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Sustainable Product Lifecycles: A Systemic Approach to the Regulation of E-Waste

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Abstract: International, regional, and national laws have failed to control the transportation and management of electronic waste. This study focuses on Agbogbloshie, a scrap metal yard in Accra, Ghana, which has received worldwide attention for its unsustainable recycling practices. The social and environmental impacts as a result of these practices are well-documented. This paper proposes a polycentric perspective on regulation, in which the state is not seen as the sole locus of authority. This approach enables a broader perspective on who or what regulates and how these modes of regulation interact. We discuss our systemic approach with the concept of regulatory ecology, in which the interactions between law, social norms, markets, and architecture are explored to provide a better understanding of why unsustainable behavior continues. This approach is explored in the mapping of the regulatory ecology of the burning of cables in Agbogbloshie, a fast and cheap method used for extracting copper. This practice continues even though more sustainable options, such as cable-stripping machines, are available in the scrap metal yard. A systemic approach to regulation brings a deeper understanding to regulatory ineffectiveness. We conclude that legislation that doesn't address the interaction of hazardous waste and marginalization, will fail to deliver the social and environmental gains it pursues.

Introduction

Waste from electrical and electronic equipment (WEEE or e-waste) is the fasted growing stream of hazardous waste (Asante, Amoyaw-Osei, & Agusa, 2019; Awasthi, Li, Koh, & Ogunseitan, 2019; Lucier & Gareau, 2019). In 2016, almost 50 million tons of e-waste was generated globally, but only 20% was recycled via appropriate channels. Four percent of e-waste was sent to landfill sites. What happened with the other 76% is unknown (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017).

At least some of that e-waste will have ended up at Agbogbloshie, a neighborhood of Accra, Ghana. Agbogbloshie has become synonymous with e-waste, not least as a result of various media reports and documentaries.[1]

In fact, Agbogbloshie consists of a food market (see Figure 1); an industrial area; a large slum called Old-Fadama, housing about 100.000 people; a household waste dump; and a scrap metal yard. The Odaw river passes through between the slum and the scrap yard. A large part of the household waste dump is located on a wetland, the Korle Lagoon.

Most of the e-waste handled at Agbogbloshie arrives at the scrap yard, which is the focus of our study. It is relatively small in size, covering about 0.5 km^2, and employing about 4-6000 people, mostly young men. At the scrap yard, cars, buses, bicycles, and e-waste, such as air conditioners, computers, fans, televisions, and mobile phones are recycled. E-waste is brought in by scavengers going around the city looking for scrap. The majority of scrap is generated domestically (Schluep et al., 2012). Another source of scrap is imported used electrical and electronic equipment (UEEE) that is not functioning and not repairable

[1] E.g., https://www.vice.com/en_us/article/4x3emg/inside-the-worlds-biggest-e-waste-dump; https://www.theguardian.com/environment/gallery/2014/feb/27/agbogbloshie-worlds-largest-e-waste-dump-in-pictures; http://www.welcome-to-sodom.com/. For a critique, see https://africasacountry.com/2019/03/six-myths-about-electronic-waste-in-agbogbloshie-ghana.

(Amoyaw-Osei, 2011; Odeyingbo, Nnorom, & Deuzer, 2018).[2]

Figure 1. Agbogbloshie. © SMART/Maja van der Velden.

The activities in and around Old-Fadama, the scrap yard, and the household waste dump have resulted in severe pollution of land and water and has seriously affected the health of communities living and working in the area (Asamoah, Essumang, Muff, Kucheryavskiy, & Søgaard, 2018; Chama, Amankwa, & Oteng-Ababio, 2014; Tue et al., 2016; van der Velden & Taylor, 2017). The pollution of the Korle Lagoon and its surroundings started long before the arrival of e-waste, but is exacerbated by e-waste recycling (Grant, 2006; Karikari, Asante, & A. Biney, 2009). The burning of car tires for the extraction of steel wire and cables and coils for the extraction of copper, on the outskirts of the scrap yard, is a particularly visible manifestation of unsustainable recycling practices (see Figure 2).

Initiatives to address this situation have resulted in a range of measures, from new e-waste legislation (Republic of Ghana, 2016), development programs,[3] and even the eviction of residents of Old-Fadama. (Akese & Little, 2018) . Most of these initiatives have sought to solve symptoms of the e-waste challenge to sustainability, without considering the regulatory difficulties arising from the complexity of local conditions or from the product lifecycles of electronics (Hoffman, 2017). Few, if any, have taken a systemic approach to the regulation of e-waste.

Figure 2. Burning cables. © SMART/Maja van der Velden.

This study has sought to approach the problem of e-waste recycling based on ethnographic fieldwork in Agbogbloshie and a systems approach to regulation. Fieldwork in Agbogbloshie has been implemented over several years, with the last visit taking place in September 2017. During fieldwork we observed electronics end-of-life (EoL) activities in Accra (repair, disassembling, burning, weighing, and storing) and implemented short ethnographic interviews (Pink & Morgan, 2013) with people involved in EoL activities, such as repairers, disassemblers, cable burners, as well as some of the organizations governing these activities, such as the Greater Accra Scrap Metal Association and the Environmental Protection Agency (EPA).

The data gathered forms the basis for considering attempts at regulation from a systems perspective. Critical systems thinking (Jackson, 1991) encourages socioecological awareness and human and non-human

[2] WEEE stands for Waste Electrical and Electronic Equipment and is in this paper used interchangeably with e-waste, which stands for electronic waste. The transportation and management of WEEE is covered by national and international legislation. UEEE or Used Electrical and Electronic Equipment is not a formal term. In this paper, it refers to both second-hand EEE as well as EEE that is collected as WEEE in one jurisdiction, but often still functioning, and exported as UEEE to another jurisdiction. It is estimated that 10-30% of UEEE imports in Ghana are non-functional (Amoyaw-Osei, 2011; Odeyingbo, Nnorom, & Deuzer, 2018).

[3] E.g. https://accra.diplo.de/gh-en/botschaft/themen/ewaste-project-launch/1164856

emancipation; it enables an analysis of complex societal and environmental problems and can propose interventions in support of addressing such problems (Stephens, Taket, & Gagliano, 2019) In this paper we take a critical systems approach to regulation in order to facilitate a different perspective on cause and effect, on who or what can regulate (the subjects and objects of regulation), as well as on interactions between different modes of regulation.

Regulation can be defined as the "act or process of controlling by rule or restriction." (Garner, Newman, & Jackson, 2011). A critical system approach to regulation builds forth on a polycentric approach to regulation, in which the power to regulate lies not solely the state, but arises from a system of constraints. As such, regulatory systems show system characteristics, such as non-linearity, emergence, and self-organization. Our approach is informed by the work of Lessig (1998), who describes four modes of regulation and their direct and indirect interactions: law, social norms, markets, and architecture. Architecture, encompassing nature, materials, and design, is a non-human actor with sometimes strong regulatory effects, constraining both directly and indirectly the regulatory effectiveness of national and international laws. The mapping of this polycentric system of regulation results in a so-called regulatory ecology (Sjåfjell & Taylor, 2015; van der Velden, 2016), which is intended to facilitate perspectives in the development of policy and law that are better adapted to the social and material complexities of product lifecycles.

Recycling e-waste in Agbogbloshie

The recycling of e-waste in Agbogbloshie consists of different phases. Scavengers collect e-waste from households, offices, and UEEE dealers, etc. in Accra and its surroundings. The work of the scavengers is highly efficient, with a collection rate of around 95% (Grant & Oteng-Ababio, 2016). The e-waste is brought into the yard on pushcarts and motorized three-wheelers, where it is disassembled into parts that can be sold to scrap metal dealers or to repairers. Disassembling takes place in open-air workplaces and shacks. Cherry-picking particular parts and materials, such as printed circuit boards, aluminum, copper, and batteries, is very common (Amoyaw-Osei, 2011).

Recycled materials leave the yard in several ways. Small pieces are collected in bags. Dealers weigh these bags and pay the worker. The bags are stored and leave the yard in trucks once enough bulk is collected. Large pieces of metals are stored and then loaded on trucks. Many materials remain on the yard. Some get a new purpose, such as chest freezers used for the storage of tools. Others, such as plastic computer monitor casings, are stored, waiting for a buyer, or used as fuel for the cable-burning fires (Figure 2 and 3).

Figure 3. Stored computer monitors and freezer boxes. © SMART/Maja van der Velden.

Recyclers use rudimentary tools to disassemble e-waste. We observed the same size chisel and hammer used for the dismantling of air conditioners as for mobile phones. None of the recyclers used health and safety equipment, such as steel-nosed boots, helmets, gloves or mouth/nose/ear protectors. The scrap yard also houses a container with two cable stripping machines, which we didn't see being operated during our fieldwork.

Cable burning

Copper is one of the most sought-after materials by the scavengers. They bundle the plastic-covered copper cables together in balls up to twice the size of a football (see Figure 2). Young men throw the cables in very hot fires, fueled by plastic materials from e-waste, such as insulation from fridges or computer monitor casings. The fire melts the plastic from the copper within a few minutes. The cables are then taken out of the fire for cooling down (Figure 2 and 4).

Conversations with young men during the burning of cables disclosed the hazardousness of their work. They were severely affected by the smoke of the fires (eyes, lungs), they had burns (legs and arms), and experienced

nausea, coughs, and headaches. They continued their burning practices, because their daily earnings were too low to practice other ways of extracting copper from cables. Burning cables is much faster and cheaper than using the cable stripping machines (Figure 5; see below "Persistence of Cable Burning").

Figure 4. Burned cables. © SMART/Maja van der Velden.

The burning of cables is part of a much larger ecosystem of activities in which young migrant workers find income and community (Oteng-Ababio et al., 2018). It is a rather dynamic community. Some young men remain cable burners for years, while others move on to other recycling work. We interviewed a young man who, as an orphaned youth from the North, started with burning cables in Agbogbloshie and later became a disassembler of e-waste. Working with e-waste enabled him to pay for his education and livelihood. At the time of the interview, he was just finishing his bachelor degree at a community college.

Regulating hazardous waste

Ghana has ratified the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* (1992), an international treaty designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from high-income to low-income countries.[4] Its intention is to decrease the amount of hazardous wastes generated as well as to safeguard the sustainable management of hazardous materials – as closely as possible to where the waste is generated. Ghana has also ratified the *Montreal Protocol on Substances that Deplete the Ozone Layer* (Montreal Protocol), an international treaty designed to protect the ozone layer, which came into force in 1989; and the *Stockholm Convention on Persistent Organic Pollutants* eliminates or restricts the production and use of persistent organic pollutants (POPs), which came into effect in May 2004. Especially polychlorinated biphenyls (PCBs) are found in electronics and are released during the burning or landfilling of electronics (Liu, Ma, Li, Yu, & An, 2019).

Figure 5. One of the cable-stripping machines. © SMART/Maja van der Velden.

In addition, Ghana has ratified the Bamako Convention and Malabo Protocol. The failure of the Basel Convention to prevent the export of hazardous waste to low-income countries prompted the Bamako Convention. The *Bamako Convention on the Ban on the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa*[5] of 1991 prohibits African nations to import hazardous wastes. The Convention is stronger in its prohibition than the Basel Agreement. In 2013, the African Union adopted the *Malabo Protocol*, which

[4] The Basel Convention (United Nations): http://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-3&chapter=27&lang=en

[5] Bamako Convention: https://au.int/en/treaties/bamako-convention-ban-import-africa-and-control-transboundary-movement-and-management

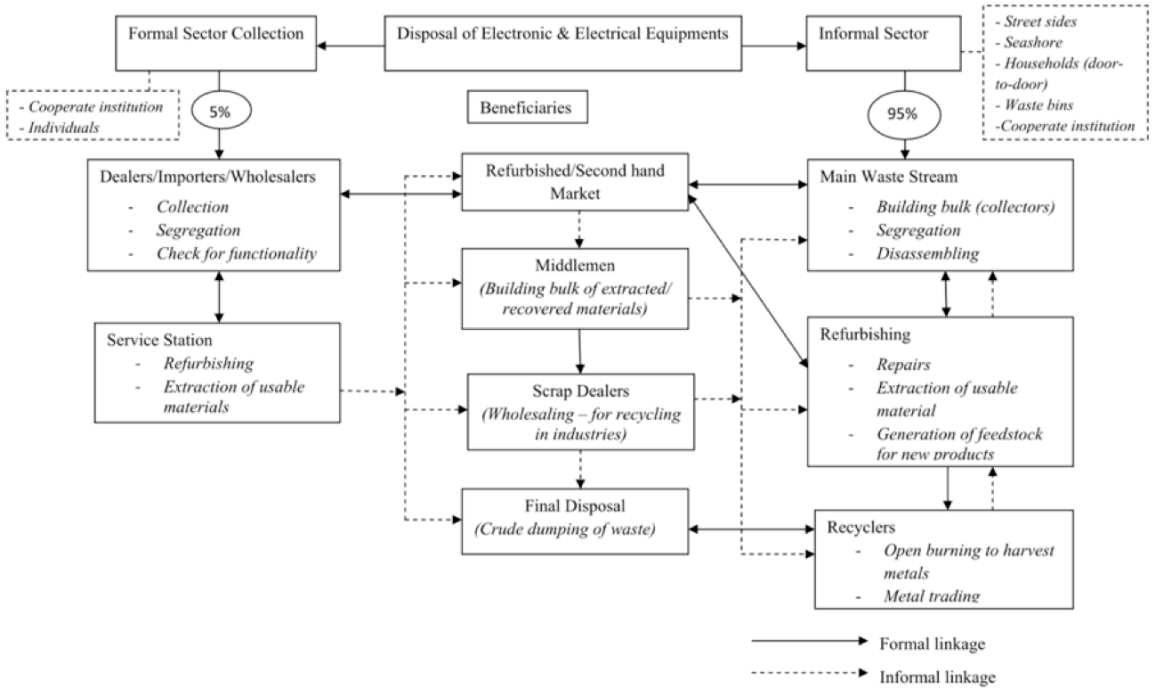

Figure 6. Formal and informal e-waste management in Ghana (Oteng-Ababio, 2012).

criminalizes the trafficking of hazardous waste and opens up for the creation of a tribunal.[6]

Ghana's Environmental Protection Agency (EPA) implemented in 1991 a National Environmental Action Plan, providing a framework for the control and management of potentially toxic substances (Atiemo et al., 2016). Specific regulation of e-waste and hazardous materials goes back to 2008, with the adoption of the Energy Efficiency Regulations (L.I.1932), prohibiting the manufacture, sale or import of incandescent filament lamps and used refrigerators, freezers, and air conditioners. This Act made it a criminal offence to transport or offer for sale such an appliance (ibid.). Opposition from scrap dealers delayed the implementation of the Act until 2013, but the Act seems not to be enforced as imported UEEE fridges are openly traded on markets.

In 2016, the *Hazardous and Electronic Waste Control and Management Act* (Act 917) and its accompanying *Hazardous and Electronic Waste Control and Management Regulations* (LI 2250), were passed in the Ghanaian parliament. The implementation of Act 917 is based on the formalization of the e-waste sector and a ban on burning e-waste. The Act prohibits the import, export, trade, storage, and transport of hazardous waste and other wastes. Exemptions are based on the Basel Convention and need approval from the EPA. Part II of Act 917 deals specifically with electronic waste. Among others, Part II sets provisions for an e-waste recycling plant and the obligation to a manufacturer, distributor or wholesaler of EEE or UEEE to take-back used or discarded EEE for recycling purposes. It also stipulates that the disposal and recycling of e-waste should be carried out in an environmentally sound manner.

The persistence of cable burning

Understanding how the four modes of regulation, *architecture*, *market*, *social norms*, and *law*, interact, can explain why cable burning persists within the current legal framework.

[6] Malabo Protocol hasn't come into force yet, because it hasn't received enough ratifications:https://au.int/en/treaties/protocol-amendments-protocol-statute-african-court-justice-and-human-rights

Architecture constrains the implementation of the *law* in several ways. Generally, the design of electrical and electronic equipment doesn't take the end-of-life of products in consideration by designing for recycling. For example, the unsustainable practice of cable burning continues in part because other methods are made less efficient by the functional design of the cables. A research project comparing the burning of cables and the stripping of cables with tools was implemented with workers at Agbogbloshie. It found that the burning of 40 lb mixed cables took on average 10 minutes, while the stripping of 40lb mixed cables took on average 185 mins (GreenAd, 2012). As a follow-up, stripping machines were installed (Figure 5). There is however a mismatch between the design of the cable-stripping machines and the size and shape of the most common cables recycled in Agbogbloshie. The cables are too warped to run smoothly through the machines or they are too thin to fit in the machine.

The health impacts of cable burning are obvious enough to those doing the work. An alternative method for stripping cables – even a slower one - would normally be preferred, but low copper prices paid to the e-waste workers constrain the use of more sustainable forms of cable stripping. The price of copper fluctuates daily and is set by scrap metal dealers, who are mainly from Nigeria. These dealers have captured a certain position in the market, which gives them control over local copper prices and thus the wages of the local cable burners. Another economic incentive is set by the steady stream of foreign media, attracted by the striking images of tire and cable burning in Agbogbloshie. Some of the young men feature in several photo reports and documentaries and have mastered the spectacular burning of car tires using large amounts of lighter fluid. [7,8, 9]

This simple example illustrates the point that a particular architecture, originating from a product design decision made at the start of the product life-cycle, interacts with the market dynamics operating at the end-of-life of that product. Together, these architectural and market-based realities constrain the effectiveness of the law, in this case Ghana's attempts to regulate e-waste sustainability in a manner that meets its international treaty obligations. In short, legislation that seeks to ban informal recycling at the end of life of products is unlikely to be effective where the architecture of the product and the market dynamics of recycling are mutually reinforcing.

It is important to note that there are structural aspects of making a livelihood in Agbogbloshie, which constitute important factors in shaping recycling activities. Briefly, recycling in Agbogbloshie is shaped by several aspects of social and economic marginalization;

i) Labour in the e-waste sector is based almost exclusively on informal work (Figure 6) (Oteng-Ababio, 2012). Poverty and widespread labour market informality combine to keep wages low and workers impoverished.

ii) Recycling work is dominated by migrants from the North of Ghana, affected by local conflicts and climate change (Oteng-Ababio, 2012). These migrant laborers are more vulnerable to exploitation and harassment by city authorities (Imoro, 2017), and they have less opportunities for safe and decent work (Yeboah, 2017).

iii) There is a gendered division of labor in e-waste recycling: men burn cables or disassemble e-waste, while women work as *kayayei*, selling food and water to the men (Agyei, Kumi, & Yeboah, 2016);

The result is that recycling in Agbogbloshie is precarious work [10]; it is extremely low paid,

[7] "Photojournalism is Agbogbloshie's biggest import": https://www.linkedin.com/pulse/victimhood-jujitsu-vs-compassionate-capitalism-robin-ingenthron/

[8] Awal Muhammed in action for the documentary "Welcome to Sodom": https://www.deutschlandfunk.de/film-der-woche-welcome-to-sodom-die-schattenseite-der.807.de.html?dram:article_id=424290

[9] http://retroworks.blogspot.com/2018/07/nuance-delivery-2-awal-is.html

[10] People in precarious work generally "…lack job security and generally have lower salaries, limited social protection, and few, if any, benefits. Precarious workers face more difficulties to exercise their rights, notably to join a union and bargain collectively for better wages and working conditions. Injury rates are higher for precarious workers… People in precarious work have little or no choice in determining their working hours and pay…" (IndustriALL, 2018)

dangerous, and insecure. It has a significant impact on the environment. At the same time, it provides the basis for livelihoods of several thousand people and is a key part of Accra's recycling system.

Concluding remarks

Our systemic approach to regulation, in the form of the regulatory ecology of cable burning, brings out the complex reality in which this unsustainable activity is entangled. Efforts to ban the activity through legislation will not be effective, because the law doesn't address the marginalization of workers and the design of e-waste. This becomes especially clear in the technical guidelines for the implementation of Ghana's Act 917 (EPA & SRI, 2018), which focuses on materials, not on people (workers) or products (design). Its focus on the formalization of the e-waste recycling sector results in the imposition of collection standards and materials standards that are almost impossible to fulfil for low-income migrant laborers. Similar license-based approaches in India and China have shown not to work (Shinkuma & Managi, 2010).

Alternative interventions are based on creating interactions between the informal and formal sector recycling activities (Davis & Garb, 2015). Most known are Best-of-2-Worlds (Bo2W) initiatives, in which informal workers are doing the manual dismantling and recycling takes place in formal recycling facilities. The main critique on the Bo2W approach is that while it can make their work less hazardous, it doesn't address the marginalization of e-waste workers (Lepawsky, Araujo, Davis, & Kahhat, 2017). Based on a study of cable burning in an e-waste recycling area on the West Bank, Davis and Garb (2015, 2019) therefore call for interventions based on a synergetic and deeper engagement between the informal and formal sector than proposed by the Bo2W approach. Ignoring the precarious social and legal status of informal e-waste workers will just move cable burning to less visible places.

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