
Analysis of household preferences on waste electrical and electronic equipment management

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Abstract: The management of waste electrical and electronic equipment (WEEE) has become an environmental concern in Malaysia due to its rapid growth. To address this issue, we tried to investigate the relationship between household's willingness to pay (WTP) and WEEE management system in Kuala Lumpur, Malaysia. In order to quantify household's WTP for improved WEEE management system, we employed a contingent valuation method (CVM). The household's WTP was then elicited through a series of face-to-face interviews of residents in 350 randomly selected households. The results showed that 73.52% of the households were willing to pay. The mean WTP was RM 23.47 (\$8.09) per household monthly fee. In order to establish the relationship between endogenous variables and household's WTP, a logistic regression model was constructed. It was found that education level, age and household income significantly affected households' WTP for improving WEEE management system in Kuala Lumpur.

Keywords: electronic waste management; household; willingness to pay; WTP; contingent valuation method; CVM; Malaysia.

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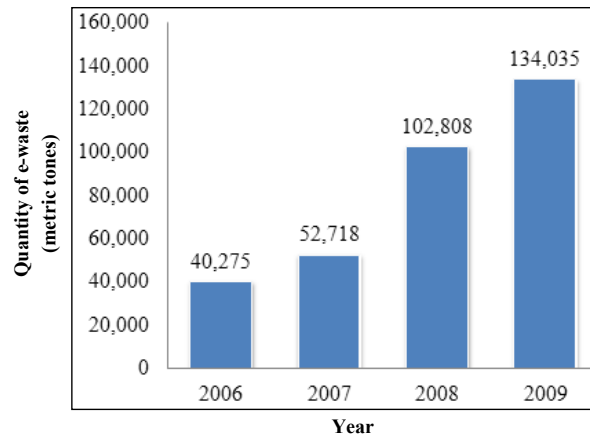
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1 Introduction

The transformation of Malaysia from an agriculture-based to an industrial-based socio-economy, in the 1980s, led to a consequent increase in the number of Malaysians living in urban areas and maintaining modern lifestyles. Therefore, Malaysia has been facing problems with rapid growth of domestic WEEE volume which is generated from households, business entities and institutions (Figure 1). In addition, it is a very attractive country for smugglers of WEEE, because it lies in the middle of the international trade route for Waste of Electrical and Electronic Equipment (WEEE) (Pucket et al. 2002). For this reason, there is continual illegal shipment of WEEE from other countries. In Malaysia, the existing law related to WEEE only controls and manages the WEEE which is generated from industries. It does not have any provisions for controlling and managing WEEE generated by the households. This is a serious weakness of the existing law. Under these circumstances, extended producer responsibility (EPR) is found to be a prospective strategy for providing a suitable base in the formulation of new legislation which will overcome the weakness of the existing law.

Figure 1 Quantity of WEEE generated in year 2006–2009 (see online version for colours)

Source: Department of Environment (2009)

However, most studies so far have focused on how to formulate and implement EPR policy and the role of the government in WEEE recycling (Fleckinger and Glachant, 2010; Nnoroma et al., 2009; Zhao et al., 2010; Mo et al., 2009). But few researches on WTP and consumers' behaviour regarding improvement of WEEE have been conducted in developing countries like Malaysia. For example, Nnoroma et al. (2009) examined the willingness of households to play a part in mobile phone recycling in Nigeria in 2009; and Wang et al. (2011), investigated the behaviour of households towards WEEE recycling in Beijing in 2011. To date, few studies have been carried out to estimate the willingness to pay (WTP) of the consumers for improved solid waste management system in Kuala Lumpur and Petaling Jaya using CVM (Mourato, 1999; Othman and Noor, 2001; Othman, 2002; Pek and Othman, 2010; Afroz and Masud, 2011). The reason behind all these researches is to assist policy makers to formulate the relevant policies and laws in order to remove the misunderstanding between development and conservation. If the Malaysian government wants to implement effective policies based on EPR or individual producer responsibility (IPR) and build appropriate facilities for recycling of WEEE, the willingness of the consumers to be involved in recycling activities is essential. Without this, neither government policies such as EPR nor involvement by producers such as IPR can be fully realised in practice. Therefore, there is an urgent need to investigate the household's preferences or WTP for improving the WEEE management system in Kuala Lumpur, Malaysia. The objective of this study addressed this very need by investigating the households' WTP for improving WEEE in Kuala Lumpur, Malaysia using the CVM. This study also analysed the reasons for household's unwillingness to pay for improving WEEE; relationships between WTP and household characteristics; and household's detail WTP for improving WEEE in Kuala Lumpur, Malaysia.

The contingent valuation method (CVM), fortunately can deal with this type of issue and it can obtain a monetary value for an intangible good that does not have a market price. In order to obtain the monetary value of an intangible good, CVM presents consumers with a hypothetical market to buy public goods and asks them to elicit their preferences or WTP. In this way, CVM tries to circumvent the absence of a real market for the particular intangible good (Mitchell and Carson, 1989). In this study, WEEE

improvement in Kuala Lumpur is considered as the non-market good. We employed CVM to estimate the WTP of the households to improve the WEEE management system in Kuala Lumpur, Malaysia taking into consideration the advantages of this method. We hope that our research can determine the households' degree of satisfaction with WEEE and provide useful information as guidelines for the establishment and implementation of environmental policy. The remainder of this study is organised as follows: Section 2 gives a general description of the study design and data collection process. Section 3 describes the data analysis using a regression model. Finally, we briefly conclude the study by discussing the implications of the findings, limitations of the study and potential directions for future research.

2 Methodology

2.1 Type of survey

In our study, we chose to use face-to-face interviews by well-trained interviewers because such a method provides the most complete, comprehensive and meaningful high quality data (CRS, 2010). The survey response rate, for the study was over 94% which was much higher than what could be expected from a telephone interview or a mail survey.

2.2 Sampling methods

The total number of households in Kuala Lumpur is 2.8 million. In order to select a random sample of this population, the following sample size formulae were adopted in our research (CRS, 2010):

$$ss' = \frac{z^2 (p(1-p))}{d^2} \quad (1)$$

where ss' = sample size, z = z value (e.g., 1.96 for 95% confidence level), p = percentage of respondents who selected a choice, expressed as a decimal (0.5 is used for the sample size needed), d = confidence interval or margin of error expressed as a decimal. The above equation is appropriate for infinite sampling but since the number of households is known in our study, the correction for a finite number of households is as follows.

$$ss = \frac{ss'}{1 + \frac{ss'-1}{F}} \quad (2)$$

where ss = estimated sample size, F = the number of households in Kuala Lumpur. Based on the sample size formulas, we selected $z = 1.96$, $p = 0.5$ and $d = 5\%$ and estimated the sample size to be 383. Due to limited resources, such as money and manpower, we have selected 350 as our sample size. A total of 350 questionnaires were disseminated among households through face to face interviews. Out of the 350 questionnaires, only 20 questionnaires were unacceptable. In September 2010, we conducted the final data gathering in Kuala Lumpur. In this study, Kuala Lumpur was chosen as the study area since the households of Kuala Lumpur are the instantaneous recipients of the waste

collection system which is maintained by DBKL (Dewan Bandaraya Kuala Lumpur). DBKL is a local authority which administrates *Kuala Lumpur city centre* and other areas in the *Federal Territory* of Kuala Lumpur. In this study, 70 households were selected randomly from each of the five urban areas in Kuala-Lumpur, i.e., Selayang, Cheras, Ampang, Taman Jaya and Kuala Lumpur.

2.3 Design of the questionnaire

The questionnaire had three sections. The first section collected information on the households' socio-economic characteristics. The second section asked the respondents about their impression on the quality of the environment in Kuala Lumpur, their knowledge about the WEEE and their attitude towards solid waste management. In the CVM questionnaire, in order to give the households a full understanding of the proposed hypothetical project, all the required information about the attributes of the proposed project should be presented (Lee and Han, 2002). In this way, the researcher can reduce the rejection rate and allow the households to reveal their true WTP. For this reason, the third section included a description of the current situation regarding WEEE collection and disposal, existing problems and stakes of the current WEEE management system, the contingent market about a new proposed WEEE management system and the payment method. In this research endeavour, we used the recycling fee as the payment method to improve the WEEE management system in Kuala Lumpur. The current and the proposed WEEE management systems are presented in Table 1.

Table 1 The current and the proposed WEEE management system in Kuala Lumpur

<i>Attributes</i>	<i>Current WEEE management system</i>	<i>Proposed WEEE management system</i>
Collection system of small and large items	No collection system.	Small items such as used mobile phones, mobile phone's batteries and their accessories, computers and their accessories and large items such as TV, refrigerator will be collected by the waste collectors.
Number of times per week recycling vehicles pick-up small and large items	Households need to send their WEEE to WEEE recycling centres or DBKL if they want to recycle and dispose them.	Small and large items will be picked-up weekly.
Separation of WEEE at house	Not mandatory.	Mandatory, households are requested to separate the WEEEs at house and put it into different bag.
Hazard free recycling centres for WEEE	Only few.	More hazard-free recycling centres for WEEE will be established.
Waste disposal	Landfill	Sanitary landfill.
Recycling fee	Not available	The households need to pay the monthly recycling fee to the waste collector.

The residents of the households were apprised that if they decided to select the proposed WEEE management system, they would need to pay the recycling fee directly to the service provider, not like the current practice where they pay through the annual house assessment. We also informed them that if they agreed to pay the extra cost, their disposable income would be reduced. On the other hand, if they decided to select the current WEEE management system, we assumed that they were happy with the current system and were willing to continue paying the household assessment tax.

If the occupants of the households agreed to select the proposed WEEE management system, they were asked the following valuation question:

Considering your household's income and expenditure, would you be willing to pay this increased cost in terms of monthly recycling fee, so that the government can implement this programme? Remember that this will leave you less money for, for example, food, clothing, shoes, travel car use and savings.

Different methods of eliciting WTP have been used before in CVM, such as open-ended questions (Bateman et al., 1995; Hansen, 1997), a payments card (Kima et al., 2007; Peters and Hawkins, 2009), dichotomous choice (Lockwood et al., 1996; Pollicino and Maddison, 2001; Afroz and Masud, 2011), iterative bidding games and referendums (Dutta et al., 2007). We employed a payment card with ten different prices on the basis of the pre-test (RM 5, 10, 15, 25, 35, 50, 100, 150 and 250, with USD 1 = RM 3.15). The respondents were asked to tick one price which would represent their WTP. The prices used on the payment card indicated the recycling fee per month to improve the WEEE management system in Kuala Lumpur.

3 Results and discussion

3.1 Impression about the local environment

The respondents were asked about their impression on the quality of the environment in Kuala Lumpur. It was found that 69% of the respondents for the households had positive impression about the quality of the local environment, while 31% had negative impression about the local environment.

3.2 Knowledge of the households about WEEE

Less than half of the households (32%) knew that the electrical and electronic equipment could create problems in the environment as well as in human health. On the other hand, 68% of the households replied that they did not know about it. Other studies conducted in Malaysia revealed that the majority of the respondents had knowledge about the unsafe ingredients which existed in electronic products but only a handful recycled their wastes (Kalana, 2010; Gatke, 2003).

3.3 Attitude of the households about solid waste management

The attitude of the respondents was measured by their willingness to sort and willing to pay for solid waste management improvement. This study shows that 81% of the respondents were willing to sort their wastes if the proper facilities were provided and

that they were also willing to pay for the improvement of solid waste management systems.

3.4 Households' WTP for improving WEEE management in Kuala Lumpur

In our study, monthly recycling fee was adopted in order to estimate the households' WTP for improving WEEE management. A regression model was developed to explore the factors that might affect the WTP of the households for improving WEEE management system in Kuala Lumpur. Here, households selected their WTP for improving WEEE management system in Kuala Lumpur from two alternatives: 1 – willing to pay for improving WEEE management system, and 0 – not willing to pay for improving WEEE management system. When the dependent variable is in 0–1 style, researchers can choose between logistic regression and probit regression (Wang et al., 2011). For this reason, in this study, logistic regression was selected. It was assumed that the factors listed in Table 2 might affect WTP. Thus, these factors were included in the model as independent variables. The model of the probability of WTP, $P(Y_i) = 1$, was represented as:

$$\text{Log}_e \left[\frac{\{P(Y=1|X_1, \dots, X_p)\}}{\{1-P(Y=1|X_1, \dots, X_p)\}} \right] = \text{Log}_e \left[\frac{\pi}{1-\pi} \right] \quad (4)$$

$$= \alpha + \beta_1 X_1 + \dots + \beta_p X_p = \alpha + \sum_{j=1}^p \beta_j X_j \quad (5)$$

where, π is a conditional probability of the form $P(Y=1|X_1, \dots, X_p)$. That is, it is assumed that success is more or less likely dependent on combinations of values of the predictor variables. The log-odd, as defined above, is also known as the logit transformation of π and the analytical approach described here is sometimes known as the logit analysis. The logistic function takes the form of:

$$\langle P(Y=1|X_1, \dots, X_p) \rangle = \frac{e^{\alpha + \sum_{j=1}^p \beta_j X_j}}{1 + e^{\alpha + \sum_{j=1}^p \beta_j X_j}} \quad (6)$$

This can also be transformed into:

$$\langle P(Y=1|X_1, \dots, X_p) \rangle = \frac{1}{1 + e^{-\alpha - \sum_{j=1}^p \beta_j X_j}} \quad (7)$$

The non-response probability is:

$$P(Y=0|X_1, \dots, X_p) = 1 - P(Y=1|X_1, \dots, X_p) = \frac{1}{1 + e^{\alpha + \sum_{j=1}^p \beta_j X_j}} \quad (8)$$

Such like 'Yes' (= 1) if the households state a positive WTP and 'No' (= 0) when they are not WTP any amount. Using the set of predictors, the LR equation for the log-odds in favour of WTP is estimated to be:

$$\log \left[\frac{p_i}{1-p_i} \right] = b_0 + b_i \times X_i \quad (9)$$

Table 2 List of independent variables used in logit analysis

<i>Variables</i>	<i>Description of the variables</i>	<i>Category</i>
Gender	Gender	1 = Male 0 = Female
Age	Age	1 = 18–30 years 2 = 31–45 years 3 = 46–60 years 4 = 61 and above
Edu	Educational status	1 = Secondary 2 = Higher secondary 3 = Diploma 4 = Bachelor 5 = Postgraduate
Income	Monthly family income	1 = RM 2,000 and less 2 = RM 2,001–4,000 3 = RM 4,000–6,000 4 = RM 6,000–8,000 5 = RM 8,001 and above
Impression	Impression about environmental quality in Kuala Lumpur	1 = Bad 2 = Neutral 3 = Good
Attitude	Attitude towards WEEE management system in Kuala Lumpur	1 = Willingness to sort and willing to pay for waste management improvement 0 = Not willing to sort and willing to pay for waste management improvement

Table 3 The results of logistic regression analysis ($N = 330$)

	β	<i>S.E.</i>	<i>Sig.</i>	<i>Exp(\beta)</i>
Gender	.571	.460	.215	1.769
Age	-.314	.103	.012	.443
Education	.707	.053	.013	.898
Income	.369	.215	.015	.691
Impression	.383	.488	.432	1.467
Attitude	.260	.112	.050	3.525
Constant	3.386	1.179	.004	29.539
Model χ^2 value	26.89			

Table 3 The results of logistic regression analysis ($N = 330$) (continued)

	β	<i>S.E.</i>	<i>Sig.</i>	<i>Exp(β)</i>
Two-log likelihood	150.16			
Percentage of correct prediction	92.4			

Using the partial coefficients, b_i , informing the change to log odds of agreeing to pay for improving WEEE management system in Kuala Lumpur. The maximum likelihood estimates for the logistic regression model are presented in Table 3. The signs for all coefficients were consistent with our intuition. In this study, age, education and income were positive as expected and highly significant, at the 1% significance level as we expected. This results support the hypothesis that the probability of the households' saying 'yes' to the WTP question increases with education level and household income. Many scholars' results support the conclusion that income and education level have positive relationship with the willingness of households in e-waste recycling (Hornik et al., 1995; Tonglet et al., 2004) which is in accordance with our research results. The coefficient of age is negative which makes sense because usually the young people have a higher education level and are more knowledgeable about environmental pollution and most of all, they hope to take appropriate methods to improve their living environment. This also indicates that older people in Malaysia are more resistant to changing their ways of doing things around the house and since waste separation and recycling may be considered relatively new WEEE management practices, the households with older people as leaders are less likely to engage in waste management. They might also think that they will be paying more for a new management system whose expected improvement would not take place without the intervention of a regulatory body that can regulate the activities of the private companies acting in the waste management sector. This leads them to pay less for the WEEE management improvement. This result is consistent with few other studies (Afroz et al., 2005; Afroz and Masud, 2011). Another variable, attitude of the households towards waste management, is also significant at 5% significance level. Other variables, such as households' gender and impression about the environmental quality in Kuala Lumpur were not statistically significant. This shows that these characteristics have little influence on households' WTP. The result of the χ^2 tests indicated that, on the whole, the estimated model was satisfactory and the predictions of the logit model were fairly accurate (92.4%). Lastly, it can be recommended that education level was found to play the major role in households' WTP ($\beta = .705$) compared with the other two main factors ($\beta = -.314$ and $\beta = .369$ and $\beta = .260$). Therefore, the most effective method for improving WEEE management system is to increase the education level of the population. This approach, however, is a long-term plan; for the short term, it will be more effective to propagandise WEEE knowledge to promote households' understanding of WEEE impacts.

3.5 Estimation of WTP

The results from the logit equations in Table 3 were used to demonstrate the relationship between socio-economic variables, environmental attitudes and mean WTP. Mean WTP

was calculated by assuming no negative values for waste management improvement in Kuala Lumpur and using the formula suggested by Hanemann (1989):

$$E(WTP) = \left(\frac{1}{\beta_1} \right) \ln(1 + \exp^{\beta_0}) \quad (10)$$

Table 4 Willing to pay

<i>Items</i>	<i>Frequency</i>	<i>Percentage</i>
RM 5	94	38.68
RM 10	67	27.59
RM 15	44	18.10
RM 25	14	5.76
RM35	10	4.11
RM 50	7	2.88
RM 200	7	2.88
Total	243	100

Table 5 The statistics of willing to pay

<i>N = 243</i>	<i>243</i>
Mean	23.47 (std error of mean 2.40)
Median	10
Std deviation	43.84
Skewness	3.556 (std error of skewness 0.134)
Kurtosis	11.59 (std error of kurtosis 0.267)

Tables 4 and 5 present the summary statistics of the WTP for improving WEEE in Kuala Lumpur. The results show that 73.52% of the households were willing to pay and that RM 5, 10 and 15 were the most popular responses. The mean and median of WTP are RM 23.47 (\$8.09) and RM 10 (\$3.44), per month respectively. It is observed that the mean is higher than the median. It indicates that the majority of the households are willing to pay less than the mean WTP. It is also found that the limited number of high bidders made the response distribution skewed. The results also indicate that the households are willing to share 0.12% of their income. Although, this is very low compared to the values obtained in other studies (Morrison et al., 1998; Jin et al., 2006; Altaf and Deshazo, 1996), it appears to be reasonable based on the current amount they are paying for waste collection.

3.6 Reasons for households not willing to pay

The most important reasons for not willing to pay are presented in Table 6. Just over a quarter (26.48%) was not willing to pay anything at all. The rate shown may be high but is acceptable, compared with some previous studies that have estimated WTP for environmental goods (Giraud et al., 2002; Cho et al., 2005; Jin et al., 2006). In the literature, there are no guidelines which can indicate how much protest invalidates a WTP study (Brouwer et al., 2008). These households were asked why they were not willing to

pay for improving their WEEE management system. Several major reasons were given by them to explain why they gave negative responses, based on the households' answers in our survey. First, majority of the households (51.72%) stated that they were not willing to pay because they considered that it was government's responsibility. It was found that 27.58% of the households lacked sufficient extra income and 14.94% thought that it was the responsibility of those people who are polluting the environment. A small percentage of the households did not believe in this kind of WEEE management project and the rest thought that it was not important.

Table 6 Households reasons for not paying

<i>Items</i>	<i>Frequency</i>	<i>Percentage</i>
Have no extra income but otherwise could contribute	24	27.58
Do not believe that e-waste management programme would bring changes	2	2.29
It is the responsibility of the government	45	51.72
WEEE management is not important	3	3.44
It is responsibility of those Who pollute the environment	13	14.94
Total	87	100

4 Conclusions

- Based on our survey, 32% of the households knew that the electrical and electronic equipment has created problems in the environment as well as for human health. Therefore, there is a need for an educational campaign to disseminate the suitable methods of recycle and reuse of WEEE for the households. Although the households reported low level of knowledge about the WEEE (32%), they reported a positive attitude towards waste management (81% were willing to sort the waste). This is a welcome attitude for the development of hazard free WEEE management system in Kuala Lumpur. But the problem is there is no appropriate facilities to treat (dismantling and recovery) WEEE in Kuala Lumpur. Hence, the construction and improvement of WEEE recycling infrastructure should be emphasised as the first step. A WEEE recycling and effective monitoring system could be implemented. So, the concerned authorities should establish hazard free recycling and sanitary landfill centers. Obviously, the setting and running of such centers will involve considerable costs. However, the extent of concern and the WTP of the households, in this study, indicate that the respondents were even willing to bear this cost to a reasonable degree.
- In addition, the results of this study show that the probability of the households' saying 'yes' to the WTP question increases with education level and household income and decreases with the age of the respondent. Consequently, the government can take effective measures to further improve the households' WTP for improving WEEE management system. The result of the study also illustrates that another factor, attitude towards WEEE management system in Kuala Lumpur, has significant impacts on households' WTP for improving WEEE management system in Kuala Lumpur. Therefore, in order to enhance the attitude and impression of the

households towards waste management and environmental quality, the management of the solid waste should introduce interpretation programmes and publicise widely the environmental and health impacts of hazardous WEEE management system.

- A key policy implication of the results of this study is that policymakers will be informed about the status of the issue, households' attitudes and WTP for improving WEEE management system in Kuala Lumpur. This will be helpful for the policy makers to design an improved WEEE management project for Kuala Lumpur and can be used to promote the recycling of WEEE in Kuala Lumpur. Without knowing the costs of providing various service improvements, we cannot recommend specific improvement measures. What we can state with clarity, nonetheless, is that the survey respondents show a clear preference for improvements in waste management services and a considerable WTP for it.
- There are a few limitations of this study. Firstly, this study only addressed the WTP of households and it is possible that other Stakeholders such as producers and recyclers may also be willing to contribute towards improving the WEEE management system. Secondly, the knowledge of the population sample is low (103 households, 32%), thus the findings should be used with caution. Therefore, future researchers should consider all these limitations when they plan their research regarding WEEE management. Conducting research targeted specifically on those samples who participate on solid waste management might give a different output to the study.

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Appendix

- 1 Do you know about electronic waste?
 - a Yes (Go to Q 10)
 - b No (Go to Q 11)
- 2 From where did you know about the electronic waste?
 - a Newspaper
 - b TV
 - c Friend
 - d Advertisement
 - e Internet
 - f Community disseminate
 - g Using several pathways
- 3 Your attitude towards solid waste sorting at the source.
 - a I am willing to sort household wastes into separate containers
 - b I will sort my household waste if the government requires me to do it
 - c It is not a proper time since there is no sorting and collecting system
 - d It is impossible because of the lack of public environmental awareness even if there is a sorting and collecting system
- 4 Currently all of the e-wastes recovery facilities in Malaysia are built and operated by private companies. The industry or e-waste generators send their e-waste to these e-waste facilities or department of environment. The government is planning to implement a project on how to effectively collect the e-wastes from the residential areas. The proposed project is below.

	<i>Current e-waste management system</i>	<i>Proposed e-waste management system</i>
Collection system of small items	No collection system.	Small items such as used mobile phones, mobile phone's batteries and their accessories, computers and their accessories, will be collected by the waste collectors
Store for disposal stickers	Not available	For the large items such as television, refrigerators and furniture, the households need to purchase disposal stickers from shopping complex and department of environment.
Number of times per week recycling vehicles pick-up small and large items	Households need to send their electronic waste to e-waste facilities or department of environment if they want to recycle and dispose them.	Small and large items will be picked-up weekly
Separation of e-waste at house	Not mandatory	Households are requested to separate the e-wastes at house and put it into different bag.
Hazard free recycling centres for e-waste	Not available	Hazard-free recycling centres for e-waste will be established
Waste disposal	Landfill	Sanitary landfill

- 5 Considering your household's income and expenditure, would you be willing to pay this increased cost in terms of increase in your household assessment tax so that the government can implement this programme? Remember that this will leave you less money for, for example, food, clothing, shoes, travel car use and savings.
- Yes (Go to Q. 6)
 - No (Go to Q. 8)
- 6 If you are willing to pay, what is the household assessment tax are you willing to pay per month?
- RM 5
 - RM 10
 - RM 15
 - RM 25
 - RM 35
 - RM 50
 - RM 200
 - Others, please specify _____

- 7 What is the maximum household assessment tax you would be willing to pay for the system per month?
-
- 8 If you are not willing to pay, what is the reason?
- a Have no extra income but otherwise could contribute
 - b Do not believe that waste management programme would bring changes
 - c It is government's responsibility
 - d Electronic waste management is not important
 - f It is responsibility of those who pollute the environment.