An Assessment of Public Awareness Regarding E-Waste Hazards and Management Strategies

Anuj Shah
Tara Dhakal, Academic Director
Trilochan Pandey, ISP Advisor, SIT World Learning
Dr. Nisha K. Shah, ISP Advisor, Gujarat University, Ahmedabad
SIT World Learning – India: Sustainable Development and Social Change
Spring 2014

Acknowledgements

First and foremost, I would like to acknowledge my family members, Pragna and Shailesh Shah, for their extensive efforts to ensure my attendance to interviews with members of the general public, civil society, private companies, and the government, and for the enthusiasm, love, and motivational support they never ceased to provide.

I would also like express my sincere thanks to Trilochan Pandey for facilitating the formulation of this project, and for his continued work throughout the ISP period in guiding my data analysis and connecting me to local experts in the field of e-waste management.

Additionally, I would like to thank Prapti Shah for her assistance in contacting and interacting with more e-waste experts, and for providing guidance in bringing my findings together cohesively.

Similarly, I would like to thank Professor Ashwani Kumar of CEPT University for providing secondary resources, and for connecting me to government level officials involved in waste management strategies.

Furthermore, I would like to thank Dr. Nisha K. Shah for connecting me to Prapti Shah.

Finally, I would like to express my gratitude to the Ahmedabad Municipal Corporation, Gujarat Pollution Control Board, E-Coli Waste Management, Wealth Out of Waste, the informal e-waste workers, Gujarat Cleaner Production Center, Eco-Sarjan, GiZ-ASEM, Toxics Link, the Jaipur Institute of Development Management, and numerous interviewees for helping me create a comprehensive analysis of issues surrounding e-waste management in Ahmedabad.

Table of Contents

Abstract

The fast pace of innovation both within India and abroad, along with the increasing affordability of electronic goods due to economic growth, has led to the rapid turnover of these consumer goods and thus enormous amounts of electronic waste (or e-waste). In addition to the sheer volume that must be managed, electronics contain highly toxic chemicals that complicate the waste handling process and can be detrimental to human health and the environment. However, India has only recently implemented regulations that directly address this issue through the Ministry of Environment and Forests (MoEF). Public awareness of this government policy and e-waste hazards is key to both active participation in management systems and the ability to put pressure on producer compliance. Thus, the study here attempts to assess this aspect of the e-waste situation through personal interviews with Indian families in Ahmedabad, a large city in Gujarat. Insight from government officials, NGO representatives, and formal and informal e-waste processing workers were also sought in order to give the general public interviews a structural context. It was found that most respondents do not participate in formal e-waste recycling systems, do not know specific details about the health and environmental hazards of e-waste, and do not know about the 2011 e-waste legislation. Additionally, only about one quarter acknowledge the possibility of extracting raw materials or spare components from unused electronics. Thus, government bodies must invest more in creating a public with greater knowledge of and agency in India's e-waste issue.

Introduction

The international boom in technological innovation has propelled the global electronics industry to become the largest manufacturing industry in the world. With the massive growth seen in the past 25 years, the concurrent rapid product obsolescence has resulted in a dramatic rise of electronic waste (or e-waste) streams in industrialized countries. E-waste may be described as waste electrical and electronic equipment, in whole or in part from their manufacturing and repair process, which are intended for disposal (E-Waste Rules, 2011).

Not only does this create a general waste management issue – due to the presence of many materials and chemicals in electronic products, resulting waste has the potential to severely compromise human health and the environment. Hazardous chemicals typically found in e-waste include (but are not limited to) various heavy metals – mercury, cadmium, and lead – brominated flame retardant plastics (BFRs) that can convert into dioxins and furans when burned at high temperatures, and polychlorinated biphenyls (PCBs) (Wath et al., 2010). Thus, the toxic chemicals derived from these consumer goods can have a high bodily accumulation capacity, are carcinogenic, or are highly detrimental to the nervous system, kidney, bones, and reproductive and endocrine systems. Without effective government regulation of the disposal of electronic consumer goods, and without public awareness of the inherent hazards, accumulation of such waste will have dire consequences for the human population.

The issue of e-waste is highly relevant to India, which has become a popular global site for e-waste dumping. While its annual domestic production of e-waste is quite large – approximately 800,000 tons – its rate of import is no small factor either. Official figures estimate that 50,000 tons of e-waste are imported from foreign countries per year, with actual figures significantly larger due to lack of compliance with international trade policies (Agarwal, 2012).

The current body of research provides extensive information about health and environmental consequences of e-waste, and the extent of infrastructural support in India. However, there is limited information on the Indian public's awareness of the use of toxic chemicals in these products, government policies regarding e-waste management, and proper practices of disposal. Additionally, the general population's perception of unused electronics – whether or not they consider it to be a form of waste – is still unclear. An assessment of public awareness at the level of the individual is vital to understanding what is missing from management strategies, and to understanding the public's behavior toward e-waste. Indeed, building public awareness will be key to active and effective participation in e-waste systems. Awareness is also necessary if India hopes to have active consumers who will demand more responsibility from electronics producers and more action from policymakers. Additionally, if producers become responsible for the end-of-life costs of their products, a feedback loop will be created to encourage product developers to reduce such costs, by making their product less toxic and more amenable to material recycling ("*TakeBack Blues: An Assessment…*" 2008).

Therefore, this study will focus on public awareness, specifically in Ahmedabad, of issues surrounding e-waste. The household electronics of interest will be personal computers and mobile phones. Ahmedabad was chosen because of Gujarat's status as a model of development for other Indian states, and because of the high generation of e-waste relative to other regions of the country. While official estimates of e-waste generation are based on manufacturer estimates of product lifetime rather than real amounts of waste, the western region of India seems to lead the country, accounting for 35% of total waste electrical and electronic equipment (WEEE) production. Additionally, in 2008, Gujarat ranked 8th by state in terms of e-waste generation, while Ahmedabad ranked 6th by city (Pinto, 2008).

In order to assess awareness, interviews will be conducted with individuals to determine their consumption and disposal of household electronics; awareness regarding government regulation of e-waste; and awareness regarding the presence of hazardous materials in electronics. Local and federal regulatory action will also be explored to understand the structure of e-waste management systems, along with the effectiveness of efforts from government bodies in Ahmedabad and Gujarat at large. Voices from NGOs working in this field will also be considered to gain insight into civil society's efforts to build momentum behind the e-waste issue. To understand the problem from the ground level, interviews with formal and informal collectors, dismantlers, and recyclers will be conducted as well. Taken together, this study will evaluate the general population's awareness of e-waste hazards and issues surrounding proper management, and thus shed light on possible successes and shortcomings in policy implementation.

Background

A global review of e-waste management indicates that, generally, waste production is high and on the rise, mainly in the realm of IT and communications equipment (Ongondo et al., 2011). India's dramatic economic growth has largely promoted the domestic market for a variety of electronics, most notably mobile phones, personal computers, televisions, refrigerators, and washing machines. However, upon purchase of new products, most consumers do not know about the proper methods for disposing of the older product. It is estimated that 75% of electronic items are stored due to uncertainty of how to manage it. Thus, unused electronics lie unattended in homes, offices, and warehouses until they are eventually mixed in with regular waste and dumped in landfills (Borthakur and Sinha, 2013).

In turn, Indian businesses, and more recently, individual households, have begun to contribute enormous amounts of WEEE to the waste stream in India. Although, per capita, waste production in populous countries such as India and China is relatively small, these countries produce huge amounts of aggregate WEEE. Several studies even indicate that the annual rate of e-waste production will reach 0.7 million metric tons by 2015 and 2.0 million metric tons by 2025 (Borthakur and Sinha, 2013). Importantly, it appears that the growth of e-waste will continue for some time, given the rate of innovation and emergence of affordable products.

However, it seems that most countries, except for those in Europe, have been slow in implementing effective strategies that comply with WEEE regulations, which also originated in Europe. Handling of WEEE in developing countries is largely done by the informal sector, which often utilizes repair and reuse practices that are harmful to health (Ongondo et al., 2011). In both developed and developing nations, the landfilling of WEEE is still a concern; in India, most landfills are not well equipped to handle such waste, and thus can promote air, water, and soil pollution (Borthakur and Sinha, 2013). With the projected growth of e-waste streams in this country, management solutions will become ever more necessary in the coming years.

Almost every task involved in waste management – collection, transportation, segregation, and dismantling – has been carried out by the unorganized sector in India (Wath et al., 2010). The lack of government regulation has allowed for the growth of an informal economy that provides a livelihood for the urban poor. However, rudimentary handling methods increase the severity of this health and environment-related problem (Wath et al., 2010). Additionally, as the WEEE supply grew in India over the past 15 years, the previously existing scrap metal industry began to collect, dismantle, sort, and recycle e-waste. Yet the same practices used for material extraction in regular waste were being applied here, presenting a multitude of

occupational hazards (Borthakur and Sinha, 2013). Current practices include open burning of plastic waste, use of toxic solders, dumping of acids, and widespread general dumping. Most of this work is done without Personal Protection Equipment (PPE), and carried out under poor lighting and insufficient ventilation (Wath et al., 2010). According to Greenpeace, businesses often encourage this work by selling discarded electronic equipment to informal recyclers for quick money, without realizing the hazardous implications for human health and the environment (2008).

The unorganized sector processes far more e-waste than does the formal sector – 2012 estimates show that 95% of e-waste is handled by informal workers (Borthakur and Sinha, 2013). There are currently over 2,000 informal recyclers in India, and Gujarat ranks among the top states for this practice. Generally, formal sector e-waste plants only carry out segregation and dismantling, leaving the recycling and final disposal of e-waste to the informal sector, or sending it to foreign countries. While e-waste management can be a profitable business, most formal processing centers currently do not have the capacity to handle all e-waste properly (Agrawal, 2013).

The majority of toxicological research regarding e-waste has been carried out in China, though all core findings are applicable to India as well. A study carried out in Guiyu, China indicates the hazards of direct exposure to electronic waste (Huo et al., 2007). Though many foreign nations, particularly the US, export such waste to Guiyu for processing and recycling, the city has very limited technology and practices for proper handling. The researchers drew comparisons between the blood lead levels (BLLs) of children under six years of age in Guiyu to the BLLs of similarly aged children in the neighboring city of Chendian. Strikingly, Guiyu

children had an average BLL of 15.3 μg/dL, whereas Chendian children exhibited a BLL of 9.94 μg/dL.

As stated above, India has also become a hotspot for e-waste dumping by developed countries, where environmental and health regulations increase the cost of recycling and processing. The researchers note that the US is the only developed country that has not signed the UN Basel Convention, which prohibits the export of hazardous waste to developing countries ("The Basel Convention at a Glance…"). Granted, countries that have signed the Convention often violate its policies as well. Dishonest organizations from developed countries will use donations of obsolete electronics as a loophole in the Basel Convention to export both functioning and nonfunctioning equipment to countries like India (Borthakur and Sinha, 2013). Thus, the Guiyu study highlights a dire need at both the international and local level for greater governmental regulation of e-waste transport and processing.

Many more studies highlight the significant toxicity of improperly handled e-waste. In a more localized study conducted in Wenling, an emerging e-waste processing center in the Taizhou district of China, heavy metal content of soil samples exceeded Chinese federal limits. It was also found that soil from areas surrounding small household workshops contained more heavy metals and polycyclic aromatic hydrocarbons (PAHs) than did soil from areas around large-scale plants (Tang et al., 2010). This points to the increased risks inherent to unregulated work by the informal sector, making such findings highly relevant to India's situation. A similar study that took place in the Guangdong province of South China investigated the heavy metal content of soil and vegetables from the area surrounding an e-waste processing site that utilized open burning (Luo et al., 2011). The researchers found, as expected, high concentrations of

cadmium, copper, lead, and zinc in soil samples, and levels of lead and cadmium that exceed limits for food in China.

Toxics Link, an NGO based in Delhi and Kolkata devoted to eliminating human exposure to hazardous materials, has published numerous studies and articles on the issue of electronic waste management in India. Because of the extensive involvement of unorganized labor, the NGO studied the hazards of handling brominated flame retardant (BFR) plastics, which are present in 12.5% of all electronic goods (Sinha, Mahesh, and Sharma, 2011). Polybrominated diethyl ethers (PBDEs) tend to leak from these electronics into the environment very easily, eventually finding their ways into the body, where, like heavy metals, they tend to accumulate at high levels. In this study conducted in Delhi, Sinha and Mahesh found a lack of occupational and environmental safety norms during processing of BFR plastics. Additionally, the conversion of BFRs to plastic pellets via high temperature processes for use in new products is shown to release brominated dibenzofurans, which are known to be carcinogenic. Another study from Guangzhou City, China indicates that such direct exposure to handling processes is not necessary for harmful exposure to PBDEs (Wang et al., 2010). Based on dust samples collected from households near e-waste recycling facilities, researchers found the estimated daily intake of such chemicals to be alarmingly high, especially for toddlers, raising concerns for at-risk populations.

Another Toxics Link study focusing on e-waste processing in Kolkata shows that the city of 14 million people is rapidly generating such waste due to a surge in computer usage (Ghosh and Mahesh, 2007). The researchers estimated that, at the time of study, Kolkata produced 9,000 tons of e-waste per year, 3,000 tons of which were solely from computers and its peripherals. Offices were largely unaware of the toxins present in this waste, and thus disposed of it indiscriminately. Users of electronics largely believed that producers should be responsible for

end-of-life processing, though unorganized laborers, again, have largely assumed this task. Additionally, there was no effective legislation in Kolkata for e-waste handling, creating a major bottleneck for this issue. Thus, there appeared to be a lack of awareness from the bottom (general population), a lack of effort from the top (government regulators), and negligence in the middle (from producers).

Similarly, in a study of e-waste management in Mumbai, Toxic Link researchers found that the city produces 19,000 tons of e-waste per year, including computers, televisions, refrigerators, and washing machines (Sinha, Wankhade, and Sinha-Khetriwal, 2007). As India's hub of banking and financial activity, it produces massive amounts of this waste, yet these institutions, at the time of the study, had no safe method of handling and disposal. Strikingly, they also found that much waste is sent to recycling markets outside of Mumbai (notably Delhi), thus sustaining this hazardous activity beyond state borders.

A study carried out by Greenpeace in 2008 revealed troubling findings on many producers' lack of action in the e-waste management problem. Researchers found that global EEE giants Apple, Microsoft, Panasonic, PCS Technology, Philips, Sharp, Sony, Sony Ericsson, and Toshiba had no take-back services operating in India. Many companies did exhibit take-back services, including Acer, Dell, HCL, Hewlett-Packard (HP), Lenovo, LG Electronics, Motorola, Nokia, WIPRO, Samsung and Zenith. However, HCL, WIPRO, LG Electronics, Motorola and Nokia were the only brands having relatively fully operating take-back services in the country, with other ones working effectively only in major cities. Additionally, no brand, up until the time of study, had invested significantly in education and awareness for customers on e-waste management, and few had invested in training their staff for take-back and recycling services ("*TakeBack Blues: An Assessment…*" 2008).

Studies have been conducted in other countries to assess the general public's sensitivity to the e-waste issue and inclination to partake in management strategies. In one study from Ningbo, a port city in the Zhejiang province of China, researchers found that about half of all Ningbo respondents were dissatisfied with their local environment, with 26% choosing solid waste (within which e-waste was included) as the most serious environmental problem. Interestingly, survey results showed that almost equal numbers of respondents chose the government and individual as the most responsible actors in environmental protection, with producers following close behind. Very few cited all three as responsible stakeholders. Of the respondent sample, 60% stated that they were willing to sort household waste before formal collection, and 80% said they were willing to pay more for environmentally sound products. The top reason for purchasing new electronics, namely computers and mobiles phones, was the ability to buy a new product and the need for greater power and capacity. When asked about methods of disposal, most respondents sold their WEEE to secondhand markets or gave them to friends and relatives (Huang, Zhang, and Deng, 2006).

A similar public awareness study was conducted in Kuala Lumpur, which is the capital city of Malaysia, a country with similar issues of domestic production and import of WEEE to India (Afroz et al., 2013). The researchers found that 59% of respondents had some knowledge about the health and environmental impacts of e-waste, and that 65% considered environmental factors when purchasing electronics for household use. Unfortunately, very few respondents seemed to put this knowledge to its full use, as only 2-3% were involved in the recycling of e-waste. However, 52.5% of households surveyed were willing to pay to improve the WEEE management system in Kuala Lumpur. Thus, with the proper public infrastructure and greater

awareness, the Malaysian government could motivate the public to partake in e-waste management strategies.

A study in the US assessed the effectiveness of state bans on the disposal of e-waste in municipal landfills, taking into account general awareness of environmental issues, pro-environmental behavior, and attitudes towards recycling small electronics (i.e. cell phones) (Milovantseva and Saphores, 2013). The results showed that California's Cell Phone Recycling Act had a significant and positive impact on the recycling rates of cell phones, decreasing the probability of trashing or holding unused cell phones for future recycling. However, other states' disposal bans on junk TVs were generally ineffective, due to poor publicizing and enforcement. Strikingly, those who exhibited greater environmentally friendly activity in the past than other respondents were no more likely to recycle cell phones than to trash, store, or hold on to them for future use. This indicates that previous pro-environmental behavior does not necessarily predict specific recycling practices. Thus, focused public awareness campaigns are necessary to inform consumers of government policies specifically addressing e-waste and proper practices of disposal.

Through a great deal of advocacy and pressure from civil society, the Indian federal government enacted the E-Waste (Management and Handling) Rules in 2011 through the MoEF, and began enforcement in May 2012. This was the first bill that directly addressed the issue of e-waste ("Implementation of E-Waste Rules, 2011"), and essentially required producers, collection centers, dismantlers, and recyclers to comply with WEEE policies. These regulations also provided guidelines for both households and small businesses in processing hazardous waste in a sustainable manner. Domestic residents do not have any responsibility under these regulations, apart from simple separation of hazardous from nonhazardous waste ("Domestic Households: A

Guide…" p. 2). Small businesses, on the other hand, are encouraged to determine if they produce hazardous waste, segregate and store such waste safely, ensure proper management of waste, and maintain consistent bookkeeping ("Small Businesses: A Guide…" p. 1). However, such guidelines are not law, and thus cannot be enforced.

A major component of the 2011 legislation is the Extended Producer's Responsibility (EPR), which placed the responsibility of environmentally sound management of end-of-life products on the manufacturer of the electronic consumer goods (E-Waste Rules, 2011). Specifically, producers are in charge of financing and organizing collection centers, and channelizing e-waste to government-authorized dismantlers and recyclers. For the consumer's benefit, this policy also requires producers to generate adequate awareness of health hazards and proper disposal via product labeling, publications, and advertisements, while informing customers about the location of authorized e-waste collectors. Technically, producers are prohibited from selling their electronic goods unless they register under the EPR regime (Agrawal, 2012), though actual compliance, as noted above, is highly questionable. However, Agrawal notes that MoEF policies also shy away from some key issues – incorporating the informal sector, e-waste imports, and setting collection targets, to name a few (2013).

The 2012 bill is closely tied to the Restriction of Hazardous Substances (RoHS) policy, adopted from Europe in July 2006. The RoHS sets limits on the amount of lead, mercury, cadmium, chromium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs) used in the manufacture of electronics ("Environmental Regulations"). Some large-scale Indian companies have complied with such policies in order to market products on a global scale, though widespread compliance in India still must be addressed.

As mentioned before, public awareness will be key in pressuring companies to comply with these government standards. However, the current body of research does not include studies that have tracked progress in e-waste management or changes in public awareness in India since WEEE policy implementation. Therefore, such an assessment is necessary to gain insight into India's most current situation on the e-waste front.

Methods

General Public Questionnaires: Individuals were sought through extended family members living in various municipalities of Ahmedabad. The snowballing technique, in which initial contacts lead to further indirect contacts, was used to connect with a greater number of possible interviewees. For in-person interviews, if the participant spoke English, oral consent (a routine practice for research conducted in India) was obtained. If the participant did not speak English, an English-speaking colleague from the same household or institution described the nature of the project and obtained oral consent in Gujarati, the language most spoken in Ahmedabad. The questions listed in Appendix A were used for these interactions. Questionnaires with a short description of the current study and intended use of collected data were also distributed via email through extended family members and personal contacts.

Household electronics have been defined as personal computers and mobile phones because these products exhibit the greatest turnover, due to rapid changes in software and the fast pace of their technological development. Questions 1-5 focus on use of household electronics, and are structured in a systematic way in order to quantify and explain an individual's consumption habits. Questions 6-8 seek insight into perceptions on waste disposal, question 9 focuses on individual knowledge of e-waste hazards, and question 10 looks into public

awareness of India's e-waste management policies. Information on participants' age and profession was also requested at the end of the survey. Thus, general public interviews will serve as a source of primary data on public awareness of the e-waste management issue. In total, 65 sufficiently complete surveys were collected. Appendix B describes the coding system used to quantify responses from the data set.

E-Waste Processing Workers: Interviews with formal and informal collection and dismantling workers and companies were sought through extended family connections and personal relations. The expectation for interactions with these workers was to provide insight into the hazards of such an occupation, and, possibly, to give another perspective on household waste disposal practices. Additionally, it was hoped that they would have personal views on which section of society should take primary responsibility for e-waste management, and what role they see the government playing. It was also expected that formal e-waste processing workers and companies would discuss their perspective on the role of the informal sector. The questions listed in Appendix C served as a general framework for these interviews. Translation was provided by an extended family contact when necessary.

The following sources were interviewed: kabadiwallahs operating under Sola Flyover in Memnagar; Wealth Out of Waste (WOW), a formal waste collection warehouse with headquarters in Navrangpura; Eco-Sarjan, an initiative begun by Ahmedabad's Society for Environment Protection (SEP); and E-Coli Waste Management Pvt. Ltd., a formal waste processing company with an operating e-waste facility. (While Eco-Sarjan is not a formal stakeholder within the e-waste processing chain, it facilitates such work and thus has been included in this category.)

NGO and Government Interviews: NGO representatives, along with government officials or policymakers, were sought via independent research and the assistance of personal contacts. The snowballing technique was used here as well to connect to a greater number of experts on e-waste. The questions in Appendix D served as a general framework for interactions with both NGO and government interviewees. NGO representatives were sought for an indication of civil society's efforts to increase public awareness of e-waste issues and facilitate government management strategies, providing a mediating perspective between consumers and the government. Policymakers were sought to shed light on prioritization of this issue at the federal level, along with the effectiveness of any implementation efforts. Of equal importance were both sources' views of producer responsibility in e-waste processing systems. Interviews were conducted in person for contacts within Ahmedabad, and over the phone for those throughout Gujarat or in other regions of India.

Two representatives from the Gujarat Pollution Control Board (GPCB) and two representatives from the Ahmedabad Municipal Corporation (AMC) provided the governmental perspective on e-waste management. The following NGOs were contacted as well: Jaipur Institute for Development Management (IDM); Toxics Link; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) India, an India-Germany partnership geared toward addressing environmental, energy related, and private sector demands in India; and Gujarat Cleaner Production Center (GCPC).

Findings

General Public Questionnaires

In total, 94% of questionnaire respondents reported that they use household electronics (again, defined in this study as mobile phones and personal computers), while 85% indicated that they use both mobile phones and computers frequently. Over the past 10 years, respondents purchased, on average, 4.3 mobile phones and 2.5 personal computers. Thus, consumers in Ahmedabad purchase a new mobile phone approximately every 2.3 years and a new computer every 4.2 years. In the same timeframe, 2.8 mobile phones and 1.3 computers went unused per person.

Figures 1-6 of Appendix E visually depict the data collected for Questions 5-10 of the general public questionnaire. Data from Question 5 indicate that most people – approximately 61% – purchase new electronic items due to a desire for the latest technology (Figure 1). Data from Question 6 show that many people tend to sell or give unused electronic items to a personal contact (35%), or keep these electronics in the home (26%) (Figure 2). Data collected for Question 7 indicate that most respondents – about 61% – do not consider unused electronics to be waste, and can either be repaired or reused, or can be a source of raw materials or spare parts (Figure 3). Responses from Question 8 show that 63% of respondents either do not know of any unused electronics collection service or only know of informal services, while 37% of respondents know of formal collection services (Figure 4). Data collected for Question 9 show that 65% of respondents either do not perceive any health or environmental hazards to e-waste, or do not know of specific hazards (Figure 5). Finally, responses from Question 10 indicate that 89% of respondents either do not think there are any government policies in place to handle e-waste, or do not know of any pertinent policies or governing bodies (Figure 6).

The data were also cross tabulated to determine if any trends exist across age groups. In response to Question 8, 50% of people 30 years or younger (n = 28) indicated that they did not know of any collection services, while 25% knew of formal collection systems. In contrast, 31% of people older than 30 years of age (n = 37) stated that they did not know of any collection systems, while 47% knew of formal services. These age groups had similar percentages of respondents knowing of informal e-waste collection services. In response to Question 9, 21% of people 30 years or younger said they know of e-waste hazards without indicating any specifics, and 29% conveyed knowledge of environmental hazards. For people older than 30 years of age, 49% stated they know of e-waste hazards without indicating specific ones, while only 8% mentioned environmental hazards. The age groups had similar percentages of respondents knowing of no hazards, respondents knowing of health hazards, and respondents acknowledging both health and environmental hazards.

Views on E-Waste Rules and Perceptions of Government Action

M.G. Kagzi of the GPCB openly discussed key flaws in the E-Waste Rules of 2011 – namely, that it lacks strong teeth to punish illegal e-waste processing (though he noted that the government may, in some cases, take action under Section 5 of the Environment Protection Act, 1986), and that the weak EPR regime must be bolstered in order to overcome the consumer's incentive to pass WEEE on to the informal sector (Kagzi, May 2nd, 2014). Nishit Pandya of the AMC echoed similar sentiments, and noted that public hearings, debates, and court meetings over the terms of the law during the year of deliberation watered down the policy dramatically. Specifically, Pandya asserted that the Rules do not address the number of collection points and authorized recyclers required within Ahmedabad, the amount of waste to be collected and

disposed, incentives for consumers to give unused electronics to the formal waste sector, a credible database on e-waste generation, and specifics regarding how PCBs should go about regulation (Pandya, April 28th, 2014). Ravi Kalantri of the AMC also emphasized that the 2011 legislation does not apply to individuals or small to medium-scale industries, but only to bulk consumers, manufacturers, and large industries, thus excluding major sources of e-waste from management strategies (Kalantri, April 30th, 2014).

Priyanka Porwal of GIZ India argued that the government should provide land and financial support for the establishment of collection centers, establish a monitoring system to track the effectiveness of policy implementation, put pressure on producers to raise public awareness, and give licensing and PPE to informal workers. Kalantri noted that India does not have strong regulatory agencies with enough financial resources and personnel, and thus cannot use negative reinforcement effectively. Priti Mahesh of Toxics Link also acknowledged such challenges, stating that State Pollution Control Boards (SPCBs) do not have the funding or support to follow through with federal regulations and enforce the EPR regime. However, in a general statement on the Indian government's approach to e-waste management, she also asserted that the issue is simply not a priority at either the state or local level, and is instead seen as a burden (Mahesh, March 24th, 2014), as did Vivek Agrawal of IDM (Agrawal, March 21st, 2014). Prakesh Vagela of E-Coli Waste Management (hereafter referred to as E-Coli) similarly argued that, while the law is satisfactory on paper, few people in the Central Pollution Control Board (CPCB), GPCB, and AMC truly want to take responsibility for e-waste management, with problems such as water sanitation and municipal solid waste still to be addressed (Vagela, April 15th, 2014). Kalantri confirmed this statement, indicating that, though a few officials are heavily

interested in tackling e-waste, most hold other waste management issues as higher priorities (Kalantri, April 30th, 2014).

The Consumer

Most sources from civil society, government bodies, and the formal e-waste processing sector asserted that public awareness of health hazards, environmental consequences, and federal regulations of e-waste was very low. Agrawal of IDM emphasized that there are three steps to effectively changing public behavior for a given problem: sensitization (i.e. understanding that unused electronics are waste), orientation (i.e. knowing how to deal with e-waste), and awareness (i.e. acknowledging that e-waste management is a growing issue that must be addressed). However, he stated that, unfortunately, India as a whole has not even become sensitized, presenting one of the largest obstacles to effective e-waste management (Agrawal, March 21st, 2014).

Mahesh agreed with this perspective, asserting that at least 99 percent, if not more, of consumers across India do not understand what e-waste is, let alone the hazards inherent to their electronics. Thus, there is almost no active participation in existing e-waste management systems (Mahesh, March 25th, 2014). Vagela stated that e-waste management is not a priority for the public in Ahmedabad, given that the company has invested over Rs. 3 crore in conducting 4-5 public awareness campaigns, without any tangible results. From the government level, Kagzi asserted that the AMC is the primary body in charge of building public awareness (GPCB, May 2nd, 2014). However, Pandya of the AMC argued that, contrary to the notion that lack of public awareness regarding the hazards of e-waste is a big hindrance for proper e-waste management,

lack of proper collection and monitoring is the main cause for haphazard disposal of e-waste (Pandya, April 28th, 2014).

Kalantri additionally provided insight into how consumer perceptions of WEEE transactions hinder formal e-waste systems. First and foremost, Indian consumers are simply not willing to part with electronic goods without some monetary compensation. Kalantri also pointed out that buyers and sellers do not know the definitive value of an unused electronic, unlike paper and other common goods. Without such set prices, a trust deficit arises between the buyer and seller, whether the buyer is seeking raw materials and single components or a whole, functioning product. Thus, both buyers and sellers are discouraged from operating in the formal system, in turn encouraging informal exchanges (Kalantri, April 30th, 2014).

Similarly, GPCB Member Secretary Hardik Shah stated that India needs a robust, formalized value system for unused electronic items for the consumer to have more trust in formal transactions. Shah also noted that consumer insecurity about the data present on their unused electronics prevents the removal of such electronics from the home or from "trusted" personal contact circles (Shah, May 8th, 2014). Kalantri echoed other e-waste experts, mentioning that the informal sector is often, if not always, willing to pay more than registered recyclers, further incentivizing the informal recycling economy. Porwal added that door-to-door collection is very common and easy, while there is no incentive to give unused electronics to authorized collectors and recyclers (Porwal, April 16th, 2014). Within this economy, there is no method of tracking exchanges, meaning that estimates of e-waste generation are most likely lower than actual figures (Kalantri, April 30th, 2014).

Formal and Informal E-Waste Processing

The Memnagar kabadiwallah district obtains most of its WEEE from Relief Road, a key market for cheap electronics where shops sell away defective products, and private homes. Kabadiwallahs indicate that they collect both functioning and nonfunctioning unused electronics. For those that are functional or have small defects, kabadiwallahs typically repair and resell in a secondhand market, while those that are completely unusable are dismantled in a rudimentary manner, as indicated by previous studies (Anonymous kabadiwallah, April 15th, 2014). The kabadi market does not exhibit separation of e-waste from other forms of waste, such as scrap metal and plastics. Oftentimes, one shop will handle multiple forms of waste. Thus, inappropriate methods of dismantling are applied to e-waste. Kabadiwallahs will bifurcate plastic components from computer chips by hand, grind the chips, and smelt plastics, all in shop. Oftentimes, after informal dismantling, most materials go to the Delhi informal sector (similar to findings from the Toxics Link Mumbai case study) for recycling and reprocessing via very crude and harmful methods (Porwal, April 16th 2014).

Mahesh asserted that, while informal workers must be incorporated into management strategies, they must be restricted to collection and basic dismantling but removed from recycling processes, due to occupational hazards (Mahesh, March 24th, 2014). While dangerous, WEEE work can be profitable – circuits fetch Rs. 300/kg, copper gets Rs. 440/kg, and aluminum is worth Rs. 128/kg. Additionally, the government provides a 20% subsidy for the informal sector's work to increase the sustainability of this livelihood, though most, unfortunately, do not understand the application procedure for such a subsidy (Anonymous kabadiwallah, April 15th, 2014).

Wealth Out of Waste (WOW) represents a formal alternative to the kabadiwallah collection system. Essentially, WOW attempts to bypass the informal sector and connect households directly to formal recyclers by providing competitive prices for all forms of waste, including e-waste. Compared to informal kabadi shops, the warehouse exhibits a more systematic form of waste management, and a greater degree of product separation. The company provides a pickup service for all consumers, though operations are currently active only in West Ahmedabad, Maninagar, and Gandhinagar, the nearby capital of Gujarat. Additionally, unused electronics with small defects are repaired and resold, extending product lifetime. However, this formal collector has its shortcomings. While it collects computers, computer peripherals, and wires, it does not collect mobile phones. Additionally, representatives of WOW understand that government e-waste policies exist, but compliance is not a priority – e-waste is seen as a premature market, and thus not worth the investment of time and money to handle and store properly or safely (Anonymous employee, April 15th, 2014).

Eco-Sarjan operates in the same vein as WOW, though it presents a more viable collection model. Dipan Shah of Eco-Sarjan, echoing common sentiments about e-waste, noted that this emerging economy of collection and recycling has a high profit potential, due to the materials used in electronics and the uncertainty regarding the value of a used product. Thus, informal e-waste collectors always underpay the consumer for their WEEE, and each proceeding collector in the informal chain will pay a slightly higher price until the unused electronics reach the formal or informal recyclers.

Therefore, Eco-Sarjan attempts to interject in multiple ways, both inclusive and independent of the informal sector, through its E-Waste Management Awareness Campaign (EMAC), established in 2009. In coexistence with the informal chain, Eco-Sarjan allows first and

second-level kabadiwallahs to maintain their livelihoods, and buys e-waste from them at the same price as the third or fourth level collectors. It then directly sells such e-waste to formal recyclers. Shah of Eco-Sarjan argued that supporting the informal sector in this way could itself reduce the amount of e-waste in India. As mentioned earlier, unused electronics are often converted into usable products for a secondhand market (e.g. converting an old computer monitor into a TV), thus increasing the item's lifetime. Eco-Sarjan attempts to do the same outside of the informal sector as well by passing unused electronics on to college research centers, where students can study hardware issues and make minor fixes.

For individuals, EMAC offers a helpline for the collection of unused electronics, and a three-hour window for consumers to drop off e-waste to the NGO every Saturday. On the bulk consumer level, Eco-Sarjan sets up multiple campaigns throughout the year in industrial sites for companies to receive a quote for the cost of collecting their e-waste. Upon collection, Eco-Sarjan issues the company a SAFE disposal certificate, a joint certificate from the Gujarat Pollution Control Board (GPCB) and authorized recyclers. Companies may continue to collaborate with Eco-Sarjan via their helpline. The NGO is also currently in the process of establishing an online resource to locate collection centers (Shah, May 2nd, 2014). The one shortcoming that Eco-Sarjan exhibits is its extensive focus on unused computer collection, and the concurrent, limited discussion about old mobile phones (similar to WOW).

In total, Eco-Sajan collects at least 1 ton of e-waste per month, and sends most of this to E-Coli, a general waste management company based in Ahmedabad that operates a formal L2 e-waste recycler. L2 recyclers have the capacity to dismantle WEEE and shred components before passing the waste to formal L3 recyclers – none of which exist in India – where safe material extraction may take place. Unfortunately, E-Coli only receives a total of 6-7 tons/month, far

below its e-waste facility's capacity of 500 tons/month. Thus, it operates at a meager 1.5% of its capacity, far below AMC estimates of recyclers operating at 30% capacity (AMC, April 30th, 2014). Vagela argues that formal recyclers often cannot compete with informal workers for the consumer's unused electronics, as high investment and operational costs reduce the price that formal recyclers can offer for a given item (Vagela, April 16th, 2013).

The Producer

Both Mahesh of Toxics Link and Agarwal of IDM asserted that producers have not put nearly enough effort into e-waste management and building public awareness. Mahesh states that, while some larger companies have begun compliant systems and EPRs, they are merely tokens of compliance. Companies do not make their policies clear, and put forward the bare minimum work required to gain government approval (Mahesh, March 24th, 2014). Furthermore, Agarwal noted that there is no infrastructure, incentive, or disincentive for companies to follow the EPR regime of the 2011 legislation (Agarwal, March 21st, 2014). Mahesh also emphasized that, because electronic goods producers have immense financial resources, they must apply their marketing skills not only to advertising their products, but also to awareness campaigns (Mahesh, March 24th, 2014).

However, Kalantri used the example of Nokia to highlight the challenges of stimulating public participation in formal recycling processes. While Nokia's efforts in tackling e-waste management are far beyond those of other major companies, it collects only 100 metric tons of WEEE per year from 1200 stores. Granted, Nokia is primarily a mobile phone producer, and thus does not contribute as much, weight-wise, to the e-waste stream as other producers. But with India producing, by low estimates, 400,000 tons per year, and by higher estimates mentioned

earlier, 800,000 tons per year, this is no significant amount of collection (Kalantri, April 30th, 2014).

While the job of collecting unused electronics legally falls on the producer, the AMC also acts as a sort of safety net. Differentiating between the collection responsibilities of producers and the government, Pandya noted that Urban Local Bodies (ULBs) must collect "orphaned e-waste" (WEEE from companies that are out of business, and WEEE made of parts from multiple companies) and e-waste separated from municipal solid waste, while producers must implement buyback policies to build public awareness and force consumers into the formal system. However, there currently is no financial mechanism in place for the operation of ULBs, further hindering e-waste collection activity and making producer compliance ever more vital (Pandya, April 28th, 2014).

Current Efforts

Pandya of the AMC stated that, after several meetings with key e-waste stakeholders, the AMC has proposed a government appointed, manufacturer funded collection agency that would provide incentives to individual and bulk consumers to channelize e-waste to authorized recyclers. In such a scheme, AMC would provide land for setting up collection centers at suitable locations in Ahmedabad, support awareness campaigns, and monitor performance of collection centers. Additionally, as of now, the AMC, Nokia, and Ahmedabad's Center for Environment Education (CEE) are conducting training programs for educating school children about sustainable development, focusing on e-waste recycling issues in 17 schools in the city. The end goal is to spread awareness to parents through their schoolchildren. Further along the e-waste processing chain, the AMC offers official management approval to recycling agencies that

follow government guidelines (Pandya, April 28th, 2014). The GPCB plans to establish a concurrent disincentive, stating that it is in the process of developing advertisements warning that unauthorized recyclers of e-waste will be considered a part of the informal sector, and thus will face major penalties (Kagzi, May 2nd, 2014).

Bharat Jain, Member Secretary of the Gujarat Cleaner Production Center (GCPC), also presented a possible piece to the e-waste management solution. In collaboration with the United Nations Industrial Development Organization (UNIDO), GCPC tackles waste from where it is generated, rather than handling waste at the end of the chain. Its core principle is that waste in industrial processes indicates a lack of efficiency, and thus a loss of money. GCPC can therefore appeal to companies and manufacturers by working through the stoichiometry of reducing waste in their production via green technology, and thus reduce their operational costs. Jain noted that, oftentimes, the GPCB represents the source of punishment, while GCPC offers the incentive for more environmentally friendly production, though the government also provides a 25-50% subsidy for any company that complies with GCPC policies and recommendations. GCPC also promotes and funds clean technology and production (CT/CP) education at the college level, with institutes such as LD College of Engineering in Ahmedabad. The private company additionally tries to incorporate authorized recyclers into its strategies, but oftentimes runs into conflicts with kabadiwallahs who are seeking raw metals (Jain, April 29th, 2014). GCPC currently does not have any initiatives directly related to e-waste, though it has one ongoing project titled "The Hazardous Waste (Management, Handling and Transboundary) Rules, 2009 in different industrial sectors."

Porwal of GIZ India provided a detailed picture of a future partnership between Nokia and GIZ aiming to tackle e-waste management in Ahmedabad. The strategy would incorporate

schools (concurrent with the AMC's present efforts alongside Nokia and CEE), the informal sector, and youth talent. In collaboration with the Self Employed Women's Association (SEWA), which already possesses a large network for solid waste management, GIZ India hopes to build a similar network between all stakeholders for e-waste management. This division of the GIZ initiative would promote public awareness about e-waste and sustainable consumption via various community outreach programs. Additionally, it would attempt to formalize a collection center within Ahmedabad to channelize e-waste from informal collectors to organized and authorized recyclers. Regarding the youth in the city, GIZ India hopes to harness their creativity to spread awareness via art, FM, music, and other creative media, eventually developing into a formal youth movement. GIZ India is currently operating in four cities - Delhi, Pune, Kolkata, and Bangalore – and has seen promising results. Within a week in Delhi, GIZ collected 160,000 kg of e-waste, with the help of Nokia. However, such positive results took 4 years of program implementation, meaning that progress in any future Ahmedabad-based project will take time (Porwal, April 16th, 2014).

Discussion

The fact that only 18% of questionnaire respondents participate in formal e-waste processing systems (Figure 2) substantiates the claims that there is little incentive for formal services and, concurrently, no enforced disincentive for informal collection and dismantling. Indeed, the simple fact that the 2011 e-waste legislation does not mandate individuals to participate in e-waste management strategies clearly shows that the consumer may legally operate outside of formal systems. One might argue that it is a lack of knowledge about available formal sector companies properly handling e-waste that prevents greater participation in such

systems. However, double the number of respondents who participate in formal systems indicated that they know of a formal collection, dismantling, or recycling services (Figure 4). Thus, there are at least some respondents who know of such services, yet choose not to participate.

The results displayed in Figure 2 also correspond with the lack of e-waste reaching formal collectors, according to Vagela and Kalantri. Additionally, such results could be explained by the general prioritization of monetary compensation at the consumer level when making decisions about e-waste disposal. Multiple public awareness respondents indicated that there is no reason to pass unused electronics to formal systems, as greater compensation may be found in kabadi markets, or it is simply not worth their efforts to recycle e-waste properly. Thus, as stated by Hardik Shah of the GPCB, robust value systems must be established to standardize the compensation expected for any given product. Furthermore, as mentioned by multiple e-waste experts, it is necessary to strengthen the EPR regime to place more pressure on electronics producers. The large number of respondents keeping electronic goods in the home or passing them along to personal contacts might also substantiate Hardik Shah's claim that Indian consumers are worried about the use of stored data on their unused products. Alternatively, it could point to limited understanding about the proper method of disposal.

The fact that 37% of respondents believe that unused electronics are not waste and can be reused (Figure 3) is both promising and problematic. On one hand, having such a mindset will extend the lifetime of the product. However, such responses also indicate a disconnection between the consumer and end-of-life processing. Thus, consumers cannot fulfill the role of an active participant in e-waste management systems. That 33% of respondents said they understood unused electronics to be complete waste is also problematic, as this mindset limits

product lifetime. The response that components or raw materials may be extracted from unused goods is a more productive mindset, as it acknowledges the need for recycling and reprocessing after full use of the product. It is quite possible that, as Agarwal and Mahesh noted, most of the Indian population is simply not sensitized to the idea of electronics becoming waste. Taken together, the data here show a need for both companies and government bodies to put more effort toward sensitization and orientation.

The general consensus among e-waste experts that the general public does not know about e-waste hazards and government policy is largely validated by the questionnaire data (Figure 5 and 6). Only 35% of respondents knew any specifics about health or environmental hazards, and only 11% knew of any governing body or policy related to e-waste management (not exclusive to the E-Waste Rules of 2011). Granted, legislation was only put into action two years ago, and AMC initiatives alongside Nokia and the CEE in Ahmedabad are very recent. Using the experience of GIZ India projects in Delhi, it is possible that it will take a few more years to see significant changes in consumer knowledge. However, such lack of public awareness could also stem from limited government-level prioritization and proper funding for the e-waste issue, along with minimal producer compliance with the EPR.

It is unclear whether Pandya's claim – that public awareness regarding the hazards of e-waste is not a big hindrance for proper e-waste management – is true. His focus on the lack of proper collection and monitoring addresses the problem of public orientation to e-waste. However, this does not address the preceding issue of sensitization. Additionally, such an approach places a strong emphasis on end of the line management, but neglects to consider how public awareness of e-waste hazards could be used to force producers to reduce toxic chemical

use in the first place. It appears that the government is more concerned with addressing effects, while it is equally (if not more) important to tackle the causes, as done by GCPC.

It is striking that nearly half of respondents above the age of 30 stated that they knew of e-waste hazards without indicating knowledge of specific hazards, while only a fifth of respondents under the age of 30 exhibited this behavior. Thus, there appears to be greater reluctance among the older generation to admit a lack of knowledge. Additionally, it seems that the younger generation is far more aware of the environmental risks to the growing amount of e-waste in India. In contrast, a greater percentage of the older age group than the younger group know of formal e-waste processing services, and both age groups had an equal percentage of respondents who knew of informal services. Thus, it seems that the younger generation knows more about e-waste hazards, while the older generation has a greater awareness about methods of disposal.

The fact that a large majority of respondents indicated a desire for new technology as their primary motivation for purchasing new products (Figure 1) points to the fundamental problem of companies maintaining the cycle of redundancy in technology (Kothari, March 26th, 2014). In order to reduce the extent of the e-waste problem from the source, electronics producers must stop encouraging the constant desire for the newest products, and instead promote public faith in longer-lasting devices to decrease the turnover rate. Corporations cannot continue to make new software that operates solely on new devices, a practice that requires more frequent and otherwise unnecessary disposal. Producers must reduce the amount of toxic chemicals incorporated into their devices, so that when disposal becomes necessary, they have already mitigated its impact on human health and the environment.

Conclusion

The present study attempted to assess public awareness of both toxic chemicals in WEEE and federal policies governing proper disposal and management, the first study of its kind in India. The questionnaire data greatly substantiated previous claims that technological innovation has led to rapid product obsolescence, as a majority of respondents indicated that the need or desire for new technology motivates them to purchase new products. The data also pointed to a lack of government incentive for the consumer to participate in formal e-waste management strategies – strikingly, the number of respondents who knew of formal services outnumbered those who actually participate in them. The perspectives of e-waste collectors, and AMC and GPCB officials similarly asserted a lack of e-waste reaching formal systems. Perceptions of unused electronics indicated that approximately a quarter of respondents recognized the possibility of end-of-life recycling and reprocessing, while other responses suggested a disconnect from proper e-waste management. Very importantly, very few respondents understood specific information about the health and environmental hazards of e-waste, along with the E-Waste (Management and Handling) Rules of 2011.

These findings are disconcerting, as consumers who are knowledgeable about both the responsibilities of various stakeholders and the consequences of improper handling are necessary for pushing for producer compliance with this new legislation. While some government officials in Ahmedabad are quite active and invested in tackling the e-waste issue, there is an overall lack of financial resources and government prioritization for management strategies. Thus, gaining momentum behind implementation of the Rules, which already have their shortcomings, proves to be very challenging. However, it is encouraging to see initiatives from both the local government and various NGOs to build public awareness, and to establish links between

consumers, informal workers, collectors, and formal recyclers in Ahmedabad and Gujarat. It is hoped that these efforts result in a change of public mindset, and thus a change in how all stakeholders operate within e-waste management.

Recommendations for Further Study

This study has a few limitations and unresolved questions that should be addressed in future work. Given its focus on assessing public awareness, the sample size for the general public questionnaire is quite small, and thus may not be fully representative of the general population's mindset and behavior toward e-waste in Ahmedabad. However, beyond the sample size, the findings here may be applicable to other large cities in India. Additionally, the general public questionnaire should have included questions that addressed not only respondents' knowledge of formal e-waste processing systems, but also their willingness to actively participate. Thus, one could determine whether respondents' knowledge of e-waste hazards and policies affect participation in proper disposal schemes.

There was, unfortunately, limited insight gathered directly from informal sector workers. Indeed, a large amount of information on both their current and supposed ideal place within the e-waste management framework was obtained from other interviews. It is thus possible that some of the occupational hazards and challenges informal workers face have gone unaddressed in this study. Therefore, greater information is needed on what they think of the government's role in their livelihood should be.

Future studies should also consult electronic producer representatives to understand their knowledge of and perspective on the EPR regime. Specifically, research should be done on the extent to which these companies utilize formal collection and recycling services such as Eco-

Sarjan and E-Coli, along with consultation from clean technology companies such as GCPC. Additionally, staff members from company shops and showrooms should be interviewed to determine whether companies provide proper training in e-waste collection and management to their employees.

To provide a deeper analysis of survey data, future work should determine whether awareness of e-waste hazards and policies actually affect purchasing and disposal habits. More studies must also be done to determine differences in responses across various demographics beyond age.

Expanding the scope beyond Ahmedabad, it would be very valuable to begin comparative studies between cities across India to understand variations in public awareness on a national scale.

Works Cited – Primary Sources

Agarwal, Vivek. Trustee Secretary, Institute of Development Management, Personal Interview, Jaipur, March 21st, 2014.

Anonymous Employee. Wealth Out of Waste, Ahmedabad, Personal Interview, April 16th, 2014.

Jain, Bharat. Member Secretary, Gujarat Cleaner Production Centre, Gandhinagar, Personal Interview, April 29th, 2014.

Kagzi, M.G. Gujarat Pollution Control Board, Gandhinagar, Personal Interview, May 2nd, 2014.

Kalantri, Ravi. Ahmedabad Municipal Corporation, Ahmedabad, Personal Interview, April 30th, 2014.

Mahesh, Priti. Senior Program Officer, Toxics Link, Personal Phone Interview, March 25th, 2014.

Pandya, Nishit. Ahmedabad Municipal Corporation, Ahmedabad, Email Correspondence, April 28th, 2014.

Porwal, Priyanka. Representative, GIZ India, Personal Phone Interview, April 16th, 2014.

Shah, Hardik. Gujarat Pollution Control Board, Gandhinagar, Personal Interview, May 8th, 2014.

Shah, Dipan. Eco-Sarjan, Ahmedabad, Personal Interview, May 2nd, 2014.

Vagela, Prakash. Manager, E-Coli Waste Management Pvt. Ltd., Ahmedabad, Personal Interview, April 16th, 2014.

Works Cited – Secondary Sources

Afroz, Rafia et al. "Survey and Analysis of Public Knowledge, Awareness and Willingness to Pay In Kuala Lumpur, Malaysia – a Case Study on Household WEEE Management." *Journal of Cleaner Production* 52 (2013): 185-93. Print.

Agrawal, Ravi. "E-Waste Law: New Paradigm or Business as Usual?" *Economic and Political Weekly* 47 (2012): 14-16. Web.

Borthakur, Anwesha, and Kunal Sinha. "Electronic Waste Management in India: A Stakeholder's Perspective." *Electronic Green Journal* 1.36 (2013). Web.

"Domestic Households: A Guide to the Hazardous Waste Regulations." *Electrical and Electronic Equipment (EEE)*. Environment Agency, Web. <http://cdn.environment-agency.gov.uk/LIT_8398_9bac1f.pdf>.

"Environmental Regulations." *GOV.UK*. Web. 10 Apr. 2014.

Ghosh, Sadhan, and Priti Mahesh. "E-Waste: Flooding the City of Joy." *Toxics Link* (2007): Web.

Huang, Pingsha, Xiuli Zhang, and Xingdi Deng. "Survey and Analysis of Public Environmental Awareness and Performance in Ningbo, China: A Case Study on Household Electrical and Electronic Equipment." *Journal of Cleaner Production* 14.18 (2006): 1635-643. Print.

Huo, Xia et al. "Elevated Blood Lead Levels of Children in Guiyu, an Electronic Waste Recycling Town in China." *Environmental Health Perspectives* 115.7 (2007): 1113-117. Print.

"Implementation of E-Waste Rules 2011." *Toxics Link*, Web.

Luo, Chunling et al. "Heavy Metal Contamination in Soils and Vegetables near an E-waste

Processing Site, South China." *Journal of Hazardous Materials* 186.1 (2011): 481-90. Print.

Milovantseva, Natalia, and Jean-Daniel Saphores. "E-waste Bans and U.S. Households' Preferences for Disposing of Their E-waste." *Journal of Environmental Management* 124 (2013): 8-16. Print.

Ni, Hong-Gang et al. "Environmental and Human Exposure to Persistent Halogenated Compounds Derived from E-waste in China." *Environmental Toxicology and Chemistry* 29.6 (2010): 1237-247. Print.

Ongondo, F. O., I. D. Williams, and T. J. Cherrett. "How Are WEEE Doing? A Global Review of the Management of Electrical and Electronic Wastes." *Elsevier* 31.4 (2011): 714-30. Web.

Pinto, Violetn. "E-waste Hazard: The Impending Challenge." *Indian Journal of Occupational and Environmental Medicine* 12.2 (2008): 65-70. Print.

Sinha, Satish, Kishore Wankhade, and Deepal Sinha-Khetriwal. "Mumbai: Choking on E-Waste." *Toxics Link* (2007): Web.

Sinha, Satish, Priti Mahesh, and Vinod Sharma. "Brominated Flame Retardants: Spreading the Fire." *Toxics Link* (2011): Web.

"Small Businesses: A Guide to the Hazardous Waste Regulations." *Electrical and Electronic Equipment (EEE)*. Environment Agency, Web. <http://cdn.environment-agency.gov.uk/LIT_5552_28b742.pdf>.

TakeBack Blues: An Assessment of E-waste Takeback in India. Publication. Bangalore: Greenpeace, 2008. Web.

Tang, Xianjin et al. "Heavy Metal and Persistent Organic Compound Contamination in Soil from

Wenling: An Emerging E-waste Recycling City in Taizhou Area, China." *Journal of Hazardous Materials* 173.1-3 (2010): 653-60. Print.

"The Basel Convention at a Glance..." *Basel Convention: An Overview*. Web.

Wang, Jing et al. "Brominated Flame Retardants in House Dust from E-waste Recycling and Urban Areas in South China: Implications on Human Exposure." *Elsevier* 36.6 (2010): 535-41. Web.

Wath, Sushant B., P. S. Dutt, and T. Chakrabarti. "E-waste Scenario in India, Its Management and Implications." *Springer Link* 172 (2011): 249-62. Web.

Appendix A: Questions To Be Used for General Public Interviews

1) Do you use household electronics, namely computers and cell phones?

2) If so, which ones do you use frequently?

3) Of the household electronics that you use, how many of each type have you purchased/replaced in the past 10 years?

4) Of the electronics you have purchased in the past 10 years, how many do you still own and use?

5) What was your reason for purchasing new cell phones and/or computers?

6) What have you done with the electronics that you no longer use?

7) Do you consider your unused electronics to be waste, or to have another purpose? Please explain if you believe they have another purpose.

8) Do you know someone who can collect your unused electronics for recycling, or dismantling and refabricating, or destroying?

9) Do you perceive any hazards or risks in e-waste? Do you see any hazards or risks to the growing amount of e-waste in India?

10) Do you know of any electronic waste management policies currently implemented in India? If so, what do you know of these policies?

Appendix B: Coding System Used to Classify and Analyze Data Set

1) **Do you use household electronics, namely computers and mobile phones?**
   0 = No
   1 = Only Mobiles
   2 = Only Computers
   3 = Both

2) **If so, do you use these two household electronics frequently?**
   0 = No
   1 = Only Mobiles
   2 = Only Computers
   3 = Both

3) **How many mobile phones and computers have you purchased/replaced in the past 10 years?**

4) **Of the ones you have purchased in the past 10 years, how many do you still use?**
   a. # from Q3 – # from Q4 = Unused Electronics

5) **What was your reason for purchasing new cell phones and/or computers?**
   0 = Physical Damage
   1 = Loss of Function
   2 = Need for Greater Functionality
   3 = Desire for Newest Technology
   4 = Other

6) **What have you done with the electronics that you no longer use?**
   0 = Kept in Home
   1 = Given/Sold to a Personal Contact
   2 = Sold to Informal System
   3 = Sold to Formal System
   4 = Trash

7) **Do you consider your unused electronics to be waste, or to have another purpose? Please explain if you believe they have another purpose.**
   0 = No, Can be Repaired and/or Reused
   1 = Can Utilize Components / Raw Materials
   2 = Yes, It Is Waste
   3 = Conditional (dependent on whether product is functioning)

8) **Do you know someone who can collect your unused electronics for reuse, reselling, recycling, or dismantling?**
   0 = No
   1 = Informal Service
   2 = Formal Service

9) **Do you perceive any hazards or risks in e-waste? Do you see any hazards or risks to the growing amount of e-waste in India?**
   0 = No
   1 = Yes (but no specific information)
   2 = Yes, Toxicity or Safety Hazard
   3 = Yes, Environmental Problem
   4 = Recognition of Both Health and Environmental Hazards

10) **Do you know of any electronic waste management policies currently implemented in India? If so, what do you know of these policies?**
   0 = No Policy Present
   1 = No Knowledge of Policy or Governing Body
   2 = Knowledge of Any Related Policy or Governing Body

Appendix C: Questions for NGO Representatives and Government Officials

1) What are the current policies in place for e-waste management that span across India? Are there any regulations specific to Ahmedabad or Gujarat?

2) Are there flaws to these policies?

3) How well have companies and the general population complied with such policies?

4) What is your perception of public awareness of the regulations in place for e-waste, and for the control of exposure to hazardous chemicals?

5) Are people aware of the hazardous chemicals found in e-waste?
    a. If yes, who informs them?
    b. If no, what is the best way for creating mass awareness?

6) How much of a priority is this issue at the government level? At the individual level?

7) Question "a" for NGOs, question "b" for government officials
    a. If it is currently a low priority, how do you think we can convince the public to take this issue more seriously?
    b. How much should the public and government prioritize e-waste management, relative to other public issues?

8) Are there other nations that India should look to as models of e-waste management?

9) Do you think it would be viable to support the unorganized sector's role in waste management (while providing for safer practices)?

Appendix D: Questions for Formal and Informal Recyclers

1) From where and from whom do you collect unused electronics?
2) Do you collect unused electronics that can be repaired, or are the electronics that you collect purely waste?
3) What do you do with unused electronics that are functioning?
4) What do you do with unused electronics that are not functioning?
5) For defective electronics, what components or materials are most valuable to you?
6) What methods do you use to dismantle and recycle e-waste?
7) Do you perceive any health hazards in dealing with e-waste that you collect?
8) Do you ever interact with electronics producers? If so, please describe your interactions.
9) Do you think the government should do anything to assist you in your work?
10) Who do you think should have the responsibility of dealing with e-waste in India?
11) Who is responsible for the growing amount of e-waste in India?

Appendix E. Visual Representation of Survey Data

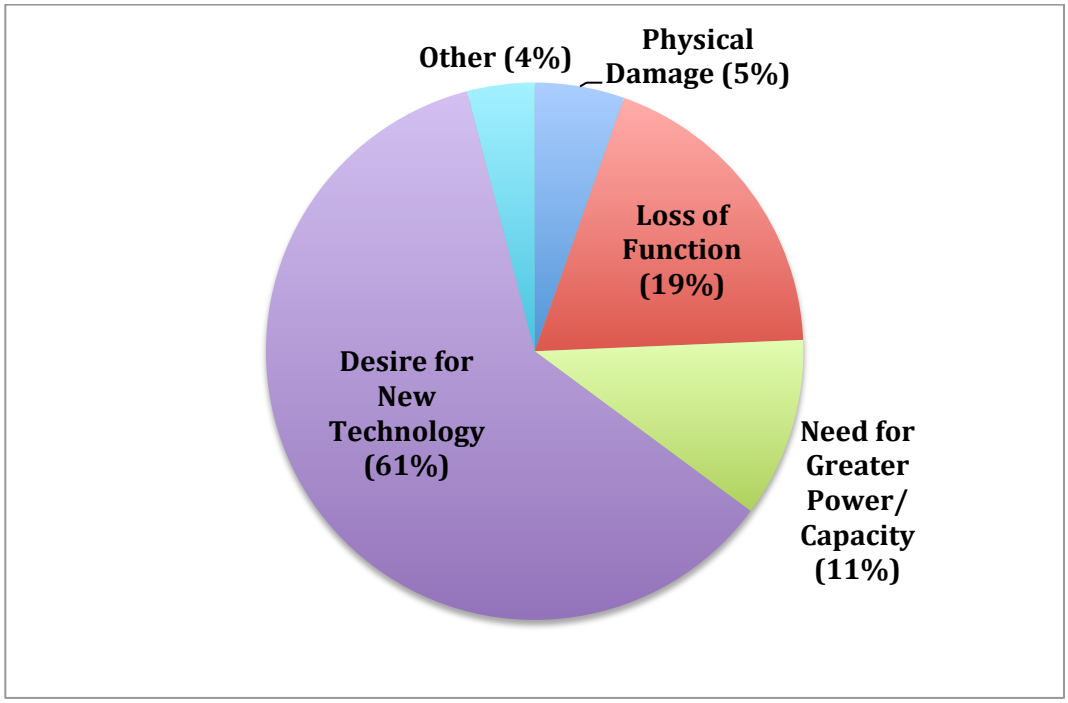

Figure 1: Reasons for Purchasing New Electronics. This depicts data collected for Question 5 of the general public questionnaire, which asks, "What was your reason for purchasing new cell phones and computers?"

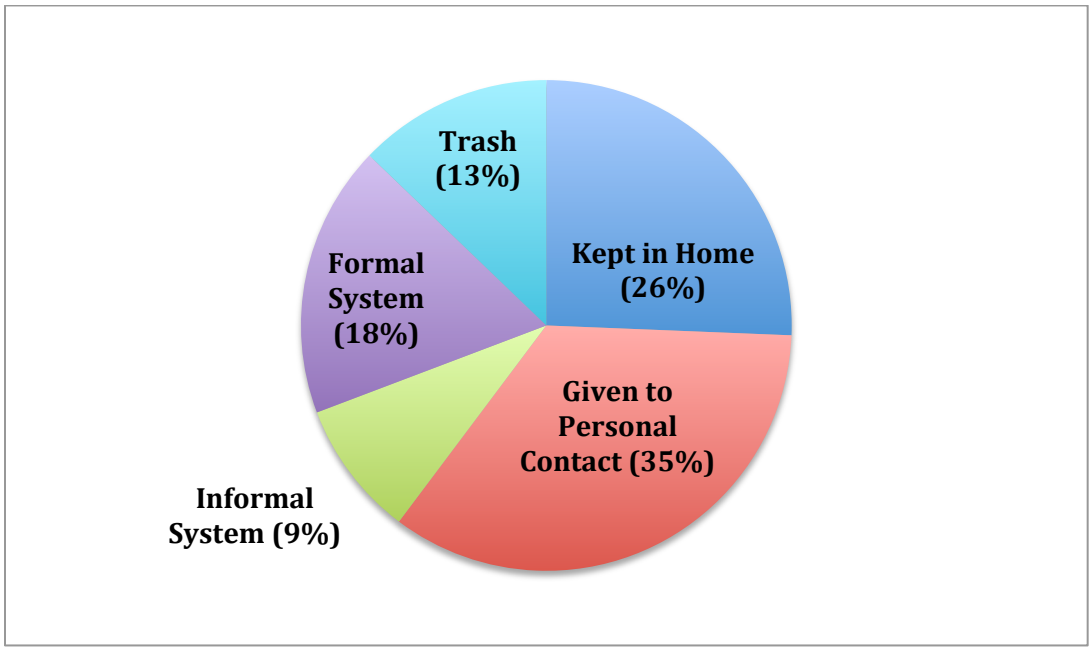

Figure 2: What Becomes of Unused Electronics. This depicts data collected for Question 6 of the general public questionnaire, which asks, "What have you done with the electronics that you no longer use?"

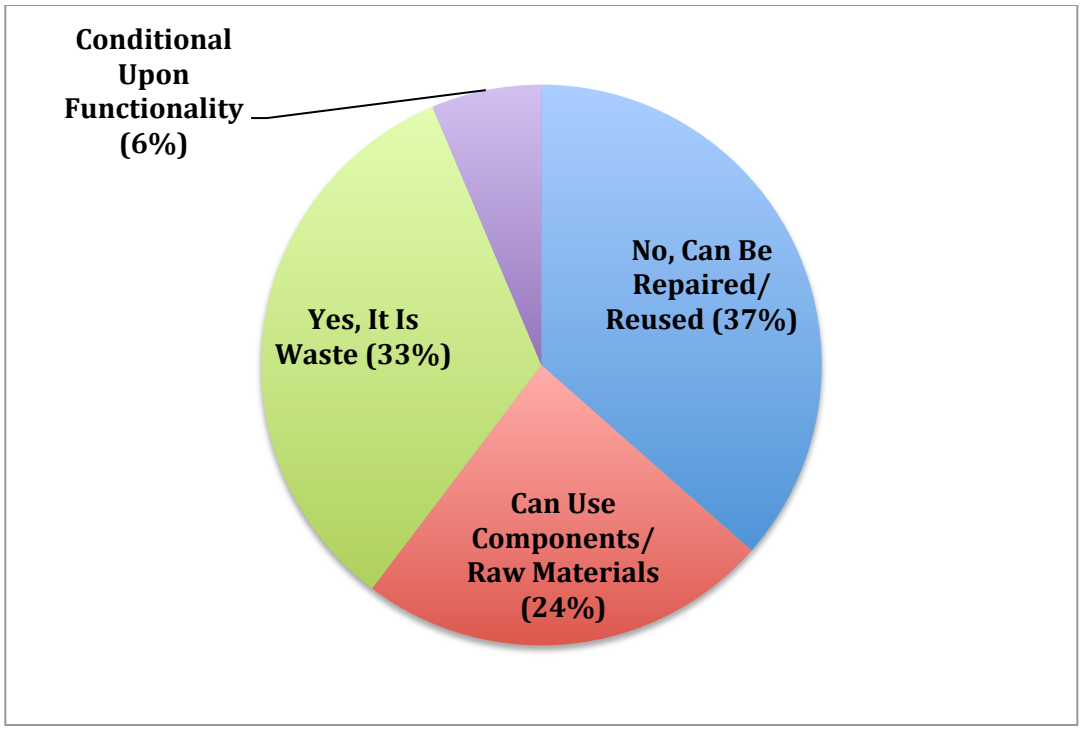

Figure 3: Perception of Unused Electronics. This depicts data collected for Question 7 of the general public questionnaire, which asks, "Do you consider your unused electronics to be waste, or to have another purpose? Please explain if you believe they have another purpose.

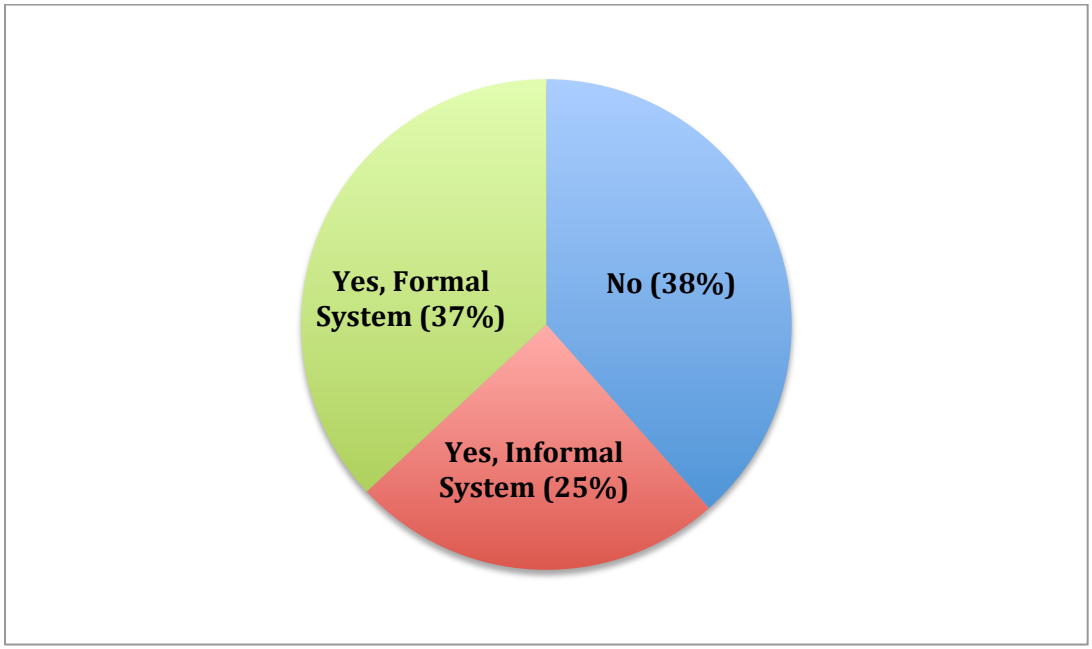

Figure 4: Knowledge of Collection Services. This depicts data collected for Question 8 of the general public questionnaire, which asks, "Do you know someone who can collect your unused electronics for recycling, or dismantling and refabricating, or destroying?"

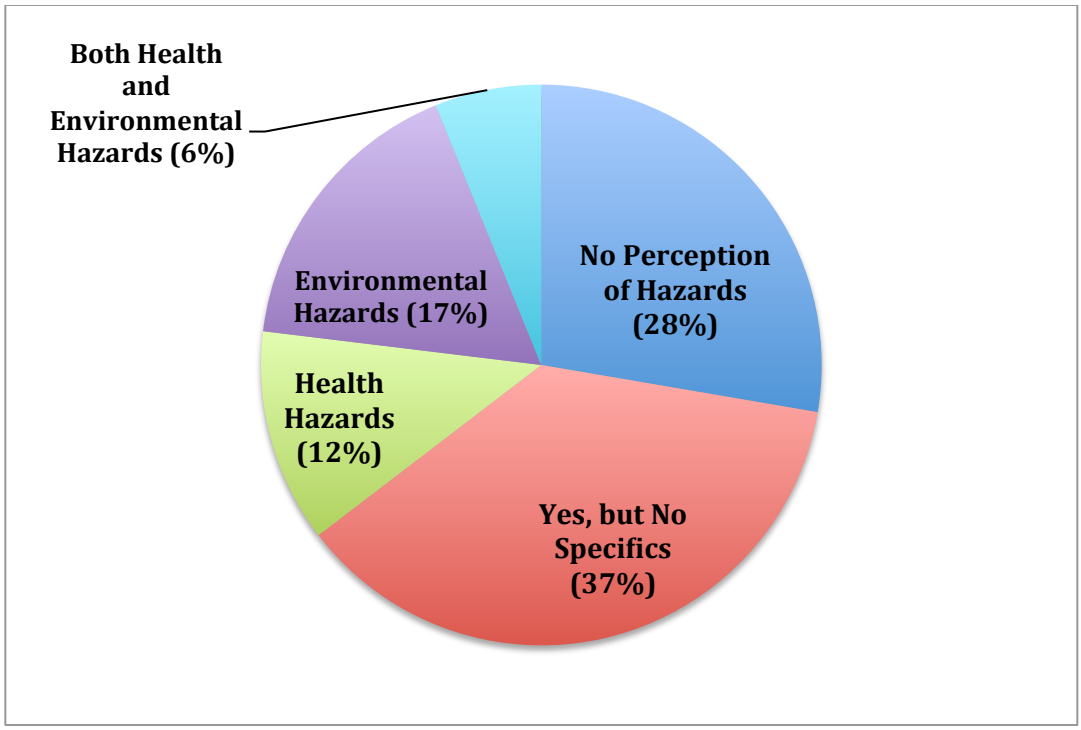

Figure 5: Perception of E-Waste Hazards. This depicts data collected for Question 9 of the general public questionnaire, which asks, "Do you perceive any hazards or risks in e-waste? Do you see any hazards or risks to the growing amount of e-waste in India?"

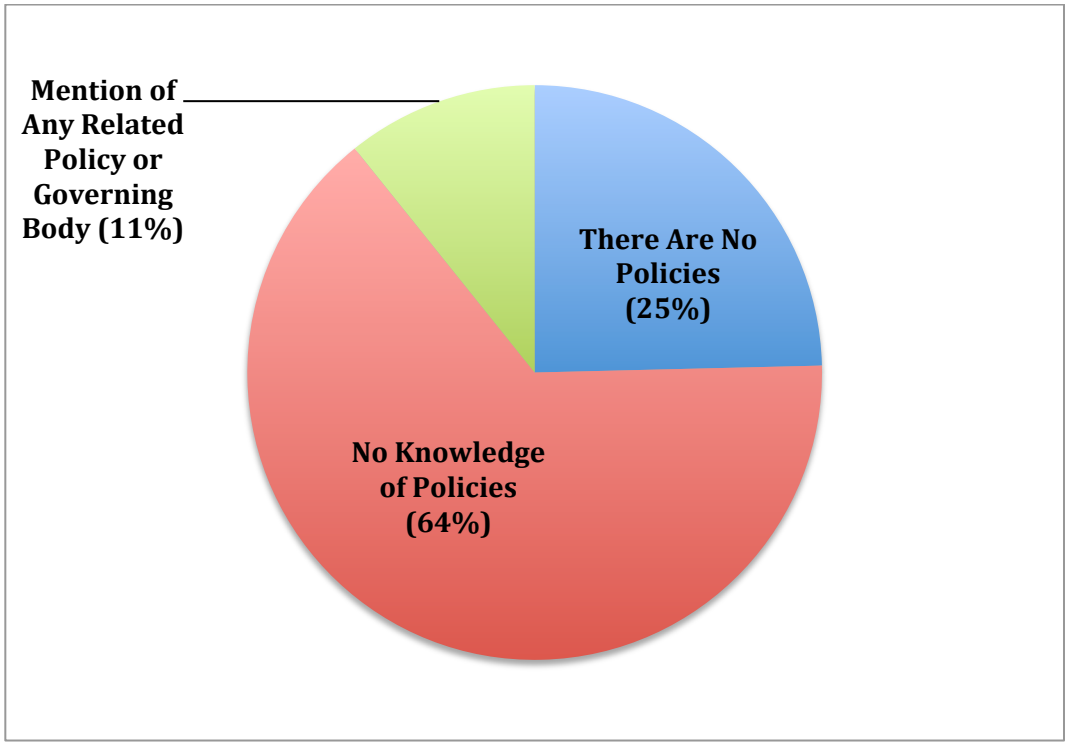

Figure 6: Knowledge of Government Policies. This depicts data collected for Question 10 of the general public questionnaire, which asks, "Do you know of any electronic waste management policies currently implemented in India? If so, what do you know of these policies?"