ECONOMICS OF E-WASTE

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Preface

E-waste or Waste Electrical and Electronic Equipment (WEEE) has been generally defined as anything with a cord or battery. Because products with cords and batteries have been around since at least the nineteenth century, managing the waste stream for those products at the end of their useful life is not a new problem. What is relatively new is the perception of WEEE not just as waste, but instead as a valuable resource that can be managed through reuse of the electronic device itself (reuse), recycling of its components (recycling), or disposal of the device or its components (disposal). Recognition of WEEE as a resource has led to a paradigm shift in WEEE management. Historically, management of WEEE simply involved choices between disposal options. That outlook has given way to a focus on recycling and reuse, with disposal becoming much less prevalent. This change has been attributed to a host of concerns—commercial, societal, and environmental. In the modern view, a successful approach to the management of WEEE seeks to achieve economic efficiency while minimizing impacts to the environment. Regardless of the perspective taken on WEEE, there can be no denying that economics are the leading policy driver. But societal or environmental concerns do not take the back seat. Acceptable WEEE management is seen as requiring harmonizing of commercial, societal, and environmental interests equally. Recycling and reuse of WEEE has become a common practice around the world due, in large part, to the ubiquity of electronics in our daily lives.

This bibliographical survey focuses on 'Economics of E-Waste'. This bibliography lists the studies relating to the broader economic policy framework that could directly or indirectly impact the financial sector and influence its activities in managing the electronic waste. This bibliography presents several economic aspects of electronic waste management. It covers a lot a regions in the world, and has a holistic value in the sense that it permits to compare the various definition of "E-waste" across the world.

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ECONOMICS OF E-WASTE

Dwivedya,M., Suchde,P and Mittal, R.K(2015) "Modelling and assessment of e-waste take-back strategies in India", *Resources, Conservation and Recycling*,96,11-18.

Concept: The problem of growing e-waste (also called as WEEE) quantities in developing countries have prompted governments to plan innovative control measures and to institutionalize environment friendly strategies to mitigate the threats emanating from such waste. In India, e-waste recycling has been primarily a market driven industry. Under India's newly drafted e-waste management handling rules, the producers are expected to introduce and implement EPR regimes as early as possible. The scope of implementing EPR has also been discussed in these guidelines. In this work, we make an attempt to assess different EPR take-back policies and investigate their suitability for the Indian conditions. We use an economic model to ascertain the profitability of different EPR take-back schemes. In order to sustain the higher costs of e-waste recycling, the overall profitability of the e-waste take-back scheme is vital to the success of any e-waste recycling mandate. The results from our modelling clearly show that from the viewpoint of both the consumers and the producers, an individual take-back scheme outperforms the collective take-back scheme. We also describe impacts and implications of these take-back schemes on the model parameters of interest

Thavalingam, V., Karunasena,G (2016) "Mobile phone waste management in developing countries: A case of Sri Lanka", *Resources, Conservation and Recycling* 109,34–43.

Concept: The fashionable and technological market has started to invent new trends of mobile phones frequently. This impacts on consumer attitude and shorten the usable life span of a mobile phone. Due to this the number of unused and waste mobile phones has started to increase and a need has arisen to manage mobile phone waste. Lack of legislation, illegal markets, second hand markets and lack of processing technologies make mobile phone waste management process more critical in developing countries compared to

developed countries. In this context, the study intended to identify major gaps in mobile phone waste management in developing countries with a special emphasis on Sri Lanka. This was achieved through three case studies and six (06) expert interviews. The case studies focused on companies involved in mobile phone industry and expert interviews targeted individuals involved and experienced in mobile phone waste management. The research findings identified major gaps in legislation and processes, focusing on public contribution. Neither e-waste policies nor strategies are stimulating; people are unaware of impacts and proper management of mobile phone waste. Thus, this research, a framework was developed by identifying gaps and makes suggestions to enhance mobile phone waste management in future.

Heeks,R., Subramanian,L and Jones,C(2015) "Understanding E-Waste Management in Developing Countries: Strategies, Determinants, and Policy Implications in the Indian ICT Sector", *Information Technology for Development,* 21(4), 653-667.

Concept: Management of e-waste is a growing problem for developing countries; one that may undermine the sustainability of information and communication technology (ICT) use if not addressed. In this paper, we focus on a somewhat under-emphasized group that contributes significantly to developing country e-waste: local organizational consumers of ICT. Although this group creates the majority of e-waste, the factors shaping their e-waste decisions are not well understood. Our purpose in the paper is to provide such an understanding. This paper, therefore, builds conceptual models of e-waste strategies and e-waste strategy determinants from the environmental management literature. It applies these models to a key ewaste producer – the ICT services sector in India – drawing qualitative data from a mix of very large and small/medium firms. While the former has been proactive in their e-waste strategy, the small/medium firms are characterized as indifferent to e-waste; a divergence explained by the very different strengths of determining factors to which they are subject. In turn, those factors relate to the size of these ICT consumers and the nature of value

chains into which they are placed. Understanding these determinants can help us plan better e-waste interventions; a point illustrated through critique of recently introduced legislation.

Bhol,N. Vinay and Shah,T (2014) "E-Waste -A new Environmental Challenge", *International Journal of Advanced Research in Computer Science and Software Engineering* ,4(2).

Concept: Central issue of the current study is electronic-waste (e-waste) which is emerging as a new environmental challenge for 21st century. The rapid growth of the electronic and IT industry, present consumer culture, increasing rates of consumption of electronic products have led to disastrous environmental consequences. E-waste, while recycling, may be hazardous because of toxicity of some of the substances it consists of. Some of the waste has been proven to contain many cancer-causing agents. The consequences and toxicity is due to discharge of lead, mercury, cadmium, beryllium and other toxic substances. Developed countries export this waste in the form of donation to developing countries. China and India, where environmental standards are low, are the biggest recipients of e-waste which, in most cases, is processed illegally. The environmental burden of e-waste is born by people who live in developing countries, especially China and India, which processes the maximum amount of e-waste. Despite various laws and directives in developed countries, the e-waste management is uncontrolled. The present study focuses on the effect of usage, dumping and recycling of the electronic waste on the natural environment.

Mehta, A., Chauhan, D., Kumar,S and Gour,A(2015) "Assessing the Environmental Impacts Associated With the Life Cycle of Electronic Equipment", *Journal of Environmental Science, Toxicology and Food Technology*,9(6),48-53.

Concept: Abstract: Electronics is increasingly becoming a part of many aspects of life. This has led to a fast-growing demand for electronic. The production of electronics requires various materials, energy, man-force and other resources. The various stages of production have their share of impact

on the environment. Discarding these electronics poses another, rapidly increasing, danger on the environment. This is the issue of e-waste or electronic waste. A lot is being done to reduce the problems being caused by the electronic industry, but with optimization even more environment-friendly and economical solutions are possible. Environmental planning involves production in a sustainable manner with consideration given to the natural environment, social, political and economic factors. This paper broadly talks about the impacts, of the current practices of the electronics industry, on the environment and suggests ways to reduce those impacts. The main study is divided into sections discussing the environmental aspects, of the industry, related to raw materials, the manufacturing process, the packaging stage and discarding the equipment, i.e., generation of e-waste.

FHA. Shibly & Thelijjagoda, Dr. S. S "Development of a Web Based Electronic Waste Management System: A Study with Special Reference to Recycling Companies in Sri Lanka" *International Journal of New Technologies in Science and Engineering*,2(2).

Abstract: Information and Communication technology (ICT) and/or Information Technology (IT) are the effective tools that have been employed in the field of education, research, administration and other ways for the betterment of the human life that brings revolution in the modern era. There are number of advantages and disadvantages available in using ICT for our activities. One of the major disadvantages of ICT and its devices is harmful substances including carbon dioxide (CO2) to the environment that are not eco-friendly. Software and hardware part of IT has touched most of the parts of social, technical, economic and natural environment. Exponentially increasing production of computer hardware has posed major challenges of proper disposal of the electronic waste (e-waste) produced by this industry. Recycling companies are the key stakeholders in managing e-wastes in developing countries. But, they don't have any proper system to handle those wastes. Therefore, the objective of this research is to explore and investigate the current condition of electronic waste's recycling system in Sri Lanka and to study the problems faced by recycling companies in handling e-wastes as

well as to develop a use case diagram to build a computerized system to solve e-waste recycling problems. A web based system, based on the use case diagram will be developed as the recycling companies of Sri Lanka and can put into operation that may be adopted for sustainable management of e-waste. The research method is case study and it is comprised of two phases: analysis the problem definition and develop a system design as a use case diagram. A structured questionnaire and informal interview methods were used to collect data. Secondary data from sources such previous research article on published and unpublished journals, websites, company database information, annual reports, magazines, etc were used. The population of the research was recycling companies of Sri Lanka and the sample size was seven registered recycling companies. The final system will be helpful for e-waste recycling companies to manage e-wastes and it will be benefited to the community and the nation as well.

Debnatha, B., Roychoudhuri R., Ghosh,S,K (2016) "E-Waste Management – A Potential Route to Green Computing*", Procedia Environmental Sciences* 35,669 – 675.

Concept: Green computing is a recent trend and an evolving field aiming towards a sustainable future. Different approaches have been established as possible directions towards green computing. Virtualization, Cloud computing, Energy minimization, reduction in use of hazardous substances in electronic items etc are a few approaches. Though major focus has shifted towards energy minimization, other approaches have churned themselves out as new subjects – cloud computing. Green computing encompasses a wide range of things. One of them is e-waste management. End of life electronic equipment known as e-waste is a threat to the whole world. Globally 41.8 million metric tonnes of e-waste was generated in 2014. These electronic items are the hardware part of the computer. The proper management of e-waste hence leaves a good potential to implement green computing. An overwhelming amount of research articles focusing on green computing are present and major focus is on energy minimization, efficient algorithms and cloud computing. Literature on green computing focusing on e-waste

management is scant. The research questions aroused are as follows. Is it actually possible to implement green computing using e-waste management? What are the issues pertaining to it? How can this be achieved? How sustainable it this approach? The study tries to answer these questions. The main objective of this study is to establish e-waste management as a parameter for green computing. The study also intends to check the sustainability potential of this approach. The paper will help the stakeholders, practitioners, researchers and decision makers for choosing a benchmark approach and will pave directions for future research

Agamuthu,P., Kasapo,P., Nordin,N(2015) "E-waste flow among selected institutions of higher learning using material flow analysis model", *Resources, Conservation and Recycling*,105,177–185.

Concept: Institutions of higher learning (universities) contribute significantly to the rapidly growing threat of e-waste. This research focused mainly on Information and Communication Technology (ICT) e-waste management in selected universities in the Klang Valley of Central Region, Malaysia. ICT equipment (computers, printers, copiers) are the most widely used and frequently replaced electronics in universities and if not soundly managed pose grave environmental hazards because of their components which contain toxic substances. The objective of the article is to analyse e-waste flow among selected institutions of higher learning using material flow analysis model. Material Flow Analysis (MFA) modelling was conducted to investigate e-waste management systems, from asset purchase, use, end-of-life and disposal. Furthermore, MFA also led to better system analysis which contributed to practical recommendations for sustainable e-waste management. STAN (subsTance flow ANalysis) 2.5 software was used to perform the MFA modelling providing graphical models of university e-waste management, data reconciliation, propagation of uncertainty and gross error detection. Findings of the research showed that some universities generated 100 tons of ICT e-waste in 2012 with an estimated market value of RM 0.3 million (US$98.500). The study also found that 7.5 tons of e-waste was discarded into the MSW stream thus contributing to heavy metal

contamination in landfill or dump sites. Extended Producer Responsibility (EPR) options i.e. take-back in university systems were practically non-existent in these universities.

Kahhata,R., Kima,J., Xua,M., Allenbya,B., Williamsa,E and Zhanga,P(2008) "Exploring e-waste management systems in the United States", *Resources, Conservation and Recycling* ,52,955–964.

Concept: Quantities of end-of-life electronics (or e-waste) around the world keep growing. More than 1.36 million metric tons of e-waste were discarded, mainly in landfills, in the U.S. in 2005, and e-waste is projected to grow in the next few years. This paper explores issues relating to planning future e-waste regulation and management systems in the U.S. It begins by reviewing the existing U.S. recycling systems in the U.S. to establish the importance of developing public responses. Other countries and regions around the world have already legislated and implemented electronic takeback and recycling systems. To establish the context of existing experience, e-waste management systems in the European Union, Japan, South Korea and Taiwan are explored. The paper then discusses what specific conditions are expected to influence the acceptability and implementation in the U.S. A key consideration is the cultural imperative in the U.S. for market-driven solutions that enable competition. Given this context, a solution is proposed that is designed to ensure a proper end-of-life option while at the same time establishing a competitivemarket for reuse and recycling services. The solution, termed e-Market for Returned Deposit, begins with a deposit paid by consumers to sellers at the time of purchase, electronically registered and tracked via a radio-frequency identification device (RFID) placed on the product. At end-of-life, consumers consult an Internet-enabled market in which firms compete to receive the deposit by offering consumers variable degrees of return on the deposit. After collection of the computer by the selected firm, the cyberinfrastructure utilizes the RFID to transfer the deposit to the winning firm when recycled. If the firm chooses to refurbish or resell the computer in lieu of recycling, the transfer is deferred until true end-of-life

processing. Finally, the paper discusses the domestic and international consequences of the implementation of the proposed design.

Nnoroma, I.C., and Osibanjob,O (2008) "Overview of electronic waste (e-waste) management practices and legislations, and their poor applications in the developing countries" *Resources, Conservation and Recycling*,52,843–858

Concept: The developing countries are facing huge challenges in the management of electronic waste (e-waste) which are either internally generated or imported illegally as 'used' goods in an attempt to bridge the so-called 'digital divide'. E-waste contains hazardous constituents that may negatively impact the environment and affect human health if not properly managed. In these countries, because of lack of adequate infrastructure to manage wastes safely, these wastes are buried, burnt in the open air or dumped into surface water bodies. Crude 'backyard' recycling practices, which are not efficient and are highly polluting are also used in material recovery activities. Most developed countries have in place legislation mandating electronic manufacturers and importers to take-back used electronic products at their end-of-life (EoL) based on the principle of extended producer responsibility (EPR). In this paper, we review the concept of EPR, and discuss selected frameworks. The aim has been to find a mid-point for the implementation of even an 'abridged' form of EPR in the developing countries. Implementation of EPR in the developing countries has become necessary in the light of the present high level of trans-boundary movement of e-waste into the developing countries and the lack of basic or state-of-the-art recycling and waste disposal facilities. Change in attitude by governments, appropriate legislation dealing specifically with e-waste, control of electronic waste dumping, implementation of EPR and transfer of technology on sound recycling of e-waste are the key issues in effective management of e-waste in developing countries.

Razi,K (2016) “Resourceful recycling process of waste desktop computers: A review study” *Resources, Conservation and Recycling*,110,30–47

Concept: Waste computer is one of the largest growing waste streams among all e-waste globally. In the recent decades, the social and environmental solutions of the e-waste become the most difficult task for many parts of the world. Therefore, the risk of increasing e-waste has raised tension in the society. Ferrous and non-ferrous metals, plastics, resins, trace amount of precious metals, rare metals, and many other materials are used for the manufacturing of computer parts that can be recovered by recycling process to reuse in the future production. Obsolete computers are valuable sources for secondary raw materials, if recycled; if not, these devices are a source of toxins and carcinogens. Although a resourceful and efficient recycling process of the waste computers is a big challenge, a successful recycling in bulk amount might diminish the environmental load. Actual technical know-how for a complete recycle process of e-waste is still unknown to the scientific and industrial community. However, the recycling method will vary for each material and component of e-waste. In this study,the author tried to work out a distinct process flow to recycle every material of waste desktop computers, which may yield maximum recovery rate of metals and other raw materials. Computer recycling is the dismantling, separation and recovery process of components and raw materials from waste computers. An efficient recycling method and procedure of waste desktop computers has been projected in this study based on field observation and scientific resources, aim to achieve maximum recovery efficiency of precious metals, base metals and other materials.

Saphores, J.D., Ogunseitanc, A., Shapiro,A. (2012) “Willingness to engage in a pro-environmental behavior: An analysis of e-waste recycling based on a national survey of U.S. households”, *Resources, Conservation and Recycling*,60 ,49–63

Concept: Using concepts from environmental psychology and economics, we investigate U.S. households’ willingness to engage in a form of pro-environmental behavior: recycling electronic waste (e-waste) at drop-off

locations. We rely on rich dataset from a 2006 national survey of U.S. households (N = 2136). Our internal variables include a modified version of the New Ecological Paradigm scale, a moral norm scale based on Schwartz's norm-activation model, and indicators of social pressure for recycling. External variables consist of detailed socio-demographic characteristics. Our logit model shows that external variables do not help characterizing people with e-waste recycling experience, except that they tend to have larger families or to be over 60 years old. However, knowing that e-waste contains potentially toxic materials, recycling conventional materials at work or at school, and especially having strong moral norms helps explain e-waste recycling behavior. Using a generalized ordered logit model, we then show that the most important variables for explaining household willingness to recycle e-waste are internal variables, followed by recycling convenience, knowledge of the potential toxicity of e-waste, prior e-waste recycling experience, as well as gender and marital status; education, age, and ethnicity play only a minor role, while knowledge of e-waste laws, availability of curbside recycling for domestic waste, and income are not statistically significant. Our results suggest that e-waste recycling can be stimulated by promoting moral norms, educating the public about the benefits of recycling e-waste, and making e-waste recycling more convenient but other measures will likely be necessary to tackle the e-waste problem.

Rhee,S(2016) "Beneficial use practice of e-wastes in Republic of Korea" , *Procedia Environmental Sciences* ,31,707 – 714.

Concept: The EPR system, Eco-Assurance System, and the Allbaro system were examined as the regulation of E-wastes in this study. And beneficial use practice of E-wastes in Korea was introduced to improve recycling activities including collection system and recovery centre with facilities. In order to improve the recycling of waste in Korea (Republic of), the act on the promotion of saving and recycling of resources was activated in 1992. Under the act, waste charges and waste deposit fee system were operated for several products from industries to promote recycling measurement. Due to the abolition of waste deposit system in 2002, extended producer responsibility

(EPR) system was introduced in 20003 by the amendment of recycling law. Since early 2004, the Ministry of Environment of Korea has carried out a feasibility study to introduce an "Eco-Assurance System (The ECOAS)" which would restrict the use of hazardous substances in electrical and electronic equipment and promote recycling of E-wastes by applying a systemic management for life cycle analysis from cradle to grave. On January 2008, the Eco-Assurance Committee System in Korea has been implemented under the Act on the Resource Circulation of Electrical and Electronic Equipment and Vehicles for resource circulation and environmental conservation in a joint legislation by the Ministry of Environment, the Ministry of Knowledge & Economy, and the Ministry of Land, Transport and Maritime Affairs. According to the ECOAS in Korea, 5 product groups and 27 items of WEEE including refrigerator, personal computer, electric oven, audio, and mobile phone are controlled to intensify the recycling capacity in electronic industries. Beneficial use practice of recycling E-waste in Korea were examined to improve recycling activities including collection system, recovery centre with facilities by the information of E-Waste generation and recycling, policy and regulations of E-Waste. Even though total generation of E-wastes was almost constant recently, the generation trend of TV, refrigerator and washing machine was very increased because those products was used in household more than 2 times for past 10 years. Also, recycling rates of those E-wastes will be increased because recycling technologies have been improved and those E-wastes were readily decomposed by heavy parts.

Parajuly, K., Habib, K., Liu,G (2016), "Waste electrical and electronic equipment (WEEE) in Denmark: Flows, quantities and management" *Resources, Conservation and Recycling.*

Concept: In this study, we comprehensively map and estimate the flows of electrical and electronic equipment (EEE) and the corresponding waste (WEEE) in Denmark. The quantitative analysis is supplemented with a thorough diagnosis of the WEEE management system. Dynamic material flow analysis (MFA) is used to estimate the flows for the period of 1990–

2025. The estimates are based on sales data of 61 household products – equivalent to 80% (by weight) of the total household EEE – and their lifespans modelled using Weibull distribution function. Building on this, the potential resources available for recovery over time, and their corresponding revenues are evaluated. The results show that the amount of WEEE generated per year increased from 45 to 81 kilo tons (kt) between 1990 and 2015. The amount of EEE put on market (PoM), on the other hand, peaked to 101 kt in 2006 from 61 kt in 1991, but declined to 84 kt in 2015. In terms of the PoM quantity, the EEE market is found saturated, and can be expected to remain largely unchanged over the next decade. Consequently, there will not be any significant increase in WEEE quantities. Denmark has a well-established WEEE management system that has been performing adequately against the WEEE Directive. However, the new set of legislations means a need for recalibration of the performance indicators for the system. A more robust and systematic documentation of the flows will support the WEEE management system in achieving higher resource recovery.

Senophiyah Mary J, Meenambal T (2016) "Inventorisation of E-Waste and Developing a Policy - Bulk Consumer Perspective" *Procedia Environmental Sciences* 35,643 – 655.

Concept: Electronic waste (e-waste) or e-scrap or Waste Electrical and Electronic Equipment (WEEE) is the waste generated from the electrical and electronic equipment(s) (EEE) which is no longer fit for its originally intended use. Its growth is increasing as there is an increase in the development of Information and Telecommunication sectors, increased market penetration and planned obsolescence. This e-waste becomes hazardous since the electrical and electronic equipments require toxic heavy metals such as chromium, cadmium, nickel, lead, mercury, lithium and harmful plastics for their assembly and efficient functions. This e-waste imparts serious environmental and health hazards when it is broken, dismantled and treated in improper ways. The main purpose of this research is to find out how e-waste (Management & Handling) Rules, 2011 can be implemented for environmentally sound management of e-waste among bulk

consumer's sector where 70% of e-waste is stagnated in our country as revealed in various researches. Collection of data, through selective questionnaire and semi structured interviews with officers or experts from key relevant areas in IT and telecommunication sectors, hospitals, private institutions, recyclers and our educational institution were generated to develop a policy for complying subsidiary regulations and standards which will pave the way for effective resource recovery and protect our environment.

Manjunath,A(2016) "Partial replacement of E-plastic Waste as Coarse-aggregate in Concrete", *Procedia Environmental Sciences*, 35,731 – 739.

Concept: The management and recycling of E plastic waste is rapidly growing as it is a valuable resource of IT industries and it is very hazardous substances and with low recycling rate. The Utilization of e plastic waste materials is a partial solution to environmental and ecological problems. As the use of E plastic waste will reduces the Aggregate cost and provides a good strength for the structures and roads. It will reduce the landfill cost and it is energy saving. The e plastic waste consists of discarded plastic waste from the old computers, TVs, refrigerators, radios; these plastics are non-biodegradable components of E plastic waste as a partial replacement of the coarse or fine aggregates. An experimental study is made on the utilization of E-waste particles as fine and coarse aggregates in concrete with a percentage replacement ranging from 0 %, 20% to 30% i.e. (0%, 10%, 20% and 30%) on the strength criteria of M20 Concrete. Compressive strength, Tensile strength and Flexural Strength Concrete with and without E- waste plastic as aggregates was observed which exhibits a good strength. The feasibility of utilizing E-waste plastic particles as partial replacement of coarse aggregate has been presented. In the present study, compressive strength was investigated for Optimum Cement Content and 10% E-plastic content in mix yielded stability and very good in compressive strength of 53 grade cement.

Milovantsevaa,N., Fitzpatrick,C(2015)"Barriers to electronics reuse of transboundary e-waste shipment regulations: An evaluation based on industry experiences" ,*Resources, Conservation and Recycling* ,102,170–177.

Concept: In our globalized economy, increasing volumes of used electronics are shipped across national borders. While global and regional regulations prioritize, electronics reuse as a prudent approach for conserving resources and reducing environmental toxicity, their effect on cross-border shipping activities of the reuse industry is not well-known. This study analyses data from nine cases collected in 2012–13 via interviews and a survey of reuse organizations to identify the effects of these regulations on transboundary reuse activities, which respondents perceive as barriers to electronics reuse. Overall, three broad areas were identified in which regulations may directly influence the reuse organizations that participated in this study: (i) definitions, classification, operating procedures, and enforcement; (ii) evaluation of shipments; and (iii) requirement for functionality testing. These findings suggest that, contrary to the goal of encouraging reuse of discarded electrical and electronic equipment, in some cases regulations may be contributing to raising barriers for reuse organizations' business. To help eliminate these barriers, policy recommendations proposed in this paper include: appropriate legislative amendments; inclusion of issues related to reuse in the development of relevant national policies; establishment of a comprehensive international legislative database; creation of refurbishment operations close to the install base and integration of informal recyclers in the reuse sector; and an introduction of a regulated green e-waste transboundary channel.

Davis, J., Garb,Y(2015) "A model for partnering with the informal e-waste industry: Rationale, principles and a case study", *Resources, Conservation and Recycling* ,105,73–83.

Concept: Various forms of informal activity have long played an under-recognized yet substantial role in solid waste management, especially in developing countries. In particular, informal activity is prominent in the

electronic waste (e-waste) sector, whose volume and impactshave grownrapidly over recent decades. While the worrying aspects of informal e-waste recycling have been widely discussed, less attention has been given to its positive potential and to its relation to formal e-waste actors and policies. These topics have direct implication for pathways for transitioning from informality, and, in particular, ways in which informal recyclers can build on their strengths while beginning to operate in cleaner ways that retain livelihoods while reducing ill effects. In this paper, we draw upon extensive field work as well as secondary literatures to offer a taxonomy of management stances towards informal e-waste practices. These range from hostility through disconnection to interaction and, finally, synergy. Our recommendation is for the latter since the informal sector has important strengths and merits, as well as its harmful aspects, while formal approaches that ignore or attempt to squelch the informal sector do not yield constructive outcomes. Specifically, we suggest an incremental ratcheting synergistic model that draws on the respective strengths of both sectors to forge a genuine partnership between them. We describe six key elements of this model, and illustrate it through application to the Israeli–Palestinian context we have studied in depth. In particular, we show how the treatment of copper cables, now one ofthis industry's largest and most harmful segments, can be improved through an incremental series of synergetic solutions that preserve or even improve livelihoods of informal recyclers while greatly reducing their health and environmental impacts.

Ni,H and ZENG,E(2009)"Law Enforcement and Global Collaboration are the Keys to Containing E-Waste Tsunami in China", Environmental Science Technology, 43, 3991–3994

Concept: Various levels of regulation are needed to stem the environmental health crisis due to e-waste importation and disposal in China. Technological innovation and intense marketing strategies engender a rapid turnover of electrical and electronic devices. Consequently, large amounts of "e-waste" are constantly generated worldwide, posing an increasing global challenge for their disposal. The concern centres not only on the vast quantity of e-

waste generated daily, but more importantly on the urgent need to deal with the large list of toxic ingredients associated with e-waste. Heavy metals and polyhalogenated organics including PCBs can be released during e-waste disposal, posing extreme risk of harm to humans and the environment. As the world's largest importer and recycler of e-waste, China experiences increasing pressure to alleviate the environmental consequences of e-waste handling. Additionally, that other Asian developing countries such as Cambodia, India, Indonesia, Pakistan, and Thailand, as well as African developing countries like Nigeria, also receive e-waste, indicates that this problem is not just China's. The difference is that while African countries mainly reuse disposed electronics, Asian countries simply dismantle them in mostly unsafe manners. As the world begins to acknowledge the scope of the problem, it is notable that China, India, and other Asian countries have recently amended their laws to address e-waste imports. Further, some companies in developing countries have also attempted to safely dispose of e-waste with advanced technologies. Despite noble efforts, there has been extensive (international) media coverage reporting the serious environmental contamination and public health endangerment stemming from the improper disposal of e-waste in Asia and specifically China. The many underlying causal factors leading to China's e-waste crisis have not been explored and evaluated. As a result, the global battle against illegal handling of e-waste continues to grow in a largely unabated fashion. In this article, we will describe China's current state of disposing imported e-waste, summarize the existing Chinese laws and regulations concerning e-waste, then examine the motivations behind illegal handling of e-waste. Finally, we will present our thoughts and recommendations on how to curb illegal handling of e-waste in China.

Tran,C and Salhofer,S.P (2016) "Analysis of recycling structures for e-waste in Vietnam", *Journal of Material Cycles and Waste Management*

Concept: E-waste management in Vietnam poses real challenges such as the lack of specific e-waste legislation, the strong involvement of ''craft villages'' and the missing of monitoring data. Many issues (e.g., pollution

level, generated waste, health of workers and resident living at recycling sites) lead to the limited access to these craft villages. Thus, there is no comprehensive picture on e-waste management in Vietnam available today. This research focuses on the current situation of e-waste management. Sources of e-waste, collection and treatment in Vietnam are investigated by utilizing most available sources of information (published journals, unpublished works from projects and reports from institutes, ministry) together with the interviewed data from experts, collectors, workers and especially, biggest traders in the field. Based on this information, the processes applied in Vietnam, both in the formal and informal sector, have been analyzed systematically in terms of inputs, outputs, potential emissions and related risks for workers. From these aspects, a comparison in terms of legal frameworks, collection and treatment at both formal and informal sector between Vietnam and other countries in Asian region was undertaken. Thus, major challenges of e-waste management and relatively comprehensive image of e-waste management and treatment in Vietnam have been identified.

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