\right) + e\left(Z_{ij}, S_i\right) \quad (11)$$

where V is the observable part. V_{ij} is a vector of the degree of the attributes Z of product j together with the economic, social, and attitudinal characteristics (S) of respondent i, e is the unobservable part. Faced with a choice set consisting of many different products with different attributes, consumers will choose the product that gives them the maximum utility (max U). The probability that individual i chooses product j over any other product m corresponds to the likelihood that $U_j > U_m$. Specifically, the probability of choosing product j of individual i (P_{ij}) will be:

$$P(i) = P\left(U_{ij} > U_{im}\right) = P\left(V_{ij} + e_{ij} > V_{im} + e_{im}\right); \forall m \in C \quad (12)$$

Assuming that the random component e_{ij} follows *a* homogeneous, independent and identical distribution (IID), akin to a Gumbell or Weibull distribution, the probability that alternative j is selected is estimated using a multinomial logit (MNL) model as follows:

$$P(y_i = j|C) = \frac{\exp(Z'_{ij}\beta + S'_i\delta)}{\sum_{m\in C}\exp(Z'_{im}\beta + S'_i\delta)} \tag{13}$$

This study employed a Hausman and McFadden (1984) test to check whether the IIA property is violated. If the IIA property is violated, the random parameter logit (RPL) is then applied. The random utility function in the RPL model is as follows:

$$U_{ij} = V_{ij} + e_{ij} = Z'_{ij}\beta + S'_i\delta + Z'_{ij}\varphi_i + e_{ij} \tag{14}$$

where v is the deterministic component of the latent utility, e is the error component stochastic term, $\beta + \varphi_i$ is the population mean, and $\varphi_i \sim N(0, \mu_i)$ is the stochastic deviation that represents the individual's preferences relative to the average preferences in the population. Considering unconditional heterogeneity in preferences across respondents, and conditional on the unobservable φ_i (Birol et al., 2006), Eq. (13) now changes as follows:

$$P(y_i = j|C)\varphi_i = \frac{\exp(Z'_{ij}\beta + S'_i\delta + Z'_{ij}\varphi_i)}{\sum_{m\in C}\exp(Z'_{im}\beta + S'_i\delta + Z'_{ij}\varphi_i)} \tag{15}$$

The stochastic portion of the utility in this model may be correlated among alternatives and across the sequence of choices through the effect of φ_i because of an unrestricted IIA assumption. The requirement of treating preference parameters as random variables is the estimation of the simulated maximum likelihood. Procedurally, the maximum likelihood algorithm searches for a solution by simulating n draws from distributions with given means and standard deviations. The probabilities are estimated by integrating the joint simulated distribution.

The linear equation of utility for the choice of the jth product is written as:

$$V_{ij} = ASC + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \cdots + \beta_k Z_k \tag{16}$$

where k is the order of the product attributes. The coefficient β can be negative or positive, different for each product attribute, and is "valued" according to the subjective preferences of each individual. The coefficient β will vary between groups of individuals in a population but be the same for individuals in the same group. Although there are many ways to remove the mismatch from the choices and improve the model fit, this research uses the MNL model to reduce the error and give the most accurate results.

Based on formula (16), the utility function of choice A, B, and C in each set of questions can be presentedmonetary attribute and
as follows:

$$\text{OptionA}V_1 = ASC + \beta_1 fee + \beta_2 waste + \beta_3 co2 + \beta_4 sep2 + \beta_5 sep3$$

$$\text{OptionB}V_2 = ASC + \beta_1 fee + \beta_2 waste + \beta_3 co2 + \beta_4 sep2 + \beta_5 sep3$$

$$\text{OptionC}V_3 = \beta_1 fee + \beta_2 waste + \beta_3 co2 + \beta_4 sep2 + \beta_5 sep3$$

where Vj is the utility function associated with choice j and the ASC is a constant for each choice in the model. The marginal willingness to pay (*MWTP*) for improved properties via the proposed MSW program is estimated by the marginal rate of substitution between the non-monetary attribute parameter $\beta_{\text{non-monetaryattribute}}$ and the monetary attribute factor $\beta_{\text{monetaryattribute}}$ as follows:

$$\text{MWTP} = -\frac{\beta_{\text{non-monetaryattribute}}}{\beta_{\text{monetaryattribute}}}.$$

The coefficients $\beta_{\text{non-monetaryattribute}}$ and $\beta_{\text{monetaryattribute}}$ are estimated from the MNL model. The variables included in the MNL model are the attributes of the MSW management service quality improvement program. These variables include the variable *fee*, variable *waste*, *co2*, and two separation variables *sep2* and *sep3*. The variable *fee* represents the charging attribute for increased MSW management service stated as the monthly payment the household will incur for the MSW service (US$/month). The variable *waste* (%) represents the percentage of recycled solid waste. The variable *co2* is a variable representing an attribute of reduced CO_2 emissions (%) from changes to waste management, while the variables *sep2* and *sep3* represent numeric attributes of the possible types that MSW may need to be separated into (recycled, organic, residual). The variable *sep2* is a dummy variable that takes two values: $sep2 = 1$, if the number of MSW types is classified into 2 types, recycled and remaining, and $sep2 = 0$ if the number of MSW types is not classified into any type (unclassified). The variable *sep3* is another dummy variable with two values: $sep3 = 1$ if the number of MSW types is classified into three categories (recycled, organic, and residual), or $sep3 = 0$ if the MSW is not classified into those three categories.

4.3.1 Welfare analysis

In order to compare welfare measurements from each technique, the CE is restricted to evaluate the welfare impact of the same improvement presented in CVM. It means our CVM examined only the MSW management program change, while the CE model estimates any welfare changes relative to different attribute levels. For the CE, the change of a suggested MSW management program was valued using the following function (for further information see Boxall et al., 1996; Morrison et al., 1999; Jin et al., 2018):

$$WTP = -\frac{1}{\beta_M}(V^0 - V^1),$$

where β_M is the coefficient of monetary attribute and is interpreted as the marginal utility income. V^0 and V^1 represent the indirect observable utility before and after the change under consideration. Data analysis in this paper was conducted using STATA version 14 and NLOGIT 5 statistical software.

5 Results and discussion

5.1 Socioeconomic characteristics of the respondents

Thirty percent of the respondents were male, and 70% were female, with the average age of respondents being 49.6 years old. About 1.32% of respondents said they did not go to school. Of those that had attended school 23.95% had attended elementary school, 33.68% went to secondary school, 30.79% went to high school, and 10.26% went on to higher studies. With respect to employment the two biggest categories, traders and homemakers, represented 33.16% and 26.84% of the sample, respectively. Other employment categories included retirees (10.25%), government roles (6.32%), and working for private enterprise (3.42%). The majority of those who responded had an average monthly income of less than US$385.44, accounting for 90.79% of those surveyed. These socioeconomic characteristics of respondents are consistent with population-level data from the Vietnam Household Living Standard Survey (VHLSS) conducted by Vietnam General Statistic Office (GSO) every two years. Therefore, the representativeness of the data in this survey was confirmed.

5.1.1 Attitudes of the respondents toward the situation of MSW

Because the research was conducted in metropolitan areas, most participants received solid waste collection services (98.42%). The average quantity of MSW emitted per residence is 1.84 kg per day, which is collected by city sanitation workers. Although localities in the MRD have not yet implemented the program of classifying MSW at source our survey results showed that 50% of respondents were aware of the process behind at-source separation MSW programs (according to the instructions of the Vietnam Government's Decree 38/2015/ND-CP on waste and scrap management), and 67.11% have implemented it on the basis of being able to sell some waste products as a small source of revenue. By contrast, 32.89% of households have no experience with selling waste goods to third parties with many complaining that the amount sold does not provide sufficient income to alter their behavior. Finally, there were some respondents (2%) who stated they had little concerns for or about waste classifying behavior.

5.2 Estimation results from CVM and CE for the improved management program

5.2.1 Estimation results: CVM approach

Our results found that 66.31% of respondents were willing to pay for improved MSW management services which is a relatively high acceptance rate. Across the bid levels, 94.87% of respondents agreed to pay the monthly cost of US$0.87; just 5.12% refused to pay. When the monthly charge was increased to $2.18, 77.63% still agreed to pay. At the price of US$3.49/month, the number of those who decided to pay fell to 65.27%. When the charge was raised to US$4.81/month, the acceptance rate dropped to 53.84%. Only 39.47% of respondents agreed to pay the maximum monthly cost of US$5.68. These outcomes are compatible with demand curve economic theory and as we would expect—but encouraging given the positive levels of participation among residents at the higher payment levels (Table 2).

Table 3 Logit regression results on factors affecting the willingness to pay for the improvement in the MSW management program

Variables	Model 1—Group 1		Model 2—Group 2		Model 3—Combined group	
	Coef	*z* value	Coef	*z* value	Coef	*z* value
Constant	1.67568***	3.15	2.72104***	2.76	1.75397***	3.81
Bid	− 0.000017***	− 6.85	− 0.000016***	− 4.13	− 0.000017***	− 8.03
Age	− 0.01263*	− 1.67	− 0.02575*	− 2.10	− 0.01549**	− 2.45
Male	− 0.10289 ns	− 0.50	0.57605*	1.75	0.09211 ns	0.54
Edu	0.02973 ns	1.22	− 0.01061 ns	− 0,23	0.02513 ns	1.18
Income	0.95496**	2.17	1.17246**	2.27	1.02106***	3.12
Non-classified					0.31167*	1.85
Urbantype2	0.61853***	2.75	0.56527 ns	1.48	0.63748***	3.04
Urbantype3	0.96389***	4.00	0.90777**	2.52	0.94405***	4.79
Log-likelihood	− 128.48043		− 54.00449		− 184.55692	
LR $chi^2(8)$	76.51		42.08		116.46	
Prob > chi^2	0.0000		0.0000		0.0000	
Pseudo R^2	0.2294		0.2804		0.2398	
Observation	255		125		380	

Source: Survey data, 2020

*, **, and *** are statistically significant at 10%, 5%, and 1%, respectively, and ns are not statistically significant

Group 1: Households with previously sorted garbage, otherwise belong to Group 2. Sorted garbage indicates activities carried out by households, in which several recycling materials such as paper, metal, and plastic bottles are separated and then sell to informal individual waste collectors

Table 4 Willingness to pay mean value estimated from CVM and CE

		MWTP	Lower Bound	Upper bound	ASL
Group 1	CVM	4.62	4.16	5.25	0.0000
	CE	4.54 (1.80)	4.04	5.04	
Group 2	CVM	5.58	4.75	7.38	0.0002
	CE	4.84 (1.83)	4.33	5.35	
Combined group	CVM	4.81	4.49	5.47	0.0000
	CE	4.61 (1.81)	4.11	5.11	

ASL is the significance level for hypothesis tests: H_0: WTP < = 0, H_1: WTP > 0, number in parentheses are std. err

Table 3 summarizes the findings of the Logit model used to estimate willingness to pay based on the respondents' socioeconomic characteristics, where the model's prediction percentage is 76.58% which is both reasonable and acceptable. We next grouped households into three categories: Group 1 comprised households with previous waste-sorting experience, Group 2 households did not have any prior experience in waste separation, and Group 3 combined both into a single collective. The main purpose of this exercise was to determine if significant differences in WTP values exist between groups.

Table 5 Estimated results of the MNL model

Variable name	Coeff	*z* value
ASC	2.70,137***	6.94
Fee	− 0.000,023,337***	− 16.92
Waste	1.53,366*	1.82
CO_2	3.09,356***	3.61
Sep2	0.11476 ^{ns}	1.63
Sep3	0.05827 ^{ns}	0.70
Log-likelihood	− 1.161,55,238	
Observation	1965	

Source: Survey data, 2020

Table 6 IIA Test results

Alternative dropped	χ^2	Degree of F	Probability
Alternative A	348,0945	6	0.0000
Alternative B	3.918,3110	6	0.0000

Source: Survey data, 2020

Interestingly, Group 2 respondents reported higher WTP for waste separation despite no prior engagement with such activity (Table 4), which may reflect a distaste for such activity generally. Overall, the determinants of the respective WTP are consistent across our three models, but there are statistically significant differences between experienced waste-sorting households and those that have never undertaken this activity. The regression findings also demonstrate that the parameter of the Bid variable (significant at the 1% level) has a negative sign, indicating that the higher the charge for the MSW management service, the lower the chance of agreeing to pay. This result is consistent with economic theory and people's preference for recycling programs, depending on how much it would cost their households to participate (Kipperberg & Larson, 2012). Furthermore, the data reveal that the older the respondent the less likely they are WTP for increased services, possibly due to limited or fixed income constraints. This may be confirmed by the fact that those with higher incomes are more likely to pay for the proposed changes. These results conform with previous research by Rahji and Oloruntoba (2009), Pek and Othman (2010), and Altaf and Deshazo (1996) in which, age, income, family size, and employment have all been identified as socio-economic predictors of household waste handing behavior. Our results also reveal important factors which previous studies have not mentioned, where living conditions and waste types would give people different incentives to recycle. This result is somewhat consistent with Heller and Vatn's (2017) results, in which the authors argue that one of the motivations for recycling is an individual's concern for the environment.

Respondents that did not perform MSW separation stated that this was because they did not have time to do so, or because sorted MSW required a lot of storage space. This set of respondents was also more likely to pay higher rates for change than others. Further, respondents in Type 2 and 3 urban regions were more likely to agree to pay than respondents in Type 1 urban regions. This may be explained by the fact that existing MSW management systems in Type 1 cities are more thorough than those in other urban settings and,

Table 7 Estimated results of RPL model on the determinant of households' willingness to pay for source separation of solid waste

Variable name	Model 1—Group 1		Model 2—Group 2		Model 3—Combined group	
	Coeff	*z* value	Coeff	*z* value	Coeff	*z* value
Fee	− 0.000088***	− 9.09	− 0.000081***	− 5.65	− 0.000089***	− 10.89
Waste	11.07539***	6.05	8.69775***	3.20	10.38837***	6.61
CO_2	17.07812***	6.29	22.96321***	4.45	19.61559***	7.74
Sep2	0.40276***	2.70	0.55241**	2.42	0.47944***	3.73
Sep3	0.20030^{ns}	0.95	1.07653***	3.40	0.50683***	2.86
Log-likelihood	− 698.86745		− 325.51282		− 1,029.320	
Observations	4065		1812		5877	
Chi^2	222.36		119.38		348.39	
Prob > Chi^2	0.0000		0.0000		0.0000	

Table 8 WTP for program attributes (US$/month)

Variables	MWTP (Confidence interval 95%: Lower bound to Upper bound)		
	Group 1	Group 2	Combined group
Waste	5.48*** (3.71–7.24)	4.65*** (1.91–7.39)	5.09*** (3.60–6.58)
CO_2	8.45*** (6.17 to10.71)	12.27*** (8.03–16.52)	9.61*** (7.62–11.60)
Sep2	0.20*** (0.06–0.34)	0.30** (0.06–0.53)	0.23*** (0.11–0.36)
Sep3	0.10 ns (0.10–0.31)	0.57*** (0.27–0.89)	0.25*** (0.08–0.42)

as a result, respondents in Type 2 and 3 cities have higher expectations for increased MSW management services that are expected to contribute to environmental improvement.

The mean WTP elicited from the CVM and CE surveys are presented in Table 4. The parameter findings from the Logit model suggest that the average WTP value for increased MSW management via the CVM is US$4.81/month/household, ranging from US$4.49/month/household to US$5.47/month/household (at the 1% significance level). Meanwhile, the mean WTP from the CE survey estimates is about US$4.61; or a little smaller than the CVM average. As stated above, the mean WTP for Group 1 respondents is also smaller than that of other groups.

5.3 Estimation results: CE approach

Table 5 reveals the results of the CE approach with MNL estimation. The results indicate that all the attributes are statistically significant except Sep2 and Sep3. The results show that the attribute variable fee, waste type and CO_2 influence people's willingness to pay for the program to improve the quality of MSW management services. The coefficient of the fee variable has a negative value, showing a negative correlation to the people's decision to pay. This is consistent with the law of demand and price effects. In contrast to the fee variable, the coefficients of the Waste and CO_2 variables have a positive value, increasing the decision to pay for an improvement in MSW management services, and the probability of people participating in the program. However, the final fee value for the program should be calculated at a reasonable level because this is a factor that reduces the probability of people participating.

The test results of IIA property are summarized in Table 6. The values of the test statistics are significantly greater than the critical value of the Chi-square distribution, which is 18.475 at the 1% significance level with seven degrees of freedom. Therefore, the null hypothesis of the IIA restriction is rejected. However, the constant variance assumption would be violated if the alternatives A and B were dropped from the choice sets; indicating that using the conditional logit (CL) model approach to analyze this data may not be appropriate in terms of the IIA assumption. A less-restrictive specification of the choice model was thus considered to obtain unbiased and better results via an RPL model, with the results shown in Table 7.

The results of the RPL regression model reveal the attribute determinants of any WTP decision in support of improved MSW management services (Table 7*)*. Across all three models the attribute variables *charge*, *waste*, *co2*, *sep2*, and *sep3* impacted people's willingness to pay for a program to increase. The coefficient of the *fee* variable has a negative sign, indicating that the charge has a negative link with the respondents' payment decision. The coefficients for *waste*, *co2*, *sep2*, and *sep3* on the other hand have a positive sign, indicating a favorable link to the choice to pay more to increase MSW management services. As a result, when the MSW management program is improved by gradually raising the proportion of recycled MSW, reducing the rate of CO_2 emitted from MSW treatment, and categorizing additional categories of MSW, people are more inclined to participate in the program.

However, the payment charge for program improvements should be calculated at an appropriate level because this is a factor that may reduce the likelihood of resident participation. Further, our results provide evidence of a strong positive relationship between *sep3* and WTP by Group 2 members as well as those in the combined Group 3. This effect is not statistically significant for Group 1. Therefore, at source separation of MSW into the three categories (recycled, organic, and residual) is not significantly correlated with an increased WTP. The MWTP values for each of the program's attribute characteristics were generated based on the RPL regression findings (Table 8).

Table 8 illustrates that individuals are interested in the attributes focused on in our research. Interestingly, Group 2 has the highest mean WTP for three of the attributes (*co2, sep2, sep3*) and the lowest MWTP for the *waste* attribute. This result conforms with the CVM findings. It is possible that this result is reflective of the perceptions and characteristics of households on MSW separation, as explained above, where households with lower education and income may not expect many environmental benefits (or attributes) from this behavioral change. However, chief among these attributes is a reduction in CO_2 emissions, where the marginal willingness to pay for the attribute (US$9.61/month) is nearly twice as high as the marginal willingness to pay for the attribute of increasing recycling rate (US$5.09/month) and forty times the marginal willingness to pay for separate types of solid waste. This result is consistent with previous studies (e.g., Sakata, 2007), which found that individuals in Japan are prepared to pay a premium to minimize dioxin emissions. This result also suggests that the willingness to pay for the program's features is more than the present charge of around US$1.13/month/household or US$3.40/year/person, indicating a favorable indicator for the enhancement of the quality of MSW management services (World Bank, 2018). Environmental attributes have been considered important factors that determine household willingness to contribute to sorting programs. Consistent with previous studies, this research indicates that concerns related to waste and CO_2 increase household engagement willingness. Furthermore, *sep2* and *sep3* which are related to environmental concerns also motivate higher willingness (Heller and Vatn 2017). Once again though, the cost of the program associated with recycling will be critical, where the fee variable clearly shows a negative influence on WTP.

More importantly, as the current fee structure is insufficient to cover the existing collection, transportation, and treatment of solid waste where the total cost is US$1.68/month/person (World Bank, 2018) the opportunity to reduce the financial burden on the state budget is significant. This is important for a country such as Vietnam where economic development is essential but budget constraints are typically high. According to the Vietnam Ministry of Finance (2015), state budget expenditures on MSW management have more than quadrupled from US$266,809.42 in 2010 to US$488,222.70 in 2015. The capacity to address that shortfall, and aid policy-makers to implement

Prime Ministerial Directive 33 (2020) as a result of this research, offers an important contribution toward expanding waste management and reuse capacity in Vietnam.

6 Conclusions and policy implications

Findings from this paper should be interesting and useful to policy-makers, especially in developing countries that are struggling to implement and maintain effective MSW programs. We find positive rates of WTP for increased MSW management services among those that have previously engaged with waste separation activity and those that have not; where interestingly those that have not undertaken the behavior previously may be willing to pay higher rates for the service. This may indicate some reluctance to engage in separation activity for revenue purposes (where income generation is possible), but still manifest as a willingness to participate in waste separation for collection purposes. This specific finding may have to be tested further through focus sessions and additional interviews with members from that group. However, we do find that separation services offered under any increased MSW program are correlated with an increased willingness by residents to pay for that service.

The WTP estimates are broadly consistent across the two survey approaches and show no statistically significant difference. This finding is consistent with the limited number of previous studies that have compared welfare estimates between these two approaches. An additional driver of higher WTP appears to be any reduction to CO_2 emissions provided by environmental changes under a new program. Environmental concerns have grown in relevance for Vietnamese residents in recent years, likely driving some of the findings reported in this study. Responses collected via the CVM survey suggested an average willingness to pay of US$4.81/month, while the CE survey WTP estimate was US$4.61/month—again consistent with other studies that show CVM estimates can often be higher than those of CE. However, the difference here is negligible as shown and offers a clear price range for policy-makers to consider adopting; and one that is well above the current US$0.86/month revenue for existing services, and also higher than the US$1.68/month real costs of Vietnamese MSW operations.

When implementing the proposed program changes it will be critical for management agencies to strengthen their communication programs in order to raise awareness of environmental benefits that can stem from improved MSW and the source separation of household waste. These awareness-raising activities should initially focus on households with higher incomes that already actively participate in environmental-related activities in their areas. However, at the margin, further useful policy advice has been provided by our study from discrepancies between the CVM and CE welfare estimate approaches. While the CVM survey determined an economic worth of changes to the existing solid waste management program, by contrast, the CE survey enabled us (and Vietnam's policy-makers) to estimate the economic worth of key MSW management program attributes. Respondents, in this case, have reported a willingness to engage in separation behavior and pay for the MSW services required to collect, process and reuse that waste. This is an important finding, as recycling habits are frequently seen as a component of everyday activities that are significantly influenced by patterns, and where further government efforts to incentivize those who would prefer the status quo (~33% in this case) may assist in motivating change and full adoption of improved MSW practices. This could involve rewards for those that do the right thing, or neighborhood competitions related to waste separation activity. In any case, our research provides useful insight for governments in developing countries to manage the growing problem of waste management and recycling needs into the future.

Acknowledgements This study is funded in part by the Can Tho University Improvement Project VN14-P6, supported by a Japanese ODA loan.

Author's contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Xuan Thi Dan Huynh and Tien Dung Khong. The first draft of the manuscript was written by Xuan Thi Dan Huynh and Tien Dung Khong and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding This study is funded in part by the Can Tho University Improvement Project VN14-P6, supported by a Japanese ODA loan.

Availability of data and material Data is available from the corresponding author upon request.

Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article. The authors have no relevant financial or non-financial interests to disclose. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

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