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List of abbreviations

Basel Convention	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
BCRC China	Basel Convention Regional Centre for Asia and the Pacific
EEE	Electrical and electronic equipment
EPR	Extended producer responsibility
E-waste	Electrical and electronic waste
GDP	Gross domestic product
GHG	Greenhouse gas
HDI	Human Development Index
ILO	International Labour Office
INTERPOL	International Criminal Police Organization
ISWM ¹	Integrated Sustainable Waste Management
MEP	Ministry of Environmental Protection (China)
METI	Ministry of Economy, Trade and Industry (Japan)
MIIT	Ministry of Industry and Information Technology (China)
MOC	Ministry of Construction (Vietnam)
MOE	Ministry of the Environment (Japan)
MOF	Ministry of Finance (China)
MOH	Ministry of Health (Vietnam)
MOI	Ministry of Industry (Vietnam)
MONRE	Ministry of Natural Resources and Environment (Vietnam)
NDRC	National Development and Reform Commission (China)
NGO	Non-governmental organization
NPCSC	The Standing Committee of the National People's Congress (China)
StEP	Solving the E-waste Problem Initiative
UNEP	United Nations Environmental Programme
UNODC	United Nations Office on Drugs and Crime
UNU	United Nations University
WEEE	Waste electrical and electronic equipment

¹ While the acronym ISWM is in some instances also used for the term Integrated *Solid* Waste Management in contemporary literature, in the context of this thesis, the term *exclusively* refers to Integrated *Sustainable* Waste Management.

1. Introduction

1.1 Research context

The constantly growing amount of waste in the world is an issue that has been of concern to humankind for centuries and will continue to be of concern for generations to come. While technological development allows for the reuse and recycling of ever more forms of waste, the development of new products also poses new challenges when these reach the end of their lifetime. Even more complicated is the treatment of hazardous waste that includes toxic, reactive, corrosive or flammable substances.

The effective management of waste is closely linked with the goal of sustainable development and has been relevant to all of the eight Millennium Development Goals that world leaders committed to at the Millennium Summit in September 2000 by adopting the United Nations Millennium Declaration (General Assembly, 2000). An analysis by the United Nations Human Settlements Programme (2010: 25) has identified the links between these goals and improved sustainable waste management. For instance, as regards goal 4, which aimed at reducing child mortality, households without access to an effective waste collection service show significantly higher rates of children being affected by diarrhea and acute respiratory infections – some of the main causes of childhood deaths. Goal 7, relating to ensuring environmental sustainability, was directly affected by prevalent attitudes among the general public towards waste reduction, reusing and recycling, which is linked to conservation of natural resources, energy savings and the reduction of greenhouse gases and other emissions.

The deadline of the Millennium Development Goals was set to 2015. After taking stock of what has and has not been achieved throughout the past 15 years, country leaders and international organizations have developed a new set of global goals, known as the Sustainable Development Goals, that lay out the post-2015 development agenda. The newly adopted 17 Sustainable Development Goals do not only address interrelated issues, such as reducing poverty or preventing child deaths, but also contain various specific indicators that directly address waste and waste management. These include indicators 11.6, 12.4 and 12.5.²

² Indicator 11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management;

Indicator 12.4: By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment;

Indicator 12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse (<https://sustainabledevelopment.un.org/sdgs>).

Electrical and electronic waste (e-waste)³ is one of the fastest growing types of waste with an annual growth rate of four to five per cent. The majority of e-waste is generated in Asia, representing 16 million tons of produced e-waste in 2014 (Baldé et al., 2015a: 24-25). At the same time, Asia is also the major recipient of illicitly trafficked e-waste (UNODC, 2013: 110). Alongside the production of a growing number of electronic appliances worldwide, the issue of managing e-waste efficiently, both on national and global scales, is becoming increasingly important, in particular, as e-waste is not only a waste management problem due to its hazardous components and the exponential growth rate, but it is also closely connected to the depletion of resources in light of the rising demand of electrical and electronic equipment (EEE) worldwide (Schluep et al., 2009: 6). While awareness of this challenge is expanding and recent years have seen an increasing number of initiatives, as well as research projects, dedicated to enhancing the understanding of the issue and promoting both the prevention and the environmentally sound management of e-waste, these efforts largely remain uncoordinated and rarely address the challenge from a holistic perspective.⁴

This thesis aims at contributing to a more comprehensive analysis of the e-waste challenge and responses to the challenge in three East Asian⁵ countries, namely China, Japan and Vietnam. The analysis focuses on the three countries as case studies, whereas each of their e-waste sectors shows different characteristics – Japan as a major e-waste export country, China as one of the world’s major e-waste import countries and Vietnam as a country that mainly imports e-waste, but shows significant re-export of e-waste to China. While Japan shows the highest rate of e-waste produced per inhabitant in Asia in 2014 at 17 kg, it ranks second to China in absolute quantities. China produced almost three times as much e-waste as Japan (6 million and 2.2 million tons respectively), but showed a comparatively low amount of kg of e-waste produced per inhabitant (less than 5 kg per inhabitant). Thus, the two countries represent regional extremes as regards e-waste production (Baldé et al., 2015a: 42-43; UNODC, 2013: 103-111). Vietnam, as the third analyzed country, on the other hand shows one of the lowest rates of annually generated e-waste in Asia (less than 2 kg of e-waste produced per inhabitant in 2014; Baldé et al., 2015a: 43).

When examining the national responses to the e-waste challenge, the three countries represent very different case examples, even though all three countries have national legislation relating to e-waste in place. Japan has been a global initiator and driving force of the

³ For a discussion of the term and meaning of ‘e-waste’, see chapter 2.1.

⁴ See chapter 1.2.

⁵ In the context of this thesis, the term *East Asia* shall refer to the broad region comprising both Northeast and Southeast Asia.

development and implementation of e-waste regulations and management practices. China, on the other hand, has only recently started to formulate specific e-waste regulations, implementation of which is still insufficient. Similarly, Vietnam shows only rudimentary e-waste management strategies as regards the legal framework, inventory and collection of e-waste, as well as deployed recycling technologies (Sthiannopkao and Wong, 2013: 1148-1152). Thus, a comparison of the three countries shows both the ‘lower end’ and the ‘upper end’ of the spectrum as regards amounts of e-waste generated and e-waste management strategies and practices in Asia. The three countries also feature different political and economic systems and different stages of development. For instance, in the 2013 Human Development Index (HDI), Japan ranks 17th with a value of 0.890, which is regarded as ‘very high human development’, China ranks 91st with a value of 0.719, showing ‘high human development’, and Vietnam ranks 121st with a value of 0.638, representing ‘medium human development’. It should however be noted that all three countries improved their values compared to the 2012 Human Development Index (UNDP, 2014: 159-161). These differences might suggest similarly diverging results when analyzing the e-waste sectors in the three countries. On the other hand, the geographical proximity of the countries and similarities in social and cultural traditions might also have led to similarities in approaching e-waste management.

The primary research question of this thesis is:

How does e-waste management in China, Japan and Vietnam differ with respect to progress made towards Integrated Sustainable Waste Management (ISWM)?

The methodological framework used to answer the research question of the thesis is based on the concept of *Integrated Sustainable Waste Management (ISWM)*. Instead of approaching the topic from a one-dimensional perspective, such as through a socio-economic, a technological or an environmental lens, the multidimensional nature of the e-waste challenge, which affects society, culture, economy, environment, politics, and other sectors alike, is recognized by applying a multidisciplinary methodology. The ISWM framework allows for a holistic examination of the various ways in which waste affects societies. While there are several variations of this concept in contemporary research, the thesis integrates the key elements that focus on ensuring both an integrated and sustainable approach, inter alia including the 3R principle (reduce, reuse, recycle), the integration of (e-)waste management into broader public health and environmental considerations, a comprehensive institutional and policy framework regulating e-waste management, as well as sustainability of financial resources. This

inclusive approach further analyzes the integration of all relevant stakeholders, to reflect the fact that e-waste affects all members of society.

On the basis of the general concept of ISWM, which is comprised of three dimensions, namely stakeholders, elements and aspects, a set of indicators is developed that is applicable to the national scale of the analysis and the specific context of e-waste. In addition to the analysis of the stakeholder ‘landscape’ and the deployed management practices, i.e. e-waste system elements, these indicators are applied in the third part of the thesis to allow for a detailed and comprehensive analysis and comparison of the progress the three countries have made in e-waste management. Based on the results matrix, advancements and shortcomings in integrated sustainable e-waste management are examined. This thesis does not aim to rank the three countries, but provide an inclusive and holistic analysis and comparison of e-waste management approaches. As a result, similarities and differences between the different countries’ approaches are identified, which allow for inferences with regard to national and regional patterns. To this end, the following secondary research questions are answered as regards the comparative aspect of the analysis:

- a) Do e-waste management approaches differ according to the distribution of import, export and transit (re-export) countries?*
- b) Can other patterns of e-waste management be identified or do specific national characteristics determine approaches in the three analyzed countries?*
- c) Could there be an ‘East Asian’ way of e-waste management?*

The diverging roles of China, Japan and Vietnam as e-waste import, export and re-export/transit countries respectively might suggest that the three countries follow similarly diverging e-waste management approaches with measures focused on import control in China and export control in Japan, while Vietnam might apply a mixed strategy (question a). On the other hand, the different levels of economic and social development and other national characteristics might be the cause for differences in the countries’ approaches (question b). Alternatively, geographical, historical and cultural similarities might have led to the development of similar methods in handling e-waste, which could even suggest an ‘East Asian’ way of e-waste management (question c).

While there have been a number of studies that apply the ISWM model to cities,⁶ analyses of national scale (e-)waste management practices are rare. Among the reasons for this imbalance in current literature is the fact that cities represent a smaller sample size, which offer more accurate and comprehensive data sets. This allows for a more in-depth analysis of the waste sector and its interrelations. However, limiting the analysis to selected cities neglects the ‘ecosystem’ of waste management practices, which reaches beyond city borders and shows interdependencies between different cities and regions. Firstly, progress in ISWM in one city might occur at the cost of other cities’ waste systems. Secondly, several factors of the ISWM framework for cities apply to the country as a whole, such as legislation or budget allocation. Thirdly, cross-country comparisons of cities might not be representative of the e-waste systems as a whole, but mere case examples. Fourthly, in particular in e-waste management, the informal sector plays a significant role in many countries and is mainly concentrated in rural areas outside of the cities (Lundgren, 2012: 25-31). Hence, focusing the analysis on one or a few cities inevitably overlooks a significant part of the e-waste management system in a country. A national scale analysis on the other hand allows for an integrated and comprehensive view on e-waste management and a comparison of progress made in different countries.

The following chapter of the thesis summarizes the state of the art of research conducted on e-waste management in East Asia, and specifically on China, Japan and Vietnam, with a view to forming the basis of the subsequent parts. Part two builds the theoretical framework of the thesis by firstly identifying and defining key concepts and terms and secondly developing the indicators for the analysis based on the ISWM model. Building on the three dimensions of this model, the indicators are adapted to the specific national scope of the thesis and the particular issues relating to e-waste as a form of waste. Part three forms the empirical part of the thesis by applying the three dimensions and the indicator set to the country cases China, Japan and Vietnam. In accordance with the comparative approach of the thesis, the structure of the application part considers each element of the ISWM model for each country rather than providing full country studies. Firstly, the extent and characteristics of the e-waste challenge are examined globally and in the context of the three countries. Subsequently, the structure of the stakeholders engaged in the e-waste sector in each country is analyzed. Thirdly, the specific practices deployed in each country to manage e-waste are examined. Finally, the last chapter of the application analyzes the six sustainability aspects that have been developed in the theoretical part in the national contexts. Building on this comprehensive analysis of the three countries, the

⁶ See, for example: Mwanza and Phiri, 2013; Imam et al., 2008; and Wilson et al., 2012.

fourth part discusses the results comparatively. The last part answers the research questions and provides areas of further research.

1.2 State of the art

Although waste and waste management have been topics of research for many years, the specific focus on e-waste is a rather new phenomenon that has emerged in academic literature in the 21st century. In particular, after the first European Union Directive on waste electrical and electronic equipment entered into force in 2003 (*Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment*), the number of studies and reports on e-waste have been increasing. While early publications often discussed the issue from a technological perspective, for instance by reviewing existing recycling methods and developing new infrastructure and technology options (Kang and Schoenung, 2005; Cui and Forssberg, 2003), a growing number of publications approach e-waste from other disciplines, such as economic or environmental perspectives. Many of these publications have stressed the growing amounts of e-waste, globally (Schluep et al., 2009; Kiddee, Naidu and Wong, 2013; Buekens and Yang, 2014) or in specific regions (Babu, Parande and Basha, 2007; Dwivedy and Mittal, 2010). In this context, a large proportion of academic literature focuses on the adverse impacts of improper e-waste processing on human health and the environment (Wong et al., 2007; Dayaneni and Doucette, 2005; Olowu, 2012). Studies which analyze the prevalent e-waste management regulations and practices often contrast developed countries, such as the European Union Member States, the United States, Canada or Australia, with developing countries, such as China, India, Kenya or Nigeria (Mohan and Bhamawat, 2008; Nnorom and Osibanjo, 2008). This differentiation not only reflects the main flow of e-waste from developing to developed countries, as discussed in chapter 3.1, but also the progress in formulating and implementing comprehensive and effective e-waste management structures and measures. In this way, the burden on many developing countries is twofold, as they not only represent the main recipients of exported e-waste from developed countries, but also lack the capacities to handle the hazard of e-waste.

Apart from academic research, international organizations have also paid increasing attention to the issue of e-waste in recent years. International organizations examine e-waste from different perspectives that stem from their respective priorities. For instance, the International Labour Office (ILO) places emphasis on economic and labor and employment issues in the e-waste management processes, in particular as created through the large informal e-waste recycling sector. Accordingly, concluding recommendations by the ILO include enhanced capacity building and the “*formalization of the e-waste recycling economy, avoiding single-sector approaches*” (Lundgren, 2012: 55). The United Nations Environmental Programme (UNEP) is one of the most active international organizations that addresses e-waste.

Its focus lies not only on the adverse environmental effects of e-waste, but also on the development of sound take back systems and the recognition and utilization of the resource value of e-waste (UNEP, 2005; UNEP, 2012; Schluep et al., 2009). Alongside the United Nations Environmental Programme, the United Nations University (UNU) has carried out leading research on e-waste, in particular in the framework of the global ‘Solving the E-waste Problem (StEP) Initiative’, which was established in 2007. The UNU ‘Global E-waste Monitor 2014’ (Baldé et al., 2015a) is the first publication that contains calculations and data on e-waste generation, flows and management for all countries of the world. Moreover, in 2015, UNU developed universal classification and reporting guidelines for the compilation of e-waste statistics (Baldé et al., 2015b), which address the most fundamental obstacle of reliable and comparable e-waste data - a common system for e-waste inventories. In the framework of StEP, several studies, Green Papers, White Papers and country assessments have been developed on various aspects of the e-waste challenge. One of the main objectives of the initiative is to improve e-waste data sets available on national, regional and global levels. Most notably, StEP has compiled country-level data on the amount of EEE put on the market, resulting amounts of waste electronic and electrical equipment (WEEE) generated, as well as legislative responses, for almost all countries of the world, and aggregated these data in an interactive world map.⁷

Other organizations approach the topic from a criminological and legal perspective. For instance, the United Nations Office on Drugs and Crime (UNODC) has analyzed the illicit trade in e-waste in East Asia and the Pacific (UNODC, 2013: 101-111). Similarly, the International Criminal Police Organization (INTERPOL) has conducted research on assessing the links between e-waste and organized crime (INTERPOL, 2009).

The increasing number of research projects, initiatives and studies on e-waste related issues conducted by international organizations shows a heightened awareness of the distinct challenges posed by this type of waste, including the need to dedicate research to the topic outside of *general* waste management analyses.

With the aim of providing a more detailed analysis of the problem within a limited scope, some publications focus on specific regions (Pariatamby and Victor, 2013; Selin and VanDeveer, 2010) or single countries (Kahhat et al., 2008; Wath et al., 2010). Asia, and in particular China, as one of the main recipients and producers of e-waste in total amounts, has been the focus of a number of publications, both as regards Asian researchers and researchers

⁷ Available on their website: <http://www.step-initiative.org/step-e-waste-world-map.html>.

from other parts of the world (Hicks, Dietmar and Eugster, 2005; Liu, Tanaka and Matsui, 2006; Pariatamby and Victor, 2013; Wendell, 2011).

However, even though the volume of publications that discuss and analyze e-waste or e-waste management is growing, systematic analyses of national e-waste management strategies in their multidimensional constitution are rare, despite the acknowledgement of the “*inherently interdisciplinary*” nature of the issue (Khetriwal and Luepschen, 2013: 2). Similarly, comparative research often focuses on one dimension, such as the legislative frameworks that have been put in place in a region or in selected countries (Nnorom and Osibanjo, 2008; Lepawsky, 2012), or merely provides a descriptive review of the challenges and national approaches in different countries (Ongondo, Williams and Cherrett, 2011; Herat and Agamuthu, 2012; Pariatamby and Victor, 2013).

Comparatively rare examples of a more analytical approach towards the comparison of e-waste management in East Asian countries, focusing on the recycling of e-waste, include: Bo and Yamamoto, 2010; Chung and Kojima, 2010; Chung and Murakami-Suzuki, 2008; Lee and Na, 2010. Using specific indicators, such as the structure of collection and cost allocation, regulations on manufacturers’ responsibilities, reuse and recycle rates and the role of various stakeholders, the authors determine substantial differences, but also similarities in the e-waste recycling systems of China, Japan, Korea and Taiwan. Among the reasons for the differences identified by the authors are the different cultural contexts, economic systems and historical policy backgrounds (Chung and Kojima, 2010: 257; Chung and Murakami-Suzuki, 2008: 143). Lee and Na (2010: 1643-1644), and Chung and Murakami-Suzuki (2008: 144) further highlight the crucial role of international cooperation, regional agreements and learning from one another for a sustainable solution to e-waste recycling. It is worth noting that all four studies see advantages and disadvantages in the various e-waste recycling systems and do not attempt to rank the countries.

In contrast, a 2005 report conducted by the Basel Convention Regional Centre in China not only compares the e-waste management approaches of five Asian countries (Cambodia, China, Malaysia, Sri Lanka and Thailand), but evaluates their progress in each of seven identified indicators on a scale of 1, representing the lowest stage of e-waste management, to 5, representing a fully developed stage of e-waste management (BCRC, 2005: 156-159).

However, despite the identification of Vietnam as one of the major recipients of e-waste exports from developing countries and the significant role of the country in Asian e-waste flows (see chapter 3.1), only very limited research has been conducted on its e-waste sector. Comparative studies often neglect the country entirely or include only general or aggregated

information on Vietnam (Pariatamby and Victor, 2013: 414; Herat and Agamuthu, 2012: 1124). Nevertheless, several Vietnamese academics have focused their research in particular on the issue of e-waste, such as Huynh Trung Hai and Nguyen Duc Quang of the Hanoi University of Science and Technology (Hai, Hung and Quang, 2015).

2. Methodology

2.1 Terminology and conceptualization

In order to understand the main principles and goals of *Integrated Sustainable Waste Management* (ISWM), it is necessary to firstly understand the different terms and concepts that form the basis of this analytical framework. ISWM is fundamentally a multidisciplinary model that is derived from various academic fields, rather than being built on a single theory. Moving away from a conventionally exclusively technical and engineering approach towards waste management, ISWM is intended to be an inclusive, comprehensive and practical analytical tool, as well as a development framework. The concept is based on international best practices from a wide range of disciplines, including environmental studies, economics and social science, which inform the various components of the concept. These different elements are connected to a holistic model through the application of systems theory, which recognizes the complexity of interdependent processes and elements within the waste management structure, while also viewing the system in its entirety (Wilson, Velis and Rodic, 2013: 52-55; McDougall et al., 2001: 15-21).

This chapter applies a layered approach to conceptualizing ISWM, from defining the terms *waste* and *e-waste* to explaining the specific characteristics and elements of *integrated* and *sustainable* waste management.

Waste

Article 2 of the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal* (Basel Convention) defines *waste* as “*substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law*” (United Nations, 1989: 10). Article 3 of the Directive 2008/98/EC of the European Union defines *waste* as “*any substance or object which the holder discards or intends or is required to discard*” (European Union, 2008: 312/9). While both definitions have three elements in common – the disposal, intention for disposal and requirement of disposal, the Basel Convention emphasizes the legal regulation aspect, whereas Directive 2008/98/EC only refers to “*the holder*” as the main subject who determines whether an object is considered to be waste. The Glossary of Environment Statistics of the United Nations contains a more sophisticated definition of waste:

“materials that are not prime products (that is, products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose [...]”

(United Nations Department for Economic and Social Information and Policy Analysis, 1997: 76)

Similarly to Directive 2008/98/EC, the basis for defining what is waste lies with the subject, although in this case, the subject is identified as ‘the generator’ instead of ‘the holder’. All of these definitions are rather general, which in practice leads to variations in what is considered to be waste and what is not. Of particular significance is the differentiation between used/reusable materials and goods, which not only has implications for internal, but also international trade. Such discrepancies in differentiating waste from reusable materials are commonly exploited to export non-reusable e-waste as reusable materials (see below).

There are numerous classification systems to distinguish different types of wastes. Commonly used classification categories include: Sources, for example municipal, industrial, medical, etc.; original use, for example packaging waste, food waste, etc.; characteristics, for example toxic, corrosive, flammable, etc.; material, for example glass, metals, etc.; safety level, i.e. hazardous or non-hazardous; control status, i.e. controlled or non-controlled; and the physical state, for example solid, liquid, etc. (Taylor and Allen, 2006: 340-342; Environment Protection Authority, 2014: 1-7; Environment Agency et al., 2015: 5-19; McDougall et al., 2001: 2). In order to harmonize the different classification systems in the European context, the European Union has adopted several framework documents that provide a comprehensive list of wastes. Most recently, the Commission Decision of 18 December 2014 established an updated categorization list, containing 20 chapters that mainly classify different types of wastes according to their source and contain six-digit numerical codes to identify specific types of wastes (European Union, 2014: Annex, 370/46-370/86). The Basel Convention contains a list of wastes characterized as hazardous (United Nations, 1989: Annex VIII, 66-73) and a list of wastes characterized as non-hazardous under certain prescribed conditions (United Nations, 1989: Annex IX, 74-87). Several other regional conventions that regulate (hazardous) wastes contain similar classification and codification lists, such as the ‘Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Transboundary Movement and Management of Hazardous Wastes within the South Pacific Region’ (Waigani Convention) of 2001 or the ‘Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous

Wastes within Africa’ of 1991. Notably, no similar regional convention has been adopted for the East Asian or Southeast Asian region. However, as a global instrument, the Basel Convention provides for a common framework for defining and classifying *waste*.

E-waste

In contrast to the term *waste*, there is no commonly accepted and utilized international framework applicable to *e-waste*. Figure 2.1 shows the different definitions formulated by leading authorities in the field, such as the European Union, the Basel Action Network or the Solving the E-waste Problem Initiative (StEP).

The common denominator of these definitions is that e-waste is described as electric or electronic equipment (EEE), containing components that control or direct electric currents, which is disposed of by the consumer/owner of the appliance. The size of such appliances can vary significantly – ranging from comparatively small products, such as mobile phones, to very large products, such as refrigerators or washing machines.

Reference	Year	Definition
StEP	2014	<i>“E-Waste is a term used to cover items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention of re-use.”</i> Definition of EEE: <i>“Any household or business item with circuitry or electrical components with power or battery supply.”</i>
European Union Directive 2012/19/EU, Article 3	2012	<i>“‘waste electrical and electronic equipment’ or ‘WEEE’ means electrical or electronic equipment which is waste within the meaning of Article 3(1) of Directive 2008/98/EC, including all components, sub-assemblies and consumables which are part of the product at the time of discarding;”</i> Definition of EEE: <i>“‘electrical and electronic equipment’ or ‘EEE’ means equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for direct current;”</i>
Barbour	2012	<i>“Electronic waste (e-waste) is a term that refers loosely to obsolete, broken, or irreparable electronic devices like televisions, computer central processing units (CPUs), computer monitors (flat screen and cathode ray tubes), laptops, printers, scanners, and associated wiring.”</i>
Basu	2008	<i>“[...] all end-of-life or disposed electrical and electronic products, components, and peripherals such as computers, cell phones, fax machines, photocopies, radio sets, televisions, and so on.”</i>
Widmer et al.	2005	<i>“‘Electronic waste’ or ‘e-waste’ for short is a generic term embracing various forms of electric and electronic equipment that have ceased to be of any value to their owners.”</i>
Basel Action Network (Puckett et al.)	2002	<i>“E-waste encompasses a broad and growing range of electronic devices ranging from large household appliances such as refrigerators, air conditioners, hand-held cellular phones, personal stereos, and consumer electronics to computers.”</i>

Figure 2.1: Selected definitions of WEEE or e-waste. Sources: StEP, 2014: 4-5; European Union, 2012: 197/43; Puckett et al., 2002: 5; Widmer et al., 2005: 438; Basu, 2008: 46; Barbour, 2012: 1.

Further differentiations of e-waste are made according to three variations, namely the hazardous content, the high-value content and the ease of recycling. The scope of appliances that are accepted in e-waste recycling systems differs across different countries (Gossart, 2011: 7).

While these definitions seem to be quite clear, it is often challenging to identify e-waste in practice. For instance, Article 4 of the Basel Convention prohibits the transboundary shipment of hazardous and other wastes, including e-wastes (United Nations, 1989: 14-18). However, to avoid violating these regulations, e-waste is instead shipped as used and reusable EEE, although at the point of destination, mainly developing countries, it appears to be e-waste (Gossart, 2011: 7). E-waste might also be smuggled in end of life vehicles, not declared in any way (Interpol, 2011: 5).

Various characteristics of e-waste distinguish it from other types of waste and pose distinct challenges to its effective management and control. Due to these specific features, the management of e-waste requires a specialized and tailored approach, which is different from conventional waste management methods.

Firstly, the rapid growth of e-waste globally exceeds most other types of waste. New electronic and electrical products are not only constantly developed, in particular alongside the evolving information and communication technology infrastructure and increasing automatization of industrial and business processes, but also discarded after ever shorter durations (Frey, 2012: 81).

Secondly, e-waste contains a number of hazardous substances that pose potential risks to the environment and public health if not treated through adequate measures. More than 1000 toxic substances have been identified in e-waste, including toxic metals, such as cadmium, mercury or lead, and persistent organic pollutants, such as polychlorinated biphenyls and polyvinyl chloride (Kiddee, 2013: 1238). When exposed to the environment, for example when recycling byproducts enter the food chain or e-waste workers come into direct contact with the substances, these hazardous materials can harm human health in various ways. Research has identified numerous health issues associated with e-waste, including radiation, respiratory failure or nausea (Olowu, 2012: 68).

Thirdly, the complexity of EEE design poses a challenge to efficient recycling of e-waste. Hazardous and non-hazardous materials are often firmly attached to each other and most types of EEE or WEEE consist of many different components and materials (Lundgren, 2012: 12).

Fourthly, contrary to many other types of waste, the resource value of recycled materials is very high. In particular in countries that lack abundant natural resources, recovering the greatest amount of metals possible through e-waste recycling can be of substantial economic benefit (Schluep et al., 2009: 6-8).

A fifth feature, which is often overlooked, is the cybersecurity aspect of e-waste. As an increasing number of computers, hard disks, smartphones, and other devices containing stored data are discarded, the potential for security breaches and targeted computer attacks rises.

Waste management

The term *waste management* is commonly defined through a set of distinct measures that are related to waste. Article 2 of the Basel Convention defines *waste management* as “*the collection, transport and disposal of hazardous wastes or other wastes, including after-care of disposal sites*” (United Nations, 1989: 10). Directive 2008/98/EC of the European Union in Article 3 expands this definition by additionally including the recovery of waste, the supervision of such operations and actions taken as a dealer or broker (European Union, 2008: 312/9). Similarly, the Glossary of Environment Statistics of the United Nations defines waste management by means of characteristic activities, which include:

*“(a) collection, transport, treatment and disposal of waste,
(b) control, monitoring and regulation of the production, collection, transport, treatment and disposal of waste and
(c) prevention of waste production through in-process modifications, reuse and recycling.”*

(United Nations Department for Economic and Social Information and Policy Analysis, 1997: 76)

Notably, the latter definition adds the prevention of waste production to the scope of waste management. While the Basel Convention does not mention measures relating to the prevention of any forms of waste, Directive 2008/98/EC dedicates Article 9 to this measure, as a core element of the waste hierarchy (see below; European Union, 2008: 312/12-13). In the context of this thesis, an inclusive approach is applied to the definition of the term *waste management* to comprise the widest scope of activities, i.e. all of the measures listed in the Basel Convention, the United Nations Department for Economic and Social Information and Policy Analysis and Directive 2008/98/EC.

Sustainable waste management

Sustainable waste management can be defined in the broader framework of sustainable development. The concept of sustainable development is fundamentally a dynamic concept, considering the constant change of the environment and society. In this process of change it has the aim of reaching a certain level of equity and balance regarding the needs (or interests) of different groups in society, regarding different generations and with respect to three major interrelated areas: economic, social and environmental. These are the preconditions for development to continue indefinitely (Soubotina, 2004: 9-10). One approach to identifying *sustainable* waste management strategies is to apply the three pillars of the sustainability model. In this context, health and safety implications of waste management processes, such as implementing occupational health standards for employees working directly with waste, are considered to ensure social sustainability of waste management. The environmental aspect encompasses the whole waste sector, but also the producing industries, for instance by aiming at minimizing the hazardous contents of produced materials and goods, which ultimately contributes to protecting the environment from harmful substances. The third sustainability factor relates to the economic value that is produced by the waste industry, for instance through the utilization of waste for energy generation or the cost-efficient production of secondary materials (International Solid Waste Association, 2013: 3-5; Finnveden et al., 2013: 842-843; Morrissey and Browne, 2004: 298).

While this model recognizes the importance of considering economic, social and environmental aspects when developing a sustainable waste management strategy or system, it does not explicitly address the necessary technological factors, the fundamental political and legal conditions and the organizational structure that create the framework of a sustainable approach. Van de Klundert and Anshütz (2001: 11) addressed these shortcomings by developing a more sophisticated model of sustainable waste management and defining a sustainable waste management system as “*appropriate to the local conditions and feasible from a technical, environmental, social, economic, financial, institutional and political perspective. It can maintain itself over time without exhausting the resources upon which it depends.*” One of the core aspects of sustainable waste management is the consideration of *time* within the planning and strategic framework. In this regard, waste management is a long-term endeavor, which requires continuous planning, development, monitoring and evaluation, and adjustment. While short-term projects, which are able to produce fast and highly visible results, might be more likely to attract funding and are therefore often favored by national or local decision-makers, the long-term effects of these projects might be very limited, or, in the worst cases,

even detrimental to overall waste management effectiveness. In addition to the three pillars of the classic sustainability model, van de Klundert and Anschütz (2011: 11) identify four complementary elements that address the policy and legal framework of the waste management system, the institutional structure, the financial resources (below integrated into the economic aspect) and the technical development of the waste sector. These elements form the analytical framework for the sustainability part of *Integrated Sustainable Waste Management*.

Integrated waste management

The United States Environmental Protection Agency defines *integrated* solid waste management as “a comprehensive waste prevention, recycling, composting, and disposal program” (United States Environmental Protection Agency, 2002: 1), thereby emphasizing the selection and combination of the most appropriate and effective waste management measures in accordance with identified local needs. Other authors apply a more holistic approach to the concept by incorporating the “objective of achieving environmental benefits, economic optimisation and societal acceptability” into the definition, which in turn links to the concept of sustainability as explained above (McDougall et al., 2001: 15). The term *integrated* within the concept of integrated waste management refers to the integration and consideration of all relevant aspects in the development of a waste management strategy or system, which includes both technical and non-technical elements, to ensure a comprehensive and inclusive approach. Van de Klundert and Anschütz (2000: 4-6) distinguish four different types of integration: integration of different aspects of sustainability, integration of habitat scales, integration of different stakeholder groups and integration with other urban systems, such as agriculture, energy or drainage. An integrated approach recognizes the interdependency of waste management systems, both as regards interconnected aspects within the internal system structure, and as regards the links between waste management and other economic sectors. In this way, integrated waste management serves as a point of reference for the development and implementation of new waste management systems, but also for enhancing existing systems (UNEP, 2005: 7-8). The benefits of an integrated approach to waste management are multiple. Firstly, it allows for most efficient coordination among all stakeholders by ensuring that capacities are optimally used. Secondly, by considering other relevant economic sectors in the process, negative spillover effects can be prevented. Thirdly, resources and technologies can be deployed in an optimized manner through the utilization of economies of scale and the integrated organization of all waste-related activities. Fourthly, a holistic approach allows for

the identification of the least expensive and most efficient solutions that complement each other in the waste management system.

According to the concept of integrated waste management, an optimal waste management system varies depending on the specific local, national or regional context. Hence, there is no one ideal system that would be applicable in any country or region. However, some key features of integrated waste management have been identified, including:

- 1) The existence of an overall waste management plan or policy that is enforced;
- 2) The utilization of a range of waste management methods;
- 3) Environmentally sound practices;
- 4) Economic cost-efficiency; and
- 5) Social acceptance and inclusion.

(McDougall et al., 2001: 15; UNEP, 2005: 7; van de Klundert and Anschütz, 2000: 4-6).

2.2 Integrated Sustainable Waste Management (ISWM)

The concept of *Integrated Sustainable Waste Management* (ISWM) was initially developed by the Dutch non-governmental organization WASTE in the 1980s. Since then, the framework has been expanded and modified by numerous academics and applied in many national contexts. ISWM is based on systems theory in order to recognize the full complexity of the waste management process. Approaching waste management from a systems analysis perspective was first suggested in 1962 by Lynn, Logan and Charnes and has formed the foundation of the ISWM framework. The core idea is to analyze the problem as an interconnected system of operations and functions. Instead of viewing the different components separately or generically, a systems approach considers the parts in their entirety and interdependency and emphasizes the importance of adapting the system to the specific context (Lynn, Logan and Charnes, 1962: 565; Clark, 1978: 14; McDougall et al., 2001: 21). While conventional waste management approaches consider waste generation, collection and disposal independently, ISWM recognizes the links and overlaps between the different processes, as well as their interdependency with other economic subsystems, such as manufacturing industries, transportation systems, urban growth and development, as well as public health. This holistic approach allows for an inclusive perspective towards waste management planning and processes and, in turn, for the development of a more sustainable system. On the other hand, it also requires a complex analytical framework to structure the different components and their interconnection (Seadon, 2010: 1640-1641).

The ISWM framework, as originally developed by WASTE, consists of three main dimensions (see Figure 2.2), which should be addressed in a holistic, inclusive manner to ensure the sustainability of the waste management system. These dimensions refer to the three questions of who should be involved (stakeholders), what should be done (elements) and how should it be done (aspects). All three dimensions are interdependent and have to be analyzed in an integrated manner (Anschütz, IJgosse and Scheinberg, 2004: 18-20; United Nations Human Settlements Programme, 2010: 27). The following sub-chapters analyze each of the three dimensions and their significance within the ISWM framework in detail.

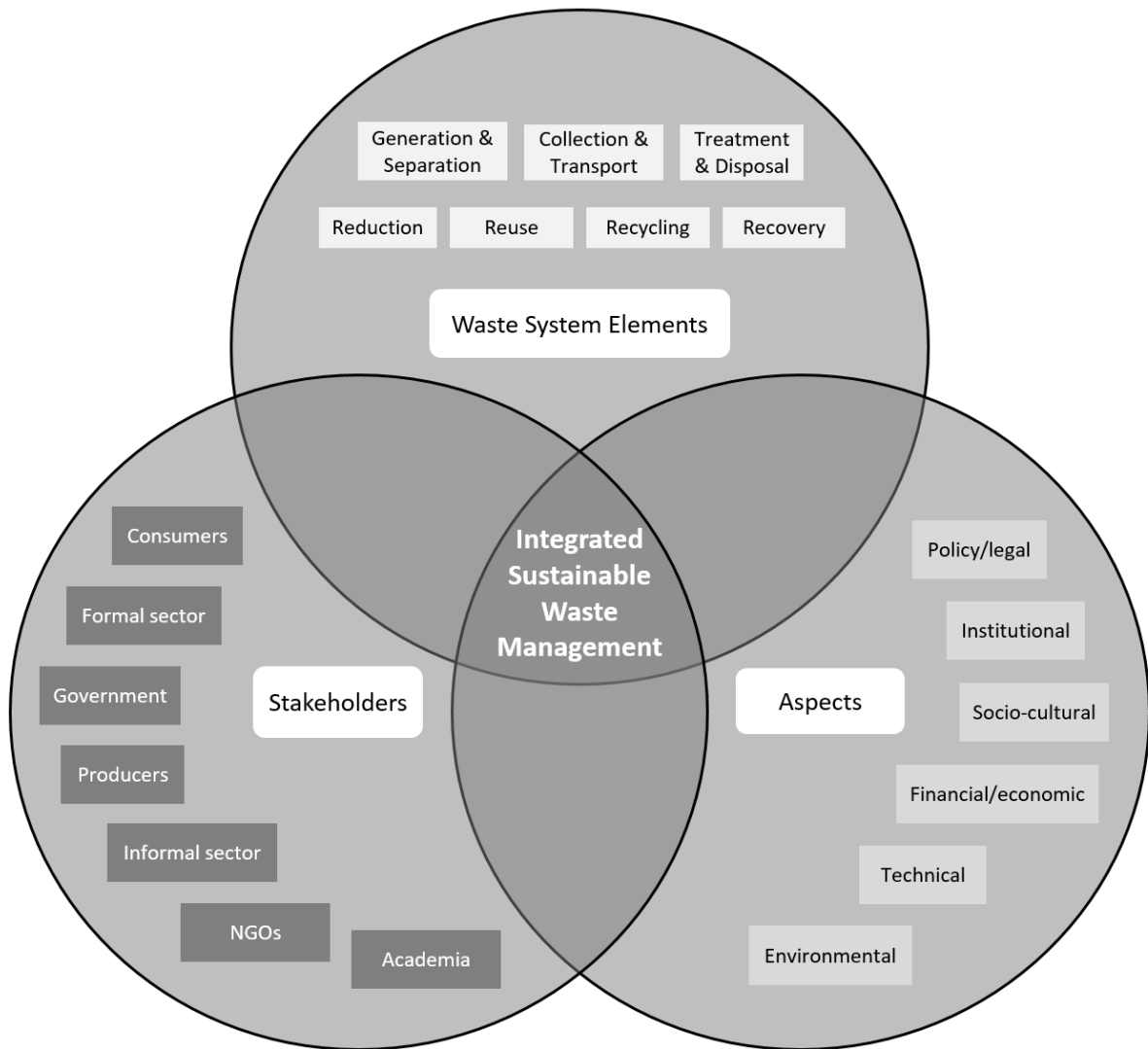


Figure 2.2: Integrated Sustainable Waste Management Model. Adapted from: United Nations Human Settlements Programme (ed.), 2010: 27; van de Klundert and Anschutz, 2001: 14; ISWA, 2011: 14.

2.2.1 Dimension 1: Stakeholders

From the production of waste to its final disposal or recycling, multiple stakeholders are involved in the process to varying extents. Primary stakeholders include local and national authorities, such as the city council, local and national waste management departments or environment ministries, as well as private sector companies involved in the collection and treatment of waste. Other stakeholders that are more immediately involved in the formal or informal waste handling process include street sweepers, workers on collection trucks, ‘waste-pickers’ and family businesses that focus on recycling. In addition, the general public itself represents a major stakeholder in the process as waste generators, including any individual, business or institution (Anschutz, IJgosse and Scheinberg, 2004: 18-19; United Nations Human Settlements Programme, 2010: 27).

The ‘landscape’ of stakeholders in waste management varies in local, national and regional contexts and therefore has to be identified for any specific analytical project. In addition, the significance of stakeholders for the overall waste management process and the ability of various stakeholders to influence the courses of action differ substantially (Van de Klundert and Anschütz, 2001: 12). In particular, the role of and interaction between stakeholders from the ‘formal’ sector, such as the official workforce involved in reuse and recycling, and from the ‘informal’ sector, that is those parts of society involved in waste handling and recycling activities that operate outside of the official structures, have to be analyzed. In particular in developing countries, the informal waste sector plays a substantial role in sustaining the lives of families that are reclaiming recyclable or reusable materials discarded by other parts of society. The informal sector can, however, pose a serious policy issue for governments, as sanitary and environmental conditions are often substandard. As a consequence, the engagement of non-official workers in the waste management sector might be restricted or even criminalized (ISWA, 2011: 22). It is estimated that in low- and middle-income countries, up to two per cent of the population earns its livings with informal activities in the waste sector (Spies, 2011: 4). Integrating the various stakeholders, including the informal sector, into the waste management planning and process is crucial to raise awareness, gain acceptance and utilize existing human resources and relationship structures in the most efficient way possible.

2.2.2 Dimension 2: Elements

The elements represent the technical constituents and measures of the waste management system. They indicate how waste is handled and where it remains at the end of the process. Over the past centuries, a vast variety of waste management measures has been developed, including disposal, reduction, re-use and recycling, which involves various stakeholders at different levels. Alongside the global move towards more comprehensive waste management systems, the scope of activities has been expanded to handle waste from ‘cradle to cradle’, that is, establishing the connection between waste management and resource management. This comparatively new approach is also known as ‘lifecycle thinking’. For example, the possibility to reuse or recycle materials is determined at the design stage of products and should be addressed at that point. This fundamental change in approaching waste management is also reflected in the emergence and adoption of the concept of extended producer responsibility (EPR), an environmental policy that extends the responsibility of the

producer to post-consumption stages of a product's life cycle as opposed to limiting it to the production process only (OECD, 2001: 9-10).

Within the ISWM system, both measures relating to the removal and safe disposal of waste, as listed in the upper row in Figure 2.2, as well as measures relating to the valorization of resources, as listed in the lower row, have to be considered (United Nations Human Settlements Programme, 2010: 27). To determine which measures should be preferred within the ISWM framework, several categorization and prioritization systems have been developed. One of the most commonly used is the 'three R's' principle, which stands for 'reduce, reuse and recycle'. Due to the simple and easy-to-understand nature of the concept, it is particularly well suited for public awareness raising purposes. Through campaigns and educational initiatives, consumers are encouraged to follow simple rules to decrease the amount of waste produced (*reduce*), use materials and goods again before discarding them (*reuse*), and integrate recycling practices into the daily life (*recycle*).⁸ The three R's are also often incorporated into the ISWM model to guide the selection of management measures (Hoornweg and Bhada-Tata, 2012: 7; Davidson, 2011: 8).

A more sophisticated model, developed by a number of national environmental ministries as operational policy guidance, is the categorization of different available measures in a waste management hierarchy. This hierarchy, as shown in Figure 2.3 aims at reversing the historical approach of focusing on waste disposal by putting prevention, minimization, recycling and recovery of materials at the center of the process. Within this hierarchy, disposal of waste is viewed as the last measure, if no other options are feasible (Anschütz, IJgosse and Scheinberg, 2004: 19; United Nations Human Settlements Programme, 2010: 27).

The primary goal is *prevention*, which aims at reducing the quantity of waste produced. Measures to prevent waste include the reduction of packaging, product redesign with longer durability and inducing a shift in social consumption patterns, usage, and waste generation (European Union, 2008: 312/10; United States Environmental Protection Agency, 2002: 2; van de Klundert and Anschütz, 2001: 15-16). Through the prevention of waste generation, further measures, such as waste handling, treatment and disposal, can be reduced, which in turn not only reduces the costs of waste handling, but also the potential negative effects on the

⁸ Examples for these guiding rules are: 'Buy products that have been made from recycled material', 'Donate old clothes and books', 'Reuse carrier bags', 'Buy only what you need', 'Buy products with little packaging', etc. Many countries have also established websites to educate the general public on the 3 R's principle and rules. See for example: <http://www.recycling-guide.org.uk> (United Kingdom), <http://www2.epa.gov/recycle> (United States), <http://www.meti.go.jp/policy/recycle/> (Japan), etc.

environment and public health of both the manufacturing process and the waste handling activities (Hoornweg and Bhada-Tata, 2012: 28).

The second most preferential option in the waste management hierarchy is *reduction*,⁹ also known as *source reduction* or *pollution prevention*. Measures within this category, such as utilizing modern manufacturing technologies, decreasing hazardous raw material inputs and enhancing product design, are intended to reduce the toxicity and other adverse effects of waste (Van de Klundert and Anschütz, 2001: 15-16; Davidson, 2011: 8).

The third level of the waste management hierarchy encompasses measures to re-use materials that have been recovered from the waste stream and recycle materials for use as inputs to new products. The difference between *re-use* and *recycling* is that the former involves using products or materials again in the current form “*for the same purpose for which they were conceived*” (European Union, 2008: 312/10), and the latter refers to recovery operations in which waste is reprocessed into new products or materials, which might serve a different purpose. Re-using and recycling measures reduce the volume of disposed waste and return valuable materials to the economy.

Other recovery activities relate to energy recovery and the reprocessing of materials, e.g. to be used as fuels. An example for such a measure is incineration of waste for energy recovery purposes, which can reduce the quantity of disposed waste by up to 90 per cent. However, this reduction rate only applies to waste streams that contain paper, cardboard and similar materials and is not applicable to e-waste. Moreover, incineration without energy recovery, in particular open-burning of waste, is less preferred due to the high costs and environmental pollution and would hence fall into the last category of disposal (European Union, 2008: 312/10; van de Klundert and Anschütz, 2001: 15-16).

The least preferred option in the waste management hierarchy, *disposal*, is used for waste that cannot be prevented or recovered. Measures include permanent storage, land treatment, deep injection, the release into a water body and the deposit into or on to land, such as landfill (European Union, 2008: 312/10). Where disposal is used, it is important that sites are engineered and operated in an environmentally sound and sanitary manner through measures such as proper siting and infrastructure, compaction of waste, liner and leachate treatment, final top cover and closure, and a post-closure plan (Hoornweg and Bhada-Tata, 2012: 29). Although not a standard element of the waste management hierarchy, as it does not

⁹ While the terms *prevention*, *minimization* and *reduction* are used interchangeably in contemporary literature, in the context of this thesis, *prevention* shall refer to decreasing the volume of waste produced, whereas *reduction* shall refer to decreasing the toxicity and other adverse effects of waste produced.

represent an actual treatment method, the export of e-waste has to be considered in the analysis, as e-waste is commonly exported from developed countries with higher standards and more sophisticated e-waste treatment practices, to developing countries that lack the sophistication and advancement in utilized technologies and methods.¹⁰ As a consequence, e-waste is most likely to be treated under less environmentally sound conditions in the import country. Moreover, the exporting country has no means of control over illegally or irregularly exported e-waste. This practice should therefore be considered as a least preferred option in the hierarchy, alongside disposal.

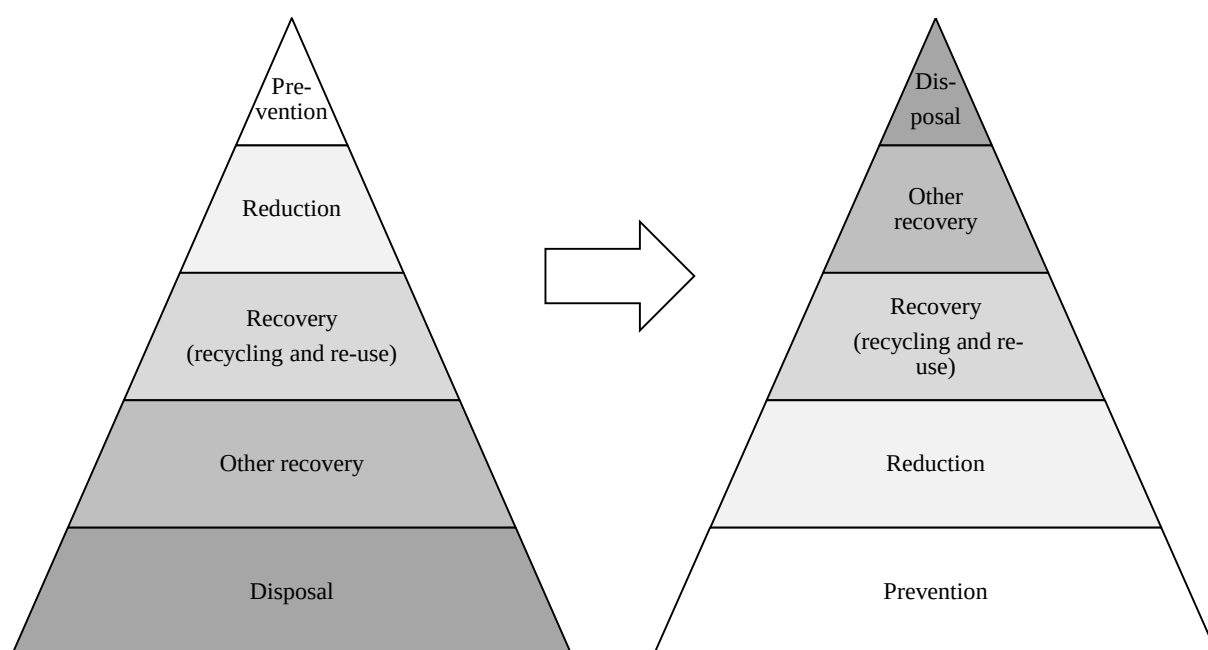


Figure 2.3: Waste management hierarchy. Adapted from: Van de Klundert and Anschütz, 2001: 15-16; European Union, 2008: 312/10; Hoornweg and Bhada-Tata, 2012: 27-29.

The waste management hierarchy is also a core element of Directive 2008/98/EC of the European Union (EU). Article 4 identifies the priority order of waste management practices, both to be applied in legislation/policy frameworks and in implementing measures (European Union, 2008: 312/10).

However, in recent years, some scientists have criticized the waste management hierarchy due to the lack of a profound scientific basis, its one-dimensional nature and because it disregards the cost factor that determines the economic affordability of the management system (Nordone et al., 2009: 93-94). The concept can be viewed as oversimplifying the waste management process by offering a ‘one size fits all’ solution, instead of assessing and selecting

¹⁰ See chapter 3.1.

a set of waste management practices in accordance with local conditions and requirements. Other authors identify the waste management hierarchy as a cornerstone of the ISWM approach, arguing that policies that follow this approach aim at maximizing options to recover waste, while minimizing waste disposal. Moreover, the hierarchy not only determines the preference of waste management components, but also requires the least favorable options, such as waste disposal, to be conducted in an environmentally sound manner in sanitary landfills (Van de Klundert and Anschütz, 2001: 9-16). Consequently, the waste management hierarchy should not be viewed as a one-dimensional technical direction, but rather as a policy guidance that favors preventative approaches over traditional waste disposal measures, while ensuring that each waste management element is deployed with consideration of all aspects (see sub-chapter 2.2.3 below) and in an integrated manner. Within the ISWM framework, the hierarchy only offers a general strategic approach, which has to be refined and adapted to the specific contextual circumstances. Hence, the resulting set and priority of measures might not necessarily represent a pyramid. For example, the EU Directive allows for deviation from the waste hierarchy if the life-cycle assessment of overall waste generation and management justifies it (European Union, 2008: 312/10).

2.2.3 Dimension 3: Aspects

The third dimension, sustainability aspects, provides different lenses that are necessary to develop a sustainable waste management system. In addition to the technical management of waste, other factors have an impact on the efficiency and sustainability of waste management activities. These include the political environment, the legislative and institutional framework, socio-cultural conditions, environmental and health aspects, as well as financial and economic factors. However, the aspects are not stand-alone criteria, but should be analyzed in context and in their interdependency. In this way, these lenses allow for a comprehensive assessment of any given waste management system (Anschütz, IJgosse and Scheinberg, 2004: 18-20; United Nations Human Settlements Programme, 2010: 27). The analysis of the stakeholder landscape, which determines the key players in the respective e-waste management systems, and waste system elements, which identifies the mainly utilized and less predominant e-waste handling practices, provides the basis for the assessment of the six distinct, yet interconnected sustainability aspects (see Figure 2.2). The following chapter looks at each of the six aspects in detail and deducts criteria and indicators for the application and comparison of these aspects with regards to China, Japan and Vietnam in the subsequent part of the thesis.

While the concept of ISWM has been developed as a universal model to analyze waste management approaches and systems of any scope and in any context, it has primarily been applied to cities rather than whole country analyses.¹¹ However, in light of the holistic and integrated approach inherent to the ISWM concept, a country-level analysis allows for a comprehensive assessment of the entire (e-)waste handling chain and could enable the identification of shortcomings throughout the system. Moreover, several indicators that have been developed for city-level analyses address nationwide factors, such as the legal framework or the existence of an ISWM plan.

¹¹ See, for instance: Mwanza and Phiri, 2013; Imam et al., 2008; and Wilson et al., 2012.

2.3 Sustainability indicators

In accordance with the ISWM model as developed in the previous chapter, the following sub-chapters identify the indicator set that is used for analysis of e-waste management approaches in China, Japan and Vietnam, in addition to the structure and composition of the stakeholder landscape and waste system elements. All three dimensions are examined for each national e-waste sector. Firstly, relevant stakeholders, as well as their status, relevance and interconnection are identified. Secondly, predominant e-waste management methods, i.e. the waste system elements and their proportion as part of the whole e-waste sector are determined. Thirdly, the six sustainability aspects of the ISWM framework are analyzed in detail through a set of indicators that is developed in the following sub-chapters, taking into consideration the distinct nature of the e-waste sector.

While the general model, as well as the broad definition of the six sustainability aspects is primarily based on the framework developed by van de Klundert and Anschütz (2001), the indicator sets have to be adapted, on the one hand to reflect the country level scope of this thesis and on the other hand to be specific to e-waste. In addition, the indicator sets also consider international actors and instruments and their application in the national contexts. Although this factor is often neglected in the application of the ISWM framework in contemporary literature, the transboundary and globalized nature of e-waste flows render the international arena an important aspect of a comprehensive analysis.

2.3.1 Policy and legal aspects

The first set of aspects, relating to the political and legal structure of the waste management system, lays out the fundamental framework and conditions in which all waste management operations are conducted. This category encompasses the objectives and priorities of the overall waste management system, the definition of roles and responsibilities, the existence of a regulatory framework or plan, as well as the structure of decision-making (Van de Klundert and Anschütz, 2001: 13).

The foundation of the policy and legal aspects of the ISWM framework is the existence of an overall national regulatory framework of (e-)waste management. In addition to a comprehensive waste management law that establishes (e-)waste management standards and practices and addresses both the public and the private sector, an ISWM plan or strategy forms the guidance document for national coordination and implementation of ISWM activities. This plan should take into consideration all aspects of the waste management system and set goals and responsibilities across different levels of government. It should further address

interdependencies with other economic systems, such as the manufacturing industry (United States Environmental Protection Agency, 2002: 2-4; Anschütz, IJgosse and Scheinberg, 2004: 18-20). While countries may choose to establish a general ISWM legal and policy framework rather than a specific framework for e-waste management, the particular challenges and characteristics of e-waste as elaborated in chapter 2.1 suggest that a separate framework or specialized component within the general framework is favorable.

Another important factor for analyzing policy and legal aspects is the integration and implementation of international rules and standards in the national ISWM framework. The main international instrument regulating waste is the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (United Nations, 1989), which entered into force in 1992. While the principle objective of the Convention was to establish a monitoring and control system for transboundary movements of hazardous waste, several guidelines for environmentally sound waste management were developed under the Convention. Although the Basel Convention is not specific to e-waste, the particular challenges relating to this waste category were recognized by the supplementary Nairobi Declaration on the Environmentally Sound Management of Electrical and Electronic Waste. The implementing work plan included specific thematic programs in Africa, Asia-Pacific and South America, a Partnership for Action on Computing Equipment (PACE), a Mobile Phone Partnership Initiative, and the preparation of technical guidelines on transboundary movements of e-waste (Secretariat of the Basel Convention, 2011; Lundgren, 2012: 33-34). Apart from the Basel Convention, a number of other global instruments, such as the Rotterdam Convention and the Stockholm Convention on Persistent Organic Pollutants address hazardous materials and might be applicable to e-waste management to some extent (Lundgren, 2012: 33-34). In addition, several regional agreements have been adopted to regulate hazardous waste in general, or e-waste in particular, in Africa (Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa, 1991; Durban Declaration on e-Waste Management in Africa, 2008), Europe (Directive 2012/19/EU on waste electrical and electronic equipment; Directive 2008/98/EC on waste) and the South Pacific (Waigani Convention) (Lundgren, 2012: 33-37). Notably, no regional instrument exists for the Asian region.

Primarily in developed countries, in particular in the framework of the European Union and the OECD, extended producer responsibility has been established as a good practice in e-waste policy making. Directive 2008/98/EC of the European Union encourages Member States in Article 8 to “*take legislative or non-legislative measures to ensure that any natural or legal*

person who professionally develops, manufactures, processes, treats, sells or imports products (producer of the product) has extended producer responsibility” (European Union, 2008: 312/12). The benefits of developing a national EPR strategy are multifold, including the reduction of landfills and their environmental impacts, the promotion of a more efficient use of natural resources, the improvement of materials management, etc. (OECD, 2001: 17). It is therefore a key factor in developing an ISWM system.

2.3.2 Institutional aspects

The institutional aspects address the political and social structures that are responsible for the management and implementation of waste management. A clear distribution of roles and responsibilities among all actors and institutions involved in the waste management process is essential for an effective ISWM system. In this context, the aspect considers the institutions that are involved in the waste management process, whether the responsibilities are concentrated in one organization or distributed among a range of different agencies, and how they interrelate. In accordance with the holistic and integrated approach of the ISWM theory, waste management should ideally be centrally coordinated to ensure the integration of all stakeholders, consideration of all aspects and selection of the most appropriate set of measures. Moreover, institutional capacities have to be sufficient to implement the activities. In particular, the private sector should be actively involved to use existing resources and capacities in the most efficient way. Apart from general participation of the private sector in e-waste management processes, public-private sector partnerships can be a useful tool in effectively managing e-waste (Van de Klundert and Anschutz, 2001: 13-21).

Considering the transnational nature of e-waste flows (see chapter 3.1), cooperation beyond the national level is crucial for effective ISWM strategies. Hence, partnerships, initiatives or other collaborative fora that address the cross-national e-waste challenge should be established at regional and global levels (Lundgren, 2012: 42). The institutional structure should also be closely linked with the policy and legal framework, both on national, regional and global levels.

2.3.3 Socio-cultural aspects

Having established the regulatory and institutional framework for e-waste management, the human component of the management process has to be considered. The socio-cultural aspects within the ISWM framework aim at influencing the culture of generating and managing waste on household, business and institutional levels, ensuring the involvement of the

community in the waste management process, gaining acceptance and establishing the necessary social conditions for workers of the (e-)waste sector (Van de Klundert and Anschütz, 2001: 14).

Based on the analysis of the stakeholder ‘landscape’ of the country, their position and integration within the e-waste management system is examined within the socio-cultural aspects. In particular, the degree of communication and cooperation between stakeholders and the government is of relevance. Measures to allow for effective collaboration mechanisms include the establishment of communication platforms for the general public, the formation of citizen committees, the organization of regular meetings or the creation of local focal points. These measures should not be limited to a sole communication function, but should enable public participation in decision-making processes. Moreover, citizens should be enabled to complain and report deficiencies in the e-waste management process, such as missed collection or illegal dumping (Van de Klundert and Anschütz, 2001: 20).

Another key element of socio-cultural ISWM aspects is public education and awareness raising. In particular, workers engaged in the informal e-waste sector often lack formal education and are not aware of health and environmental risks associated with the handling of e-waste (Lundgren, 2012: 42; United States Environmental Protection Agency, 2002: 3). Educating these workers on safe e-waste handling practices and risks accompanying their work is an important step in preventing adverse effects to the environment and public health. The scope of awareness raising should not, however, be limited to citizens directly engaged in the informal or formal e-waste management sector. Rather, it should also include general public educational and informational initiatives that raise awareness on issues such as those governmental agencies that are involved in the e-waste management process, existing e-waste collection and recycling structures, different types of e-waste, best practices regarding how to discard e-waste in an environmentally sound manner, and the environmental and health risks associated with inadequate disposal of e-waste.

2.3.4 Financial and economic aspects

An e-waste management system is not able to operate efficiently without the availability of adequate financial resources and a sound economic structure to support the system. Hence, the financial and economic aspects of the ISWM model focus on budgeting and cost accounting issues related to the waste management system, while considering local, national, regional and international economic systems. Measures to secure funds and enhance cost-efficiency of the e-waste management system include privatization of waste management processes, cost

recovery and reduction, the link between environmental and economic activities, the connection between producing industries and waste management infrastructures, and income generation (Van de Klundert and Anschütz, 2001: 14).

The primary question of this set of aspects is: How is the e-waste management system funded? Local authorities might raise funds themselves through fees or taxes, or funding might be centrally coordinated. A sustainable funding mechanism involves securing long-term funds, while considering the cost scheme. Involving other stakeholders to share costs, such as private sector engagement, can help to ensure the sustainability of the e-waste management system (Van de Klundert and Anschütz, 2001: 20). Funds might also be received from international organizations or through international partnerships. On the other hand, costs might be recovered by generating revenues through re-use and recycling activities. Utilizing the resource value of e-waste and recyclable materials can reduce the production costs of new products and save energy. The rising costs of ‘virgin’ materials and the adverse effect of their extraction on the environment suggests an increasing relative value of secondary materials (Hoornweg and Bhada-Tata, 2012: 27).

However, a large proportion of e-waste recycling is carried out through the informal sector in developing countries. To avoid competition between the formal and informal e-waste management systems and a potential resulting loss of efficiency within the e-waste processing sectors, informal processes should be integrated into the formal system, not only through regulation, but also through the establishment of incentives for informal workers, for instance by offering financial incentives to informal recyclers to deliver materials to formal collection sites instead of processing them independently in potentially unsafe conditions (Lundgren, 2012: 42).

2.3.5 Technical aspects

The fifth set of aspects addresses the technical side of the e-waste management process. They relate to the practical implementation and operation of the waste system elements, in particular considering the type of facilities and equipment used for e-waste management processes, the practical enforcement of e-waste management measures, as well as the quality of the recovered materials (Van de Klundert and Anschütz, 2001: 14; Widmer et al., 2005: 453). Indicators within this category include the collection rate, that is, how much e-waste is collected compared to the amount generated and imported, the collection coverage, representing the proportion of the population and areas of the country that have access to e-waste collection

services, as well as the sophistication of e-waste system elements and the quality of recovered material (Van de Klundert and Anschütz, 2001: 20; Widmer et al., 2005: 453).

2.3.6 Environmental aspects

The last set of sustainability aspects focusses on the environmental impact of e-waste management processes. E-waste can affect the environment in numerous ways and can lead to pollution of the land, of water and of the air, which in turn means a substantial risk to public health. Minimizing the pollution associated with the entire e-waste management chain is hence a key objective of an ISWM framework (Van de Klundert and Anschütz, 2001: 13). The primary risk of e-waste to the environment and public health stems from heavy metals, persistent organic pollutants (POPs), flame retardants and other potentially hazardous components. In addition to harmful substances that might be original constituents of EEE, such as mercury or lead, hazardous substances are also added in certain recovery processes, such as cyanide, as well as during recycling processes, such as dioxins. If these risks are not adequately addressed during the e-waste management processes, there is a threat of serious harm to the environment and human health. There are numerous examples and studies that address the impacts of improper e-waste recycling on the environment and health.¹² Adverse effects on the environment stemming from hazardous substances in e-waste include contamination of soil, crops, water and livestock, atmospheric pollution, and elevated levels of toxins in air, soil and water. Human health issues caused by unsafe e-waste handling, as a result of the environmental pollution or of occupational hazards, such as electrical shocks, include radiation, nausea, silicosis, headaches, respiratory failure, skin irritation, pneumonitis, tremors, gastritis, and even death. Many of these hazards pose long-term health risks and can hence affect communities for centuries (Mohan and Bhamawat, 2008: 821-822; Olowu, 2012: 67-69, Lundgren, 2012: 18-19; Sthiannopkao and Wong, 2013: 1150-1151).

To protect the environment and public health from these risks, environmentally sound e-waste handling, recycling and disposal practices are vital. These practices include depollution, that is, *“the removal and separation of certain materials to allow them to be handled separately to minimize impacts, including batteries, fluorescent lamps and cathode ray tubes (CRTs)”*, materials separation, and the mechanical processing of similar or mixed materials (Lundgren, 2012: 18). Analysis of environmental aspects of the ISWM model considers the safety of practices used predominantly in e-waste management, both as regards risks towards the

¹² See, for example: Robinson, 2009; Leung et al., 2008 and Wang et al., 2011.

environment and risks towards public health, the extent of e-waste disposal in unsafe landfills, the emissions of hazardous substances in regions where e-waste is handled, and the health and safety conditions of both the e-waste workers, as well as of the population living in proximity of e-waste recycling, recovery and disposal sites (Van de Klundert and Anshütz, 2001: 20; Widmer et al., 2005: 453). Although some countries might not have comprehensive national statistics and studies on the environmental and health impacts of e-waste management processes available, case studies can assist in providing an exemplary picture of the use of safe or unsafe practices in this sector. In particular, case studies identifying adverse effects of e-waste recycling sites show that sound e-waste management processes are not enforced in a comprehensive manner and broad scope, but are only deployed in a fragmented manner, if at all, which contradicts the objectives of an ISWM approach to e-waste management. Moreover, the lack of national statistics and data in itself is an indicator of insufficient monitoring and awareness of the need to gather such data.

2.3.7 Analytical matrix

Figure 2.4 summarizes the criteria and indicators as developed in the previous sub-chapters. Each of the six aspects is composed of a number of criteria, which are analyzed according to the identified set of indicators. To allow for a comprehensive assessment, indicators include both quantitative metrics, such as the coverage of e-waste collection and recycling sites or emission rates, and qualitative metrics, such as the institutional structure or the funding mechanism underlying e-waste management. While many of the indicators are binary in nature, that is, examining the existence of a certain element, such as the existence of an extended producer responsibility policy, other indicators apply a rating-scale, for example when assessing the level of skills and equipment, or calculate ratios, for example in relation to the proportion of generated e-waste that is collected. Some indicators are easy to evidence, such as the existence of e-waste specific laws or bilateral and regional partnerships, whereas others, such as the enforcement of regulations or the detailed structure and operation within the informal sectors, might show gaps in data availability. In the latter cases, case and field studies, site visits and surveys can give exemplary indication on these factors, even though results have to be treated with caution.

The matrix (Figure 2.4) forms the analytical framework that is applied to the three country cases in the following part. However, the aspects should not be considered in isolation, but as a component of the whole system. In this way, cross-cutting links and interdependencies can be incorporated in the analysis, such as national legislation having a positive impact on the

environmental aspect by putting environmentally sound e-waste management practices in place or a lack of social inclusion leading to insufficient or fragmented implementation of the national ISWM plan. Moreover, in accordance with the ideals of the ISWM framework, indicators are treated equally without any ranking, which recognizes their interdependence and the equal weight of each aspect in its function in the holistic system.

Aspects	Criteria	Indicators
Policy and legal	National legal framework on e-waste management	General and/or e-waste specific
		National/province/local level
		Comprehensive/fragmented
		Enforcement
	ISWM plan	General and/or e-waste specific
		Comprehensive/fragmented
		Clear objectives and priorities
		Clear roles and responsibilities
	Adoption and implementation of international instruments	Ratified and implemented Basel Convention
		Participating in Basel Convention e-waste programs
Institutional	Extended producer responsibility	Established/Established and enforced
	Waste management structure	Involved institutions
		Centralized/decentralized
		Clear division of responsibilities
	Institutional capacity	Sufficient/insufficient
Socio-cultural	Private sector involvement	Private sector participation in e-waste management and public-private partnerships
	International partnerships	Regional/bilateral partnerships
		Participation in global initiatives
	Citizen participation and integration	Level of public involvement
		Existence of communication mechanisms
		Existence of reporting mechanisms
Financial and economic	Public education and awareness raising	Existence and scope of awareness raising and educational campaigns
	Funding	Centralized/decentralized
		Government/private sector/international organizations
Technical	Cost recovery	Recovery mechanisms and measures
	Informal sector	Economic incentives for informal sector workers
	Collection rate and coverage	% of generated e-waste that is collected
		Location and coverage of e-waste handling facilities
	Technology and infrastructure	Sophistication of collection and treatment methods
Environmental	E-waste workers	Quality of recovered material
		Level of skills and equipment
	Safety of e-waste management processes	Safety of recycling practices
		Use of unsafe landfills for e-waste disposal
	Emissions of hazardous substances	Emission rates
		Environmental pollution
	Health conditions of the population	Health conditions of e-waste workers
		Health conditions of population living in proximity

Figure 2.4: Analytical framework - Sustainability aspects in the e-waste sector.

The criteria and indicators are derived from the six sustainability aspect of the ISWM framework and give strong indication of the extent to which a country complies with the model. However, some more detailed indicators had to be omitted in this national analysis, as they would only apply to a lower-level, such as city-level, study. Such indicators include the user satisfaction with the e-waste collection and treatment service by area of the city, or the number and duration of sick leaves and health complaints, which would demonstrate the working conditions (Van de Klundert and Anschütz, 1999: 10).

On the other hand, some indicators that would apply to the national-level adherence to ISWM are not included due to the lack of evidence in these areas. For example, although the average level of awareness among population (Van de Klundert and Anschütz, 2001: 27) would be a useful indicator of the socio-cultural aspects of ISWM, this factor would require a representative nationwide survey in the analyzed countries, which is outside of the scope of this thesis.

3. Application

3.1 The state and flows of e-waste

3.1.1 The global challenge

With a growth rate of four to five percent annually, e-waste is one of the fastest growing forms of waste. In 2014, 41.8 million tons of e-waste were generated globally, representing a substantial increase from 33.8 million tons in 2010 (Baldé et al., 2015a: 24). This constant growth is closely linked to the increasing demand of electronic products, which is fostered by the continuous development of new products and falling prices, alongside rapid obsolescence of electronics and decreasing product lifetimes. In the United States, the number of computers rose from one computer per 1,000 citizens in 1975 to more than 800 computers per 1,000 citizens in 2010 (Olowu, 2012: 62-63; Frey, 2012: 81). The role of EEE in society is becoming indispensable in all sectors, from communication, security and culture to medicine, education and food-supply. In particular, developing countries have seen a rise, not only in the production of EEE, but also in domestic demand. Recent news reports suggest that mobile phone connectivity is even considered to be more important to the poor in Africa than secured food supplies (Mungai, 2015).

While reliable data on e-waste are still insufficient, there have been numerous estimations, including of the amount of e-waste trafficked across the globe. For instance, it is estimated that more than 80 per cent of e-waste generated in the United States is exported to developing countries in South and East Asia and West Africa, with China alone receiving up to 90 per cent of the exported e-waste. Various studies suggest that e-waste flows, both legally and illegally, from developed countries to developing countries, as shown in Figure 3.1, for low-cost recycling, incineration or disposal. According to a Greenpeace report, despite the existence of comprehensive regional legislation, about 75 per cent of e-waste produced in the European Union constitutes ‘hidden flow’, i.e. amounts of e-waste calculated based on domestic EEE product sales that do not enter the formal collection and recycling system, as only one fourth of e-waste generation estimates are accounted for in national collection, reuse and recycling systems (Cobbing, 2008: 5).

Not only is e-waste exported to Asia and Africa through these ‘hidden flows’, but a proportion of the collected accounted for e-waste also flows out of the European Union through unregulated channels. Insufficient national statistics, disparities in definitions and distinguishing what constitutes e-waste and what is reusable EEE, as well as the lack of a common inventory system are enablers of the irregular transboundary e-waste flow (Cobbing,

2008: 5; Frey, 2012: 81; Nnorom and Osibanjo, 2008: 854-855; Dayaneni and Doucette, 2005: 10-11; Lundgren, 2012: 14).

The recipients of the illegal or unregulated flows, mainly developing countries, often neither have comprehensive regulatory frameworks, nor a functioning e-waste management sector with monitoring schemes in place. Recovery and treatment practices are largely rudimentary with little to no consideration of the potential adverse environmental and health impacts of these methods (Lundgren, 2012: 14-22; Ongondo, Williams and Cherrett, 2011: 719-727).

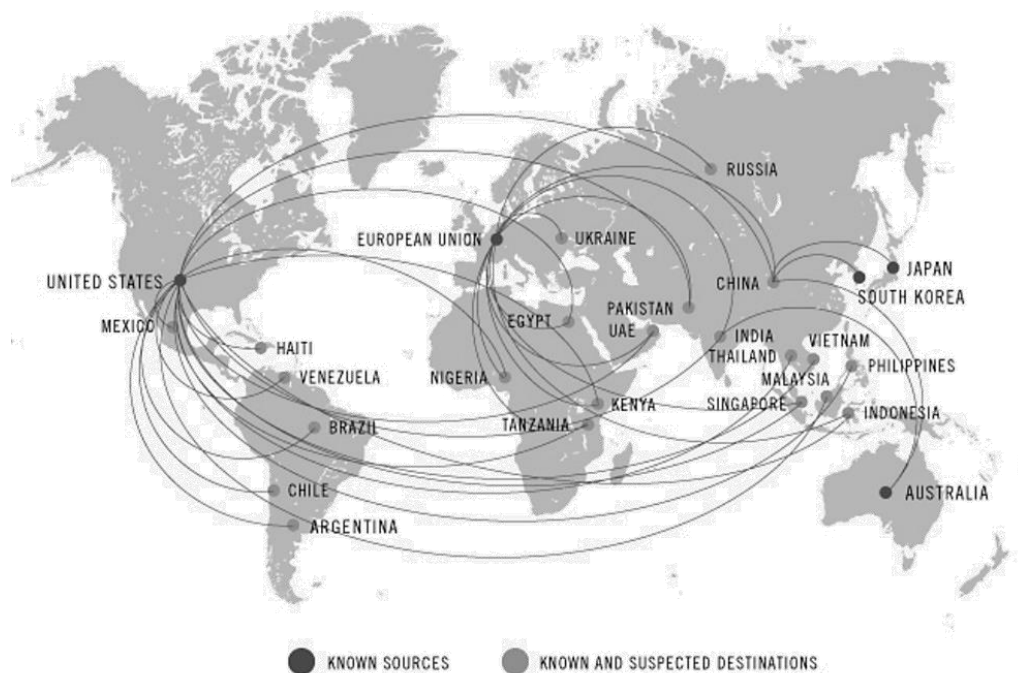
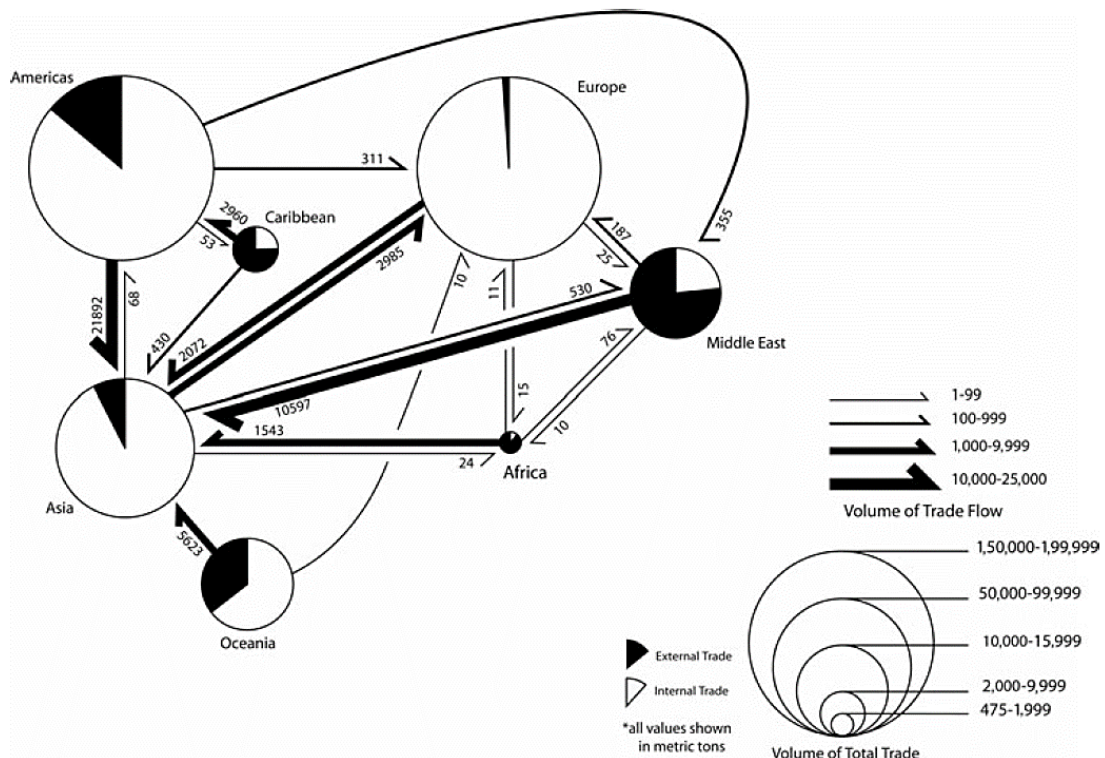


Figure 3.1: Global e-waste flows. Source: GOOD and Column Five Media, 2010, as adapted from Dayaneni and Doucette, 2005 and Lewis, 2010.

However, e-waste does not appear to only flow in a linear way from developed to developing countries, but shows a more complex structure that also comprises intraregional flows, trade between developing countries, and internal trade. Moreover, the flow of e-waste is further complicated by the non-linear network of production, consumption and disposal, which allows for the creation of value after e-waste has already been disposed of. Adverse effects of e-waste on the environment and health are neither limited to closed locations, but can affect other regions. As a result, global e-waste flow should rather be conceptualized “as open-ended and contingent processes facilitated by situated practices of wasting and valuing that rely on geographic difference and mobility for the exchanges between the domains of waste and value to occur” (Lepawsky and McNabb, 2010: 189-191). These more sophisticated global flow

patterns of e-waste are shown in Figure 3.2. The figure illustrates the significance of inter-regional trade and how countries and regions can represent export and import countries at the same time. It also shows that, although Africa is identified as a main destination of e-waste flows in literature, the region's trade volume in absolute terms is the lowest in global comparison. On the other hand, it is noteworthy that the more complex representation of the e-waste trade still shows Asia as the most prominent destination of e-waste from all other regions of the world (Ray, 2008: 5-18; Lundgren, 2012: 14; Lepawsky and McNabb, 2010: 191).



EEE/WEEE generation	Unit	China	Japan	Vietnam	Global Average
EEE put on market	Total in metric kilotons (2012)	12,405	2,310	180	56.5
	Kg per inhabitant (2012)	9.2	18.1	2.0	8.2
E-waste generated	Total in metric kilotons (2014)	6,033	2,200	116	41.8
	Kg per inhabitant (2014)	4.4	17.3	1.3	5.9
Estimated nationally generated e-waste	Unit	China	Japan	Vietnam	India
TVs	Million units (2011)	40	17.0	0.9	10.8
Refrigerators	Million units (2011)	9.8	5.6	0.5	3.1
Washing machines	Million units (2011)	12.7	6.4	0.6	1.3
Air conditioners	Million units (2011)	19.6	4.6	0.1	n/a
Personal computers	Million units (2011)	66.7	n/a	0.3	8.5
Total of 5 main household appliances	Million units (2011)	148.8	33.6*	2.4	23.7**

Figure 3.3: General e-waste indicators for China, Japan and Vietnam. Global average and Indian statistics are included for comparison. Sources: Author's calculations based on Wang et al., 2013: 12-13; Nguyen et al., 2009: 361; URENCO, 2007: 149-154; 環境省[MOE] and 経済産業省[METI], 2012; Hotta, Santo and Tasaki, 2014: 13-21; Dwivedy and Mittal, 2010: 489.

* Excluding personal computers.

** Excluding air conditioners.

3.1.2 State of e-waste in China

As mentioned above, China is one of the main recipients of e-waste, not only from the United States and the European Union, but also from other developed countries within the region, such as Japan and South Korea, despite an import ban that was established in 2000. In 2010, approximately 70 per cent of e-waste processed in China had been imported from other countries. According to estimations, between 1.5 and 3.3 million tons of e-waste arrive in China through illegal channels each year. At least four different entrance routes have been identified. Although decreasing due to enhanced customs controls and monitoring, a proportion of e-waste enters mainland China directly through ports. One method to disguise e-waste or its origin is to incorporate it in shipments of other types of waste, such as mixed-metal scrap or cables for recycling, both of which are legal to import into China. Another route is e-waste entering China via Hong Kong. Although e-waste shipments into Hong Kong are also illegal under the Basel Convention, differences in legislation and what is considered to be e-waste and reusable EEE allow e-waste to legally enter Hong Kong, from where it is transported into other regions of China. Finally, e-waste and second-hand EEE enter China via Vietnam. This route is further elaborated in sub-chapter 3.1.5 below (Wei and Liu, 2012: 507, Wang et al., 2013: 14-15).

E-waste not only flows into China from abroad, but national generation is also continuously increasing alongside accelerated growth of the electronics industry, which ranked

at fourth place globally in 2010. E-waste is one of the fastest growing types of waste in China, constituting eight per cent of the entire municipal waste and increasing at a rate of 13 to 15 per cent per year (Wei and Liu, 2012: 507; Zhou and Xu, 2012: 4713). It is estimated that the current e-waste flows in China from various forms of electronic equipment, such as televisions, mobile phones and personal computers, will be multiplied by a factor between 1.5 and 7 by 2020 (Schluep et al., 2009: 49-51). In particular, the volume of discarded large electrical household appliances (televisions, refrigerators, washing machines, air-conditioners and personal computers), has been rapidly increasing over the past 10 to 15 years. Between 2001 and 2012, the annual growth rate amounted to approximately 19.9 per cent. Among the five appliances, the volume of discarded personal computers is increasing at the highest rate at 76.3 per cent annually and also showed the largest absolute number of discarded appliances in 2011 (Veenstra et al., 2010: 450; Wang et al., 2013: 12). The number of discarded units of these five major household appliances in 2011 are presented in Figure 3.3. Considering the increasing number of household stocks of home appliances and electronics,¹³ which will eventually reach their end of life, and, in particular, the growing number of EEE in rural households (Wang et al., 2013: 11), the volume of WEEE is only going to increase, thus requiring a long-term and sustainable solution.

Consequently, China is facing a twofold burden with increasing amounts of e-waste generated domestically and a continuous flow of e-waste imported from other countries.

3.1.3 State of e-waste in Japan

Japan represents one of the early adopters of targeted e-waste legislative and regulatory frameworks. The Ministry of Economy, Trade and Industry (METI) and the Ministry of the Environment (MOE) publish annual reports on the enforcement status of the *Home Appliances Recycling Law*, which include statistics on collection and recycling rates for major home appliances. According to estimates, 50-60 per cent of generated e-waste stemming from these appliances is collected and processed in the recycling system of the country. As shown in Figure 3.3, the quantity of generated e-waste in 2011 for each of the major household appliances is approximately half as much as generated in China, but several times higher than in Vietnam and in India.

Although the total amount of e-waste generated in Japan in 2012 was three times less than the amount that was generated in China, the amount of e-waste per inhabitant was four

¹³ For instance, in 2011, Chinese households possessed approx. 797 million mobile phones, 520 million colour televisions and 227 million computers (Wang et al., 2013: 12).

times as much. Compared to the global average, Japan shows significantly higher rates, both in absolute and relative terms (see Figure 3.3).

While only a small proportion of e-waste regulated under the *Home Appliances Recycling Law* is illegally dumped within the country, irregular exports account for approximately 30 per cent of the generated e-waste (Hotta, Santo and Tasaki, 2014: 21-25). Common destinations for e-waste shipped from Japan include China, India, Pakistan, Vietnam, the Philippines, South Korea and Thailand. Although e-waste is distributed from Japan to a wide geographical area, including countries such as Russia and Saudi Arabia, the majority of import countries are located in East Asia (Fuse et al., 2011: 794; Yoshida, Tasaki and Terazono, 2009: 1602). Among the different types of WEEE, air conditioners, vacuum cleaners and televisions show the highest export rates. Concerns have been raised, not only regarding the treatment and management of e-waste in the import countries, potentially harming the environment and public health, but also regarding the loss of valuable materials, such as gold, silver or indium, which could have been extracted from WEEE (Fuse et al., 2011: 794-796; Premalatha et al., 2014: 1627).

3.1.4 State of e-waste in Vietnam

Among the three analyzed countries, Vietnam shows the lowest rates of national e-waste generated annually, both in absolute and relative terms and per major household appliance. When compared to the global average, the amount of e-waste generated per capita is significantly lower than the average, but the absolute amount of e-waste is almost three times more (see Figure 3.3). These numbers show a clear correlation with the amount of EEE put on the market annually. Televisions, having become the most widespread and affordable home appliance in Vietnam, also show the highest disposal ratio. According to a study by Nguyen et al. (2009), the amount of annually generated e-waste might rise to 17.2 million discarded units, or 567 metric kilotons in 2025. Another study estimated the increase of discarded household appliances, such as televisions, computers, mobile phones and refrigerators. The results of the study indicated an increase between 600 and 1650 per cent for these appliances between 2006 and 2020 (Nguyen et al., 2009: 365; Herat, 2012: 1124-1125; URENCO, 2007: 149-154). Although the amounts of generated e-waste are still significantly less than produced by Japan or China on an annual basis, the estimations identify a substantial increase of generated e-waste in the country, which makes a sustainable solution for the management of WEEE crucial.

Despite the fact that Vietnam has not only prohibited the import of e-waste, but also the import of electronic second-hand products, which even goes further than the obligations

imposed by the Basel Convention and its Amendments, used electronic goods and e-waste continue to enter the country, eventually posing a threat to the environment and public health as a result of rudimentary and unsafe handling practices (see sub-chapters 3.4.5 and 3.4.6 below). As explained in the following sub-chapter, the flow of second-hand EEE and WEEE into and through Vietnam follows complex patterns rather than linear structures, leading to a diffusion of the trail of e-waste through Southeast and East Asia and impeding the identification and interception of illicit trafficking chains.

3.1.5 E-waste flows between China, Japan and Vietnam

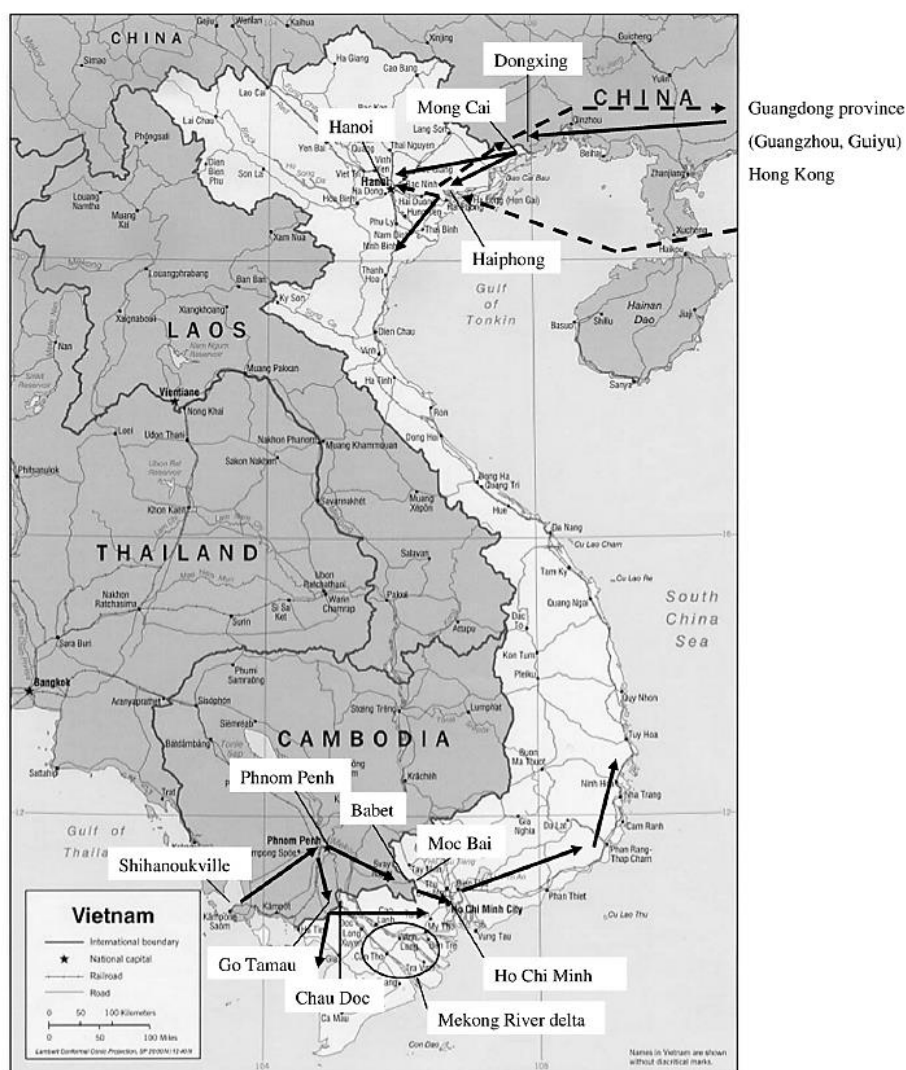


Figure 3.4: Illicit flow of second-hand EEE through Vietnam. Source: Shinkuma and Huong, 2009: 28.

Apart from their distinct characteristics and challenges, the e-waste sectors of China, Japan and Vietnam are also closely connected to each other and linked to regional dynamics. Figure 3.4 shows the main routes that have been identified concerning the illicit flow of e-waste

through Vietnam. The first route begins with e-waste or second-hand EEE exported from Japan and the United States, which enters China via Hong Kong and is then transported to Guangzhou, where it is processed and rebuilt. The products are then illegally smuggled into Vietnam through the Dongxing border. A second, more circular, transportation route has been identified at the Northern borders of Vietnam. In particular, television sets enter Vietnam via Haiphong port from Japan and the United States. The used EEE or WEEE is then re-exported to China through the border between Mong Cai and Dongxing. Similarly to the first route, the items are further transported to Guangzhou for rebuilding or refurbishment, before they are exported back to Vietnam through illegal channels. A loophole in Chinese and Vietnamese legislation, which allows for the import of secondhand electronics for the purpose of re-export, as well as a lack of common definitions of what constitutes e-waste and second-hand EEE, are enablers of this flow of e-waste between China and Vietnam (Shinkuma and Huong, 2009: 27-28; Premalatha et al., 2014: 1639).

However, the flow of materials varies depending on the type of EEE. For instance, while television sets are exported to China from Vietnam and then re-exported back to Vietnam, some other electronics, such as second-hand computers and monitors follow a reverse route by entering Vietnam through China and then being re-exported to China (Shinkuma and Huong, 2009: 27-28). As shown in Figure 3.4, e-waste also enters Vietnam through Southern borders with Cambodia. The central position in East Asia and proximity to Hong Kong and major Chinese cities which generate increasing amounts of e-waste, are among the enablers of e-waste flows into and through Vietnam.



Figure 3.5: Illegal flows of e-waste in East Asia and the Pacific. Source: UNODC, 2013: 111.

A UNODC report analyzing transnational organized crime in East Asia and the Pacific identified similar routes of illegal e-waste flows in East Asia and patterns of import, export and re-export between China and Vietnam (see Figure 3.5). In addition, major illegal export routes from Japan show e-waste flowing primarily into China and Vietnam, whereas secondary routes include the Philippines and Cambodia as import countries. Apart from the United States and Europe as primary routes, Australia is among the countries that export e-waste illegally to China.

Overall, the strong connection between China, Japan and Vietnam with regard to e-waste flows in the region suggests that cooperation among the three countries when developing effective e-waste management systems and mechanisms crucial, alongside cooperation with other export and import countries from within and outside of the region.

3.2 Stakeholders

As laid out in sub-chapter 2.2.1, this chapter analyzes the stakeholder landscape of China, Japan and Vietnam. In addition to identifying the key actors that are involved in the e-waste management process, the interaction and interrelation between these actors is examined. In this context, a particular emphasis lies on informal and formal sectors, as well as their relationship, and the involvement of all stakeholders, including the role of consumers and waste generators in the waste management processes. Based on the national structure, primary stakeholders that are directly and actively involved in the e-waste management processes, and secondary stakeholders that have a supportive or passive role in the processes, are distinguished.

3.2.1 China

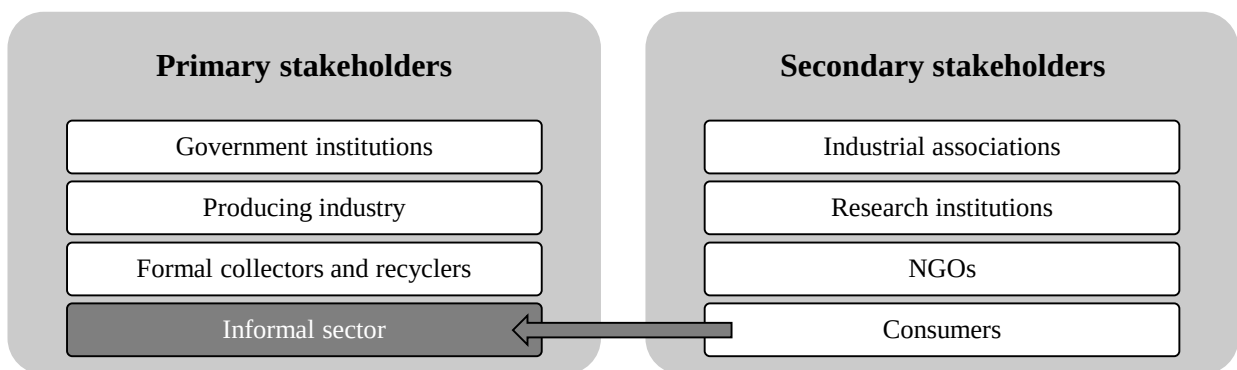


Figure 3.6: Chinese stakeholder landscape.

The range of stakeholders involved in Chinese e-waste management processes is diverse, ranging from governmental, non-governmental and business entities to informal recyclers and the consumers themselves. At the governmental level, no single institution coordinates e-waste management, but functions and responsibilities are dispersed amongst a number of government bodies, such as the National Development and Reform Commission (NDRC), Ministry of Environmental Protection (MEP) and the Ministry of Industry and Information Technology (MIIT). Sub-chapter 3.4.2 analyzes the roles and responsibilities of these institutions in detail. However, due to a lack of a single leading agency that coordinates and supervises e-waste management processes, responsibilities are not always clearly determined and overlap between multiple bodies (Wang et al., 2013: 40-41).

As regards the producing industry, the government regulates companies through national e-waste legislation, which establishes a recycling fee. The financial resources generated through this fee are used by the government to manage a take-back system. In addition, several companies have started to establish their own take-back systems, which enable

customers to return their discarded electronic goods for recycling without further costs. However, due to higher financial returns offered by informal e-waste collection systems, only few consumers utilize the available formal services (Wang et al., 2013: 41-42). Despite the government's progress in regulating the producing industry, formalizing the e-waste collection and treatment system remains a major challenge.

The vast majority of the Chinese e-waste processing and recycling system is informal in nature. Among the 700,000 people engaged in the e-waste industry in 2007, 98 per cent were part of the informal recycling sector, even though the formal sector has been growing in treatment capacity since 2010. Guiyu, with a population of 150,000 citizens, of which two thirds are engaged in e-waste recycling processes, represents the largest e-waste recycling site in China and the world. However, instead of a centrally coordinated structure, e-waste recycling in Guiyu is mainly organized in thousands of individual workshops. It is estimated that over 20 million tons of e-waste are treated annually in Guiyu. The majority of the workforce responsible for dismantling and processing the e-waste consists of unskilled rural migrants from adjacent regions, such as Hunan and Anhui, including a large proportion of women and children (Wei and Liu, 2012: 507; Baldé et al., 2015a: 42; Chi et al., 2011: 735). Other major centers for informal e-waste processing include Guangzhou, Dongguan, Foshan, Shunde, Zhongshan, Dali, Longtang and Shenzhen – all located in southern Guangdong Province. Due to the close proximity to Hong Kong, which is one of the main entry points for e-waste into China, these centers serve as initial recipients and processors of e-waste. From Guangdong, the e-waste is then further distributed across Chinese mainland, to locations such as Hunan, Jiangxi, Fujian, Zhejiang, Shanghai, Shandong and Tianjin. In addition to Guiyu, Taizhou is one of the most prominent e-waste recycling centers, with a history in the industry of more than 25 years (Ni and Zeng, 2009: 3992; Lundgren, 2012: 15; Chi et al., 2011: 735; Puckett et al., 2002: 16-18). Figure 3.7 illustrates the overall structure of the e-waste management processes in China. While there are interconnections between the formal and informal sectors in secondary management processes, the initial collection of e-waste is largely separated. E-waste from households is primarily collected by the informal sector, which offers door-to-door collection services and can simultaneously collect other types of household wastes, such as papers or plastics – services that are outside of the capacities of the current formal structures. However, e-waste generated by businesses and public bodies are largely collected and processed in the formal system (Chi et al., 2011: 736-737).

In addition to the governmental institutions, industry and informal e-waste collection and processing structures, a number of secondary stakeholders are less directly involved in the

e-waste management processes, but contribute significantly to the overall effectiveness and efficiency of e-waste management.

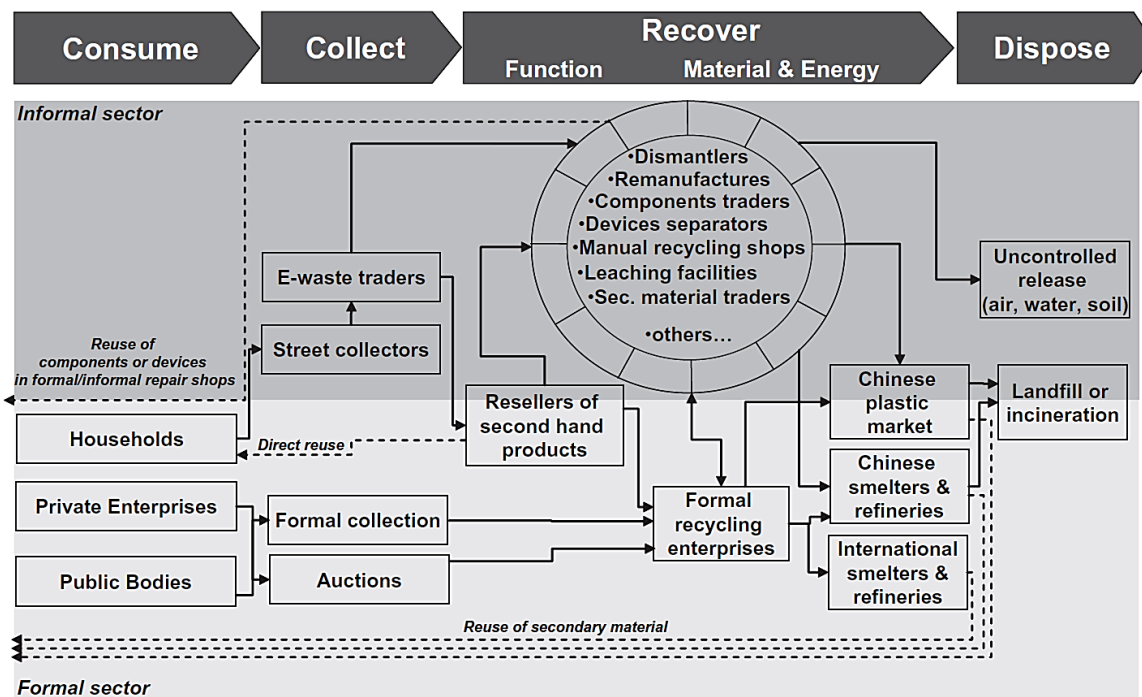


Figure 3.7: Formal and informal e-waste management processes in China. Source: Chi et al., 2011: 737.

Several industry associations play a coordinating role in connecting the government, industries and the general public. Functions of these associations include supporting industry compliance with governmental regulations, the promotion of sustainable e-waste management practices in industries, and the provision of advice to both government and businesses. Among the main actors are the China Household Electrical Appliances Association, the Executive Committee of Foreign Investment Companies, the China Resources Recycling Association and the China Electronics Energy Saving Technology Association (Wang et al., 2013: 42-43).

Furthermore, research institutions play an increasing role in e-waste management, in particular by influencing policy and decision making processes, as well as by supporting legislative drafting. Some of the most influential research institutions in the area of e-waste include Tsinghua University, the Basel Convention Regional Centre for Asia and the Pacific (BCRC China), the Chinese Academy of Science, the China National Electric Apparatus Research Institute, China Household Electric Appliance Research Institute and the E-waste Recycling Technology and Equipment Institute. Moreover, a number of international research institutions, such as the StEP initiative, have started to focus e-waste research on China. The

Japanese National Institute of Environmental Studies and Kansai University, in particular, has analyzed e-waste flows from Japan to China (Wang et al., 2013: 44-45).

Although environmental non-governmental organizations (NGOs) have expanded their activities and influence in China progressively, action in the area of e-waste is still very limited and is mainly being initiated by international actors, such as Greenpeace and the Basel Action Network,¹⁴ rather than domestic NGOs (Wang et al., 2013: 46).

Finally, consumers, as the primary e-waste generators, have a central role in any e-waste management system. However, the Chinese system does not provide for the liability or any concrete responsibility of consumers. Studies have shown that Chinese customers tend to follow economic considerations when choosing how to dispose of used electronics. Hence, (informal) collectors who offer the highest price for WEEE are often preferred, even though the technical and environmental performance of other, formal, schemes might be more advanced (Wang et al., 2013: 43). As a consequence, the formalization of the informal e-waste sector requires the government to establish competitive models that are able to provide consumers with higher benefits in comparison to the informal sector.

While some structures have been put in place to connect different stakeholders in the e-waste management system with each other, such as the industrial associations that bridge the private sector and governmental interests, or government regulation of the producing industry, a distinct separation of formal and informal sectors and a preference of consumers towards informal e-waste collection systems are inhibitors of an effective integrated sustainable e-waste management system in China. The specific impacts of the dispersed stakeholder structure on advancement in ISWM in the e-waste sector are analyzed in chapter 3.4.

3.2.2 Japan

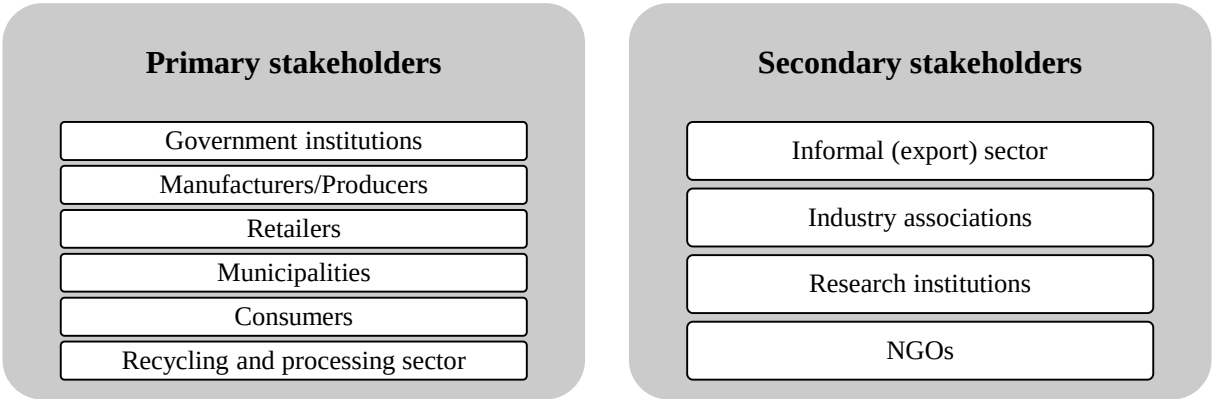


Figure 3.8: Japanese stakeholder landscape.

¹⁴ See, for instance, Brigden et al., 2005; Walters and Santillo, 2008 and Puckett et al., 2002.

While the Japanese and Chinese government have a similar role in the e-waste management system by putting in place legal and institutional frameworks that guide e-waste collection and processing, the Japanese system places a much higher emphasis on producers, retailers and consumers. In particular, as regards large household appliances, the 特定家庭用機器再商品化法 *Home Appliance Recycling Law* of 1998 lays out the specific roles and responsibilities of each of the three primary stakeholder groups.

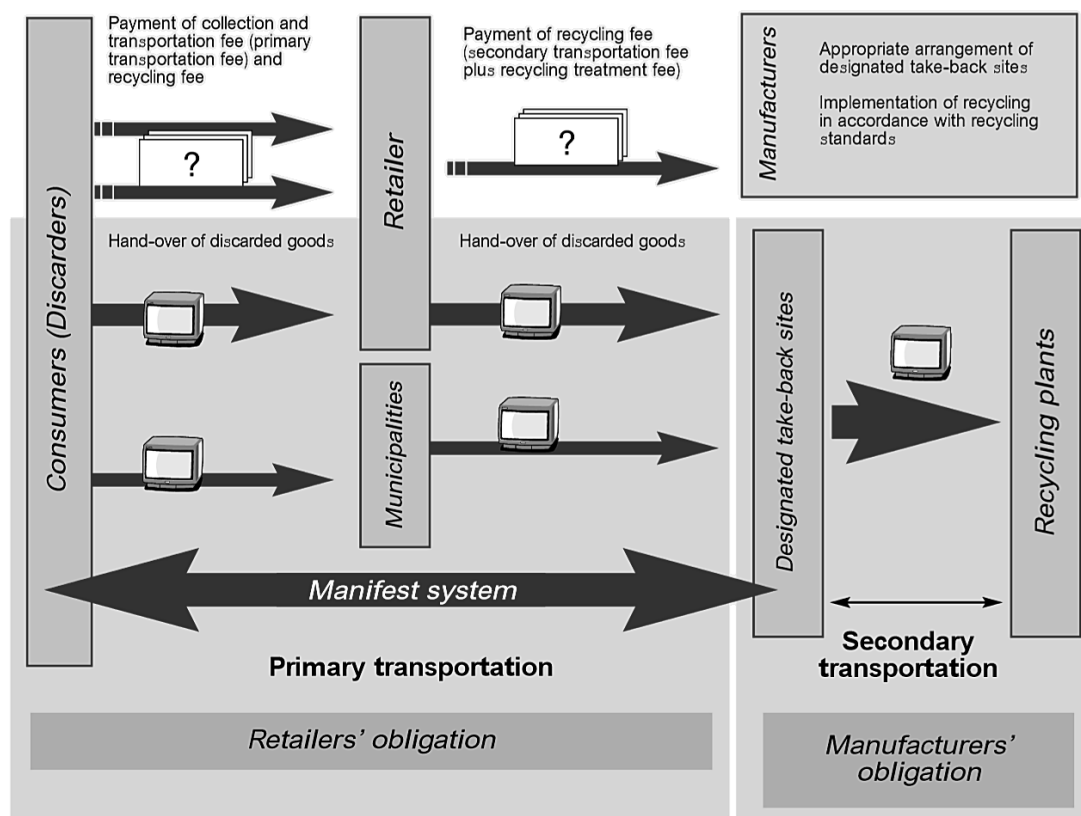


Figure 3.9: Flow of e-waste collection and transportation in accordance with the Home Appliance Recycling Law. Source: DTI Global Watch Mission, 2005: 31.

The flow of e-waste under the *Home Appliance Recycling Law* is illustrated in Figure 3.9. Consumers as the main disposers of appliances are responsible for bearing the costs for collection and recycling in the form of fees. They are also required to properly return the items to retailers. The role of the retailers is thus to collect the appliances that they have sold or other old appliances that consumers buy a replacement for, and to transfer the end-of-life product to the original manufacturer or producer. Although retailers are the primary actors in the collection of end-of-life home appliances, municipalities also collect and transfer e-waste. Finally, producers and importers are responsible for taking back the appliances that they have manufactured or imported and for recycling them. For those home appliances whose

manufacturers are unknown or where specific exceptions apply, a designated entity, the Association for Electric Home Appliances, arranges the recycling of WEEE. While the main responsibility for ensuring the proper collection and recycling of end-of-life home appliances lies with these stakeholders, the government's role is to support these activities by promoting research and development, providing technical assistance, developing appropriate facilities, offering environmental education, disseminating information and raising awareness among the general public (Hotta, Santo and Tasaki, 2014: 3-4; Sawhney et al., 2008: 31-32).

Although the *Home Appliance Recycling Law* only covers four designated home appliances, air conditioners, televisions, refrigerators, and washing machines, a number of other laws address additional EEE, such as the 資源有効利用促進法 *Law for the Promotion of Effective Utilization of Resources* of 2000, which particularly aims at promoting the '3Rs policy' (Reduce, Reuse, and Recycle) across all industries and addresses inter alia the recycling of personal computers.

A common denominator of the different legal frameworks is the principle of extended producer responsibility (EPR), which applies a circular approach to resource management by placing the main responsibility for handling end-of-life products with the manufacturers of these products. The Japanese system distributes clear roles and responsibilities for all actors involved in the e-waste management process, which allows for an integrated management system. The government itself serves as a facilitator and coordinator rather than the main responsible stakeholder for handling e-waste.

However, despite the establishment of a well-functioning system based on the EPR policy that is often used as a 'best practice' example for other countries,¹⁵ there is also a considerable proportion of e-waste flow outside of the formal system. While estimations for illegally dumped e-waste are less than one per cent, localized second-hand traders who collect discarded electronic appliances directly from consumers' homes and export them through unregulated or illegal channels to other countries account for approximately 33 per cent of e-waste in Japan. This informal sector operates outside of the formal structures and on an ad-hoc basis (Hotta, Santo and Tasaki, 2014: 17-18).

In addition to the primary stakeholders that are directly incorporated into the Japanese e-waste management system, several additional actors play a role in coordinating and advising relevant entities and supporting the development of sustainable e-waste management practices. Similarly to China, several industry associations, such as the Japan Electronics and Information

¹⁵ See, for instance, Sawhney et al., 2008 and The Economist Intelligence Unit, 2014.

Technology Industries Association (JEITA) and the Japan Electrical Manufacturers Association (JEMA) perform an overarching role across various industry groups to, inter alia, promote environmentally sound e-waste management practices, gather and disseminate statistics and best practices and support networks across industries, encourage international cooperation and conduct outreach activities (JEITA, 2011; JEMA, 2015).

Apart from industry associations, a growing number of research institutions are focusing their attention on e-waste related issues. The National Institute for Environmental Studies with its Research Center for Material Cycles and Waste Management, the Institute for Global Environmental Strategies and the Japan Environmental Sanitation Center are among the most prominent institutions that conduct research on e-waste (Terazono et al., 2006: 1-4). In addition, partnerships have been established with international organizations, such as the International Environmental Technology Centre that is part of the United Nations Environment Programme (UNEP) and the eco-town project in the industrial city Kitakyushu that has been initiated in cooperation with the United Nations Industrial Development Organization (UNIDO) (UNEP, 2015; UNIS, 2013).

Lastly, there are a number of domestic environmental NGOs that are particularly concerned about the impact of e-waste on the environment and public health. For instance, the NGO 化学物質問題市民研究会の概要 [Citizens Against Chemicals Pollution], established in 1997, has criticized the export of hazardous (e-)waste, worked to raise awareness on health risks posed by hazardous substances in e-waste, organized international civil society seminars and symposiums on e-waste, and engaged with international partners regarding these issues (CACP, 2010: 1-3). Other NGOs addressing e-waste matters, in Japan and East Asia, include 東アジア環境情報発信所 [East Asia Environmental Information Express Messenger], the Study Group for a Sustainable Society, and 国際環境 NGO [Friends of the Earth Japan] (Yoshimatsu, 2010: 13).

3.2.3 Vietnam

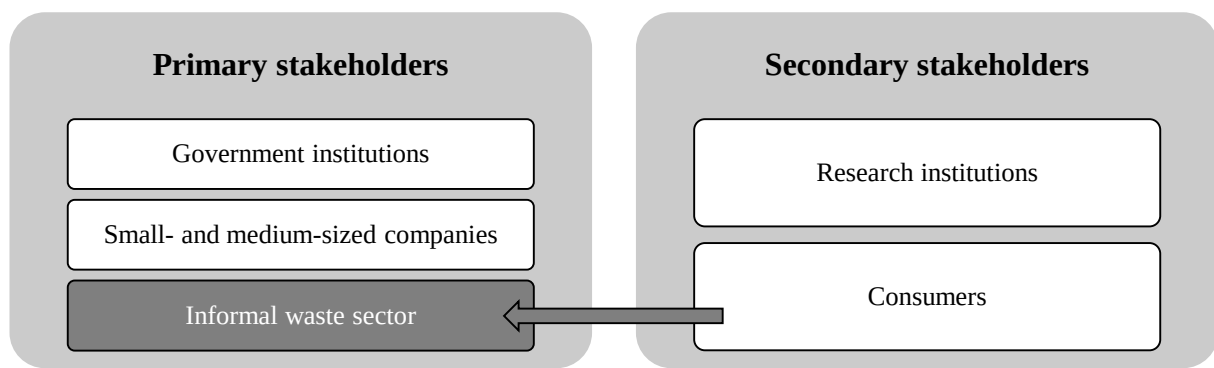


Figure 3.10: Vietnamese stakeholder landscape.

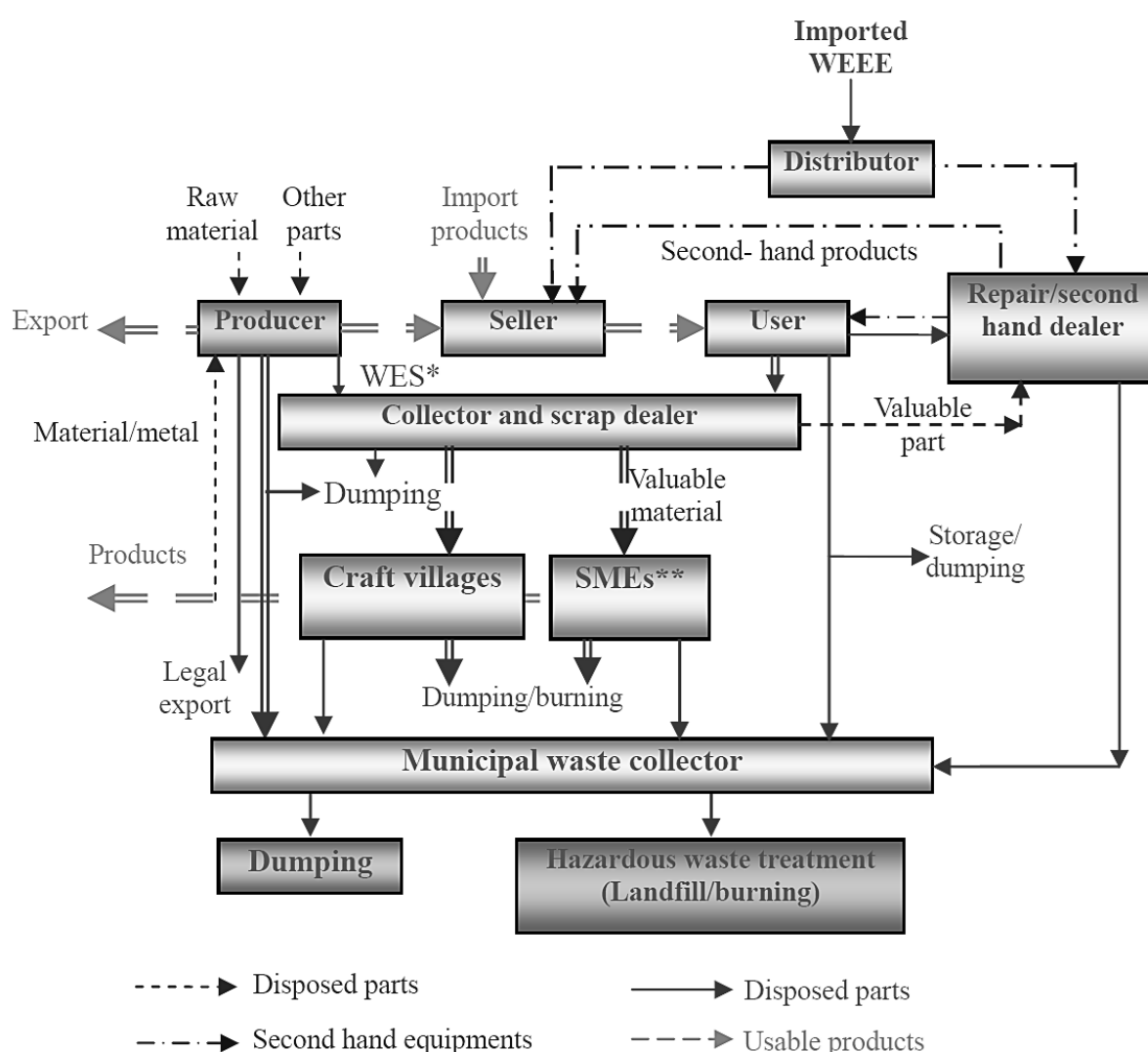
In comparison to China and Japan, the Vietnamese ‘stakeholder landscape’ in the e-waste sector has been much less studied. However, based on surveys and case studies, the main characteristics of the management structure are identifiable.

Due to a lack of formal management structures, the vast majority of e-waste is handled by the informal sector. Households sell their discarded EEE directly to small collectors (‘waste pickers’), who then transfer the collected appliances to medium and large collectors for refurbishment or directly to crafts villages for recycling. According to the URENCO report of 2007, about 1,450 craft villages are distributed across the country, with the majority being located in provinces at the Red River delta (URENCO, 2007: 113). E-waste produced by businesses might be collected directly through medium and large collectors. Another informal method for discarding used electronics, which is common in bigger cities such as Hanoi, Danang and Hochiminh, is to transfer the used EEE to friends or relatives with lower income, who live in adjacent regions, for direct reuse. Due to this practice, products will often reach their end-of-life in suburban or rural areas (Wiesmeth et al., 2012: 1-5; Nguyen et al., 2009: 358-359; URENCO, 2007: 43-46).

As shown in Figure 3.11, a significant proportion of e-waste flows into the country as imported WEEE (often disguised as second-hand EEE) and is distributed for reuse, refurbishment or recycling. Valuable parts and materials are manually extracted, either directly after import or collection of the e-waste from the end-users or at later stages from dumping sites or landfills. The extracted materials are then resold to second-hand dealers or the private electronics service system (Nguyen et al., 2009: 358-359). Due to this structure, the main actors of the Vietnamese e-waste processing system are individual informal waste collectors and recyclers, as well as small- and medium-sized companies.

The role of the government in the e-waste management process is in principle similar to those of the Chinese and Japanese governments, as a regulator and coordinator. There are a

number of bodies responsible for various aspects of e-waste management across the government, including the Ministry of Natural Resources and Environment (MONRE), Ministry of Construction (MOC), the Ministry of Health (MOH) and the Ministry of Industry (MOI). In 2001, the import of second-hand EEE was banned by the government and ‘Regulations on the Recovery, Processing and Disposal of Waste Products’ that apply to e-waste were established in 2015. However, not only are comprehensive legal frameworks that are specific to e-waste lacking, but the enforcement of the existing legislation has been insufficient, leading to a continued inflow of e-waste into the country despite the ban (URENCO, 2007: 119-121; Shinkuma and Huong, 2009: 26).



*: WES (Wastes of Electronics Scrap) **: SMEs (Small and Medium Enterprises)

Figure 3.11: E-waste management system in Vietnam. Source: Nguyen et al., 2006: 1.

As regards the secondary stakeholders, in contrast to the other two analyzed countries, there are neither national industry associations nor NGOs or other civil society organizations specifically addressing e-waste matters. Dedicated research institutions are similarly lacking. However, a number of individual academics focused their research on e-waste issues in the Vietnamese context, such as Assoc. Prof. Dr. Huỳnh Trung Hải and Dr. Nguyễn Đức Quảng of the School of Environmental Science and Technology, Hanoi University of Science and Technology.¹⁶

¹⁶ For a list of relevant publications, see: http://inest.hust.edu.vn/dv02-danh-muc-can-bo/-/asset_publisher/5t7E/content/141152?redirect=%2Fdv02-danh-muc-can-bo and http://inest.hust.edu.vn/dv02-danh-muc-can-bo/-/asset_publisher/5t7E/content/182361?redirect=%2Fdv02-danh-muc-can-bo.

3.3 Waste system elements

This chapter analyzes the main operational elements of the e-waste management processes in China, Japan and Vietnam. Chapter 2.2.2 laid out the various management practices that are deployed globally to handle e-waste, ranging from disposal in landfills to prevention of e-waste production. The utilization and prioritization of these practices in the three countries are examined with a view to determining prevalent practices in both the formal and informal sectors. The subsequent chapter then analyzes the sustainability of these practices in detail by considering the cost structures, environmental and health impacts, the sophistication of technology, etc. The previous chapter has shown that all three countries have processes in place, either through formal or informal structures, to transfer e-waste back into the economy through recycling, refurbishment/renewal or reuse operations. However, how much e-waste ends up in landfills rather than being processed? And how sophisticated are recycling methods?

Although it is not feasible to provide reliable e-waste management hierarchies for each of the analyzed countries, the analysis allows for the determination of the most prevalent e-waste management practices, i.e. main waste system elements, less prevalent practices, and non-prevalent practices, i.e. elements that are currently not applied in the countries.

3.3.1 China

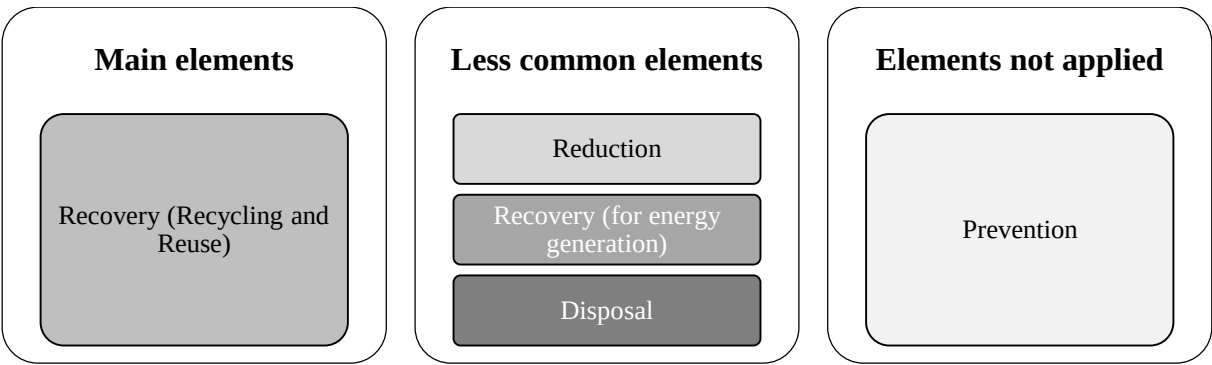


Figure 3.12: Waste system elements in the Chinese e-waste sector.

Given the discrepancy between the formal and informal e-waste sectors in China, reliable statistics on recycling rates are not available.

According to a study conducted in Beijing, about 60 per cent of collected e-waste was repaired or refurbished for reuse and 40 per cent was manually dismantled, either for parts to be reused (about 35 per cent of the dismantled materials) or for subsequent recycling (about 60 per cent). Thus, the majority of e-waste was processed for reuse. Only the residuals, less than 1 per cent of the e-waste, were transferred to landfills. However, it has to be noted that according

to the same study, about 70 per cent of e-waste was unaccounted for in the material flow, as it was being temporarily stored at houses or offices (Yang, Lu and Xu, 2008: 1592). Due to the illicit nature of the activities, statistics and data on the processing of imported e-waste are even more difficult to gather.

In an effort to establish a formal e-waste recycling mechanism to replace the existing informal structures, the government passed the 电子废物污染防治管理办法 *Administrative Measures on the Prevention and Control of Environmental Pollution by Electronic Waste* (2007) and 废弃电器电子产品回收处理管理条例 *Regulations on the Administration of Recycling and Treatment of Waste Electric and Electronic Equipment* (2011). These regulations prohibit unregistered individuals or companies from engaging in dismantling, recycling and disposal of e-waste and establish a treatment license system for companies handling the five identified main household appliances. The implementation of the regulations was enforced in stages, starting from the 家电以旧换新 [Home Appliance Old for New Rebate Program] that was initiated in nine pilot provinces and cities in 2009 and concluded in 2011. 22 designated companies dismantled collected e-waste during the pilot phase before the program was expanded to broader regions and more cities. However, despite a constant growth of the formal e-waste management sector, its capacities are still very limited and unevenly distributed across the country. Furthermore, not all facilities have been fully built and the majority of recyclers has adopted manual dismantling processes, relying on very basic mechanical technologies.¹⁷ In contrast to the informal sector, some formal procedures exist to recover energy from e-waste, though only on very limited scale. Another factor contributing to low capacity of the formal sector is the lack of established household collection networks and the inability to provide the financial incentives that informal e-waste collectors offer consumers. As a result, governmental initiatives have thus far neither been able to replace nor compete with the informal sector, which continues to collect the majority of nationally generated e-waste, potentially posing a risk to the sustainability of the formal recycling industry. Only 10 per cent of e-waste was processed in the formal sector in 2007 (Zhou and Xu, 2012: 4718; Wang et al., 2013: 25-26; Baldé et al., 2015a: 42; Chi et al., 2011: 736). The informal sector on the other hand deploys even more basic e-waste processing techniques, ranging from heating and manual removal of components from printed circuit boards to opening burning cables and wires for recovering metals. These practices do not only show low recovery efficiency, but may also

¹⁷ See sub-chapter 3.4.5.

endanger the environment as precautionary measures are rarely taken (Wei and Liu, 2012: 508: Chi et al., 2011: 736).

Thus far, recovery of e-waste in the form of reuse and recycling, although using crude techniques, has been established as the main element of the e-waste management system in China, with final disposal in landfills being estimated to account for only a low proportion of total e-waste. According to the waste management hierarchy, the recovery of waste is favorable compared to disposal, but prevention and reduction should be the highest goal to ensure a sustainable system. On a regulatory and policy level, China has adopted the *three R's* principle by promoting the reduction, reuse and recycling of waste in general throughout public and private sectors in the 中华人民共和国固体废物污染环境防治法 *Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste* (2004).¹⁸ However, the focus of the government has been largely on strengthening the formal e-waste treatment sector and establishing sophisticated, environmentally sound techniques for dismantling and recycling, so as to prevent pollution associated with common practices, rather than on the reduction or prevention of e-waste. In particular, the establishment of consumer or EEE producer responsibilities, for instance through an extended producer responsibility scheme, as has been suggested by Yu et al. (2010: 995-997), or incorporating waste prevention considerations into the design of products, is still largely unexplored.

3.3.2 Japan

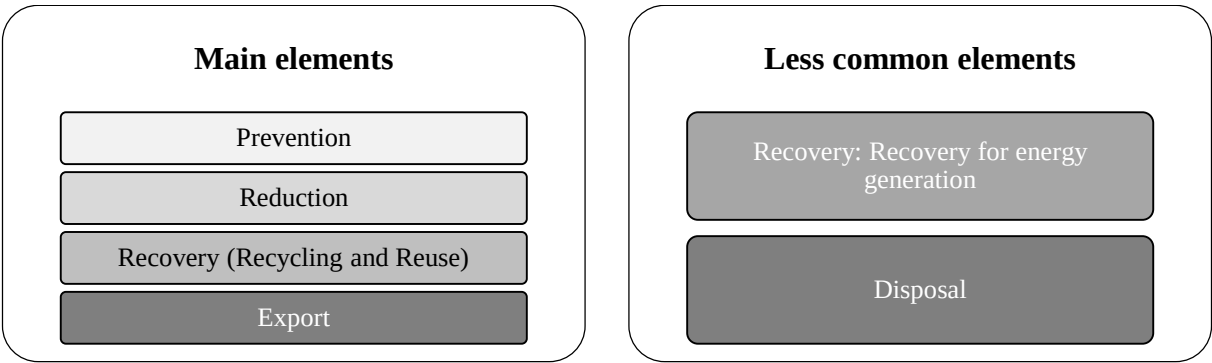


Figure 3.13: Waste system elements in the Japanese e-waste sector.

Similarly to China, the Japanese e-waste management system places a strong emphasis on recycling, both from a regulatory and an operational perspective. However, the techniques utilized in Japan are significantly more sophisticated and advanced than in China. For instance, a distinct feature of the recycling process is a primary disassembly procedure that is applied to

¹⁸ See, in particular, Article 3, 7, 16, 31 and 37.

large parts initially and ensures that residues are handled more properly through an accurate and brief process. In addition, Japanese EEE producing companies continuously invest in the design of lighter products that are cheaper and easier to recycle (Gaidajis, Angelakoglou and Aktsoglou, 2010: 198).

As mentioned, the *Home Appliance Recycling Law* has established a comprehensive framework for the recycling of four designated home appliances. A manifest system that connects the different steps of the recycling process ensures that the appliances are accounted for and enables the monitoring of the system's function. The core concept underlying the law and its implementation is the EPR policy. While the primary purpose of the law is to establish a well-functioning, efficient and environmentally sound home appliance recycling system, the ultimate aim is to achieve “*reduction in the volume of general waste and sufficient utilization of recycled resources*” (*Home Appliance Recycling Law*). Building on the same objective, the 2000 *Law for the Promotion of Effective Utilization of Resources*, focuses particularly on promoting the prevention and reduction of (e-)waste through the ‘3Rs policy’ (Reduce, Reuse, and Recycle). This approach is similar to the method known as ‘design for the environment’ and includes measures such as the reduction of manufacturing by-products and transferring used products into the manufacturing chain for reutilization. While the preceding 再生資源の利用の促進に関する法律 *Resource Recycling Promotion Law* of 1991 encouraged voluntary actions, the law of 2000 made the 3R policy a mandatory requirement, not only for manufacturers, but also for retailers, purchasers and consumers. It is noteworthy that the policy does not only aim at reducing adverse effects of e-waste, as defined in sub-chapter 2.2.2, but also comprises measures to prevent e-waste generation, such as investing in product design for longer durability of EEE (METI, 2010: 11-56).

However, in contrast to China and Vietnam, Japan exports a relatively large proportion of its e-waste to other countries, in particular developing countries in East Asia, including China and Vietnam themselves. Japan has not criminalized the export of e-waste and effective monitoring and control mechanisms are not in place. As a result, e-waste is shipped in an uncontrolled and unregulated manner, primarily to developing countries in the region, where it is likely to be treated through procedures that have adverse effects on the environment (Ladou and Lovegrove, 2008: 8; Shinkuma and Huong, 2009: 26). Consequently, the export has to be considered as an unfavorable e-waste management practice.

3.3.3 Vietnam

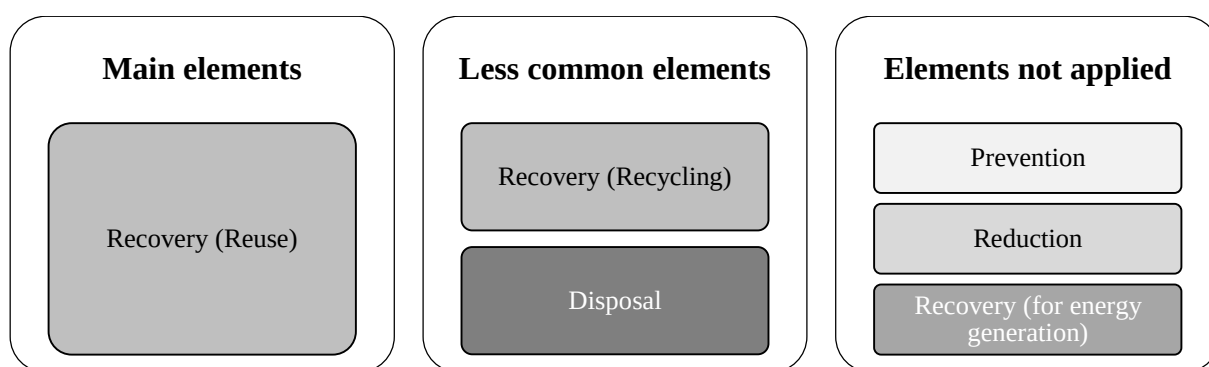


Figure 3.14: Waste system elements in the Vietnamese e-waste sector.

Although general statistics are not available, the URENCO report of 2007 provides ratios for the different handling practices of selected analyzed WEEE. Throughout all types of appliances covered in the report,¹⁹ repair and refurbishment for reuse was the prevalent e-waste management practice, with ratios between 70 and 90 per cent. In this way, e-waste is converted into ‘new’, but low-quality appliances, which are then sold to low-income households or in rural or remote regions. Recycling and disposal of e-waste in landfills both ranged between 3 and 15 per cent of all operations (URENCO, 2007: 28-36; Nguyen et al., 2009: 358-359). However, authors have noted that environmentally sound e-waste treatment techniques are virtually non-existent and landfills are usually uncontrolled (Thai, 2009: 258-260; Wiesmeth et al., 2012: 1). Unsophisticated and hazardous e-waste recycling methods, such as the burning off of plastic to recover metals in open places, are widely used (Wiesmeth et al., 2012: 1).

In order to formalize the informal e-waste processing sector, increase control over e-waste flows through the country and reduce the adverse effect of e-waste on the environment, the government has started to implement a number of measures, including: a) a registration system for hazardous waste generators; b) licenses for hazardous waste collection, transport, recycling and disposal; c) the development of a manifest system for hazardous waste; d) enhanced exchange of information between customs, environment, industry and trade authorities; and e) inspections at ports and e-waste handling facilities. However, regulations and policies aiming at the reduction and prevention of e-waste are yet to be adopted. Moreover, mechanisms to establish extended producer responsibility in Vietnam might not be effective due to the comparatively small national market for electronic products and the significance of EEE imports from international producers, for which regulatory and incentive frameworks are difficult to put in place (Wiesmeth et al., 2012: 5).

¹⁹ WEEE included in the report are: televisions, personal computers, mobile phones, refrigerators, air conditioners and washing machines.

3.4 Sustainability aspects in China, Japan and Vietnam

3.4.1 Policy and legal aspects

This sub-chapter analyzes the national frameworks that have been established to regulate e-waste and its management in the three countries. Based on the indicators developed in sub-chapter 2.3.7, the national legal framework on e-waste management standards and practices, the ISWM plan, the adoption and implementation of international instruments and standards, and the application of the EPR policy are assessed.

China

Over the last decade, the Chinese government has passed a number of laws, standards, policies and guidelines that address e-waste management, whether explicitly or generally in the form of overall waste regulations. The United Nations University and StEP Initiative (2016a) have identified 26 regulatory instruments that specifically address e-waste, ranging from standards that determine the requirements of disassembly and treatment for various categories of e-waste, such as printers or televisions, to the 中华人民共和国循环经济促进法 *Circular Economy Promotion Law of the People's Republic of China* of 2008, which inter alia prohibits the use of poisonous or otherwise harmful substances in the production of electronic products. In addition, local administrative regulations have been established in various regions and cities, such as Beijing, Shanghai or Guangdong, inter alia to manage local e-waste take-back, reuse, and recycling systems (Chi et al., 2011: 735).

As shown in Figure 3.15, the three national laws, passed by the Standing Committee of the National People's Congress (NPCSC) and representing the instruments with highest legal status (light grey), are all general in nature and only address e-waste as part of overall waste management or in a few provisions of the law. However, some of the specific e-waste regulations directly relate to the broad laws, for instance by adapting the 3R principle and the 'polluter pays' principle to e-waste management, as stipulated by the national laws.

Law/Regulation	Year entered into force	Key content
Notice on the Import of Wastes of the 7 th Category under the Interim Provisions on Wastes Import and Environmental Protection	2000	Ban on e-waste importation
中华人民共和国清洁生产促进法 Cleaner Production Promotion Law	2002 (last amended 2012)	Replacement of hazardous materials by less or non-hazardous substances in production; producer responsibility
中华人民共和国固体废物污染环境防治法 Law on the Prevention and Control of Environmental Pollution by Solid Wastes	2004	'Polluter pays' policy regarding solid waste management; 3R principle
Technical Policy on Pollution Prevention of Discarded Appliances and Electronic Products	2006	3R and 'polluter pays' principles applied to e-waste; promotion of eco-design; information disclosure of hazardous substances in electronics
Ordinance on Management of Pollution Control from Electronic Information Products	2007	Restriction on use of six hazardous substances in electronic production; mandatory labeling and provision of information on components, hazardous substances and recycling ('environmental expiry date')
Administrative Measure on Pollution Prevention of Waste Electrical and Electronic Equipment	2008	Certification requirements for e-waste recycling operations; mandatory environmental impact assessments for e-waste management facilities
中华人民共和国循环经济促进法 Circular Economy Promotion Law	2009	Endorses waste reduce, reuse and recycling measures in all aspects of economic production
Regulation on Management of Waste Electrical and Electronic Equipment Recycling and Disposal	2011	EPR policy; centralized treatment of e-waste; establishment of dedicated fund for e-waste recycling and disposal

Figure 3.15: Legislative and regulatory e-waste framework in China (e-waste specific instruments highlighted in dark grey). Source: Zhou and Xu, 2012: 4714-4715; Chi et al., 2011: 734-735; Chung and Zhang, 2011: 2638-2640; and legal analysis of the author.

Authors that have evaluated the legislative e-waste framework in China have come to the conclusion that existing laws are insufficient in their scope and implementation and neither include all stakeholders in consultations, nor incorporate all relevant considerations in the law-making process. Unclear legal provisions, such as articles 22 and 23 of the *Ordinance on Management of Pollution Control from Electronic Information Products*, which stipulate that a violation of the provisions concerning a company's responsibilities will be penalized by the relevant authorities according to the applicable legal provisions, without further specifying which authorities would be responsible, pose challenges to the enforceability of the regulations. Further problems have been identified in the implementation of the laws and policies, including a lack of adequate and sustainable allocated financial resources, overlapping or unclear division of responsibilities across agencies, as well as a lack of public acceptance of these policies. Moreover, while the legislative framework lays out the formal requirements for (e-)waste management, it does not specifically address the significant role of the informal e-waste sector and does not put in place measures for the formalization of this sector (Chung and Zhang, 2011:

2642-2644; Hicks, Dietmar and Eugster, 2005: 468-469; Yang, Lu and Xu, 2008: 1596; Zhou and Xu, 2012: 4714-4721; Lundgren, 2012: 39). Despite the existence of an increasingly comprehensive legislative framework for e-waste management in China, the enforcement, and, thus, effectiveness and practical implementation has been low, leading to a fragmented and partially uncoordinated formal management system that continues to co-exist with a large and unregulated informal e-waste sector (Chung and Zhang, 2011: 2643-2644).

Although China has shown a strong commitment to clean management of waste in general, and e-waste in particular, not least represented by the *Circular Economy Promotion Law*, it has not established an ISWM plan at the national level. With the assistance of UNEP, a pilot project was initiated in 2008 to adopt and strategically implement an ISWM plan in Wuxi New District (UNEP, 2009: 2-48). However, an expansion to other municipalities or regions or the establishment of a nationwide ISWM plan has not yet commenced.

As regards international instruments and standards, China has not only ratified the Basel Convention and its BAN Amendment,²⁰ but has also been an active player in the region in the implementation of the Convention in Asia through the Basel Convention Regional Centre for Asia and the Pacific (BCRC China), which was established in 1997. The Centre carries out research on waste management, initiates capacity building activities in Asia and promotes awareness raising and information exchange on waste matters. It is also a member of the Regional 3R Forum in Asia, established in 2009, and the regional focal point of the StEP initiative (BCRC China, 2010; Lundgren, 2012: 39). While the work of the Centre addresses waste as a general challenge, several e-waste specific projects have been initiated, such as the ‘Assessing the Status of E-waste Recycling in Selected Countries in the Asia-Pacific Region and Facilitating the Environmentally Sound Management of E-waste’ project of 2014, which inter alia involves Vietnam and several other Asian countries (BCRC China, 2014).

Finally, as shown in Figure 3.15, China has established the extended producer responsibility principle in the *Regulation on Management of Waste Electrical and Electronic Equipment Recycling and Disposal* in 2011. However, implementation of the policy is lacking, not least due to insufficient schemes laying out the time frames, general principles, mandates and financial backing (Wei and Liu, 2012: 510-512).

²⁰ The amendment sets out an absolute prohibition of exporting hazardous waste from a list of developed countries to developing countries.

Japan

The Japanese legal framework on e-waste, as shown in Figure 3.16, is built on three broad national laws that establish the basic systems and schemes for a sustainable waste management process, as well as two specific national laws regulating specific types of e-waste. Japan has been one of the first countries to adopt a comprehensive legal mechanism to manage e-waste and to apply an EPR policy to e-waste. In addition, there are also a number of guidelines and standards regulating the technical application of the law. The implementation of the laws builds on a nationally coordinated collection and take-back system, as well as recycling infrastructure and is supported by a strong monitoring system that ensures compliance with the legal requirements. The whole collection and recycling process is organized through a centralized structure rather than managed by the municipalities themselves (Yoshida and Yoshida, 2010: 22; Yoshida and Yoshida, 2014: 422-423; Baldé et al., 2015a: 42). Although the *Home Appliance Recycling Law* only covers four specific types of e-waste, it clearly lays out the responsibilities of all actors in the collection and recycling processes, sets recycling targets, establishes a detailed scheme to implement the regulations in practice, and provides for sustained government funding and recycling fees. It is due to these factors that the enforcement of the law is often seen as a success and best practice example (Yoshida and Yoshida, 2014: 420-423; Gaidajis, Angelakoglou and Aktsoglou, 2010: 198; Hotta, Santo and Tasaki, 2014: 7-28).

Law/Regulation	Year entered into force	Main topics
廃棄物の処理及び清掃に関する法律 Waste Management and Public Cleansing Law	1970 (last amended 2010)	Establishment of the overall system for waste management; treatment standards; waste reduction principles; import/export regulation; recycler registration system
資源有効利用促進法 Law for the Promotion of Effective Utilization of Resources	2001	3R principle applied to different designated industries, processes and products, from product design to recycling of used goods
循環型社会形成推進基本法 Fundamental Law for Establishing a Sound Material-Cycle Society	2001	Establishment of principles towards a sound material-cycle society; promotion of waste management hierarchy; responsibilities of stakeholders (national and local government, businesses and citizens)
特定家庭用機器再商品化法 Home Appliances Recycling Law	2001	National e-waste collection, transportation and recycling framework for four designated home appliances (television, refrigerator, air conditioner and washing machine)
使用済小型電子機器等の再資源化の促進に関する法律 Small Waste Electrical and Electronic Equipment Recycling Law	2013	Expansion of the Home Appliances Recycling Law to additional electric and electronic appliances (digital cameras, mobile phones, game consoles, computers and printers)

Figure 3.16: Legislative and regulatory e-waste framework in Japan (e-waste specific instruments highlighted in dark grey). Source: The Economist Intelligence Unit, 2014: 7; Sawhney et al., 2008: 29-30; and author's legal analysis.

However, challenges remain, in particular regarding e-waste that is not accounted for in the official system and exported out of the country in an uncontrolled manner. The nature of the funding resources and a lack of transparency regarding the use of the collected recycling fees has further been criticized (Hotta, Santo and Tasaki, 2014: 8-28, Yoshida and Yoshida, 2010: 27-28).

Although Japan, similarly to China, does not have a dedicated national ISWM plan in place, it has taken concrete steps towards a sound material-cycle society and has established plans to promote the 3R principle and waste management hierarchy and ensure a more sustainable and integrated management of waste in general. As early as in 1963, Japan adopted a *Five-Year Plan for Development of Living Environment Facilities* which instigated the move towards incineration of urban waste, thereby substantially reducing waste disposed in landfills. In 2003, Japan introduced the *Fundamental Plan for Establishing a Sound Material-Cycle Society*, which is revised in five year cycles. The plan addresses a wide range of activities, ranging from awareness raising to business measures, and sets out a number of objectives and indicators to measure the effectiveness of the plan's implementation (Premakumara and Maeda, 2015: 186-187). The last iteration of the Plan was adopted in 2013. Although the Plan does not constitute an ISWM plan per se, it reflects the basic principles of ISWM, such as a clear definition of the roles and responsibilities of all involved actors and their interrelation, tangible targets and indicators, concrete steps and measures towards achieving the objectives of the Plan, and an integration of waste management into broader economic, policy and social development strategies and considerations (MOE, 2013).

In the international arena, Japan has been one of the key actors to support sound e-waste management in Asia and globally. Japan ratified the Basel Convention in 1993, although it did not adopt the BAN amendment due to political reasons, and has been an initiator and facilitator of regional activities within the framework of the Convention. For instance, in 2003, the Japanese Government proposed and later instigated the 'Asian Network for Prevention of Illegal Transboundary Movement of Hazardous Wastes', which includes China and Vietnam as participating countries, with the aim of exchanging information on cross-border movements of hazardous wastes in the region (MOE, 2015a). In 2005, the Government further launched the 'Basel Convention Partnership on the Environmentally Sound Management of E-waste for Asia-Pacific Region' in cooperation with the Secretariat of the Basel Convention. Through a series of workshops, training courses and projects, the Partnership aims at enhancing the regional capacity to manage e-waste in an environmentally sound manner (MOE, 2015b).

Finally, as mentioned above, Japan was one of the first countries to adopt and implement an EPR policy for e-waste management (Ogushi and Kandlikar, 2007: 4503-4507).

Vietnam

Contrary to China and Japan, Vietnam does not have a specific e-waste legal or regulatory framework in place. Instead, a number of general waste management laws and regulations guide the collection and processing of e-waste. The highest legal instrument is Luật Bảo vệ môi trường *Law on Environmental Protection*. Although the law contains a dedicated chapter on waste management, which includes discarded electronic and electric equipment, it does not clearly designate relevant authorities and their responsibilities in the management process and does not provide for a comprehensive funding and implementation system. While several decrees and decisions (see Figure 3.17) specify the detailed responsibilities and management standards for waste management, the implementation of the regulations is obstructed by a lack of sufficient resources and institutional capacities to effectively carry out the required measures, as well as the absence of a supervision and monitoring mechanism to ensure adequate enforcement (URENCO, 2007: 126-127).

Law/Regulation	Year entered into force	Main topics
Luật Bảo vệ môi trường Law on Environmental Protection	2006	General principles and measures to promote environmental protection; general waste management measures
Decree No. 80/2006/ND-CP	2006	Specific guidelines for the implementation of the Law on Environmental Protection; Environmental Impact Assessments
Decree No 12/2006/ND-CP	2006	Implementing measures for the Trade Law; ban on import of secondhand EEE
Decision No. 16/2015/QĐ-TTg	2015	Guidelines on the recovery, processing and disposal of waste products; responsibilities of involved actors

Figure 3.17: Legislative and regulatory e-waste framework in Vietnam. Source: United Nations University and StEP Initiative, 2016b; URENCO, 2007: 122; Hai, Hung and Quang, 2015: 5; author's legal analysis.

Despite the fragmented regulatory framework, Vietnam has developed a general national ISWM plan entitled 'National Strategy for Integrated Management of Solid Waste up to 2025, vision towards 2050,' adopted in 2009 by *Decision No. 2149/QĐ-TTg approving the national strategy for integrated management of solid waste up to 2025, with a vision to 2050*, which particularly emphasizes the 3R policy. In addition to three general objectives, which aim to be achieved by 2025, the plan sets specific targets for the periods until 2015, 2020 and 2025, as well as implementing activities to fulfil these objectives. The plan further lays out the roles

and responsibilities of eleven ministries at the national level within ten programs under the National Strategy that are coordinated, overseen and monitored by MOC and MONRE.

Vietnam ratified the Basel Convention in 1995 and has since implemented a number of implementing measures, including trainings, legal reform and the establishment of a classification system for hazardous waste management (URENCO, 2007: 119). Vietnam also participates in the ‘Basel Convention Partnership on the Environmentally Sound Management of E-waste for Asia-Pacific Region’ and the ‘Assessing the Status of E-waste Recycling in Selected Countries in the Asia-Pacific Region and Facilitating the Environmentally Sound Management of E-waste’ project (see above). However, contrary to China and Japan, Vietnam has largely been the recipient of capacity building activities and projects related to e-waste in the region, rather than being a driving force for such initiatives itself.

Finally, in contrast to China and Japan, Vietnam has not yet established an EPR policy in the area of e-waste management, neither in the legal and regulatory framework nor in practice. However, the government is planning to adopt an EPR policy in 2016 (Hai, Hung and Quang, 2015: 1).

3.4.2 Institutional aspects

This sub-chapter analyzes the institutional framework of the national e-waste management system in the three countries. Firstly, the organizations involved in e-waste management processes, the distribution of responsibilities among them, and their institutional capacities are analyzed. Secondly, private sector initiatives and partnerships between the government and the private sector, as well as international cooperation in the area of e-waste are examined.

China

In Chinese e-waste management, the government plays a leading and coordinating role. However, there is no single institution that regulates, oversees and coordinates all elements of the e-waste management process. Instead, responsibilities are allocated across various ministries and agencies, in accordance with their respective mandates. Figure 3.18 provides an overview of relevant national institutions and their different main obligations. At the national level, six institutions are responsible for various e-waste management tasks. An equivalent institutional structure has been established at the provincial and local levels with corresponding roles and responsibilities and a top-down reporting structure to the national counterparts (Wang et al., 2013: 40). Evidently, overlaps exist between duties of various institutions, such as the

Ministry of Industry and Information Technology (MIIT) and the Ministry of Finance (MOF), both of which are responsible for communication with EEE producers. In addition, due to the lack of a central body overseeing the e-waste management processes, there is no single entity that ensures that tasks are carried out, that ministries coordinate their actions and that the entire e-waste processing chain is monitored and no illegal activities take place.

Regarding the capacity of each of the involved organizations managing a part of the e-waste management system, research is lacking. Hence, a clear indication regarding the sufficiency of available skills and resources within the ministries is not possible. Nevertheless, the overlap in responsibilities suggest that resources and skills may not be used in an efficient manner.

Organization	Main responsibilities
National Development and Reform Commission (NDRC)	Planning of pilot projects Definition of e-waste categories Development of e-waste management financing scheme Definition of stakeholders' responsibilities
Ministry of Environmental Protection (MEP), Department of Pollution Control	Supervision of prevention and control of pollution caused by e-waste Establishment of e-waste treatment standards Management of licensing system for recyclers Monitoring of environmental performance of recyclers Establishment of list of products/waste for import and export Study best treatment technologies
Ministry of Industry and Information Technology (MIIT)	Management of EEE manufacturing industry Encouragement of eco-design and regulation of use of toxics in EEE Definition of responsibilities and communication with EEE producers and OEMs
Ministry of Commerce (MOC)	Establishment and management of e-waste collection systems
Ministry of Finance (MOF)	Definition of responsibilities and communication with EEE producers and OEMs
General Administration of Customs (GAC)	Registering of EEE import and export figures Monitoring of illegal activity at customs checkpoints

Figure 3.18: Institutional e-waste framework in China. Source: Wang et al., 2013: 40-41; Ni and Zeng, 2009: 3992-3993; Yu et al., 2010: 996.

The second part of the institutional framework of ISWM addresses partnerships, both domestically between public and private sectors, and internationally, whether bilateral, regional or global in nature. While the government is at the core of all formal e-waste management activities in China, private sector companies have started to be more involved over the last decade, in particular through the implementation of the 家电以旧换新 [Home Appliance Old for New Rebate Program] program mentioned above. As of 2013, 64 official e-waste recycling companies had been certified by the government in 22 of the 31 main cities, provinces and autonomous regions through the program (OECD, 2014: 7-8). However, this relationship has

been largely driven by the public sector, rather than as a bottom-up approach from the private sector, which struggles to compete with the dominant informal e-waste recycling sector.

Apart from enhancing domestic cooperation, various partnerships have been established in the region and internationally to improve e-waste management in China. As mentioned above, China plays an active role in the region through the BCRC China and the Regional 3R Forum in Asia. In addition, projects have been initiated with international partners. An example is the ‘Pilot Project on Public-Private Partnership for E-waste Collection’ in Suzhou, initiated by UNEP in 2010 and carried out by the BCRC China. The aim of the initiative is to encourage consumers and companies to utilize formal channels for e-waste disposal rather than relying on the informal sector by establishing cooperation between manufacturers, retailers and consumers, as well as recycling companies, educational institutions and local community actors (Wang et al., 2013: 38). Another cooperative project entitled ‘Best of 2 Worlds’ was established in 2006 under the StEP Initiative and is coordinated by the United Nations University with the support of a number of Chinese and international partners from academia and the private sector. With a more technical focus than the UNEP project, the ‘Best of 2 Worlds’ initiative draws from international best practice and experience to develop the Chinese e-waste recycling facilities, while also considering local conditions (Streicher-Porte, 2009). In addition, two bilateral intergovernmental partnerships have been established with the Swiss (‘Knowledge Partnerships in E-waste Recycling’, 2004; and various activities in following years) and Dutch governments (‘Sino-Dutch Solid Waste Exchange Project’, 2008-2010), both of which brought together representatives of the private sector, academia and the government to enhance cooperation and coordination in Chinese e-waste research, management, treatment and legislative development (Wang et al., 2013: 37-39).

Although China can be characterized as having an active and, in some cases, driving role in regional and global e-waste initiatives and partnerships, these projects are rather ad-hoc in nature and lack coordination to channel resources most efficiently. Moreover, despite the involvement of academia, the private sector and civil society actors, the government remains the main actor and owner of these initiatives. Hence, a top-down rather than bottom-up institutional structure of the Chinese e-waste sector can be observed.

Japan

In contrast to the Chinese institutional e-waste management framework, research on e-waste in Japan has focused more on the operational level rather than organizational structures. Nevertheless, the main national actors that are primarily responsible for e-waste management

can be identified and have been appointed through the relevant laws in this area. Contrary to the Chinese and Vietnamese institutional ISWM framework, e-waste management responsibilities in Japan are centralized in two ministries that work in tandem, namely the Ministry of Economy, Trade and Industry (METI) and the Ministry of Environment (MOE). MOE and METI represent the key drivers of e-waste management and its different elements in Japan on the national level. They are responsible inter alia for developing and enforcing legislation and policies, ensuring monitoring of sound collection, recycling and treatment practices, and raising awareness among all relevant stakeholders (see Figure 3.19). In addition, the Ministry of Health, Labour and Welfare carries out some e-waste-related functions. Although there is no single entity overseeing all e-waste management processes, research suggests that METI and MOE work in a coordinated and cooperative manner. For example, in 2008 a joint advisory council was established between MOE and METI to review e-waste policy implementation. Members of the council include not only government representatives, but also representatives of academia, media, industrial associations, consumer groups, retailers and recyclers (Terazono and Yoshida, 2012: 139-145; Hotta, Santo and Tasaki, 2014: 7-12). Despite the centralized decision-making structure, the role of MOE and METI is, however, that of a national coordinator and facilitator. Responsibilities regarding the different stages and processes of e-waste collection and recycling are handed down to municipalities, as well as manufacturers, retailers and consumers, as described in sub-chapter 3.2.2.

Organization	Main responsibilities
Ministry of Economy, Trade and Industry (METI)	Monitoring of enforcement of the Home Appliances Recycling Law Develop e-waste legislation Develop policies and plans for the collection, transportation and recycling of e-waste under the Home Appliance Recycling Law Awareness-raising on e-waste-related issues Collecting and publishing e-waste recycling rates and related statistics Oversee import and export of e-waste
Ministry of Environment (MOE)	National waste management administration Develop e-waste legislation Monitoring of enforcement of the Home Appliances Recycling Law Develop policies and plans for the collection, transportation and recycling of e-waste under the Home Appliance Recycling Law Awareness-raising on e-waste-related issues Collecting and publishing e-waste recycling rates and related statistics Oversee import and export of e-waste
Ministry of Health, Labour and Welfare	Develop policies and plans for the collection, transportation and recycling of e-waste under the Home Appliance Recycling Law

Figure 3.19: Institutional e-waste framework in Japan. Source: *Home Appliance Recycling Law*; Terazono and Yoshida, 2012: 139-145; BCRC China, 2009: 10; DTI Global Watch Mission, 2005: 63.

Finally, similarly to China, evidence regarding the institutional capacity of the two entities in carrying out their duties is lacking.

In relation to the private sector, sub-chapter 3.2.2 has laid out the integral role of manufacturers and retailers in the e-waste management process. In addition, the Japanese government is pursuing partnerships between the private and public sector by actively engaging and reaching out to companies involved in the import and export, and production of e-waste through awareness raising seminars, consultation services and informal meetings (MOE, 2015c).

As regards regional and global initiatives, Japan has shown strong commitment to facilitating the development of sound e-waste management practices and has initiated numerous activities in Asia and beyond. One of these initiatives is the already mentioned ‘Basel Convention Partnership on the Environmentally Sound Management of E-waste for Asia-Pacific Region’, which was launched in 2005. In the realization of this partnership, the Government of Japan provided technical and financial support to countries in the region to carry out projects that enhance e-waste management locally and regionally. At least 19 projects have been implemented since 2005, focusing on East and Southeast Asia, but also including initiatives in India and Sri Lanka. The goals of the projects range from training courses and workshops to the development of e-waste inventories and technical guidelines (MOE, 2015b). Another regional program that was initiated by the Japanese government in collaboration with the Basel Convention Secretariat is the ‘Asian Network for Prevention of Illegal Transboundary Movement of Hazardous Wastes’. During its annual workshops, e-waste is one of the issues that has been discussed (MOE, 2015a).

Apart from regional activities, Japan has also been actively engaged with international partners. In particular, the country maintains a close relationship with the European Union. In November 2015, the MOE organized a ‘Symposium on Sound Management and Economic Competitiveness in the field of WEEE - Sharing European and Japanese experiences’, bringing together government experts, as well as academia and industry representatives from the EU and Japan (MOE, 2015d). Another cooperative initiative ‘International Environmental Technology Centre’ was founded in Tokyo in 1994 as the result of an agreement between the Government of Japan and UNEP. The Centre’s main objective is the promotion of environmentally sound technologies, focusing on waste management related issues, including e-waste (UNEP, 2015). Generally, Japan plays a leading role in the region, but also globally in the promotion of environmentally sound e-waste management. In addition to engaging in ad-hoc activities, Japan also actively promotes the development of regional institutional structures for technical assistance in the handling of e-waste.

Vietnam

Similarly to China and Japan, e-waste management in Vietnam is a shared responsibility among various governmental agencies. However, due to the lack of a comprehensive and specific e-waste regulatory framework, the Vietnamese institutional framework to manage e-waste follows the task distribution of general waste management and there is no entity specializing in e-waste management or coordination. While MONRE functions as the main coordinating body, in particular through three main departments (Department of the Environment, Department of Environmental Impact Assessment and Appraisal, and the Vietnam Environmental Protection Agency), for the waste management framework, several other national ministries and provincial and municipal committees share responsibilities and carry out activities related to (e-)waste, as shown in Figure 3.20 (URENCO, 2007: 119-121). Although information regarding the level of coordination and cooperation among the different involved organizations is limited, key interlinked tasks, such as the assessment of human health and environmental impacts relating to waste, are distributed across different ministries, which suggests an inefficient division of responsibilities. Moreover, several duties overlap between the organizations, such as the formulation of policies. Most importantly, Vietnam lacks a central body focusing on e-waste management and instead subordinates the issue to general waste management, which impedes an efficient and effective approach towards the complex and unique e-waste challenge.

Organization	Main responsibilities
Ministry of Natural Resources and Environment (MONRE)	Planning, formulating strategies, legislation, and policy Guidance on application of Vietnam's environmental standards Approving of impact assessment reports related to solid waste management systems Environmental monitoring and inspections Public awareness raising
Ministry of Construction (MoC)	Formulation of policy and legislation Planning and construction of solid waste facilities Development of plans for waste-related infrastructure construction
Ministry of Health (MOH)	Assessment of impacts on human health
Ministry of Industry (MOI)	Formulation of policies Overseeing operation of IZMB Supervision and assistance of industries to manage waste
Ministry of Transport (MOT)	Overseeing the URENCOs
Ministry of Planning & Investment (MPI)	Overall planning of investment projects Coordination of ODA assistance related to waste management
Provincial/Municipal People Committees (PPC)	Overseeing environmental management within its jurisdiction Planning, urban governance, and fee collection
Public urban environment companies (URENCO)	Waste collection and disposal

Figure 3.20: Institutional e-waste framework in Vietnam. Source: URENCO, 2007: 119-121.

Another issue is the lack of equipment, training and financial resources allocated to local institutions involved in waste management. The safe and environmentally sound collection and treatment or disposal of hazardous waste poses a particular challenge to these institutions. Insufficient human resources further impede the establishment of a comprehensive monitoring system to make sure that waste management operators and industries adhere to laws and regulations. Overall, the capacities of Vietnamese e-waste management agencies to enforce the legal and regulatory framework is very limited (World Bank, 2005: 10-40).

The relationship between the public and private sectors in Vietnamese e-waste management is largely formal in nature. Rather than operating jointly to enhance managing practices, the relationship is limited to government monitoring of the implementation of national regulation by licensed collectors and recyclers (Vietnam Environment Administration, 2011). Truly cooperative initiatives on a national level are lacking. Moreover, successful measures to engage with the dominant informal sector remain a challenge for the government.

Within regional and global initiatives, Vietnam largely plays a passive role as the recipient of both technical and financial assistance, rather than the instigator of activities. The country is a member of the ‘Basel Convention Partnership on the Environmentally Sound Management of E-waste for Asia-Pacific Region’ (MOE, 2015b) and the ‘Assessing the Status of E-waste Recycling in Selected Countries in the Asia-Pacific Region and Facilitating the Environmentally Sound Management of E-waste’ project (BCRC China, 2014). In 2015, a Consortium led by two American technology companies launched the *Vietnam Recycles* program to assist manufacturers and customers to adhere to national regulations on collection and recycling of e-waste. In response, the Deputy Director of the Vietnam Environment Administration noted that previous years had seen a number of waste recycling programs, but, due to their small scale and short-term orientation, the success was limited. Moreover, Vietnam lacks the social awareness and financial resources to establish a sustainable (e-)waste management system (VNS, 2015).

3.4.3 Socio-cultural aspects

This sub-chapter analyzes how e-waste management is integrated into society and culture within the three countries. Citizen participation and integration is assessed by identifying the level of public involvement in e-waste management and determining whether communication and reporting mechanisms that link consumers, private sector entities and government institutions have been established. Awareness raising and educational campaigns

for the broad public, which aim at encouraging the appropriate disposal of e-waste and inform about sound recycling practices, are further examined.

China

As laid out in sub-chapter 3.3.1, Chinese citizens tend to lean towards the informal e-waste sector rather than utilizing formal collection channels when discarding e-waste. Rather than involving consumers as active stakeholders in the e-waste management processes, the government has focused on regulatory, institutional and technical measures to enhance e-waste recycling in the country. As a result, public involvement in e-waste management remains low. This low involvement is also reflected in the limited participation of civil society. Although there are many environmental NGOs, they are fragmented and there is no organization focusing specifically on e-waste related issues. Brooks et al. (2012: 10) argue that this gap is due to the dual nature of e-waste related issues, affecting both the environment, but also human health, thereby touching upon human rights and justice issues, which might pose a political risk for these organizations. However, Greenpeace, representing one of the largest international NGOs with a presence in China, has actively addressed e-waste as a primary campaign target in the country (Brooks et al., 2012: 11).

As regards communication and reporting mechanisms, no evidence can be found that such platforms have been established or are being developed.

Despite the low level of citizen participation and integration in e-waste management, some research points towards the government trying to raise awareness on the issue with the wider public. One example is the already mentioned policy of 2009 家电以旧换新 [Home Appliance Old for New Rebate Program], which involved inter alia financial incentives for the engagement of consumers in recycling of electronic home appliances. On the city level, a government-funded ‘Discarded Appliances Demonstration Project’ was launched in 2003 in Beijing with the aim of promoting the disposal of discarded EEE (Wang et al., 2011: 978). Some private sector companies, such as Dell and Lenovo, have similarly invested in campaigns that aim at stimulating the behavior of consumers, for instance by offering free take-back of old electronics to Chinese consumers. The ‘Green Box’ program, a joint project by Nokia, Motorola and China Mobile was established in 2005 to collect end-of-life mobile phones from consumers in 40 cities throughout China. Six other mobile phone producers also joined the program in 2006 (Chi et al., 2011: 736). Another campaign, launched in 2014 through a cooperation between UNDP and Baidu, ‘Baidu Recycle Green Service Alliance’, builds on a mobile phone

application, which connects consumers who wish to dispose of electronic waste with dismantling and recycling companies for individual collection (李 [Li], 2014).

However, the effect of these initiatives is limited. A study on consumer behavior towards e-waste recycling in Beijing showed that existing awareness raising and educational campaigns are not sufficient to incentivize e-waste recycling in the population. According to the study, 60 per cent of recycled e-waste in the city was collected by peddlers and only 10 per cent of e-waste flows into the formal recycling processes. Moreover, most of the e-waste reached neither formal nor informal recycling systems, with 70 per cent of e-waste produced in the city instead remaining stored in homes or offices for months or even years. The study further identified recycling habits as the primary reason for a lack of willingness among Beijing residents to discard their electronics in a proper manner through official channels. As consumer responsibility is an unknown concept, many respondents indicated that they would be reluctant to pay a fee for recycling, rather than receiving financial rewards, as is current practice through informal channels. These observations were made across the city's population, regardless of level of income or level of education (Wang et al., 2011: 978-983). Surveys in other cities throughout China have provided similar results as regards the consumers' attitudes towards and awareness of e-waste issues (Liu, Tanaka and Matsui, 2006: 98; Yu et al., 2010: 994).

Overall, the socio-cultural aspect of e-waste has been insufficiently addressed in China. The integration of citizens into the e-waste management system is low and public awareness of the importance of proper disposal of e-waste remains one of the main challenges.

Japan

Contrary to China, the citizens, in their role as consumers, play an integral role in the Japanese e-waste management system. The *Home Appliance Recycling Law* clearly stipulates that consumers are responsible for the appropriate disposal of e-waste and are required to pay collection and recycling fees. Moreover, the law also encourages consumers to reduce the production of e-waste, for instance by only disposing of home appliances that can no longer be used. Citizens are also able to inform themselves about e-waste related issues and contact relevant government agencies through an interactive online platform and a phone hotline.²¹

In addition, civil society actors are actively engaged in e-waste management. As shown in sub-chapter 3.2.2, several domestic environmental NGO have focused part of their work on e-waste and its environmental and public health impacts, including 化学物質問題市民研究会

²¹ See <http://www.kaden-recycle.net/>.

の概要 [Citizens Against Chemicals Pollution], 東アジア環境情報発信所 [East Asia Environmental Information Express Messenger], the Study Group for a Sustainable Society, and 国際環境 NGO [Friends of the Earth Japan] (Yoshimatsu, 2010: 13; CACP, 2010: 1-3).

As regards reporting mechanisms to enable citizens to report cases of illegal e-waste dumping, Japan has not established such a mechanism. Instead, responsibility for detection and collection of illegally dumped e-waste lies with local government institutions (Lee and Na, 2010: 1639).

Having established a clear role for, and responsibilities of, citizens/consumers in the e-waste management process, the Japanese government is further investing into public awareness raising to promote the proper disposal of e-waste. Both METI and the Association for Electric Home Appliances (AEHA), a public-interest corporation founded in 1980 under authorization from METI, have developed websites²² that aim at enhancing citizens' understanding of the *Home Appliance Recycling Law* and provide information on how to discard e-waste appropriately, offer interactive learning materials and answer common questions on the recycling process. Some specialized websites provide similar information on specific types of e-waste, such as how to dispose of PCs.²³ Citizens not only use these online materials to inform themselves, but increasingly use the opportunity to visit recycling plants. Such visits are also commonly organized by schools as part of education and awareness raising for children (Hotta, Santo and Tasaki, 2014: 12-13).

Several public education campaigns, often in collaboration between government institutions and private sector companies, complement the national awareness raising efforts. Since 2011, October is the specifically designated month to promote the 3R policy through public events. This government initiative is the result of a partnership that involved eight ministries. In 2015, 34 events were organized in the context of the campaign, up from 24 events in the previous year (METI, 2015). An example of public-private cooperation to raise citizen awareness is the cell phone recycling campaign that was initiated in 2009 by several ministries and implemented by the mobile phone operator NTT DoCoMo Inc. The campaign was a response to a drop in the recycling rates of mobile phones in Japan between 2003 and 2007. Consumers were urged to dispose of their end-of-life cell phones at collection points, so that they could be properly recycled and the precious metals re-channeled into the economy (The Japan Times, 2009).

²² See http://www.aeha.or.jp/action_of_recycling/, <http://www.kaden-recycle.net/> and http://www.meti.go.jp/policy/it_policy/kaden_recycle/index.html.

²³ See <http://www.pc3r.jp/>.

Apart from awareness raising campaigns, waste and e-waste management is also the key driver of the ‘eco-town’ projects that were initiated in Japan between 1997 and 2006. Their goal was to take full advantage of economic and environmental benefits based on urban and industrial areas in close proximity. Recycling and reuse of waste for industrial production is the core foundation of this concept. Between 1997 and 2006, 26 ‘eco-towns’ were established throughout the country. Many of these cities relied heavily on private sector and civil society participation in realizing the vision of an industrial process that is in synergy with environmental protection (Van Berkel et al., 2009: 1544-1555).

Vietnam

Similarly to China, consumers are not active primary stakeholders in the Vietnamese e-waste management system. The customary link between consumers and the informal e-waste collection sector poses a challenge to the government, not only in establishing the formal e-waste sector, but also in incorporating citizens into e-waste management processes effectively. As a result, the role of civil society in e-waste management is limited. There are no civil society organizations focusing specifically on e-waste and general community participation is low. Similarly, awareness of the environmental damage and lost economic value caused by improper handling of e-waste is generally low (World Bank, 2005: 10; Georange, 2012: 2). Channels for communication and reporting of illegal e-waste dumping have yet to be established.

However, recent years have seen the emergence of first attempts towards raising awareness and educating the public, which aim at promoting safe e-waste disposal and recycling practices. In 2015, the Consortium ‘Vietnam Recycling Platform’, established by the regional branches of Hewlett-Packard and Apple, launched the *Việt Nam Tái Chế [Vietnam Recycles]* program. The campaign involves free take-back for e-waste to ensure safe and environmentally sound recycling (VNS, 2015). It also supports manufacturers and customers with adhering to regulations on collection and recycling of e-waste, which came into force in 2015 (see sub-chapter 3.4.1 above). Customers who want to dispose of their end-of-life EEE can request a pick-up through a web application on the program’s website,²⁴ via a mobile phone application, or via phone. Moreover, in order to increase public awareness about e-waste and promote the program, a range of art performances and interactive events have been organized (Hat, 2015). Although the program has received mainly positive responses in the media (Hat, 2015; VNS, 2015), questions have been raised regarding the effectiveness of the program, as many citizens

²⁴ See <http://www.vietnamrecycles.com/>.

continue to use informal collection channels, which offer financial rewards for e-waste (McKay, 2015). Another awareness raising initiative, although not specific to e-waste, is the annual waste recycling day in Ho Chi Minh City, which aims at raising public awareness and encouraging citizens to adopt the 3R principle. During the 8th Waste Recycling Day in 2015, Việt Nam Tái Chế [Vietnam Recycles] organized a number of events to address the particular challenge of e-waste (Vietnam Recycles, 2015).

3.4.4 Financial and economic aspects

A sustainable funding supply is a core requirement of any ISWM system, in order to ensure that the existing legislative, institutional and social structures are able to operate efficiently and continuously. This sub-chapter analyzes how e-waste management is funded in the three countries and who is the main financial contributor. In addition, the economic benefits of e-waste, utilized through the recovery of materials and re-channeling into the economy, are examined. Finally, this sub-chapter identifies existing economic incentives for informal sector workers to join the formal sectors. This factor is particularly important in China and Vietnam, which have a strong informal e-waste recycling sector.

China

Since 2012, the funding of the Chinese e-waste management system is based on a centralized, government-organized disposal fund scheme that was initiated under the *Measures for the Collection and Administration of the Funds for the Recovery and Disposal of Waste Electronic and Electrical Products*. The scheme is based on fees, which are collected by the tax and customs authorities, to be paid by EEE manufacturers and importers for each unit they produce or import. The collected funds are then used as subsidies to support the formal, certified recycling sector. The Ministry of Finance (MOF) is the main administrator of the fund within the central government and coordinates the collection and distribution of the financial resources. The General Administration of Customs and the State Administration of Taxation are responsible for the collection of the fees from manufacturers and importers, and the MEP oversees and monitors the certification and recycling process. A multi-stakeholder consultation, which brought together experts and private sector representatives from e-waste manufacturing, import and recycling industries, was the basis for determining the unit fee and subsidy rates. In order to ensure that local authorities do not gain a surplus during the collection of the fees, the rate was set considerably lower than the subsidy. In addition, the scheme is supported by comprehensive monitoring and inspection mechanisms carried out by different ministries to

ensure the correct implementation of the procedures (OECD and MOE, 2014: 16; OECD, 2014: 2-9). However, the effectiveness of the scheme is impeded by multiple factors, in particular the low e-waste collection rates. The majority of collected WEEE within the scheme is television sets, even though it covers four other types of appliances, namely refrigerators, air conditioners, washing machines and personal computers. Moreover, the costs and complexity of the scheme pose a challenge to the Chinese administration. The governance of the funds is entirely in public hands, rather than handing responsibility to EEE producers. Finally, in its current form, the Chinese disposal fund scheme does not provide any incentives to encourage improved product design and, hence, remains reactive in nature (OECD, 2014: 11-15).

The structure of the e-waste disposal fund scheme shows that cost recovery in e-waste management is low. Even though service charges represent a crucial step towards the realization of the 'polluter pays' principle, the collected fees do not cover the whole scope of the e-waste recycling and recovery system, which poses a challenge to ensuring sustainable funding.

Competition between the formal and informal e-waste sector aggravates this situation and is a major impediment to ISWM in China. While the formal sector has gained momentum in the more developed parts of China, such as Beijing, Shanghai or Guangdong, supported by the above mentioned government-initiated pilot projects and take-back programs, the majority of Chinese e-waste is still collected and treated in the informal sector. Informal recyclers have various advantages compared to the formal certified recycling companies. Firstly, the Chinese informal recycling sector is self-organized and demand-driven with a well-established supply system based on illegal imports and individualized domestic collection. Secondly, through their household collection networks, informal recyclers collect e-waste and other forms of waste directly door-to-door. Formal recyclers not only lack the networks and door-to-door collection capacities, but are also not able to collect other wastes that fall outside their recycling categories. Thirdly, informal recyclers are able to offer higher financial awards to citizens, whereas formal recyclers risk making losses due to the costs for collection and treatment within the official system. Fourthly, due to the proliferation of basic e-waste treatment methods, which do not regard the detrimental environmental and public health consequences, the treatment costs are considerably lower for informal recyclers (Chi et al., 2011: 735-737).

Government interventions to approach the informal e-waste recycling sector have been mainly focused on legislative and regulatory measures. As these measures have proved to be ineffective, alternative approaches are being explored. For example, there are efforts to integrate scattered individual recycling activities in industrial recycling parks, which are still focused on manual dismantling of e-waste, but enhance the treatment processes in terms of

pollution control. Such industrial parks have been established in Tianjin, Taicang, Ningbo, Taizhou and Zhangzhou (Shinkuma and Huong, 2009: 30). Through this measure, more jobs are created, while the benefits of labor-intensive processes are utilized. Moreover, some government initiatives have started to promote the technical improvement of informal recycling workshops, e.g. by replacing coal-fired grills with electrical heaters (Chi et al., 2011: 738). Although these measures recognize the value of creating economic incentives for the informal e-waste sector rather than relying on regulatory interventions, the scope and reach of the initiatives remains low and they are implemented in an ad-hoc manner. Creating a comprehensive market structure that provides economic incentives for the integration of the informal recyclers into the formal e-waste management system through supportive policies would allow for the creation of large-scale job opportunities and, in turn, represent an economic stimulus for the entire country.

Japan

The Japanese funding of the e-waste recycling mechanism under the *Home Appliance Recycling Law* is based on two different types of fees that are carried by the consumers. This system is an alternative to European models, which mostly rely on cost-internalization or advance recovery fees, that is, the inclusion of costs into the product price at the time of purchase. In Japan, the consumer firstly pays a collection and transportation fee for end-of-life EEE at the time of disposal. This fee is designated to cover the costs of e-waste collection from the consumer and the transportation to the collection site. In addition to the collection fee, consumers are also required to buy a recycling ticket, which they use to show the collection agent that the recycling fee has been paid. The recycling fee is intended to cover the transportation of e-waste from the collection sites to the recycling facilities, as well as the recycling costs. While the collection fee is set by the retailer or other collection agent, the recycling fee is set by the manufacturer. In accordance with the *Home Appliance Recycling Law*, the recycling fee must not exceed the recycling costs. In contrast to the Chinese system, where government agencies determine a fixed price, the Japanese system encourages competition between different retailers and manufacturers. However, in practice, fees have been relatively consistent within the various product types. Even though a lack of transparency regarding how the fees are set by manufacturers has been criticized, fees have decreased between 2006 and 2012, suggesting an increased efficiency and cost reductions in the recycling processes (INFORM, 2003: 2; Hotta, Santo and Tasaki, 2014: 4-9; Sawhney et al., 2008: 33).

As regards cost recovery, the value from selling recovered materials varies depending on the type of e-waste. For instance, air conditioners offer comparatively higher recovery revenues due to their high proportion of copper and aluminum content (19 per cent). Most other categories of e-waste are only composed of five per cent of these materials. In general, revenues from the sale of recovered materials account for only 10 to 30 per cent of the total costs. Despite the dual consumer fee system and measures to recover costs through the sale of recovered raw materials, the total costs of e-waste collection and recycling under the *Home Appliance Recycling Law* exceed the revenues. Consequently, in the current funding system, the private sector makes a financial loss, even though a social benefit analysis, which compares the costs and revenues of the recycling system to a non-enforcement scenario, reveals substantial net benefits for society in general and for local governments in particular (Hotta, Santo and Tasaki, 2014: 17-27).

Despite the strong formal e-waste collection and recycling sector in Japan, there are financial incentives to dispose of e-waste outside of the formal system, either by illegally dumping or exporting e-waste through informal channels. As consumers have to pay end-of-life rather than up-front collection and recycling fees, they might feel inclined to circumvent the payment and dump the discarded appliances illegally. On the other hand, the formal recycling system results in financial losses for retailers and manufacturers, which might incite some companies or individuals to gain higher sales revenues through illegal export out of the country (Lee and Na, 2010: 1641; Hotta, Santo and Tasaki, 2014: 18). Positive incentives, which prevent illegal dumping and export of e-waste through informal channels, have yet to be established in Japan.

Vietnam

Only limited data are available on the funding processes of the Vietnamese waste management system. While China and Japan have established different, yet comprehensive funding mechanisms that provide the foundation for their e-waste management systems and put the main burden of financing collection and recycling processes on producers and (in the case of Japan) consumers, the Vietnamese waste system largely relies on investments, primarily in the form of official development assistance, supported by government spending. Moreover, no funds have been dedicated specifically to the collection and treatment of e-waste (World Bank, 2005: 42-43). Within the formal waste management system, consumers have to pay fees for the collection and disposal of waste, but these revenues are comparatively low. Despite a continuous increase in investments into the waste management system, these funds have

primarily been used to improve the infrastructure, while the resources allocated towards the operation and maintenance of waste collection and disposal systems are not adequate and only partially cover the costs. This situation is aggravated by the fact that current recycling and disposal practices are comparatively cheap, but harmful to the environment. Implementing more sophisticated e-waste management practices would increase the required financial resources. Consequently, ISWM in the Vietnamese e-waste sector requires a substantial improvement of the funding system and the establishment of a sustainable scheme to ensure continuous funding. In addition, cost recovery in waste management is very low, as disposal and recycling site operators rely heavily on government subsidies. Consumer fees recover only 58 per cent of the costs of operation and maintenance of the waste management system (World Bank, 2005: 42-48; Pham, 2007: 5).

Finally, incentives for integrating the informal sector into the formal e-waste management sector are low. As consumers have to pay fees for the formal collection of e-waste, the financial rewards offered by informal ‘waste pickers’ are considered to be preferential (Wiesmeth et al., 2012: 1; Nguyen et al., 2009: 358-359).

Overall, the establishment of a sustainable funding system of Vietnamese e-waste management remains one of the most critical challenges to the implementation of ISWM.

3.4.5 Technical aspects

This sub-chapter considers the practical implementation and operation of the e-waste system elements. It firstly analyzes how much of the nationally generated e-waste is collected and whether there are sufficient e-waste handling facilities. Secondly, the level of advancement in e-waste handling techniques and the quality of recovered materials is examined. The third indicator relates to the skills and equipment of e-waste workers, which is assessed with particular emphasis on differences between the formal and informal sectors.

China

According to national statistics, in 2011, the formal Chinese e-waste system collected 61.3 million units of the five major home appliances for recycling, with television sets accounting for the majority of the collected e-waste (51.5 million units). The generated e-waste in the same year amounted to approximately 150 million units, with computers showing the highest e-waste generation rate (67 million units). Accordingly, the approximate collection rate in 2011 was 41 per cent (Wang et al., 2013: 17-28). As shown in sub-chapters 3.2.1 and 3.3.1, the majority of Chinese e-waste collection and treatment is however handled by the informal

sector. In particular, formal collection rates only account for domestically produced e-waste. The majority of e-waste enters the country through illegal import and is handled entirely by the informal sector. In addition, formal collectors are concentrated in the more developed regions in Eastern China, such as Zhejiang, Jiangsu or Guangdong. Most Western provinces, such as Tibet, Qinghai or Gansu, only have one or two designated formal e-waste recycling companies (Wang et al., 2013: 25-26; Wei and Liu, 2012: 507-509). Similarly, all formal e-waste recycling sites that have been established by the government in the national pilot project are located in the coastal regions of China (Chi et al., 2011: 735-736). Given this uneven distribution of formal collection and recycling companies and sites, the informal sector not only treats imported e-waste, but also covers the majority of the nationally generated e-waste. As data on the informal e-waste sector in China are limited, a reliable assessment of the informal e-waste collection and treatment system is difficult. However, the structure and operating procedures of the informal sector provide an indication regarding its coverage and reach. Research shows that the trading network of the informal e-waste sector is more comprehensive and efficient than the formal sector, with a reach throughout the country. Through a well-established household connection network and door-to-door collection service, informal collectors are able to cover regions that lack wide-ranging formal e-waste collection services. The large scale of the informal sector is a further indicator of extensive collection and treatment capacity. In Guiyu alone, more than 300 enterprises and 3000 individual workshops are engaged in e-waste recycling (Chi et al., 2011: 735; Wei and Liu, 2012: 507-508). Overall, the e-waste collection capacity appears to be fairly advanced in China, even though largely driven by the dominant informal sector.

However, the level of advancement in commonly applied e-waste treatment methods in the informal sector is very low. Most processes are at primitive levels and involve crude techniques, such as:

- “(1) Physical dismantling by using tools such as hammers, chisels, screw drivers and bare hands to separate different materials;*
 - (2) Removing components from printed circuit boards by heating over coal-fired grills;*
 - (3) Stripping of metals in open-pit acid baths to recover gold and other metals;*
 - (4) Chipping and melting plastics without proper ventilation;*
 - (5) Burning cables to recover copper, and burning unwanted materials in open air;*
 - (6) Disposing unsalvageable materials in fields and riverbanks;*
 - (7) Refilling of toner cartridges”*
- (Chi et al., 2011: 735).

These very rudimentary techniques not only pose serious harm to the environment and public health, but they also result in inefficient recycling results. Only the most precious materials that can be easily extracted, e.g. copper wiring or gold plating, are recovered, while less valuable components or components that require more sophisticated recovery techniques, e.g. toner cartridges and printed wiring boards, are discarded (Chi et al., 2011: 736; Hicks, Dietmar and Eugster, 2005: 463). As a result, recovery efficiency is very low and rare resources that could be channeled back to the economy are lost. An aggravating factor of the primitive recycling technologies utilized in the informal sector is the fact that e-waste workers often do not take any precautionary measures to protect themselves from the toxic heavy metals and organic pollutants that are disseminated into the workplace and the environment in the process (Wei and Liu, 2012: 508). Both the level of skills and the level of equipment sophistication used by the informal sector workers are very low. Many recycling processes are carried out directly with bare hands, without further protection. Awareness of the dangers of these methods is equally low (Zhou and Xu, 2012: 4717).

As regards the formal e-waste treatment sector, the level of adherence to environmental standards and recycling efficiencies varies across the regions (Wang et al., 2013: 26; Chi et al., 2011: 735). A government-initiated pilot program has however established complete e-waste recycling systems that draw from international best practice, consisting of a collection channel, integrated recycling processes and a production line for reuse. Some recycling facilities have been able to achieve high recovery rates for metals through advanced recycling technologies. Recycled metals made up 40 per cent of the production of China in 2010 (Zhou and Xu, 2012: 4719). However, recycling processes in the formal sector still face several obstacles. Firstly, advanced technologies are more expensive than manual recovery technologies utilized in the informal sector. Secondly, despite the availability of these advanced technologies, the utilization rate of equipment is still very low and reliability remains a challenge. Thirdly, the capacities of the recycling facilities and workers vary significantly. Some recycling facilities have only been partially built and manual dismantling processes, which are based on basic mechanical technologies, have been adopted by many formal recyclers (Zhou and Xu, 2012: 4721; Wang et al., 2013: 26).

Japan

Even though the Japanese e-waste management system is more advanced than the Chinese system in policy and institutional structure, as well as social integration, the collection rate of target home appliances under the *Home Appliance Recycling Law* is only slightly higher

at 50-60 per cent. Remaining e-waste is traded as second-hand goods or metal scrap, or is exported out of the country. Notably, the *Home Appliance Recycling Law* sets recycling targets for the four designated home appliances, but not collection targets (Hotta, Santo and Tasaki, 2014: 21). Some types of e-waste show even lower collection rates. For instance, in the case of personal computers, the collection rate did not even reach 10 per cent of discarded appliances in 2005 (Yoshida and Yoshida, 2010: 22).

The logistics of the collection and recycling processes in Japan follow a dual structure, as manufacturers have organized themselves into two major groups. Group A holds 40 per cent of the market shares and consists of companies such as Matsushita (Panasonic) and Toshiba. They own 25 recycling plants, which are operated by external waste management contractors. Group B holds 60 per cent of the market shares and consists of companies such as Sony, Fujitsu, Sanyo, Hitachi and Mitsubishi. In contrast to Group A, the 15 recycling plants owned by Group B have been built and are operated by the companies themselves. Both groups' recycling plants are relatively evenly distributed across the different regions of Japan. 380 designated collection sites are supplying the two manufacturer groups with the waste appliances. Overall, all regions of Japan are covered by the collection and recycling system of the two groups and the distribution of the sites is relatively even in proportion to population size and density (DTI Global Watch Mission, 2005: 24-25; Bo and Yamamoto, 2010: 501-502; Yoshida and Yoshida, 2010: 22).

An analysis of the predominant sophistication of recycling facilities shows that manual disassembly and mechanization still co-exist in the Japanese system. There are dedicated treatment lines for each household appliance and products are sorted by type and manufacturer, which provides an efficient structure of the subsequent recycling process (DTI Global Watch Mission, 2005: 38). Japanese companies have been leading in developing novel recycling technologies that reduce the negative environmental impact. Examples include “*welding without insulation and the electrical panel board connections without bromide compounds*” (Gaidajis, Angelakoglou and Aktsoglou, 2010: 198). Compliance with regulations, market conditions and environmental protection are incentives for recycling plants to maximize recycling rates. As reuse is a less common practice in Japan, manufacturers have started to invest into design for environment (DfE), also referred to as ‘eco-design’, through measures that enhance the recycling of appliances, for instance by easing the dismantlement of materials, by reducing the amount of plastic in products, or by using more materials that are easier to separate and recycle (Yoshida and Yoshida, 2010: 25; Aizawa, Yoshida and Sakai, 2008: 1402-1405). In this way, recycling is integrated as a consideration of manufacturing practices rather

than seen as a separate process, which is particularly important in a resource-poor country such as Japan.

As a result of continuous improvements to recycling technologies and processes, Japan has been able to both increase the volume and the quality of recovered materials over time. The recovery rate has increased to more than 70 per cent. Manufacturers have also placed particular emphasis on the management of hazardous materials, inter alia by providing information on known contaminants and adequate treatment methods to recycling plants and sophisticated machines that enable the most efficient and safe handling of hazardous materials (Aizawa, Yoshida and Sakai, 2008: 1402-1405). Overall, the level of knowledge, skills and equipment of workers engaged in the Japanese e-waste sector can be considered high in comparison to the Chinese and Vietnamese sectors.

Vietnam

Due to data limitations and the dominance of the informal e-waste sector in Vietnam, no reliable e-waste collection rates are available. However, given the common practice of reusing end-of-life appliances through repair or refurbishment, rather than applying proper and comprehensive recycling processes that would recover valuable raw materials, the amount of e-waste collected for recycling can be considered comparatively low. As sufficient capacity in the formal e-waste sector has yet to be developed, collection and recycling sites for e-waste are scattered across the country in the form of crafts villages, rather than covering the different regions evenly in proportion to population size and density.

Methods and technologies utilized for e-waste recycling in Vietnam are very basic and only cover bulk materials such as copper, aluminum or some types of plastic. Moreover, the manufacturing market that consumes recovered materials has yet to be developed, which poses an obstacle to the development of the formal recycling sector (Hai, Hung and Quang, 2015: 3-4). Among the 15 licensed official e-waste recycling companies, only three have sufficient capacities to treat e-waste. Even these three companies mainly focus on industrial e-waste rather than household appliances, due to the higher profits, and the volume of e-waste they are able to cover is very low compared to the e-waste generation rates. The treatment and recycling lines used by formal recyclers is mostly comprised of three main stages, utilizing manual or semi-mechanized sections. Overall, treatment methods show a low level of sophistication and the equipment used is basic. Accordingly, the e-waste recovery efficiency is comparatively low (Hai, Hung and Quang, 2015: 5-6).

In addition to the rudimentary methods utilized in the formal and informal e-waste sectors in Vietnam, environmental protection, as well as ensuring clean and safe e-waste processes, is rarely considered in e-waste management processes. Similarly, the level of education and skills, and commonly used equipment of e-waste workers are obsolete and basic (URENCO, 2007: 91-115).

3.4.6 Environmental aspects

This sub-chapter analyzes the environmental implications of e-waste management practices in the three countries, with consideration of the direct damage to the environment, but also of subsequent repercussions to human health. Firstly, the safety and conditions under which e-waste workers are disposing of and recycling e-waste is analyzed. The second criterion examines the environmental pollution through hazardous substances that are released into the environment. Finally, the effects on human health, both through immediate contact with contaminants during e-waste treatment processes and indirectly on people living in the proximity of e-waste treatment sites, are assessed.

China

Alongside increasing concerns about crude and unsafe e-waste treatment practices in China, researchers have started to conduct studies on the detrimental effects that these practices can have on the environment and public health.²⁵ A multitude of shortcomings have been revealed, in particular relating to the release of hazardous substances during e-waste recycling processes. Even though official recycling plants utilize advanced recycling and recovery technologies and efforts are made to improve measures that protect the environment and health in the formal sector, the economic viability remains low. Hence, the majority of e-waste management continues to be handled by the informal sector (He et al., 2006: 510-511). In Guiyu, where most of the informal e-waste recycling is carried out, a number of potentially harmful practices have been observed, including the unprotected removal of printer cartridge toner, the open burning of printed circuit boards and wires to recover copper, chemical stripping through acid along riverbanks, and the use of acid dips to recover gold from chips and other components. Moreover, as these basic methods do not allow for the efficient and complete recycling of appliances, but focus on the most valuable and easy-to-extract materials, large amounts of residues, such as CRT glass and polychlorinated biphenyl (PCB) liquid, are dumped

²⁵ See, for example, Chan et al, 2013; Leung et al., 2008; Chen et al., 2010 and Zheng et al., 2011.

in unsafe conditions into rivers, irrigation ditches or other soil or water sources (Hicks, Dietmar and Eugster, 2005: 460-461; Wang et al., 2013: 22-24). As a consequence, toxic substances are emitted into air, water and soil.

Sample studies that analyze these emissions have uncovered concerning rates of toxic heavy metals, such as lead or mercury, and organic pollutants, such as polychlorinated biphenyls (PCBs), in the informal e-waste recycling sites – not only limited to the workplaces themselves, but also in the surrounding areas. For instance, an analysis of water samples of the Lijiang River showed cadmium and lead rates that were between 4 and 2000 times higher than the guidelines of the World Health Organization (Hicks, Dietmar and Eugster, 2005: 460-461). Other studies of toxic metal dusts recycling workshops in China found that the concentrations of lead were hundreds or thousands of times higher than global standard levels for indoor dusts or at other sample sites. No difference was observed between the dust levels within and in the surroundings of the workshops (Brigden et al., 2005: 4; Leung et al., 2008: 2677). The contamination is not only limited to the workplace and the surrounding areas, but even the home environment of e-waste workers who live in remote areas are affected through contaminated work clothing (Brigden et al., 2005: 4).

E-waste workers and residents living in the proximity are exposed to these toxic substances through air, dermal exposure or food and water. It was reported that in Guiyu, the human exposure of dioxins is 10 to 15 times higher than recommended by the World Trade Organization. In particular, children living in the proximity of Guiyu have shown high levels of toxic heavy metals in their blood. As a consequence, the rates of diseases, including leukemia, skin infections and breathing ailments, is substantially higher than the national average. It is of particular concern that the risk of children suffering health conditions in the studied areas was eight times greater than that of adults (Wei and Liu, 2012: 508-509; Leung et al., 2008: 2679).

Even though these studies of the environmental and health impacts of inadequate e-waste treatment methods in the Chinese informal sector are only exemplary and would have to be extended and validated for a reliable and complete nationwide assessment, they indicate that, at the least, some informal e-waste recycling sites, in particular in Guiyu, not only pose serious risks, but have already resulted in environmental damage and health conditions. On the other hand, as regards the formal sector's impact on the environment and health, analyses are, so far, lacking.

Japan

As shown in sub-chapter 3.4.5, Japan has developed sophisticated and specialized treatment methods for the recycling of four major home appliances. Although manual disassembly is still commonly applied, a number of techniques are implemented to enhance the environmental performance of the treatment process. For instance, in plastics recycling, a technique known as closed material recycling is applied to allow for the reuse of plastic parts in EEE rather than only other plastic goods, which is the case in open material recycling. Similarly, various methods are applied in the processing of metals to separate valuable components for recovery, apply measures for depollution, manage hazardous substances, and ensure a high quality of recovered metal. Although environmental considerations are not yet incorporated as mainstream within industrial design engineering, substantial efforts have been made to promote environmentally sound product design, applying methods such as ‘design for environment’, ‘design for disassembly’ and ‘automated disassembly using smart materials’ (Aizawa, Yoshida and Sakai, 2008: 1403-1405; DTI Global Watch Mission, 2005: 40-49). Using landfills for e-waste residues is an uncommon practice, as recycling rates have been continuously high, ranging between 75 and 92 per cent in 2014 for the four designated household appliances, thereby exceeding the legally set recycling rates (環境省[MOE] and 経済産業省[METI], 2015). Some companies are even able to achieve effective ‘zero emissions’ e-waste treatment by disposing of close to zero percent of e-waste residues in landfills (DTI Global Watch Mission, 2005: 55-95). Manufacturers are also conducting life-cycle assessments and impact analyses of carbon dioxide emissions to assess and decrease the environmental impact of electric and electronic household appliances in the course of their life cycles (Aizawa, Yoshida and Sakai, 2008: 1403).

A study of the greenhouse gas (GHG) emissions produced by the Japanese e-waste management system showed that the largest proportion of emissions (more than 70 per cent) results from smelting and recycling of e-waste due to the high consumption of fossil based energy. Logistical processes, including the collection and transportation of e-waste, are responsible for the least GHG emissions during e-waste processing (Menikpura, Santo and Hotta, 2014: 188). At the same time, the recycling of e-waste allows for the recovery of valuable resources. Thereby, emissions that would arise during the extraction of these resources through virgin production, which includes procedures, such as mining, transportation of resources and processing, can be avoided. When subtracting the GHG emission rates of the virgin resource production from those of the current e-waste management process, the result is net negative values for all four types of household appliances. Hence, rather than increasing the GHG

emissions of Japan, e-waste recycling contributes to the avoidance of emissions that would otherwise arise from resource extraction processes (Menikpura, Santo and Hotta, 2014: 188-190). It also shows that the recycling of e-waste can have positive climate co-benefits for countries.

As regards the health condition of e-waste workers and of persons living in the vicinity of e-waste recycling sites, no information is available. When assessing the environmental impact of e-waste management in Japan, more consideration has to be given to the human element.

Vietnam

As shown, the majority of e-waste management is handled by the informal sector in Vietnam, which focuses on dismantling and refurbishing, rather than recycling of e-waste. The conditions of the workplace in these craft villages is mostly very poor. Workers often live in close proximity to the workplace and utilize obsolete and rudimentary equipment. Dismantling processes are primarily carried out manually and in unsafe conditions, which poses risks to the environment and human health. Even the few formal treatment and recycling sites mostly use manual or semi-mechanized methods, with little regard to environmental impacts (URENCO, 2007: 113-114; Hai, Hung and Quang, 2015: 3-6). Moreover, treatment facilities for hazardous waste that meet safety and environmental standards are currently lacking in Vietnam. Common practices in the treatment of hazardous substances in e-waste include the disposal of hazardous substances in landfills without segregation from non-hazardous wastes and the discharge of toxic liquids within the wastewater effluent stream (Thai, 2009: 260-262). In some areas, solid e-waste is dumped into ponds and rivers without any safety measures (URENCO, 2007: 118).

Several studies have analyzed the detrimental effects of these practices on the environment and public health.²⁶ Air, water and soil pollution in the vicinity of crafts villages has been recorded with levels between two and twelve times higher than national standards (URENCO, 2007: 115-117).

A recent analysis of various toxic heavy metal and flame retardant concentrations in soils and river sediments of informal e-waste recycling areas in Northern Vietnam revealed that the levels were multiple times higher than in rural and urban areas in Europe and similar in magnitude to those examined in e-waste recycling areas in China. In particular, the open storage of e-waste was identified as a facilitator of environmental pollution (Matsukami et al., 2015:

²⁶ See, for example, Tue et al., 2010a; Tue et al., 2010b; and Matsukami et al., 2015.

496). Other studies focused their attention on the human exposure to flame retardants and organic pollutants by analyzing house dust and breast milk from women living in proximity to Vietnamese e-waste recycling sites. All studies showed high levels of toxic substances, which greatly exceeded the samples taken from reference sites and are comparable to the highest levels observed in developed countries. While resulting health conditions of the population have not been comprehensively evaluated, the measured levels of pollutants pose severe health risks, in particular to infants and might lead to distorted motor behavior, decreased learning capabilities or even more serious health conditions (Tue et al., 2010a: 2161; Tue et al., 2010b: 9196-9199).

Although research into the health conditions of e-waste workers and population living in the proximity of e-waste treatment and recycling sites in Vietnam is limited, a survey in three crafts villages showed that common diseases relating to dust, noise, toxic substances and other occupational hazards included respiratory, ear, throat, skin and nervous disorders. In one village, 87 per cent of the population suffered from abrasions and ulcerations. Moreover, accidents caused by power presses, electrical furnaces or dysfunctional equipment were common (URENCO, 2007: 118).

4. Comparative analysis

The previous part has analyzed the e-waste management systems of China, Japan and Vietnam by examining the three dimensions of the ISWM framework: Stakeholders, waste system elements and sustainability aspects. The analysis of these different elements showed that the three countries share similarities regarding certain aspects and diverge regarding other aspects. This part examines these similarities and differences in more detail.

4.1 Stakeholder landscape

The analysis of the stakeholder landscape within the e-waste management system in China, Japan and Vietnam is summarized in Figure 4.1. All three countries show a distinct structure of stakeholders and their role and interaction within the system, while also showing some similarities.

<i>Stakeholder</i>	China		Japan		Vietnam	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
<i>Government institutions</i>	✓		✓		✓	
<i>Producers</i>	✓		✓			
<i>Retailers</i>			✓		✓	
<i>Formal collectors and recyclers</i>	✓		✓			
<i>Informal collectors and recyclers</i>	✓			✓	✓	
<i>Consumers</i>		✓	✓			✓
<i>Industrial associations</i>		✓		✓		
<i>Research institutions</i>		✓		✓		✓
<i>NGOs</i>		✓		✓		

Figure 4.1: Stakeholder landscape in China, Japan and Vietnam.

The government plays a key and primary role within all three countries – as regulator, coordinator and facilitator of e-waste management activities. This centralized governing approach to e-waste management is important for ensuring that all stakeholders cooperate and know their roles and responsibilities, representing a crucial element of ISWM. While this role could also be fulfilled by a non-state actor, such as a business leader, the three countries have placed their emphasis on strong government leadership.

However, in the implementation of e-waste management policies, China, Japan and Vietnam apply profoundly different approaches. In fact, government institutions are the only actors that function as a primary stakeholder group across all three countries. In day-to-day e-

waste management, the formal e-waste collection and recycling sector, as well as producers, retailers and consumers share the main responsibilities in Japan. Conversely, China and Vietnam have not yet been able to establish a strong formal e-waste sector, which integrates consumers and manufacturers as the main producers of e-waste. Instead, both the Chinese and Vietnamese informal e-waste collection and recycling sectors play key roles in handling the growing amounts of e-waste produced domestically or entering the countries through illegal channels. While the Chinese government has put substantial efforts into establishing a formal e-waste collection and treatment system, the integration of informal recyclers into that system remains a challenge. In Vietnam, on the other hand, the development of a formal system has not yet been effective, as the significance of approaching e-waste as a distinct issue, which requires targeted measures, has not, so far, been sufficiently recognized. In Japan, the informal sector is only a secondary stakeholder group in the vastly regulated and monitored e-waste management system. As the export of e-waste has not been criminalized, local informal traders are able to collect WEEE directly from consumers and export it to other countries within the region, including China, Vietnam, Cambodia and the Philippines.

In addition, the role of consumers in the three analyzed countries' e-waste sectors differs substantially. In China and Vietnam consumers are not integrated into the formal system as a primary stakeholder, which would recognize their principal role as producers of e-waste. Instead, their link to the e-waste management system is more indirect, as they do not have a specific role, but informal e-waste collectors gather appliances directly from the consumers' households in a door-to-door manner. Awareness of consumer responsibility, as well as environmental awareness, is low in both countries compared to Japan. The Japanese system on the other hand fully recognizes the significance of integrating consumers as primary stakeholders into e-waste management, not least through explicit responsibilities assigned to them in relevant legislation.

Overall, the comparison of the stakeholder landscapes shows that Vietnam and Japan are at opposing sites of the spectrum, whereas China shows similarities with both, mainly due to the government's efforts to develop a more integrated stakeholder structure. The Vietnamese stakeholder landscape has a dispersed structure, which heavily relies on the informal sector. Formal integration of the main e-waste producers has not yet begun and other groups of society that could facilitate this process, such as civil society organizations or industrial associations, remain inactive in this area. The Chinese e-waste sector is similarly dominated by the informal sector, with consumers preferring to gain financial rewards when disposing of e-waste. However, first steps towards establishing a formal e-waste collection and treatment system and

integrating producers to hold them accountable for domestic e-waste production have commenced. Moreover, secondary stakeholders from academia, civil society and industry play an increasing role in promoting environmentally sound e-waste recycling. Among the three countries, the Japanese e-waste stakeholder landscape is closest to the ideal of the ISWM model. The government has successfully established a comprehensive system, in which consumers, manufacturers, retailers, collectors and recyclers have clear roles and responsibilities. A manifest system, licensing schemes and regular monitoring ensure that each actor performs its function within this structure. Secondary stakeholders, including industry associations, NGOs and researchers, support these processes. However, while less significant than in China and Vietnam, a proportion of e-waste is handled outside of the formal system. If not illegally dumped, this fraction of domestically produced e-waste is exported to developing countries in the region, which do not adhere to the same extent with the ISWM framework. Thus, in order to ensure a comprehensive ISWM approach to e-waste in Japan, this detached part of the e-waste sector would have to be integrated into the formal system.

4.2 Waste system elements

The main waste system elements applied in China, Japan and Vietnam have been analyzed in relation to the five measures of the waste management hierarchy. Export was added as a sixth element due to its significance in Japan. While exporting waste is not an actual treatment method, it has to be considered in the analysis, as e-waste is most likely to be treated in less environmentally sound conditions in the import country (see sub-chapter 3.1.1). It therefore represents an unfavorable element within the hierarchy. Recycling and reuse have been included as separate recovery-related elements, as they show significant variances regarding their prevalence in the three countries. Consequently, in total, seven measures were distinguished. The results of the waste system elements analysis are summarized in Figure 4.2.

<i>Waste system elements</i>	China		Japan		Vietnam	
	Main	Less common	Main	Less common	Main	Less common
<i>Prevention</i>			✓			
<i>Reduction</i>		✓	✓			
<i>Recovery (recycling)</i>	✓		✓			✓
<i>Recovery (reuse)</i>	✓		✓		✓	
<i>Recovery (energy generation)</i>		✓		✓		
<i>Disposal</i>		✓		✓		✓
<i>Export</i>			✓			

Figure 4.2: Waste system elements in China, Japan and Vietnam.

Although there are no detailed data on the share of the various measures within the e-waste management systems (which would allow for a graph that shows the shape of the waste system hierarchy ‘pyramid’ in the three countries), a distinction between elements that are predominantly applied, elements that are less commonly applied, and elements that have little to no significance within the system was made. A similarity between China, Japan and Vietnam is the prevalence of reuse as one of the predominantly applied measures, although its significance in Vietnam is much higher than in the other two countries as the single most frequently applied e-waste handling measure. The second similarity is the secondary role of e-waste disposal. While utilized in all three countries, it does not represent a main waste system element, which is in accordance with the ISWM model. However, the utilization of the other five elements varies across the three countries.

Out of the three analyzed countries, only Japan applies all seven waste system elements. The most preferential elements, such as prevention, reduction and recycling, are among the

most commonly applied measures. Recovery for energy generation and disposal of e-waste, which represent the least preferential elements of the hierarchy, are less commonly utilized. In this regard, compared to China and Vietnam, the composition and emphasis of the waste system elements in the Japanese e-waste sector are closest to the optimal ISWM framework. Nevertheless, one major shortcoming of the system is the prevalence of e-waste export.

As laid out in sub-chapter 3.1.5, a proportion of illegally imported e-waste flows through Vietnam and is re-exported to China. Through a second illegal route, e-waste flows from China to Vietnam. Due to this virtually circular e-waste flow, the significance of export in China and Vietnam is comparatively low among the common waste system elements. Instead, reuse (in the case of Vietnam), and recycling and reuse (in the case of China) are the most commonly applied e-waste treatment methods. The emphasis lies thus on the middle parts of the waste management hierarchy. While there are some efforts to promote the reduction of e-waste in China, reduction and prevention measures have yet to be implemented in Vietnam. Contrary to Vietnam, China also deploys recovery processes to generate energy from e-waste as a secondary waste system element. This method is one of the less preferential elements in the hierarchy.

Overall, the comparison of the waste system elements in the Chinese, Japanese and Vietnamese e-waste management system reveals similar patterns to the stakeholder landscapes, with Japan and Vietnam representing the lower and upper ends as regards sophistication, diversification and adherence to the waste system hierarchy and the ISWM framework. Only three of the seven identified waste system elements are prevalent in Vietnam, which are at the lower and middle levels of the waste system hierarchy. Most preferential methods, such as prevention and reduction of e-waste, have not been developed. While China similarly focusses on recovery measures, which are in the middle of the hierarchy, efforts towards reduction of e-waste have commenced. Moreover, the Chinese waste system elements are more diversified than those deployed in Vietnam. However, only Japan applies all seven waste system elements. Although the preference across these elements mostly adheres to the optimum of the waste system hierarchy, a significant proportion of e-waste is exported to developing countries, which is one of the least preferential waste system elements. For ISWM to be effective in Japan, measures that reduce the export of e-waste, such as financial incentives for informal e-waste traders that discourage e-waste export, have to be implemented.

4.3 Sustainability aspects

The third dimension of the ISWM model, sustainability aspects, was analyzed through six sets of criteria and indicators, which address the various elements of a sustainable e-waste management system. This chapter compares the results of this analysis across China, Japan and Vietnam. Similarly to the stakeholder landscape and waste system elements, each of the aspects revealed similarities and differences between the three countries.

Policy and legal aspects

A comprehensive legal and policy framework forms the basis of an operative national e-waste management system. This framework is ideally comprised of effectively enforced e-waste specific legislation that complies with international instruments and a corresponding ISWM plan or policy that is tailored to address the unique challenges of e-waste and sets clear roles and responsibilities, including the establishment of extended producer responsibility. Figure 4.3 summarizes to what extent China, Japan and Vietnam have established this framework in their national contexts.

Criteria	Indicators	China	Japan	Vietnam
National legal framework	<i>General and/or e-waste specific</i>	General and e-waste specific	General and e-waste specific	General
	<i>National/province/local level</i>	National and local	National	National
	<i>Comprehensive/fragmented</i>	Fragmented	Comprehensive	Fragmented
	<i>Enforcement</i>	Yes (partially)	Yes	No
ISWM plan	<i>General and/or e-waste specific</i>	No national plan	General	General
	<i>Comprehensive/fragmented</i>	n/a	Comprehensive	Comprehensive
	<i>Determination of objectives and priorities</i>	n/a	Clearly defined	Clearly defined
	<i>Determination of roles and responsibilities</i>	n/a	Clearly defined at all levels	Clearly defined at national level
Adoption and implementation of international instruments	<i>Ratified and implemented Basel Convention</i>	Yes	Yes	Ratified
	<i>Participation in Basel Convention e-waste programs</i>	Yes (active)	Yes (active)	Yes (passive)
Extended producer responsibility	<i>Established/enforced and enforced</i>	Established, partially enforced	Established and enforced	Not established

Figure 4.3: Policy and legal aspects of e-waste management in China, Japan and Vietnam.

All three countries have adopted legislation that is applicable to e-waste management, have ratified the Basel Convention and participate in e-waste related activities conducted under the Convention. However, as regards the reach, specificity and implementation of the legal and

policy framework, China, Japan and Vietnam are at different stages. Among the three countries, the Japanese legal framework is the most comprehensive and most effectively enforced. Although the Chinese government has also developed e-waste specific national and local legislation, its scope is limited and does not cover all aspects of the e-waste management system. Moreover, its enforcement has only been partially achieved. Vietnam, on the other hand, lacks an e-waste specific legal framework and instead relies on general waste management laws, which have not yet been enforced in relation to e-waste collection and recycling.

None of the three countries have developed a specific ISWM plan that addresses e-waste. However, Japan and Vietnam have both adopted general plans that cover the core aspects of ISWM, distribute clear roles and responsibilities and set objectives and milestones, namely the *Fundamental Plan for Establishing a Sound Material-Cycle Society* (Japan) and the *National Strategy for Integrated Management of Solid Waste up to 2025, vision towards 2050* (Vietnam). Conversely, China has not established a similar plan.

In the regional and international arena, all three countries participate in e-waste programs under the Basel Convention. However, Japan has been the most active player in the region and instigator of a number of activities, thereby acting as one of the donor countries and inter alia providing technical and financial support across the region. China has a similarly active role, although it acts both as a provider and as a recipient of assistance and activities. In contrast, Vietnam has yet to fully implement the Basel Convention in its national laws and policies and acts as a recipient of e-waste management assistance, rather than pursuing an active role. This factor supports the results of the stakeholders and waste system elements analysis, which suggest that Vietnam and Japan represent the lower and higher levels of compliance with ISWM principles, while China's advancement can be located between the two ends of the spectrum.

This inference is reinforced when examining the implementation of extended producer responsibility policy in the three countries. EPR is one of the key elements of the Japanese e-waste management framework and Japan was an early adopter of the policy. In contrast, China has only recently established an EPR policy and full enforcement is still pending. Finally, although the government has indicated an intention to implement EPR on a national level, Vietnam has not yet adopted such a policy.

Apart from these differences, the indicators show that all three countries are on a path towards a more integrated and sustainable e-waste legal and policy framework that adheres to the ideal of the ISWM model.

Institutional aspects

Having established a comprehensive and integrated legal and policy framework, the implementation of this framework requires central coordination, a clear allocation of roles and responsibilities with sufficient capacities to perform the required functions, as well as effective cooperation with the private sector and international partners. The results of the analysis of the institutional aspects in China, Japan and Vietnam are presented in Figure 4.4.

Criteria	Indicators	China	Japan	Vietnam
Waste management structure	<i>Involved institutions</i>	6 main	2 main, 1 support	8+ main
	<i>Centralized/decentralized</i>	Centralized	Centralized	Not clear
	<i>Clear division of responsibilities</i>	Partially	Yes	No
Institutional capacity	<i>Sufficient/insufficient</i>	n/a	n/a	Low
Private sector involvement	<i>Private sector participation in e-waste management and public-private partnerships</i>	Yes	Yes	No
International partnerships	<i>Regional/bilateral partnerships</i>	Yes	Yes	Yes (passive)
	<i>Participation in global initiatives</i>	Yes	Yes	Yes (passive)

Figure 4.4: Institutional aspects of e-waste management in China, Japan and Vietnam.

The institutional structure in the three countries varies significantly. The only similarity across all countries is the engagement with international partners, which differs however in its form and scope.

Similarly to the factors analyzed above, Japan complies to the greatest extent with ISWM standards. Contrary to China and Vietnam, only two institutions share the main responsibilities and coordinating role of the centralized Japanese e-waste management system at the national level, namely MOE and METI. The two ministries carry out their duties in close collaboration. In contrast, the number of institutions directly involved in the e-waste management process in China and Vietnam is considerably higher, amounting to six and more than eight respectively. Among these organizations, tasks are disbursed and overlap partially, or are not clearly defined. In the case of Vietnam, no institution has been appointed to specifically address e-waste and the division of responsibilities in the general waste management process is unclear. Having one or two lead institutions with the mandate to oversee and coordinate e-waste management on all levels is crucial to ensuring the efficient use of resources and effective cooperation among the various institutions.

A clear data gap has been revealed relating to the capacities of the relevant organizations in carrying out their assigned tasks. Apart from sources that indicated a severe lack of capacities and resources in Vietnamese agencies responsible for (e-)waste management, no information is

available on the level of capacity in China and Japan. Carrying out an assessment of the capacities and gaps within the Chinese and Japanese institutional e-waste frameworks would allow for the strategic investment of resources and enhancement of the implementation of national policies at the institutional level.

While private sector entities do play a role in e-waste management in all three countries, their role differs. In Vietnam, public-private partnerships have not been established, which reflects the fragmented organizational structure of the e-waste management process. The Chinese and Japanese governments, on the other hand, have both recognized the vital role of engaging private sector entities and have developed cooperative relationships with manufacturers, import and export enterprises, recycling companies, etc. This process is however driven by the government as a top-down rather than a bottom-up approach.

Similarly, both governments have actively engaged with international partners to initiate cooperation projects, which often bring together national and international stakeholders from various backgrounds. Apart from these government-driven initiatives and international organizations and companies launching domestic campaigns to promote the environmentally sound disposal and recycling of e-waste, local companies have yet to enhance their role in proactively instigating similar projects and enhancing cooperation across different industrial sectors. Vietnam, on the other hand, is primarily engaging with international partners in a reactive manner.

In general, the analysis of the institutional e-waste framework in China, Japan and Vietnam confirms the previous observation, which placed Japan and Vietnam at the two ends of the spectrum, whereas China is at an intermediate stage between the two countries.

Socio-cultural aspects

The third set of criteria and indicators relates to the social and cultural aspects of ISWM. As consumers and society at large are the primary producers of e-waste, whether by discarding appliances individually or as businesses and organizations, creating awareness and a culture of responsible e-waste disposal is a key element in a sustainable e-waste management framework. Integrating the public into this framework, for instance by enabling citizen reporting of illegal dumping, establishing online communication platforms or implementing large-scale awareness raising campaigns, ensures that ISWM is not only conducted through a top-down approach, but that it ultimately leads to a broad mind-set of responsible and environmentally sound e-waste disposal. The analysis of the socio-cultural aspects of e-waste management in China, Japan and Vietnam is summarized in Figure 4.5.

Criteria	Indicators	China	Japan	Vietnam
Citizen participation and integration	<i>Level of public involvement</i>	Low	High	Low
	<i>Existence of communication mechanisms</i>	No	Yes	No
	<i>Existence of reporting mechanisms</i>	No	No	No
Public education and awareness raising	<i>Existence and scope of awareness raising and educational campaigns</i>	Yes (ad-hoc, low effectiveness)	Yes (large-scale)	Yes (ad-hoc, pilot phase)

Figure 4.5: Socio-cultural aspects of e-waste management in China, Japan and Vietnam.

The table shows that the integration of the general public into e-waste management varies significantly across the three analyzed countries. In Japan, the general public is recognized as a core stakeholder in effective e-waste management. Apart from requiring consumers to pay collection and recycling fees under the *Home Appliance Recycling Law*, the Japanese government has also put substantial effort into promoting safe e-waste disposal practices through targeted awareness and educational initiatives, by providing information online and by establishing communication channels for citizens. Among the four analyzed indicators of the socio-cultural aspects, Japan only lacks reporting mechanisms. Establishing such a mechanism would address the existing issue of illegally dumped e-waste by enabling a clear channel for citizens to report such incidents in a timely fashion. It would thereby support local authorities who are responsible for detecting and handling illegally disposed e-waste.

In contrast to Japan, the integration of citizens into the Chinese and Vietnamese e-waste management system is low. Neither communication nor reporting mechanisms have been established and the recognition of consumer responsibility as main e-waste producers, as well as the potential of citizen participation in e-waste management processes is lacking. While China promotes awareness and education of the general public through national campaigns, their effectiveness is comparatively low and they are not yet implemented strategically. Similarly, Vietnam has only just begun promoting citizen awareness of e-waste related issues. The effectiveness of these initiatives will be shown in the coming years. Generally, China and Vietnam deviate substantially from the ISWM model regarding socio-cultural aspects of the e-waste sectors. Inclusion of citizens into e-waste management is still low. On the other hand, Japan complies with most factors of the socio-cultural ISWM aspects.

Financial and economic aspects

The ISWM framework is only viable if sufficient and sustainable resources have been allocated for its implementation. Thus, the analysis of the funding mechanism and cost recovery measures indicates to what extent the national policy and institutional structures can be

implemented at the local levels. In order to ensure that funding of the e-waste management system is sustainable, it should ideally not depend on a single donor, such as a government agency or a foreign investor, but be dispersed among various actors and supported by a cost recovery mechanism which exploits the resource value of recycled e-waste materials.

In addition, the informal sector can pose a challenge in the establishment of a large-scale formal sector for e-waste collection and recycling, in particular in developing countries. Establishing economic incentives to encourage informal waste collectors and recyclers to engage in formal activities is thus an important factor of the economic aspects of ISWM.

The findings from evaluating the financial and economic aspects of the e-waste management systems in China, Japan and Vietnam are presented in Figure 4.6.

Criteria	Indicators	China	Japan	Vietnam
Funding	<i>Centralized/decentralized</i>	Centralized	Decentralized	Mixed
	<i>Government/private sector/international organizations</i>	Private sector (government-administered)	Private sector/local government	Official development assistance/government
Cost recovery	<i>Recovery mechanisms and measures</i>	Low	Medium	Low
Informal sector	<i>Economic incentives for informal sector workers</i>	Low	None	None

Figure 4.6: Financial and economic aspects of e-waste management in China, Japan and Vietnam.

Similarly to the socio-cultural aspects, China, Japan and Vietnam differ substantially regarding the economic and financial setup of the e-waste management activities. As regards the overall funding mechanism, China has established a centralized, government-coordinated structure which places the burden of financing e-waste collection and recycling on the private sector. Japan, on the other hand, applies a decentralized approach in which manufacturers and local governments share the costs of collection and recycling, while part of the funding is raised directly from consumers. The differences in the two systems reflect the overall political and economic structure of China and Japan. In this way, both countries have established a funding mechanism which adheres to ISWM standards, but considers local characteristics. In contrast, the Vietnamese (e-)waste management system relies mainly on foreign donations through official development assistance and government funds. Developing a sustainable funding scheme with dedicated resources for the management of e-waste would form a crucial step towards ISWM in Vietnam.

In addition, utilizing the resource value of e-waste by extracting valuable resources and channeling them back to the economy is an important element of ISWM, which is insufficiently implemented in China and Vietnam. Among the three countries, Japan is able to recover the most costs through e-waste recycling and recovery. However, private sector entities involved

in the formal e-waste recycling system in Japan are still making losses, which renders cost recovery measures only partially effective.

As regards the last indicator of the financial and economic aspects, which relates to the existence of economic incentives for informal sector workers, none of the three countries have developed a comprehensive incentive structure that would effectively integrate informal waste collectors and recyclers into the formal economy. This shortcoming is particularly important in the Chinese and Vietnamese systems which are characterized by a strong informal sector which operates in underdeveloped and unsafe conditions and impedes the functioning of the formal operators. Only China has begun to introduce first actions that provide positive incentives to informal workers, after regulatory and punitive measures have proven ineffective in solving the problem. These initiatives, such as the integration of individual recyclers in industrial recycling parks which are focused on manual dismantling of e-waste or the technical improvement of informal recycling workshops, are however ad-hoc in nature and have to be scaled up in order to induce a wide-reaching shift in the e-waste management sector. While no incentivizing measures have been implemented in Vietnam, Japan not only lacks such a structure, but the inherent features of its e-waste management system have led to negative incentives. The financial costs of disposing of and recycling e-waste encourage some citizens and informal traders to dispose of e-waste through illegal channels outside of the formal system, either by uncontrolled dumping or export of e-waste. Therefore, among the six analyzed sustainability aspects, the economic performance is lowest in Japan. This last indicator further represents the only factor in which Japan adheres the least to the ISWM model, compared to China and Vietnam.

Technical aspects

The fifth set of indicators analyzes the practical implementation of the e-waste management framework and, thus, relates closely to the prevalent waste system elements. Utilizing the resource value of e-waste to its fullest and maximizing the recovery of materials requires an e-waste collection system, which spans across the country and is able to achieve a high collection rate, sophisticated technologies and treatment methods, as well as a well-trained workforce. Figure 4.7 summarizes the extent to which China, Japan and Vietnam have achieved these optimums.

The analysis of the indicators showed diverse results for the three countries. In particular, the difference between the informal and formal sector in China is most apparent as regards technical aspects. Although the achieved e-waste collection rate of 41 per cent in 2011

was not greatly different from the average collection rate of 50 to 60 per cent in Japan, this number only applies to domestically produced e-waste collected by the formal sector. Hence, the high amount of illegally imported e-waste is unaccounted for in available statistics. While indications regarding the collection rate of the informal sector are lacking, its network spans across the country through door-to-door e-waste collection. The not fully developed formal sector on the other hand is mainly concentrated in East China and its capacities do not yet reach all areas of the country. In Japan, although collection rates should be improved, e-waste collection and treatment facilities are evenly distributed across the different regions. Vietnam, on the other hand, lacks a functioning collection network, which leads to a lack of data on collection rates.

Criteria	Indicators	China	Japan	Vietnam
Collection rate and coverage	% of generated e-waste that is collected	Formal: 41% (2011) Informal: n/a	50-60%	n/a
	Location and coverage of e-waste handling facilities	Formal: Uneven, concentrated in East China Informal: Nation-wide network	Even, nation-wide	Unstructured
Technology and infrastructure	Sophistication of collection and treatment methods	Formal: Low to High Informal: Low	Medium	Low
	Recovery efficiency	Formal: Low to High Informal: Low	High	Low
E-waste workers	Level of skills and equipment	Formal: Low to High Informal: Low	High	Low

Figure 4.7: Technical aspects of e-waste management in China, Japan and Vietnam.

As regards technology and infrastructure, China and Vietnam mainly deploy crude and basic methods in the treatment of e-waste, although some of the formal treatment facilities in China have more advanced equipment and techniques. Accordingly, the recovery efficiency in both countries is generally low, with some exceptions in the Chinese formal sector. This low level of sophistication is confirmed by the level of skills and equipment among e-waste workers in China and Vietnam. Overall, China has taken steps towards advancing techniques, equipment and skills, but this progress is uneven and limited to the formal e-waste sector, whereas Vietnam is still lacking similar improvements. Japan, on the other hand, is closest to the ISWM standards in technical advancement and skills and equipment applied in the e-waste sector. Although not all formal recycling sites utilize advanced automated technologies, and manual e-waste processing is still partly applied, the overall technical sophistication is high and has led to high

recovery rates. Moreover, companies have invested in improving the environmental performance of EEE by taking measures to promote design for environment (DfE).

When comparing the technical aspects of e-waste management in China, Japan and Vietnam, the previous observation is reinforced. Japan complies to the greatest extent with the ISWM model, while Vietnam complies the least. China, although still at an early stage in its technical development, has started to improve its technical capabilities. As a next step, these sophisticated techniques should be implemented across the formal sector and the informal sector.

Environmental aspects

The threat of unsafe e-waste management lies in the potential adverse effects to the environment and public health. Analyzing the environmental impact of prevalent e-waste handling practices is therefore an important aspect of ISWM. Within this factor, three criteria were examined which focus on the safety of e-waste recycling and disposal, the emission of hazardous substances and associated health implications. The results of this analysis in China, Japan and Vietnam are presented in Figure 4.8.

Criteria	Indicators	China	Japan	Vietnam
Safety of e-waste management processes	<i>Safety of recycling practices</i>	Formal: Medium Informal: Low	High	Low
	<i>Use of unsafe landfills for e-waste disposal</i>	Formal: n/a Informal: Common	Uncommon	Sometimes
Emissions of hazardous substances	<i>Emission rates</i>	High	Co-benefits	High
	<i>Environmental pollution</i>	High	Low	High
Health conditions of the population	<i>Health conditions of e-waste workers</i>	High risks to health	n/a	High risks to health
	<i>Health conditions of population living in proximity</i>	High risks to health	n/a	High risks to health

Figure 4.8: Environmental aspects of e-waste management in China, Japan and Vietnam.

Similarly to the socio-cultural, economic and technical sustainability aspects, China, Japan and Vietnam differ substantially in the environmental and health performance of the respective e-waste sectors. Among the three countries, Japan adheres to the greatest extent with the ISWM model. The general safety of deployed e-waste recycling practices is comparatively high and landfills are only used for a small amount of residues. Rather than contributing to environmental pollution, the net emission rates are negative, i.e. the recovery of materials through e-waste recycling results in lower emissions than the virgin resource production. Even though data regarding the public health implications of e-waste treatment in Japan are lacking, the high environmental performance suggests that public health is less negatively affected than

in China and Vietnam. However, in order to ensure a comprehensive application of the ISWM model in Japan, the health conditions of e-waste workers and population living in the vicinity of e-waste recycling sites should be analyzed.

In contrast to Japan, China and Vietnam face serious environmental damage from unsafe e-waste recycling and disposal, even though the Chinese formal recycling sector shows a slightly better performance. In accordance with the analysis of waste system elements and the technical aspects of e-waste management, the recycling practices applied in both countries are mostly rudimentary and unsafe. In addition, although not the predominant practice, unsafe landfills are in some cases used for the disposal of e-waste.

As a consequence, emission rates and environmental pollution of air, soil and water resources are high in China and Vietnam, in particular in areas where e-waste is handled informally. Case studies further show that the environmental pollution has led to a number of health issues, which not only affect e-waste workers, but also persons living close to e-waste recycling sites and even families of e-waste workers that do not live in the proximity through the transport of hazardous substances via clothing items.

In general, the analysis of the environmental aspects of e-waste management in China, Japan and Vietnam corresponds with the previous results. While Japan mostly adheres to the ISWM standards, the results place China and Vietnam at the lower end of environmental and public health performance.

Another finding within this set of indicators is the limited availability of data. Health conditions of e-waste workers and of populations living in proximity to recycling and disposal sites is one of the least studied areas of ISWM in the e-waste sector. While there are no data for Japan, China and Vietnam are analyzed through sample studies, which need to be expanded to broader regions within the countries and validated in order to gather reliable long-term data. A detailed understanding of the health impacts of unsafe e-waste handling is key to preventing and mitigating the risks posed by hazardous substances contained in e-waste.

5. Conclusion

This thesis set out to compare e-waste management in China, Japan and Vietnam. The objective of the thesis was to identify similarities and differences in the respective e-waste management approaches according to the international best practice standard of *Integrated Sustainable Waste Management*. After giving a broad overview of the state of e-waste at the global and national levels in the three countries, emphasizing the interconnected cross-national flows, part four examined to what extent China, Vietnam and Japan comply with the three dimensions of ISWM: Stakeholder structure, waste system elements and the six sustainability aspects. According to the ISWM model, the various analytical components were assessed independently and without ranking or hierarchical order, but under consideration of interlinkages among the different factors. Within all three dimensions, substantial differences between the three e-waste management approaches were identified. Figure 5.1 summarizes the results of this analysis, demonstrating in which dimensions and aspects the three countries show similarities or differences.

<i>Dimensions/Aspects</i>	Japan	China	Vietnam
<i>Stakeholders</i>	<i>Similar</i>		
<i>Waste system elements</i>	<i>Similar</i>		
<i>Policy and legal aspects</i>			
<i>Institutional aspects</i>	<i>Similar</i>		
<i>Socio-cultural aspects</i>		<i>Similar</i>	
<i>Financial and economic aspects</i>			
<i>Technical aspects</i>			
<i>Environmental aspects</i>		<i>Similar</i>	

Figure 5.1: Similarities and differences in e-waste management approaches in China, Japan and Vietnam.

This comparison demonstrates several findings. In none of the analyzed dimensions and aspects are all three countries consistent. It is only within 4 of the total of 53 analytical categories that the three countries correspond, namely the primary role of the government in e-waste management, the existence of research institutions dedicated to e-waste related issues, the utilization of reuse as a waste system element, and the lack of a citizen reporting mechanism for illegal e-waste dumping. This strong divergence is mainly due to the significant differences between the Japanese and Vietnamese e-waste management systems. As shown in Figure 5.1, the two countries do not overlap in any of the eight main elements of the ISWM framework. Conversely, the Chinese system intersects with the Japanese and Vietnamese system regarding

various factors. China and Japan mainly resemble each other in aspects relating to the general structure of e-waste management, such as the overall composition of stakeholders, the institutional framework or the utilized e-waste handling processes. However, the two countries differ in the implementation and realization of this structure. While Japan is characterized by a generally highly advanced approach in relation to the ISWM framework, China faces challenges in the enforcement of laws and policies, in the technical and economic performance of the e-waste sector, as well as in the environmental and health impact of its e-waste handling practices, which is predominantly a result of the persistent informal e-waste sector. Vietnam shares many of these challenges, but shows an even higher dependence on the informal e-waste collection and recycling industry. Moreover, it differs from the Chinese approach in its insufficient and fragmented legal, institutional and structural e-waste management framework, which fails to recognize the distinct challenges associated with e-waste and instead applies general waste management processes. It is noteworthy that none of the three countries had an ISWM plan or strategy specifically for e-waste in place, even though the distinct challenges were recognized through the adoption of specific legal and regulatory instruments.

Overall, the analysis shows that the Vietnamese e-waste management approach is least consistent with the ISWM model, whereas Japan complies to the greatest extent with the ideals of the framework. Chinese progress towards ISWM is mostly located between the two countries, with efforts being made to elevate the e-waste system towards ISWM. However, Japan's adherence to ISWM ideals, while generally high, is limited to domestically treated e-waste. Approximately one third of produced e-waste is exported to developing countries, including China and Vietnam. This proportion of Japanese e-waste is thus likely handled in less sustainable conditions and needs to be considered in the overall assessment.

Having analyzed the progress of each country towards ISWM and the inherent similarities and differences across China, Japan and Vietnam, it is possible to answer the secondary research questions, which aimed at identifying patterns. A distribution of the e-waste management approaches according to import, export and transit (re-export) countries tends to suggest an 'intermediary' role for Vietnam, as the country engages in both import and export of e-waste through different flows and entry and exit points. China and Japan on the other hand can both be clearly identified as import and export countries respectively. These characteristics are not fully reflected in the results of the comparative analysis. Although there are inherent differences between the countries which relate to their status as an import or export country,²⁷

²⁷ For example, China and Vietnam have both enacted legislation that bans the import of e-waste, while Japan lacks similar laws. Similarly, the Japanese e-waste management system that was enforced under the *Home*

the position of China, Vietnam and Japan in their progress towards ISWM in the e-waste sectors differ from these statuses, as Vietnam holds the least advanced, rather than the intermediary position, and e-waste management approaches cannot be clearly assigned to an ‘import’ or ‘export’ control strategy.

However, other patterns can be identified. The characteristics of the three countries’ e-waste management approaches correspond with their overall level of development, as represented by the differences in HDI, which showed a very high, high and medium development for Japan, China and Vietnam respectively in 2014 (UNDP, 2014: 159-161). A similar relationship can be established with the comparative gross domestic product (GDP) per capita. In 2014, Japan ranked 27th, China ranked 78th and Vietnam ranked 131st in a global comparison of GDP per capita (World Bank, 2016). Although these correlations are largely generalized and would need to be substantiated by broader studies across different countries and regions, the analysis suggests that national development and characteristics have a strong influence on the e-waste management approach a country applies.

The Chinese government utilized an experimental policy approach when developing its formal e-waste collection and recycling industry by initiating a pilot project in selected cities and regions before expanding the program to broader areas. This mode of governance that relies on ‘innovating through implementation’ has been adopted in many areas of Chinese decision- and policy-making, most known through its application to targeted economic development in special economic zones (Heilmann, 2008: 3-18). Similarly, the historically strong Japanese private sector, the central role of industry associations, the increasingly influential civil society and a growing decentralization of public matters (Schwartz and Pharr, 2003: 214-336) are all reflected in the Japanese e-waste management system. While the government retains a central role in coordinating e-waste management activities, the main burden of financing and handling e-waste lies with producers and consumers. In addition, Japanese e-waste management benefited from the move towards engraining environmental protection into all areas of policy since the 1970s (Imura and Schreurs, 2005: 10-48). In Vietnam, the significance of the informal sector within the economy, accounting for a fourth of all jobs in the country, is also represented by its dominant role in e-waste management. Characterized by a weak link to the formal sector and a lack of incentive or support structures provided by the government, the informal sector operates as an independent economic system (Cling, Razafindrakoto and Roubaud, 2010: 5-33). These patterns are similarly reflected in the Vietnamese e-waste collection and treatment

Appliance Recycling Law contributes to the establishment of a sound national material-cycle. This system aims at accounting for all domestically produced e-waste, which is also an indirect measure to counter illegal export.

sector. Overall, the analysis shows that national characteristics have a strong impact on e-waste management approaches in China, Japan and Vietnam.

The last secondary research question concerned the existence of an ‘East Asian approach’ towards e-waste management. Although the sample size of this thesis is relatively low compared to the total number of East Asian countries, the results of the comparative analysis clearly indicate substantial differences among the approaches, which have put Japan and Vietnam at the upper and lower ends of ISWM compliance. Consequently, an ‘East Asian way’ of e-waste management is highly unlikely. Nevertheless, similar analyses that include a wider range of East Asian countries and compare the results to other regions of the world would be required to provide a definite answer.

The collection of more data in China, Japan and Vietnam would further enhance the identification of achievements and shortcomings within their e-waste management approaches, as the thesis has revealed significant data gaps and an imbalance of available information in the three countries. This lack of data in itself represents evidence for insufficient gathering and dissemination of information relating to e-waste management, which limits informed strategic decision- and policy-making. Among the three analyzed countries, the most comprehensive data set was available for China, which has been the focus of e-waste research as its main global recipient. Ample information was also available on the Japanese e-waste management system as regards the structure and application of the *Home Appliance Recycling Law* and the EPR policy, which is considered an international good practice example. However, little research focused on the socio-cultural, environmental and health aspects of e-waste handling in Japan. The availability of data was most restricted in Vietnam, which is partly due to the national subordination of e-waste related issues to general waste management, which neglects the distinct challenges posed by e-waste.

Overall, abundant data were available regarding the legal and regulatory e-waste framework, the ratification and implementation of international treaties due to attached reporting requirements, the commonly applied technical recycling processes and, apart from Vietnam, the funding scheme of the e-waste management systems. Data were most scarce regarding the environmental and health aspects of e-waste treatment, as well as the implementation of institutional structures and capacities, such as the applied division of tasks and the decision-making and policy-making processes.

Beyond the national and regional significance, the findings of this thesis have wider implications for global e-waste flows. While government interventions to establish an effective formal e-waste management sector have not yet been successful on a large scale, e-waste

continues to flow through illegal channels into China and Vietnam, among other developing countries. As shown, the impacts of improper handling of e-waste in these countries are not restricted to the unsafe recycling sites, and they are not limited within national borders, but environmental damage and associated health problems can affect wide regions and populations. For instance, hazardous materials that are dumped in rivers can lead to the pollution of crucial water resources, which has cascading effects on adjacent industry, agriculture and human health. Emissions that are distributed through air can affect even broader regions and are difficult to contain. In contrast, Japan has made significant progress towards establishing a sound e-waste material-cycle, which adheres to most standards of the ISWM framework. However, this advancement was partially achieved at the cost of developing countries, such as China, the Philippines, Vietnam or Cambodia, which carry the burden of one third of Japan's domestically produced e-waste, in addition to hundreds of kilotons of e-waste exported from other developed countries in Europe and the Americas. This 'export of harm' (Puckett et al., 2002) poses serious risks to the environment, to human health and to the overall development of these countries.

Further research is needed to advance the understanding of these risks, in particular how environmental pollution caused by e-waste management activities affects the health of workers, and that of populations living in the vicinity of unsafe e-waste recycling sites and wider regions. In addition, the social aspects of e-waste management require a more detailed analysis to determine the role of different stakeholders and stakeholder groups and how they influence progress towards ISWM.

Similar studies of national e-waste management approaches and adherence to ISWM standards in other (East) Asian countries would further assist in gaining a comprehensive view on the state of e-waste in Asia. The findings from such studies could then be compared to studies within other regions of the world, such as European countries that contribute to e-waste export, or African countries that are among the major recipients of e-waste. Besides offering broader observations that would potentially allow for a ranking of countries in relation to their progress towards ISWM, these studies would help identify best practices, as well as interventions that have not been successful, for instance relating to creating an incentive structure for inclusion of the informal e-waste sector into formal recycling systems.

Another area for further research relates to the methodology of the ISWM framework itself. This thesis has shown that the model is not only applicable to cities, but also to nation-wide analyses of waste management. Given the cross-regional interdependency of e-waste management and, as demonstrated by the Chinese and Vietnamese e-waste management

systems, the strong role of informal practices that are often located outside of cities, a national view on waste management approaches allows for more accurate and holistic assessments. Moreover, focusing on a specific type of waste provides more in-depth results than a broad analysis of all forms of waste, which range from solid to liquid and from food waste to industrial sludge. To enable a country-level assessment of e-waste management approaches, this thesis has incorporated additional elements into the ISWM model. A national ISWM framework should be refined to encompass the characteristics of matters of nationwide concern, in particular the role of international aid and cooperation in the form of official development assistance, regional and international treaties and bilateral collaboration.

Another aspect that would complement the ISWM model when applied to e-waste management and is commonly overlooked, is cybersecurity. Apart from the adverse environmental and health impacts e-waste poses, the potential security risk has started to be recognized. While some initial research has been conducted in recent years to analyze the relationship between cybercrime and the transboundary flow of e-waste,²⁸ awareness and understanding of the risks is still low. Electronic devices, such as computers or mobile phones, which are discarded by users without consideration of the data stored on them, can offer opportunities for criminals to obtain personal data, such as credit card numbers or bank account numbers. Because a high amount of e-waste is illegally exported from developed to developing countries across jurisdiction, tracing and investigation measures in this area prove difficult.

Alongside the increasing sophistication and diffusion of information and communication technologies, as more and more everyday objects become digital and, thereby, electronic and electrical devices, the generation of e-waste will only expand in the future and its management will continue to be a challenge. A sustainable solution to this challenge will only be possible, if measures are enhanced that solve the issue at its origin – at the design and production stage of EEE, so that, over time, prevention and reduction become the main e-waste management approaches.

²⁸ See, for example: Doyon-Martin, 2015.

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7. Appendix

7.1 Abstract (English)

This thesis comparatively analyzes the e-waste sector in China, Japan and Vietnam by examining progress towards the international best practice model of *Integrated Sustainable Waste Management* (ISWM) within each country. Through three distinct, yet interdependent dimensions of ISWM (stakeholders, waste system elements and sustainability aspects), similarities and differences between the three East Asian countries are identified. The analysis shows that the e-waste management approaches differ substantially. The Vietnamese e-waste management approach is least consistent with the ISWM framework, while Japan complies the most with the ideals of the model. Chinese progress towards ISWM is mostly located between the two countries, with efforts being made to elevate the development towards ISWM. However, Japan's adherence to ISWM ideals, while generally high, is limited to domestically treated e-waste, while a substantial proportion is exported to developing countries, including China and Vietnam, in an uncontrolled manner. The analysis further suggests that the state of development and national characteristics have a significant impact on how the three countries approach e-waste management. In particular, the central role of the informal e-waste sectors in China and Vietnam pose a challenge to the establishment of an effective integrated sustainable e-waste management system. In light of the transnational flow of e-waste in the region, only joint actions will lead to long-term solutions to the increasing threat of e-waste to the environment and human health.

7.2 Abstract (German)

Diese Masterarbeit führt eine komparative Analyse des Elektroaltgerätesektors in China, Vietnam und Japan durch. Die methodische Grundlage bildet das internationale Best-Practice-Konzept für integrierte und nachhaltige Abfallwirtschaft (*Integrated Sustainable Waste Management*, ISWM). Durch drei interdependente Dimensionen des ISWM Modells (Stakeholder, Abfallsystemelemente *und* Nachhaltigkeitsaspekte) werden Ähnlichkeiten und Unterschiede zwischen den drei ostasiatischen Ländern herausgestellt. Die Analyse zeigt, dass die Herangehensweisen bezüglich der Elektroaltgeräte-Abfallwirtschaft stark variieren. Der vietnamesische Ansatz stimmt dabei am wenigsten mit dem ISWM Modell überein, während Japan den Idealen des Konzepts am meisten entspricht. Der chinesische Fortschritt im Hinblick auf die Nachhaltigkeit und Integration der Elektroaltgeräte-Abfallwirtschaft ist hauptsächlich zwischen den beiden Ländern positioniert. Es sind Bemühungen zu verzeichnen, die Entwicklung des Sektors bezüglich des ISWM Modells zu verbessern. Auch wenn Japan mit den ISWM Idealen am meisten übereinstimmt, bleibt dieser Fortschritt auf die inländische Abfallwirtschaft beschränkt, da ein großer Teil der Elektroaltgeräte unkontrolliert in Entwicklungsländer exportiert wird, einschließlich nach China und Vietnam. Die Analyse weist weiterhin darauf hin, dass der Entwicklungsstand und die nationalen Charakteristika einen signifikanten Einfluss auf den Umgang der drei Länder mit Elektroaltgeräten haben. Insbesondere die zentrale Rolle des informellen Sektors in China und Vietnam ist eine Herausforderung für die Etablierung eines effektiven nachhaltigen und integrierten Elektroaltgeräte-Abfallwirtschaftssystems. Angesichts des unregulierten transnationalen Handels mit Elektroaltgeräten in der Region, werden nur gemeinsame Maßnahmen eine langfristige Lösung bieten, um der zunehmenden Gefährdung der Umwelt und Gesundheit durch Elektroaltgeräte nachhaltig Einhalt zu gebieten.

7.3 Curriculum Vitae

EVA IGORJEVNA IGNATUSCHTSCHENKO

PERSONAL DATA

Address	35 Church Lane, OXFORD, OX30PT, UK
E-mail	eva.ign@gmail.com
Date of birth	06/12/1988
Nationality	German

EDUCATION

2011 – 2016	Master of Arts in East Asian Economy and Society <i>University of Vienna, Vienna, Austria</i> Department of East Asian Studies, Chair of East Asian Economy and Society <u>Thesis topic:</u> Electronic waste in China, Japan and Vietnam: A comparative analysis of waste management strategies
2009 – 2010	Year abroad, Chinese Language Studies <i>Renmin University of China, Beijing, People's Republic of China</i> Faculty of Languages
2007 – 2011	Bachelor of Arts in Sinology (grade 1.1) <i>University of Leipzig, Leipzig, Germany</i> Department of East Asian Studies, Chair of Sinology <u>Thesis topic:</u> HIV/AIDS politics in PR China
2001 – 2007	Abitur (A-levels, grade 1.0) <i>Kurfürst-Joachim-Friedrich-Gymnasium, Wolmirstedt, Germany</i>

WORK EXPERIENCE

09/2015 – present	University of Oxford, Global Cyber Security Capacity Centre (Oxford, UK) <i>Research Fellow</i> <u>Responsibilities:</u> • Representation of the Centre at international conferences • Development of a national-level cyber harm model • Conducting national cybersecurity capacity assessments • Close collaboration with senior cybersecurity experts from academia, private sector, governments, etc. • Research and drafting of papers and reports on cyber harm, cybercrime, cybersecurity and international cooperation
09/2013 – 07/2015	United Nations Office on Drugs and Crime (UNODC), Organized Crime and Illicit Trafficking Branch (Vienna, Austria) <i>Knowledge Management Consultant</i> <u>Responsibilities:</u> • Project coordination, management and advocacy of online knowledge management portals on cybercrime (http://cybrepo.unodc.org) and organized crime (http://sherloc.unodc.org) • Research and drafting of reports, concept notes, background papers, and briefing notes on cybercrime and emerging crimes

- Representation of UNODC at expert meetings
- Coordination with UN partner organizations and Member States
- Organization of international expert meetings
- Recruitment and supervision of interns and volunteers

12/2013

International Organization for Migration (IOM), Regional Office for South-Eastern Europe, Eastern Europe and Central Asia, Labour Migration and Human Development (Homebased)
Consultant

Responsibilities:

- In-depth development of virtual exchange platform on labor migration
- Creation of training materials and training of staff

07/2013 – 09/2013

International Organization for Migration (IOM), Regional Office for South-Eastern Europe, Eastern Europe and Central Asia, Migrant Assistance/Integrated Border Management (Vienna, Austria)
Intern

Responsibilities:

- Research on European legislation and best practices in assisted voluntary return, detention and readmission of migrants
- Drafting, review & editing of project proposals and donor reports
- Development of a regional virtual exchange platform
- Project tracking and monitoring

10/2012 – 02/2013

United Nations Office on Drugs and Crime (UNODC), Organized Crime and Illicit Trafficking Branch (Vienna, Austria)
Intern

Responsibilities:

- Analysis of legislation and case law on organized crime
- Assistance with the drafting of the Comprehensive Study on Cybercrime
- Assistance with the organization of intergovernmental meetings

LANGUAGES

Mother tongue	German
Other languages	English (Fluent - C2)
	Russian (Working knowledge - C1)
	Chinese (Working knowledge - C1)
	Japanese (Basic - A2)

SCHOLARSHIPS

2007 - 2014	Scholarship from German National Academic Foundation
2012 - 2013	Merit-based scholarship from the University of Vienna
2009 - 2010	Scholarship from German Academic Exchange Service

COMPUTER SKILLS

Proficient in MS Office, WebCMS, Lotus Notes, HTML and image processing/layout software