# Electronic Waste in China, Japan, and Vietnam: A Comparative Analysis of Waste Management Strategies

Eva Ignatuschtschenko

## Abstract

*This paper comparatively analyses 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 and Chinese progress towards ISWM is mostly located between the two countries. However, a substantial proportion of Japanese e-waste is exported to developing countries 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 poses 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.*

**Keywords:** e-waste, ISWM, waste management

Ignatuschtschenko, Eva. "Electronic Waste in China, Japan, and Vietnam: A Comparative Analysis of Waste Management Strategies." In *Vienna Journal of East Asian Studies*, Volume 9, eds. Rudiger Frank, Ina Hein, Lukas Pokorny, and Agnes Schick-Chen. Vienna: Praesens Verlag, 2017, pp. 29–58.
https://doi.org/10.2478/vjeas-2017-0002

## Introduction

With a growth rate of four to five per cent annually, which represents an annual increase of approximately two million tons, e-waste is one of the fastest growing forms of waste.[1] In 2014, 41.8 million tons of e-waste were generated globally, representing a substantial increase from the 33.8 million tons in 2010 (Baldé et al. 2015: 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. The role of electric or electronic equipment (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 regarding the amount of e-waste trafficked across the globe. Various studies suggest that e-waste flows, both legally and illegally, from developed to developing countries 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 that accounted for e-waste also flows out of the European Union through unregulated channels. Insufficient national statistics, disparities in definitions, distinguishing what constitutes e-waste and what is reusable EEE, and 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).

This paper aims at contributing to a more comprehensive analysis of the e-waste challenge and the subsequent responses based on the comparison of China, Japan, and Vietnam. The analysis focuses on the three East Asian 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

[1] In comparison, the estimated annual increase of municipal waste generated within the Organisation for Economic Co-operation and Development (OECD) area is 1.3% (OECD 2008: 244).

countries; and Vietnam as a country that mainly imports e-waste, but shows significant re-export of e-waste to China.

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 (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). 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.

Japan represents one of the early adopters of targeted e-waste legislative and regulatory frameworks, fostered by a general shift towards environmental policies in the country. Keizai sangyō shō 経済産業省, the Ministry of Economy, Trade and Industry (METI), and Kankyōshō 環境省, the Ministry of the Environment (MOE), publish annual reports on the enforcement status of the Tokutei katei yō kiki sai shōhin ka hō 特定家庭用機器再商品化法, the *Home Appliances Recycling Law*, which include statistics on collection and recycling rates for major home appliances. According to estimates, 50 to 60 per cent of generated e-waste stemming from these appliances is collected and processed in the recycling system of the country. While only a small proportion of e-waste regulated under the *Home Appliances Recycling Law* is illegally disposed 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 (Fuse et al. 2011: 794; Yoshida, Tasaki, and Terazono 2009: 1602).

Vietnam shows the lowest rates of national e-waste generated annually, in both 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, but the absolute amount of e-waste is almost three times more. 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 1,650 per cent for these appliances between 2006 and 2020 (Nguyen et al. 2009: 365; Herat and Agamuthu 2012: 1124-1125; URENCO 2007: 149-154). Although

the amounts of generated e-waste are still significantly less than those 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 e-waste crucial. Despite the fact that Vietnam has not only prohibited the import of e-waste, but also the import of second-hand electronic products, used electronic goods and e-waste continue to enter the country nonetheless, eventually posing a threat to the environment and public health as a result of rudimentary and unsafe handling practices.

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. A loophole in Chinese and Vietnamese legislation, which allows for the import of second-hand 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 allowing the flow of e-waste between China and Vietnam (Shinkuma and Huong 2009: 27-28; Premalatha et al. 2014: 1639).

The different levels of economic and social development of the three countries would suggest a correlating state of e-waste. The overall level of development, as represented by the differences in Human Development Index (HDI), showed a very high, high, and medium development in 2014 for Japan, China, and Vietnam, respectively (UNDP 2014: 159-161). In a global comparison of the gross domestic product (GDP) per capita of the same year, an equal distribution was evidenced: Japan ranked 27th, China 78th, and Vietnam 131st (World Bank 2016).

The state of e-waste generation is similar to the aforementioned distribution. 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, but showed a comparatively low amount of kg of produced e-waste per inhabitant (less than 5 kg per inhabitant). Thus, the two countries represent regional extremes as regards e-waste production (Baldé et al. 2015: 42-43; UNODC 2013: 103-111). Vietnam shows one of the lowest rates of annually generated e-waste in Asia (less than 2 kg per inhabitant in 2014; see Baldé et al. 2015: 43).

Correspondingly, when examining the national responses to the e-waste challenge, the three countries represent very different cases, even though all three countries have in place national legislations relating to e-waste. Japan has been a global initiator and driving force of the 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, the 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’ and the ‘upper’ end of

the spectrum as regards amounts of e-waste generated and e-waste management strategies and practices in Asia.

These differences may suggest similarly diverging results when analysing the e-waste sectors in the three countries. Yet again, 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 paper is: how and why 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 is based on the concept of ISWM. Instead of approaching the topic from a one-dimensional perspective, such as through a socio-economic, a technological, or an environmental perspective, the multidimensional nature of the e-waste challenge, which affects society, culture, economy, environment, politics, and other sectors alike, is recognised by applying a multidisciplinary methodology. The ISWM framework, which is comprised of three dimensions, namely stakeholders, waste system elements, and sustainability aspects, allows for a holistic examination of the various ways in which waste affects societies.

Based on the results of the analysis, advancements and shortcomings in integrated sustainable e-waste management are examined. This paper provides an inclusive and holistic analysis and comparison of e-waste management approaches. Consequently, similarities and differences between the different countries' approaches are identified, which allow for inferences to be drawn with regard to national and regional patterns.

## Methodology

### Conceptualising E-waste

Although there is no commonly accepted international framework applicable to e-waste, definitions share a common denominator by describing e-waste as EEE containing components that control or direct electric currents, which is disposed of by the consumer/owner of the appliance (StEP 2014: 4-5; Puckett et al. 2002: 5; Widmer et al. 2005: 438; Basu 2008: 46; Barbour 2012: 1). 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 (Gossart 2011: 7).

Due to specific characteristics of e-waste, its management requires a specialised 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, but

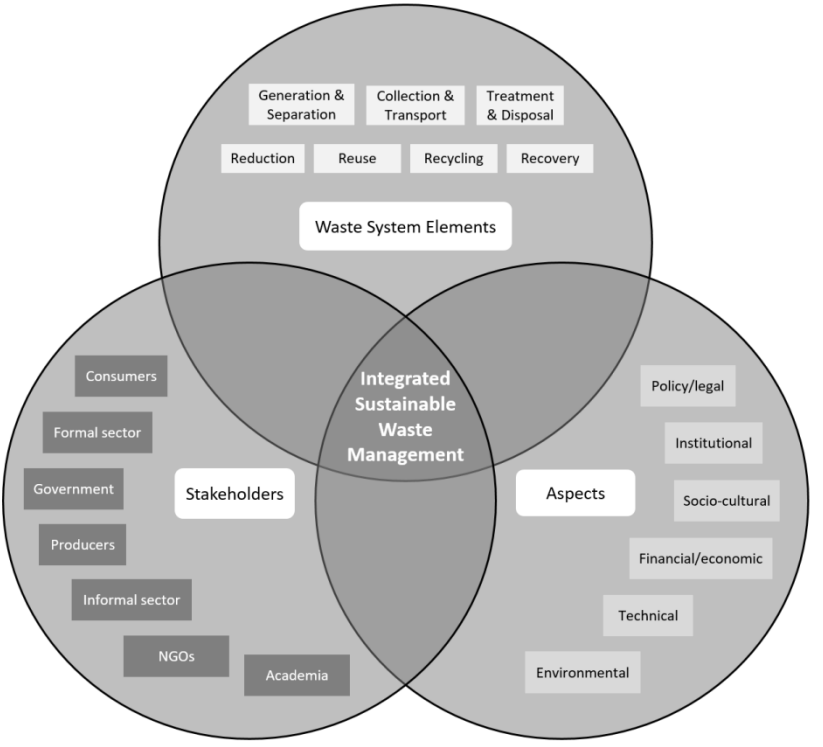
also discarded after ever shorter durations (Frey 2012: 81). Secondly, e-waste contains a number of hazardous substances that pose potential risks to the environment and public health if not treated through adequate measures (Kiddee 2013: 1238). Thirdly, the complexity of EEE design poses a challenge to efficient recycling of e-waste. Hazardous and non-hazardous materials are often firmly attached to each other, and most types of EEE 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. Although some of these characteristics are also found in other types of waste, the combination of the five features poses a particular challenge to an effective e-waste management system, as it needs to limit the environmental, health, and security risks while ensuring that resources are recovered efficiently.

## Integrated Sustainable Waste Management (ISWM)

The concept of *Integrated Sustainable Waste Management* (ISWM) was developed in the 1980s. Since then, the framework has been expanded and modified by numerous academics and applied in many national contexts. While conventional waste management approaches consider waste generation, collection, and disposal independently, ISWM recognises 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, and 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. Moreover, it requires a complex analytical framework to structure the different components and their interconnection (Seadon 2010: 1640-1641).

The ISWM framework consists of three main dimensions, corresponding to the three questions of: 1) who should be involved (stakeholders); 2) what should be done (elements); and 3) how should it be done (aspects). All three dimensions are interdependent and have to be analysed in an integrated manner (Anschütz, IJgosse, and Scheinberg 2004: 18-20; United Nations Human Settlements Programme 2010: 27).

Figure 1 Integrated Sustainable Waste Management Model




Source: Adapted from United Nations Human Settlements Programme 2010: 27; Van de Klundert and Anschütz 2001: 14; ISWA 2011: 14)

## 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, 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, 'waste-pickers', and family businesses that focus on recycling. In addition, the general public itself represents a major stakeholder as waste generators, including any individual, business, or institution (Anschütz, IJgosse, and Scheinberg 2004: 18-19; United Nations Human Settlements Programme 2010: 27).

The significance of stakeholders for the overall waste management process and their ability to influence the courses of action differ substantially (Van de Klundert and Anschütz 2001: 12). In particular, the role of and interaction between stakehold-

ers 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 analysed. Especially in developing countries, the informal waste sector plays a significant 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 criminalised (ISWA 2011: 22).

## 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. Alongside the global move towards more comprehensive waste management systems, the scope of activities has been expanded from mere recycling or disposal to handle waste from 'cradle to cradle', that is, establishing the connection between waste management and resource management (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 1, as well as measures relating to the valorisation 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 categorisation and prioritisation systems have been developed. One of the most commonly used is the 'three R's' principle, which stands for 'reduce, reuse and recycle' (Hoornweg and Bhada-Tata 2012: 7; Davidson 2011: 8). A more sophisticated model is the categorisation of different available measures in a waste management hierarchy. This hierarchy aims at reversing the historical approach of focusing on waste disposal by putting prevention, minimisation, recycling, and recovery of materials at the centre 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). Although not a standard element of the waste management hierarchy, as it does not represent an actual treatment method, the export of e-waste has to be considered, since 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 utilised technologies and methods. As a consequence, e-waste is most likely to be treated under less environmentally sound conditions in the receiving 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.

## Dimension 3: Aspects

The third dimension, sustainability aspects, provides different lenses that are necessary to develop a viable 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 analysed 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 first set of aspects, *policy and legal aspects*, lays out the fundamental framework and conditions within 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, and the structure of decision-making (Van de Klundert and Anschütz 2001: 13; United States Environmental Protection Agency 2002: 2-4; Anschütz, IJgosse, and Scheinberg 2004: 18-20). Another important factor is the integration and implementation of international rules and standards in the national ISWM framework, such as the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal* of 1989 (Basel Convention) and its supplementary *Nairobi Declaration on the Environmentally Sound Management of Electrical and Electronic Waste*. Primarily in developed countries, in particular in the framework of the European Union and the Organisation for Economic Co-operation and Development (OECD), extended producer responsibility (EPR) has been established as a good practice in e-waste policy making. The benefits of developing a national EPR strategy are manifold, 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.

The *institutional aspects* address the political and social structures that are responsible for the implementation and administration 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 aspects consider the institutions that are involved in the waste management process—whether the responsibilities are concentrated in one organisation or distributed among a range of different agencies—and how they interrelate. Moreo-

ver, institutional capacities have to be sufficient to implement the activities. 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 Anschütz 2001: 13-21).

Having established the regulatory and institutional framework for e-waste management, the human factor 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 at the household, business, and institutional level, 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 in 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. Moreover, citizens should be encouraged to complain and report about any deficiencies in the e-waste management process, such as missed collection or illegal disposal (Van de Klundert and Anschütz 2001: 20). Another key element of socio-cultural ISWM aspects is public education and awareness raising.

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. Measures to secure funds and enhance cost-efficiency of the e-waste management system include privatisation of waste management processes, cost recovery and reduction, the connection between producing industries and waste management infrastructures, and income generation (Van de Klundert and Anschütz 2001: 14). 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 (Lundgren 2012: 42).

The fifth set of aspects addresses the technical side of the e-waste management process. *Technical aspects* 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, and the quality of the recovered materials (Van de Klundert and Anschütz 2001: 14; Widmer et al. 2005: 453).

The last set of sustainability aspects, *environmental aspects*, focusses on the environmental impact of e-waste management processes. E-waste can affect the envi-

ronment in numerous ways and can lead to soil, water, and air pollution, which in turn means a substantial risk for public health. Minimising 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). 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 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 and the population living in proximity of e-waste recycling, recovery, and disposal sites (Van de Klundert and Anschütz 2001: 20; Widmer et al. 2005: 453).

## Three Dimensions of E-waste Management in China, Japan, and Vietnam

### Stakeholders

The government plays a key and primary role as regulator, coordinator and facilitator of e-waste management activities within all three analysed countries. This centralised governing approach to e-waste management is important for ensuring that all stakeholders cooperate and realise both their roles and responsibilities, thus representing a crucial element of ISWM. While this function 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. In China, functions and responsibilities are dispersed amongst a number of government bodies, such as the National Development and Reform Commission (NDRC), the Ministry of Environmental Protection (MEP), and the Ministry of Industry and Information Technology (MIIT) (Wang et al. 2013: 40-41). Similarly, a number of bodies share responsibility for various aspects of e-waste management across the Vietnamese government, including the Ministry of Natural Resources and Environment (MONRE), the Ministry of Construction (MOC), the Ministry of Health (MOH), and the Ministry of Industry (MOI) (URENCO 2007: 119-121; Shinkuma and Huong 2009: 26). In contrast, e-waste management responsibilities in Japan are centralised in two ministries that work in tandem, namely the Ministry of Economy, Trade and Industry (METI) and the Ministry of Environment (MOE).

In the implementation of e-waste management policies, China, Japan, and Vietnam adopt 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 responsi-

bilities in Japan under the *Home Appliance Recycling Law* of 1998 (Hotta, Santo, and Tasaki 2014: 3-4; Sawhney et al. 2008: 31-32). Conversely, China and Vietnam have not yet been able to establish a strong formal e-waste sector that integrates consumers and manufacturers as the main e-waste producers. 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 (Ni and Zeng 2009: 3992; Lundgren 2012: 15; Chi et al. 2011: 735; Puckett et al. 2002: 16-18; URENCO 2007: 113). The Chinese government has put substantial efforts into establishing a formal e-waste collection and treatment system, for instance through the Jiādiàn yǐ jiù huànxīn 家电以旧换新 (*Home Appliance Old for New Rebate Programme*) that was initiated as a pilot project in nine provinces and cities in 2009 and concluded in 2011. Twenty-two designated companies dismantled collected e-waste during the pilot phase before the programme 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. The integration of informal recyclers into the formal system remains an additional challenge (Zhou and Xu 2012: 4718; Wang et al. 2013: 25-26; Chi et al. 2011: 736-737). In Vietnam, on the other hand, the development of a formal system has not yet been effective, since the significance of approaching e-waste as a distinct issue that requires targeted measures has not, so far, been sufficiently recognised (URENCO 2007: 119-121; Shinkuma and Huong 2009: 26). 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 criminalised, local informal traders are able to collect appliances directly from consumers and export them to other countries of the region, including China, Vietnam, Cambodia, and the Philippines (Hotta, Santo, and Tasaki 2014: 17-18).

In addition, the role of consumers in the three discussed countries' e-waste sectors differs substantially. In China and Vietnam consumers are not integrated into the formal system as a primary stakeholder, which would recognise 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 (URENCO 2007: 113; Chi et al. 2011: 736-737). Awareness of consumer responsibility, as well as environmental awareness, is low in both countries in comparison to Japan. The Japanese system fully recognises the significance of integrating consumers as primary stakeholders into e-waste management, not least through explicit responsibilities assigned to them in the *Home Appliance Recycling Law*.

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 stake-

holder structure. The Vietnamese stakeholder landscape has a scattered structure, which heavily relies on the informal sector. Formal integration of the main e-waste producers has not yet commenced, and other groups of society that could facilitate this process—such as civil society organisations 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 (Wang et al. 2013: 43). However, first steps towards establishing a formal e-waste collection and handling system, as well as integrating producers to hold them accountable for domestic e-waste production, have been taken. Moreover, secondary stakeholders from academia, civil society, and industry play an increasing role in promoting environmentally sound e-waste recycling (ibid.: 44-46). 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 (Hotta, Santo, and Tasaki 2014: 3-4; Sawhney et al. 2008: 31-32). However, while less significant than in China and Vietnam, 33 per cent 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 that do not equally adhere to the ISWM framework (Hotta, Santo, and Tasaki 2014: 17-18).

## Waste System Elements

This section analyses the main operational elements of the e-waste management processes in China, Japan, and Vietnam based on the five main elements identified in the waste management hierarchy, which range from the most to the least preferential options: prevention, reduction, recycling and re-use, other recovery (such as energy recovery), and disposal.

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, with ratios between 70 and 90 per cent operations (URENCO 2007: 28-36; Nguyen et al. 2009: 358-359; Yang, Lu, and Xu 2008: 1592). The second similarity is the secondary role of e-waste disposal. While utilised in all three countries, and in accordance with the ISWM model, it does not however represent a main waste system element (Yang, Lu, and Xu 2008: 1592). However, the utilisation of the other five elements varies across the three countries, with Japan being the only one which 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 utilised (Gaidajis, Angelakoglou, and Aktsoglou 2010: 198; METI 2010: 11-56). 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. The recycling techniques utilised 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 initially applied to large parts 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). Nevertheless, one major shortcoming of the Japanese system is the prevalence of e-waste export.

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 (Shinkuma and Huong 2009: 27-28; Premalatha et al. 2014: 1639). 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 (Zhou and Xu 2012: 4718; Wang et al. 2013: 25-26; Baldé et al. 2015: 42; Chi et al. 2011: 736; Wiesmeth et al. 2012: 5). Scholars have noted that environmentally sound e-waste treatment techniques are virtually non-existent in Vietnam, and landfills are usually uncontrolled (Thai 2009: 258-260; Wiesmeth et al. 2012: 1).

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 taken place. 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.

## Sustainability Aspects

### Policy and Legal Aspects

All three countries have adopted legislation that is applicable to e-waste management, ratified the Basel Convention, and participate in e-waste related activities conducted under the Convention. However, as regards the scope, specificity, and implementation of the legal and policy framework, they are at different stages. Among the three countries, the Japanese legal framework, in particular the *Home Appliance Recycling Law*, is the most comprehensive and most effectively enforced (Yoshida and Yoshida 2014: 420-423; Gaidajis, Angelakoglou, and Aktsoglou 2010: 198; Hotta, Santo, and Tasaki 2014: 7-28). Although the Chinese government has also developed e-waste specific national and local legislation,[2] its scope is limited and does not cover all aspects of the e-waste management system. Moreover, its enforcement has only been partially achieved (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). Vietnam, on the other hand, lacks an e-waste specific legal framework and instead relies on general waste management decrees, which have not yet been enforced in relation to e-waste collection and recycling (URENCO 2007: 126-127). 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* in Japan and the *National Strategy for Integrated Management of Solid Waste up to 2025, vision towards 2050* in Vietnam (Premakumara and Maeda 2015: 186-187; MOE 2013). Conversely, China has not established a similar plan.

In the regional and international arena, all three countries participate in e-waste programmes under the Basel Convention. However, Japan has been the most active player in the region and instigator of a number of activities, such as the 'Asian Network for Prevention of Illegal Transboundary Movement of Hazardous Wastes', thereby acting as one of the donor countries and inter alia providing technical and

[2] The United Nations University and StEP Initiative (2016) have identified 26 domestic regulatory instruments that specifically address e-waste.

financial support across the region (MOE 2015a and 2015b). China has a similarly active role, although it acts both as a provider and as a recipient of assistance and activities (Bāsāiěr gōngyuē yàtàiqū yù zhōngxīn 巴塞尔公约亚太区域中心 [BCRC China] 2010 and 2014; Lundgren 2012: 39). 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 (Ogushi and Kandlikar 2007: 4503-4507). In contrast, China has only recently established an EPR policy and full enforcement is still pending (Wei and Liu 2012: 510-512). Finally, although the government has indicated an intention to implement EPR on a national level, Vietnam has not yet adopted such a policy (Hai, Hung, and Quang 2015: 1).

## Institutional Aspects

The institutional structure in the three countries varies significantly. Their only similarity is the engagement with international partners, which differs however in its form and scope. Similarly to the factors analysed above, Japan complies to the greatest extent with ISWM standards. Contrary to China and Vietnam, only two institutions share the main responsibilities and the coordinating role of the centralised Japanese e-waste management system at the national level, namely MOE and METI. The two ministries carry out their duties in close collaboration (Terazono and Yoshida 2012: 139-145; Hotta, Santo, and Tasaki 2014: 7-12). 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 organisations, 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 (Wang et al. 2013: 40; URENCO 2007: 119-121). A clear data gap exists regarding the capacities of the relevant organisations in carrying out their assigned tasks. Apart from past sources that indicated a severe lack of capacities and resources in Vietnamese agencies responsible for (e-)waste management (World Bank 2005: 10-40), no information is available on the level of capacity in China and Japan.

While private sector entities do play a role in e-waste management in all three countries, their role nevertheless differs. In Vietnam, 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). The Chinese and Japanese governments, on the other hand, have both recognised 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 (Wang et al. 2013: 38; Streicher-Porte 2009; MOE 2015c).

Similarly, both governments have actively engaged with international partners, such as the Swiss and Dutch governments in the case of China and the United Nations Environment Programme (UNEP) in the case of Japan, in order to initiate cooperation projects that often bring together national and international stakeholders from various backgrounds (Wang et al. 2013: 37-39; UNEP 2015). Apart from these government-driven initiatives and international organisations 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 (Bāsāiěr gōngyuē yàtàiqū yù zhōngxīn 巴塞尔公约亚太区域中心 [BCRC China] 2014; VNS 2015). 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 integration of the general public into e-waste management varies significantly across the three countries, which corresponds to the general structure and role of civil society within the respective political systems. In Japan, the general public is recognised 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 (Hotta, Santo, and Tasaki 2014: 12-13; Keizai sangyō shō 2015).

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 man-

agement 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 (Wang et al. 2011: 978-983; Liu, Tanaka, and Matsui 2006: 98; Yu et al. 2010: 994). Similarly, Vietnam has only just begun promoting citizen awareness of e-waste related issues (VNS 2015). The effectiveness of these initiatives will be shown in the coming years. Generally, China and Vietnam deviate substantially from the ISWM model regarding the socio-cultural aspects of the e-waste sectors. Inclusion of citizens into e-waste management is still low.

## Financial and Economic Aspects

Similarly to the socio-cultural aspects, the three countries differ substantially regarding the economic and financial setup of the e-waste management activities. As regards the overall funding mechanism, China established—under the *Measures for the Collection and Administration of the Funds for the Recovery and Disposal of Waste Electronic and Electrical Products*—a centralised, government-coordinated structure in 2012, which places the burden of financing e-waste collection and recycling on the private sector (OECD and MOE 2014: 16; OECD 2014: 2-9). Japan, on the other hand, applies a decentralised approach in which manufacturers and local governments share the costs of collection and recycling, while part of the funding is raised directly from consumers under the *Home Appliance Recycling Law*. The differences in the two systems reflect both China's and Japan's overall political and economic structure. In this way, both countries have established a funding mechanism which adheres to ISWM standards, but takes into consideration the local characteristics. In contrast, the Vietnamese (e-)waste management system relies mainly on foreign donations through official development assistance and government funds (World Bank 2005: 42-43). 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, utilising the resource value of e-waste—by extracting valuable resources and channelling them back to the economy—is an important element of ISWM, which is insufficiently implemented in China and Vietnam (World Bank 2005: 42-48; Pham 2007: 5; OECD 2014: 11-15). 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 (Hotta, Santo, and Tasaki 2014: 17-27).

As regards 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 characterised by a strong informal sector that 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 (Shinkuma and Huong 2009: 30; Chi et al. 2011: 738). 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 incentivising 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 (Lee and Na 2010: 1641; Hotta, Santo, and Tasaki 2014: 18). Therefore, among the six analysed sustainability aspects, the economic performance in Japan is the lowest.

## Technical Aspects

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 (Wang et al. 2013: 17-28) was not significantly different from the average collection rate of 50 to 60 per cent in Japan (Hotta, Santo, and Tasaki 2014: 21), 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 (Wang et al. 2013: 25-26; Wei and Liu 2012: 507-509; Chi et al. 2011: 735-736). In Japan, although collection rates should be improved, e-waste collection and treatment facilities are evenly distributed across the different regions (DTI Global Watch Mission 2005: 24-25; Bo and Yamamoto 2010: 501-502; Yoshida and Yoshida 2010: 22). Vietnam, on the other hand, lacks a functioning collection network, which leads to a lack of data on collection rates.

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 (Chi et al. 2011: 736; Hicks, Dietmar, and Eugster 2005: 463; Hai, Hung, and Quang 2015: 5-6; Zhou and Xu 2012: 4719). This low level of sophistication is confirmed by the level of skills and equipment among e-waste workers in China and Vietnam (URENCO 2007: 91-115; Zhou and Xu 2012: 4717). 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 (Hai, Hung, and Quang 2015: 5-6). Japan, on the other hand, is closest to the ISWM standards in technical advancement and skills as well as equipment applied in the e-waste sector. Although not all formal recycling sites utilise 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 (Gaidajis, Angelakoglou, and Aktsoglou 2010: 198; Yoshida and Yoshida 2010: 25; Aizawa, Yoshida, and Sakai 2008: 1402-1405).

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 both the formal and the informal sector.

## Environmental Aspects

Similarly to the socio-cultural, economic, and technical sustainability aspects, the three countries differ substantially in the environmental and health performance of the respective e-waste sectors. Among the three countries, Japan adheres to the greatest extent to the ISWM model. 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. Moreover, the general safety of deployed e-waste recycling practices is comparatively high and landfills are only used for a small number of residues (Kankyōshō and Keizai sangyō shō 2015; DTI Global Watch Mission 2005: 55-95). 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 (Menikpura, Santo, and Hotta 2014: 188-190). Although 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. 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 (He et al. 2006:

510-511). 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 (Hicks, Dietmar, and Eugster 2005: 460-461; Wang et al. 2013: 22-24; URENCO 2007: 118; Thai 2009: 260-262). 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 (Tue et al. 2010a: 2161; 2010b: 9196-9199; Wei and Liu 2012: 508-509; Leung et al. 2008: 2679), 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 (Brigden et al. 2005: 4). 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.

## Conclusion

This paper set out to compare e-waste management in China, Japan, and Vietnam. The objective of the paper was to identify similarities and differences in the e-waste management approaches according to the international best practice standard of ISWM. Based on the respective levels of social and economic development, the hypothesis was that the e-waste management systems in China, Japan, and Vietnam differ accordingly. Overall, the hypothesis was confirmed by the analysis of the stakeholder structure, waste system elements, and sustainability aspects. It 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, not all analysed factors showed this expected distribution. In particular, 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. Moreover, the fact that a substantial proportion of generated e-waste is able to exit the formal collection and recycling system indicates inadequacies in the Japanese e-waste management system.

In addition, there are four noteworthy similarities between the three analysed countries, namely: the primary role of the government in e-waste management; the existence of research institutions dedicated to e-waste related issues; the utilisation of reuse as a waste system element; and the lack of a citizen reporting mechanism for illegal e-waste dumping. The Chinese system further 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 utilised e-waste handling processes. However, the two countries differ in the implementation and realisation of this structure. While Japan is characterised 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 recognise the distinct challenges associated with e-waste and instead applies general waste management processes. It is noteworthy that none of the three countries had in place an ISWM plan or strategy specifically for e-waste, even though the distinct challenges were recognised through the adoption of specific legal and regulatory instruments.

Overall, the characteristics of the three countries' e-waste management approaches correspond with their overall level of development, as represented by the comparative HDI and GDP. Although these correlations are largely generalised 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 utilised 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 programme 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 decentralisation 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. Characterised 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 sector. Overall, the analysis shows that national characteristics have a strong impact on e-waste management approaches in China, Japan, and Vietnam.

Beyond the national and regional significance, the findings of this paper 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 effects of improper handling of e-waste in these countries are not restricted to the unsafe recycling sites, nor are they 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 vital water resources, which has cascading effects on adjacent industry, agriculture, and human health. Emissions through air can affect even broader regions and are difficult to be contained. 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.

Cybersecurity is a commonly overlooked aspect that requires further research in the context of e-waste management. Apart from the adverse environmental and health effects that e-waste poses, the potential security risk has started to be recognised. While some initial research has been conducted in recent years to analyse the relationship between cybercrime and the transboundary flow of e-waste (Doyon-Martin 2015), awareness and understanding of the risks are 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 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, the number of electronic and electrical devices rises, the generation of e-waste will only expand in the future and its management will continue to be a challenge.

## LIST OF ABBREVIATIONS

| | |
|---|---|
| BCRC | Basel Convention Regional Centre for Asia and the Pacific |
| EEE | Electric or electronic equipment |
| EPR | Extended producer responsibility |
| GDP | Gross domestic product |
| HDI | Human Development Index |
| ISWM | Integrated Sustainable Waste Management |
| MEP | Ministry of Environmental Protection |
| METI | Ministry of Economy, Trade and Industry |
| MIIT | Ministry of Industry and Information Technology |
| MOC | Ministry of Construction |
| MOE | Ministry of the Environment |
| MOH | Ministry of Health |
| MOI | Ministry of Industry |
| MONRE | Ministry of Natural Resources and Environment |
| NDRC | National Development and Reform Commission |
| OECD | Organisation for Economic Co-operation and Development |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNODC | United Nations Office on Drugs and Crime |

## REFERENCES


Aizawa, Hirofumi, Hideto Yoshida, and Shin-ichi Sakai. "Current Results and Future Perspectives for Japanese Recycling of Home Electrical Appliances." In *Resources, Conservation and Recycling*, 52, 2008, pp. 1399–1410

Anschütz, Justine, Jeroen IJgosse, and Anne Scheinberg. *Putting Integrated Sustainable Waste Management into Practice: Using the ISWM Assessment Methodology*. Gouda: WASTE, 2004

Baldé, Cornelis Peter, Feng Wang, Ruediger Kuehr, and Jaco Huisman. *The Global E-waste Monitor – 2014*. Bonn: United Nations University, IAS – SCYCLE, 2015

Barbour, Emily C. *Issues in International Trade Law: Restricting Exports of Electronic Waste*. Washington, D.C.: Congressional Research Service, 2012

Bāsāiěr gōngyuē yàtàiqū yù zhōngxīn 巴塞尔公约亚太区域中心 [BCRC China]. "Bāsāiěr gōngyuē yàtàiqū yù zhōngxīn jiǎnjiè" 巴塞尔公约亚太区域中心简介 [Introduction of BCRC China]. 2010, http://ch.bcrc.cn/col/1256346605715/index.html, accessed 1 January 2016

Bāsāiěr gōngyuē yàtàiqū yù zhōngxīn 巴塞尔公约亚太区域中心 [BCRC China]. "Assessing the Status of E-waste Recycling in Selected Countries in the Asia-Pacific Region and Facilitating the Environmentally Sound Management of E-waste." 2014, http://en.bcrc.cn/col/1257152616046/2014/05/12/1399858044771.html, accessed 1 January 2016

Basu, Subhankar. "E-waste Generation, Mitigation, and a Case Study, Delhi." In *E-waste: Implications, Regulations, and Management in India and Current Global Best Practices*, edited by Rakesh Johri. New Delhi: The Energy and Resources Institute, 2008, pp. 45–68

Bo, Bi and Kayoko Yamamoto. "Characteristics of E-waste Recycling Systems in Japan and China." In *World Academy of Science, Engineering and Technology*, 38, 2010, pp. 500–506

Brigden, Kevin, Iryna Labunska, David Santillo, and Michelle Allsopp. *Recycling of Electronic Wastes in China and India: Workplace and Environmental Contamination.* Amsterdam: Greenpeace International, 2005

Chi, Xinwen, Martin Streicher-Porte, Mark Y. L. Wang, and Markus A. Reuter. "Informal Electronic Waste Recycling: A Sector Review with Special Focus on China." In *Waste Management*, 31, 2011, pp. 731–742

Chung, Shan-Shan and Chan Zhang. "An Evaluation of Legislative Measures on Electrical and Electronic Waste in the People's Republic of China." In *Waste Management*, 31, 2011, pp. 2638–2646

Cling, Jean-Pierre, Mireille Razafindrakoto, and François Roubaud. *The Informal Economy in Vietnam*. Geneva: International Labour Organization (ILO), 2010

Cobbing, Madeleine. *Toxic Tech: Not in Our Backyard. Uncovering the Hidden Flows of E-waste*. Amsterdam: Greenpeace, 2008

Davidson, Gary. *Waste Management Practices: Literature Review*. Nova Scotia: Dalhousie University, 2011

Dayaneni, Gopal and John Doucette. *System Error*. San Jose: Silicon Valley Toxics Coalition, 2005

Doyon-Martin, Jacquelynn. "Cybercrime in West Africa as a Result of Transboundary E-Waste." In *Journal of Applied Security Research*, 10/2, 2015, pp. 207–220

DTI Global Watch Mission. *Waste Electrical and Electronic Equipment (WEEE): Innovating Novel Recovery and Recycling Technologies in Japan*. London: Department of Trade and Industry, 2005

Frey, R. Scott. "The E-Waste Stream in the World-System." In *Journal of Globalization Studies*, 3/1, 2012, pp. 79–94

Fuse, Masaaki, Eiji Yamasue, Barbara K. Reck, and T. E. Graedel. “Regional Development or Resource Preservation? A Perspective from Japanese Appliance Exports.” In *Ecological Economics*, 70, 2011, pp. 788–797

Gaidajis, Georgios, Komninos Angelakoglou, and Despoina Aktsoglou. “E-waste: Environmental Problems and Current Management.” In *Journal of Engineering Science and Technology Review*, 3/1, 2010, pp. 193–199

Gossart, Cédric. *StEP Green Paper on E-waste Indicators*. Bonn: United Nations University/Step Initiative, 2011

Hai, Huynh Trung, Ha Vinh Hung, and Nguyen Duc Quang. “An Overview of Electronic Waste Recycling in Vietnam.” In *Journal of Material Cycles and Waste Management*, December 2015, pp. 1–9

He, Wenzhi, Guangming Li, Xingfa Ma, Hua Wang, Juwen Huang, Min Xu, and Chunjie Huang. “WEEE Recovery Strategies and the WEEE Treatment Status in China.” In *Journal of Hazardous Materials*, B136, 2006, pp. 502–512

Heilmann, Sebastian. “Policy Experimentation in China’s Economic Rise.” In *Studies in Comparative International Development*, 43/1, 2008, pp. 1–26

Herat, Sunil and P. Agamuthu. “E-waste: A Problem or an Opportunity? Review of Issues, Challenges and Solutions in Asian Countries.” In *Waste Management & Research*, 30/11, 2012, pp. 1113–1129

Hicks, Charlotte, Rolf Dietmar, and Martin Eugster. “The Recycling and Disposal of Electrical and Electronic Waste in China—Legislative and Market Responses.” In *Environmental Impact Assessment Review*, 25, 2005, pp. 459–471

Hoornweg, Daniel and Perinaz Bhada-Tata. *What a Waste: A Global Review of Solid Waste Management*. Washington, D.C.: World Bank, 2012

Hotta, Yasuhiko, Atsushi Santo, and Tomohiro Tasaki. *EPR-based Electronic Home Appliance Recycling System under Home Appliance Recycling Act of Japan*. Tokyo: IGES, 2014

Imura, Hidefumi and Miranda A. Schreurs. *Environmental Policy in Japan*. Cheltenham and Northampton: World Bank, 2005

ISWA. *Solid Waste: Guidelines for Successful Planning*. São Paulo: ISWA, 2011

Kankyōshō 環境省 [Ministry of the Environment] and Keizai sangyō shō 経済産業省 [Ministry of Economy, Trade and Industry]. “Heisei 26 nendo niokeru kaden risaikuru jisseki nitsuite” 平成 26 年度における家電リサイクル実績について [Report on Progress in Recycling Home Appliances in 2014]. 2015, http://www.env.go.jp/press/101129.html, accessed 9 February 2016

Keizai sangyō shō 経済産業省 [Ministry of Economy, Trade and Industry]. “10 tsuki wa 3 R (ridyūsu.riyūsu.risaikuru) suishin gekkan desu!” 10 月は 3R (リデュース・リユース・リサイクル) 推進月間です! [October is 3R (Reduce, Reuse and Recycle) Awareness Month]. 2015, http://www.meti.go.jp/press/2015/10/20151001004/20151001004.html, accessed 2 February 2016

Kiddee, Peeranart, Ravi Naidu, and Ming H. Wong. “Electronic Waste Management Approaches: An Overview.” In *Waste Management*, 33, 2013, pp. 1237–1250

Lee, Soo-cheol and Sung-in Na. “E-Waste Recycling Systems and Sound Circulative Economies in East Asia: A Comparative Analysis of Systems in Japan, South Korea, China and Taiwan.” In *Sustainability*, 2, 2010, pp. 1632–1644

Leung, Anna O. W., Nurdan S. Duzgoren-Aydin, K.C. Cheung, and Ming H. Wong. “Heavy Metals Concentrations of Surface Dust from E-waste Recycling and Its Human Health Implications in Southeast China.” In *Environmental Science and Technology*, 42/7, 2008, pp. 2674–2680

Liu, Xianbing, Masaru Tanaka, and Yasuhiro Matsui. "Electrical and Electronic Waste Management in China: Progress and the Barriers to Overcome." In *Waste Management & Research*, 24, 2006, pp. 94–101

Lundgren, Karin. *The Global Impact of E-waste: Addressing the Challenge*. Geneva: International Labour Organization (ILO), 2012

Menikpura, Nirmala, Atsushi Santo, and Yasuhiko Hotta. "Assessing the Climate Co-benefits from Waste Electrical and Electronic Equipment (WEEE) Recycling in Japan." In *Journal of Cleaner Production*, 74, 2014, pp. 183–190

METI. *Towards a 3R-Oriented, Sustainable Society: Legislation and Trends 2010*. Tokyo: METI, 2010

MOE. "Fundamental Plan for Establishing a Sound Material-Cycle Society." 2013, https://www.env.go.jp/en/recycle/smcs/3rd-f_plan.pdf, accessed 2 January 2016

MOE. "The Asian Network for Prevention of Illegal Transboundary Movement of Hazardous Wastes." 2015a, http://www.env.go.jp/en/recycle/asian_net/index.html, accessed 2 January 2016

MOE. "Asia E-waste Project." 2015b, http://www.env.go.jp/en/recycle/asian_net/Project_N_Research/ Asia_E-waste_Project.html, accessed 2 January 2016

MOE. "Activities for Prevention of Illegal Import/Export." 2015c, http://www.env.go.jp/en/recycle/basel_conv/Activities/index.html, accessed 31 January 2016

Mungai, Christine. "The Mobile Phone Comes First in Africa; Before Electricity, Water, Toilets or Even Food." *Mail & Guardian Africa*, 3 March 2015, http://mgafrica.com/article/2015-03-03-mobile-come-first-in-africa-before-electricity-water-toilets-or-even-food, accessed 29 July 2015

Nguyen, Duc-Quang, Eiji Yamasue, Hideyuki Okumura, and Keiichi N. Ishihara. "Use and Disposal of Large Home Electronic Appliances in Vietnam." In *Journal of Material Cycles and Waste Management*, 11/4, 2009, pp. 358–366

Ni, Hong-Gang and Eddy Y. Zeng. "Law Enforcement and Global Collaboration are the Keys to Containing E-Waste Tsunami in China." In *Environmental Science & Technology*, 43/11, 2009, pp. 3991–3994

Nnorom, Innocent C. and Oladele Osibanjo. "Overview of Electronic Waste (E-Waste) Management Practices and Legislations, and Their Poor Applications in the Developing Countries." In *Resources, Conservation and Recycling*, 52, 2008, pp. 843–858

Ogushi, Yasuhiko and Milind Kandlikar. "Assessing Extended Producer Responsibility Laws in Japan." In *Environmental Science & Technology*, July 2007, pp. 4502–4508

OECD. *Extended Producer Responsibility: A Guidance Manual for Governments*. Paris: OECD, 2001

OECD. *Environmental Outlook to 2030*. Paris: OECD, 2008

OECD. "How Does the Chinese E-waste Disposal Fund Scheme Work." 2014, http://www.oecd.org/environment/waste/China%20case%20study%20final.pdf, accessed 30 January 2016

OECD and MOE. "The State of Play on Extended Producer Responsibility (EPR): Opportunities and Challenges." In *Global Forum on Environment: Promoting Sustainable Materials Management through Extended Producer Responsibility (EPR)*, Tokyo, Japan, 17-19 June 2014

Pham, Sy Liem. "Handling of Solid Waste in Vietnam." Presentation at the *4th Civil Engineering Conference in the Asian Region held by the Asian Civil Engineering Coordinating Council (ACECC)*, Taipei, Taiwan, 26-28 June 2007

Premakumara, Dickella G. J. and Toshizo Maeda. "Municipal Solid Waste: The Burgeoning Environmental Threat." In *Routledge Handbook of Environment and Society in Asia*, edited by Paul G. Harris and Graeme Lang. Abingdon and New York: Routledge, 2015, pp. 176–196

Premalatha, M., Tabassum-Abbasi, Tasneem Abbasi, and Sakineh Abbasi. "The Generation, Impact, and Management of E-Waste: State of the Art." In *Critical Reviews in Environmental Science and Technology,* 44/14, 2014, pp. 1577–1678

Puckett, Jim, Leslie Byster, Sarah Westervelt, Richard Gutierrez, Sheila Davis, Asma Hussain, and Madhumitta Dutta. *Exporting Harm: The High-Tech Trashing of Asia*. Seattle and San Jose: Basel Action Network and Silicon Valley Toxics Coalition, 2002

Sawhney, Puja, Mikael Henzler, Stefan Melnitzky, and Anita Lung. *Best Practices for E-waste Management in Developed Countries*. Berlin: Adelphi Research, 2008

Schluep, Mathias, Christian Hagelueken, Ruediger Kuehr, Federico Magalini, Claudia Maurer, Christina Meskers, Esther Mueller, and Feng Wang. *Recycling – From E-waste to Resources*. Berlin: United Nations Environment Programme and United Nations University, 2009

Schwartz, Frank J. and Susan J. Pharr. *The State of Civil Society in Japan*. Cambridge: Cambridge University Press, 2003

Seadon, Jeffrey K. "Sustainable Waste Management Systems." In *Journal of Cleaner Production*, 18, 2010, pp. 1639–1651

Shinkuma, Takayoshi and Nguyen Thi Minh Huong. "The Flow of E-Waste Material in the Asian Region and a Reconsideration of International Trade Policies on E-waste." In *Environmental Impact Assessment Review*, 29, 2009, pp. 25–31

StEP. *One Global Definition of E-waste*. Bonn: United Nations University/Step Initiative, 2014

Sthiannopkao, Suthipong and Ming Hung Wong. "Handling E-waste in Developed and Developing Countries: Initiatives, Practices, and Consequences." In *Science of the Total Environment*, 463-464, 2013, pp. 1147–1153

Streicher-Porte, Martin. "An Introduction to 'Best of 2 Worlds' Project." 2009, http://ewasteguide.info/files/Streicher-Porte_2009_Bo2W.pdf, accessed 30 January 2016

Terazono, Atsushi and Aya Yoshida. "Current International Flows of Electronic Waste, Future Tasks, and Possible Solutions." In *E-waste Management: From Waste to Resource*, edited by Klaus Hieronymi, Ramzy Kahhat and Eric Williams. London and New York: Routledge, 2012, pp. 137–164

Thai, Nguyen Thi Kim. "Hazardous Industrial Waste Management in Vietnam: Current Status and Future Direction." In *Journal of Material Cycles and Waste Management*, 11, 2009, pp. 258–262

Tue, Nguyen Minh, Agus Sudaryanto, Tu Binh Minh, Tomohiko Isobe, Shin Takahashi, Pham Hung Viet, and Shinsuke Tanabe. "Accumulation of Polychlorinated Biphenyls and Brominated Flame Retardants in Breast Milk from Women Living in Vietnamese E-waste Recycling Sites." In *Science of the Total Environment*, 408/9, 2010a, pp. 2155–2162

Tue, Nguyen Minh, Go Suzuki, Shin Takahashi, Tomohiko Isobe, Pham T. K. Trang, Pham Hung Viet, and Shinsuke Tanabe. "Evaluation of Dioxin-like Activities in Settled House Dust from Vietnamese E-waste Recycling Sites: Relevance of Polychlorinated/brominated Dibenzo-p-dioxin/furans and Dioxin-like PCBs." In *Environmental Science & Technology*, 44/23, 2010b, pp. 9195–9200

UNDP. *Human Development Report 2014. Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience*. New York: United Nations Development Programme (UNDP), 2014

UNEP. "International Environmental Technology Centre (IETC)." 2015, http://www.unep.org/ietc/AboutIETC/tabid/56241/Default.aspx, accessed 15 December 2015

United Nations Human Settlements Programme (ed.). *Solid Waste Management in the World's Cities*. London and Washington, D.C.: United Nations Human Settlements Programme (UN-HABITAT), 2010

UNODC. *Transnational Organized Crime in East Asia and the Pacific: A Threat Assessment*. Bangkok: United Nations Office on Drugs and Crime (UNODC), 2013

United Nations University and Step Initiative. "China." 2016, http://www.step-initiative.org/Overview_China.html, accessed 1 January 2016

United States Environmental Protection Agency. "What Is Integrated Solid Waste Management?" 2002, http://www.epa.gov/climatechange/wycd/waste/downloads/overview.pdf, accessed 11 July 2015

URENCO. *The Development of E-waste Inventory in Vietnam*. Hanoi: URENCO Urban Environmental Company Limited, 2007

Van de Klundert, Arnold and Justine Anschütz. *Integrated Sustainable Waste Management — The Concept*. Gouda: WASTE, 2001

Vietnam Environment Administration. "Introduction on E-Waste Management in Vietnam." 2011, http://www.unep.org/ietc/Portals/136/Events/ WEEE-E%20workshop%20July%202011/12.Vietnam.pdf, accessed 31 January 2016

VNS. "Consortium Launches E-waste Recycling Programme in Vietnam." 2015, http://english.vietnamnet.vn/fms/environment/127608/consortium-launches-e-waste-recycling-programme-in-vietnam.html, accessed 31 January 2016

Wang, Feng, Ruediger Kuehr, Daniel Ahlquist, and Jinhui Li. *E-waste in China: A Country Report*. Bonn: United Nations University/StEP Initiative, 2013

Wang, Zhaohua, Bin Zhang, Jianhua Yin, and Xiang Zhang. "Willingness and Behavior Towards E-waste Recycling for Residents in Beijing City, China." In *Journal of Cleaner Production*, 19, 2011, pp. 977–984

Wei, Lin and Yangsheng Liu. "Present Status of E-Waste Disposal and Recycling in China." In *Procedia Environmental Sciences*, 16, 2012, pp. 506–514

Widmer, Rolf, Heidi Oswald-Krapf, Deepali Sinha-Khetriwal, Max Schellmann, and Heinz Böni. "Global Perspectives on E-waste." In *Environmental Impact Assessment Review*, 25/5, 2005, pp. 436–458

Wiesmeth, Hans, Dennis Häckl, Quang Trung Do, and Duy Cam Bui. "A Holistic Approach to Recycling of CRT Glass and PCBs in Vietnam." In *Journal of Vietnamese Environment*, 2/1, 2012, pp. 1–7

World Bank. *Vietnam Environment Monitor 2004*. Washington, D.C.: World Bank, 2005

World Bank. "GDP Per Capita (current US$)." 2016, http://data.worldbank.org/indicator/NY.GDP.PCAP.CD, accessed 20 February 2016

Yang, Jianxin, Bin Lu, and Cheng Xu. "WEEE Flow and Mitigating Measures in China." In *Waste Management*, 28, 2008, pp. 1589–1597

Yoshida, Aya, Tomohiro Tasaki, and Atsushi Terazono. "Material Flow Analysis of Used Personal Computers in Japan." In *Waste Management*, 29, 2009, pp. 1602–1614

Yoshida, Fumikazu and Haruyo Yoshida. "Japan, the European Union, and Waste Electronic and Electrical Equipment Recycling: Key Lessons Learned." In *Environmental Engineering Science*, 27/1, 2010, pp. 21–28

Yoshida, Fumikazu and Haruyo Yoshida. "E-Waste Management in Japan: A Focus on Appliance Recycling." In *Advanced Materials Research*, 878, 2014, pp. 420–423

Yu, Jinglei, Eric Williams, Meiting Ju, and Chaofeng Shao. "Managing E-waste in China: Policies, Pilot Projects and Alternative Approaches." In *Resources, Conservation and Recycling*, 54, 2010, pp. 991–999

Zhou, Lei and Zhenming Xu. "Response to Waste Electrical and Electronic Equipments in China: Legislation, Recycling System, and Advanced Integrated Process." In *Environmental Science & Technology*, 46, 2012, pp. 4713–4724