UNIVERSITI PUTRA MALAYSIA

HOUSEHOLDS' PERCEPTIONS OF SERVICE QUALITY AND ECONOMIC VALUATION OF ELECTRONIC WASTE RECYCLING IN PUTRAJAYA, MALAYSIA

NAZATUL FAIZAH BINTI HARON

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By

NAZATUL FAIZAH BINTI HARON

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chair: Associate Prof. Shaufique Fahmi Bin Ahmad Sidique, PhD

Faculty: Economics and Management

The importance of electronic waste (e-waste) management became a growing concern, especially in developing countries and over international boundaries. Therefore, effective management systems need to be created and infrastructure facilities for recycling needs to be developed to prevent an accumulation of e-waste that contain hazardous materials in landfill areas. However, an understanding of people's willingness to recycle e-waste is important. This research aims to identify the perceptions of service quality, determinant factors of e-waste recycling, and examine the economic valuation on recycling preferences.

Several methods were used in this research, namely, Critical Incident Technique (CIT), Factor Analysis (FA) and Choice Modelling (CM). A total of 600 respondents were randomly selected in nine precincts in Putrajaya. The CIT methods were used to analyse the satisfaction or dissatisfaction level. Five successful constructs were identified and prioritised, namely 'Good Feeling', 'Secured Environment', 'Facilities and Efficiency', 'Educational' and 'Peer Pressure'. Recovery strategies were also recorded and evaluated for response and recovery service dissatisfaction. Meanwhile, the FA method was used to identify the influencing factors in e-waste recycling with an applied logit model for regression. The most significant factors that contribute to recycling behaviour are: 'Attitude', 'Belief', 'Convenience' and 'Social Pressure', in addition to socioeconomic factors, such as 'Education' and 'Income'. People who have a higher income and higher education levels are more likely to recycle. To examine the economic valuation in recycling preferences, choice modelling (CM) was used to evaluate the recycling service attributes with applied conditional logit (CL) to estimate marginal value of the attributes. The results suggest that people are concerned about separation of waste in recycling services.

The findings outline policy recommendations to policy makers, the waste management industry and consumers: especially when faced with existing issues on activities and recycling services. As recycling and environmental issues are gaining national attention, government agencies are charged with promoting and increasing recycling behaviour with an emphasis on the motivation and importance of information as necessary components of any campaign. Even though many local communities made recycling more accessible through a 'drop-off program', that program alone however is not sufficient to optimise rates of recycling. Residents must understand details of how to recycle their e-waste with the help of accessible recycling information, providing rationale and motivation to individuals in order to promote recycling activity and guiding them in necessary recycling skills. In addition, greater exposure to environmental issues and recycling through public service announcements, public forum and media will help to enhance individual motivation as well as improving the recycling facilities to cope with problems in the provision of better services in the future.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PERSEPSI ISI RUMAH TERHADAP KUALITI PERKHIDMATAN DAN PENILAIAN EKONOMI TERHADAP KITAR SEMULA SISA ELEKTRONIK DI PUTRAJAYA, MALAYSIA

Oleh

NAZATUL FAIZAH BINTI HARON

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Pengerusi: Prof. Madya Shaufique Fahmi Bin Ahmad Sidique, PhD

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Kepentingan pengurusan sisa elektronik semakin mendapat perhatian khususnya dari negara-negara maju dan masyarakat antarabangsa amnya.Oleh itu, sistem pengurusan yang efektif haruslah di wujudkan dan kemudahan insfrastruktur kitar semula perlu di bangunkan untuk membendung dan menghentikan pengumpulan sisa elektronik yang mengandungi komponen merbahaya dari tapak pelupusan. Walaubagaimanapun, pemahaman berkenaan kesanggupan pengguna untuk melakukan kitar semula terhadap sisa elektronik sangat penting. Oleh yang demikian, kajian ini antaranya adalah untuk mengenalpasti mutu perkhidmatan kitar semula, menyelidik faktor penentu kitar semula sisa elektronik dan melakukan penilaian ekonomi terhadap keutamaan kitar semula.

Antara kaedah yang digunakan adalah Critical Incident Technique (CIT), Faktor Analisis (FA) dan Choice Modelling (CM). Seramai 600 responden dipilih secara rawak di setiap presint Putrajaya. Untuk menilai perkhidmatan kitar semula, kaedah CIT di gunakan untuk menganalisis tingkat kepuasan atau ketidakpuasan terhadap perkhidmatan. Lima kategori terhadap kepuasan perkhidmatan di kenalpasti dan di beri keutamaan iaitu, *'PerasaanYang Baik'*, *'Pemeliharaan Alam Sekitar'*, *'Kemudahan dan Kecekapan'*, *'Pendidikan'* dan*'Tekanan Rakan Sebaya'*. Strategi pemulihan juga direkod dan dinilai untuk tindakan dan pemulihan ketidakpuasan perkhidmatan. Kaedah FA digunakan untuk mengenal pasti faktor-faktor yang mempengaruhi aktiviti kitar semula sisa elektronik dengan menggunakan model logit. Antara faktor yang signifikan dalam menyumbang kepada gelagat kitar semula adalah seperti *'Sikap'*, *'Kepercayaan'*, *'Keselesaan'* dan *'Tekanan Sosial'* selain dari faktor sosio ekonomi seperti *'Pendidikan'* dan *'Pendapatan'*. Responden yang berpendapatan dan berpendidikan tinggi di lihat lebih cenderung untuk melakukan aktiviti kitar semula sisa elektronik. Manakala, di dalam kaedah CM terdapat sifat-sifat perkhidmatan kitar semula seperti kaedah pengumpulan, pengasingan sisa, perolehan kembali bahan kitar

semula dan harga tambahan peralatan elektronik. Model *Conditional Logit* (CL) digunakan untuk menganggar nilai margin bagi sifat-sifat tersebut. Hasil kajian mendapati orang ramai mengutamakan sifat pengasingan di dalam perkhidmatan kitar semula.

Penemuan kajian menggariskan cadangan polisi kepada penggubal dasar, industri pengurusan sisa dan pengguna terutamanya kepada isu yang timbul di dalam aktiviti dan perkhidmatan kitar semula. Melihat kepada isu alam sekitar dan kitar semula yang telah mendapat perhatian Negara, agensi-agensi kerajaan di saran untuk menggalakkan dan meningkatkan gelagat kitar semula dengan menekankan motivasi dan maklumat yang penting sebagai antara komponen yang diperlukan terhadap mana-mana kempen yang dibuat. Walaupun masyarakat tempatan telah memilih kitar semula lebih mudah di akses menerusi 'program drop-off' tetapi program itu sahaja tidak mencukupi untuk mengoptimakan kadar kitar semula. Masyarakat seharusnya memahami secara terperinci berkenaan cara untuk melakukan aktiviti kitar semula dengan di bantu oleh maklumat kitar semula yang mudah diakses, penyediaan motivasi yang rasional kepada individu untuk mempromosikan aktiviti kitar semula dan membimbing mereka di dalam kemahiran terhadap kitar semula dan isu-isu kitar semula menerusi hebahan perkhidmatan awam, forum awam dan media yang akan turut membantu untuk meningkatkan motivasi individu dan juga meningkatkan kemudahan-kemudahan kitar semula bagi mengatasi masalah dalam penyediaan perkhidmatan yang lebih baik pada masa hadapan.

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I certify that a Thesis Examination Committee has met on 29 June 2015 to conduct the final examination of Nazatul Faizah binti Haron on her thesis entitled "Households'

Perceptions of Service Quality and Economic Valuation of Electronic Waste Recycling in Putrajaya, Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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LIST OF ABBREVIATIONS

BFR	Brominated Flame Retardants
CBA	Cost and Benefits Analysis
CFA	Confirmatory Factor Analysis
CIT	Critical Incident Technique
CM	Choice Modelling
DOE	Department of Environment
EEE	Electrical and Electronic Equipment
EFA	Exploratory Factor Analysis
EHA	Electronic Home Appliances
EPA	Environmental Protection Agency
EPR	Extended Producer Responsibility
ERP	E-waste Recycling Practices
FA	Factor Analysis
HARL	Home Appliance Recycling Law
HPM	Hedonic Pricing Method
LCA	Life Cycle Assessment
MFA	Material Flow Analysis
NDRC	National Development and Reform Committee
RFMB	Recycling Fund Management Board
SEPA	State Environmental Protection Administration
SMD	Surface Mount Devices
SWG	Solid Waste Generation
TCM	Travel Cost Method
UNEP	United Nations Environmental Programme
WEEE	Waste Electrical and Electronic Equipment

CHAPTER 1

INTRODUCTION

Electrical and electronic waste, which is formally known as waste from electrical and electronic equipment (WEEE), or in short called e-waste, is used to describe obsolete or end of life (EOL) electrical and electronic equipment (EEE). E-Waste is the most rapidly growing waste problem in the world, and this type of waste includes all household equipment, big and small. These include: television sets, washing machines, sewing machines, computers, irons, toasters, calculators, cellular phones, printer cartridges, etc. Historically, waste from the consumption and production of electronic products were typically burned, put in landfills, hoarded in storage or sometimes dumped into oceans and other water bodies. These handling methods generate a bad public image through negative impacts on environmental and human health. E-Wastes are considered dangerous, as certain types of electrical and electronic products contain hazardous chemicals and disposal of such e-wastes became a major problem in recent years.

Proper management of e-waste is of concern not only because of a tremendous increase in quantity, but also an increase in handling complexity. E-Wastes reached precarious levels because of toxic contents like mercury, which can accumulate in the kidney and liver and cause neural damage; while cadmium, which has an irreversible toxic effect on human health whereas lead affects brain development in children and can damage central peripheral nervous systems. Other toxic materials include beryllium, barium and brominated flame retardants (BFRs). Brominated flame retardants are organic compounds that have an inhibitory effect on the ignition of combustible organic materials. It was routinely added to consumer products for several decades in a successful effort to reduce fire-related injuries and property damage. These chemicals are highly toxic, and they pose both environmental health and occupational hazards.[1]

Approximately, 20-25 million tons per year of e-waste is produced globally, with most e-waste being produced in Europe, the United States and Australasia. Meanwhile, countries like China, Eastern Europe and Latin America will become major e-waste producers in the next ten years (Robinson, 2009). Due to huge amounts of e-waste that needs to be disposed every year, many countries began to institute proper monitory and management of e-waste. Effective monitoring and management were practiced in some countries. In the Asian region, Japan, North Korea, China, South Korea and Taiwan implemented the Extended Producer Responsibility (EPR) to electrical and electronic manufacturers. EPR is a strategy designed to promote the integration of environmental costs associated with goods throughout their life cycles into the market price of the

[1] http://www.greenpeace.org

product. EPR encourages manufacturers to design environmentally-friendly products by holding producers liable for the costs of managing their products at the end of product life (Xiang and Ming, 2011).

Previously, e-waste was yet to be taken seriously by industries, governments and consumers in many countries, mainly because its impact on the public was not immediate, unlike municipal solid waste, which affects our daily life. However, under the Basel Convention (1992), which was designed to control the movements of hazardous waste between nations, e-wastes are categorised as hazardous wastes and are presently under greater control. This means that it is being taken seriously because environmentalists are becoming alarmed with the growing number of electronic items being discarded in landfills every year. The Basel Convention has 175 parties and aims to protect human health and the environment. It is the most comprehensive global environmental agreement on hazardous and other wastes. A major issue in developing countries is the existence of e-waste from electronic goods that are produced in industrialised countries. The dangerous rise in the amounts of such waste will pose health hazards and might cause pollution if the toxic materials in e-waste are not properly disposed. Asian countries are gradually having various recycling schemes. They have their own way of handling and managing e-waste. For example, Korea started their recycling policy by introducing the Waste Deposit-Refund System (1992), which are guidelines for the Improvement of Materials/Structure of Products for Stimulating Recycling (1993) and Extended Producer Responsibility System (2003). In China, policies were formulated by several ministries such as the management regulation on pollution control of electronic information products that are issued by 7 ministries, including the Ministry of Information Industry, National Development and Reform Committee (NDRC) and State Environmental Protection Administration (SEPA) since 2003[2]. As for Malaysia itself, e-waste was categorised as scheduled wastes in the First Schedule of the Environmental Quality (Scheduled Wastes) Regulations 2005, administered by the Department of Environment (DOE). In Malaysia, scheduled wastes are required to be transported to licensed recycling plants or disposed in the centralised scheduled waste treatment and disposal facility at Bukit Nenas, Negeri Sembilan.

As technology keeps progressing at an unprecedented rate, more and more diverse types of e-wastes are discarded. E-Wastes will pose serious threats to human health and the environment as a whole. However, the harmful threats on human health can be mitigated by proper enforcement of occupational safety and health provisions that govern electronics' production and assembly process. E-Wastes can also be recycled for recovery of recyclable materials as well as precious metals, such as gold and platinum and maybe some other valuable materials and this will create economic value. All issues and the crisis in the management of e-wastes have to be taken seriously by the government and the effectiveness of recycling could be achieved with the cooperation and participation of the public. With effective recycling, e-wastes can be regarded as valuable resources rather than sheer waste. One of the solutions that were identified is to recycle household electronic waste. Even though these methods were

[2] http://www.chinacp.org.cn

practiced in most countries a year ago, but in Malaysia it is still considered as a new issue and households are encouraged to recycle and be trained to think about it. In this study, the perceptions of e-waste recycling among households are highlighted and the objectives are to assess the awareness, behaviour, and participation of Putrajaya's residents in relation to e-waste recycling and the environment. Each of the objectives presented are related to each other.

1.1 Electronic waste management in Malaysia

The management of wastes in Malaysia is clearly demarcated between scheduled or hazardous waste and solid waste. Solid waste falls under the newly established Department of National Solid Waste Management whereas scheduled or hazardous waste is under the purview of the Department of Environment. Nonetheless, there is a close cooperation between the two departments because the management of these two types of waste often crisscross each other, especially in their collection and disposal. The management of electronic waste become an environmental concern in many developing countries as urbanisation continues to take place.

Electronic waste was regulated in Malaysia since 2005 under the Environmental Quality (Scheduled Wastes) Regulations. This regulation included e-waste as scheduled wastes and the 2005 regulation replaced the 1989 regulation to enable Malaysia to control trans-boundary movement of e-waste. In the schedule waste sector, the 3R (reduce, reuse, and recycle) effort by the DOE is highly concentrated on waste from electrical and electronic equipment due to the huge amounts generated in the country. The 3R program was introduced by local governments to encourage the private and the public sector to accept and practice these activities with the policy to guide them. In 2008, creation of e-waste was about 688,000 metric tons and forecasted to be 1.11 million metric tons in 2020[3]. Currently, there are 138 e-waste recovery facilities in Malaysia, consisting of 16 full recovery facilities and the others consisting of partial recovery facilities. E-Waste will be exported if the local recovery facilities do not have the capability and capacity to carry out such activities. E-Wastes are regulated under various regulations in Malaysia since 2005, such as:

- Environmental Quality (Scheduled Wastes) Regulations, 2005
- The 2005 regulation replaced the 1989 regulation in order to enable Malaysia to control trans-boundary movement of e-waste
- Guidelines for the Classification of Used Electrical and Electronic Equipment in Malaysia, 2nd edition; and
- Environmental Quality (Prescribed Premises) (Treatment) Disposal Facilities for Scheduled Wastes Regulations, 1988 (control on collection, treatment, recycling and disposal of scheduled waste, including e-waste).

According to Table 1.1, the distribution of e-waste recovery facilities in Malaysia provided by the Department of Environment Malaysia include partial and full recovery

[3]http://www.doe.gov.my

facilities. Full recyclers are those material recovery facilities with the capacity to recycle all parts of the electronic equipment they receive, while partial recyclers are those with limited capability to recycle all or part of the e-waste they receive. It can be said that these activities are concentrated on refurbishment for re-use purpose, although they also assist in separation and dismantling before sending to full recyclers.

Table 1.1: E-waste Recovery Facilities in Malaysia

State	Partial Recovery Facility	Full Recovery Facility
Johor	17	3
Kedah	12	1
Melaka	12	3
Negeri Sembilan	5	1
Perak	4	0
Pulau Pinang	37	6
Sarawak	5	0
Selangor	25	2
Wilayah Persekutuan	5	0
Total	122	16
Grand Total		138

Currently, private companies are responsible for building and operating all e-waste recovery facilities in Malaysia. The e-waste recovery facilities will pay industries or e-waste generators when they obtain the supply of e-wastes. Domestic dwellings are a source of e-waste besides the industries, and they will also be one of DOE's impending tasks. For a start, the public can send their e-wastes including: mobile phones, mobile phone's batteries and their accessories, television sets, and computers plus their accessories to the e-waste collection centres that are managed by solid waste concessionaires or local authorities. A sustainable e-waste management system is needed to safeguard public health, protect and conserve the environment, and preserve natural-resources.

1.2 Waste characteristics

In 1999, Schmidt noted that more than 400 million tons of hazardous wastes are produced worldwide as estimated by the United Nations Environmental Programme (UNEP). The fast growth of electronic wastes was demarcated as a dangerous threat to human health and possesses global environmental problems, therefore attracting increased attention at the national level. There are several examples of hazardous chemicals as listed by Ramesh Babu *et al*. (2007). Some of the toxic effects that are contained in electrical and electronics equipment (EEE) are given in the table below:

Table 1.2: Negative Effects in EEE

Toxic	Negative effect	Application
Lead	Lead is a chemical element where the effects are well established and recognised. Lead causes damage to the central and peripheral nervous systems, blood systems, kidney and reproductive systems in human.	In computers: glass panels and gasket (frit) in computer monitors, solder in printed circuit boards and other components.
Cadmium	Pose a risk of irreversible effects on human health.	Normally occurs in certain components, such as surface mount devices (SMD) chip resistors, infra-red detectors and semiconductor chips.

1.3 Problem Statement

The importance of information and communication technology to the world economy has brought about a surge in demand for electrical and electronic equipment, and Malaysia is facing the scenario whereby with economic development and technological progress, the stocks of electronic products and equipment were increasing every year. Therefore, our country will also face problems from managing and handling waste generated from these items. Moreover, improper management of electronic waste will have an adverse long term impact on the environment and human health, and we do not want to burden the next generation with this problem. In 1994, approximately 20 million PCs became obsolete and this figure increased to over 100 million in 2004. The huge proliferated numbers in terms of quantity of electronic waste will lead to a growing problem of disposal throughout the world (Widmer *et al*., 2005). Meanwhile, the amount of electronic products discarded globally skyrocketed recently. With 20-50 million tonnes generated every year, it is hard to imagine how much e-wastes will be disposed around the world[4].

[4]http://www.greenpeace.org

As a developing country, the use of electrical and electronic appliances is increasing in Malaysia due to a growing population that contributes to higher demands of electronic consumptions. This situation contributed to the disposal of electronic waste and threatens the environment and human health. Although there are various technical solutions to overcome electronic waste disposal problems, the compliance is still relatively low. And because of that, an effort towards understanding this particular issue is needed to increase awareness and participation from the whole society by implementing several programs to address this salient environmental issue, such as recycling.

Recycling is one of the activities that can reduce aggregate percentage waste sent to landfills. In Malaysia, the intractability and lack of involvement is a main constraint when we talk about recycling practices. As reported from the Borneo Post (2013), almost all Malaysian citizens are aware of the importance of e-waste recycling, but the number of those who are putting it into practice is not parallel. A previous study noted that most households do not know where and how to dispose of their electronic waste in a proper manner, because most electronic device users end up disposing their electronic devices in landfill sites without proper treatment because of no segregation mechanism, collection infrastructure and service provider. As a result, they decided to discard e-waste outside their premises together with other household wastes (Junaidah, 2010). Even though there was a poor documentation of e-waste generation recycling rates and presently no periodical and systematic analysis and documentation, there have some collection and compilation efforts by the Ministry of Housing and Local Government, which stated that only 5% of e-waste is being recycled and submitted to thermal treatment in Malaysia.

Because of this scenario, management approaches need to be included to ensure that electronic waste disposal can be reduced in a landfill. The figures released by the Department of Environment as shown below indicates the fluctuation trend of e-waste generation in Malaysia. According to the United Nations Environment Program, about 20-50 million metric tonnes will be produced annually and the rate of increase of electronic waste is about 5% worldwide.

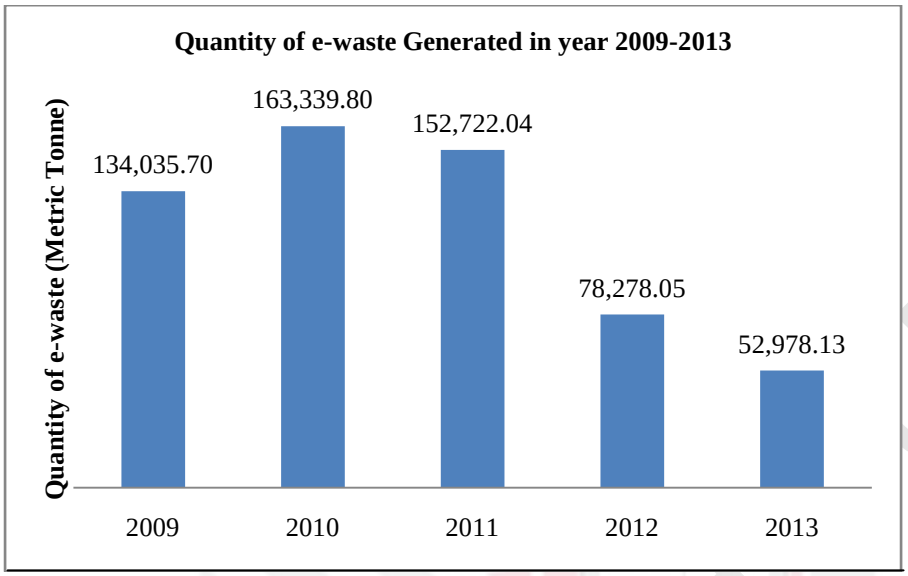

Figure 1.1: Quantity of e-waste in Malaysia
(Source: Department of Environment Malaysia)

There are various studies done by previous researchers. Researchers analysed methods to overcome solid and electronic waste dumping problems and identify actions to overcome this problem by implementing programs, such as recycling programs (Hicks *et al*., 2005), drop-off programs (Sidique *et al*., 2010), curbside collection (Matsumoto, 2011), and extended producer responsibility policy (Mckerlie *et al*., 2006). Nevertheless, most of the studies were focused on solid waste and garbage only, with slight emphasis and attention given to electronic waste management, which obviously cause pollution and also health problems (Oskamp *et al*., 1991, Valle *et al*., 2004, Giusti, 2009 and Lee and Paik, 2011). A few of the earlier studies only briefly discussed problems of consumer attitude on electronic waste disposal and actions to be taken on electronic waste (Darby and Obara, 2005, Widmer *et al*., 2005, Timlett and Williams, 2008 and Purcell and Magette, 2010). The present study will consider in greater detail one of the ways to mitigate the dangers of electronic wastes, focusing primarily on recycling activity in Malaysia. This method will be effective for conservation and it is good for the economy and the environment. This study will concentrate on finding factors that influence electronic waste recycling activities. This study will include economic valuation of recycling methods to access feasibility and benefits of e-waste recycling.

1.4 Research Objectives

i) General Objective

The general objective of this study was to assess awareness, perception and participation of Putrajaya's residents in relation to e-waste recycling and the environment.

ii) Specific Objectives

The specific objectives of this study are as follows:

1) Identify the quality of e-waste recycling services in Putrajaya
2) Investigate the determinants of households e-waste recycling in Putrajaya
3) Examine the economic valuation of recycling preferences

1.5 Significance of the study

Recent developments in the world economy brought a tremendous increase in usage of electronic appliances. A high consumption of these appliances led to disposal problems when those equipment reached their end-of-life. This phenomenon caused problems in e-waste management, which will be of increasing concern because of the hazardous materials contained in electronic appliances. High rapid population growth and urbanisation increased the demand for consumption of electronic products, and it is expected to increase over time. Preventive measures and appropriate management should be taken seriously so as to help reduce the risks to the environment and human health in the future. Therefore, recycling can be one of the solutions to facilitate these issues. The e-waste recycling infrastructure needs to be developed. However, little is known about people's willingness to fund its expansion and willingness to pay for e-waste recycling programs.

This study will help fill the gaps on the recycling behaviours, attitudes and preferences in Putrajaya. In order to attract and gain the participation and involvement from the consumers, it is important to know their inclination for recycling programs and their evaluation of the facilities for recycling. In addition, the results will be useful to develop public policy in the future for a better view and offer recommendations for policy makers to consider while they address the numerous issues in e-waste facing the nation. It is also important to see whether such policies are able to improve e-waste management in this country. Perhaps, the government will be more responsible on planning, development and management of waste in the country and will eventually achieve economic sustainability.

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