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Alignments between e-waste legislation and the Sustainable Development Goals: the United Kingdom, Brazil, and Ghana case studies

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Abstract

The first two decades of the 21st century had a significant increase in e-waste generation. While improper recycling technologies applied to this type of waste pose severe risks to the environment and human health, several e-waste management legislation has been recently enforced worldwide, reaching 78 countries and covering 71% of the global population. In common, most of them aim to recycle minerals and plastic from the disposed waste of electric and electronic equipment (WEEE) to reinsert them in the industry, promoting the so-called circular economy. From the comparative case study of countries that integrate the world-system in different social and economic conditions – the United Kingdom (as core or developed country), Brazil (as semi-periphery or emergent country), and Ghana (as periphery or developing country) –, this article aims to understand to what extent the national legislation on e-waste management in these territories align with the Sustainable Development Goals 3, 6, 8, 11, 12, 14, and 15. This research has an exploratory approach and is methodologically structured as a controlled comparison of most different cases. Results reveal that selected legislation has different levels of alignment with SDG, ranging from generic mentions of social-environmental topics to description of legal instruments to be enforced regarding environmental preservation, improvement of population's life quality, and changes in the unsustainable production, consumption, and disposal patterns. The article also seeks to contribute to the geographical debate by establishing the relation between e-waste legislation and SDG, considering the territorial particularities of the case studies.

KEYWORDS

comparative case studies, E-waste, legislation, SDG, world-system analysis

1 | INTRODUCTION

The expansion in the generation of waste electrical and electronic equipment (WEEE) at the beginning of the twenty-first century is one of the many consequences of the deepening of the consumer society (Baudrillard, 1995) forged from the Third Industrial Revolution. In 2019, approximately 53.6 Mt of e-waste was generated worldwide, and it is estimated that this volume will reach 74.7 Mt in 2030 if current production, consumption, and disposal patterns are maintained (Forti et al., 2020). At the same time as this expansion takes place, much national legislation dedicated to the proper management of WEEE has been developed worldwide.

Such legislation is structured based on the polyvalent nature of the waste (Levidow & Raman, 2019), which is eventually considered a pollutant and ultimately considered a commodity. This polyvalence is explained, on the one hand, by numerous studies worldwide that have revealed the harmful impacts of WEEE on both human health and the environment if not properly managed (Amankwaa, 2013; Asante et al., 2011; Baldé et al., 2017; Brigden et al., 2008; Frazzoli et al., 2010; Huang et al., 2013; Kuper & Hojsik, 2008; Robinson, 2009; Rucevska et al., 2015). On the other hand, regardless of the technical conditions employed, WEEE management has significant economic potential and has served as a source of income for formal and informal recyclers worldwide (Gutberlet, 2015; Santos, 2021).

National e-waste legislation has developed over the past two decades adopting several management models, such as extended producer responsibility (EPR), shared responsibility, and taxation. As Lepawsky (2012) points out, the literature on e-waste legislation has focused on aspects such as enforcement and compliance (Krishna & Kulshrestha, 2008), jurisdictional effectiveness (Bergner, 2004; Billinghurst, 2005; Boon, 2005; Daub, 2004; Drayton, 2007; Gibson & Tierney, 2006; Hagen, 2005; Herat, 2009; Konoval, 2006; Kuschnik, 2008), and proper division of responsibility among producers, consumers, and governments for waste management schemes, especially on EPR case studies (Boland, 2004; Courtney, 2006; Fordyce, 2004; Hollerud, 2009; Knee, 2009).

Based on an exploratory approach, this study aims to understand the alignments among national e-waste legislation from three case studies — the United Kingdom, Brazil, and Ghana — and six Sustainable Development Goals (SDGs) directly related to WEEE management according to the reports from *Global E-Waste Monitor 2020*. The selected SDGs are 3 (Good Health and Well-Being); 6 (Clean Water and Sanitation); 8 (Decent Work and Economic Growth); 11 (Sustainable Cities and Communities); 12 (Responsible Consumption and Production); 14 (Life below Water); and 15 (Life on Land) (Forti et al., 2020; United Nations, 2020).

Regarding the case studies selection, it is fundamental to notice that the United Kingdom, Brazil, and Ghana have distinct social and economic conditions, impacting the total amount of e-waste generated by each of them and, more specifically, the amount of e-waste *per capita* generated. Also, they have e-waste management legislation structured in distinct models — extended producer responsibility, shared responsibility, and taxation, respectively — adding complexity and diversity to the existing scenarios under comparison.

The intended contribution of this article to the existing literature lies not only in the comparative analysis of these legislations but in the understanding of to what extent they align to the SDGs. Lucien Georgeson and Mark Maslin pointed out the little engagement of geography and SDG, despite the geographers' potential "to contribute and to improve SDG implementation" (2018, p. 2), and to collaborate on theoretical and critical discussions of each goal significance (Georgeson & Maslin, 2018). We understand that the SDGs could be considered a relevant parameter for comparative case studies in geography. Furthermore, we also argue that this comparison is essential to reveal the various ways in which countries — in their multiple social, economic, and territorial particularities — are organised in order to reduce the negative impacts of WEEE and to ensure its reintegration into value chains through the implementation of reverse logistics systems.

This article is organised in the following sections. First, a theoretical framework on geographic studies on waste is presented, mentioning the relevance of geographic studies on e-waste legislation and the innovation on its alignments to the SDGs. The three case studies' materials, methods, and general economic and social aspects are presented in section 3 to contextualise the comparative analysis. The comparative analysis of the legislations concerning the management models they adopt, the role of the government, the recycling goals, and the alignments to SDG 3, 6, 8, 11, 12, 14, and 15 are presented in section 4. Final remarks reiterate the importance of expanding comparative studies on e-waste legislation in geography, considering their alignments to the SDGs and considering the territorial particularities given by the political economy. In addition to pointing out similarities and differences, these studies could guide the development and improvement of legislation for this type of waste.

2 | THEORETICAL FRAMEWORK

Interdisciplinarity is a common aspect of geographic studies on waste electrical and electronic equipment. Sarah Moore explains that geographers generally have three distinct and possibly complementary approaches to analysing waste in general (Moore, 2012). In a vigorous debate with the natural sciences and public health, the first approach understands "waste as a pollutant" and results in studies on the negative impacts of different types of waste on the environment and human health (Towers, 2000; Williams, 1999).

The second approach understands "waste as a resource" in an intense social and economic sciences debate. In this case, scholars focus on the recycling process and the social, political, and economic organisation of the multiple actors involved (Gutberlet, 2015; Ngo, 2001; Sicular, 1992).

Also promoting a debate with the social and economic sciences, Moore's third approach understands waste as a commodity. In addition to considering this matter as a possible pollutant and a potential resource, this approach is attentive to the standards and processes that involve waste recycling, circulation and trade (Shinkuma & Huong, 2009; Shinkuma & Managi, 2010). In this approach, Josh Lepawsky and Mather (2011) suggested an interpretation of the e-waste economy based on Bruno Latour's "actor-network" theory.

Lepawsky innovates in the "geographies of waste" literature, specifically when he ventures into the interface between WEEE and the legislation related to its management. In his article entitled "Legal geographies of e-waste legislation in Canada and the US" (Lepawsky, 2012), the author presents a comparative study between the legal framework on e-waste management in two different countries, considering jurisdiction, responsibility, and the electric and electronic equipment (EEE) production dynamics. Although it has been little explored in geography — particularly in the "legal geography" literature — the comparative analysis on e-waste management is highly relevant, especially given the different existing management models (Kiddee et al., 2013) and their diverse impact on stakeholders from the EEE value chain operating in different territories.

The lack of geographical studies on e-waste legislation could partially be explained because these are relatively recent. Although many developing countries have passed legislation in the last decade, they predominate in the Global North (Figure 1). In 2019, 78 countries had enforced e-waste policy, laws, regulations, and institutional frameworks, covering 71% of the world population, against 44% in 2014 (Forti et al., 2020; Lepawsky, 2012; Santos, 2021).

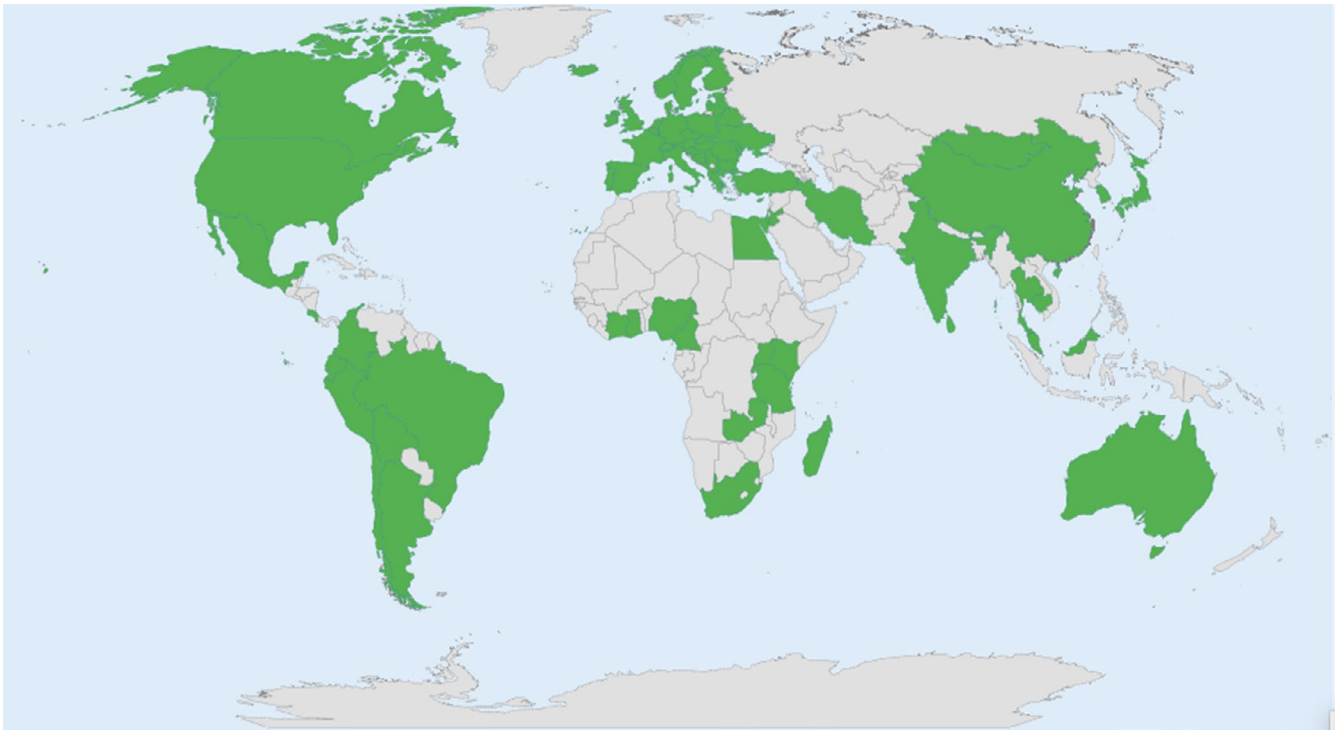

FIGURE 1 Countries with WEEE legislation (in green). *Source*: Forti et al. (2020)

Historically, the European Union (EU) played a central role by setting the guidelines to regulate e-waste management in the early 2000s. Since all debates developed from the 1989 Basel Convention, the WEEE Directive of 2002 was the first significant normative effort to ensure the recycling of this type of waste and the reinsertion of its mineral components into different industries, making mining activities more sustainable (Isernia et al., 2019; Stonewell, 2013). The Directive served as a basis for elaborating different legislations in Europe in the following years. In other parts of the Global North, this Directive also inspired national legislation in countries like Japan and Australia and state legislations in countries like the United States and Canada, given the federative character of later constitutions (Bandyopadhyay, 2008; Gough, 2016; Kumar et al., 2017).

WEEE legislation represents a crucial political effort towards sustainability, and it commonly operates in direct synergy with some Sustainable Development Goals (SDGs) established by the United Nations in 2015. The 17 SDGs (and their 169 targets) represent the commitment of signatory countries to implement national actions and international cooperation to enable sustainable development (Georgeson & Maslin, 2018; Izzo et al., 2020; Sachs et al., 2019). Governments are not the only representatives of these national and international efforts; many companies, associations, cooperatives, NGOs, research institutes and universities, in addition to civil society, are considering SDGs as a sustainability reference for their actions. The literature on the SDGs is getting extremely robust in many social and environmental sciences in recent years, but not in geography (Georgeson & Maslin, 2018), even regarding the specificities of the discipline to promote vigorous and critical analysis on sustainability.

The exploratory character of this article is much related to the innovative articulation of the comparative analysis on e-waste legislation and its alignments to the SDGs. It is essential to highlight that this paper does not address the enforcement of these regulations, therefore focusing on the legal texts. The material, methods, and selection of the case studies related to this research are explained in the following section.

3 | MATERIAL, METHODS, AND SELECTION OF THE CASE STUDIES

The materials that supported the comparative analysis of e-waste legislation in the UK, Brazil, and Ghana were their respective legal documents: a statutory instrument, a decree, and an act, respectively (Figure 2). These legislations were developed and enforced in different years, but they can be accessed in full on the websites of the three countries' governments.

As these documents were analysed and compared, we also sought to identify the extent to which they were aligned with the Sustainable Development Goals 3, 6, 8, 11, 12, and 14 defined by the United Nations General Assembly. The SDG can be accessed directly on the United Nations website, on a platform that describes each goal and its specific targets (Figure 3). The analyses and results presented in the following section also relied on other secondary sources, such as books, articles, and reports on e-waste generation and management in the selected countries.

To design the alignments between the e-waste legislation and the SDGs, we selected specific targets directly related to WEEE management that were already established by *The Global E-Waste Monitor 2020* (Forti et al., 2020). This monitor became one of the most relevant reports regarding e-waste generation, and researchers collaboratively developed it from different institutions, such as the UN University (UNU), the International Telecommunication Union (ITU), the International Solid Waste Association (ISWA), and the UN Environment Programme (UNEP).

Legislations	Brief description
Waste Electrical Electronic Regulation from the United Kingdom (common law system)	It is a statutory instrument (secondary legislation) passed by the parliament in 2006, and its function is to transpose the EU Directive (that the UK government had already approved in Brussels.
Decree No 10240 on the Implementation of a Reverse Logistics System for Household Electro-electronic Products and their Components from Brazil (civil law system)	It is a decree passed by the president in 2020, and it is based on a sector agreement from 2019 and transposes some directives from the National Solid Waste Policy.
Hazardous and Electronic Waste Control and Management Act (Act 917) from Ghana (common and customary law)	It is an Act (primary legislation) passed by the parliament in 2016 and assent by the president.

FIGURE 2 Selected e-waste legislation and its description. Sources: United Kingdom (2006); Brazil (2020); Ghana (2016)

TARGETS REGARDING SELECTED SDG

On SDG 3: ***3.9.*** *By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination.* **On SDG 6: 6.3.** *By 2030, improve water quality by reducing pollution, eliminating dumping, and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally.* **On SDG 8:** ***8.4.*** *Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of sustainable consumption and production programs, with developed countries taking the lead.* **On SDG 11:** ***11.6.*** *By 2030, reduce the adverse per capita environmental impact of cities, including paying particular attention to air quality and municipal and other waste management.*

On SDG 12: ***12.5.*** *By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse.* **On SDG 14:** ***14.1.*** *By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.* **On SDG 15:** ***15.1.*** *By 2020, ensure the conservation, restoration, and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.*

FIGURE 3 Selected SDGs related to WEEE management and their targets. *Source*: United Nations (2020)

We then seek to classify the extent to which selected e-waste legislations align to SDG 3, 6, 8, 11, 12, 14, and 15. To achieve that aim, we developed an experimental classification system based on five gradual levels, namely: **Level 0 (non-existent)** when the legislation does not mention the SDG theme; **Level 1 (weak)** when the legislation mentions the theme of the SDG (such as environment, health, consumption, among others) in a generic way (possibly as a guiding principle); **Level 2 (medium)** when the legislation offers instruments that indirectly enable the alignment to an SDG; **Level 3 (strong)** when the legislation offers instruments that directly enable the alignment to an SDG; and **Level 4 (not applicable)** when the legislation makes no mention of the SDG, as the territory in question has already achieved the goal. Regarding specifically the classificatory level 4, it points out possible particularities of the interface among legislation and territory. For example, in many countries where access to drinking water and basic sanitation is already established as a universal right (especially in the Global North), there is no compelling need to seek the alignment to SDG 6.

Using an exploratory and qualitative approach, the research presented in this article is structured methodologically as a comparative case study on e-waste legislation and its alignment to the SDGs. In order to capture the diversity of ways in which these regulations are settled around the world, we selected territories with different social and economic features to promote a controlled comparison of very different cases (Skocpol & Somers, 1980; Slater & Ziblatt, 2013). Considering

the classification of countries according to Immanuel Wallerstein's world-system analysis (Wallerstein, 2006), which classified countries as core, semi-periphery, and periphery, we selected a case for each of these three divisions: the UK, Brazil, and Ghana, respectively.

The selection of these three countries highlights how territories with different social and economic features—such as GDP, population, GDP per capita and e-waste generation per capita (Figure 4)—develop their national legislation on their WEEE management. In addition, the selection of these countries is related to the availability of their legislation and to the fact that they are structured according to different management models: extended producer responsibility (in the United Kingdom); shared responsibility (in Brazil); and taxation (in Ghana), as will be analysed in the next section. The study's objective is not to establish generalisations from the compared cases, so the sample has an exploratory character.

Representing the core—or developed countries, also known as the Global North — the UK registered a GDP of USD2.8 trillion in 2019, and its GDP per capita was USD42,328. It is estimated that only 0.2% of the country's population lived on less than USD1.90 per day (World Bank, 2021). In the same year, *The Global E-waste Monitor* estimated that the country had generated 1.59 million tons of WEEE (23.9 kg per capita) (Forti et al., 2020).

The UK developed its "Waste Electrical Electronic Regulation" in 2006 and implemented it in 2007, even before the consolidation of Agenda 2030. This Statutory Instrument was inspired by Directive 2002/96/EC of the European Parliament and the Council of 27 January 2003 on WEEE, as amended by Directive 2003/108/EC of the European Parliament and the Council of 8 December 2003 on WEEE (United Kingdom, 2006).

Brazil, in turn, represents the semi-periphery, or the group of emerging economies that have gone through a successful industrialisation process in the Global South. In 2019, the country recorded a GDP of USD1.8 trillion and a GDP per capita of USD8717. In the same year, 4.4% of the population lived on less than USD1.90 a day (World Bank, 2021).

In 2019, *The Global E-waste Monitor* estimated that the country generated 2.1 million tons of WEEE (10.2 kg per capita) (Forti et al., 2020). In the same year, the country approved the "Sectoral Agreement for the Implementation of a Reverse Logistics System for Household Electro-electronic Products and their Components," which became a decree in 2020 (Brazil, 2020). The recommendation for establishing the sectoral agreement was already made by the 2010 "National Solid Waste Policy" (Brazil, 2010). The expectation is that the agreement will come into force in 2020/2021, but the COVID-19 pandemic combined with the national political crisis has left much uncertainty regarding many legal enforcements in the country.

In the periphery of the world system is Ghana — also classified as a developing economy or non-industrialised Global South — a country whose economy is heavily dependent on exports of commodities, such as gold, oil, and cocoa (Santos, 2018). In 2019, the country's GDP reached USD66 billion, while GDP per capita was USD2202 (annual). In 2016, 13.3% of the population lived on less than USD1.90 per day (World Bank, 2021).

In 2019, *The Global E-waste Monitor* calculated that the country generated 53 thousand tons of WEEE (1.8 kg per capita) (Forti et al., 2020). Notably, in this case, e-waste imports from the Global North and its informal management in peripheral neighbourhoods of the capital, Accra, are relevant particularities that journalists, environmentalists, and

Country	**The United Kingdom**	**Brazil**	**Ghana**
Region	West Europe	South America	West Africa
Location			
GDP (2019)	USD 2.8 tri.	USD 1.8 tri.	USD 0.066 tri.
Population (2019)	66.8 mi	211.0 mi.	30.4 mi.
GDP *per capta*	USD 42,328.9	USD 8,717.1	USD 2,202.1
E-waste generation *per capta*	23.9 kg	10.2 kg	1.8 kg

FIGURE 4 GDP, population, GDP per capita, and e-waste generation per capita in selected countries. *Sources*: Forti et al. (2020); World Bank (2021)

scientists have been analysing since 2008 (Kuper & Hojsik, 2008). Ghana developed the "Hazardous and Electronic Waste Control and Management Act, 2016 (Act 917)" in 2016 (Ghana, 2016).

Among the cases analysed, the UK, Brazil, and Ghana have structured legislation in different models, presenting advantages and disadvantages within their territorial contexts. These laws show stronger or weaker alignment to certain SDGs, and this assessment allows reference to the countries' progress towards sustainable development. The following section will analyse some aspects of management models, addressing the funding, stakeholders' responsibilities and stipulated WEEE recycling goals. Then we will examine their alignment to SDG 3, 6, 8, 11, 12 and 14. In addition, some comments on the alignment of the Ghanaian Act 917 to SDG 15 will be developed.

4 | RESULTS AND DISCUSSION

4.1 | Management models

There are different models regarding WEEE management. These assign roles to different stakeholders involved in the production, distribution, trade (including import and export), and consumption of electric and electronic equipment (EEE).

The extended producer responsibility model (EPR) is the most debated (Kiddee et al., 2013; Lepawsky, 2012) since it was adopted by the WEEE Directive of 2002, which inspired many of the regulations in the European Union countries. In EPR, the financing of WEEE management falls on producing and importing companies, depending on the country. Another model is the shared responsibility, which assigns responsibilities (ultimately financial) to other stakeholders, such as distributors, traders, and consumers (Wagner, 2009). Less common is the taxation model, in which the government assumes the responsibilities of managing e-waste and defrays the process through taxes collected from different stakeholders in the EEE value chain.

We understand that these models can be potentially favourable and unfavourable to stakeholders involved in collecting, repairing, and recycling the WEEE generated (Figure 5). Each of the legislations analysed in this study adopts one of these three management models, helping to build the comparative analysis structured on the most different cases (Skocpol & Somers, 1980; Slater & Ziblatt, 2013).

The favourable or unfavourable aspects in each model are related to the number and attributions of stakeholders involved in WEEE management: financing, execution, decision-making, data collection, and reporting. Thus, on the one hand, management with fewer stakeholders can guarantee a more centralised and less bureaucratic recycling process, marked by scale gains and management efficiency. On the other hand, management with more stakeholders could reduce costs and engage multiple EEE chain companies in e-waste recycling.

	Extended Producer Responsibility	Shared Responsibility	Taxation
Favourable Aspects	• Scale gains; • Better governance; • The costs and efficiency of the process are optimised.	• The information is well consolidated, and the statistics are documented and known; • No stakeholder in the chain is overwhelmed.	• Scale gains; • The information is well consolidated, and the statistics are documented and known; • High efficiency; • Lower inspection cost.
Unfavourable Aspects	• There is no cost-sharing among other stakeholders; • Little openness to smaller or independent initiatives.	• Routines for apportioning costs among system participants; • Governance is more complex, the alignment between actions and data is less accurate; • It requires a more complex structure for the involvement of more stakeholders.	• Usually made possible with taxes, fees, or contributions from other stakeholders; • Higher system management cost; • Do not stimulate sustainable practices from companies on the EEE chain.
Example	The United Kingdom	Brazil	Ghana

FIGURE 5 Favourable and unfavourable aspects of different e-waste management models. *Source*: ABDI (2013)

In the case of the United Kingdom, the EPR model prevails, as EEE producers and importers have to "finance the costs of the collection, treatment, recovery, and environmentally sound disposal of the WEEE from private households" (United Kingdom, 2006, p. 54). EEE producers must join a Producer Compliance Scheme (PCS) to facilitate the waste management process, which covers the entire chain, prioritising the reuse of objects (for reinsertion in the market) and recycling. PCS should use the most modern recycling technologies available and produce reports communicating the annual results of the management process. In other words, these reports must specify the amount of waste collected, the percentage of repaired objects retaining their original functionality (for reuse purposes), and the percentage of objects properly recycled (and their final destination). Other stakeholders — such as distributors and retailers — should help collect and communicate to consumers about the proper way to dispose of e-waste (United Kingdom, 2006).

Most advantages of this model rely on the low number of stakeholders involved in management. This model facilitates economies of scale since the processed volume of e-waste per producer or importer is already defined by national authorities. With this model, better governance could happen as there are fewer stakeholders to establish consensus. Finally, for the same reason, a more efficient inspection of management practices is expected. The disadvantages would be the lack of cost-sharing with other stakeholders and little openness for smaller scale (and independent) initiatives.

In Brazil, where the shared responsibility model prevails, many stakeholders finance the e-waste management, albeit in different proportions. Stakeholders should choose representatives (mostly sectoral associations) to integrate a performance monitoring group, facilitating and structuring the recycling process for management companies. Funds invested in these companies should also cover the entire chain (Brazil, 2020).

The main advantage of the shared responsibility model is that it generates less cost overheads for stakeholders involved in recycling, despite governance being hampered by the number of stakeholders, namely EEE producers, importers, retailers, the consumer market, and the government.

In Ghana, where the taxation model prevails, importers, and producers indirectly finance the system through the prepayment of the WEEE eco-levy (Ghana, 2016). However, Act 917 also considers other sources of funding for the management of e-waste, such as unspecified levies, "any other money received from other sources or that may come in any manner lawfully payable and vested in the Fund; grants, donations, and other voluntary contributions; and money approved by Parliament" (Ghana, 2016, pp. 16–17).

Therefore, the taxation model offers gains in scale and more centralised governance, providing efficiency to decision-making processes. However, the legislation also overloads the government in the e-waste management process. It also does not stimulate the companies involved in the production chain, distribution, and trade to develop strategies to reformulate the current unsustainable production and consumption standards. Currently, there is no consensus on whether other WEEE management models would promote transformations in the design and production of EEE.

4.2 | The role of the government

The government has a regulatory role in the UK and Brazilian e-waste legislation through their ministries and environmental agencies. Among some public functions, they recommend: to register the producer (and eventually other stakeholders like importers, distributors, wholesalers, and retailers in the Brazilian case); to approve the recycling scheme and facilities established by stakeholders; to determine (in the UK case) the amount of relevant WEEE for which that producer shall be responsible; and to monitor the accuracy of information provided by all the stakeholders. This information concerns the amount of EEE put into the market, and the amount of WEEE collected and recycled; to facilitate the positioning of collecting points in public spaces, facilitating communication on the ideal WEEE disposal practices to the population.

Differently, in Ghana, the government plays a significant role by centralising the collection of taxes to the "WEE Management Fund," which should "provide finance for the management of EEW and reduce the adverse impact of EEW on human health and the environment" (Ghana, 2016, p. 16). It is up to this fund: to provide support for the construction and maintenance of WEEE recycling treatment facilities; to support research into methods of WEEE preservation, prevention, and control; to research into WEEE treatment and recycling; to publish reports; to facilitate the communication on the proper WEEE disposal practices to the population; to offer incentives for the collection, transportation, and disposal of WEEE; to guarantee monitoring, compliance, enforcement; training (workshops); collection, safe disposal, and recycling of WEEE.

The government has a regulatory character in WEEE management, although the legislation does not specify what constitutes "to provide support for the construction and maintenance of WEEE recycling facilities," among other attributions. The generalist character prevails in the Ghanaian Act, conferring weak or medium alignment to most selected SDGs.

4.3 | Recycling goals

The UK and Brazilian legislations set goals related to the amount of WEEE to be collected for recycling. In the UK, the Statutory Instrument establishes a certain amount of waste to be collected and recycled each year based on an equation that considers the amount of EEE that the company put into the British market, the amount put in by other companies, and the total amount of WEEE generated in the same year (United Kingdom, 2006).

In Brazil, the Decree establishes progressive goals based on the undergoing WEEE management system structuring (explicitly named as a reverse logistic system). These goals foresee the evolution from 1% to 17% of the national WEEE treated between 2021 and 2025 (Brazil, 2020). In this gradual process, the number of cities served by the system will grow from 25 to 400, prioritising the most populated ones. A performance monitoring group, made up of EEE producers, distributors, and traders, is responsible for collecting data and developing annual reports, where the goals are communicated to the Ministry of Environment. The multiplicity of stakeholders makes it difficult to monitor the success of these goals, unlike the British case. This aspect of the country's legislation may translate into a low efficiency in inspection and treatment in the coming years.

Ghanaian Act 917, in turn, does not set any goals regarding e-waste recycling, which makes it difficult to control the dynamic of the recycling process itself. The complexity of the Ghanaian case is also associated with the new dynamics of e-waste importing, given that it is difficult to measure the flow due to its illegal nature and the fact that a large part of this waste arrives at the Tema Port, labelled as second-hand goods, which have been legally imported since 2004 (Amankwaa, 2013; Grant, 2016; Oteng-Ababio, 2012).

4.4 | Legislation alignments to SDG 3 (Good Health and Well-Being)

To ensure Good Health and Well-Being is a goal closely related to ensuring the quality of the air, water, and soil, as expressed by target 3.9 of the SDG: "By 2030 substantially to reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination" (United Nations, 2020, n.p.). Some research has been devoted to raising the harmful impacts of inadequate WEEE management on air, water, and soil quality in recent years, especially when recycling is carried out informally using precarious techniques (Oteng-Ababio, 2012; Santos, 2018). In Accra, burning WEEE wires in open space is a regular practice in the Agbogbloshie neighbourhood, and it can release toxic substances (e.g., emitting volatile organic compounds [VOC], pentabromophenol [PBP] and polychlorinated biphenyls [PCB] into the atmosphere) (Asante et al., 2011; Huang et al., 2013). Moreover, the dissolution of residues using water and acid substances can also contaminate soil and water bodies with the release of lead, mercury, arsenic and nickel (Huang et al., 2013). By ensuring the reduction of environmental pollution, aspects related to the health and well-being of the population are also guaranteed.

In Ghana, the Act organises the recycling process to be conducted in an environmentally sound manner. However, there is no other specification on how this will be guaranteed or which institutions will work with this goal. The issue is addressed broadly, corresponding to a weak alignment (level 1) to SDG 3 (Ghana, 2016).

Brazil and the United Kingdom legislations have a strong (level 3) alignment to SDG 3. While air pollution, especially in urban areas, is an environmental problem that remains to be solved in the United Kingdom (Font et al., 2019), in Brazil, air, water and soil pollution occur at different levels throughout the national territory (Jacobi, 2013; Théry & Mello-Théry, 2018).

In order to avoid air pollution, the British Statutory Instrument for WEEE management requires that operators in the recycling systems have "a relevant authorisation," which is determined by previous environmental legislation. Examples of this legislation are: Pollution Prevention and Control Regulations 2000 (England and Wales), Pollution Prevention and Control Regulations 2000 (Scotland), Environmental Protection Act 1990, Waste Management Licensing Regulations 1994, and Pollution Prevention and Control Regulations 2003 (Northern Ireland) (United Kingdom, 2006).

In the Brazilian case, the WEEE Decree mentions that recyclers must obtain an environmental license to operate, offered by the National Council for the Environment (CONAMA). Regarding these premises, and considering a planning

system based on the environmentally proper final destination of electronic products, the legislation also mentions that business sectors committed to logistics reverse are intended to contribute, directly or indirectly, to "decrease the pollution of soil, water and air" (Brazil, 2020, p. 62; Demajorovic et al., 2016; Rodrigues et al., 2020).

4.5 | Legislation alignments to SDG 6 (Clean Water and Sanitation)

The universality of drinking water and basic sanitation is still a challenge in many countries, especially in the Global South. Target 6.3 expects that: "By 2030, improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally" (United Nations, 2020, n.p.). Providing access to drinking water to 100% of the population and sanitation to 99% (UNESCO, 2020), the UK has already achieved the goal of SDG 6 so that the country's Statutory Instrument does not need to address the issue. For this reason, it has a level 4 (not applicable) alignment to SDG 6.

In 2017, 98% of the Brazilian population had access to drinking water, and 49.2% had access to safely managed sanitation services (UNICEF, 2020), so the sanitation infrastructure is not yet universal. This goal is adequately covered in the legislation linked to environmental licensing (Brazil, 2020), ensuring a strong (level 3) alignment to the SDG.

In the same year, 36.4% of the Ghanaian population had access to safely managed drinking water services, and 45% had access to drinking water (when the collection time is not more than 30 min). Regarding sanitation, only 18% of Ghanaians had access to sanitation services (UNICEF, 2020). However, as observed in the case of SDG 3, the WEEE legislation addresses environmental issues broadly, without indicating strategies, instruments or stakeholders who will be responsible for ensuring clean water and sanitation services. This issue is even more severe since the pollution generated in the informal processing of WEEE directly impacts the water quality in rivers and lakes (Huang et al., 2013). Thus, the country's legislation again presents a weak (level 1) alignment to the SDG.

4.6 | Legislation alignments to SDG 8 (Decent Work and Economic Growth)

The world of work and its association with economic growth are the themes of SDG 8. The focus is on encouraging micro, small and medium-scale enterprises, protecting labour rights, promoting safe work environments, and combating forced labour and child labour. These working conditions must be associated with an economy that operates on a more sustainable logic regarding carefully using resources. Target 8.4 mentions that countries shall: "improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, following the 10-year framework of programs on sustainable consumption and production, with developed countries taking the lead" (United Nations, 2020, n.p.).

The British legislation has the fourth level (non-applicable) of alignment to SDG 8. In the United Kingdom, the law stipulates the amount of WEEE that each producer has to recycle. Regarding the decent work aspect of SDG 8, the Statutory Instrument does not mention labour conditions. However, since the activity is regulated, compliance with the country's labour legislation is implicit.

Brazilian legislation has the strongest (level 3) alignment to the goal. The Decree aims to consolidate a reverse logistics system, guaranteeing to recycle the minerals contained in the WEEE and their reinsertion into other industrial chains, thus enabling the circular economy. Also, the sectoral agreement encourages the entry of waste pickers' associations and cooperatives as significant players in the recycling process. Numerous studies point out these actors' central role in recycling solid urban waste in Brazil (Gutberlet, 2015; Jacobi & Besen, 2011). The agreement also provides the mandatory use of technologies that do not expose workers to any risk of accident (Brazil, 2020).

Ghanaian legislation has a medium (level 2) alignment with SDG 8 as the law expresses itself to guarantee an adequate insertion of workers in all recycling stages. The idea is to reduce the informality of the activity in the country. As the law is incorporated, this may occur, but there is no consolidated strategy in the material for this to happen (Ghana, 2016).

4.7 | Legislation alignments to SDG 11 (Sustainable Cities and Communities)

The goal of guaranteeing sustainable cities and communities is related to everyday social practices, whether on a community or urban scale. The practices related to waste management in these spaces are noteworthy. According to Target

11.6, "by 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management" (United Nations, 2020, n.p.).

British and Brazilian laws present specific strategies in WEEE management, particularly concerning the most problematic aspect of the e-waste recycling process: collection. Waste collection targets are presented objectively in both legislations, as previously mentioned. This aspect justifies the strong alignment of both laws to SDG 11 (Brazil, 2020; United Kingdom, 2006). In this sense, in Brazil, the law projects the expansion of WEEE collection points in the most populous cities in the country. These points are expected to jump from 70 to 5,000 between 2020 and 2025 (Brazil, 2020). These points are already established in the UK, especially in public spaces such as parks and bus stops. However, Dindarian and Gibson (2011) reveal how it is still necessary to improve consumer awareness strategies, given that much of the WEEE discarded is damaged during the actual practice of disposal.

There is no established goal on the collection of waste in Ghanaian law, revealing, once again, a generic approach. To the extent that the legislation itself seeks the proper management of WEEE, one can understand that various instruments proposed in the law — especially the financing of recycling facilities by the government — ensure the collection within the general framework of WEEE management, which justifies a medium (level) alignment to SDG 11. The informal collection has strong relevance in the recycling of e-waste in the Greater Accra Region (the most populated region in Ghana) so that there would be an urgency in the development of a law that would objectively specify how to improve the working conditions of collectors in the country (Atiemo et al., 2016).

4.8 | Legislation alignments to SDG 12 (Responsible Consumption and Production)

The goal of responsible production and consumption is closely related to the management of WEEE. Target 12.5 expressed that: "by 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse" (United Nations, 2020, n.p.).

All the analysed laws have mechanisms that hold different stakeholders involved in recycling (producers, distributors, traders, recyclers, and governments) responsible for creating population awareness. The Brazilian case mentions the need "to develop and implement awareness campaigns to the population to inform and disseminate knowledge about the importance of properly managing discarded WEEE" (Brazil, 2020, p. 62). In the Ghanaian case, it is ensured that one of the WEEE funds' uses is for "education of the public on the safe disposal of electrical and electronic waste and the negative effects of electronic waste" (Ghana, 2016, p. 16). In the British case, large waste bins can be found for the exclusive collection of WEEE. Such bins are located mainly near the entrance to parks and bus stops and have instructive information on which e-waste should be deposited. In this sense, the three legislations have a strong alignment with SDG.

4.9 | Legislation alignments to SDG 14 (Life below Water) and 15 (Life on Land)

The maintenance of aquatic ecosystems is related to WEEE management based on the risk of water contamination that inappropriate recycling techniques can generate. The alignment of the legislation to the goal repeats what was observed in SDG 6. Target 14.1 states: "by 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities" (United Nations, 2020, n.p.).

Since the United Kingdom has already universalised its sanitation system, its legislation does not need to problematise the issue and therefore has a level 4 alignment to the SDG. In Brazil, the goal is covered due to the obligation for recyclers to have an environmental license (Brazil, 2020), a mechanism that reveals a strong (level 3) alignment to SDG 6 and 14. Finally, in Ghana, the law only generically addresses environmental issues without specifying instruments, strategies or goals, so alignment to the SDG in question represents level 1. Regarding the Ghanaian case, some considerations will be made about the relationship between Act 917 and SDG 15.

Considering the Ghanaian particularities, negative impacts of WEEE recycling activities in the Greater Accra Region have been revealed by numerous studies (Grant, 2016; Kuper & Hojsik, 2008). In Accra, the e-waste recycling process occurs through precarious techniques, and workers have operated under informal conditions since 2004 when the import of second-hand electronic equipment was authorised. Most of this equipment arrived in Ghana in deteriorated condition. Thus, a significant volume of WEEE has been recycled through inexpensive and improper techniques. These techniques include burning plastic wires in the open and using toxic solutions for dissolving objects. These procedures occur without

any mechanisms to protect workers' health or the environment, especially the soil, air and water resources, such as the Odaw River and Korle Lagoon, which are highly polluted (Huang et al., 2013).

Given this issue, the expectation is that the 2016 legislation would show clear strategies to mitigate the harmful impacts of this informal recycling. This issue aligns to SDG 15, Target 15.1, which advocates that: "by 2030, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements" (United Nations, 2020, n.p.).

In this sense, the quality of soil, air and water resources — which play a fundamental role in developing tropical native vegetation — should be the subject of debate in the Ghanaian case. However, again, the legislation mentions the issue and its solution generically without offering instruments, making building a management and accountability plan challenging. Nor does the Act provide a strategy to enable the impacted areas to recover.

4.10 | Debates on e-waste legislation, SDG and geography

The studied legislations were developed and enforced in different years, within different territorial contexts. In common, they all represent the efforts of countries from the core, semi-periphery and periphery of the world system to manage their e-waste properly. It is crucial to mention that the comparative analysis in this article does not aim to determine which legislation is the best but rather to understand the extent to which each one of them is aligned to selected SDGs. Figure 6 synthesises the alignments between the regulations analysed (in different colours) and SDG 3, 6, 8, 11, 12 and 14, forming a polygon.

Even in the case of the United Kingdom, where the Statutory Instrument was developed and enforced seven years before the United Nations General Assembly approved the SDG, it is possible to establish an alignment. One can observe that the British legislation has a strong alignment to SDG 3, 11 and 12, revealing a concern for health, responsible cities, communities, consumption and production. Considering that the country has already achieved SDG 6, 8 and 14 — making unnecessary the alignment between the e-waste legislation and the later SDGs — we should highlight the role of territorial particularities to develop a comparative study on legal geography.

As it was the last to be developed and enforced, the Brazilian Decree strongly aligns with all selected SDGs. It should be taken into account that this legal framework was developed almost nine years after the enforcement of the National Solid Waste Policy. Therefore, the development of the regulation considers international experiences and the particularities of the Brazilian EEE market and WEEE recyclers.

Among the three case studies, Ghanaian legislation should draw attention in our comparative analysis. Weak alignment to SDG 3, 6, and 14 and the medium alignment to SDG 8 and 11 reveal a regulation that deals broadly with crucial topics of sustainability. The Act also offers only a few instruments and targets to facilitate law enforcement and measure the success of its application. Considering Ghana's political economy and territorial particularities, that fact is even

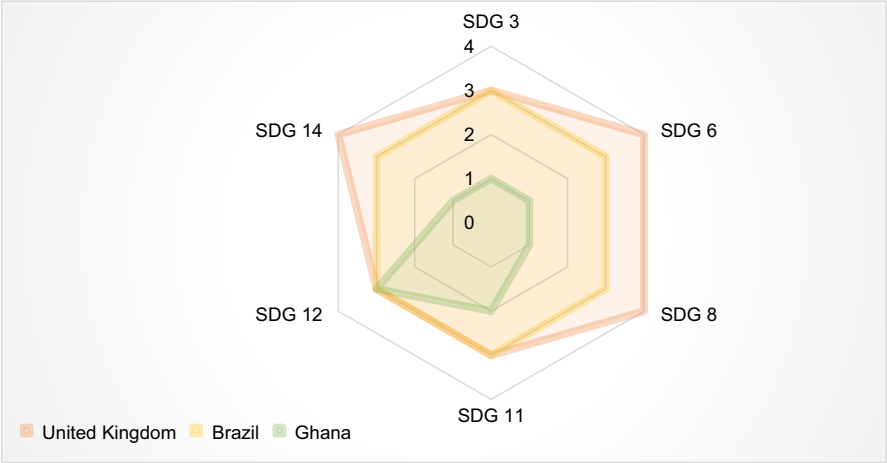

FIGURE 6 Legislation alignment to selected SDGs. *Source*: Authors (2020)

more severe since there predominates the informal recycling of e-waste, negatively impacting human health and the environment.

At the same time, strong alignment of all legislations to SDG 12 reveals efforts and clarity in the need to develop feasible educational actions concerning consumerism and the proper disposal of waste by the populations, especially valuing the reuse and repair of objects and indirectly pressuring unsustainable commodity production patterns, which have significant impacts on natural resources.

These three legislations establish different alignments to the SDGs. If SDG 3, 6, 8, 11, 12, and 14 and experimental alignment levels 0, 1, 2, 3, and 4 could work as a parameter to establish a controlled comparison of these laws, they also serve to identify which of them have more instruments aimed at the implementation of appropriate e-waste management in their countries. These instruments may be aimed at environmental conservation, improving the population's health conditions, searching for the consolidation of sustainable production, consumption, and disposal patterns, and improving the population's working conditions, among many others.

At the same time, when analysing the relevance of the alignment between legislations and SDG, geography is essential to identify greater or lesser urgency in each territory. That was revealed by the UK's access to drinking water and sanitation, which means that the Statutory Instrument does not need to delve into the issue, contrary to what happens in Ghana's legislation. In the Brazilian case, the regulatory instruments that seek to attract more small players (especially in the WEEE collection stages) are linked to the tradition of waste pickers in urban Brazil.

5 | FINAL REMARKS

This comparative study has an exploratory character and sought to establish an experimental alignment between e-waste legislation and six selected SDGs. From a controlled comparison of the most different cases, we sought to understand this alignment within geography, considering the territorial particularities of the United Kingdom, Brazil, and Ghana.

We understand that e-waste management studies are relevant to different fields of geography, given that it mobilises issues related to the environment, social welfare and the economy. Because of the diversity of ways that the management of this type of waste can occur worldwide — due to different legislations and social actors — geographic science can interpret this diversity as part of the spatial complexity.

The interface between the legal e-waste framework, the SDGs and geography allows us to survey the multiple ways that countries of the core, semi-periphery, and periphery develop legislation that promotes the appropriate management of e-waste. We suggest that identifying the alignments between national regulations and the SDGs through geography could guide the development of legal instruments that consider the territorial particularities of different countries.

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DATA AVAILABILITY STATEMENT

The authors guarantee that the data available in this article were obtained from different documents, such as articles, books (and book chapters), reports and legislation, duly listed in the reference section below. In the case of articles, they can be located by referring to their DOI. All reports and legislation that were obtained from electronic sites have their links duly referenced (as well as the date of access). Physical books and book chapters are also referenced. The authors also guarantee that there was no type of misuse or transformation of the data obtained, only analyses of authorship in the service of the objectives of the article.

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