THE ELECTRONIC WASTE MANAGEMENT SYSTEMS – A COMPARISON OF THE E-WASTE MANAGEMENT POLICIES, PROCESSES AND PRACTICES AMONG SELECTED COUNTRIES IN THE GREATER MEKONG SUBREGION

BY

LI LIANG

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (ENGINEERING AND TECHNOLOGY)

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A Dissertation Presented

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LI LIANG

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Abstract

THE ELECTRONIC WASTE MANAGEMENT SYSTEMS – A COMPARISON OF THE E-WASTE MANAGEMENT POLICIES, PROCESSES AND PRACTICES AMONG SELECTED COUNTRIES IN THE GREATER MEKONG SUBREGION

by

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Waste electrical and electronic equipment or e-waste is one of the fast growing wastes in the solid waste stream in urban environment worldwide. It has become a widely recognized social- and environmental-problem; therefore, proper management of e-waste is vital to protecting the fragile environment from its improper disposal. This study employed a set of quantitative criteria to analyze policies, processes and practices of the respective e-waste management systems adopted in China, Laos and Thailand. Questionnaire surveys of electrical and electronic equipment retailers and consumers were conducted to determine current status of the policy, process and practice of the e-waste management and the knowledge of environmental impacts of e-waste disposal as it relates to mobile phones in these three countries. Results of the survey showed that there were no significant differences in the levels of respondents' satisfaction toward the take-back systems adopted by manufacturers (S_{202}) (F=2.702, $p>0.05$). However, significant differences were observed in the levels of respondents' satisfaction toward manufacturers using recyclable or reusable materials (S_{201}) (F=3.459, $p<0.05$) and toward the incentives provided to retailers and consumers to practice reuse and recycle of e-waste (S_{203}) (F=6.394, $p<0.01$) among the three countries surveyed. A total of 5, 3 and 6 variables relating to Policy (P_1), Process (P_2) and Practice (P_3), respectively, were analyzed and their weighted averages were calculated. The results showed that for $P_{1\ average}$ and $P_{3\ average}$, Laos was the highest among the three countries, followed by Thailand and China. For $P_{2\ average}$, however, China was the highest and then followed by Laos and Thailand. Results of $P_{1\ average}$, $P_{2\ average}$ and $P_{3\ average}$ were factored into an equation to obtain a sum of the weighted averages (P_{total}) for each of the three countries, which showed that China had the highest score of P_{total} (0.141) among the three countries, followed by Laos (0.132) and Thailand (0.121). The survey results also revealed that gender was positively correlated with respondents' knowledge of the status of environmental conditions (P_{104}) (r=0.077, n=1994, p<0.01) and negatively correlated with their knowledge of how to improve environmental conditions (P_{105}) (r=-0.067, n=2037, p<0.01). The results further demonstrated that the increase in age was positively correlated with respondents' concern over environmental conditions (P_{103}) and P_{105}. Similarly, the increase in respondents' educational level was positively correlated with P_{105}. However, the increase in respondents' income was negatively correlated with P_{104}. Therefore, an effort to bridge the knowledge gaps through initiating proper educational programs in the three countries was necessary. This, coupled with strong enforcement of e-waste related laws, would be the most reliable way to prevent deterioration of the environment in a country. This PPP approach could be a useful tool to decision makers for quantitative analysis and weighing of complex issues associating with e-waste management in a country before a sound decision is rendered. It could also be useful for comparing e-waste management systems or other systems with multiple variables adopted by different countries or entities. Based on the results of this study, a comprehensive e-waste management system was proposed.

Keywords: e-waste management system, quantitative approach, policy-process-practice analysis, e-waste disposal, environmental impacts, questionnaire survey, China, Laos, Thailand, gender, age, education, income

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List of Acronyms and Abbreviations

ADB	Asian Development Bank
EEE	Electrical and Electronic Equipment
EOL	end-of-life
EPR	Extended Producer Responsibility
EC	European Commission
EU	European Union
GMS	Greater Mekong Subregion
ITU	International Telecommunication Union
MD	Mean Difference
MEP	Ministry of Environmental Protection, China
MOF	Ministry of Finance, Thailand
MONRE	Ministry of Natural Resources and Environment, Thailand
NLA	National Legislative Assembly, Thailand
NPC	National People's Congress, China
PCD	Pollution Control Department, Thailand
PPP	Policy-Process-Practice
SEPA	State Environmental Protection Administration, China
USEPA	United States Environmental Protection Agency
WEEE	Waste Electrical and Electronic Equipment

Chapter 1
Introduction

1.1 Background

Solid waste is defined as “useless and sometimes hazardous material with low liquid content, including municipal garbage, industrial and commercial waste, sewage sludge, wastes resulting from agricultural and animal husbandry operations and other connected activities, demolition wastes and mining residues” (United Nations, 1997).

The waste disposal was not a major concern in the past due to the relatively small size of population scattered in large areas. It became a problem when people started congregating and the communities were expanding. In the early 1900s, a few of solid waste disposal methods were commonly practiced such as dumping on land or to water, feeding to swine, mixing with soil, and incineration (Shah, 2000). However, with the increase of the quantities of solid waste being generated, the waste management becomes urgent and important. Solid waste management is a part of an integrated waste management plan, which involves waste collection, processing, resource recovery and disposal.

Waste electrical and electronic equipment (WEEE) or e-waste is a generic term encompassing various forms of electrical and electronic equipment wastes that are old or end-of-life and have ceased to be of any value to their owners (UNEP, 2007). It is one of the fast growing wastes in the solid waste stream in urban environment. Production of electrical and electronic equipment (EEE) is increasing rapidly worldwide, which has heightened a severe concern over the potential problems associating with e-waste. The technological innovation and also the market expansion accelerate the replacement of equipment leading to a significant increase of e-waste (Cui & Forssberg, 2003). E-waste equals to an average of 1% of the total solid waste generated in developed countries. In USA, for example, it accounts for 1 to 3% of the total municipal waste generation (UNEP, 2007). The U.S. Environmental Protection Agency (USEPA) (2006) reported that Americans owned nearly 3 billion electronic products; of which, an estimation of 26-37 million computers and a large number of TVs, VCRs, mobile phones and monitors became obsolete annually. Also reported was that about 304 million electronic devices weighing 1.9-2.2 million tons were removed annually from U.S. households (USEPA, 2008). According to the Consumer Electronics Association, about two-thirds of the electronic devices removed from service in the U.S. were still in working condition; however, only about 15% of which was recycled, while the remaining 85% was disposed in landfills (USEPA, 2008). In European Union (EU), e-waste increases by 16-28% every five years, which is three times faster than the average annual municipal solid waste generation. It is estimated that the total amount of e-waste generation in EU ranges from 5 to 7 million tons per year or about 14 or 15 kg per capita and is expected to grow at a rate of 3 to 5% per year (UNEP, 2007). In developing countries, however, it ranges from 0.01 to 1% of the total municipal solid waste generation. The less percentage e-waste generation rate in developing countries may have more impact on the environment and human health due to poor management (Liu et al., 2006; Osibanjo & Nnorom, 2007; UNEP, 2007). In countries like China, though annual generation per capita is less than 1 kg, it is growing at an exponential pace due to the increase in the populations. The increasing “market penetration” in developing countries, “replacement market” in developed countries and “high obsolescence rate” make e-waste one of the fastest growing waste streams (UNEP, 2007).

The composition of e-waste is very diverse and differs in products across different categories. UNEP (2007) reported that the e-waste contained more than 1000 different substances, falling under hazardous and non-hazardous categories, which included ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete and ceramics, rubber and other items. UNEP (2007) also reported that iron and steel constituted about 50% of the e-waste, followed by plastics (21%), non-ferrous metals (13%) and other constituents. Non-ferrous metals consisted of copper, aluminum, and precious metals like silver, gold, platinum and palladium. Elements such as lead, mercury, arsenic, cadmium, selenium, hexavalent chromium and fire retardants, which exceeded the threshold quantities in e-waste, were classified as hazardous waste. Cui and Zhang (2008) reported that these toxic materials could contaminate the environment upon disposal, posing a threat to human health and polluting the environment. However, the precious metals contained in e-waste offer opportunities for economic extraction. It was reported that precious metals contributed to well over 70% of all metal-related values in mobile phones, calculators and printed circuit board scraps. These precious metals were also estimated to have contributed about 40% of the value in other items such as TV boards and DVD players (Cui & Zhang, 2008). As such, it requires specialized segregation, collection, transportation, treatment and disposal of e-waste (UNEP, 2007). Considering the large amount of e-waste produced every year, there is an urgency to deal with it before it imposes severe threats to human being and environment.

The Greater Mekong Subregion (GMS) is not a geological region, but rather, an area formed by the Asian Development Bank (ADB) in 1992 that brought six countries of the Mekong River basin together, including Cambodia, Laos, Myanmar, Thailand, Vietnam, and the Yunnan Province and Guangxi Zhuang Autonomous Region of China. This subregion covers 2.6 million square kilometers with a combined population of around 326 million (ADB, 2014a). The GMS countries are gradually evolving from self-subsistence farming to a more diversified, market-oriented economic system. Meanwhile, the recent economic booming occurred in Southeast Asia greatly enhanced the transboundary trading, investment and labor mobility within the subregion.

With the population increase in this subregion, the consumption pattern has also changed accordingly. As a result, solid waste has become one of the major environmental concerns in the GMS countries due to the drastic increase in its generation. However, awareness of the potential risks to the public health and environment associated with the solid waste is seriously lacking among the people in this subregion (Sharp & Sang-Arun, 2012).

In order to prepare countries to tackle e-waste, it is imperative to investigate the current status of e-waste generation and management in the GMS, especially in the selected countries within the GMS, which are the focus of this study.

1.2 Rationale of the study

Among the EEE, the advance of technology in the past two decades has significantly enhanced the development of the mobile phones and their usage in the world. Despite its fast-growing, mobile phones' market share has yet to reach its maturity in the world market. By the end of 2013, International Telecommunication Union (ITU) estimated that the number of mobile phone subscriptions would have reached 6.8 billion, which is close to the figure of the world's population (7 billion). A previous study showed that mobile phones had the highest per-capita ownership rate of all household appliance types surveyed in Baoding, China (Li et al., 2012). This dramatic increase in the number of mobile phones sold in the market has created an emerging problem of waste generation from the obsolete mobile phones to be disposed and the need for their proper management.

Comparing among the GMS countries, the mobile phone subscriptions per 100 inhabitants during 2002-2012 growing the fastest was Myanmar from 0.1 in 2002 to 11.2 in 2012 by 111 times, followed closely in Laos from 1.0 in 2002 to 101.9 in 2012 by 100.9 times. (ITU, 2011, 2013).

Given the complexity of the e-waste in the solid waste stream and the technologies associated with resource recovery, reuse and recycling continuing to evolve, a review of the literature available from the selected GMS countries shows a lack of clear sustainable e-waste management systems being implemented in these countries. Therefore, it is imperative that a study be conducted to determine which e-waste management systems currently utilized effectively in treating e-waste in other countries could be adopted to fit the social, economic and environmental needs to manage the e-waste in the selected GMS countries. Therefore, results of this study could be useful to prevent e-waste from posing environmental risks in these countries while policies on collection and processing of e-waste for reuse or recycling are being formulated. This study aims at evaluating issues relating to e-waste management in the selected GMS countries, developing a quantitative approach considering Policy-Process-Practice (PPP) to analyze these existing e-waste management systems, and finally proposing a comprehensive e-waste management system to be adopted in these targeted GMS countries.

To compare the existing e-waste management systems within the GMS countries, a reliable, quantitative method is required to provide an unbiased assessment of their strengths and weaknesses. Currently, there is a lack of such quantitative method available in the literatures; as such, a mathematical equation is developed for quantifying the policies, processes and practices to facilitate a comparison of the e-waste management systems adopted in these countries. The term "Policy-Process-Practice Approach", coined PPP approach, proposed here is for the ease of achieving the comparative and analytical purposes in this study.

PPP was previously applied in the fields such as politics (Australian Dance Council – Ausdance, 1993) and sport development (Hylton, 2013). This study not only adopted the concept of PPP but also developed it further into an equation to enable the assessment of the e-waste management systems adopted in the GMS countries on a quantitative basis. To develop a method to quantify PPP in this study was necessary as the applications of PPP reported in literatures were based primarily on the analysis of qualitative information. As such, attempts were made in this study to develop a quantitative PPP approach for use to quantify the variables of policies, processes and practices associating with an e-waste management system. Using mobile phone as a representative, attempts were also made to apply this quantitative method to compare the strengths and weaknesses of the e-waste management systems of selected GMS countries in solving the emerging e-waste problems in the respective countries.

1.3 Research objectives

The overall goal of this study was to propose a policy-process-practice approach for decision-making in formulating e-waste management strategies among the selected GMS countries. Four specific objectives were to:

1. Compare the e-waste management issues and identify e-waste management problems among the selected GMS countries using mobile phone as case study;
2. Propose the use of policy-process-practice approach for decision-making to evaluate and analyze e-waste management issues in the selected GMS countries;
3. Determine the awareness of e-waste disposal impacts on the environment among different gender and age groups at different educational and income levels in the selected GMS countries; and
4. Propose a sustainable e-waste management mechanism for adoption among the selected GMS countries.

1.4 Scope of the work

The intent of this study was to evaluate e-waste management related policies, processes and practices adopted or implemented in the GMS countries; develop a quantitative approach to analyze and compare their strengths and weaknesses; and finally propose a comprehensive e-waste management system for consideration by the GMS countries for adoption. To achieve this goal and its associated objectives enumerated in §1.3, the scope of work for this study was laid out in consideration of the availability and accessibility of the data and the reality of the short time frame and budgetary constraints as follows:

- Grouping GMS countries on the basis of the socio-economic indicators and selecting representative countries for this study;
- Using mobile phone for a case study to address the emerging e-waste problems;

- Means of data collection through questionnaire surveys, interviews of focus groups, field visits, and review of existing policies, processes and practices adopted to manage e-waste in the selected GMS countries;
- Developing a PPP approach for comparing e-waste management systems among the selected GMS countries;
- Analyzing the relationships of retailers and consumers at different gender, age, educational and income levels with their knowledge of e-waste disposal impacts on the environment in the respective countries selected for this study; and
- Proposing a sustainable e-waste management mechanism for adoption among the selected GMS countries.

Chapter 2

Literature Review

2.1 Solid waste management

Solid waste is defined as useless and sometimes hazardous material with low liquid content, including municipal garbage, industrial and commercial waste, sewage sludge, wastes resulting from agricultural and animal husbandry operations and other connected activities, demolition wastes and mining residues (UN, 1997). Management of solid waste mainly emphasizes supervised handling of waste material from generation at the source through the recovery processes to disposal (UN, 1997). It includes a stream of waste generation, prevention, characterization, monitoring, treatment, handling, reuse and residual disposition. Therefore, the strategies that are employed to manage solid waste in the waste stream vary among countries, regions and sectors (Davidson, 2011), which often need to take their respective political, social, economic and other unique situations into consideration (Shah, 2000). To facilitate an evaluation of the waste management strategies adopted, a pyramid hierarchy was proposed to rank the strategies from the most preferred to the least in source reduction and reuse, recycling/composting, energy recovery, treatment and disposal (USEPA, 2014).

2.2 E-waste components

European Commission (EC) (2003) defines e-waste as unwanted or ready to be disposed electrical or electronic equipment, including all components, subassemblies and consumables, which are part of the product at the time of discarding. Categories of EEE covered under this definition include: large household appliances, small household appliances, IT and telecommunications equipment, consumer equipment, lighting equipment, electrical and electronic tools (with the exception of large-scale stationary industrial tools), toys, leisure and sports equipment, medical devices (with the exception of all implanted and infected products), monitoring and control instruments and automatic dispensers.

Similar categories were also adopted by UNEP (2007). In addition, e-waste has been classified on the basis of its components, which include metal, plastic, insulation, LCD, textile, fluorescent lamp, batteries and others (UNEP, 2007). Such a classification facilitates the identification and removal of hazardous components.

Cui and Forssberg (2003) suggested the need for identifying and quantifying valuable materials and hazardous substances in e-waste for the purpose of developing an environmentally friendly, mechanically sound recycling system. The Association of Plastics Manufacturers in Europe (APME) in 1995 released that the main materials found in EEE in Western Europe were ferrous (38%), non-ferrous (28%) and plastics (19%). Effective separation of these materials is a key to the success of a recycling system.

2.3 Life cycle of EEE

UNEP (2007) described a conceptual life cycle of EEE, which included EEE production, sales and consumption, and WEEE generation, treatment and disposal (Fig. 2.1). Crowe et al. (2003) summarized the stakeholders involving in different phases of the life cycle of EEE to include manufacturers, importers, exporters, retailers, consumers, collectors, traders, dismantlers and waste treatment operators.

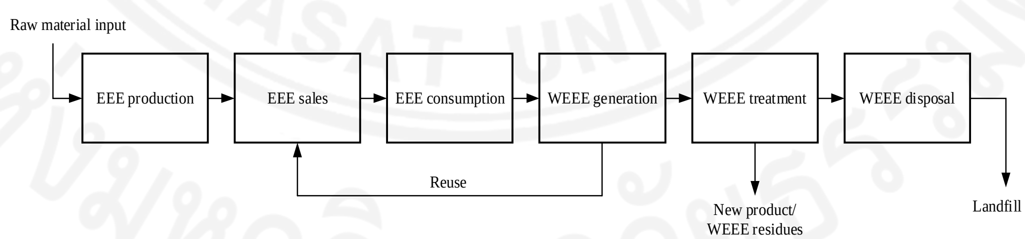

Fig. 2.1. Conceptual life cycle of electrical and electronic equipment.
Source: E-waste assessment manual (UNEP, 2007)

2.4 E-waste management practices in some selected countries

2.4.1 Shared responsibility for managing e-waste in U.S.

In the U.S., the household e-waste was not regulated and managed at the federal level; instead, it was under the administration and responsibility of states (Wagner, 2009). Before 2004, the preferred method to deal with the e-waste was storage and only a small portion of e-waste was disposed and recycled. It was estimated that 75% of obsolete electronics were in storage (USDOC, 2006). Also, USEPA (2002) estimated that 20 to 24 million obsolete computers and televisions were stored every year. Among those not stockpiled, about 85% was disposed of while only 15% was recycled (USEPA, 2007). This high rate in disposal but low in recycling of e-waste indicated that exportation of e-waste to developing countries for recovery would happen. Meanwhile, reliance on municipalities to take on the responsibility of e-waste management has been unsuccessful in the U.S.; thus, a household e-waste management law with provisions in which e-waste producers were charged with the responsibility of e-waste management was adopted in Maine in 2004. This was the first of this kind of e-waste management law established in a state in the U.S. (Wagner, 2009). Under this household e-waste law, a shared responsibility was assumed by three key stakeholders, namely producers, households and municipalities. These stakeholders would also share the costs of e-waste management. Among the three stakeholders, producers were to bear the costs of handling and recycling of e-waste, households were to shoulder the transportation costs of bringing e-waste to designated municipal collection sites, and municipalities were responsible for collecting, storing and preparing e-waste for shipment. This shared responsibility approach was considered a success in Maine (Wagner, 2009).

2.4.2 Extended producer responsibility in EU

Unlike the shared responsibility program in Maine, the extended producer responsibility (EPR) adopted in EU required transfer of the responsibility of the end-of-life (EOL) of EEE from municipalities and consumers to their producers and sellers (OECD, 2006; Widmer et al., 2005). This approach has evolved and has been refined and widespread adopted in Europe (Wagner, 2009). In 2012, EU adopted this approach under the WEEE Directive 2012/19/EU (Waste Electrical and Electronic Equipment) (EC, 2012) and its complimentary RoHS Directive 2002/95/EC (Restriction on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment) (EC, 2003). EPR adopted in EU involved different ways of e-waste disposal practices, including establishment of take-back systems, minimum product standards, material use bans, disposal bans, mandated recycling, taxes, fee assessments and subsidies (OECD, 2001). EPR, if designed properly and implemented efficiently, could facilitate reduction of e-waste disposal in landfills, improvement of product designs to increase recyclability, establishment of collection centers, financing of collection and recovery systems, and ultimate reduction of hazardous components (Wagner, 2009).

2.4.3 Management of used and end-of-life mobile phones in South Korea

Jang and Kim (2010) reported that, due to an increased demand for mobile phone products and an improved information and communication technology, a large amount of obsolete mobile phones had been produced in South Korea. Improper treatment and uncontrolled disposal of e-waste could pose threat to both environment and human health. How to manage and process discarded mobile phones has become a serious issue in South Korea and around the world (UNEP, 2006). Thus, a resource recovery and recycling program was initiated in South Korea to deal with EOL mobile phones (Jang & Kim, 2010). Also, an EPR related regulation was adopted by the South Korea Ministry of Environment for EEE including mobile phones in 2005 to enhance the effectiveness of recovery and processing of e-waste and to reduce its impact on the environment. An additional legislation, entitled “the Act on the Resource Recycling of WEEE and EOL Vehicles”, was adopted in South Korea in 2007 to further address the concern of the e-waste from the perspective of producers. This Act requires producers to eliminate the use of six hazardous substances to achieve “green” products, and to provide information on the components in a mobile phone and the hazardous substances present in the phone for its safe use and recycling (Jang & Kim, 2010).

Summary of e-waste management systems adopted in certain developed countries was shown in Table 2.1. A set of criteria following the PPP concept was developed to present an overall picture of e-waste management systems adopted in industrialized countries.

Table 2.1. Summary of e-waste management systems adopted in certain developed countries

Country	Legislation	Regulation	Collection	Recovery	Reuse	Recycle	EPR	Reference
EU	√	√	√	√	√	√	√	EC, 2003, 2012
Japan	√	√	√	√	√	√	√	Nnorom & Osibanjo, 2008; Terazono et al., 2006; Widmer et al., 2005
South Korea	√	√	√	√	√	√	√	Jang & Kim, 2010; Lee et al., 2007; Terazono et al., 2006
Taiwan	√	√	√	√	√	√	√	Nnorom & Osibanjo, 2008; Terazono et al., 2006
U.S.	√	√	√	√	√	√	√	Kahhat et al., 2008; Wagner, 2009

2.5 Review of e-waste related policies, processes and practices in China

China promulgated the Environmental Protection Law in 1989 to protect and improve the environment, prevent and control pollution and other public hazards, safeguard human health, and facilitate the development of social modernization (National People's Congress [NPC], 1989). This Law was amended in 2014 and effective 2015 (NPC, 2014). The revisions included raising environmental awareness, promoting public participation, providing education and training; integrating environmental protection into social and economic development planning process; emphasizing environmental impact assessment, establishing and improving the environmental monitoring system (NPC, 2014). The amended law also specified the reduce, reuse and recycle (3R) concept, municipal solid waste management, and public health concern (NPC, 2014). A complete new chapter about information disclosure and public participation was added to the 2014 version of the law (NPC, 2014). The Law on Promotion of Cleaner Production was promulgated in 2002 to promote cleaner production, increase the utilization ratio of resources, reduce and prevent pollutant-generating, protect and improve the environment, protect human health, and promote the sustainable development of the economy and society (NPC, 2002). In 2004, the Solid Waste Pollution Prevention and Control Law was adopted to prevent and control environmental pollutions caused by solid waste, safeguard human health, protect the ecological environment, and promote sustainable development (NPC, 2004). In addition, China also adopted the Guidelines for Electronic Waste Environmental Pollution Prevention and Control in 2007, which was implemented by the State Environmental Protection Administration (SEPA) effective February 2008 to prevent or control environmental pollutions caused by e-waste and to strengthen environmental management of e-waste (SEPA, 2007). Also promulgated were the Circular Economy Promotion Law (NPC, 2008) and the Regulations for the Administration of the Recovery and Disposal of Waste Electric and Electronic Products (State Council, 2009).

To implement these laws and rules, China adopted the Guidelines for Old-for-New Home Appliance Implementation Measure in July 2009 (Ministry of Environmental Protection [MEP], 2009), which was jointly implemented by Ministry of Commerce, Ministry of Finance, National Development and Reform Commission, Ministry of Industry and Information Technology, MEP, State Administration for Industry and Commerce, and the General Administration of Quality Supervision, Inspection and Quarantine (Wang et al., 2013). This innovative process aimed to stimulate both the buying of new home appliances and the proper recycling of old appliances (Wang et al., 2013). Four provinces, which include Jiangsu Province, Zhenjiang Province, Shandong Province and Guangdong Province and five cities which include Beijing, Tianjin, Shanghai, Fuzhou and Changsha, were selected to carry out the activities in the first phase of a pilot project from June 2009 to May 2010. More than 30 recycling companies were selected during this period. The program was expanded in the second phase of the project to 19 provinces and cities from June 2010 to December 2011. Subsidies were provided to consumers, collectors and recyclers for five home appliances, namely television, refrigerator, washing machine, air conditioner and personal computer when trade-in an old product of the same type of appliances (MEP, 2009). The total amount of old home appliances collected during July 2009 – June 2011 was 58 million units (Chen, 2011). To handle these old appliances, twenty-two treatment facilities were identified in May 2010 with a total treatment capacity of 80,000 units/day, which was below the total initial designed capacity of 30 million units/year (Chen, 2011). It was also reported that as of May 2010, 13.13 million units of new appliances have been sold and 13.88 million units of e-waste collected in those selected provinces and cities (Wen & Jin, 2010). The trade-in project, described by Wang et al. (2013), was summarized in Fig. 2.2 as follows:

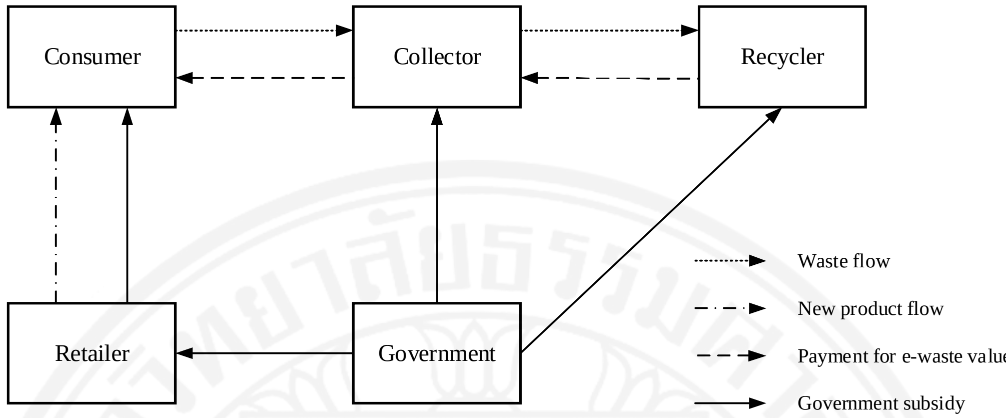

Fig. 2.2. Flow chart of the old-for-new appliance trade-in project in China.
Source: E-waste in China: A country report (Wang et al., 2013)

Fig. 2.2 shows that consumers received double financial benefits; one from the payment from old appliance collectors for the old appliance that was traded in and discarded through regulated collection channels and the other from the discount obtained for the new appliance purchased from appliance retailers (Wang et al., 2013). Fig. 2.2 also shows that the Chinese government provided subsidies not only directly to appliance retailers, collectors and recyclers but also indirectly to consumers the new appliance purchased from appliance retailers. In addition to the direct subsidy, collectors were also benefited by getting a higher mark-up in price, which they received from recyclers, than that was paid to consumers for the old appliance traded in (Wang et al., 2013).

An overview schematic diagram from e-waste generation to disposal in China, developed in 2013 by Wang, Kuehr, Ahlquist, and Li, was modified as shown in Fig. 2.3:

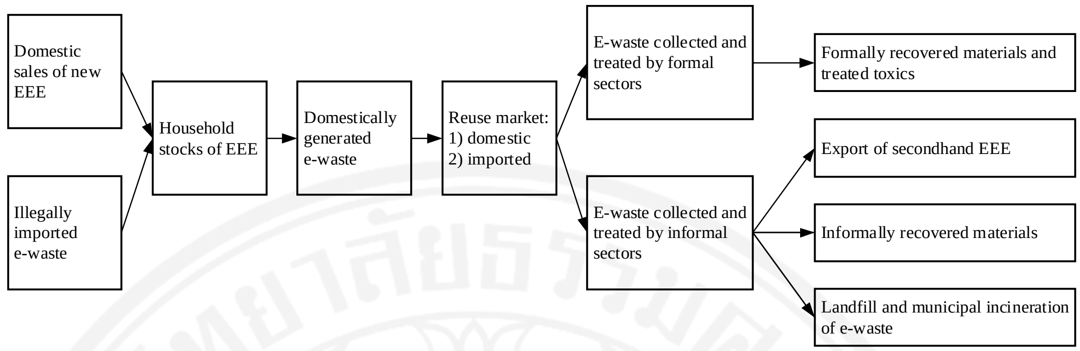

Fig. 2.3. An overview schematic diagram from e-waste generation to disposal in China.
Source: E-waste in China: A country report (Wang et al., 2013)

China has recently confronted with a number of key challenges in regulating the e-waste processing industry, implementing e-waste regulations, and enforcing EPR (Hicks et al., 2005). These challenges included an increased number of non-official e-waste recycling facilities, lack of environmental awareness among e-waste collectors, consumers and recyclers; illegal e-waste transboundary movement; and ineffective regulatory and legal system on the e-waste management. These challenges were reported to be attributable to China's difficulties in developing and implementing an environmentally, socially and financially sound e-waste recycling and disposal system (Hicks et al., 2005; Wei & Liu, 2012; Song & Li, 2014; Liang & Sharp, 2013).

2.6 Review of e-waste related policies, processes and practices in Thailand

In 1992, Thailand adopted the Enhancement and Conservation of National Environmental Quality Act to reform and improve the law on enhancement and conservation of national environmental quality (National Legislative Assembly [NLA], 1992a). Also adopted was the Hazardous Waste Act to improve the law on hazardous waste and refine the definitions of each hazardous waste (NLA, 1992c). The Public Health Act was also adopted to amend the law on public health and the law on control of use of fecal matter as fertilizer (NLA, 1992d).

In Thailand, there were about 2,000 electrical and electronic manufacturers, 9,000 junk shops and 30 formal e-waste recycling facilities recorded in 2010

(Komonweeraket, 2011). The Pollution Control Department (PCD) was reported to have implemented a series of WEEE related projects since 2006, which include establishing and updating e-waste inventory, conducting fluorescent lamp take-back pilot program, capacity building for customs and ports officers on the import/export of hazardous waste, identifying WEEE life cycle tracking system, prioritizing WEEE types, producing e-waste dismantling and recycling manual, studying on rules, procedures, conditions, and setting fees for WEEE management in Thailand (Aree, 2010).

The WEEE management strategies adopted in Thailand presented different approaches and practices from those in China. A project implemented by PCD showed that among the respondents, 52% of WEEE was stored at home, 23% was donated or given away, 11% was thrown away, 9% was sold to informal recyclers and 5% was traded in (Komonweeraket, 2011). Under the e-waste take-back system adopted in Thailand, a preponderant proportion (47%) of the respondents preferred it to be picked up with monetary compensation, followed by dropping off with monetary compensation (25%), picking up but without compensation (23%), and finally dropping off without compensation (5%) (Komonweeraket, 2011).

In Thailand, a bounty program was successfully conducted in Nonthaburi Province during 2011-2013, which was organized by Nonthaburi Municipality, PCD, Electrical and Electronics Institute, Wongpanit and Amporn. Central and local government officials, researchers and recyclers were involved in the program to help raise public awareness and interest in e-waste (P. Pumwiset, personal communication, September 7, 2013). This successful bounty program could be tailored to fit the economic and social conditions of a city, province, state, country or region. An overview schematic diagram of the flow from e-waste generation to disposal in Thailand described by Jiaranaikhajorn (2013) was modified and presented in Fig. 2.4:

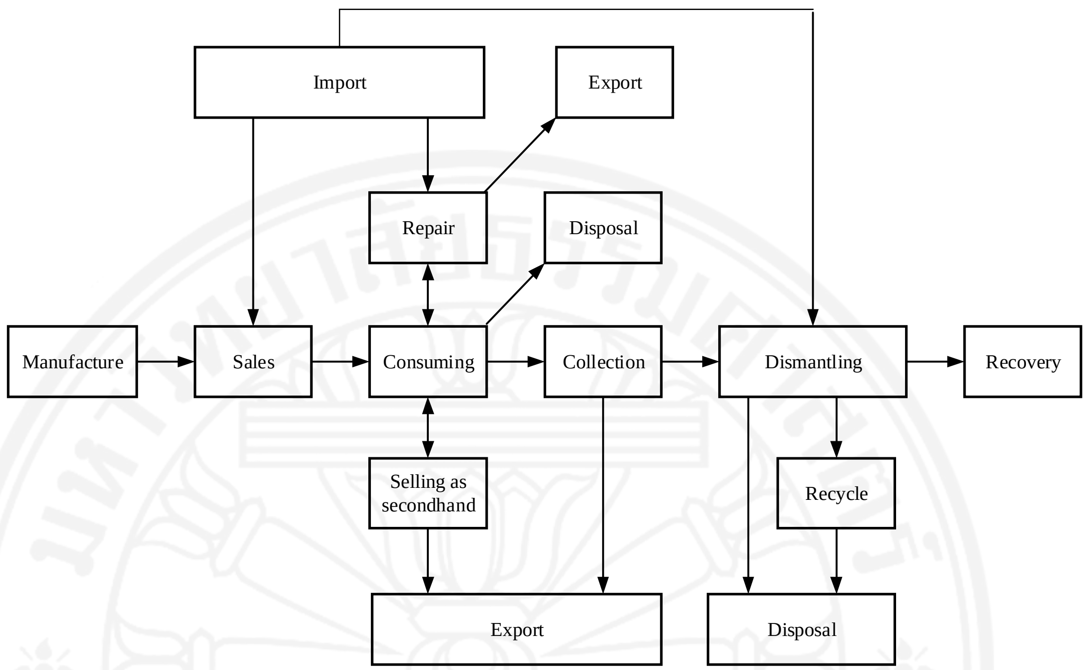

Fig. 2.4. An overview schematic diagram from e-waste generation to disposal in Thailand.
Source: WEEE management policy update from Thailand (Jiaranaikhajorn, 2013)

2.7 Review of e-waste related policies, processes and practices in Laos

In Laos, the records showed that the Environmental Protection Law was adopted in 1999 to specify necessary principles, regulations and measures for managing, monitoring, restoring and protecting the environment in order to protect human health, natural resources and the richness of nature, and to ensure the sustainable socio-economic development of the nation (National Assembly, 1999). However, there were no other laws or rules relating to solid waste or e-waste management adopted. Based on the assessment conducted under the Global Partnership on Waste Management (UNEP, 2014), it was concluded that the capacity building in the e-waste management was in dire need in Laos due to its lack of appropriate laws or rules to regulate e-waste disposal. Moreover, UNEP (2014) also summarized that in Laos, confidential information on the composition of electronic products was not accessible; thus, monitoring and tracking of e-waste disposal become difficult (UNEP, 2014). Contrary to China and Thailand, neither e-waste recycling, take-back or other management processes nor practices were recorded and available in Laos.

2.8 Cause and effect analysis

Reviews of the literature showed that a cause-and-effect analytical approach has been employed to determine the cause and effect of a pollution prevention process in a dairy processing facility (Aikenhead et al., 2015), a soil salinity management in agricultural watersheds in Pakistan (Inam et al., 2015), and a sustainability analysis of the integrated community case management system in Rwanda (Sarriot et al., 2015). The steps taken in this approach included 1) stakeholder interviews; 2) construction of individual causal loop diagrams for problems identification, analysis of causes and consequences, identification of feedback loops and potential solution strategies; 3) construction of an overall group causal loop diagram; and 4) qualitative analysis of the merged model (Aikenhead et al., 2015; Inam et al., 2015).

2.9 The "multi-criteria matrix" methodological framework

The multi-criteria decision analysis method has been widely used to aid in decision-making in the financial sector (Ballestero, 2000; Brimberg & ReVelle, 2000; Ogryczak, 2000; Mansini & Speranza, 1999; Kwak et al., 1996; Zopounidis & Doumpos, 2001). It was also used to assist decision makers in manure management system (Gebrezgabher et al., 2014), forestry (Diaz-Balteiro & Romero, 2008), construction (Jato-Espino et al., 2014), aquaculture development (El-Gayar & Leung, 2001) and marketing (Chen et al., 2014).

In the e-waste management field, Iakovou et al. (2009) adopted this method to assist EEE manufacturers in identifying components of a product at the end of its life to optimize the disassembly and recovery processes (Fig. 2.5). This method was also employed to assist in decision-making in reusing components of an end-of-life product, and to facilitate the redesign of a product after taking into account of its disassembly and recovery needs and costs (Iakovou et al., 2009). Thus, this method adopted considered such parameters as residual/market value of components, environmental burden, weight, quantity of the particular component in the product, and ease of disassembly (Iakovou et al., 2009). This method was subsequently adopted to assist in decision-making in the location of e-waste treatment facility in Greece; in which, key Greek stakeholders were informed of the status of e-waste alternative management, the special characteristics of the problem, and the country's specific geographical features. After a proper consultation with and interview of experts, nine criteria were chosen, including local population, population served, distance from existing units of treatment and recycling, land value, unemployed population, land connection, financial status of local population, distance from the capital of the region, and distance from nearest port (Achillas et al., 2010). Similarly, Queiruga et al. (2008) applied this method to assist in the selection of alternatives for potential locations of recycling plants in Spain. The criteria used in this application were categorized into economic, infrastructural and legal groups. The factors considered in the economic group were land costs, personnel costs and energy prices; those considered in the infrastructural group were facility access, agglomeration effects, proximity to inhabited areas, absence of other WEEE recycling plants, and availability of labour; and those considered in the legal group were availability of a local waste processing program, and environmental grants (Queiruga et al., 2008). In addition, Rousis et al. (2008) employed this method to assist in the decision-making for the best e-waste management scenario in Cyprus. Using this method, 12 alternative management systems were compared and ranked according to their performance and efficiency, which were determined by 17 criteria classified in four groups; social, environmental, economic, and technical. Among which, the social criteria included harmonization with the existing institutional/legislative frame, application of priorities of legislation, social acceptance, and potential employment opportunities. The environmental criteria included level of potential environmental impacts, air emissions, generation of wastewater, production of solid waste, noise pollution and aesthetic nuisance. The economic criteria included investment cost, operation and maintenance cost and land demands. Finally, the technical criteria included functionalism, existing experience in terms of its reliability, adaptability to local conditions and flexibility.

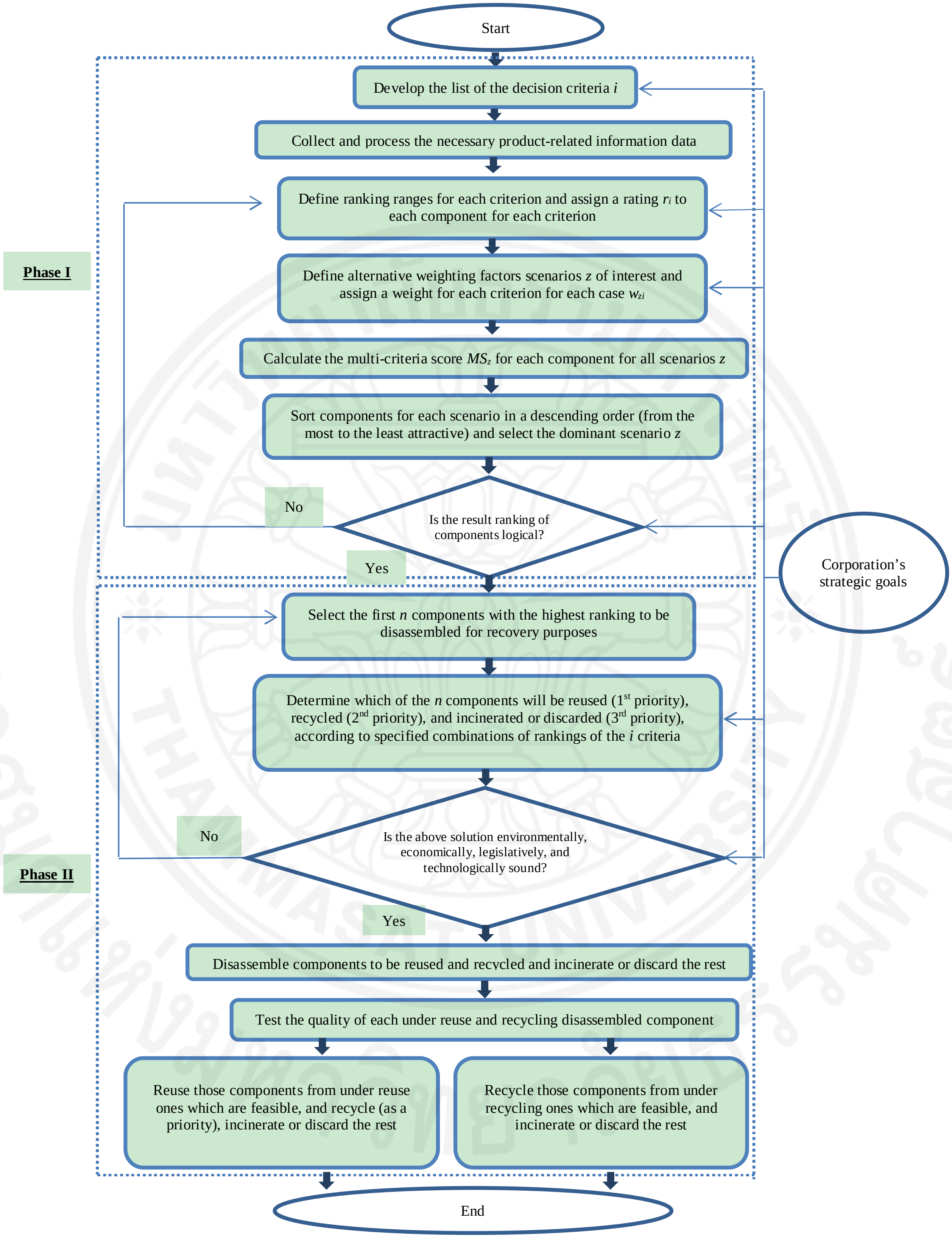

Fig. 2.5. Outline of the "multi-criteria matrix" methodological framework.

Source: A methodological framework for end-of life management of electronic products (Iakovou et al., 2009)

Based on the synoptic review presented above, the multi-criteria decision analysis method considered those parameters that are not directly related to e-waste policies, processes or practices; hence, it is not applicable to the objectives of this study. Therefore, a quantitative approach that incorporates such pertinent factors as policies, processes and practices of an e-waste management system has to be developed in this study to assist decision makers in better handling e-waste treatment or disposal in the GMS countries. In addition, the concepts of the cause and effect analysis are also adopted in this study to evaluate the e-waste management systems in China, Thailand and Laos.

2.10 Different gender, age, educational and income levels and their knowledge on e-waste disposal impacts on the environment

Reviews of the literature showed that gender, age, educational and income levels have been considered in the surveys of U.S. households for their knowledge of the effectiveness of the household recycling policies (Nixon & Saphores, 2007; Saphores et al., 2009; Saphores et al., 2012; Saphores & Nixon, 2014), and on the preferences for disposing of their e-waste (Milovantseva & Saphores, 2013). Gender, age, educational and income levels have also been considered in three other surveys of residents conducted in Beijing, China, Macau and Nigeria on their willingness to participate in e-waste recycling (Wang et al., 2011; Song et al., 2012; Nnorom et al., 2009). In addition, gender and age were also considered in a survey conducted at five universities in the United Kingdom to determine students' behavior toward the use and disposal of mobile phones (Ongondo & Williams, 2011). Education and income were considered in a survey conducted in Baoding, China to determine behavior of urban residents toward the discarding of WEEE (Li et al., 2012). Despite all the studies mentioned above, no surveys have been conducted in the GMS countries about the opinions of different gender, age, educational and income levels toward their environmental conditions or toward the effectiveness of their e-waste management systems. As such, attempts were made in this study to assess, through questionnaire surveys, the awareness of different gender, age, educational and income levels of the residents in China, Thailand and

Laos on the current status of their environmental conditions and the effectiveness of the e-waste related laws and rules adopted in the respective countries.

Chapter 3
Materials and Methods

3.1 Grouping and selecting GMS countries and cities for study

Considering the time and budgetary constraints of this study, it would be an insurmountable challenge if data collection would cover each of the GMS countries, which geographically include Cambodia, Laos, Myanmar, Thailand, Vietnam, Yunnan Province and Guangxi Zhuang Autonomous Region of China. As such, a set of arbitrary criteria of average income and per capita waste generation was developed to group the GMS countries to facilitate data collections (Table 3.1). Based on these criteria, the GMS countries were categorized into three groups; high, medium, and low, and one representative country from each of the three groups was selected for this study; among which, China, Thailand and Laos were for representing the high, medium and low groups, respectively.

Table 3.1. Selected socio-economic indicators for the six GMS countries in 2013

Indicator	Cambodia	China	Laos	Myanmar	Thailand	Vietnam
Annual population growth (%)	1.5	0.5	2.5	1.1	0.4	1.1
Urban population (%)	21.4	53.9	35.3 (2012)	30.8 (2012)	44.5	32.2
GDP at PPP (million US$)	46,039	16,157,704	30,923	215,992 (2012)	1,036,003	474,840
GDP per capita at PPP (US$)	3,069	11,874	4,630	3,542 (2012)	15,519	5,293
Growth rates of real GDP (%)	7.5	7.7	8.0	7.6 (2012)	2.9	5.4
* Environmental performance index (0-100) (2010)	41.7	49.0	59.6	51.3	62.2	59.0
** Human development index	0.584	0.719	0.569	0.524	0.722	0.638
*** Waste generation per capita (kg/cap/day) (2011)	0.52	-	0.55	-	0.64	0.61

Source: Key Indicators for Asia and the Pacific 2014 (ADB, 2014b)
* *Human Development Report 2011* (UNDP, 2011)
** *Human Development Report 2014* (UNDP, 2014)
*** *Key Indicators for Asia and the Pacific 2012* (ADB, 2012)

Using the information available on the e-waste management and disposal among the three countries mentioned above, Bangkok and Vientiane Capital were selected as the sites for this study to represent Thailand and Laos, respectively. In selecting a city to represent China, a city in Yunnan or Guangxi would be the logical site of choice. However, literature reviews showed a scarcity in official publications relating to EEE usage and disposal and, at an even lesser extent, to e-waste management and disposal in those two provinces. Therefore, Beijing was selected as an alternative city to represent China. The findings of this study and the lessons learned from Beijing may be eventually applied to Yunnan and Guangxi as both provinces are going through a transformation due to the recent booming in economic development and industrialization there. In addition, selection of Beijing, which is the capital of China, would align well with the selection of

Bangkok and Vientiane Capital as they both are the capital cities in their respective countries.

3.2 Data collection

According to the profiles of the stakeholders in the e-waste management stream, the stakeholders in this study were categorized into five subgroups; EEE manufacturers, retailers, consumers, e-waste recyclers and policy makers. Primary data were collected through questionnaire surveys in conjunction with field visits and personal interviews of stakeholders. Data on e-waste related policies including laws and rules, management processes and disposal practices were collected through the questionnaire surveys of EEE retailers and consumers in Thailand, Laos and China. Separate questionnaires were designed specifically for these two subgroups. For the subgroups of EEE manufacturers, e-waste recyclers and policy makers, however, data were collected through personal interviews, individually or in groups. This data collection through interviews was necessary due to the small numbers of these subgroups and the concern over revealing proprietary information.

3.3 Questionnaire surveys

The questionnaires, as presented in Appendices A and B, were consisted of four parts. Part I was designed to collect such general information as demographic characteristics of respondents. Part II was formulated to collect respondents' environmental awareness and concerns, and to gather pertinent information on e-waste disposal and 3R practices in general. Part III focused on the questions relating to the current policy-process-practice status of mobile phones and Part IV contained questions specifically developed for each subgroup of stakeholders.

Questionnaires for the retailer and consumer subgroups were developed in English and then translated into Thai, Lao and Chinese. Pretest surveys were conducted for each version of the questionnaires; the English version in March 2013, followed by the Thai version in June 2013, the Lao version in November 2013 and then the Chinese version in December 2013. These pretest surveys were to determine the validity of the questionnaires before initiating the surveys (Groves, 1989). Modifications to the questionnaires, when appropriate, were made on the basis of the results of the pretest surveys.

Separate groups of surveyor, predominantly college students, were recruited respectively in Thailand, Laos and China and orientation sessions were provided to the surveyors to ensure a consistency in interviewing respondents and completing the questionnaires (Groves, 1989). The orientation sessions covered the objectives of the surveys, procedures to be followed and clarification of each question. Potential answers to some open questions were also provided to familiarize the surveyors with the questions. Avoidance of duplication in completing a questionnaire by the same respondent was particularly emphasized. The validity of the questionnaire surveys conducted in this study was determined by following the thresholds proposed by Babbie (1990), in which a response rate of 60% was considered good and 70% was very good.

The actual questionnaire surveys were conducted in Bangkok, Thailand during June – September 2013, in Vientiane Capital, Laos in December 2013, and in Beijing, China in April 2014.

After all of the returned questionnaires were received, answers or comments written in local languages were translated into English.

3.4 Data coding

The survey data collected were coded and the coding for the two types of variables; nominal and ordinal; is summarized as follows:

For example, EEE retailers in Thailand, Laos and China were surveyed for their responses to three questions; including whether or not manufacturers use recyclable or reusable materials, whether or not there is a take-back system adopted by manufacturers, and whether or not there is any incentive provided to retailers and consumers to practice reuse and recycle of e-waste. Data on the answers to the lead questions on whether or not manufactures used recyclable or reusable materials ($PreS_{201}$), whether or not there was a take-back system adopted by manufacturers ($PreS_{202}$), and whether or not there was an incentive provided to retailers and consumers to practice reuse and recycle of e-waste ($PreS_{203}$) were coded as nominal data, in which, "1" was to represent "yes" answer and "0" was to represent "no" answer to each question mentioned above. However, the responses to the above questions without providing answers were treated as missing data; thus "9" was entered into the database for ease of distinction.

If the answers to the lead questions, $PreS_{201}$, $PreS_{202}$ and $PreS_{203}$, were "yes", respondents were further requested to provide answers by rating their levels of satisfaction to the respective lead questions. The rating included the level of their satisfaction toward manufacturers using recyclable or reusable materials (S_{201}), the take-back system adopted by manufacturers (S_{202}), and the incentives provided to retailers and consumers to practice reuse and recycle of e-waste (S_{203}). Data on the answers to the follow-up questions, S_{201}, S_{202} and S_{203}, were coded as ordinal data, in which, "-2" was entered for "strongly dissatisfied", "-1" for "dissatisfied", "0" for "neutral", "1" for "satisfied", and "2" for "strongly satisfied". Variables, such as age, educational level and monthly income, were also categorized as ordinal data. For example, coding to distinguish the age groups was assigned by using "1" for the age group ≤17 years, "2" for 18-22 years, "3" for 23-30 years, "4" for 31-35 years, "5" for 36-45 years, and "6" for ≥46 years. The missing ordinal data was coded as "9" for ease of distinction.

Coding to distinguish the targeted countries was designed by using "1" for Thailand, "2" for Laos and "3" for China. Likewise, the targeted retailer and consumer subgroups were identified by using "1" for the retailer subgroup and "2" for the consumer subgroup. Coding to distinguish gender was assigned by using "1" for male and "2" for female.

3.5 Policy-Process-Practice approach

3.5.1 PPP variables

Given the characteristics of e-waste, a quantitative Policy-Process-Practice approach was developed and proposed to be used for evaluating the tangible and intangible values in a country's e-waste related policies, management processes and disposal practices by a numerical zero-or-sum system; in which, "0" was assigned to represent the lack of data in policy, process or practice and "1" represented the opposite of "0". After evaluating the entire variables for both retailer and consumer subgroups, a total of 5, 3 and 6 variables were determined to be most pertinent variables to Policy (P_1), Process (P_2) and Practice (P_3), respectively (Table 3.2). These variables were numerically coded and then calculated into the equation.

Table 3.2. List of PPP variables

PPP	Variable	Question
Policy (P_1)	P_{101}	Knowledge of existing e-waste related laws and rules
	P_{102}	Willingness to comply with e-waste related laws and rules
	P_{103}	Concern over environmental conditions
	P_{104}	Status of environmental conditions
	P_{105}	Knowledge of how to improve environmental conditions
Process (P_2)	P_{201}	Environmental impact in segregation
	P_{202}	Environmental impact in extraction
	P_{203}	Environmental impact in incineration
Practice (P_3)	P_{301}	Supporting to control the rate of environmental deteriorating
	P_{302}	Paying extra for environmental friendly e-products
	P_{303}	Replacing phones due to exchange schemes
	P_{304}	Replacing phones for upgrading for new technology
	P_{305}	Sending e-waste to recovery centers
	P_{306}	Treating e-waste themselves

3.5.2 Scoring of Policy, Process and Practice variables

Different types of variables used different coding systems. The variables identified in the final list of P_1, P_2 and P_3 were all nominal data; therefore, coding for the data followed that mentioned in §3.4. The score of each variable was calculated using the total number of valid responses to that particular question divided by the number answering "yes". For example, when calculating one variable P_{i0j} for Country A, assuming the total number of valid responses to P_{i0j} in Country A was *n*; of which, *m* respondents answered "yes"; the score of P_{i0j} for Country A was *m*/*n*. Likewise, the scores for all individual variables P_{i0j} (i=1,2,3; j=1,2,3…k; in which, k is the total number of variables for P_i) for each country were calculated. Based on the scores, an average for each of P_1, P_2 and P_3 was then obtained.

The valid sample size of a particular variable within the total sample for one country was calculated into $P_{i\ average}\ (i=1,2,3)$. Again, taking $P_{1\ average}$ for Country A as an example, there were 5 variables identified under Policy (P_1); thus i=1, k=5 and j=1,2,3,4,5;

When

$P_{10j} = m_j / n_j$

Where,

m_j (j=1,2,3…k): The number of respondents answering "yes" to P_{i0j};
n_j (j=1,2,3…k): Total number of valid responses to P_{i0j};

then,

$$P_{1\ average} = \left(m_1 \times \frac{n_1}{n_a} + m_2 \times \frac{n_2}{n_r} + m_3 \times \frac{n_3}{n_c} + m_4 \times \frac{n_4}{n_a} + m_5 \times \frac{n_5}{n_a} \right) / \left(n_a + n_r + n_c + n_a + n_a \right)$$

Where,

n_r: Total number of valid sample size of respondents from retailer subgroup;
n_c: Total number of valid sample size of respondents from consumer subgroup;
n_a: Total number of valid sample size of all respondents.

Whether to use n_r, n_c, or n_a as a divider in the calculation depends on which target subgroup; retailer, consumer or both; is of the interest. Assuming the retailer subgroup is of the interest, then n_r is the choice. On the other hand, if the consumer subgroup is of the interest, n_c will be the choice. Similarly, if both the retailer and consumer subgroups are of the interest, then n_a will be the choice.

Results of $P_{i\ average}\ (i=1,2,3)$ were then factored into the equation to obtain a total weighted average (P_{total}) of a country, which was then used for comparison with other countries. Generally, the higher the P_{total} score was, the better the system of a country would be.

In calculating P_{total}, a weighting factor of 20% was assigned to P_1 (Policy) and the remaining 80% was evenly divided between P_2 (Process) and P_3 (Practice) at 40% each. The logics behind the proposed weighting scheme were that in order to determine the effectiveness of an e-waste management system in a country, its related policies, processes and practices should first be evaluated. Among the three key parameters, the policy parameter describes the e-waste management laws or rules adopted in a country that provide legal authorities and set standards for regulators, e-waste generators, and other stakeholders involving in e-waste management to follow. Under the established laws or rules, the process parameter determines whether or not technologically sound treatment processes for different types of e-waste are being implemented to meet the standards set forth in the laws. Finally, to carry out those treatment processes, the practice parameter evaluates whether or not proper treatment actions or activities are undertaken to treat, recycle, reuse, or dispose of e-waste in a country.

Theoretically, all three of the parameters are equally important to ensure that e-waste is properly managed and its disposal does not pose a threat to the environment. If so, the weight for each parameter would not be an issue for concern as the three parameters should have the same weight. However, based on the program actions taken separately in China and Thailand, e-waste was collected through an old-for-new appliance trade-in program implemented in China under the auspices of the Guidelines for Electronic Waste Environmental Pollution Prevention and Control (SEPA, 2007) or through a bounty program implemented in Thailand in the absence of related e-waste laws. This shows that, though laws are important in providing legal authorities and setting standards for e-waste management, the goal to collect e-waste for proper treatment or disposal could be achieved through instituting innovative actions while legislation for e-waste related laws is being deliberated. The bounty program instituted in Thailand serves as a good example to emphasize the importance of the process and practice parameters. The weights for the process and practice parameters are therefore increased to 40%

each while the weight for the policy parameter is decreased to 20%. Based on these weighting factors assigned, respectively, to P_1, P_2 and P_3, the P_{total} for each country was calculated.

$$P_{total} = P_{1\ average} \times 20\% + P_{2\ average} \times 40\% + P_{3\ average} \times 40\%$$

3.6 Data analysis

Using SPSS Statistics 17.0 (SPSS Inc, 2008), the survey data were subject to the chi-square (χ^2) test or the analysis of variance and means were separated and compared by the Tukey's multiple range test, whenever applicable. Also, weighted averages (Schneider, 2000) were calculated to facilitate comparisons of environmental performances in e-waste related policies, management process and disposal practices among Thailand, Laos and China.

In addition, Pearson product-moment correlation coefficients were computed to assess the relationships of different gender, age groups, educational and income levels with five policy variables; knowledge of existing e-waste related laws and rules (P_{101}), willingness to comply with e-waste related laws and rules (P_{102}), concern over environmental conditions (P_{103}), status of environmental conditions (P_{104}) and knowledge of how to improve environmental conditions (P_{105}); among Thailand, Laos and China.

Chapter 4
Results and Discussion

4.1 Questionnaire surveys results

Questionnaire surveys were intensively conducted in Bangkok, Thailand during June – September 2013; in Vientiane Capital, Laos in December 2013; and in Beijing, China in April 2014.

Table 4.1 shows that of the number of questionnaires distributed, the valid rates from both retailer and consumer subgroups in Laos and China exceeded 95%; for which, the validity of the responses was considered very good (Babbie, 1990). Despite that both of the response- and valid-rates from the retailer and consumer subgroups in Thailand were much lower than those of Laos, the validity of the response rates was considered good from Thai retailers at 68% and very good from Thai consumers at 77% (Babbie, 1990).

Table 4.1. Number and percentage of the questionnaires for the retailer and consumer subgroups distributed, returned and deemed valid in the surveys conducted in Thailand (Th), Laos (La) and China (Cn)

	Retailer			Consumer		
	Th	La	Cn	Th	La	Cn
No. Distributed	427	178	320	734	385	667
No. Returned (%)	311 (73)	177 (99)	210 (66)	615 (84)	376 (98)	659 (99)
No. Valid (%)	210 (68)	173 (98)	202 (96)	474 (77)	376 (100)	653 (99)
No. Invalid	101	4	8	141	0	6

Table 4.1 also shows that the consumer subgroup had higher response- and valid-rates than those of the retailer subgroup in the three countries. These higher rates were attributed to: i) the population of mobile phone users was much higher than

that of retailers; thus easier to identify and target as respondents for the consumer subgroup; and ii) some retailers considered certain information contained in the questionnaires to be proprietary; therefore, were reluctant to provide their answers, despite that the intent of the survey for research purposes was adequately explained.

The reason for the low response- and valid-rates from both of the retailer and consumer subgroups in Thailand was due to the fact that Thailand was the first country in which the survey was conducted. As such, the surveyors' approach toward respondents, while conducting the surveys, was not skillful in soliciting cooperation from respondents to willingly provide their answers in the questionnaires. The lessons learned from the surveys in Thailand were applied to the subsequent surveys conducted in Laos and China. Therefore, better response- and valid-rates were obtained in these two countries, resulting from the better instructions provided at the survey orientation sessions.

4.2 Results of 3R practice, take-back system and incentive related questions

4.2.1 Chi-square (χ^2) analysis of lead questions data

As mentioned in §3.6, the data collected on the responses to the lead questions $PreS_{201}$, $PreS_{202}$ and $PreS_{203}$ were subjected to χ^2 analyses and the results were presented in Table 4.2. The null hypothesis established for the χ^2 test was that there were no significant differences in answering "yes" and "no" from respondents to each of the lead questions, $PreS_{201}$, $PreS_{202}$ and $PreS_{203}$, among the three countries surveyed.

Table 4.2 shows that there was no significant difference in providing "yes" or "no" answers to $PreS_{203}$ (χ^2=0.977, p>0.05) among Thailand, Laos and China. However, there were significant differences in respondents' answering "yes" and "no" to $PreS_{201}$ (χ^2=33.901, p<0.01) and $PreS_{202}$ (χ^2=37.329, p<0.01) among the three countries. Of these three countries, the respondents from China provided the highest percentage (75.3%) of "yes" answer to $PreS_{201}$, indicating that the respondents from China appeared to have practiced using recyclable or reusable materials in their manufacture process as compared to those from Thailand and Laos. Conversely, the respondents from Thailand provided the highest percentage (69.4%) of “yes” answer to $PreS_{202}$ among the three countries. This result indicated that the respondents from Thailand appeared to be more knowledgeable about the take-back system and the importance of adopting it in Thailand as compared to those from Laos and China. This high percentage of knowledge of the take-back system in Thailand may be a result of the bounty program implemented in Thailand, which achieved the purpose of public education under the campaign of taking back e-waste in exchange for a minimal reward from the program.

Table 4.2. Chi-square test of the observed counts of responses to the three lead questions on using 3R materials in manufacture ($PreS_{201}$), adopting take-back system ($PreS_{202}$) and providing incentives for reuse/recycle of e-waste ($PreS_{203}$) among Thailand (Th), Laos (La) and China (Cn)

Variable	Observed count (%)	Th	La	Cn	Total
$PreS_{201}$	Yes (%)	150 (71.4)	82 (47.7)	119 (75.3)	351
	No (%)	60 (28.6)	90 (52.3)	39 (24.7)	189
	Total	210	172	158	540
	χ^2		33.901**		
$PreS_{202}$	Yes (%)	145 (69.4)	67 (38.7)	98 (50.0)	310
	No (%)	64 (30.6)	106 (61.3)	98 (50.0)	268
	Total	209	173	196	578
	χ^2		37.329**		
$PreS_{203}$	Yes (%)	90 (42.9)	71 (41.0)	75 (38.1)	236
	No (%)	120 (57.1)	102 (59.0)	122 (61.9)	344
	Total	210	173	197	580
	χ^2		0.977		

* Significant at df=2, $p<0.05$
** Significant at df=2, $p<0.01$

Table 4.2 also shows that the respondents from Laos provided the highest percentage of "no" answers to both $PreS_{201}$ (52.3%) and $PreS_{202}$ (61.3%). The results indicated that the respondents from Laos appeared to have the least knowledge on using recyclable or reusable materials in the manufacture process and the adoption of a take-back system in Laos. This result appeared to be consistent with the findings through the review of government published documents and the interview of government officials, in that there was a lack of electronic equipment manufacturing facilities or plants in Laos and also there was no e-waste recycling system, nor recycling centers or take-back programs, established in Laos. Therefore, it is not a surprise to find that the respondents from

Laos were least knowledgeable about the questions relating to $PreS_{201}$ and $PreS_{202}$ among the three countries.

4.2.2 Analysis of variance of scale data on follow-up questions

If the answers to the lead questions of $PreS_{201}$, $PreS_{202}$ and $PreS_{203}$ were "yes", respondents were further requested to provide answers to the follow-up questions by rating their levels of satisfaction to the respective lead questions. The mean numbers of the responses to S_{201}, S_{202} and S_{203} were subject to the analysis of variance. The results showed that at df=2, the F values for S_{201}, S_{202} and S_{203} were 3.459, 2.702 and 6.394, respectively; and the mean numbers of their responses to S_{201} and S_{203} were significantly different in the three countries at $p<0.05$. However, the mean numbers of their responses to S_{202} were not significantly different at $p>0.05$. Therefore, no attempt was made to separate and compare the mean numbers of the responses to S_{202} in the three countries. However, the mean numbers of the responses to the question S_{201} were separated and compared by using the Tukey's multiple range tests and the results showed that Laos was significantly greater than Thailand (Mean Difference [MD] = 0.340, $p<0.05$), but not significantly different from China (MD=0.115, $p>0.05$). Also, China was not significantly different from Thailand (MD=0.225, $p>0.05$). Likewise, the mean numbers of the responses to the question of S_{203} were separated and compared by using the Tukey's multiple range tests and the results showed that Laos was significantly greater than Thailand (MD=0.573, $p<0.01$), but not significantly different from China (MD=0.209, $p>0.05$). Also, China was not significantly different from Thailand (MD=0.364, $p>0.05$). The reason for Laos having a greater mean number than Thailand in the responses to both questions of S_{201} and S_{203} was unexplainable as there were no relevant documents available to prove that recyclable or reusable materials were actually used by EEE manufacturers or any incentive was provided to retailers and consumers for practicing reuse and recycle of e-waste in Laos. In contrast, Thailand has initiated strategies to promote EEE production using recyclable material and facilitating recycling technology through tax benefit and investment incentives in Thailand (PCD, 2007). Therefore, it was unexplainable why Thailand received a lower mean number than Laos. One possible explanation is that the social desirability (Groves, 1989), rather than the actual knowledge of fact, was used by the respondents from Laos in providing answers to these two questions, S_{201} and S_{203}. As such, a further study is needed to pinpoint the discrepancy in the future.

4.3 PPP results

The PPP equation was developed in this study to enable the analysis and comparison of the strengths and weaknesses of the e-waste management systems adopted in China, Laos and Thailand. A total of 5, 3 and 6 variables were determined to be pertinent to the policy (P_1), process (P_2) and practice (P_3), respectively. Three subtotal scores were obtained from a summation of all the individual scores assigned to the respective variables under P_1, P_2, and P_3; and then a weighted average for each of P_1, P_2 and P_3 was calculated and factored into the PPP equation to obtain a total score (P_{total}) for each country.

4.3.1 Policy (P_1) variables

There were five questions designed to receive responses on issues related to e-waste laws and rules and awareness of environment concerns and conditions, which include knowledge of existing e-waste related laws and rules (P_{101}), willingness to comply with e-waste related laws and rules (P_{102}), concern over environmental conditions (P_{103}), status of environmental conditions (P_{104}) and knowledge of how to improve environmental conditions (P_{105}), among Thailand, Laos and China. The responses to P_{101}, P_{102}, P_{103}, P_{104} and P_{105} in Thailand, Laos and China and the results of the χ^2 analyses were presented in Table 4.3. The null hypothesis established for the χ^2 test was that there were no significant differences in answering “yes” and “no” from respondents to each of the questionnaires on P_{101}, P_{102}, P_{103}, P_{104} and P_{105} among the three countries surveyed.

Table 4.3 shows that there were significant differences in respondents’ answering “yes” and “no” to P_{101} (χ^2=132.665, p<0.01), P_{102} (χ^2=68.213, p<0.01), P_{103} (χ^2=37.146, p<0.01), P_{104} (χ^2=128.826, p<0.01) and P_{105} (χ^2=34.340, p<0.01) among the three countries. Of these three countries, Lao respondents had the highest percentage in answering “yes” to P_{101} than the respondents from Thailand and China. However, based on the review of the laws and rules adopted by each country and the interviews of government officials in the three countries, it was abundantly clear that despite Laos has adopted only an Environmental Protection Law in April 1999 (National Assembly, 1999), it did not promulgate any other laws pertinent to either solid waste management or e-waste management. UNEP (2014), under its Global Partnership on Waste Management, conducted an assessment of country needs in management of e-waste and the result showed the deficiency of Laos in its e-waste management. Thus, improvement in the capacity building in Laos in the area of e-waste management was urgently needed due to its lack of legislation for regulating e-waste disposal. Besides the lack of regulation, inaccessible confidential information relating to the composition of electronic products made their tracking and monitoring more difficult. Hence, at the institutional level, training and awareness-raising activities needed to be heightened to promote the reuse, recycle or even proper disposal of e-waste to prevent it from becoming a major environmental concern in Laos in the future (UNEP, 2014). Based on this, the possible reason for Laos to receive the highest percentage in answering “yes” to P_{101} may be attributed to the social desirability (Groves, 1989), instead of the actual knowledge of fact.

Table 4.3. Chi-square test of the observed counts of responses to five Policy variables; knowledge of existing e-waste related laws (P_{101}), willingness to comply with e-waste related laws (P_{102}), concern over environmental conditions (P_{103}), status of environmental conditions (P_{104}) and knowledge of how to improve environmental conditions (P_{105}); among Thailand (Th), Laos (La) and China (Cn)

Variable	Observed count (%)	Th	La	Cn	Total
P_{101}	Yes (%)	71 (10.8)	181 (33.7)	107 (12.5)	359
	No (%)	586 (89.2)	356 (66.3)	748 (87.5)	1690
	Total	657	537	855	2049
	χ^2		132.665**		
P_{102}	Yes (%)	193 (93.2)	133 (77.8)	116 (58.6)	442
	No (%)	14 (6.8)	38 (22.2)	82 (41.4)	134
	Total	207	171	198	576
	χ^2		68.213**		
P_{103}	Yes (%)	624 (91.4)	531 (96.7)	835 (97.7)	1990
	No (%)	59 (8.6)	18 (3.3)	20 (2.3)	97
	Total	683	549	855	2087
	χ^2		37.146**		
P_{104}	Yes (%)	308 (47.5)	210 (38.9)	170 (20.3)	688
	No (%)	341 (52.5)	330 (61.1)	669 (79.7)	1340
	Total	649	540	839	2028
	χ^2		128.826**		
P_{105}	Yes (%)	340 (50.7)	343 (62.6)	399 (46.8)	1082
	No (%)	330 (49.3)	205 (37.4)	454 (53.2)	989
	Total	670	548	853	2071
	χ^2		34.340**		

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Results of the review of the adoption of laws and rules in each of the three countries and the interview of government official further showed that China adopted its Environmental Protection Law in December 1989 (NPC, 1989), and the Solid Waste Pollution Prevention and Control Law in December 2004 (NPC, 2004). Besides these two laws, China also promulgated a rule on the Guidelines for Electronic Waste Environmental Pollution Prevention and Control under its SEPA in September 2007 (SEPA, 2007). These guidelines became effective in February 2008, containing a total of 26 articles in five chapters on dissemblance, utilization and treatment of e-waste, targeting six major groups, which include manufacturers, importers, distributers, utilizers, dissemblers and recyclers. Also included were the monitoring and management of dissemblance, utilization and treatment of e-waste; designating responsibilities of related parties; and establishing penal codes and enforcement actions (Liang & Sharp, 2013). This clearly demonstrated that China has the most complete set of e-waste management related laws and rules among the three countries. However, due to the lack of enforcement data on the actual fines or other enforcement actions taken against violations in China, it was difficult to evaluate the effectiveness of the guidelines adopted to prevent or control environmental pollutions caused by transboundary movement, improper disposal, dissemblance, utilization or treatment of e-waste in China (Liang & Sharp, 2013).

The results also showed that Thailand adopted the Enhancement and Conservation of National Environmental Quality Act B.E. 2535 in April 1992 (NLA, 1992a). Also, Thailand adopted the Hazardous Waste Act B.E. 2535 (NLA, 1992c) and the Public Health Act B.E. 2535 (NLA, 1992d), both effective in April 1992. In the absence of the e-waste management related laws or rules adopted in Thailand, its Pollution Control Department (PCD, 2007) formulated a set of unenforceable Integrated Strategies for Electrical Appliance and Electronic Waste Management and implemented its Phase I during 2007-2011. The unenforceable Strategies outlined the objectives and targets, enumerated six management guidelines, five strategies and 13 operational measures. The Strategies emphasized that an important approach for the Thai Government to take was to develop a legal system integrated with a financial mechanism to manage WEEE in the future (PCD, 2010). Manomaivibool et al. (2009) summarized that several attempts had been made to develop a legal framework in Thailand in the last decade, which included a Draft Act on Management of Hazardous Substance from Used Products (WEEE and other products) in 2004 spearheaded by the Ministry of Natural Resources and Environment (MONRE), a Draft Act on Fiscal Instruments/Measures for Environmental Management spearheaded by the Ministry of Finance (MOF) in 2008 and reviewed by the State Council in 2011, and also a Draft Royal Decree on Product Fee Management in 2010 spearheaded by MONRE. However, due to the lack of progress in revising the Draft Act on Fiscal Measures for Environmental Management and no deadline set by MOF to complete the revision, MONRE was considering either redrafting an Act, which would dovetail the Draft Royal Decree on Product Fee Management or developing a new law to extend producers' responsibility (Manomaivibool et al., 2009).

In Thailand, there were demonstrated challenges in formulating, enforcing and implementing environmental laws due to its political instability in the last decade, which impedes the continuity in the execution and enforcement of the laws; its lack of demarcation line in defining enforcement responsibility among multiple ministries causing interagency confusion in execution of the laws; and its cumbersome budgetary control and procurement systems precluding effective implementation of the laws (Vassanadumrongdee & Manomaivibool, 2014). Besides these impediments, the management system adopted by the Thai government was an input orientated system rather than an output driven system, rendering it more difficult to monitor or evaluate the performance of government agencies of concern in the execution of environmental laws.

Table 4.3 also shows that the respondents from Thailand provided the highest percentage (93.2%) of "yes" answer to P_{102} among the three countries. This indicated that the respondents from Thailand appeared to be more willing to comply with e-waste related laws and rules as compared to those from Laos and China. Conversely, the respondents from China provided the highest percentage (41.4%) of "no" answer to P_{102} among the three countries. This result indicated that there should be a challenge for the Chinese government or environmental organizations in China to improve their public campaigns or educational programs to enhance compliance to e-waste related laws and rules. Table 4.3 further shows that the respondents from China provided the highest percentage (97.7%) of "yes" answer to P_{103} and also highest percentage (79.7%) of "no" answer to P_{104} among the three countries, indicating that the respondents from China appeared to have more concerns over environmental conditions, particularly over the deteriorating environmental conditions in China, as compared to those from Thailand and Laos. Table 4.3, however, shows that the respondents from China also provided the highest percentage (53.2%) of "no" answer to P_{105} among the three countries, indicating that Chinese respondents appeared to have the least knowledge on how to improve environmental conditions, even though they were indeed aware of the deteriorating environment. This result showed that the Chinese government and relevant educational agencies should also have the challenge to enhance Chinese people's knowledge of how to improve their environment.

4.3.2 Process (P_2) variables

Three variables were chosen as the key elements to represent the Process (P_2), which were relating to their impact to the environment in the e-waste recovery operations. These three variables were represented by the questions used to poll the consumer subgroup on its knowledge of the environmental impacts associating with the e-waste recovery operations through segregation (P_{201}), extraction (P_{202}) and incineration (P_{203}). The questions were designed as multiple choices allowing respondents to choose their answers based upon their knowledge or experience. The questionnaire survey data were subject to the χ^2 test to compare the frequency distributions of responses to P_{201}, P_{202} and P_{203} among the three countries. The responses to the three Process variables and the results of the χ^2 analyses were presented in Table 4.4. The null hypothesis established for the χ^2 test was that there were no significant differences in answering "yes" and "no" from respondents to each of the questionnaires on P_{201}, P_{202} and P_{203} among Thailand, Laos and China.

Table 4.4 shows that there were significant differences in providing their "yes" and "no" answers to P_{201} (χ^2=89.291, p<0.01), P_{202} (χ^2=128.921, p<0.01) and P_{203} (χ^2=271.731, p<0.01) among the respondents of the three countries. Of the three countries surveyed, the respondents from Thailand had the highest percentage in answering "yes" to P_{201} than those from Laos and China. The respondents from China, however, consistently provided the highest percentage of "yes" answer to P_{202} and P_{203}.

Table 4.4. Chi-square test of the observed counts of responses to three Process variables; knowledge of the environmental impacts associating with the e-waste recovery operations through segregation (P_{201}), extraction (P_{202}) and incineration (P_{203}); among Thailand (Th), Laos (La) and China (Cn)

Variable	Observed count (%)	Th	La	Cn	Total
P_{201}	Yes (%)	300 (63.3)	120 (31.9)	280 (42.9)	700
	No (%)	174 (36.7)	256 (68.1)	373 (57.1)	803
	Total	474	376	653	1503
	χ^2		89.291**		
P_{202}	Yes (%)	62 (13.1)	70 (18.6)	270 (41.3)	402
	No (%)	412 (86.9)	306 (81.4)	383 (58.7)	1101
	Total	474	376	653	1503
	χ^2		128.921**		
P_{203}	Yes (%)	141 (29.7)	273 (72.6)	493 (75.5)	907
	No (%)	333 (70.3)	103 (27.4)	160 (24.5)	596
	Total	474	376	653	1503
	χ^2		271.731**		

* Significant at df=2, p<0.05

** Significant at df=2, p<0.01

The reasons for China to have the highest percentage of "yes" answer to P_{202} and P_{203} in the three countries were attributable to its adoption of two e-waste management related rules; one on the recovery and disposal of waste electric and electronic products in 2008 (State Council, 2009) and the other on the guidelines for electronic waste environmental pollution prevention and control adopted in China in 2007 (SEPA, 2007). The former rule requires the establishment of a system to recover e-waste through multiple channels for its centralized disposal or reusing it as an important resource (State Council, 2009). The latter rule establishes guidelines not only for dissemblance of EEE, but also for utilization and disposal treatment of e-waste (SEPA, 2007). Thailand, however, provided the highest percentage of "yes" answer to P_{201}. It may be the result of the adoption of the Factory Act (NLA, 1992b), which is administered by the Thailand Department of Industrial Works. In the Act, factories engaging in the business of sorting and/or landfill of waste are regulated in Thailand. Also regulated under the Act are factories engaging in the business of recycling operation in which unusable industrial products or industrial waste being utilized to produce raw materials or new products (NLA, 1992b). PCD (2010) listed 22 factories engaging in businesses of sorting, refurbishing, repairing and/or recycling EEE.

In addition, the take-back system adopted in Thailand, as evident in the survey results of $PreS_{202}$ presented above, appeared to have enhanced the knowledge of the respondents from Thailand on the importance of proper reuse, recycle and disposal of e-waste. On the other hand, the old-for-new appliance trade-in project was implemented in selected provinces and cities in China. These two programs were both effective in their respective ways in educating the public on the importance of collection for proper disposal of e-waste in Thailand and China. Either of the programs may serve as good models for other countries to follow, such as Laos where neither a take-back system nor an old-for-new appliance measure was adopted or implemented.

4.3.3 Practice (P_3) variables

There were six variables chosen as the key elements to represent the Practice (P_3), which were relating to the impact on environmental protection and e-waste treatment and disposal; including controlling the rate of environmental deterioration (P_{301}), willingness to pay extra for an environmental friendly electronic product (P_{302}), replacing mobile phones due to attractive exchange schemes (P_{303}) and upgrading technology (P_{304}), sending e-waste to recovery centers (P_{305}), and treating e-waste themselves (P_{306}). The questionnaire survey data were subject to the χ^2 test to compare the frequency distributions of responses to P_{301}, P_{302}, P_{303}, P_{304}, P_{305} and P_{306} among the three countries. The responses to the six Practice variables and the results of the χ^2 analyses were presented in Table 4.5. The null hypothesis established for the χ^2 test was that there were no significant differences in answering "yes" and "no" from respondents to each of the questionnaires on P_{301}, P_{302}, P_{303}, P_{304}, P_{305} and P_{306} among Thailand, Laos and China.

Table 4.5 shows that there were no significant differences in providing "yes" or "no" answers to P_{305} (χ^2=0.654, p>0.05) and P_{306} (χ^2=2.457, p>0.05) among Thailand, Laos and China. The results showed that around 70% of respondents in the three countries did not send e-waste to recovery centers (P_{305}) or treat by themselves (P_{306}). However, there were significant differences in providing their "yes" or "no" answers to the remaining four practice variables; including P_{301} (χ^2=27.861, p<0.01), P_{302} (χ^2=14.705, p<0.01), P_{303} (χ^2=285.374, p<0.01) and P_{304} (χ^2=72.114, p<0.01) among the three countries. Of the three countries surveyed, the respondents from Thailand provided the highest percentage (94.6%) of "yes" answer to P_{301} than those from Laos and China. The results indicated that Thai respondents appeared to have practiced and supported more effort invested in controlling the deteriorating environment as compared to Lao and Chinese respondents. For example, a bounty program was recently initiated in Thailand to encourage its citizenry to turn in e-waste, for a minimal reward, at centralized locations for proper disposal. This bounty program was effective even in the absence of the e-waste related laws or rules established in Thailand. The respondents from Laos, however, provided the highest percentage (83.0%) of "yes" answer to P_{302} than those from Thailand and China, indicating that Lao respondents appeared to be more willing to pay extra for environmental friendly e-products, followed by those from China and Thailand. Although there might have fewer chances to have access to environmental friendly e-products in Laos as compared to China and Thailand, the respondents from Laos showed their willingness to pay extra for those e-products if they were available in Laos. P_{303} and P_{304} were designed to identify reasons for replacing mobile phones. Of the three countries surveyed, the respondents from Thailand provided the highest percentage (50.4%) of answering “yes” to P_{303}; while the respondents from Laos and China provided the similar level of percentage of answering “yes” to the same question at 10.9% and 10.7%, respectively. The results indicated that Thai respondents appeared to replace their mobile phones mainly because of attractive exchange schemes provided in Thai market. Conversely, the respondents from China and Laos provided the similar level of percentage of answering “yes” to P_{304} at 45.3% and 44.4%, respectively. This result indicated that the respondents from China and Laos appeared to have replaced their phones in keeping with the advancement of new technology.

Table 4.5. Chi-square test of the observed counts of responses to six Practice variables; controlling the rate of environmental deterioration (P_{301}), willing to pay extra for an environmental friendly electronic product (P_{302}), replacing mobile phones due to attractive exchange schemes (P_{303}) and upgrading for new technology (P_{304}), sending e-waste to recovery centers (P_{305}) and treating e-waste by themselves (P_{306}); among Thailand (Th), Laos (La) and China (Cn)

Variable	Observed count (%)	Th	La	Cn	Total
P_{301}	Yes (%)	625 (94.6)	514 (93.6)	746 (87.6)	1885
	No (%)	36 (5.4)	35 (6.4)	106 (12.4)	177
	Total	661	549	852	2062
	χ^2		27.861**		
P_{302}	Yes (%)	498 (73.8)	448 (83.0)	646 (77.1)	1592
	No (%)	177 (26.2)	92 (17.0)	192 (22.9)	461
	Total	675	540	838	2053
	χ^2		14.705**		
P_{303}	Yes (%)	239 (50.4)	41 (10.9)	70 (10.7)	350
	No (%)	235 (49.6)	335 (89.1)	583 (89.3)	1153
	Total	474	376	653	1503
	χ^2		285.374**		
P_{304}	Yes (%)	105 (22.2)	167 (44.4)	296 (45.3)	568
	No (%)	369 (77.8)	209 (55.6)	357 (54.7)	935
	Total	474	376	653	1503
	χ^2		72.114**		
P_{305}	Yes (%)	64 (30.5)	55 (31.8)	69 (34.2)	188
	No (%)	146 (69.5)	118 (68.2)	133 (65.8)	397
	Total	210	173	202	585
	χ^2		0.654		
P_{306}	Yes (%)	65 (31.0)	42 (24.3)	52 (25.7)	159
	No (%)	145 (69.0)	131 (75.7)	150 (74.3)	426
	Total	210	173	202	585
	χ^2		2.457		

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

4.3.4 PPP values

After factoring in the average scores from each of Policy (P_1), Process (P_2), and Practice (P_3) into the PPP equation with the respective weighting factors of 20%, 40% and 40%, a P total weighted average (P_{total}) for each country was obtained as follows:

$$P_{total} = P_{1\,average} \times 20\% + P_{2\,average} \times 40\% + P_{3\,average} \times 40\%$$

$$P_{total}\ Th = 0.114 \times 20\% + 0.118 \times 40\% + 0.128 \times 40\% = 0.121$$

$$P_{total}\ La = 0.130 \times 20\% + 0.137 \times 40\% + 0.129 \times 40\% = 0.132$$

$$P_{total}\ Cn = 0.101 \times 20\% + 0.177 \times 40\% + 0.125 \times 40\% = 0.141$$

Table 4.6 presents a summary of the individual values of P_1, P_2, P_3 and P_{total} for Thailand, Laos and China.

Table 4.6. A summary of the values of P_1, P_2, P_3 and P total weighted average (P_{total}) for Thailand (Th), Laos (La) and China (Cn)

Variable	Th	La	Cn
P_{101}	0.11	0.34	0.13
P_{102}	0.93	0.78	0.59
P_{103}	0.91	0.97	0.98
P_{104}	0.47	0.39	0.20
P_{105}	0.51	0.63	0.47
$P_{1\ average}$	***0.114***	***0.130***	***0.101***
P_{201}	0.63	0.32	0.43
P_{202}	0.13	0.19	0.41
P_{203}	0.30	0.73	0.75
$P_{2\ average}$	***0.118***	***0.137***	***0.177***
P_{301}	0.95	0.94	0.88
P_{302}	0.74	0.83	0.77
P_{303}	0.50	0.11	0.11
P_{304}	0.22	0.44	0.45
P_{305}	0.30	0.32	0.34
P_{306}	0.31	0.24	0.26
$P_{3\ average}$	***0.128***	***0.129***	***0.125***
P_{total}	**0.121**	**0.132**	**0.141**

4.4 Comparisons of PPP values among the three countries

The average values for Policy ($P_{1\ average}$), Process ($P_{2\ average}$) and Practice ($P_{3\ average}$) were obtained and calculated from the questionnaire survey results on the basis of the subjective responses from the respondents. Table 4.6 shows that of the three countries surveyed, Laos received the highest $P_{1\ average}$ at 0.130 and $P_{3\ average}$ at 0.129, and China received the highest $P_{2\ average}$ at 0.177. The results indicated that the respondents from Laos appeared to be more knowledgeable about the e-waste related laws and rules and also how to improve environmental conditions, despite the fact that there were no e-waste related laws and rules adopted in Laos, which was discussed previously in §4.3.1. It was, however, logical for China to receive the highest $P_{2\ average}$ as it was a reflection on China's adoption of environmental protection and e-waste management related laws and rules as well as its establishments of e-waste handling processes, which were discussed in §4.3.2. In a further comparison of the values of P_2 variables, Laos received a higher score in P_{203} than Thailand. In addition, Laos also received higher scores in three variables of P_{302}, P_{304} and P_{305} than Thailand. It is of particular interest to mention that among these variables, Laos received a higher score than Thailand in the variable P_{305} (variable relating to sending e-waste to recovery centers for processing). This result appeared to be inconsistent with the review of the official publications, which showed no e-waste recovery centers established in Laos. The fact of lacking e-waste treatment plants or recovery centers in Laos was further confirmed by personal interviews of management officials of two mobile phone brands. The management officials interviewed also confirmed that as a practice, the e-waste generated in Laos has been shipped to either Thailand or China for disposal or treatment. Therefore, the survey results showing that Laos received higher scores than Thailand in most of the variables in P_2 and P_3 may be attributed to the social desirability (Groves, 1989), but not the actual knowledge of facts, used as basis by the respondents in Laos while answering the questions pertaining to those variable in P_2 and P_3. Besides the lack of actual knowledge of facts, another plausible cause of the higher scores for P_2 and P_3 may be attributed to the misunderstanding of the survey questions on the part of Lao respondents even though the questionnaires were professionally translated into Laos and each survey question was properly explained at the pre-survey orientation session conducted in Laos. Thus, further study may be needed in the future to discern the discrepancy found in the survey results in P_2 and P_3 from the actual facts.

The combined P_{total} summarized in Table 4.6 showed that China had the highest score of P_{total} at 0.141 among the three countries, which was followed by Laos at 0.132 and then Thailand at 0.121. This result demonstrated that in receiving the highest score for P_{total}, China, except for $P_{1\ average}$ (0.101), scored well for $P_{2\ average}$ (0.177) and $P_{3\ average}$ (0.125), both of which have a weighting factor of 40%, compared to Laos and Thailand. Conversely, Thailand had the lowest score $P_{2\ average}$ (0.118) compared to China and Laos; thus, it had the lowest P_{total} (0.121) among the three countries. This result further demonstrated that using PPP approach to assist decision makers in making sound decisions, a decision maker must carefully evaluate all the issues involved before a decision is rendered. That final decision will be affected by the consistent standing of all the issues under consideration and the weighting factor assigned to each issue. This study showed that PPP approach could be effectively applied to assist decision makers in making choices by using category data available through questionnaire surveys.

4.5 Determination of the knowledge of e-waste disposal impacts on the environment among different gender, age, educational and income levels in China, Laos and Thailand

4.5.1 Gender

Pearson product-moment correlation coefficients (*r*) were calculated to determine the relationship of gender with five policy variables; knowledge of existing e-waste related laws and rules (P_{101}), willingness to comply with e-waste related laws and rules (P_{102}), concern over environmental conditions (P_{103}), status of environmental conditions (P_{104}) and knowledge of how to improve environmental conditions (P_{105}); among Thailand, Laos and China. The result was summarized in Table 4.7.

Table 4.7 shows that there was a strong, positive correlation between gender and status of environmental conditions (P_{104}) at r=0.077, n=1994, p<0.01, indicating that compared with male respondents, females were more positive toward the status of the environmental conditions and considered it to be improving.

However, there was a strong, negative correlation between gender and knowledge of how to improve environmental conditions (P_{105}) at r=-0.067, n=2037, p<0.01, indicating that female respondents were less knowledgeable about how to improve environmental conditions than male respondents in these three countries.

Table 4.7. Correlation coefficients (*r*) of the responses (n) from different gender, age groups, educational and income levels to five variables; knowledge of existing e-waste related laws (P_{101}), willingness to comply with e-waste related laws (P_{102}), concern over environmental conditions (P_{103}), status of environmental conditions (P_{104}) and knowledge of how to improve environmental conditions (P_{105}); among Thailand, Laos and China

		P_{101}	P_{102}	P_{103}	P_{104}	P_{105}
Gender	*r*	-0.019	0.078	-0.025	0.077**	-0.067**
	n	2017	562	2053	1994	2037
Age	*r*	-0.010	0.066	0.052*	0.007	0.061**
	n	2040	573	2077	2018	2061
Education	*r*	0.017	0.056	0.016	-0.015	0.072**
	n	2024	565	2062	2004	2045
Income	*r*	-0.039	-0.022	0.038	-0.151**	0.034
	n	1857	571	1888	1836	1873

* Significant at $p<0.05$

** Significant at $p<0.01$

The questionnaire survey data were subject to Pearson's chi-square test to compare the frequency distributions of responses from male and female respondents from Thailand, Laos and China to P_{101}, P_{102}, P_{103}, P_{104} and P_{105}. The responses of male and female to P_{101}, P_{102}, P_{103}, P_{104} and P_{105} and the results of the χ^2 analyses were presented in Tables 4.8, 4.9, 4.10, 4.11 and 4.12. The null hypothesis established for the χ^2 test was that there were no significant differences in answering "yes" and "no" from male and female respondents among Thailand, Laos and China to the five variables mentioned above.

Table 4.8 shows that male (χ^2=45.001, p<0.01) and female (χ^2=96.713, p<0.01) surveyed in Thailand, Laos and China were significantly different in answering “yes” or “no” to the question on their knowledge of e-waste related laws and rules (P_{101}). Of the three countries surveyed, both male (30.2%) and female (38.9%) respondents from Laos had the highest percentage in providing “yes” answer to P_{101}. Conversely, male (89.3%) and female (89.6%) respondents from Thailand had the highest percentage in answering “no” to P_{101}. This could be attributable to Thailand’s inadequate education in raising public awareness of its e-waste related laws and rules adopted.

Table 4.8. Chi-square test of the observed counts of responses from male and female respondents to the question on knowledge of existing e-waste related laws (P_{101}), among Thailand (Th), Laos (La) and China (Cn)

Gender	Observed count (%)	P_{101}			
		Th	La	Cn	Total
Male	Yes (%)	26 (10.7)	94 (30.2)	62 (13.8)	182
	No (%)	216 (89.3)	217 (69.8)	386 (86.2)	819
	Total	242	311	448	1001
	χ^2	45.001**			
Female	Yes (%)	41 (10.4)	84 (38.9)	45 (11.1)	170
	No (%)	352 (89.6)	132 (61.1)	362 (88.9)	846
	Total	393	216	407	1016
	χ^2	96.713**			

* Significant at df=2, p<0.05

** Significant at df=2, p<0.01

Table 4.9 shows that male (χ^2=29.821, p<0.01) and female (χ^2=34.503, p<0.01) in Thailand, Laos and China were significantly different in answering "yes" or "no" to the question on their willingness to comply with e-waste related laws and rules (P_{102}). Both male (92.2%) and female (93.7%) of Thai respondents provided the highest percentage of "yes" answer to P_{102} among the three countries, which was followed by Laos and China. Chinese respondents, however, provided the highest percentage of "no" answer to P_{102}, indicating that Chinese respondents had the least willingness to comply with e-waste related laws and rules.

Table 4.9. Chi-square test of the observed counts of responses from male and female respondents to the question on willingness to comply with e-waste related laws (P_{102}), among Thailand (Th), Laos (La) and China (Cn)

Gender	Observed count (%)	P_{102}			
		Th	La	Cn	Total
Male	Yes (%)	83 (92.2)	71 (75.5)	85 (59.9)	239
	No (%)	7 (7.8)	23 (24.5)	57 (40.1)	87
	Total	90	94	142	326
	χ^2		29.821**		
Female	Yes (%)	104 (93.7)	54 (78.3)	31 (55.4)	189
	No (%)	7 (6.3)	15 (21.7)	25 (44.6)	47
	Total	111	69	56	236
	χ^2		34.503**		

* Significant at df=2, p<0.05
** Significant at df=2, p<0.01

Table 4.10 shows that male (χ^2=15.933, p<0.01) and female (χ^2=20.924, p<0.01) in Thailand, Laos and China were significantly different in answering “yes” or “no” to the question on the concern over environmental conditions (P_{103}). Both male (97.3%) and (98.0%) of Chinese respondents provided the highest percentage of “yes” answer to P_{103} among the three countries, indicating that Chinese respondents had the highest concern over environmental conditions.

Table 4.10. Chi-square test of the observed counts of responses from male and female respondents to the question on concern over environmental conditions (P_{103}), among Thailand (Th), Laos (La) and China (Cn)

Gender	Observed count (%)	P_{103}			
		Th	La	Cn	Total
Male	Yes (%)	224 (91.4)	311 (97.2)	436 (97.3)	971
	No (%)	21 (8.6)	9 (2.8)	12 (2.7)	42
	Total	245	320	448	1013
	χ^2	15.933**			
Female	Yes (%)	377 (91.1)	210 (95.9)	399 (98.0)	986
	No (%)	37 (8.9)	9 (4.1)	8 (2.0)	54
	Total	414	219	407	1040
	χ^2	20.924**			

* Significant at df=2, p<0.05
** Significant at df=2, p<0.01

Table 4.11 shows that male (χ^2=46.315, p<0.01) and female (χ^2=77.121, p<0.01) in Thailand, Laos and China were significantly different in answering "yes" or "no" to P_{104}. Both male (43.7%) and female (49.7%) of Thai respondents provided the highest percentage of "yes" answer to P_{104}, indicating that Thai respondents considered that the environmental conditions in Thailand were improving. Conversely, Chinese respondents, male (80.4%) and female (79.0%), provided the highest percentage of "no" answer to P_{104} among the three countries, indicating that Chinese respondents considered that the environmental conditions were not improving, but even deteriorating in China. This result may be attributable to that Chinese respondents in Beijing have recently experienced severe air pollution problems there (MEP, 2015).

Table 4.11. Chi-square test of the observed counts of responses from male and female respondents to the question on status of environmental conditions (P_{104}), among Thailand (Th), Laos (La) and China (Cn)

Gender	Observed count (%)	P_{104}			
		Th	La	Cn	Total
Male	Yes (%)	100 (43.7)	110 (34.7)	86 (19.6)	296
	No (%)	129 (56.3)	207 (65.3)	353 (80.4)	689
	Total	229	317	439	985
	χ^2	46.315**			
Female	Yes (%)	197 (49.7)	96 (45.1)	84 (21.0)	377
	No (%)	199 (50.3)	117 (54.9)	316 (79.0)	632
	Total	396	213	400	1009
	χ^2	77.121**			

* Significant at df=2, p<0.05
** Significant at df=2, p<0.01

Table 4.12 shows that there was no significant difference at χ^2=5.608, p>0.05 in females answering "yes" or "no" to the question on the knowledge of how to improve environmental conditions (P_{105}) among the three countries. However, there was significant difference at χ^2=28.290, p<0.01 in males answering "yes" or "no" to the same question of P_{105}. Of the three countries surveyed, Lao male respondents provided the highest percentage (67.2%) of "yes" answer to P_{105}, while Chinese male respondents provided the highest percentage (52.1%) of "no" answer to the same question. This indicates that Lao male respondents had the best knowledge of how to improve environmental conditions as opposed to Chinese respondents, which had the least knowledge about it.

Table 4.12. Chi-square test of the observed counts of responses from male and female respondents to the question on knowledge of how to improve environmental conditions (P_{105}), among Thailand (Th), Laos (La) and China (Cn)

Gender	Observed count (%)	P_{105}			
		Th	La	Cn	Total
Male	Yes (%)	133 (54.7)	215 (67.2)	214 (47.9)	562
	No (%)	110 (45.3)	105 (32.8)	233 (52.1)	448
	Total	243	320	447	1010
	χ^2	28.290**			
Female	Yes (%)	197 (48.9)	121 (55.5)	185 (45.6)	503
	No (%)	206 (51.1)	97 (44.5)	221 (54.4)	524
	Total	403	218	406	1027
	χ^2	5.608			

* Significant at df=2, p<0.05

** Significant at df=2, p<0.01

Overall, there was no consistency in the responses provided by male and female respondents to the five variables among the three countries surveyed. Male and female respondents from Thailand had the highest percentage in providing “yes” answer to P_{102} and P_{104}, as opposed to those from China who had the highest percentage in providing “no” answer to both of the same variables. In addition, Chinese male respondents also provided the highest percentage of “no” answer to P_{105}. The above results indicate that Thai respondents were not only positive toward the improving environmental conditions in Thailand, but also willing to comply with the laws in implementing environmentally friendly practices to dispose of e-waste. Chinese respondents, though pessimistic about the deteriorating environmental conditions in China, were least willing to comply with e-waste related laws and had the least knowledge as to how to improve the environment there. It is, therefore, imperative that in order to arrest the deteriorating environmental conditions in China, effective educational programs be developed by the Chinese government or related institutions to raise public awareness of the e-waste disposal impacts on the environment, educate people to comply with e-waste related laws governing its disposal, and equip people with more knowledge about how to improve environmental conditions. Some of the practices for environmental improvements that were suggested by respondents included tree planting, waste sorting and recycling, relying on public transportation and using less plastic bags.

4.5.2 Age

Similarly, correlation coefficients were computed to assess the relationship of the responses from six different age groups with five variables; P_{101}, P_{102}, P_{103}, P_{104} and P_{105}; among Thailand, Laos and China. The result was summarized in Table 4.7.

Table 4.7, as presented in §4.6.1, shows that the increase in age was positively correlated with respondents’ concern over environmental conditions (P_{103}) (r=0.052, n=2077, p<0.05) and their knowledge of how to improve environmental conditions (P_{105}) (r=0.061, n=2061, p<0.01). This indicates that the older the respondents were, the more was their concern over environmental conditions, and their knowledge about how to improve environmental conditions. These positive correlations were consistent with the correlation found between the age of U.S. households and their awareness of environmental conditions and their willingness to participate in recycling of household appliances in the U.S. (Saphores et al., 2012; Saphores & Nixon, 2014).

The questionnaire survey data were subject to the χ^2 test to compare the frequency distributions of the responses of each age group from Thailand, Laos and China to P_{101}, P_{102}, P_{103}, P_{104} and P_{105}. The responses of different age groups to P_{101}, P_{102}, P_{103}, P_{104} and P_{105} in Thailand, Laos and China and the results of the χ^2 analyses were presented in Tables 4.13, 4.14, 4.15, 4.16 and 4.17. The null hypothesis established for the χ^2 test was that there were no significant differences in answering "yes" and "no" from the respondents of different age groups to each of P_{101}, P_{102}, P_{103}, P_{104} and P_{105} among Thailand, Laos and China.

Table 4.13 shows that, of the six age groups of respondents surveyed in Thailand, Laos and China, Age ≤17 was the only age group that did not show significant difference at χ^2=1.290, df=2, p>0.05, indicating that there was no difference in answering "yes" or "no" from Age ≤17 to their knowledge of e-waste related laws or rules (P_{101}) adopted in the three countries. Unlike Age ≤17, however, respondents of the remaining five age groups; 18-22 (χ^2=38.122, p<0.01), 23-30 (χ^2=40.577, p<0.01), 31-35 (χ^2=23.046, p<0.01), 36-45 (χ^2=32.537, p<0.01), and ≥46 (χ^2=14.918, p<0.01); showed significant differences in their answer of "yes" and "no" to P_{101}.

Table 4.13. Chi-square test of the observed counts of responses from six different age groups to the question on knowledge of existing e-waste related laws (P_{101}), among Thailand (Th), Laos (La) and China (Cn)

Age	Observed count (%)	P_{101}			
		Th	La	Cn	Total
≤17	Yes (%)	4 (12.5)	3 (9.4)	9 (18.0)	16
	No (%)	28 (87.5)	29 (90.6)	41 (82.0)	98
	Total	32	32	50	114
	χ^2		1.290		
18-22	Yes (%)	25 (14.0)	48 (36.6)	32 (12.2)	105
	No (%)	154 (86.0)	83 (63.4)	230 (87.8)	467
	Total	179	131	262	572
	χ^2		38.122**		
23-30	Yes (%)	19 (10.1)	58 (33.5)	28 (12.7)	105
	No (%)	170 (89.9)	115 (66.5)	193 (87.3)	478
	Total	189	173	221	583
	χ^2		40.577**		
31-35	Yes (%)	10 (8.3)	28 (33.7)	16 (14.5)	54
	No (%)	110 (91.7)	55 (66.3)	94 (85.5)	259
	Total	120	83	110	313
	χ^2		23.046**		
36-45	Yes (%)	10 (10.0)	26 (37.7)	11 (8.5)	47
	No (%)	90 (90.0)	43 (62.3)	118 (91.5)	251
	Total	100	69	129	298
	χ^2		32.537**		
≥46	Yes (%)	2 (6.1)	17 (37.0)	11 (13.6)	30
	No (%)	31 (93.9)	29 (63.0)	70 (86.4)	130
	Total	33	46	81	160
	χ^2		14.918**		

* Significant at df=2, $p<0.05$
** Significant at df=2, $p<0.01$

Of the three countries surveyed, Lao respondents had consistently the highest percentage in answering "yes" to P_{101} among the three countries. This indicated that despite the lack of e-waste laws or rules adopted in Laos, the respondents from Laos appeared to have provided their answers on the basis of social desirability (Groves, 1989), instead of the actual knowledge of fact. The respondents from Thailand had a higher percentage than China from Age 23-30, 31-35 and ≥46 in answering "no" to the question on their knowledge of the existing e-waste related laws and rules, while China had a higher percentage at Age 18-22 and 36-45 in answering "no" to the same question.

Table 4.14 shows that no significant differences were observed in the age groups 36-45 (χ^2=1.634, p>0.05) and ≥46 (χ^2=2.582, p>0.05) in answering "yes" or "no" to the question on their willingness to comply with e-waste related laws and rules (P_{102}) adopted in their respective countries. This indicated that at these two age groups, respondents from the three countries surveyed had a similar level of willingness to comply with e-waste related laws and rules in their respective countries. Unlike the above two age groups, however, respondents of the remaining four age groups; including ≤17 (χ^2=6.240, p<0.05), 18-22 (χ^2=12.131, p<0.01), 23-30 (χ^2=39.240, p<0.01), and 31-35 (χ^2=11.617, p<0.01); showed significant differences in providing "yes" and "no" answers to P_{102}. Of these four age groups, the respondents from Thailand consistently provided the highest percentage of "yes" answer to P_{102}, indicating that Thai respondents of these age groups had the highest willingness to comply with e-waste disposal practices as prescribed in the e-waste related laws and rules.

Table 4.14. Chi-square test of the observed counts of responses from six different age groups to the question on willingness to comply with e-waste related laws (P_{102}), among Thailand (Th), Laos (La) and China (Cn)

Age	Observed count (%)	P_{102}			
		Th	La	Cn	Total
≤17	Yes (%)	6 (100.0)	0 (0.0)	4 (80.0)	10
	No (%)	0 (0.0)	1 (100.0)	1 (20.0)	2
	Total	6	1	5	12
	χ^2	6.240*			
18-22	Yes (%)	30 (85.7)	18 (75.0)	22 (50.0)	70
	No (%)	5 (14.3)	6 (25.0)	22 (50.0)	33
	Total	35	24	44	103
	χ^2	12.131**			
23-30	Yes (%)	75 (94.9)	46 (80.7)	54 (54.5)	175
	No (%)	4 (5.1)	11 (19.3)	45 (45.5)	60
	Total	79	57	99	235
	χ^2	39.240**			
31-35	Yes (%)	48 (96.0)	38 (77.6)	24 (68.6)	110
	No (%)	2 (4.0)	11 (22.4)	11 (31.4)	24
	Total	50	49	35	134
	χ^2	11.617**			
36-45	Yes (%)	26 (89.7)	20 (80.0)	9 (75.0)	55
	No (%)	3 (10.3)	5 (20.0)	3 (25.0)	11
	Total	29	25	12	66
	χ^2	1.634			
≥46	Yes (%)	5 (100.0)	11 (73.3)	3 (100.0)	19
	No (%)	0 (0.0)	4 (26.7)	0 (0.0)	4
	Total	5	15	3	23
	χ^2	2.582			

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Table 4.15 shows that of the six age groups of respondents surveyed in Thailand, Laos and China, no significant differences were observed in the age groups of 36-45 (χ^2=6.011, p>0.05) and ≥46 (χ^2=0.291, p>0.05) in providing "yes" and "no" answers to the question on the concern over environmental conditions (P_{103}) in the three countries. Unlike these two age groups, however, respondents of the remaining four age groups; ≤17 (χ^2=7.451, p<0.05), 18-22 (χ^2=6.558, p<0.05), 23-30 (χ^2=16.705, p<0.01), and 31-35 (χ^2=11.332, p<0.01); showed significant differences in providing "yes" and "no" answers to P_{103}. Of these four age groups, the respondents from China consistently provided the highest percentage of "yes" answer to P_{103}, which is not a surprise, as China has recently experienced air pollution problems, especially in Beijing, where respondents might be under the influence of recent media publicity relating to the poor air quality there (MEP, 2015).

Table 4.15. Chi-square test of the observed counts of responses from six different age groups to the question on concern over environmental conditions (P_{103}), among Thailand (Th), Laos (La) and China (Cn)

Age	Observed count (%)	P_{103}			
		Th	La	Cn	Total
≤17	Yes (%)	28 (84.8)	29 (90.6)	50 (100.0)	107
	No (%)	5 (15.2)	3 (9.4)	0 (0.0)	8
	Total	33	32	50	115
	χ^2	7.451*			
18-22	Yes (%)	170 (88.5)	126 (94.0)	248 (94.7)	544
	No (%)	22 (11.5)	8 (6.0)	14 (5.3)	44
	Total	192	134	262	588
	χ^2	6.558*			
23-30	Yes (%)	181 (92.3)	174 (98.3)	219 (99.1)	574
	No (%)	15 (7.7)	3 (1.7)	2 (0.9)	20
	Total	196	177	221	594
	χ^2	16.705**			
31-35	Yes (%)	110 (91.7)	86 (100.0)	108 (98.2)	304
	No (%)	10 (8.3)	0 (0.0)	2 (1.8)	12
	Total	120	86	110	316
	χ^2	11.332**			
36-45	Yes (%)	99 (95.2)	67 (97.1)	129 (100.0)	295
	No (%)	5 (4.8)	2 (2.9)	0 (0.0)	7
	Total	104	69	129	302
	χ^2	6.011			
≥46	Yes (%)	32 (97.0)	46 (95.8)	79 (97.5)	157
	No (%)	1 (3.0)	2 (4.2)	2 (2.5)	5
	Total	33	48	81	162
	χ^2	0.291			

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Table 4.16 shows that significant differences were observed in all of the six age groups of respondents from Thailand, Laos and China; ≤17 (χ^2=21.874, p<0.01), 18-22 (χ^2=56.610, p<0.01), 23-30 (χ^2=38.299, p<0.01), 31-35 (χ^2=27.329, p<0.01), 36-45 (χ^2=8.845, p<0.05), and ≥46 (χ^2=7.866, p<0.05); in providing "yes" and "no" answers to the question on status of environmental conditions (P_{104}). Among them, the respondents from Thailand provided the highest percentage of "yes" answer to P_{104}, except at Age 23-30 and 31-35, in which Lao respondents had the highest percentage in providing "yes" answer. This indicates that Thai respondents appeared to be more optimistic than Lao and Chinese respondents about the improving environmental conditions in their respective countries.

Table 4.16. Chi-square test of the observed counts of responses from six different age groups to the question on status of environmental conditions (P_{104}), among Thailand (Th), Laos (La) and China (Cn)

Age	Observed count (%)	P_{104}			
		Th	La	Cn	Total
≤17	Yes (%)	19 (65.5)	12 (38.7)	7 (14.0)	38
	No (%)	10 (34.5)	19 (61.3)	43 (86.0)	72
	Total	29	31	50	110
	χ^2		21.874**		
18-22	Yes (%)	108 (61.0)	58 (44.3)	63 (25.0)	229
	No (%)	69 (39.0)	73 (55.7)	189 (75.0)	331
	Total	177	131	252	560
	χ^2		56.610**		
23-30	Yes (%)	65 (34.2)	63 (36.4)	26 (11.9)	154
	No (%)	125 (65.8)	110 (63.6)	192 (88.1)	427
	Total	190	173	218	581
	χ^2		38.299**		
31-35	Yes (%)	51 (44.0)	38 (44.2)	16 (14.7)	105
	No (%)	65 (56.0)	48 (55.8)	93 (85.3)	206
	Total	116	86	109	311
	χ^2		27.329**		
36-45	Yes (%)	43 (42.6)	21 (30.4)	31 (24.2)	95
	No (%)	58 (57.4)	48 (69.6)	97 (75.8)	203
	Total	101	69	128	298
	χ^2		8.845*		
≥46	Yes (%)	19 (61.3)	16 (34.0)	27 (33.8)	62
	No (%)	12 (38.7)	31 (66.0)	53 (66.3)	96
	Total	31	47	80	158
	χ^2		7.866*		

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Table 4.17 shows that of the six age groups of respondents surveyed in Thailand, Laos and China, only two age groups, 18-22 (χ^2=23.091, p<0.01) and 23-30 (χ^2=10.365, p<0.01), had significant differences in providing "yes" and "no" answers to the question relating to their knowledge of how to improve environmental conditions (P_{105}). However, there was no consistently dominant number of responses among the three countries surveyed. At Age 18-22, for example, Lao respondents provided the highest percentage (66.9%) of "yes" answer to P_{105}, as opposed to Chinese respondents who provided the highest percentage (58.4%) of "no" answer to P_{105}. This indicates that respondents at Age 18-22 from Laos appeared to be most knowledgeable than Thai and Chinese respondents about how to improve environmental conditions in their respective countries. A similar result was also observed at Age 23-30. Unlike the two age groups, 18-22 and 23-30, there were no significant differences in providing "yes" and "no" answers to P_{105} from respondents of the remaining four age groups; ≤17 (χ^2=1.422, p>0.05), 31-35 (χ^2=0.792, p>0.05), 36-45 (χ^2=5.946, p>0.05), and ≥46 (χ^2=4.442, p>0.05); among Thailand, Laos and China.

Table 4.17. Chi-square test of the observed counts of responses from six different age groups to the question on knowledge of how to improve environmental conditions (P_{105}), among Thailand (Th), Laos (La) and China (Cn)

Age	Observed count (%)	P_{105}			
		Th	La	Cn	Total
≤17	Yes (%)	18 (54.5)	13 (40.6)	22 (44.0)	53
	No (%)	15 (45.5)	19 (59.4)	28 (56.0)	62
	Total	33	32	50	115
	χ^2	1.422			
18-22	Yes (%)	89 (47.1)	89 (66.9)	109 (41.6)	287
	No (%)	100 (52.9)	44 (33.1)	153 (58.4)	297
	Total	189	133	262	584
	χ^2	23.091**			
23-30	Yes (%)	89 (46.4)	105 (59.3)	97 (43.9)	291
	No (%)	103 (53.6)	72 (40.7)	124 (56.1)	299
	Total	192	177	221	590
	χ^2	10.365**			
31-35	Yes (%)	64 (54.2)	52 (60.5)	63 (57.3)	179
	No (%)	54 (45.8)	34 (39.5)	47 (42.7)	135
	Total	118	86	110	314
	χ^2	0.792			
36-45	Yes (%)	56 (55.4)	49 (71.0)	69 (53.9)	174
	No (%)	45 (44.6)	20 (29.0)	59 (46.1)	124
	Total	101	69	128	298
	χ^2	5.946			
≥46	Yes (%)	20 (62.5)	32 (66.7)	39 (48.8)	91
	No (%)	12 (37.5)	16 (33.3)	41 (51.3)	69
	Total	32	48	80	160
	χ^2	4.442			

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Overall, there was no consistency in the responses from six age groups to the five variables among China, Laos and Thailand. However, the respondents from China in providing the highest percentage of "yes" answer to P_{103} indicated they had high concern over the environmental conditions in China. This result corresponded well with the same respondents' pessimism toward the deteriorating environmental conditions occurring in China, as indicated by the highest percentage of "no" answer provided by Chinese respondents to P_{104}. The Chinese government should, therefore, capitalize on this concern over its environmental conditions by developing effective educational programs to equip those age groups of 18-22, 23-30, 36-45 or older, which provided the highest percentage of "no" answer to P_{105}, with better appreciation of the fragility of the environment and the knowledge of how to improve China's deteriorating environment.

4.5.3 Educational level

Similar to the gender and age sections, correlation coefficients were also calculated to determine the relationship of educational levels with five variables; P_{101}, P_{102}, P_{103}, P_{104} and P_{105}; among Thailand, Laos and China. The result was summarized in Table 4.7.

Table 4.7, as presented in §4.6.1, shows that educational level was positively correlated with respondents' knowledge of how to improve environmental conditions (P_{105}) (r=0.072, n=2045, p<0.01). This indicates that the higher educational level the respondents had, the more was their knowledge of how to improve environmental conditions.

The questionnaire survey data were subject to the χ^2 test to compare the frequency distributions of responses of each educational level from Thailand, Laos and China to P_{101}, P_{102}, P_{103}, P_{104} and P_{105}. The responses of different educational levels to P_{101}, P_{102}, P_{103}, P_{104} and P_{105} in Thailand, Laos and China and the results of the χ^2 analyses were presented in Tables 4.18, 4.19, 4.20, 4.21 and 4.22. The null hypothesis established for the χ^2 test was that there were no significant differences in answering "yes" and "no" from respondents of an educational level to each of the questionnaires on P_{101}, P_{102}, P_{103}, P_{104} and P_{105} among Thailand, Laos and China.

Table 4.18 shows that of the four educational levels of respondents surveyed in Thailand, Laos and China, the primary and secondary school level was the only educational level that did not show significant difference at χ^2=1.492, p>0.05, indicating that there was no difference in answering "yes" or "no" from respondents having this educational level to P_{101} adopted in the three countries. Unlike respondents of the primary and secondary education level, however, those of the remaining three educational levels; including high school (χ^2=23.950, p<0.01), undergraduate (χ^2=87.787, p<0.01), and postgraduate (χ^2=38.090, p<0.01); showed significant differences in their answers of "yes" or "no" to the same question. Of the three countries surveyed, Lao respondents had consistently the highest percentage in answering "yes" to P_{101} among the three countries. This indicated that despite the lack of e-waste laws or rules adopted in Laos, the respondents from Laos appeared to have provided their answers on the basis of social desirability (Groves, 1989), instead of the actual knowledge of fact. Chinese respondents, however, had a slightly higher percentage in answering "no" to P_{101} than Thai respondents at the high school and the undergraduate levels. On the other hand, at the postgraduate level, Thai respondents had the highest percentage in providing "no" answer to P_{101} among the three countries. Therefore, the respondents in Thailand and China at all four educational levels should be educated to raise their awareness of the established e-waste laws in their respective countries.

Table 4.18. Chi-square test of the observed counts of responses from four different educational levels to the question on knowledge of existing e-waste related laws (P_{101}), among Thailand (Th), Laos (La) and China (Cn)

Educational level	Observed count (%)	P_{101}			
		Th	La	Cn	Total
primary and secondary school	Yes (%)	9 (14.5)	14 (22.6)	21 (16.9)	44
	No (%)	53 (85.5)	48 (77.4)	103 (83.1)	204
	Total	62	62	124	248
	χ^2		1.492		
high school	Yes (%)	19 (14.1)	61 (31.0)	32 (13.6)	112
	No (%)	116 (85.9)	136 (69.0)	203 (86.4)	455
	Total	135	197	235	567
	χ^2		23.950**		
undergraduate	Yes (%)	38 (10.2)	80 (35.9)	42 (9.9)	160
	No (%)	333 (89.8)	143 (64.1)	383 (90.1)	859
	Total	371	223	425	1019
	χ^2		87.787**		
postgraduate	Yes (%)	1 (1.4)	24 (46.2)	12 (17.4)	37
	No (%)	68 (98.6)	28 (53.8)	57 (82.6)	153
	Total	69	52	69	190
	χ^2		38.090**		

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Table 4.19 shows that respondents at the postgraduate level surveyed in Thailand, Laos and China did not show significant difference at χ^2=2.057, p>0.05, indicating that there was no difference in answering "yes" or "no" to the question on their willingness to comply with e-waste related laws (P_{102}) adopted in their respective countries. However, respondents of the remaining three educational levels; including primary and secondary school (χ^2=7.451, p<0.05), high school (χ^2=26.481, p<0.01), and undergraduate (χ^2=26.439, p<0.01); showed significant differences in providing "yes" or "no" answers to P_{102}. Of these three educational levels, the respondents from Thailand consistently provided the highest percentage of "yes" answer to P_{102}, indicating that Thai respondents had the highest willingness to comply with e-waste related laws and rules as compared to those from Laos and China.

Table 4.19. Chi-square test of the observed counts of responses from four different educational levels to the question on willingness to comply with e-waste related laws (P_{102}), among Thailand (Th), Laos (La) and China (Cn)

Educational level	Observed count (%)	P_{102}			
		Th	La	Cn	Total
primary and secondary school	Yes (%)	24 (88.9)	12 (80.0)	33 (61.1)	69
	No (%)	3 (11.1)	3 (20.0)	21 (38.9)	27
	Total	27	15	54	96
	χ^2	7.451*			
high school	Yes (%)	64 (92.8)	59 (77.6)	65 (58.6)	188
	No (%)	5 (7.2)	17 (22.4)	46 (41.4)	68
	Total	69	76	111	256
	χ^2	26.481**			
undergraduate	Yes (%)	87 (93.5)	49 (76.6)	17 (53.1)	153
	No (%)	6 (6.5)	15 (23.4)	15 (46.9)	36
	Total	93	64	32	189
	χ^2	26.439**			
postgraduate	Yes (%)	8 (100.0)	12 (80.0)	1 (100.0)	21
	No (%)	0 (0.0)	3 (20.0)	0 (0.0)	3
	Total	8	15	1	24
	χ^2	2.057			

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Table 4.20 shows that of the four educational levels of respondents surveyed in Thailand, Laos and China, there was no significant difference at the postgraduate level at χ^2=1.757, p>0.05, indicating that there was no difference in providing "yes" or "no" answers to the question on concern over environmental conditions (P_{103}) in the three countries. However, respondents of the remaining three educational levels; including primary and secondary school (χ^2=7.437, p<0.05), high school (χ^2=18.418, p<0.01), and undergraduate (χ^2=19.422, p<0.01); showed significant differences in providing "yes" or "no" answers to P_{103}. Of these three levels, Chinese respondents provided the highest percentage of "yes" answer to P_{103} at the primary and secondary school level (93.5%) and the high school level (99.1%); while Lao respondents provided the highest percentage of "yes" answer at the undergraduate level (98.7%).

Table 4.20. Chi-square test of the observed counts of responses from four different educational levels to the question on concern over environmental conditions (P_{103}), among Thailand (Th), Laos (La) and China (Cn)

Educational level	Observed count (%)	P_{103}			
		Th	La	Cn	Total
primary and secondary school	Yes (%)	52 (81.3)	57 (91.9)	116 (93.5)	225
	No (%)	12 (18.8)	5 (8.1)	8 (6.5)	25
	Total	64	62	124	250
	χ^2		7.437*		
high school	Yes (%)	126 (90.0)	193 (96.0)	233 (99.1)	552
	No (%)	14 (10.0)	8 (4.0)	2 (0.9)	24
	Total	140	201	235	576
	χ^2		18.418**		
undergraduate	Yes (%)	360 (92.8)	227 (98.7)	416 (97.9)	1003
	No (%)	28 (7.2)	3 (1.3)	9 (2.1)	40
	Total	388	230	425	1043
	χ^2		19.422**		
postgraduate	Yes (%)	67 (94.4)	51 (96.2)	68 (98.6)	186
	No (%)	4 (5.6)	2 (3.8)	1 (1.4)	7
	Total	71	53	69	193
	χ^2		1.757		

* Significant at df=2, $p<0.05$
** Significant at df=2, $p<0.01$

Table 4.21 shows that all of the four educational levels of respondents surveyed in Thailand, Laos and China; including primary and secondary school (χ^2=12.314, p<0.01), high school (χ^2=31.600, p<0.01), undergraduate (χ^2=83.809, p<0.01), and postgraduate (χ^2=14.207, p<0.01); showed significant differences in answering "yes" or "no" to the question on status of environmental conditions (P_{104}). Of the four educational levels, the respondents from Laos provided the highest percentage of "yes" answers to P_{104}, except at undergraduate level, in which Thai respondents had the highest percentage in providing "yes" answer to this question. However, the respondents from China consistently provided the highest percentage in "no" answer to P_{104} at the four educational levels, indicating that Chinese respondents appeared to be more pessimistic about the deteriorating environmental conditions in China, particularly in Beijing where the survey was conducted.

Table 4.21. Chi-square test of the observed counts of responses from four different educational levels to the question on status of environmental conditions (P_{104}), among Thailand (Th), Laos (La) and China (Cn)

Educational level	Observed count (%)	P_{104}			
		Th	La	Cn	Total
primary and secondary school	Yes (%)	22 (37.3)	29 (46.8)	26 (22.0)	77
	No (%)	37 (62.7)	33 (53.2)	92 (78.0)	162
	Total	59	62	118	239
	χ^2	12.314**			
high school	Yes (%)	51 (38.1)	77 (39.1)	39 (16.7)	167
	No (%)	83 (61.9)	120 (60.9)	194 (83.3)	397
	Total	134	197	233	564
	χ^2	31.600**			
undergraduate	Yes (%)	199 (54.2)	80 (35.6)	95 (22.7)	374
	No (%)	168 (45.8)	145 (64.4)	324 (77.3)	637
	Total	367	225	419	1011
	χ^2	83.809**			
postgraduate	Yes (%)	27 (39.1)	23 (43.4)	10 (14.7)	60
	No (%)	42 (60.9)	30 (56.6)	58 (85.3)	130
	Total	69	53	68	190
	χ^2	14.207**			

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Table 4.22 shows that respondents at the postgraduate level surveyed in Thailand, Laos and China did not show significant difference at χ^2=4.303, p>0.05, indicating that there was no difference in answering "yes" or "no" to the question on the knowledge of how to improve environmental conditions (P_{105}) in their respective countries. However, the respondents with the remaining three educational levels; including primary and secondary school (χ^2=7.249, p<0.05), high school (χ^2=9.993, p<0.01), and undergraduate (χ^2=23.653, p<0.01); showed significant differences in providing "yes" or "no" answers to P_{105}. Of the four educational levels, the respondents from Laos provided the highest percentage of "yes" answers to P_{105}, except at the primary and secondary school level, in which Thai respondents had the highest percentage in providing "yes" answer to this question.

Table 4.22. Chi-square test of the observed counts of responses from four different educational levels to the question on knowledge of how to improve environmental conditions (P_{105}), among Thailand (Th), Laos (La) and China (Cn)

Educational level	Observed count (%)	P_{105}			
		Th	La	Cn	Total
primary and secondary school	Yes (%)	27 (42.9)	25 (41.0)	32 (25.8)	84
	No (%)	36 (57.1)	36 (59.0)	92 (74.2)	164
	Total	63	61	124	248
	χ^2	7.249*			
high school	Yes (%)	63 (46.3)	123 (61.2)	113 (48.1)	299
	No (%)	73 (53.7)	78 (38.8)	122 (51.9)	273
	Total	136	201	235	572
	χ^2	9.993**			
undergraduate	Yes (%)	203 (53.0)	157 (68.3)	206 (48.7)	566
	No (%)	180 (47.0)	73 (31.7)	217 (51.3)	470
	Total	383	230	423	1036
	χ^2	23.653**			
postgraduate	Yes (%)	36 (53.7)	37 (69.8)	47 (68.1)	120
	No (%)	31 (46.3)	16 (30.2)	22 (31.9)	69
	Total	67	53	69	189
	χ^2	4.303			

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Overall, there was no consistency in the responses from four educational levels to the five variables among China, Laos and Thailand. However, the respondents from Thailand and China provided higher percentage of “no” answer to P_{101} and P_{105}, which indicated that Thai and Chinese respondents at all the educational levels need to be trained or educated to become more knowledgeable about the existing e-waste laws and also the knowledge of how to improve environmental conditions in their respective countries. The respondents from China in providing the highest percentage of “yes” answer to P_{103} indicated they had high concern over the environmental conditions in China. This concern over environmental conditions corresponded well with the pessimism expressed by the same Chinese respondents toward the deteriorating environmental conditions occurred in China. Therefore, Chinese government needs to adopt effective energy policies and implement corrective measures to reduce the release of carbon and to prevent its environment from further deteriorating. Meanwhile, public educational programs need to be developed to target those from the primary and secondary school level to the undergraduate level to enhance their willingness to comply with e-waste related laws. In addition, the reason for the social desirability demonstrated by the Lao respondents needs to be further explored in future studies.

4.5.4 Income level

Similar to the previous sections, correlation coefficients were also calculated to determine the relationship of six income levels with five variables; P_{101}, P_{102}, P_{103}, P_{104} and P_{105}; among Thailand, Laos and China. The result was summarized in Table 4.7.

Table 4.7, as presented in §4.6.1, shows that the increase in income level was negatively correlated with respondents’ knowledge of the status of environmental conditions (P_{104}) (r=-0.151, n=1836, p<0.01). This indicates that the higher the income levels, the more pessimistic toward the deteriorating status of the environmental conditions.

The questionnaire survey data were subject to the χ^2 test to compare the frequency distributions of responses of each income level (US$) from Thailand, Laos and China to their knowledge about e-waste related laws and rules adopted in the respective country (P_{101}), willingness to comply with e-waste related laws and rules (P_{102}), concern over environmental conditions (P_{103}), status of environmental conditions (P_{104}), and knowledge of how to improve environmental conditions (P_{105}). The responses of different income levels to P_{101}, P_{102}, P_{103}, P_{104} and P_{105} in Thailand, Laos and China and the results of the χ^2 analyses were presented in Tables 4.23, 4.24, 4.25, 4.26 and 4.27. The null hypothesis established for the χ^2 test was that there were no significant differences in answering "yes" and "no" from respondents of an individual income level to each of the questionnaires on P_{101}, P_{102}, P_{103}, P_{104} and P_{105} among Thailand, Laos and China.

Table 4.23 shows that respondents of all of the six income levels surveyed in Thailand, Laos and China; including ≤300 (χ^2=36.063, p<0.01), 301-500 (χ^2=23.427, p<0.01), 501-800 (χ^2=13.023, p<0.01), 801-1200 (χ^2=41.552, p<0.01), 1201-1500 (χ^2=11.954, p<0.01), and ≥1501 (χ^2=19.012, p<0.01); showed significant differences in providing their "yes" and "no" answers to P_{101} adopted in the three countries. Of the three countries surveyed, Lao respondents had consistently the highest percentage in answering "yes" to P_{101} among the three countries. This result could also be attributed to the similar social desirability of the Lao respondents as mentioned in §4.6.3 (Groves, 1989). The respondents from Thailand, however, had a higher percentage than those from China in answering "no" to P_{101}, except at ≤300. At the income level ≤300, Chinese respondents had the highest percentage in providing "no" answer to P_{101}. Since the respondents from Thailand and China at all the income levels provided a higher percentage of "no" answer to P_{101} than those from Laos, it indicates that the respondents from Thailand and China lacked the knowledge of the established e-waste laws in their respective countries. Therefore, a proper educational program to enhance their knowledge needs to be developed.

Table 4.23. Chi-square test of the observed counts of responses from six different income levels to the question on knowledge of existing e-waste related laws (P_{101}), among Thailand (Th), Laos (La) and China (Cn)

Income level (US$)	Observed count (%)	P_{101}			
		Th	La	Cn	Total
≤300	Yes (%)	22 (13.7)	83 (30.9)	8 (6.7)	113
	No (%)	139 (86.3)	186 (69.1)	111 (93.3)	436
	Total	161	269	119	549
	χ^2		36.063**		
301-500	Yes (%)	18 (12.9)	46 (37.7)	23 (19.8)	87
	No (%)	121 (87.1)	76 (62.3)	93 (80.2)	290
	Total	139	122	116	377
	χ^2		23.427**		
501-800	Yes (%)	19 (11.8)	22 (28.2)	22 (12.2)	63
	No (%)	142 (88.2)	56 (71.8)	158 (87.8)	356
	Total	161	78	180	419
	χ^2		13.023**		
801-1200	Yes (%)	5 (5.2)	17 (44.7)	17 (9.8)	39
	No (%)	92 (94.8)	21 (55.3)	156 (90.2)	269
	Total	97	38	173	308
	χ^2		41.552**		
1201-1500	Yes (%)	2 (9.1)	8 (57.1)	12 (20.0)	22
	No (%)	20 (90.9)	6 (42.9)	48 (80.0)	74
	Total	22	14	60	96
	χ^2		11.954**		
≥1501	Yes (%)	1 (2.4)	4 (66.7)	10 (16.7)	15
	No (%)	41 (97.6)	2 (33.3)	50 (83.3)	93
	Total	42	6	60	108
	χ^2		19.012**		

* Significant at df=2, *p*<0.05
** Significant at df=2, *p*<0.01

Table 4.24 shows that income levels of ≤300 (χ^2=1.063, p>0.05) and 1201-1500 (χ^2=1.527, p>0.05) did not show significant differences in answering "yes" or "no" to the question on their willingness to comply with e-waste related laws (P_{102}) adopted in their respective countries. Unlike the above two levels, however, respondents of the remaining four income levels; including 301-500 (χ^2=20.706, p<0.01), 501-800 (χ^2=24.456, p<0.01), 801-1200 (χ^2=17.312, p<0.01), and ≥1501 (χ^2=6.162, p<0.05); showed significant differences in answering "yes" or "no" to P_{102}. Of these four income levels, the respondents from Thailand consistently provided the highest percentage of "yes" answer, as opposed to those from China who provided the highest percentage of "no" answer, to P_{102}, indicating that Thai respondents had the highest willingness and Chinese respondents had the least willingness to comply with e-waste related laws.

Table 4.24. Chi-square test of the observed counts of responses from six different income levels to the question on willingness to comply with e-waste related laws (P_{102}), among Thailand (Th), Laos (La) and China (Cn)

Income level (US$)	Observed count (%)	P_{102}			
		Th	La	Cn	Total
≤300	Yes (%)	14 (87.5)	41 (77.4)	2 (66.7)	57
	No (%)	2 (12.5)	12 (22.6)	1 (33.3)	15
	Total	16	53	3	72
	χ^2		1.063		
301-500	Yes (%)	50 (92.6)	36 (80.0)	15 (50.0)	101
	No (%)	4 (7.4)	9 (20.0)	15 (50.0)	28
	Total	54	45	30	129
	χ^2		20.706**		
501-800	Yes (%)	61 (95.3)	29 (74.4)	45 (59.2)	135
	No (%)	3 (4.7)	10 (25.6)	31 (40.8)	44
	Total	64	39	76	179
	χ^2		24.456**		
801-1200	Yes (%)	28 (96.6)	18 (81.8)	36 (56.3)	82
	No (%)	1 (3.4)	4 (18.2)	28 (43.8)	33
	Total	29	22	64	115
	χ^2		17.312**		
1201-1500	Yes (%)	10 (90.9)	4 (66.7)	12 (80.0)	26
	No (%)	1 (9.1)	2 (33.3)	3 (20.0)	6
	Total	11	6	15	32
	χ^2		1.527		
≥1501	Yes (%)	27 (93.1)	4 (80.0)	6 (60.0)	37
	No (%)	2 (6.9)	1 (20.0)	4 (40.0)	7
	Total	29	5	10	44
	χ^2		6.162*		

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Table 4.25 shows that of the six income levels of respondents surveyed in Thailand, Laos and China, respondents of the four income levels; including 301-500 (χ^2=5.991, p>0.05), 801-1200 (χ^2=2.069, p>0.05), 1201-1500 (χ^2=1.205, p>0.05), and ≥1501 (χ^2=3.101, p>0.05); did not show significant differences in providing "yes" or "no" answers to the question on their concern over environmental conditions (P_{103}) in the three countries. Unlike these four levels, however, respondents of the remaining two income levels; including ≤300 (χ^2=23.805, p<0.01) and 501-800 (χ^2=8.997, p<0.05); showed significant differences in answering "yes" and "no" to P_{103}. Of these two income levels, the respondents from China consistently provided the highest percentage of "yes" answer to P_{103}, indicating that Chinese respondents had more concerns over environmental status as compared to those from Thailand and Laos.

Table 4.25. Chi-square test of the observed counts of responses from six different income levels to the question on concern over environmental conditions (P_{103}), among Thailand (Th), Laos (La) and China (Cn)

Income level (US$)	Observed count (%)	P_{103}			
		Th	La	Cn	Total
≤300	Yes (%)	144 (87.3)	265 (96.0)	119 (100.0)	528
	No (%)	21 (12.7)	11 (4.0)	0 (0.0)	32
	Total	165	276	119	560
	χ^2		23.805**		
301-500	Yes (%)	132 (91.7)	123 (98.4)	109 (94.0)	364
	No (%)	12 (8.3)	2 (1.6)	7 (6.0)	21
	Total	144	125	116	385
	χ^2		5.991		
501-800	Yes (%)	152 (91.6)	76 (96.2)	177 (98.3)	405
	No (%)	14 (8.4)	3 (3.8)	3 (1.7)	20
	Total	166	79	180	425
	χ^2		8.997*		
801-1200	Yes (%)	97 (97.0)	38 (100.0)	171 (98.8)	306
	No (%)	3 (3.0)	0 (0.0)	2 (1.2)	5
	Total	100	38	173	311
	χ^2		2.069		
1201-1500	Yes (%)	20 (90.9)	13 (92.9)	58 (96.7)	91
	No (%)	2 (9.1)	1 (7.1)	2 (3.3)	5
	Total	22	14	60	96
	χ^2		1.205		
≥1501	Yes (%)	42 (95.5)	7 (100.0)	60 (100.0)	109
	No (%)	2 (4.5)	0 (0.0)	0 (0.0)	2
	Total	44	7	60	111
	χ^2		3.101		

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Table 4.26 shows that of the six income levels of respondents surveyed in Thailand, Laos and China, respondents of the three income levels; including 301-500 (χ^2=2.608, p>0.05), 1201-1500 (χ^2=2.024, p>0.05), and ≥1501 (χ^2=5.612, p>0.05); did not show significant differences in answering "yes" or "no" to the question on status of environmental conditions (P_{104}) in their respective countries. However, respondents of the remaining three income levels; including ≤300 (χ^2=58.965, p<0.01), 501-800 (χ^2=21.792, p<0.01), and 801-1200 (χ^2=15.685, p<0.01); showed significant differences in answering "yes" and "no" to the same question. Of these latter three income levels, respondents at the income levels of ≤300 and 801-1200 from Thailand provided the highest percentage of "yes" answer to P_{104}, which indicates that Thai respondents appeared to be most optimistic among the three countries about the improvement of the environmental conditions. Conversely, Chinese respondents provided the highest percentage of "no" answer to P_{104}, indicating that Chinese respondents appeared to be most pessimistic about the deteriorating environmental conditions in China.

Table 4.26. Chi-square test of the observed counts of responses from six different income levels to the question on status of environmental conditions (P_{104}), among Thailand (Th), Laos (La) and China (Cn)

Income level (US$)	Observed count (%)	P_{104}			
		Th	La	Cn	Total
≤300	Yes (%)	106 (67.9)	115 (42.4)	26 (22.0)	247
	No (%)	50 (32.1)	156 (57.6)	92 (78.0)	298
	Total	156	271	118	545
	χ^2		58.965**		
301-500	Yes (%)	56 (41.5)	47 (37.9)	35 (31.5)	138
	No (%)	79 (58.5)	77 (62.1)	76 (68.5)	232
	Total	135	124	111	370
	χ^2		2.608		
501-800	Yes (%)	61 (38.6)	30 (39.0)	31 (17.5)	122
	No (%)	97 (61.4)	47 (61.0)	146 (82.5)	290
	Total	158	77	177	412
	χ^2		21.792**		
801-1200	Yes (%)	40 (40.8)	8 (21.1)	33 (19.2)	81
	No (%)	58 (59.2)	30 (78.9)	139 (80.8)	227
	Total	98	38	172	308
	χ^2		15.685**		
1201-1500	Yes (%)	7 (31.8)	3 (21.4)	10 (17.2)	20
	No (%)	15 (68.2)	11 (78.6)	48 (82.8)	74
	Total	22	14	58	94
	χ^2		2.024		
≥1501	Yes (%)	13 (31.0)	2 (28.6)	7 (12.1)	22
	No (%)	29 (69.0)	5 (71.4)	51 (87.9)	85
	Total	42	7	58	107
	χ^2		5.612		

* Significant at df=2, $p<0.05$
** Significant at df=2, $p<0.01$

Table 4.27 shows that similar results were also found from the χ^2 test of the observed counts of responses from different income levels to the question on to their knowledge of how to improve environmental conditions (P_{105}) in the three countries. Of the six income levels of respondents surveyed in Thailand, Laos and China, respondents of the two income levels; including 1201-1500 (χ^2=3.381, p>0.05) and ≥1501 (χ^2=2.462, p>0.05); did not show significant differences in answering "yes" or "no" to P_{105} in the three countries. Unlike these two income levels, however, respondents of the remaining four income levels; including ≤300 (χ^2=8.515, p<0.05), 301-500 (χ^2=25.917, p<0.01), 501-800 (χ^2=12.679, p<0.01), and 801-1200 (χ^2=7.759, p<0.05); showed significant differences in answering "yes" and "no" to P_{105}. Of these four income levels, the respondents from Laos provided the highest percentage of "yes" answer to P_{105}, meaning that Lao respondents had the best knowledge about how to improve the environmental conditions among the three countries. Except at the income level of 801-1200, the Chinese respondents, as opposed to the Lao respondents, had the least knowledge as they provided the highest percentage of "no" answer to the same question. As such, the government of China and its educational institutions or organizations should take actions in educating Chinese people, particularly targeting those at the income levels of ≤300, 301-500 and 501-800, to enhance their knowledge about how to improve the environmental conditions in China.

Table 4.27. Chi-square test of the observed counts of responses from six different income levels to the question on knowledge of how to improve environmental conditions (P_{105}), among Thailand (Th), Laos (La) and China (Cn)

Income level (US$)	Observed count (%)	P_{105}			
		Th	La	Cn	Total
≤300	Yes (%)	79 (48.5)	154 (56.0)	48 (40.3)	281
	No (%)	84 (51.5)	121 (44.0)	71 (59.7)	276
	Total	163	275	119	557
	χ^2	8.515*			
301-500	Yes (%)	64 (45.4)	84 (67.2)	41 (35.3)	189
	No (%)	77 (54.6)	41 (32.8)	75 (64.7)	193
	Total	141	125	116	382
	χ^2	25.917**			
501-800	Yes (%)	91 (55.5)	53 (67.1)	79 (43.9)	223
	No (%)	73 (44.5)	26 (32.9)	101 (56.1)	200
	Total	164	79	180	423
	χ^2	12.679**			
801-1200	Yes (%)	49 (50.0)	29 (76.3)	99 (57.6)	177
	No (%)	49 (50.0)	9 (23.7)	73 (42.4)	131
	Total	98	38	172	308
	χ^2	7.759*			
1201-1500	Yes (%)	10 (47.6)	11 (78.6)	36 (61.0)	57
	No (%)	11 (52.4)	3 (21.4)	23 (39.0)	37
	Total	21	14	59	94
	χ^2	3.381			
≥1501	Yes (%)	27 (64.3)	6 (85.7)	34 (56.7)	67
	No (%)	15 (35.7)	1 (14.3)	26 (43.3)	42
	Total	42	7	60	109
	χ^2	2.462			

* Significant at df=2, $p<0.05$

** Significant at df=2, $p<0.01$

Again, there was no consistency in the responses from the six income levels to the five variables among China, Laos and Thailand. However, due to the higher percentage of "no" answer to P_{101} and P_{105} provided by the respondents from Thailand and China, effective educational programs need to be developed targeting these respondents to improve their knowledge about the existing e-waste laws and how to improve environmental conditions in their respective countries. Also, among the three countries, Thai respondents demonstrated the highest willingness to comply with e-waste related laws as opposed to Chinese respondents who appeared to have shown the least willingness. Therefore, public educational programs need to be initiated in China to enhance its citizenry's willingness to comply with the existing e-waste related laws.

4.6 Cause and effect analysis of e-waste management systems in China, Thailand and Laos

The concepts of the cause and effect analytical approach mentioned in §2.8 were adopted here to illustrate the interactions between the possible causes and effects among the issues observed in the existing e-waste management policies, processes and practices in China, Thailand and Laos. These issues, identified from the interviews of focus groups, field visits, and review of the existing e-waste management systems in the respective countries were summarized as follows:

<u>China</u>:

Possible issues identified:

- Under the old-for-new appliance trade-in project, mobile phone was not listed as a trade-in item;
- Difficulty in tracking the final destination of used or broken mobile phones;
- Legal vs. illegal recycling practices: factors to be considered including costs, availability, accessibility, and convenience;
- Tax or other incentives supported by the government;

- Official e-waste treatment or recycling facilities invested by governments requiring sufficient tonnage of waste to be disposed of or recycled to reach their economical sustainability;
- In the absence of official e-waste treatment or recycling facilities, the number of non-official facilities increased to fill the void;
- Illegal e-waste transboundary movements;
- Ineffective regulatory and legal systems; and
- Lack of environmental awareness; not willing to comply with e-waste related laws and rules; and lack of knowledge on how to improve environmental conditions.

Thailand:

- Limited numbers of permitted factories relate to e-waste collection and dismantling (Chareonsong, 2014);
- No specific license issued for recycling e-waste, and no formal recycling facilities for e-waste; thus, most of e-waste went to non-official treatment or recycling facilities;
- No large-scale dismantling machines or equipment;
- Challenges in formulating, enforcing and implementing environmental laws;
- Lack of continuity in the execution and enforcement of the laws;
- Lack of demarcation line in defining enforcement responsibility among multiple ministries; and
- Lack of knowledge on how to improve environmental conditions.

Laos:

- Lack of legislation for regulating e-waste disposal;
- Lack of awareness on the environmental impact from improper disposal and recovery operations from the e-waste;
- No e-waste treatment companies or recycling facilities available;
- No proper e-waste collection systems in place;

- Inaccessible confidential information relating to the composition of electronic products (UNEP, 2014); and
- Difficulty in tracking and monitoring the e-waste.

The cause and effect analysis of e-waste management systems in China, Thailand and Laos was presented in Fig. 4.1:

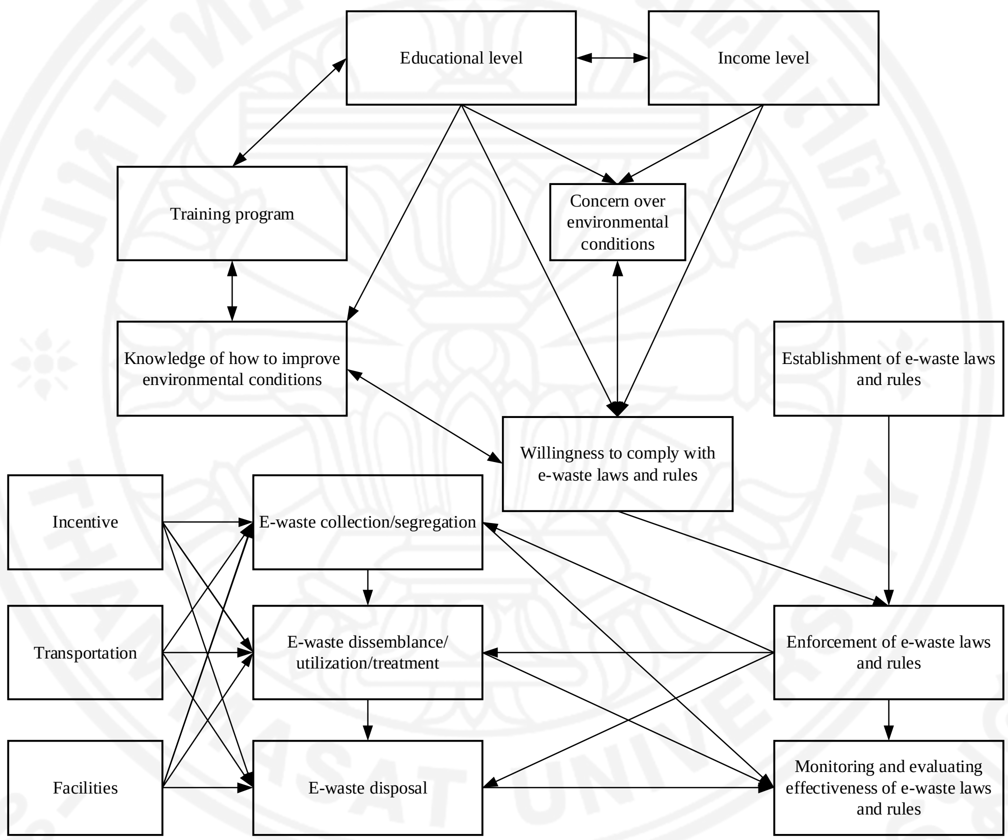

Fig. 4.1. The cause and effect analysis of e-waste management systems in China, Thailand and Laos.

Chapter 5
Conclusion and Recommendations

5.1 Conclusion

Proper management of e-waste disposal is vital to protecting the wellbeing of the fragile environment in the world. However, issues involved in establishing an effective system to manage e-waste sustainably from its generation to disposal in a country are complicated as it relies not only on a set of well-established policies, processes and practices but also a well-coordinated enforcement or implementation program. It is imperative that a decision maker or implementer of an e-waste management program be provided with an adequate tool to aid in decision-making. A quantitative PPP approach developed has been shown in this study to be a useful tool for a decision maker or program implementer to quantitatively analyze and weigh all the issues involved before a sound decision is rendered.

This study shows that despite strong correlations existed between the different gender, age, educational and income levels of EEE retailers and consumers surveyed and their knowledge about the impacts of e-waste disposal on the environmental wellbeing in China, Laos and Thailand, there were definitive knowledge gaps detected in females and certain age groups in the three countries. Therefore, sound outreach and educational programs need to be established targeting those groups to mend the knowledge gaps.

Transboundary movement of e-waste, legal or illegal, among the GMS countries has become an issue of concern. This concern needs to be addressed through adoption and enforcement of e-waste management guidelines to prevent this subregion from becoming an e-waste dumping ground; thus ensuring its economic wellbeing, social equity and environmental protection.

Laos appeared to have scored better than Thailand based on the comparison using the quantitative PPP approach. This may be attributed to respondents' social desirability or assumption of facts rather than their actual knowledge of facts;

therefore, further studies are needed to pinpoint where the discrepancy occurs in the future. Results of this study also showed that there were definitive gaps detected in females on their knowledge of how to improve environmental conditions.

Further study is needed to evaluate the effectiveness or accuracy of the multi-criteria analysis and the cause and effect analysis in determining the impacts of e-waste from its generation to disposal on the environment and to compare it, if feasible, against the quantitative PPP approach proposed in this study.

5.2 Recommendations

The quantitative PPP approach proposed in this study is to be used as a tool for integrating complex variables or factors in a decision-making process for e-waste management to ensure that the final decisions are environmentally sound, logical and effective.

5.2.1 Proposed comprehensive e-waste management system

Based on the results of this study and the knowledge gained, a comprehensive e-waste management system is proposed to apply the "cradle-to-grave" concept to manage e-waste from its generation to final disposal as summarized in a flowchart (Fig. 5.1).

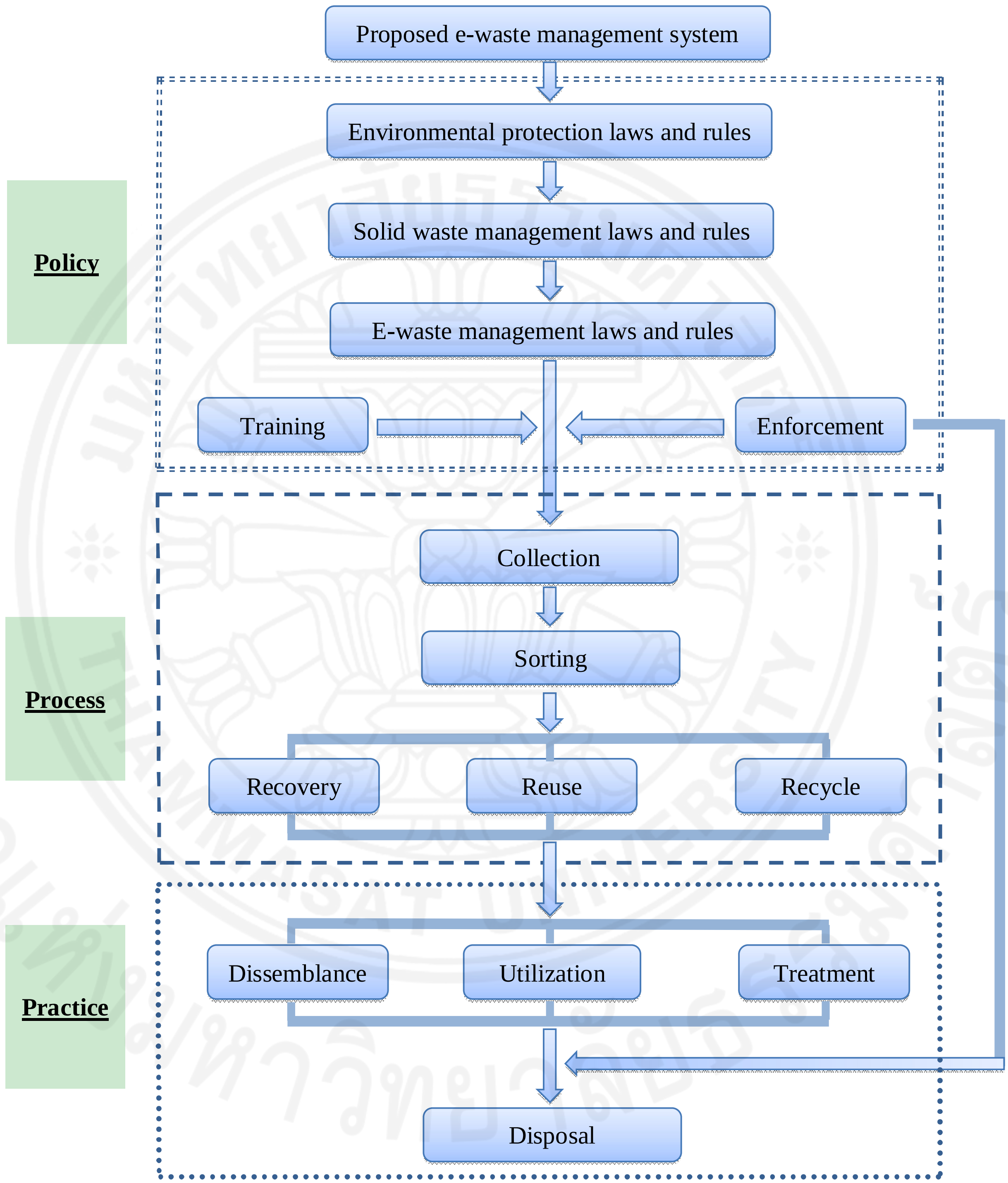

Fig. 5.1. Proposed e-waste management system.

Policy, the first parameter to be considered in the system, is to establish a sound waste management policy by adopting an umbrella environmental protection law to protect, among others, the ambient environment, minimize CO_2 emission, prevent groundwater contamination, and remove heavy metals and other toxic materials. Establishment of the umbrella environmental protection law would facilitate the development of guidelines and regulations for regulating solid waste, particularly e-waste, from its generation to final disposal. Establishment of the law also mandates the government to provide sufficient funds for implementing the guidelines supported by a strong training and enforcement program throughout the waste management system to ensure that the laws and rules are properly administered and complied with by those engaging in waste generation, processing, and final disposal.

Process, the second parameter to be considered in the system, is to develop a workable waste management program to capture the thrust of the modified 3R (recovery, reuse and recycle) approach to enable the initiation of effective waste management practices to collect and treat the waste before it is disposed of.

Practice, the third parameter to be considered in the system, is to initiate effective waste management practices to gather the waste for proper dissemblance, utilization and treatment before its disposal through incineration or other environmentally safe methods. Disposal of the waste in a well-designed and well-constructed incinerator would not only prevent emission of CO_2 and other toxic gas and convert waste into energy for generating electricity but also relieve the use of dwindling landfills and prevent land and water contamination worldwide.

5.2.2 Country specific recommendations

Specific recommendations for China, Thailand, and Laos were presented in Fig. 5.2, Fig. 5.3, and Fig. 5.4, respectively.

For Laos, there is a lack of e-waste management related laws or rules adopted in Laos. Likewise, this is also true in Thailand. As such, adoption of e-waste management related laws and rules in Laos and Thailand is urgently needed to provide a legal basis for promoting proper reduction, reuse or recycling of e-waste in these two countries. In addition, the government and educational institutions of Thailand should take actions to educate Thai people to increase their awareness of e-waste related laws and rules adopted. Chinese respondents, however, appeared to have the least willingness to comply with e-waste related laws and rules. Hence, a public educational program should be developed to enhance a better awareness of the deteriorating environment and how to improve it in China. More importantly, the established environmental related laws and rules, including the e-waste management guidelines, should be strictly enforced in China.

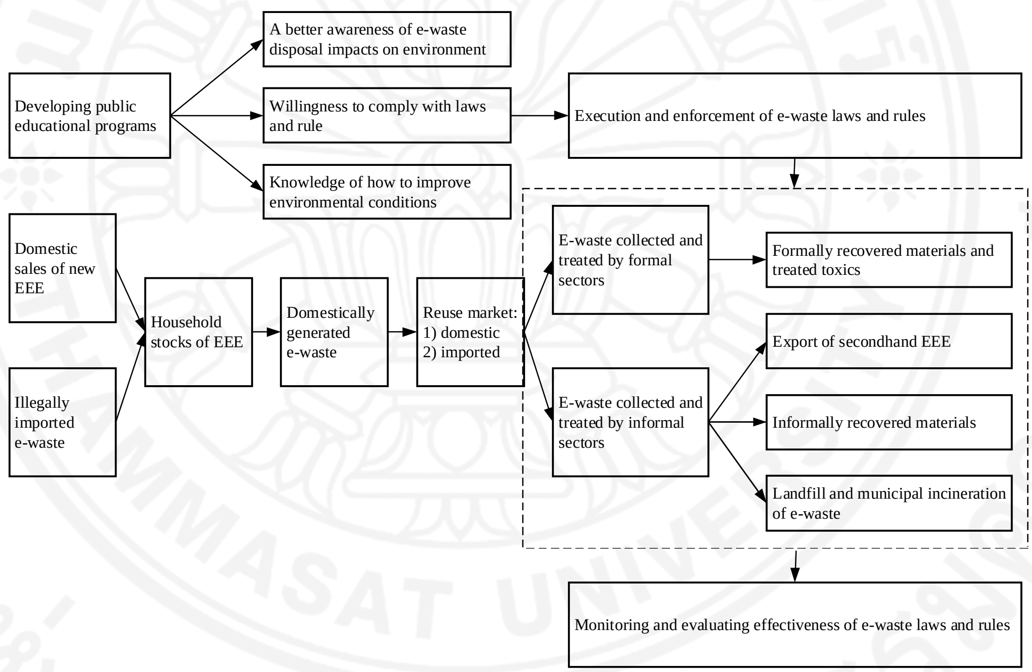

Fig. 5.2. Specific recommendations for e-waste management system in China.

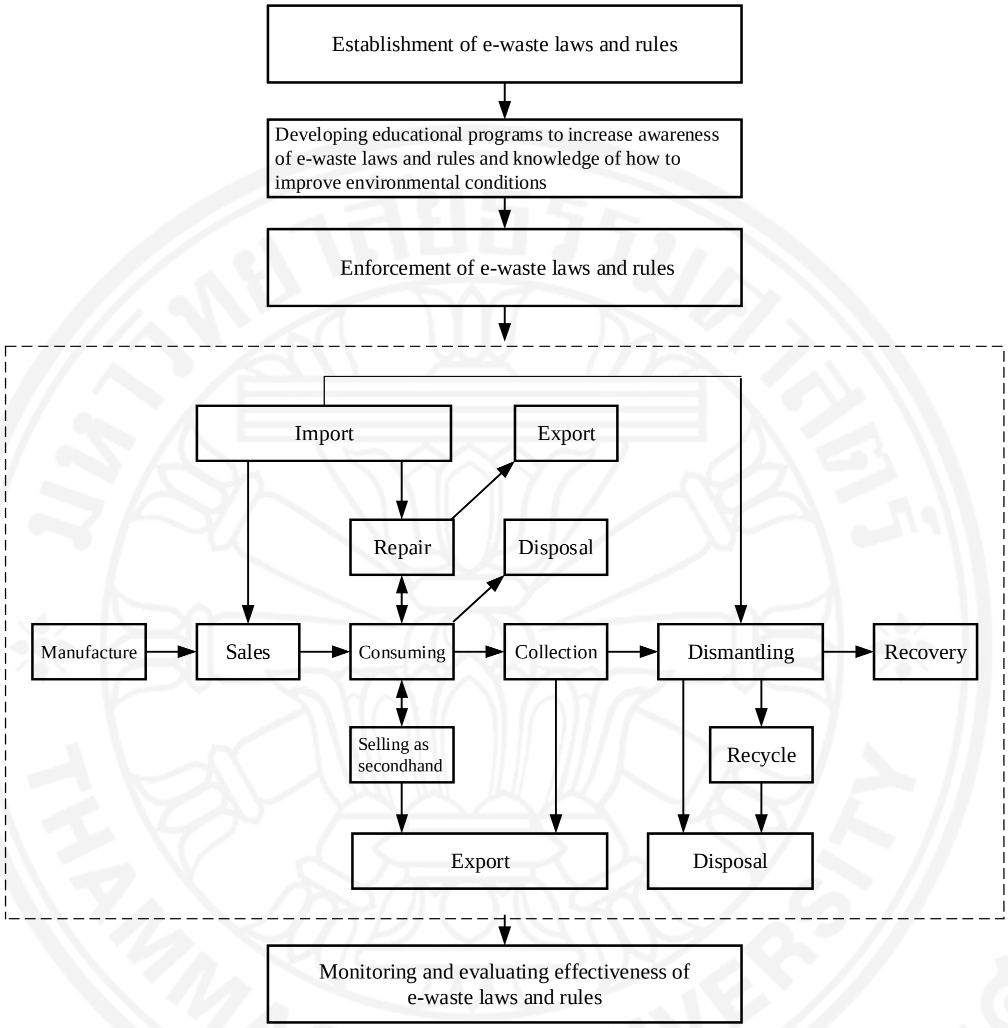

Fig. 5.3. Specific recommendations for e-waste management system in Thailand.

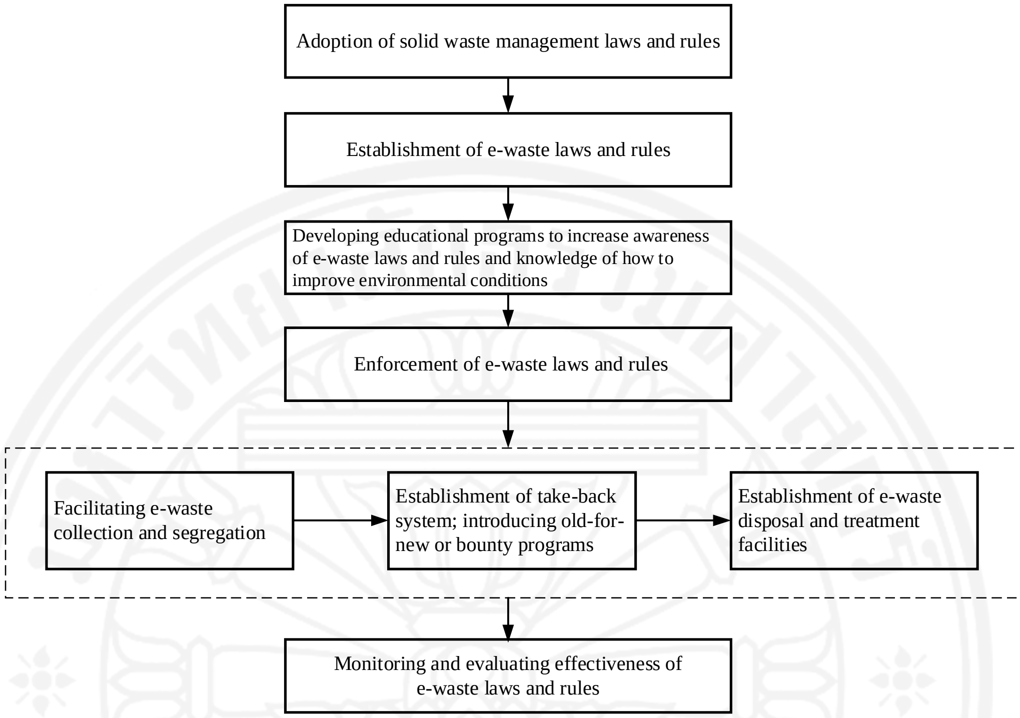

Fig. 5.4. Specific recommendations for e-waste management system in Laos.

In addition to the country specific recommendations mentioned above, other pertinent recommendations are:

1. Enactment of transboundary movement prevention law to prohibit illegal importation or exportation of e-waste;
2. At strategic locations, establishment of facilities for collecting, disassembling, processing, treating and disposing of e-waste;
3. Establishment of incinerators to process e-waste in place of new landfills;
4. Once #3 is achieved, decommissioning of landfills that are known to cause environmental pollution; and
5. Development of enforcement and training programs under the authority provided by e-waste management laws and rules to prevent improper treatment or disposal of e-waste.

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Appendices

Appendix A

Questionnaires for retailer subgroup

Dear respectful respondent,

Thank you for your kind cooperation to spend your time on responding to this questionnaire. It designs to support the thesis work about the electronic waste management systems – a comparison of the e-waste management policies, processes and practices in selected countries of the Greater Mekong Subregion. The glossary is listed below for your kind information.

- E-waste: “electrical or electronic equipment which is waste including all components, subassemblies and consumables, which are part of the product at the time of discarding” (European Union definition)
- Incineration: “a waste treatment process that involves the combustion of substances contained in waste materials”
- Secure landfill: “a system of trash and garbage disposal in which the waste is buried between layers of earth to build up low-lying land” (http://www.merriam-webster.com/dictionary/landfill?show=0&t=1365502241)

Part I: Respondents’ selected demographic characteristics

No.	Age		Gender		Educational level		Monthly income (USD)		Housing location	
1	< 18		Male		Illiterate		< 300		City center	
2	18-22		Female		Primary		301-500		Urban poor area	
3	23-30				Medium		501-800		Rural area	
4	31-35				High school		801-1,200		Others	
5	36-45				Undergraduate		1,201-1,500			
6	> 45				Postgraduate		> 1,500			

Part II: Checklist on respondents' awareness and concern about the e-waste management in general (target to non-government officials)

1. Are you concerned about the environment in which you live? A) Yes; B) No. If the answer is yes, what are those environmental concerns (multiple choices)? A) air quality; B) water quality; C) soil quality; and D) others. Please specify……
2. In your opinion, are the environmental conditions in your city improving or deteriorating? A) Improving; B) Deteriorating If the answer is the latter (deteriorating), which environmental condition is most severely deteriorating? ………
3. Do you know how to improve or correct the environmental condition that is deteriorating? A) Yes; B) No. If the answer is yes, how? ………..
4. Would you support any effort to control the rate of environmental deterioration? A) Yes; B) No. If the answer is yes, how? ………..........
5. Are you familiar with laws and rules governing e-waste disposal in your city? A) Yes; B) No.
6. Have you involved with any voluntary organizations working for the benefits of the environment? A) Yes; B) No.
7. Would you be willing to pay extra for an environmental friendly electronic product? A) Yes; B) No.
8. Would you be willing to drop off no-longer-in-use electronics at a nearby recycling station if there is one available? A) Yes; B) No.
9. Are you aware of the dangers of dumping e-waste in common waste sites? A) Yes; B) No. If yes, what are the dangerous factors/concerns? Please choose environmental concerns (multiple choices): A) air quality; B) water quality; C) soil quality; and D) others. Please specify………………………………………………………………………………………………………..
10. Are you involved in improper dumping of e-waste? A) Yes; B) No. If yes, what kind of improper activities have you ever involved? ………..........
11. Do you know how to address the problems resulted from improper dumping of e-waste? A) Yes; B) No. If yes, how? ………..........

Part III: Current policy-process-practice status of mobile phones

Note: 5-strongly satisfied; 4-satisfied; 3-no comment; 2-dissatisfied; 1-strongly dissatisfied. If choosing 3, 2, and 1, please explain and suggest.

<table>
<tr><td colspan="8">At process level (target to manufacturers and retailers)</td></tr>
<tr><td>No.</td><td>Questions</td><td colspan="5">Answers</td><td>Remarks</td></tr>
<tr><td rowspan="2">1</td><td>Do manufacturers use recyclable or reusable materials in producing their products?</td><td colspan="2">Yes</td><td colspan="3">No</td><td></td></tr>
<tr><td>If yes, are you satisfied with products using recyclable or reusable materials? Please rate your satisfactory level.</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td></td></tr>
<tr><td rowspan="2">2</td><td>Is there any incentive provided to sellers, consumers to practice reuse and recycle of e-waste?</td><td colspan="2">Yes</td><td colspan="3">No</td><td></td></tr>
<tr><td>If yes, are you satisfied with the incentive? Please rate your satisfactory level.</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td></td></tr>
<tr><td rowspan="2">3</td><td>Is there any take-back system adopted by manufacturers to encourage reuse or recycle of their products?</td><td colspan="2">Yes</td><td colspan="3">No</td><td></td></tr>
<tr><td>If yes, are you satisfied with the system adopted? Please rate your satisfactory level.</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td></td></tr>
<tr><td>4</td><td>Are you willing to comply with laws and rules to recycle and reuse products? If no, please explain.</td><td colspan="2">Yes</td><td colspan="3">No</td><td></td></tr>
<tr><td rowspan="4">5</td><td>What is the quantity of e-waste generated in your manufactory last year?</td><td colspan="5">Quantity of e-waste (tonne)</td><td></td></tr>
<tr><td rowspan="3">How to deal with generated e-waste (multiple choices)?</td><td colspan="5">Send to recovery centers</td><td></td></tr>
<tr><td colspan="5">Send to treatment companies</td><td></td></tr>
<tr><td colspan="5">Treat them by yourself</td><td></td></tr>
</table>

Part IV: Analysis of the matrix of stakeholders and concerns

Target group #2 retailers, recovery recyclers, and service providers				
No.	Questions	Answers		Remarks
1	How many phones have you sold out yearly in your shop? Among them, how many secondhand phones? And How many brand new phones?	Total (piece)		
		Secondhand (piece)		
		Brand new (piece)		
2	How many imported secondhand phones are usable and how many are not?	Usable (%)		
		Unusable (%)		
3	How many phones are recoverable? (piece)			
4	Do you know how to deal with unusable secondhand phones or components?			
	If for selling, what is the average price for a phone?	Selling price? (USD)		
	If treating it yourself, what are the methods?	Treatment methods?		
	If returning to assemblers/manufacturers, how many phones have you returned?	No. of returned phones (piece)		
5	Is it economically justifiable to repair a broken mobile phone?	Yes	No	
	Please explain either of your choice.			
6	How many mobile phones that you received, on a yearly basis, for repair? (piece)			
7	What is the percentage of mobile phones that you received on a yearly basis for the following conditions (100% in total)?	Returned to customers after proper repair (%)		
		Stripped for components (%)		
		Used for recovery (%)		
		Disposed by self (%)		

Appendix B

Questionnaires for consumer subgroup

Dear respectful respondent,

Thank you for your kind cooperation to spend your time on responding to this questionnaire. It designs to support the thesis work about the electronic waste management systems – a comparison of the e-waste management policies, processes and practices in selected countries of the Greater Mekong Subregion. The glossary is listed below for your kind information.

- E-waste: “electrical or electronic equipment which is waste including all components, subassemblies and consumables, which are part of the product at the time of discarding” (European Union definition)
- Incineration: “a waste treatment process that involves the combustion of substances contained in waste materials”
- Secure landfill: “a system of trash and garbage disposal in which the waste is buried between layers of earth to build up low-lying land” (http://www.merriam-webster.com/dictionary/landfill?show=0&t=1365502241)

Part I: Respondents’ selected demographic characteristics

No.	Age		Gender		Educational level		Monthly income (USD)		Housing location	
1	< 18		Male		Illiterate		< 300		City center	
2	18-22		Female		Primary		301-500		Urban poor area	
3	23-30				Medium		501-800		Rural area	
4	31-35				High school		801-1,200		Others	
5	36-45				Undergraduate		1,201-1,500			
6	> 45				Postgraduate		> 1,500			

Part II: Checklist on respondents' awareness and concern about the e-waste management in general (target to non-government officials)

1. Are you concerned about the environment in which you live? A) Yes; B) No. If the answer is yes, what are those environmental concerns (multiple choices)? A) air quality; B) water quality; C) soil quality; and D) others. Please specify……
2. In your opinion, are the environmental conditions in your city improving or deteriorating? A) Improving; B) Deteriorating If the answer is the latter (deteriorating), which environmental condition is most severely deteriorating? ……
3. Do you know how to improve or correct the environmental condition that is deteriorating? A) Yes; B) No. If the answer is yes, how? ……
4. Would you support any effort to control the rate of environmental deterioration? A) Yes; B) No. If the answer is yes, how? ……
5. Are you familiar with laws and rules governing e-waste disposal in your city? A) Yes; B) No.
6. Have you involved with any voluntary organizations working for the benefits of the environment? A) Yes; B) No.
7. Would you be willing to pay extra for an environmental friendly electronic product? A) Yes; B) No.
8. Would you be willing to drop off no-longer-in-use electronics at a nearby recycling station if there is one available? A) Yes; B) No.
9. Are you aware of the dangers of dumping e-waste in common waste sites? A) Yes; B) No. If yes, what are the dangerous factors/concerns? Please choose environmental concerns (multiple choices): A) air quality; B) water quality; C) soil quality; and D) others. Please specify……
10. Are you involved in improper dumping of e-waste? A) Yes; B) No. If yes, what kind of improper activities have you ever involved? ……
11. Do you know how to address the problems resulted from improper dumping of e-waste? A) Yes; B) No. If yes, how? ……

Part III: Analysis of the matrix of stakeholders and concerns

<table>
<tr><td colspan="13">Target group #3 consumers/end users</td></tr>
<tr><td>No.</td><td>Questions</td><td colspan="6">Options</td><td colspan="5">Answers</td></tr>
<tr><td>1</td><td>How many phones did you have in the past 5 years?</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="5">2</td><td rowspan="5">Did you replace your mobile phones for the following reasons? (multiple choices)</td><td colspan="6">Attractive exchange schemes?</td><td colspan="5"></td></tr>
<tr><td colspan="6">Upgrade for new technology?</td><td colspan="5"></td></tr>
<tr><td colspan="6">The old phone was broken</td><td colspan="5"></td></tr>
<tr><td colspan="6">The old phone got lost</td><td colspan="5"></td></tr>
<tr><td colspan="6">Others. Please specify</td><td colspan="5"></td></tr>
<tr><td rowspan="2">3</td><td>Do you replace your mobile phone by purchasing it from an illegal mobile phones market?</td><td colspan="3">Yes</td><td colspan="3">No</td><td colspan="5"></td></tr>
<tr><td>Please explain either of your choice.</td><td colspan="11"></td></tr>
<tr><td rowspan="5">4</td><td rowspan="5">How did you dispose of your used mobile phones by: (multiple choices)</td><td colspan="6">Storing at home</td><td colspan="5"></td></tr>
<tr><td colspan="6">Exchanging for a new one</td><td colspan="5"></td></tr>
<tr><td colspan="6">Giving it away to others</td><td colspan="5"></td></tr>
<tr><td colspan="6">Disposal in trash bin</td><td colspan="5"></td></tr>
<tr><td colspan="6">Others. Please specify</td><td colspan="5"></td></tr>
<tr><td rowspan="4">5</td><td rowspan="4">How to deal with your broken (which cannot be reused) phones? (multiple choices)</td><td colspan="6">Sending to professional companies</td><td colspan="5"></td></tr>
<tr><td colspan="6">Sending to retailers</td><td colspan="5"></td></tr>
<tr><td colspan="6">Do not care; and just leave it</td><td colspan="5"></td></tr>
<tr><td colspan="6">Others. Please specify</td><td colspan="5"></td></tr>
<tr><td rowspan="3">6</td><td rowspan="3">Are you aware of any environmental impact found in recovery operations for: (multiple choices)</td><td colspan="6">Segregation or sorting of wastes?</td><td colspan="5"></td></tr>
<tr><td colspan="6">Extraction?</td><td colspan="5"></td></tr>
<tr><td colspan="6">Burning or incineration?</td><td colspan="5"></td></tr>
</table>