E-Waste Management in Malaysia: Residents' Willingness to Pay for Household E-Waste Recycling in Kuching, Sarawak

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ABSTRACT

'E-waste' refers to electronic and electrical appliances that are no longer beneficial to consumers. An increasing amount of e-waste generated due to an increasing demand for electrical and electronic equipment in line with the rapid growth of the global population has become a growing global concern. Furthermore, limitation of the assimilative capacity of the environment and depleting natural resources have also urged the need to prioritize sustainable household e-waste management. This paper aims to examine the resident's willingness to pay for household e-waste recycling in Kuching, Sarawak. A questionnaire survey was administered among 397 residents living in Kuching. The findings of the study show that majority of the residents in Kuching are not willing to pay for household e-waste recycling of electrical appliances such as fridges (50.6%) and fans (59.4%). However, it also depends on the distinctive types of household electrical appliances they possess. In this study, 10 types of household electrical appliances were selected and the average cost of WTP is expressed based on a percentage of its purchased values of the respective electrical household items listed. It was found that residents from Kuching are only willing to pay an average of 2.3% till 2.6% of recycling fees based on 10 types of the purchased values of their electrical home appliances in this study. This could be explained by the findings that show a low awareness level of sustainable e-waste management practices among the residents in Kuching. Therefore, the study recommends that more environmental education programs are to be carried out in the formal education system to sensitize the residents and children to the risks associated with the importance of household e-waste recycling to promote sustainable household e-waste management, particularly among the growing population in Kuching, Sarawak. Chiam (2013) reported that the residents of Kuching lack knowledge of how to manage their household e-waste and are unaware of the available recycling facilities in the region. However, over time, the e-waste management situation in Kuching has improved, with more recycling facilities being made available to the public for proper disposal of e-waste (Louis, 2020). The Kuching Integrated Waste Management Park, which caters to municipal solid waste and scheduled waste (including e-waste), is claimed to be one of the first integrated waste management parks in Southeast Asia (Trienkens, n. d.).

Keywords: E-waste; Recycling; Sustainable; Willingness to pay; Electronic; Household

INTRODUCTION

Background

The rapid increase in the amount of e-waste generated due to the increased demand for electronic and electrical equipment (EEE) has become a growing global concern. Studies have shown that 53.5 million tons of e-waste were produced worldwide in 2019, with 7.3 kilograms of e-waste generated per capita (Forti et al, 2020). In 1970, the global population was only 3.7 billion, but it has reached more than 7 billion inhabitants in 2016 (World Bank, 2016). It is estimated that the world population will likely exceed 9 billion by 2050, and could potentially reach 11 billion by 2100 (Koop & Van, 2017).

Significant growth in the human population, along with the growing consumption of household electronic and electrical equipment (EEE), has contributed to the increasing generation of household e-waste. This global concern is exacerbated by the limited assimilation capacity of the environment and the depletion of natural resources. Thus, there is an urgent need to prioritize sustainable e-waste management (SEWM). SEWM is defined as the ability of people to uphold or partake in e-waste recycling activities to reduce the amount of global e-waste generated that would ultimately end up in landfills or exposed to the surrounding environment. According to Wath (2010), sustainable e-waste management (SEWM) plays a pivotal role in developing countries, including Malaysia. Therefore, determining their willingness to pay for household e-waste recycling is crucial to allow policymakers to execute relevant policies regarding household e-waste management in the country.

To practice sustainable e-waste management, people are recommended to recycle their household e-waste products formally in the provided formal e-waste recycling facilities in Malaysia. This would not only save costs in the electronic manufacturing industry due to the scarcity of raw materials but also protects the environment and the well-being of humanity. Improper management of e-waste allows toxic chemical leachates to be exposed to the environment, thereby endangering human health (Utkucan et al., 2010). Hence, sustainable e-waste management as a systematic approach is a must for economic development. The natural resources required for EEE production are facing a decline due to the increasing demand for electronic gadgets, appliances, and equipment (Forti et al., 2020). The raw materials used in EEE production include precious metals such as gold, silver, palladium, and platinum (Prince, 2015). Base metals such as iridium, nickel, rhodium, and copper are also essential materials required in EEE production (Yong et al., 2019). Based on a report provided by Matric Group (2021), a 30% growth in the demand for semiconductors has caused a worldwide shortage of electrical components.

In many developing countries, such as Malaysia, relevant authorities, such as the Department of Environment (DoE), often closely monitor the recycling process of industrial e-waste. The Environmental Quality Act of 1974 governs Malaysia’s environmental quality, including industrial E-Waste Management (EWM) in Malaysia. Thus, there is legislative control over industrial e-waste management in Malaysia. It is mandatory for any form of industrial e-waste to be recycled on licensed premises, and its disposal should be conducted in formal registered e-waste recycling facilities (Hamzah et al., 2011). However, the management of household e-waste is often taken lightly and not formally engaged in a systematic process in Malaysia. Unlike the proper procedures for disposing of household e-waste in Singapore with the involvement of their local e-waste collectors (Wong, 2015), Malaysia still lacks an understanding of systematic household e-waste management procedure. Therefore, it is important to study households’ willingness to pay for household e-waste management before having relevant institutions take responsibility for managing it more effectively (Hamzah et al., 2011).

There is scanty literature and studies on the e-waste management status in Kuching, as most of the studies related to e-waste management in Malaysia only covered bigger cities such as Penang and Kuala Lumpur. Although Suhaili and Abdullah (2023) have conducted a study on the awareness of household e-waste management among Sarawakians in the state, their study is limited to younger participants who are mostly still pursuing their studies (68.8%). This study aims to fill the research gap on the status of EWM from a larger population sample in Kuching, Sarawak.

E-waste Generation and Management

The world has been witnessing an ongoing accumulation of electronic and electrical waste for the past decade, which has been identified as a pressing socio-environmental issue that necessitates immediate attention (UNEP, 2007). According to Widmer, Oswald-Krapf, Sinha-Khetriwal, Schnellmann, and Böni (2005), e-waste is defined as “a general term that includes various forms of electronic equipment that are no longer valuable to their owners” (p. 439). Furthermore, the EU Directive 2002/96/EC of the European Parliament has provided a list of categories that define e-waste, as shown in Table 1.

Table 1: List of categories defined as E-Waste based on the EU Directive 2002.

No.	Category	Label
1	Large Household Appliances	Large HH
2	Small Household Appliances	Small HH
3	IT and Telecommunications Equipment	ICT
4	Consumer Equipment	CE
5	Lighting Equipment	Lighting
6	Electrical and electronic tools	E&E tools
7	Toys, Leisure, and Sports Equipment	Toys
8	Medical Devices (Exception for implanted & infected products)	Medical equipment
9	Monitoring and Control Instruments	M&C

Source: Liu et al. (2006)

A total of 53.6 million metric tons (MT) of e-waste was recorded worldwide in 2019, and this amount is expected to increase to 73 million MT by 2030 (Forti et al., 2018). This indicates the need for urgent action to mitigate the environmental damage caused by e-waste leachates (Forti et al., 2020). In Asia, 24.9 million tons of e-waste were accumulated in 2019, with Malaysia estimated to contribute approximately one million tons of e-waste that same year (Lim, 2019). However, the Department of Environment has set a target of 200 metric tons for e-waste collection in Malaysia in 2020 (Chang, 2020). Increased demand for the latest electronic goods has resulted in a rise in household e-waste generation. Additionally, electrical and electronic appliances have shorter lifespans over time, and it is more cost-effective and convenient to replace them rather than repair them (Akhtar et al., 2014). This not only leads to an annual increase in e-waste generation but also contributes to the depletion of natural resources, including precious metals (gold, silver, and platinum) and base metals (iridium, nickel, and copper).

The growing global population necessitates a higher supply of electrical and electronic equipment (EEE) due to the increased reliance on electronic telecommunication gadgets and household appliances (Shiroishi, 2018). This trend has become even more pronounced since the outbreak of COVID-19 in December 2019, which led to widespread stay-at-home measures to curb the spread of the virus (Anderson et al., 2020). During this period, there was a significant surge in the demand for electrical appliances such as mobile phones and laptops for communication purposes during isolation (Barnes, 2020).

Informal practices of household e-waste recycling and e-waste management (EWM) have been proven to be harmful to human health and the environment (Barnes, 2020). This is evident when municipal solid waste (MSW) and e-waste are disposed of in landfills, leading to the production of toxic leachates that gradually permeate the surroundings (Xiang et al., 2014). Chiam (2013) reported that the residents of Kuching lack knowledge of how to manage their household e-waste and are unaware of the available recycling facilities in the region. However, over time, the e-waste management situation in Kuching has improved, with more recycling facilities being made available to the public for proper disposal of e-waste (Louis, 2020). The Kuching Integrated Waste Management Park, which caters to municipal solid waste and scheduled waste (including e-waste), is claimed to be one of the first integrated waste management parks in Southeast Asia (Trienkens, n. d.).

Nevertheless, there is limited literature and research on the status of household e-waste management in Kuching. Most studies on household e-waste management in Malaysia only focus on the Peninsular region. Moreover, there have been few studies have examined the willingness to pay (WTP) for household e-waste recycling among the residents of Kuching, Sarawak. Therefore, this study aims to bridge the research gap by investigating the WTP of Kuching citizens for household e-waste recycling.

LITERATURE REVIEW

The E-Waste Situation in Malaysia

Many households in Malaysia still practice informal methods of electronic waste management (EWM), such as disposing of e-waste to scavengers who make a living from e-waste trading because e-waste owners get paid to give their household e-waste to them (Wong, 2015). In Malaysia, proper methods of disposing of e-waste are feasible only by sending it to a licensed e-waste recycling facility (Cho, 2018). However, such facilities are outnumbered by the total amount of e-waste accumulated every year (Yong et al., 2019). Furthermore, only a limited number of e-waste recycling (EWR) facilities in Malaysia can provide convenient e-waste recycling services, such as household e-waste doorstep collections for Malaysians (Chern, 2020). This has led to Malaysian residents being unwilling to pay for household e-waste recycling as they are still required to go out of their way to deliver their household e-waste to the e-waste recycling facilities at their own expense, causing inconvenience (Yong et al., 2019).

The significant increase in demand for electronic and electrical equipment (EEE) in Malaysia has not declined during the pandemic since March 2020 (Chern, 2020). It has been reported that there has been a steep rise in the demand for electrical household appliances, especially between May and June 2020, when the Movement Control Order (MCO) was partially lifted in the country (Chern, 2020). The demand for electrical home appliances such as fans, microwaves, electric ovens, food mixers, and printers has spiked as Malaysian residents are required to work from home (Chern, 2020). Therefore, this indicates that it is significant for the public to take household EWM seriously since the amount of household e-waste accumulated annually increases. Without a systematic approach to curbing this issue, greater amounts of household e-waste would only end up in the country’s landfills.

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Willingness to Pay for Household E-Waste Recycling

Scholars from China, Bangladesh, Macau, and Malaysia have utilized the concept of willingness to pay (WTP) to measure the maximum amount of money respondents in their respective countries are willing to pay for something with no market value (Daud et al., 2012). Daud, Rahim, Shamsudin and Shuid (2012) defined WTP as the amount of money that a person is ready to pay, forgo, or trade-off for services or to prevent unwanted events from happening, such as avoiding the cultivation of a polluted environment (that brings no benefit to anyone).

Sujauddin, Huda, and Hoque (2008) investigated the features and management of household solid waste in Chittagong, Bangladesh. The random sampling method was used to select 75 houses to be included in the study sample. A typical household was willing to pay the trash collector between $0.30 and $0.40 per month. According to the study, the price of trash pickup should be determined by the amount of waste generated by households. It was discovered that segmenting household solid waste before discarding them to solid waste disposal centers can ease the entire waste recycling process. Similarly, Begum, Siwar, Pereira, and Jaafar (2006) conducted a study on the WTP of the residents in Klang Valley for better construction waste management. Using a tiered random selection procedure, 130 sellers were surveyed. The research found that 68.5% of the contractors would welcome improved construction disposal services. The WTP for improved waste management among the sellers averaged RM69.88 per ton. According to the study, the government can intervene to improve the trash collection and disposal services offered by the business sector. Moreover, Ezebilo (2013) estimated the WTP of households to improve household garbage handling in Kwara State, Nigeria. For this purpose, 236 houses were sampled, and more than 80% of respondents in this survey preferred domestic waste management. The WTP among the households averaged $24. The researcher suggests that informing people about the benefits of involving the business sector in Solid Waste Management (SWM) will help improve the WTP for better solid waste management.

Banga, Lokina, and Mkenda (2011) studied the willingness of households to pay for improved solid waste disposal services in Kampala, Uganda. The research used 381 houses as its data source. Random sampling was used to gather the statistics. The double-bounded dichotomous choice method was used to determine the mean WTP of households for improved solid waste pickup service. The study findings revealed that the majority (79.8%) of the families were willing to pay more, with an average of 24,391 Ugandan Shillings (USh), for improved solid waste removal services. To address the issue of free riders, researchers suggest setting a socially acceptable price that the majority are willing to pay.

Afroz et al. (2009) used the contingent valuation method (CVM) to determine how much respondents in Dhaka, Bangladesh, were willing to pay to improve the waste collection system. This study examined the variations in WTP between residences that employ a door-to-door trash collection method (RDDW) and residences that do not (NRDDW). Four hundred and eighty houses were selected using the stratified random selection technique, and the double-bounded binary choice method was used to calculate respondents' WTP. The study concluded that respondents in Dhaka were willing to pay an average of Taka 13 per household per month. While the mean WTP per family in the NRDDW area was Taka 12, the mean WTP per household in the RDDW area was Taka 15.8. The main reason for the difference in WTP is the difference in people's awareness. The research highlights the importance of a comprehensive, integrated, and incentive-compatible approach to solid waste management in Dhaka. Researchers recommend educating households about the planned solid waste management efforts and encouraging their participation, which will increase the WTP of households.

Bhattarai (2015) examined households' willingness to pay for improved solid waste management in Nepal's Banepa Municipality. This study found that 83% of respondents were willing to spend more for improved solid waste management. For typical households, the monthly WTP for improved solid waste management was 166 Rupees (USD 1.69). The municipality currently charges each household a daily garbage fee of Re 1 (US $0.01). This indicates that the current garbage fee is considerably less than the WTP for a typical household. The findings of the study show that bid amount, age of the respondent, sex of the respondent, household size, level of education of the respondent, present waste collection service, and household income are significant factors in influencing households' WTP for improved solid waste management. Larger families may be required to pay higher trash costs based on their WTP (Bhattarai, 2015). When calculating the expense of garbage collection, the amount of trash generated by homes can also be taken into consideration. However, there should be special accommodations for the poor. They should either not be liable to one at all or pay a relatively small garbage fee.

RESEARCH METHODOLOGY

In this research, the residents' willingness to pay (WTP) is projected using a contingent valuation method (CVM). A CVM is a questionnaire-based assessment technique that determines respondents' real readiness to pay for or acceptance of a specific product or service. Therefore, the procedure is applicable in all circumstances (Akhtar et al., 2014). CVM has mainly been used for non-commercial items, especially those that have to do with resources or goods for the environment. Within this context, a fictitious market for non-commercial objects is explained, and the participants are requested to provide their WTPs (or WTAs) (Akhtar et al., 2014). Subject interviews, which can be conducted by phone, mail, or in person, are a component of the CVM study (Xie & Zhao, 2018). At the start of a typical CVM study, the participants are usually informed about the environmental resource being studied (such as air quality), the proposed change

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to the environmental resource, and the technique to be used to finance the proposed change in the environmental quality (Jones et al., 2017). This information is provided to familiarize the respondents with the change that will be evaluated and increase the probability that they will give truthful and precise answers. The respondents were then asked about their willingness to pay considering this information (Xie & Zhao, 2018). To confirm the given WTP (or WTA) and to gather socioeconomic background information, follow-up questions related to gender, age, employment, and income are usually included. The willingness-to-pay (WTP) of residents in Kuching for household e-waste recycling in this research may reflect the residents' concern for a better environment, contributing to reducing environmental pollution caused by improper household e-waste disposal. Researchers utilize the WTP concept to instill value into something of zero market value (Daud et al., 2012).

The contingent valuation method (CVM) plays a crucial role in this research as it is used to determine every respondent's WTP for household EWM in Kuching. The CVM approach allows the research participants to state their preferred WTP in monetary values (MYR) for recycling based on a percentage of the cost of household electrical appliances that the respondents bought in the market. This expresses the WTP for environmental benefits or the willingness to pay for the prevention of environmental pollution through HEWR (household e-waste recycling) (Carson, 2000). However, the actual values of currency that the residents in this research are willing to pay can only be obtained by multiplying the chosen percentage by the current market values of the respective household electrical items listed.

In assessing WTP among the residents of Kuching, there are two ways to obtain the results: open-ended questions and multiple-choice questions (Zhen et al., 2011). In this paper, results are obtained by using a range of percentages from which respondents must choose, ranging from less than 1% to more than 5%. This allows future researchers to use the same method to obtain relevant data and discover the range of percentages based on the purchase value of household electrical appliances.

The study employed a descriptive research design. The residents' willingness to pay (WTP) for household e-waste recycling (HEWR) in Kuching, Sarawak, is captured through a questionnaire survey. The population of the study was the households in Kuching. The cluster sampling method was used to select a total of 397 respondents representing 397 households residing in the Kuching, Bau, and Lundu districts of the Kuching Division in Sarawak for this study. A questionnaire survey was administered among the selected residents living in Kuching, Sarawak. A descriptive analysis was carried out, and the results are presented.

The number of households in Sarawak against the respective divisions is shown below, which presents the enumerative values of households against the targeted divisions for this research:

1. Kuching – 133,687 households (336 representatives)
2. Bau – 11,166 households (28 representatives)
3. Lundu – 7,900 households (19 representatives)

Hence, the sample size chosen in this study was based on the following equation proposed by Cochran (1963) for unlimited sampling:

$ss' = Z^2(p(1-p)) \div d^2$

$ss' = 1.96^2\ (0.5)(0.5) \div 0.05^2 = 384.16$

Where:

– Z = Z value (1.96 for a 95% confidence level)

– p = percentage (%) of respondents in the sample size who expressed a choice, depicted in decimal form

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(0.5 utilized for the required sample size)

– d = confidence interval 5% (decimal = 0.05)

The above equation shows it is best suited for infinite sampling (Cochran, 1963). However, since the total number of households in Kuching is known, the known number of households in a population sample can be expressed as follows:

ss' = ⟦Z^2(p(1-p))⟧ ÷ d^2

ss' = 1.96^2 (0.5)(0.5) ÷ 0.05^2 = 384.16

; Where is the sample size and F is the population size of the study (F = 152,753).

Therefore, would be greater or equal to the number of 383 respondents in the survey. In this research, the result of the total number of respondents who showed interest in providing data to the cause of the study is a total number of 397 individuals from different households in Kuching.

FINDINGS AND DISCUSSION

The WTP for E-Waste Recycling

Table 2: Accountability of household e-waste recycling

Household E-Waste Recycling Responsible Parties	Frequency	Percentage
My family members and/or I	140	35.3
My housemates/flat mates	2	0.5
My landlord/house owner	6	1.5
Electrical household appliance manufacturers	42	10.6
Electrical household appliance retailers	20	5
The Local Council	84	21.2
The Malaysian Federal Government	61	15.4
The Sarawak State Government	42	10.6
Total	**397**	**100**

Source: Survey (2021)

Table 2 presents the respondents' perceptions regarding the parties that should be held accountable for household e-waste recycling. More than one-third of the respondents (35.3%) noted that family members and themselves are responsible for paying for household e-waste recycling. Approximately one-fifth (21.2%) of the respondents indicated that the local council should bear the costs of household e-waste recycling. A total of 61 respondents (15.4%) mentioned that the Malaysian federal government is responsible for covering the cost of e-waste recycling, and 10.6% specified that electrical household appliance manufacturers and the Sarawak State Government should be accountable for the costs of household e-waste recycling. Only a few respondents (5%) mentioned that electrical household appliance retailers should bear the costs of household e-waste recycling. This evidence shows that despite one-third of the respondents indicating their responsibility for paying the cost of e-waste recycling, a significant number of Kuching residents still believe that e-waste management is the responsibility of others. In contrast to the findings of a study conducted by Bhattarai (2015), where the majority (70%) of households in Nepal's Banepa Municipality were willing to pay for improved solid waste management, only 30% of them were unwilling to pay for it.

Table 3 further presents the viewpoints of Kuching residents regarding their willingness to pay if the Malaysian government were to impose a fee for e-waste recycling services on their purchases of new household electrical and electronic appliances.

Table 3: Household Appliance Taxation

Types of household electrical appliances	No	Yes
New Washing Machine Taxation	50.10%	49.90%
New Fridge Taxation	50.60%	49.40%
New Fan Taxation	59.40%	40.60%
New Steam Iron/Iron taxation	65.70%	34.30%
New Air Conditioner Taxation	55.20%	44.80%
New Television Taxation	57.70%	42.30%
New Computer/Laptop taxation	58.90%	41.10%
New Speakers/Sound Systems Taxation	67.00%	33.00%
New Rice Cooker taxation	66.20%	33.50%
New Blender Taxation	68.80%	31.20%

Source: Survey (2021)

Table 3 shows that more than half of the respondents (indicated by a percentage greater than 50%) were not willing to pay any taxation or fees imposed by the government for e-waste recycling services on their purchases of electrical and electronic items. The largest percentage of objections to the government's imposition of taxation or fees for recycling services came from purchasers of new blenders (68.8%). This was followed by those who purchased new speakers/sound systems (67.0%), new rice cookers (66.2%), new steam iron/iron (65.7%), new fans (59.4%), new televisions (57.7%), new air conditioners (55.2%), new fridges (50.6%), and new washing machines (50.1%). The findings indicate that only 31.2% (for new blenders) to 49.9% (for new washing machines) of the respondents were willing to pay taxes to the government for recycling fees on their purchases of these new electrical and electronic goods. This raises concerns about the increasing amount of electronic and electrical waste generated without many being willing to pay for e-waste recycling services.

This problem needs to be addressed properly since there is a growing global demand for electrical and electronic goods, indicating an increase in the amount of electronic waste being generated and collected. Additionally, the steady rise in the amount of electronic trash produced is recognized as a significant socio-environmental issue (Koshta et al., 2022; Nguyen et al., 2021; Zhong et al., 2022). Although the systematic procedure for recycling waste from households is improving in Malaysia (Begum et al., 2006), economic incentives for household e-waste recycling have little economic value in industrialized nations. This is in contrast to developing countries, where consumers are expected to derive economic benefits from the disposal of their end-of-life (EOL) household e-waste (Wong, 2015).

On the other hand, a cross-tabulation analysis was performed on groups of respondents based on their age, gender, household location by district, individuals living with, number of household members, education level, and monthly income level, concerning their willingness to pay for household e-waste recycling based on the value of their purchases. The findings of the study are presented in Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, and Table 10, respectively.

Table 4: Cross-tabulation of age and willingness to pay for household e-waste recycling

Age and willingness to pay for e-waste recycling based on the percentage of purchased values	18 to 25 years	26 to 35 years	36 to 45 years	46 to 55 years	56 to 65 years	Chi-Square	Sig
0	69	67	35	20	8	44.657	0.024
Less than 1%	16	20	11	0	2		
1.00%	19	14	3	1	5		
2.00%	21	9	6	0	2		
3.00%	13	11	1	2	1		
4.00%	4	1	0	0	0		
5.00%	17	3	4	1	1		
More than 5%	5	2	1	2	0		

Source: Survey (2021)

Table 4 shows a cross-tabulation analysis performed on the age of the respondents and their willingness to pay for the recycling of household e-waste. The result of the Pearson Chi-square test with a p-value of 0.024 and a value of 44.657 signifies that there is a significant association between age and respondents' willingness to pay for recycling. Therefore, age differences affect the willingness of Kuching residents to pay for the recycling of household e-waste.

Table 5: Cross-tabulation between gender and willingness to pay for recycling

Gender and WTP for Household E-Waste Recycling	Female	Male	Chi-Square	Sig.
0	110	89	4.115a	0.766
Less than 1%	33	16		
1.00%	24	18		
2.00%	26	12		
3.00%	17	11		
4.00%	3	2		
5.00%	16	10		
More than 5%	6	4		

Source: Survey (2021)

Table 5 presents a summary of the findings obtained from cross-tabulation analysis conducted on the gender of the respondents and their willingness to pay for e-waste recycling. The values of Pearson Chi-square (4.115) and p-value (0.766) in Table 5 indicate that there is no significant association between gender and the willingness to pay for household e-waste recycling among the residents in Kuching. This contradicts the results of a study conducted by Bhattarai (2015), which suggested that the sex of the respondents is a significant factor influencing the willingness to pay for improved solid waste management among households. The difference in results could be attributed to the fact that both male and female participants in our study had limited knowledge or awareness regarding e-waste recycling and its importance.

On the other hand, Table 6 displays the results of the cross-tabulation analysis performed on the household location by district and the willingness to pay for the recycling of household e-waste.

Table 6: Cross-tabulation of household location and willingness to pay for e-waste recycling

Household Location by District					
Willingness to pay for e-waste recycling based on the percentage of its purchased values	**Bau**	**Kuching**	**Lundu**	**Chi-Square**	**Sig**
0	15	169	15	17.004a	0.256
Less than 1%	2	47	0		
1.00%	2	38	2		
2.00%	6	32	0		
3.00%	1	26	1		
4.00%	1	4	0		
5.00%	1	24	1		
More than 5%	0	10	0		

Source: Survey (2021)

According to Table 6, the values of Pearson Chi-square and p-value are 17.004 and 0.256, respectively. This indicates that there is no significant association between household location by district and the respondents' willingness to pay for e-waste recycling. Therefore, the district of residence, such as Bau, Kuching, and Lundu, does not significantly affect the willingness to pay for the recycling of household e-waste. This finding is interesting since it contradicts the results of Bhattarai's study (2015), which suggested that household location significantly influences the willingness to pay for improved solid waste management. The similarity in infrastructure facilities across all districts in the Kuching division of Sarawak might explain this difference.

Additionally, we conducted a cross-tabulation analysis on the individuals with whom the respondents are living and their willingness to pay for the recycling of household e-waste. The results are presented in Table 7

Table 7: Cross-tabulation of individuals living with and willingness to pay for households' e-waste recycling

Individual Respondents Living With					
Willingness to pay for e-waste recycling based on the percentage of its purchased values	**Alone**	**Family**	**Non-Family Members**	**Chi-Square**	**Sig**
0	16	172	11	9.162a	0.821
Less than 1%	1	45	3		
1.00%	4	37	1		
2.00%	3	33	2		

3.00%	2	26	0		
4.00%	0	5	0		
5.00%	1	24	1		
More than 5%	2	7	1		

Source: Survey (2021)

The Pearson Chi-square value of 9.162 and the p-value of 0.821 indicate that there is no significant association between the individuals with whom the respondents are living and their willingness to pay for e-waste recycling. In other words, whether the resident is staying alone or with family or non-family members does not significantly affect the willingness to pay for household e-waste recycling in Kuching.

Table 8 shows the results of the cross-tabulation analysis conducted on the number of household members and the willingness to pay for the recycling of household e-waste.

Table 8: Cross-tabulation of the number of household members and willingness to pay for e-waste recycling

Willingness to pay for e-wasterecycling based on the purchased value percentage and number of household members	Less than 3 members	3 to 5 members	6 to 9 members	More than 9 members	Chi-Square	Sig
0	57	59	32	51	26.52	0.187
Less than 1%	14	20	7	8		
1.00%	13	14	3	12		
2.00%	9	8	6	15		
3.00%	12	8	3	5		
4.00%	1	1	0	3		
5.00%	4	9	9	4		
More than 5%	4	2	2	2		

Source: Survey (2021)

In Table 8, the Pearson Chi-square value of 26.52 and the p-value of 0.187 suggest that there is no significant association between the number of household members and the respondents' willingness to pay for e-waste recycling in Kuching. This result does not support the hypothesis that a greater number of household members indicates a higher willingness to pay for the recycling of household e-waste. This finding contradicts the findings of Bhattarai (2015), which indicated that household size is a significant factor influencing the respondents' willingness to pay for improved solid waste management.

Table 9: Cross-tabulation between education level and willingness to pay for e-waste recycling

Willingness to pay for e-waste recycling based on the purchased value percentage and education level	Primary School	Secondary School	Pre-University	Bachelor's Degree	Master's Degree	Doctor of Philosophy/PhD	Chi-Square	Sig
0	2	24	51	100	19	3	28.34	0.78
Less than 1%	0	4	10	29	5	1		

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1.00%	0	8	13	17	4	0		
2.00%	0	5	14	15	4	0		
3.00%	0	2	9	13	4	0		
4.00%	0	1	0	4	0	0		
5.00%	0	2	11	12	1	0		
More than 5%	0	2	1	4	2	1		

Source: Survey (2021).

Table 9 displays the results of the cross-tabulation analysis performed on the education level and the willingness to pay for the recycling of household e-waste in the Kuching division. The Pearson Chi-square value (28.34) and the p-value (0.78) reveal that there is no significant association between education level and the respondents' willingness to pay for e-waste recycling in Kuching. This finding again contradicts the findings of previous studies (Bhattarai, 2015; Ezebilo, 2013), which indicated that educational level does affect the willingness to pay for improved solid waste management among households.

Moreover, a cross-tabulation analysis was conducted on the respondents' monthly income and their willingness to pay for the recycling of household e-waste. Table 10 provides a summary of the findings.

Table 10: Cross-tabulation of monthly income level and willingness to pay for e-waste recycling.

Purchased value percentage of new household electrical appliances

Monthly Income Level	< 1%	1.00%	2.00%	3.00%	4.00%	5.00%	> 5%	Chi-Square	Sig.
RM0-RM999	21	20	21	16	6	7	21	92.223	0.746
RM1,000-RM1,499	7	6	7	8	0	4	7		
RM1,500-RM1,999	6	4	7	8	1	10	9		
RM2,000-RM2,499	4	9	7	3	0	2	3		
RM2,500-RM2,999	7	8	4	2	0	2	5		
RM3,000-RM3,499	3	7	4	5	0	1	7		
RM3,500-RM3,999	4	2	1	2	0	3	2		
RM4,000-RM4,499	1	2	4	4	0	2	2		
RM4,500-RM4,999	1	3	0	4	1	1	0		
RM5,000-RM5,499	4	2	3	3	0	1	3		
RM5,500-RM5,999	0	1	1	1	0	1	0		
RM6,000-RM6,499	3	1	1	1	0	0	4		
RM6,500-RM6,999	3	0	0	0	0	1	0		
RM7,000-RM7,499	0	2	1	1	0	1	0		
RM7,500-RM7,999	1	0	0	2	0	1	2		
RM8,000-RM8,499	4	2	2	0	0	1	1		
RM8,500-RM8,999	2	1	1	1	0	0	0		
RM9,000 and above	5	3	2	2	0	2	5		

Source: Survey, 2021.

The Pearson Chi-square value of 92.223 and the p-value of 0.746 in Table 10 indicate that there is no significant association between the monthly income level and the respondents' willingness to pay for e-waste recycling in Kuching. Therefore, this finding rejects the hypothesis that a higher monthly income level indicates a higher willingness to pay for the recycling of household e-waste. These findings also contradict the findings of Ezebilo (2013), which suggest that income affects respondents' willingness to pay for improved residential solid waste management.

Table 11 Types of Household Electrical Appliances and Respondent Willingness to Pay for E-Waste Recycling based on Purchased Value Percentage

	Less than 1%	1.00%	2.00%	3.00%	4.00%	5.00%	More than 5%	WTP value (Average)
Washing Machine	17.60%	19.60%	16.90%	15.60%	2.00%	9.80%	18.40%	2.668
Fridge	19.10%	18.40%	16.60%	15.90%	2.00%	10.10%	17.90%	2.342
Fan	23.40%	18.60%	15.90%	15.10%	2.50%	9.80%	14.60%	2.483
Steam Iron/Iron	25.40%	20.20%	14.60%	13.90%	3.30%	7.80%	14.90%	2.449
Air Conditioner	18.10%	17.60%	18.10%	15.40%	2.30%	10.80%	17.60%	2.356
Television	19.10%	19.40%	15.60%	15.60%	3.00%	10.10%	17.10%	2.363
Computer/ Laptop	19.10%	17.10%	16.60%	15.10%	2.30%	11.80%	17.90%	2.402
Speaker/ Sound system	24.40%	18.10%	15.60%	15.40%	2.30%	9.30%	14.90%	2.488
Rice Cooker	24.90%	19.10%	14.40%	15.40%	3.00%	8.60%	14.60%	2.487
Blender	26.20%	19.60%	15.10%	13.60%	2.30%	8.30%	14.90%	2.461

Source: Survey, 2021.

Table 11 presents the respondents' willingness to pay for e-waste recycling based on the purchased value of their electrical and electronic appliances. The study evaluated how much respondents would be willing to pay for e-waste recycling based on the value of the electronic gadgets they purchased. The findings revealed that approximately one-fifth (19.6%) of washing machine owners are only willing to pay 1% of the purchased value of their electrical and electronic appliances for e-waste recycling. Similarly, about one-fifth (19.1%) of fridge and laptop/computer owners are willing to pay less than 1% of the purchased value for recycling. Approximately 23.4% of respondents who own fans expressed their willingness to pay less than 1% for e-waste recycling costs. Regarding other appliances, approximately one-quarter of steam iron owners (25.4%), speaker/sound system owners (24.4%), and rice cooker owners (24.9%) stated that they were willing to pay less than 1% for recycling. For air conditioner owners, less than one-fifth (18.1%) expressed a willingness to pay less than 1% of the e-waste recycling cost. About one-fifth (19.4%) of television owners declared their readiness to pay 1% of the recycling costs. Slightly more than one-quarter (26.2%) of blender owners indicated that their willingness to pay for recycling is less than 1%. These findings demonstrate that only a small proportion of the surveyed respondents (less than one-fifth) are willing to pay more than 5% of the e-waste recycling costs for washing machines, fridges, fans, steam irons, air conditioners, televisions, computers/laptops, speaker/sound systems, rice cookers, and blenders.

However, except for owners of air conditioners and computers/laptops, most owners of other electrical appliances were more inclined to pay less than 1% rather than more than 5% of the e-waste recycling value. The study findings suggest that most of the population in Kuching, Sarawak is unwilling to pay for recycling e-waste items. However, other studies (Afroz et al., 2009) have shown that residents in areas with garbage collection service regions have higher mean willingness-to-pay values compared to those in areas without such services, although the difference was not statistically significant. This lack of willingness to pay may be attributed to the population lack of awareness about environmental conservation. These findings align with a study done by Islam, Huda, Baumber, Hossain and Sahajwalla (2022), which found that while consumers generally recognize the harmful effects of improper disposal, they often fail to act accordingly when disposing of used batteries. The main factors influencing improper disposal behavior among most customers were limited information regarding collection locations for discarded batteries and lack of convenience (Islam et al., 2022). Thus, raising awareness is crucial to educate the public about the importance of environmental consciousness, particularly in terms of e-waste management and proper e-waste disposal locations in Kuching.

To examine the association between demographic factors and willingness to pay for e-waste recycling based on the purchased value of the appliance in the binary stage, a binary logistic regression was employed. Table 12 presents the study's findings, indicating that, apart from the age of respondents, all other demographic factors were not significantly correlated with willingness to pay for e-waste recycling.

Table 12 Logistic Regression Results

Characteristics	B	S.E.	Wald	df	Sig.	Exp(B)
1. Age of the Respondents	-0.012	0.011	1.234	1	0.024	0.988
2. Gender	0.416	0.257	2.633	1	0.105	1.516
3. Household Location by District	0.565	0.503	1.265	1	0.261	1.76
4. Household Location by Area	-42.406	49225.37	0	1	0.999	0
5. Individuals respondents live with	-1.044	0.68	2.356	1	0.125	0.352
6. Number of Household Members (Including respondent)	0.048	0.066	0.532	1	0.466	1.05
7. Education Level	-21.397	28420.72	0	1	0.999	0
8. Household Monthly Income	1.609	1.125	2.045	1	0.153	5

Source: Survey, 2021.

Table 12 also demonstrates a statistically significant association between the age of respondents and their willingness to pay for e-waste recycling for the acquired appliances ($p < 0.05$). A marginal change in respondents' age would correspond to a 0.988 times change in their willingness to pay for e-waste recycling. This suggests that the age of respondents has a minimal impact on their willingness to pay for e-waste recycling. Gender, on the other hand, was not found to have a statistically significant correlation with respondents' willingness to pay for the recycling of their electronic waste ($p > 0.05$).

Furthermore, the willingness to pay for e-waste recycling of the acquired appliances was not significantly related to the respondents' household location by district ($p > 0.05$). This implies that the geographic location of households within different districts does not influence their willingness to pay for e-waste recycling in Kuching. This might be due to the similar attitudes regarding willingness to pay for e-waste across different areas.

In addition, there was no statistically significant correlation between household membership, the number of household members, and their willingness to pay for the recycling of electronic waste ($p > 0.05$). Similarly, as mentioned earlier, education level and income were not found to be statistically associated with willingness to pay for e-waste recycling among residents of Kuching.

CONCLUSION

This study focused solely on households' e-waste management, specifically the willingness to pay (WTP) for household e-waste recycling among residents in Kuching, Sarawak, in the sampled population. In addition, only ten types of common household electrical and electronic appliances were selected to assess the respondents' willingness to pay for e-waste recycling. These ten appliances are the most commonly used by Malaysian residents and include washing machines, fridges, fans, steam irons, air conditioners, televisions, computers, speakers, rice cookers, and blenders. As the sampled population may not be fully representative of the entire population in the Kuching division of Sarawak, no generalizations can be made from the findings of this study. However, the results provide insights for policymakers and relevant authorities regarding the state of e-waste management and the willingness to pay for e-waste recycling among the surveyed population in Kuching. The policy implications of this study are essential for developing more efficient and sustainable waste management strategies in a rapidly growing city like Kuching, Sarawak. It may be feasible to impose a small recycling fee only on respondents who indicated their willingness to pay for e-waste recycling in Table 3.

The findings of this study revealed that most households disposed of their household e-waste to garbage collectors. Based on the study's findings, it is evident that most respondents have a low willingness to pay for the recycling of household e-waste. Instead, most agreed that the Sarawak government, municipal councils, and the manufacturers of EEE should bear the recycling costs of their household e-waste. Additionally, it is important to note that among all the demographic factors associated with the residents' willingness to pay for household e-waste recycling in Kuching, only age plays a significant role in affecting WTP for household e-waste recycling. There was no statistically significant association between the level of household income or education and their WTP for household e-waste recycling. Furthermore, other variables such as gender, household location, with whom the residents are living, and the number of household members are also insignificant in affecting their willingness to pay for household e-waste recycling, based on the survey carried out in Kuching, Sarawak.

However, contrary to the findings from Zhong, Zhou, Zhao, Zhang Nie and Simayi (2022), the age factor is found to have a significant relationship with WTP for household e-waste recycling in Kuching, Sarawak. This result may indirectly reflect the hypothesis that presumes the older the age of residents, the higher their willingness to pay, and vice versa. This might be explained by the assumption that the older an individual is, the more knowledge they gain, and thus their awareness level of the proper management of household e-waste also increases (Afroz et al., 2009). Based on the estimation of WTP for household e-waste recycling utilizing the contingent valuation method, it was determined that WTP for household e-waste recycling among the majority of households is less than 1% of the purchased value of new household electrical appliances.

RECOMMENDATION

The study findings demonstrated that most of the respondents expressed a low willingness to pay for household e-waste management, and the level of education did not seem to improve respondents' willingness to pay for proper e-waste management. Therefore, the findings of this study imply an urgent need for closer collaboration among relevant authorities toward more sustainable e-waste management among households in the city area of Kuching, in particular.

Therefore, it is recommended that the Ministry of Housing and Local Government, the Ministry of Health, academic institutions, Non-Governmental Organizations, and the Ministry of Environment work hand in hand to provide more concrete information about proper e-waste management by instilling awareness among them. This could be done through free seminars, workshops, and training sessions that will provide residents with insight into the need to observe e-waste recycling. If e-waste management is not strictly monitored and controlled, illegal actions such as discarding household e-waste into the ocean or rivers will endanger the lives and well-being of nature (Koop & Van, 2017).

Research carried out by Hamzah, Tengku and Adura (2011) affirms that e-waste recovery facilities are essential in the management of domestic e-waste. However, the critical technology used in e-waste recovery is limited to electrolysis and wet chemical processes. All e-waste recovery facilities in Malaysia are mainly built and operated by private organizations. Therefore, it is recommended that a more holistic approach to e-waste management be established, involving a collaborative effort among all key stakeholders with strong institutional support, to improve the current e-waste management, particularly among households in big cities like Kuching, Sarawak.

Although a study on e-waste management in Sarawak was carried out by Suhaili and Abdullah (2023), it is shown that their population sample mostly involved young adults aged 21 to 25 years old. It is believed that future studies should cover a greater range of ages throughout Sarawak, as no generalization can be made due to the insufficiency of demographic information in their study. However, more resources are required to conduct a study of e-waste management on a larger scale in Sarawak due to its significant size in Malaysia. Nevertheless, Suhaili and Abdullah (2023) have also discovered that among their respondents, the knowledge about how to manage e-waste is relatively high in Sarawak. Hence, this contradicts the results shown in this paper, where there is no association between education level and willingness to pay (WTP) for e-waste recycling in Kuching. This aspect provides a research gap, allowing future researchers to investigate the reasons why there is no association when education should play a vital role in a person’s contribution to a better environment free from the pollution of household e-waste.

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