Received: 3 June 2022 | Revised: 29 July 2022 | Accepted: 12 August 2022

DOI: 10.1002/bsd2.222

RESEARCH ARTICLE

Business Strategy and Development | WILEY

Ultimate producer responsibility for e-waste management–A proposal for just transition in the circular economy based on the case of used European electronic equipment exported to Nigeria

Kaustubh Thapa[1] | Walter J. V. Vermeulen[1] | Pauline Deutz[2] | Olawale Olayide[3]

[1]Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, Netherlands

[2]Department of Geography, Geology and Environment, University of Hull, Hull, UK

[3]Department of Sustainability Studies, University of Ibadan, Ibadan, Nigeria

Correspondence
Kaustubh Thapa, Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, Netherlands.
Email: k.thapa@uu.nl

Funding information
European Union's Horizon 2020 research and innovation programme, Grant/Award Number: 765198

Abstract

Used European electric and electronic equipment (UEEE) has multiple use cycles in various countries, including Nigeria. Although the EU-Nigeria e-waste trade is illegal under EU and Nigerian law, previous research shows that some imported equipment is only fit for disposal. Imported UEEE has a short lifespan. Such European e-waste exports imported to Nigeria have sustainability and circularity implications for both places and raise questions about justice and equity. Using a transdisciplinary approach, we identify existing practices and challenges in Nigeria and co-create actionable solutions towards a sustainable, circular and fairness-driven UEEE and e-waste value chain. We find current extended producer responsibility (EPR) does not focus on the entire global value chain, is linear, and lacks transparency, accountability, and consideration for spatial equity. To overcome these shortcomings, we propose ultimate producer responsibility (UPR). UPR aids sustainability and circularity transition while paying attention to justice and equity. The research adds global and social dimensions to the European circular economy (CE), otherwise primarily focused on national material cycles.

KEYWORDS
equity, e-waste, just circular economy, just transition, Nigeria, used or secondhand electric and electronic equipment, ultimate producer responsibility

1 | INTRODUCTION

Waste and used products are shipped between countries like any other commodity according to existing laws and market conditions. Additionally, there is a grey area of illicit transboundary shipment of waste. Despite their circularity and sustainability intentions, most national circular economy (CE) policies and practices do not effectively address the transboundary movement of waste and used products. "Closing the loop" considerations are implicitly restricted to territorial boundaries of the policies, for example, EU CE policies only aim to retain materials within the EU despite their frequent transboundary movement. So far, only the Sound Material Cycle Society – the CE policy in Japan, has an explicit "international resource circulation" policy as one of its key pillars implemented by various ongoing international collaborations (Ministry of Environment, 2018).

Circular economy (CE) worldwide, as the saying goes, is selling like hotcakes. Japan implemented CE in 2000, China in 2002 and European Union in 2015. Chatham House's (2020) data shows that

39 countries have adopted the national CE policy. However, there are multiple interpretations, definitions and implementations of CE (Kirchherr et al., 2017; Korhonen, Nuur, et al., 2018; Murray et al., 2015). Our research analyses European Union (EU) waste governance that has direct implications in Nigeria and elsewhere, so we use the European Parliament's understanding of CE. The EU views the CE as a consumption and production model involving "sharing, leasing, reusing, repairing, refurbishing and recycling existing material and products as long as possible to extend the life cycle of the product" (European Parliament, 2021). The EU also identifies multiple motivations and benefits to transitioning from the traditional take-make-consume-throw economic model to a circular "closing the loop". Some EU motivations include: reducing waste and creating value, securing crucial finite raw materials for increasing resource demand while reducing environmental impact from extracting and using raw materials, reducing emissions, boosting economic growth, creating an estimated 700,000 jobs, and helping consumers within the EU (European Commission, 2020a; European Parliament, 2021). The European CE approach also seems vital to global well-being for current and future generations. If everyone on the planet consumed as unsustainably as EU residents, a resource capacity of 2.8 earths annually would be required (WWF & Global Footprint Network, 2019). EU is a significant contributor to the ecological crisis and, historically and presently, a top contributor to global CO_2 emission (Hickel et al., 2021).

The EU adopted a Circular Economy Action Plan in 2015 to facilitate the transition to a CE. Revised in 2020, the new CE Action Plan adds aspiration towards the international dimension. Acknowledging the "millions of tons of European waste exported to countries without consideration for proper treatment", the EU wants to "ensure that the EU does not export its waste challenges to third countries" (European Commission, 2020a). Furthermore, the EU acknowledges the "just transition movement" as a key tool for transitions to happen fairly, "leaving no one behind" within a "safe operating space" to stay within thresholds for resource use in some of its policies (European Commission, 2020a, 2020b, 2020c). Despite the circular action plans and just transition aspirations, shipment of European waste electric and electronic equipment (e-waste) and used electric and electronic equipment (UEEE), especially to places with little or no capacity to sustainably manage them, is ongoing. Such practices that can cause socio-ecological harm far away and contribute to global inequality are neither circular nor part of a just transition, both frequently cited in the EU's discourses. Such gaps between policy rhetoric and practices create harm outside the EU and have generated criticisms by scholars (Calisto Friant et al., 2021; Gregson et al., 2015).

Nigeria is a top destination for European e-waste and UEEE exports, both because and despite the weaknesses in waste management practices. The Person in the Port Project in 2015/2016 found 71,000 tonnes of UEEE being imported to Nigeria, 77% of which arrived from the EU and 11% of which being e-waste (Odeyingbo et al., 2017). Research led by an NGO installing trackers on UEEE in Europe found illegal exports to destinations without proper waste management capacity and identified such leakages as "holes in the circular economy" (Basel Action Network, 2018). Some exported UEEE evades functionality checks, so their durability remains uncertain. Nigeria explicitly recognises UEEE import as cover for e-waste import in its National Environmental (Electric/Electronic) Regulations of 2011 (Federal Republic of Nigeria, 2011). Like elsewhere, Nigeria also aspires towards a CE (African Development Bank Group, 2021). Even without national CE policies, various circular platforms exist in Nigeria. However, lack of waste collection and the presence of many active open dumpsites with frequent open burnings remain everyday realities in Nigeria, associated with traditional, financial, political, social, institutional, regulatory and technical realities (Aremu, 2020). The skilled informal sector actively engages in waste management in Nigeria, fulfilling the vacuum of a functioning waste management system. For instance, only a few formal e-waste processing facilities exist in Nigeria. The informal sector in Nigeria is characterised by causal working arrangements, both within the law or outside it, either for family or friends or self-employed, without job security, social protection or enforcement of labour standards (Ohajinwa et al., 2017). Every year, over 100,000 informal workers process half a million tonnes of e-waste, which are toxic (Ogungbuyi et al., 2012). About 8000 small businesses refurbish and resell UEEE, employing 21,600 people (Ogungbuyi et al., 2012). Often people in the informal sector work in precarious health and environmental condition without knowledge about occupational health risks (Osibanjo & Nnorom, 2007; Nnorom & Osibanjo, 2008; Sullivan., 2014; Perkins et al., 2014; Ohajinwa et al., 2017). With perils, their practices aid CE by reintroducing discarded materials to the economy (Gutberlet & Carenzo, 2020). The imported e-waste and non-durable e-waste further burden the waste management system in Nigeria.

The current EU-Nigeria exports of e-waste and UEEE are neither circular nor fair. With these twin considerations for CE and fairness concepts, our research aims to (i) understand the current trends of imported e-waste and UEEE and their management practices in Nigeria, (ii) understand the problems, perceptions, and challenges from various stakeholders' points of view, and (iii) to co-create a contextual solution-oriented knowledge that might have a societal impact. Our research is guided by transdisciplinary research (TDR) principles, which enable academic work to address a societal need. We combine research findings, practitioners' reflections and their needs, and integrate them with multidisciplinary knowledge on CE and just transition to create solutions-oriented knowledge for identified challenges. We propose a context-specific co-created solution-oriented pathway for sustainable e-waste governance–the ultimate producer responsibility (UPR), which adds justice, equity and circularity to the existing extended producer responsibility (EPR). As there is limited TDR research in the field of transboundary waste or just CE transition, this research fulfils the vacuum and hopefully sets an example for future TDR research.

2 | RESEARCH DESIGN

In a review of the transboundary waste movement, we have argued for more contextual, nuanced and collaborative research and suggest

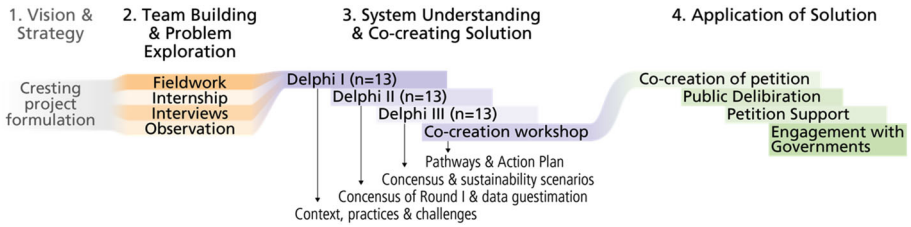

FIGURE 1 The transdisciplinary research (TDR) steps integrated various disciplinary methods to enable team building and problem exploration, system understanding and co-creation of solutions, and application of knowledge

TDR as a problem-solving approach for knowledge creation (Thapa, Vermeulen, Deutz, & Olayide, 2022). This study uses a TDR approach that integrates various academic disciplines and works with society to generate contextual and useful knowledge (Gibbons et al., 1994; Hadorn et al., 2007; Leavy, 2011; Vermeulen & Witjes, 2021). Scholars acknowledge TDR as a way to solve "wicked problems" and transition towards "strong sustainability" (Brown, 2010; Pelenc & Ballet, 2015). In TDR, academic knowledge is combined with TD principles like abductive reasoning, open-minded multi-actor reflection, iterativeness and long-term systemic perspective as required by the context (Witjes & Vermeulen, 2021). These TDR principles informed our research process. For example, multi-level learning enabled the research process to be guided by academic and non-academic knowledge, and multi-actor reflection enabled crucial collective reflections that shaped the research outcome. Abduction is the process of adapting research based on a hunch by utilising the emerging findings, theoretical knowledge and researcher's past experiences and positionality (see Sætre & van de Ven, 2021; van Breda & Swilling, 2018; Witjes & Vermeulen, 2021). Abduction helped the research adapt to contextual needs and challenges. The emergent research design, rooted in doing TDR in the African context, enabled theory and research practice to inform each other as the research unfolded and adapt the research to the contextual needs (van Breda & Swilling, 2018). While developing understanding or co-creating solutions, the focus was on long-term and system perspectives with an open mind. Although we started from conceptual ideas in CE and transboundary movement of waste, other concepts from e-waste literature, just transition and global inequality, shaped the various steps of our research process and provided scientific validity. Adapting from Witjes and Vermeulen (2021) synthesis of TDR phases, the fairness-driven research can be divided into four distinct steps, as depicted in Figure 1 and discussed below.

A team of experienced academics conducted the vision and strategy phase to investigate the sustainability implications of CE by creating a PhD training consortium. The present research is one of the 15 PhD projects in the Circular Economy: Sustainability Implications and Guiding Progress project (CRESTING). The team wrote the grant, formulated guiding questions for the research, created collaborations, and secured funding, which enabled the first author to be hired to undertake the project.

The team building and problem exploration phase included month-long exploratory fieldwork in Nigeria for the lead researcher to be embedded in the research and cultural context. This placement at the University of Ibadan included a week-long internship with the Basel Convention Coordinating Centre for the African Region (Basel-Africa). Researchers visited six recycling factories (e-waste and plastic) for observation, conducted 12 in-person semi-structured stakeholder interviews in English and attended two conferences. These provided opportunities for the researcher to be situated in the problem context and build relationships, which contributed to an epistemic community central to the unfolding and emerging of the TDR (van Breda & Swilling, 2018). This embeddedness of the researchers helped to adapt the research to the contextual needs and design for societal impact. With support from local partners, it was easy to reach out to most stakeholders like the government, recyclers, non-profits, researchers and academics. However, our interactions with the informal sector remain limited. The pandemic and adapting the research to online interactions limited us to include them as planned.

The system understanding and co-creating solutions phase was adapted amid the uncertainties and chaos of COVID-19. Due to the pandemic, the planned four-month visit was impossible, so the research was adapted online. To incorporate open multi-actor reflections, we incorporated an online Delphi research, which consisted of three rounds of research with e-waste experts in the African context, followed by three workshops and frequent communication throughout the process. Delphi enabled a systemic and diverse understanding of the problem, built consensus using multiple consultations and confirmation rounds, and helped build societal relevance and validity of the created knowledge. Used initially as a consensus-building method among experts (Dalkey & Helmer, 1963), we adapted the Delphi method to map out existing knowledge on challenges, practices and prioritisation (Franklin & Hart, 2007, Yousuf, 2007, Campbell-Johnston et al., 2021; Wurster, 2021). A total of 24 African e-waste experts, mainly from Nigeria but also from Kenya, Ghana, South Africa, Zimbabwe and Italy, representing government, recycling companies, researchers, academics and national, international and non-governmental organisations, participated in the three Delphi rounds. Each round of the Delphi study consisted of 13 participants (though not the same ones). The Delphi I gathered a stock of challenges and practices. Delphi II helped build consensus on the mapped-out challenges and practice keys from round one and generated expert estimates to quantify the problem. Building on research thus far, Delphi III created three transition scenarios (see Tablee 2). Expert feedback, desirability and feasibility on the scenarios were collected. The Delphi followed three online workshops of 3 h each, intended to create action items for the scenarios.

We designed 3 and 2-h online workshops ($n = 16$, 8 and 5) iteratively to build consensus and assure shared outcome ownership. The first was organised as part of the Circularity Africa 2021 conference. We used the *Art of Hosting* method to design the workshops, ask participants to identify actors and their specific actions and rank the top five actions based on urgency and practicality to reach the desired

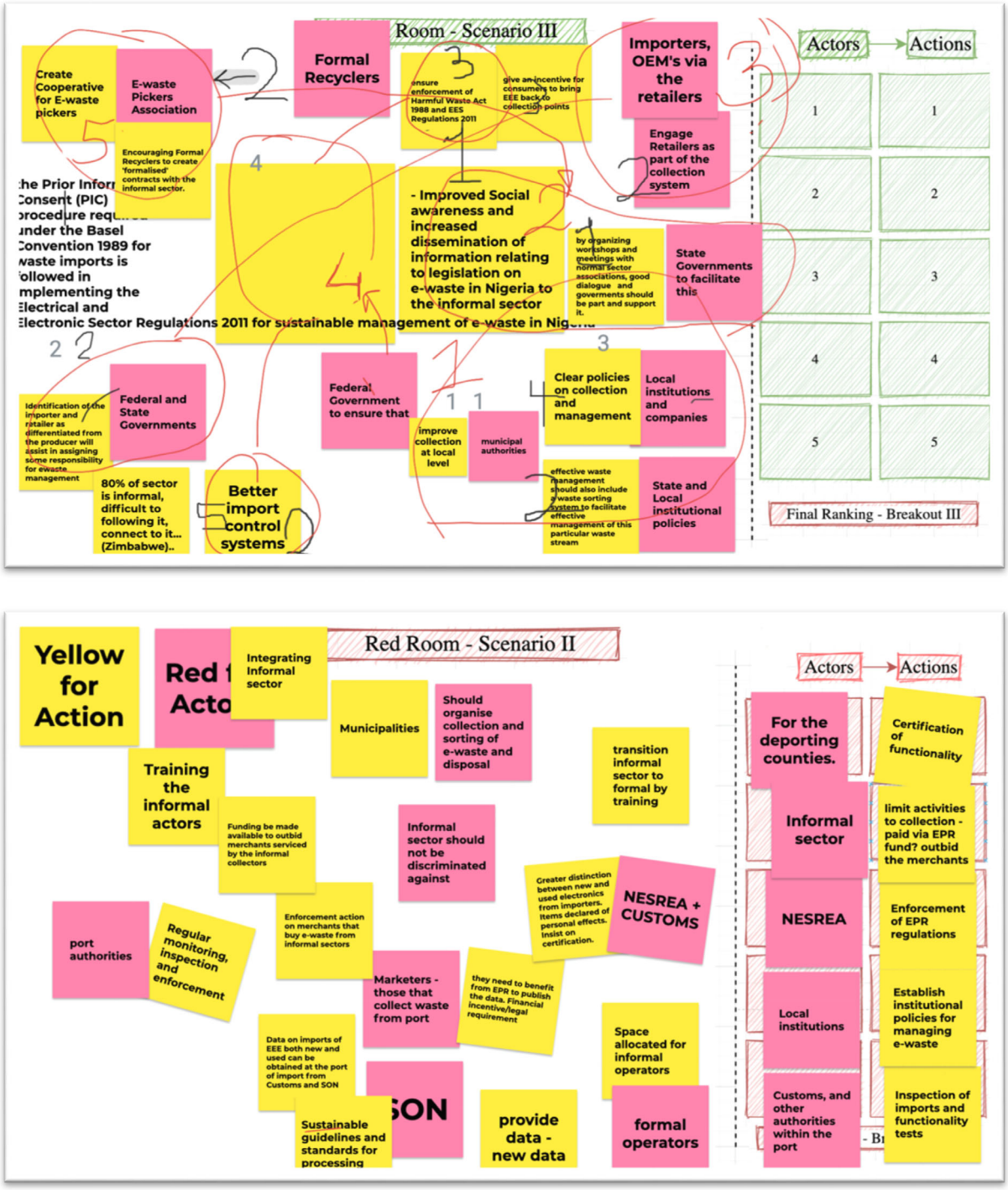

FIGURE 2 Examples of an online workshop to pick the top five actions to achieve a desirable sustainability scenario for imported used electric and electronic equipment (UEEE) and e-waste in Nigeria

scenarios. The *Art of Hosting* method aims to facilitate a safe, open and inclusive space for participants. As reliable and fast internet connection for all participants was challenging, we used the simplest online sticky notes for capturing ideas (see Figure 2).

The application of solution phase enables the researcher to take co-created knowledge based on doing science *with* society to a broader public for future societal impact. We had planned to disseminate solutions during the Circularity Africa conference for support from experts and politicians before taking the results to the governments. Due to the pandemic, this phase was adapted into an online petition to seek broader public support. Petitions have played a significant role in societal transformation and are an integral political instrument for collective action and transformation (Hale, 2013; Carpenter, 2016). Petition creation involved multiple drafts, with

feedback from research participants in each round. The petition draft was shared with 24 experts for comments, modifications and co-ownership. Consequent drafts were shared three times, and the petition was finalised with eight co-authors and taken online publicly. The research output was strategically incorporated into the petition to benefit waste governance in Nigerian and European contexts. The Nigerian government is designing an extended producer responsibility (EPR) (UNEP, 2019). And the European Parliament acknowledges their problem with shipping waste internationally in its revised CE action plan with ambitions to improve (European Commission, 2020a).

During all phases, there was ongoing research work in Europe focusing on the transboundary movement of European waste and a case study of e-waste governance in the Netherlands. The researchers were embedded in a research team that looked at European CE's discourses, policies and practices. This embeddedness in similar projects and a bigger research team shaped the research and brought a more nuanced context and systemic understanding to the research process.

2.1 | Limitations

Online workshops enabled us to reach out to diverse e-waste experts, including those outside Nigeria, versed in the Nigerian context. However, it limited participation by the informal sector workers in Nigeria. The informal sector plays an invaluable role as local experts in what they do, yet their voices are marginalised. Even though the project aspired to incorporate their voices during the exploratory fieldwork, it was impossible to build relationships and garner trust in an online setting. We consider this the most significant limitation of the research. However, their voices, albeit represented by other stakeholders, are present in the research.

Although 24 experts participated in the Delphi, each round consisted of only 13 individuals. Closely collaborating with our local partners, we reached out to 62 experts, including the informal sector for the Delphi I and received 29 responses, 16 of which were incomplete. Online research enables access but can also be limiting. To overcome this, we planned multiple and adequate feedback for the participants and stakeholders during all the research phases.

3 | THEORETICAL CONTEXT: CIRCULARITY AND JUST TRANSITION

We use academic literature to make sense of current practices in EU-Nigeria shipment of UEEE and e-waste in the context of circularity, global inequality and just transition.

3.1 | Circular economy and transboundary UEEE shipment

Some see the CE as beneficial or potentially beneficial for the people and the planet (Bressanelli et al., 2021; European Parliament, 2021; Wijkman & Skånberg, 2015). Others question such views and show rebound effects of CE (Makov & Font Vivanco, 2018; Zink & Geyer, 2017). The mainstream CE discourse of efficiency, rather than sufficiency, hinges on economic growth (Bauwens, 2021; Calisto Friant et al., 2020), albeit constrained by environmental considerations (Ellen McCarthur Foundation et al., 2015; European Commission, 2020b). Such discourses reflect the ideology that the economy can grow forever without harming the environment (Allen et al., 2012; von Weizsäcker, 2014). Such "green growth", especially in the global north countries with its alarming historical and current ecological footprint, has been criticised as a strategy that aids little in creating solutions for urgent socio-ecological crises (Genovese & Pansera, 2020; Hickel & Kallis, 2019; Korhonen, Honkasalo, & Seppälä, 2018). Asserting the impossibility of absolute decoupling economic growth from environmental pressures, Parrique et al. (2019) call to rethink what constitutes growth and progress. Apart from CE being a "green growth" centric model, scholars criticise CE for not being inclusive (Calisto Friant et al., 2020), lacking the social and human dimensions (Lemille, 2020; Schröder et al., 2020a, 2020b) and the moral dimension (Gregson et al., 2015). Thus, the literature shows that the mainstream CE narrative has been subject to several criticisms and needs careful reconsideration.

The various value retention options topology and the "CE leakages" discussed by Reike et al. (2018) are particularly important for our analysis. Resell, reuse and repair options retain products' value and functionality more, create less waste, and are thus preferred. Recycling or down cycling, where products lose original functionality, create waste, or wasteful by-products, is less desirable. Incineration, landfilling, and so forth, are least preferable. "CE Leakages" refer to waste shipment outside these circular loops from Europe. Some of whose fate (value-retention options) is unknown (European Commission, 2020a). Transboundary e-waste and UEEE shipments from Europe to Nigeria exemplifies CE leakage. A non-profit sector engaged in justice advocacy revisits leakages of e-waste from Europe as "an externalisation of costs with real consequences in terms of harm to human health and the environment" (Basel Action Network, 2018). Such actions could aid in increasing global inequality and injustice.

3.2 | Need for just transition in the CE

There are multidisciplinary explorations and understandings of just transition. The International Labour Organisation (ILO) calls a transition just if maximising social and economic opportunities "is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind" (ILO, 2021). Scholars advocate that a just transition should amount to procedural, distributive and restorative justice (Newell & Mulvaney, 2013; McCauley & Heffron, 2018; Stevis & Felli, 2020). Wang and Lo (2021) identify five thematic areas of just transition: a labour-oriented concept, an integrated framework for justice, a theory for socio-technical transition, governance strategy and public perception. Velicu and Barca (2020) show just transition as a democratic way out of the social and ecological crisis and inequalities, the causes of such crises. Agyeman (2008) points out that sustainability discourse and practice usually leave out

inequity and injustice, racism and classism and calls for "just sustainability". Adding geographical dimension to just transition, Soja (2010) calls for "spatial justice" for an equitable geographic distribution of resources, services and access as a basic human right. Schröder et al. (2020b) adds just transition to CE, calling for effective and fair governance, transparent and accountable institutions and new financial mechanisms to support the CE transition globally. The transboundary shipment of hazardous waste, including e-waste in the past, has been associated with environmental injustices and toxic colonialism (Clapp, 2001; Iles, 2004; Pellow, 2008; Lipman, 2015; Temper & Shmelev, 2015), with researchers often advocating fairness and distributive justice. A just socio-technical transition, like the CE, then must address environmental sustainability, well-being and the deeper causes of inequality in a democratic way globally in action and not merely words. The idea of UPR, discussed later, proposes to bring these concepts to CE policies and practices.

3.3 | Transboundary e-waste shipment: Challenges, solutions and EPR

The transboundary shipment of e-waste, which contains toxic elements, to countries without the capacity to handle their sustainability, is often associated with exporting harm to people and the environment far away (Heacock et al., 2016; Perkins et al., 2014; Sullivan., 2014; Thapa, Vermeulen, Deutz, & Olayide, 2022). Because of the toxic nature, exports from OECD to non-OECD countries are banned under the Basel Convention, yet we find illegal and illicit exports ongoing. Exporters and importers of e-waste are both complicit in prioritising their own short-term economic interests and the expense of environmental justice (Kim, 2006). Academics from various disciplines propose solutions to the e-waste problem. Manhart (2010) and Wang et al. (2012) suggest best-of-two-worlds combining cheap manuals from global south countries with state-of-the-art facilities. Lepawsky et al. (2017) call for electronics repair, reuse, repurposing and recycling with ethical and sustainable considerations. Various EPR versions make producers and importers responsible for e-waste recycling and have been studied or proposed as domestic solutions (Atasu & Subramanian, 2012; Campbell-Johnston et al., 2021; Campbell-Johnston et al., 2022; Lin et al., 2001; Schnoor, 2012; Thapa et al., 2022; Widmer et al., 2005). In the EU's WEEE directive, EPR guides e-waste management and Nigeria aspires to establish one. However, existing EPR structures have been criticised for heavily focusing on recycling instead of various circular value retention options, for not being inclusive of circular actors and for producers not taking responsibility once the product is out of the national or EPR jurisdiction (Vermeulen et al., 2022).

3.4 | Global inequality: Waste trade as unequal exchange

Existing technologies dictate the capacity and quality of e-waste recycling (Awasthi et al., 2016; van Yken et al., 2021). However, lack of financial resources means limited access to technology–one of the reasons why the global south does not have a sound waste management system (Aremu, 2020; UNEP, 2015). Hickel (2018) argues that the income gap between the global north and the global south has tripled since 1960 because of the politics of integrating poorer countries into the global economic system on unequal terms. Using a theory of unequal exchange, Hickel et al. (2022) show the global north relies on the net appropriation of resources and labour from the global south in the post-colonial era, responsible for inequality, uneven development and ecological breakdown. Citing ecologically unequal exchange as a source of environmental conflicts, Hornborg and Martinez-Alier (2016) discuss the need to incorporate realities of unequal exchange into mainstream economics and policies. As far as we know, no studies measure the correlation between wealth and waste management practices. However, global waste management outlook (UNEP, 2015) and (D-Waste, 2013; D-Waste, 2014) show the concentration of dumpsites in the global south and more technology and resource-dependent management systems concentrated in the global north. Similarly, large informal sectors of waste workers are associated with waste management in the global south (including Nigeria) with precarious livelihoods and working conditions (Terada, 2012; Wilson et al., 2006). Yet, waste management practices (including CE) tend to focus more on material cycles, and economic and environmental aspects, leaving out the social dimension. Using the Nigerian example, Woggsborg and Schröder (2018) show the lack of informal sector inclusion in the EPR as an obstacle to meeting the triple bottom line of people, planet and prosperity, which is essential for just transition.

3.5 | Combining concepts to make sense of practices

Even though the EU CE action plan values reuse, repair, and refurbishment and explicitly discusses reducing waste and just transition (European Commission, 2020; European Commission, 2020a), non-functional and non-durable UEEE is still shipped to destinations like Nigeria, which lack sound infrastructure for e-waste management. Transboundary shipment of toxic e-waste has been linked with unsustainability and injustices (Lawhon, 2013; McAllister et al., 2014; Sullivan., 2014; Perkins, 2014; Hossain et al., 2015; Amuzu, 2018; Akese & Little, 2018). The abovementioned concepts on CE, transboundary waste, just transition, and global inequality helps make sense of the context and guide the research.

4 | RESULTS

The dynamic interplay between theory and practice enhanced understanding and provided fundamental scientific and societal knowledge for intervention. In this section, we show how EU e-waste and UEEE export creates harm in Nigeria and present a co-created solution to make it sustainable, circular and just.

4.1 | UEEE and e-waste: A Nigerian overview

We found omnipresent usage of used items, from mobiles and cars to aeroplanes. Most people we encountered saw quality UEEE as an enabler for development and progress. However, a few people were strongly vocal about how UEEE hurts Nigerian resilience, ingenuity and innovation. Often people mentioned the irony that one of the wealthiest countries in terms of resources could not produce its domestic mobile phones or computers and had to depend on imports. Most people we interacted with were aware of UEEE imports providing a loophole for importing what is effectively e-waste into Nigeria.

By contrast, the interviewed government officials stated that the problem of e-waste imports was illegal and rarely occurred. During our time there, the Nigerian government, supported by the UNEP, was preparing an EPR system led by the National Environmental Standards and Regulations Enforcement Agency (NESREA), which was still in its preliminary phase (UNEP, 2019). A 2014 operational guideline produced by NESREA served as a general guide for all waste. The 2011 National Environmental (Electrical/Electronic Sector) Regulation, focusing on the 5Rs (reduce, repair, reuse, recycle and recover), served as the official regulation for e-waste in the absence of e-waste specific EPR. As a signatory to the Basel Convention, Nigeria observed the rules of the Convention. The Basel-Africa in Ibadan serves the need for "capacity building to tackle the technical, legal and institutional requirement for the implementation of the Convention" (Basel-Africa, 2017). Even though some people criticised the Basel Convention for not addressing the real problem, in line with scholarly work (Portas, 2016), others, including the staff at the Basel-Africa, saw it as influential in shaping the existing Nigerian and African policies regarding the imports of e-waste. Complicated protocols for public access to ports meant that we could not visit the port authorities to observe the imports of UEEE (and potentially e-waste). The government viewed e-waste imports as illegal and thus not a significant challenge.

However, from our interactions with formal EEE recyclers and the informal refurbishing and reusing sector, we confirmed that imports of UEEE and even e-waste were ongoing. These initial findings would later be validated in the Delphi survey and workshops. During our visit to the Computer Village in Lagos, one of Nigeria's biggest informal EEE facilities, we could observe the repair, reuse, and scavenging of parts from non-functional EEE and resell. We observed scavengers gathering discarded parts to extract valuable material. We did not see the crude recycling (burning, acid-leaching, etc.) that is mentioned in the literature (Adesokan et al., 2016; Manhart et al., 2011; Nnorom & Odeyingbo, 2020), but we were told such would be the fate of collected e-waste for material recovery before being dumped elsewhere. Some workers in the informal sector were concerned about health and safety. However, most people did not have access to basic safety and precautions (gloves, masks, protective glasses, etc.). Injuries from pushing handcarts, cuts from sharp e-waste parts, electric shocks, inhalation of lead fumes, exposure to other hazardous substances like dioxin and heavy metals, and frequently poor health, including eye irritation, cough and headache, were identified during the problem exploration phase. Despite this, we also noticed self-organisation and self-governance. The informal sector organised against the local authorities, who perpetually wanted them to move out of the current location. They collectively invested in generators to tackle the frequent power cuts in Nigeria. Often judged as unorganised, they seem high and organically organised. One workshop participant working closely with the informal sector observed that "the informal sector is well organised. The formal institutions do not understand the informal sector and seem to criminalise it. There is a need to understand and appreciate the informal sector" (workshop participant).

The formal recycling industries also lacked essential health and safety precautions. During fieldwork, we could only identify two formal e-waste recycling companies. They focused on the collection and mechanical extraction, after which the most complex, hazardous and valuable parts were sent to Europe for recycling for a fee. They expressed that the technology associated with e-waste recycling was prohibitively expensive, which kept them from investing in advanced systems. They often partnered with big businesses and institutions for their e-waste demand. In the absence of organised e-waste collection by local authorities, one of their challenges was to get hold of e-waste. In the absence of an adequate formal sector, the informal sector fulfilled most functions of e-waste processors, albeit crudely at the cost of the environment and health. Although some CE practices of reducing, reusing, repairing, refurbishing, recycling and recovering were seen in Nigeria's existing e-waste and UEEE governance practices, these came at the cost of harming the workers and their environment.

In the broader waste management context in Nigeria, we notice a lot of unsustainable practices and a lack of proper system and infrastructure. StreetSide dumps, dumping on open lands and burning outdoors were commonplace observations. Some social enterprises transformed these challenges into opportunities (Wecyclers, n.d.) to create social and environmental value but were limited to plastic waste at the local scale.

4.2 | Imported UEEE and e-waste: Practices and challenges

Current practices of UEEE imports were identified as one of the primary loopholes for e-waste import or soon-to-be e-waste. Similarly, imports without proper practices or infrastructure were associated with environmental, health harm and exploitation of society (e.g., child labour was discussed and observed during field visits). Reselling, repairing, recycling and reusing were standard practices with imported UEEE, while imported e-waste was used as repair parts and extracted for resources. The national government's role was identified as policy-making, monitoring, regulating and implementing, whereas hardly any roles were associated with the local or regional government. The informal sector, often viewed as waste workers outside the system by research participants, engaged in dirty and dangerous jobs while salvaging, repairing, and reusing. Experts agreed that the informal sector played an important role in dealing with imported UEEE and e-waste and should be an integral part of the future EPR system. Citing

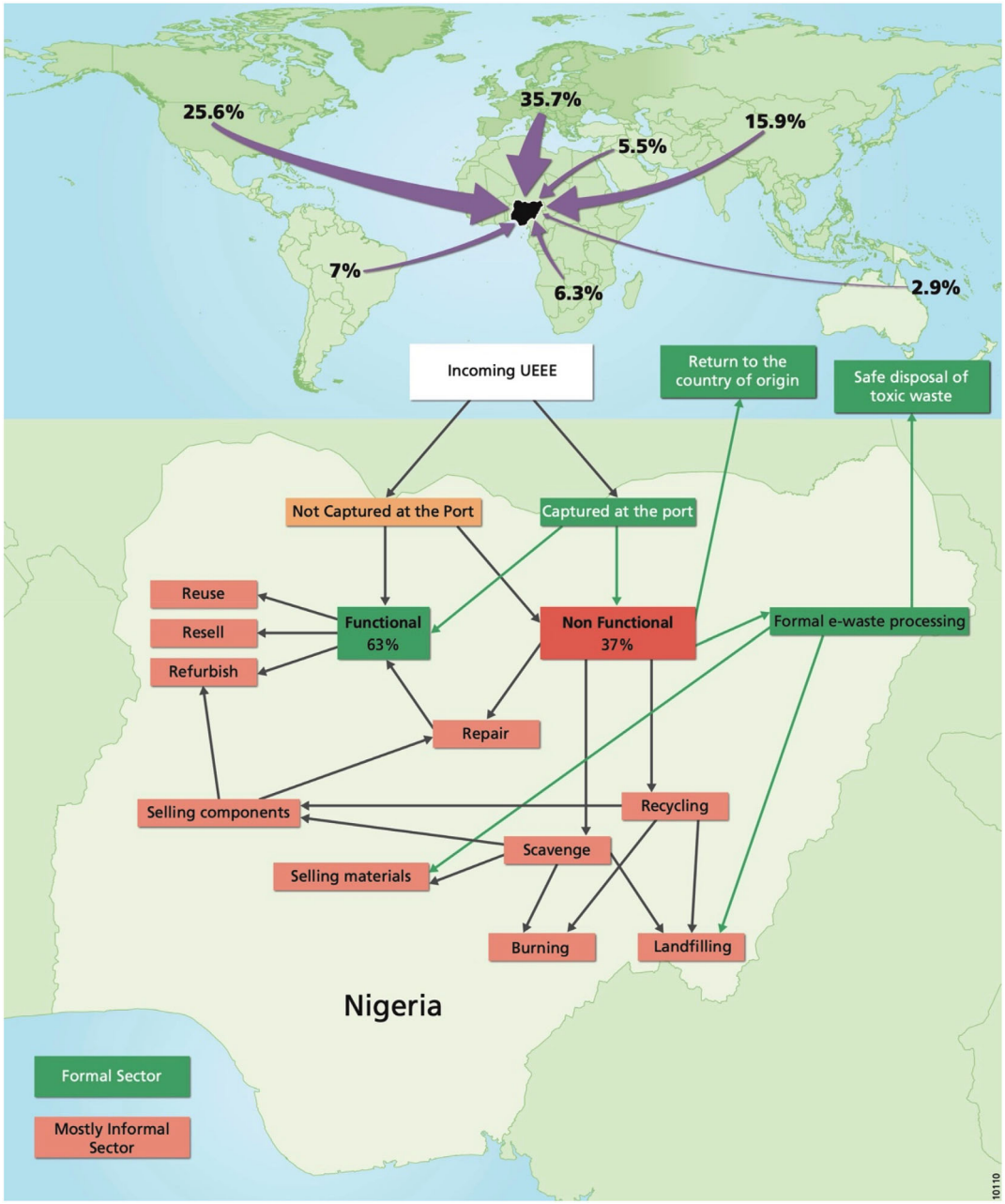

FIGURE 3 Expert guesstimated international used electric and electronic equipment (UEEE) exports to Nigeria and various practices for imported UEEE in Nigeria as identified by the Delphi participants. Green represents more formal practices, and orange represents informal

hazards associated with processing e-waste without training, some expressed that the informal sector should be limited to collection only. When asked about the main challenges for sustainable governance of imported UEEE and e-waste, lack of regulation, lack of infrastructure and funds, corruption and lack of transparency and lack of producers' involvement were identified. Main opportunities included economic gains from proper management, job creation, bridging the digital divide, opportunities to create better regulation that brings human and environmental benefits, and capacity building.

We included a collective mapping exercise and distilled a graphical representation of the existing practices for imported UEEE (Figure 3) and e-waste (Figure 4). Again, the informal sector played a significant role in the current practices of both UEEE and e-waste. UEEE and e-waste practices undergo various R-hierarchies like reuse, repair, resell, recycle and recover (components, material). Of all imported UEEE, our expert guesstimates show that functioning UEEE (63%) are reused, refurbished, and resold, whereas non-functioning UEEE (37%) are either repaired, recycled or recovered formally or informally. E-waste captured at the port is sent back to the country of origin (although the frequency remains low) or sent to proper e-waste recycling. Those not captured undergo refurbishing, repair, recovery/scavenging, recycling, and reuse for parts before either burning or

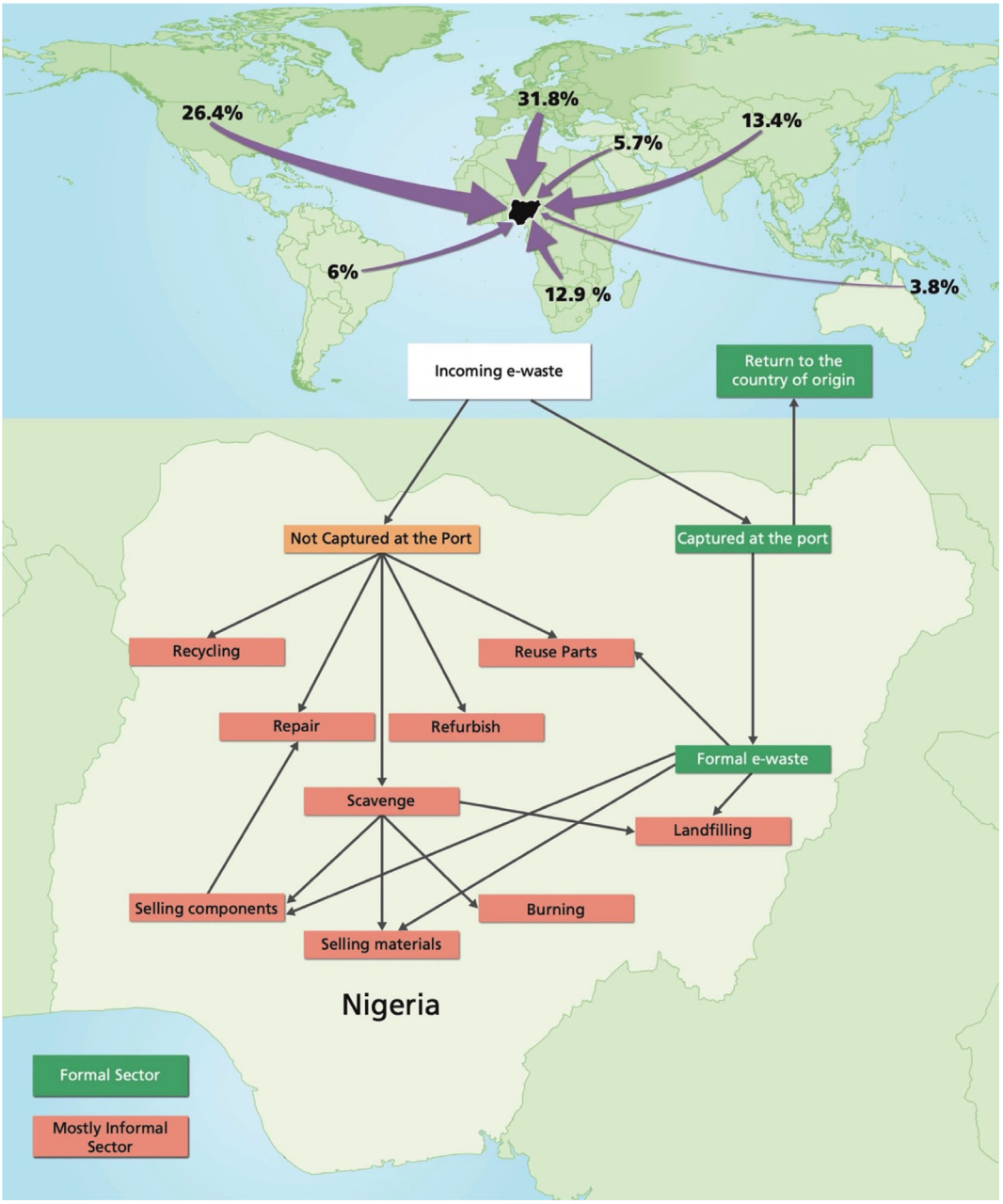

FIGURE 4 Expert guesstimated international e-waste exports to Nigeria and various practices for imported e-waste in Nigeria identified by the Delphi participants. Green represents more formal practices, and orange represents informal

landfilling by the informal sector. Formal companies are not allowed to process imported e-waste.

We asked experts for the current and reliable data source. Without much success, we asked experts to quantify the problem with a guesstimate during Delphi II. Those guesstimates are similar to the ones provided by existing research reports. Based on the EEE categories (mobile, PCs, household equipment, etc.), the UEEE presents 33% to 50% of the EEE market and has a life span of 1.5 to 3.25 years (see Table 1) before becoming e-waste. Up to 41% (an average of 37%) of imported UEEE are e-waste in disguise, thus creating a significant loophole for importing e-waste in Nigeria even though it is illegal to do so (see Table 1).

Experts identified an EPR system, where producers and importers were responsible for e-waste management, as a way forward for sustainable e-waste management. Collaboration between the various governmental and non-governmental actors nationally and internationally and sound enforcement and monitoring remained the top conditions for such EPR to function well. Experts identified corruption, lack of awareness, lack of monitoring, lack of infrastructure, lack of transparency and lack of coordination between countries in the current system as the top challenges for a transition to sustainable governance of UEEE and e-waste in Nigeria.

TABLE 1 Average guesstimates of Nigerian e-waste for the various categories of EEE

Product category	UEEE in all EEE products purchase	Average UEEE lifetime	Imported UEEE that are e-waste
Mobile phones and tablets	49%	17 months	41%
PCs and laptops	69%	27 months	36%
Small household products (microwave, mixer etc.)	52%	24 months	36%
Large household products (washing machine, refrigerator etc.)	69%	37 months	36%

Abbreviations: EEE, electric and electronic equipment; UEEE, used electric and electronic equipment.

4.3 | Towards circularity and fairness

Three scenarios based on the imports, domestic usage, national policy, local policy, informal sector and the EPR were introduced to the experts as ways forward (see Table 2 for a summary and Appendix A for a more detailed description).

The *Policy as usual* scenario describes the ongoing observed practices. Currently, UEEE and e-waste imports are not controlled, and there is limited value retention and resource recovery before being burnt or dumped on the streets, dumpsites and landfills. Existing policies are not strong enough and lack enforcement and monitoring. There is a discussion for future EPR, but yet to be implemented. In the lack of a functioning public waste management system, the informal sector is active and dominates the market with few formal sector engagements. It results in severe health, social, environmental and economic harm.

The *Small Step Forward* scenario envisions a future with occasional port authority regulation of UEEE and e-waste imports. Some collection, value retention and material recovery exist but are still not appropriately organised. National environment and waste law provide some guidance with better enforcement and monitoring than *policy as usual*. The local government is engaged in some collection in big cities only. Future EPR is still under discussion, and the informal sector still plays a vital role but without the highest value retention or material recovery practices. Still, severe health, social, environmental and economic harm exists.

The *Transformative Step Forward* envisions scenarios where imports are closely and systematically monitored, and there are sufficient collection points for domestic e-waste, providing consumer incentives across Nigeria. The highest possible value retention and material recovery are mandated by the national government and organised by a mix of the EPR (that includes the informal sector). Producers and importers fully fund EPR with special provisions for UEEE. The informal sector is well organised, trained and regularly partners with state-of-the-art recycling facilities. There is hardly any e-waste in the landfills. Health, social, environmental and economic harm is reduced significantly, and there are plenty of economic opportunities in the e-waste management sector.

Transformative Step Forward was the most supported (mean = 8.79/10), followed by other scenarios (mean = 4.93/10 each). However, scenarios *II* and *III* had similar feasibility for implementation (mean = 6.86/10 and 6.14/10, respectively). Identified actors responsible for bringing any transformation in Nigeria included NESREA, Extended Producer Responsibility Organisation in Nigeria (EPRON), Environmental Ministry, local government and formal and informal sectors. The workshops collaboratively identified actors and their actions for future pathways leading to a mix of most desirable and most feasible scenarios (*III* and *II*). Table 3 depicts the workshop results of the first workshop. The three workshops co-created action points to solve the challenge of imported e-waste and UEEE in Nigeria.

4.4 | TDR for change-making

The co-created knowledge with social and scientific validity enabled two interventions: a policy brief for policymakers and a science-based public petition for concerned citizens (Appendix B). In the petition addressed to the government of Nigeria and the EU, we publicly present the problem context and the co-created solutions for support. Some recommendations include: empowering the informal sector, globally accountable e-waste reduction and sustainable management, e-waste governance with transparency and monitoring, raising e-waste awareness and making producers' responsible internationally for e-waste management. Furthermore, certification of functionality and durability with UEEE exports, easy access to repair and other circular value retaining options and international collaboration of port authorities for sound shipments are also recommended (see discussion). This petition calling for a global just CE transition is ongoing at the time of writing.

5 | DISCUSSION

Our research shows that the challenge of sustainable e-waste management gets even more complicated when UEEE and e-waste are shipped internationally. Market mechanisms, political equalities or inequalities, national and international policies implementations and enforcement, and various actors and motivations dictate waste shipments and what happens to the waste. In this context, decreasing e-waste generation by reducing consumption, designing more durable EEE, practising circular value retention options within Europe and taking precautions whenever necessary in the first place seem to be the best solution. But this seems impractical given the current political-

TABLE 2 Summary of the three scenarios depicting the sustainable ambitions of e-waste and UEEE management in Nigeria

	I–Policy as usual	II–Small step forward	III–Transformative step forward
Imports	• Occasional control and inspections • Illegal import prevalent • No monitoring, no data • Loopholes for e-waste importation	• Regular sampling of imports • Occasional monitoring and limited data • No transparency	• All e-waste and UEEE controlled • All UEE inspected for functionality and durability • Illegal imports sent back • Activities logged for data and transparency • Partnership with international destinations for–no unwanted imports
Domestic usage	• No data on new EEE/UEEE ratio • No instruction for disposal • Lack of collection and proper disposal dumping prevalent • Active informal sector	• Some data on new EEE/UEEE ratio • Limited municipal disposal with active informal sector • Landfilling with very few value capture opportunist	• Monitoring of new EEE/UEEE with data availability • Consumers aware of sustainable disposal and collection points • Collection points based on value maintenance • No landfilling/dumping, circular practices enforced
National policy	• Weak waste management policy with no focus on e-waste • Lack of enforcement and coordination between implementing bodies • No value retention policy	• Existing guidelines on toxic waste implemented • Some EPRs focus on recycling rather than value maintenance • Clear and specific regulations for e-waste categories • Limited coordination	• Integrated national policies for value maintenance and sustainable management • Specialised government body for facilitation and coordination • National targets and plans to achieve these targets • Support for state-of-the-art facilities and sustainable practices
Local policy	• No collection • No recycling policy • No awareness • E-waste in dumpsites and landfills	• Some local collection activities • Few collection points in urban areas • Some quality assurance at local level • Some social awareness creation	• Policies for collecting, creating awareness and value retention • Coordination and support from national government • Easily accessible collection point in all communities with incentives for proper disposal • NGOs integrated with local governance
Informal sector	• Unorganised, polluting and dangerous • No government support • Health, environmental and social problems • Unsystematic: Cherry-picking value retention process at high social and environmental cost	• Limited support and control from the government, still seen as a nuisance to be replaced by big facilities • Recognised as crucial for collection and value maintenance but without the active support	• Integrated into EPR with well-defined roles • Support from the government and collaboration with the formal sector • Trained and well equipped for the highest value retention • Recognised and organised
EPR	• No EPR, only discussed as a normative principle • Producers and importers not organised • Few formal sectors only deal with a fraction of e-waste	• EPR as information and logistic responsibility for producers and importers • EPR not integrated into the local context, lack of monitoring • Little sustainable guidelines for processing and recycling, lack of capacity building	• Producers and importers financially responsible for product life extension, value maintenance and end-of-life processing • EPRs of exporting countries and national importers are financial contributions to the management of imported UEEE • Robust collaboration with stakeholders in the value chain • Dedicated EPR organisation responsible for capacity building with state-of-the-art facilities and knowledge

Abbreviations: EPR, extended producer responsibility; UEEE, used electric and electronic equipment.

TABLE 3 Top actors and action points identified during the first workshop ($n = 16$)

Top actors and action points
National government • Incorporate and upgrade capacities of the informal sector as part of the EPR to empower • Improve awareness in the informal sector related to the harms of e-waste • To limit activities of the informal sector to reduce environmental and health hazards
Customs and port authorities • Regular inspection, functionality tests and monitoring • Capturing data • Prior informed consent to be enforcement • Ensure certification of functionality for all used imports from the importing countries
Local authorities • Organises collection, sorting, and disposal of e-waste • Establish policies for e-waste management • Organise municipal authorities, companies, and institutions
Stakeholders for effective EPR • National government to enforce EPR • National government to establish sustainability guidelines and standards • Organise OEM, importers, and retailers in compulsory ERP structure • Retail engagement in the collection system • Incorporate the informal sector

Abbreviation: EPR, extended producer responsibility.

economic contexts of profit-maximisation at any cost and only lip-serving attention to global inequalities.

As EEE consumption increases globally and in the EU (Eurostat, 2022), waste management tools like EPR need to be more circular, sustainable and just. The current European EPR makes European producers and importers financially and logistically responsible for the sound management of e-waste within their national boundaries, primarily for recycling. This producers' responsibility no longer applies when UEEE or e-waste is shipped outside national jurisdiction. Such shipments of e-waste and non-durable or non-functional UEEE to Nigeria represent an ecologically unequal exchange that causes environmental and health harm goes against European CE ambitions and aids in inequality.

Current policies and practices overlook the multiple-use phase of European EEE, in and outside the EU. Functionality and durability are not guaranteed for transboundary UEEE shipment, so exported UEEE has a short life span. This only delays the shipped UEEE from becoming e-waste when outside the EU and out of the jurisdiction of the responsible EPR system. Responsibility is shifted to Nigeria, where the informal sector mostly engages in value retention practices like reuse, resell, refurbish, repair, scavenge, recovery and e-waste management without proper safety, technology or infrastructure. This responsibility shifting encourages bad actors to find loopholes to ship e-waste, which is illegal (expert guestimate showed 37% of incoming UEEE is non-functional). Current export–import practices in unequal terms hinder sustainability and circularity, cause harm and aid to global spatial injustice and inequity. The future transition should focus on ethical and equitable collaboration to minimise harm, facilitate safe multiple-user cycles globally and build capacities to make the global e-waste value chain safer, just and circular. The now marginalised informal sector workers, who add circularity and perform some of the responsibilities of European EPR, should be empowered. Another research also highlights such unethical behaviour of global north producers who transfer responsibilities for waste recovery and recycling to the South, creating environmental risks and social burdens, especially for the marginalised (Cotta, 2020).

In our research context, "reuse", a preferred CE value retention option in the literature, leads to delaying waste, unfairly shifting polluters' responsibilities under the EPR to others and creating harm in Nigeria. Reuse further enables illegal and illicit actors to ship e-waste via "twilight" routes–which are neither clear nor documented well (see Figure 5). For a just transition to the CE, UEEE exports must have a functionality and repairability guarantee to extend the use of the product as long as possible while minimising harm as much as possible. Despite the ultimate destination, the original producers must be responsible for sound management of the end-of-life phase (e-waste). For a just CE transition, we propose revising EPR to UPR.

The basic idea behind UPR, that the producers should be responsible for their waste everywhere, first emerged when visiting recycling companies in Lagos. This hunch emerged due to the embeddedness in the Nigerian research context, interacting with stakeholders and getting insights into the e-waste management challenges. Emergent TDR (see Thapa, Vermeulen, & Deutz, 2022; van Breda & Swilling, 2018) facilitates such emergence based on contextual needs. Concepts of just transition (Velicu & Barca, 2020; Wang & Lo, 2021), just sustainability (Agyeman, 2008) and spatial justice (Soja, 2010), which advocate equality, justice, equal distribution and access, also guide this emergence of UPR. UPR proposes solutions to overcome the three EU EPR design flaws that hinder a CE transition identified by Vermeulen et al. (2022). These flaws are (i) focus on efficient and lowest value retention option via downcycling, (ii) exclusive inclusion of actors only focused on recycling, and (iii) no consideration for multiple user phases, especially outside of the EU (Vermeulen et al., 2022). Unlike EPR, UPR (see Figure 5 and Thapa, Vermeulen, Olayide, & Deutz, 2022) incorporates multiple contextual realities of the UEEE and e-waste value chain. With circularity and sustainability considerations, UPR acknowledges the shifting geographies of UEEE and e-waste flow from one country to another and their socio-ecological impacts; depending on the destination countries sound waste management practices and infrastructures. UPR further acknowledges global socio-economic inequalities and questions the ethics of shifting waste or soon-to-be waste to another country with fewer sound (e-) waste management capacities. UPR emerged during open-minded multi-actor engagement and reflections focused on understanding the bigger problem while building consensus and legitimacy during the process.

Following the polluters pay principle, the UPR suggests the producer either set up infrastructure or pay a fair share to ensure sound

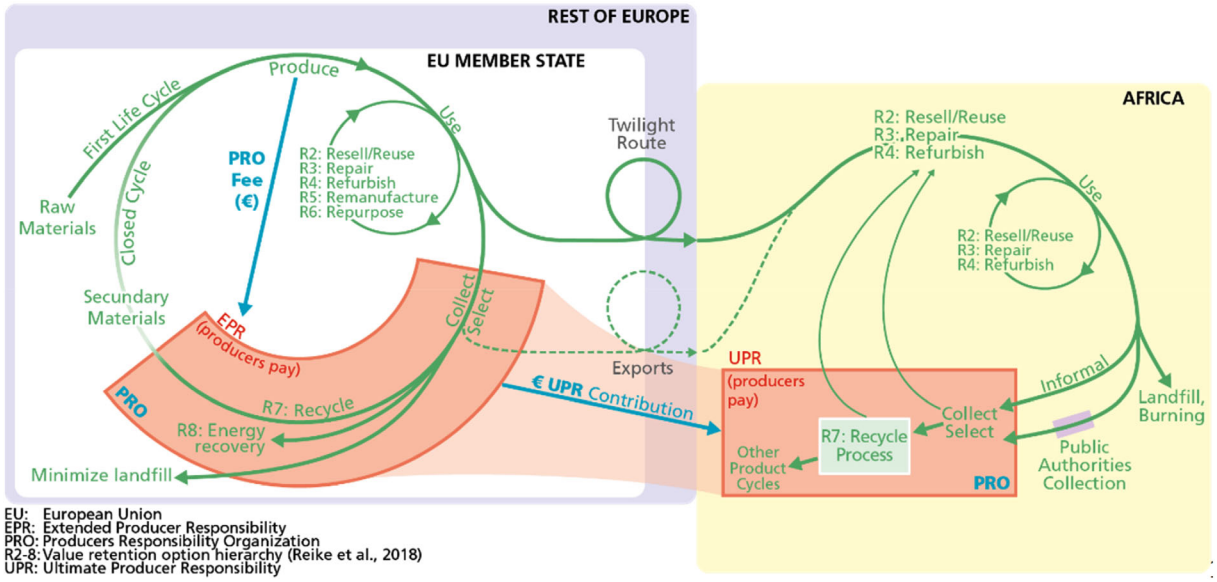

FIGURE 5 Diagram showcases the current multi-phase flows of used electric and electronic equipment (UEEE) and e-waste from Europe to the rest of Europe and Africa (Nigeria) via. Exports and twilight (illegal and illicit) route. The ultimate producer responsibility (UPR) extends producers' responsibility for the sound end-of-life management anywhere the product becomes e-waste, irrespective of the geographic location, to enable a just and circular transition for collection, reuse, repair, refurbishing and recycling. The UPR extends the European extended producer responsibility (EPR) globally, as shown in the figure with the red shade connecting the EU with the rest of the EU and Africa

e-waste collection and management for their discarded products globally. In the Nigerian context, UPR makes either the original producer responsible for e-waste management in Nigeria or creates a fund transfer mechanism via existing EPR structures to facilitate and ensure sound e-waste management. Such a fund transfer mechanism of UPR is not a charity transfer or questionable development aid but a fair fee transferred to responsible parties to prevent harm if the producers' responsibilities shift elsewhere. UPR proposes fair funds transfer mechanism within existing EU EPR schemes. Doing so provides resources and infrastructure to prevent harm caused by shifting geographies of EU waste and create safe, well-paying jobs in destination countries, adding equity and justice dimension that the current EPR lacks.

With CE consideration before end-of-life management, UPR prioritises the highest value retention options to maintain value for as long as possible and prevent waste globally. Moving away from the recycling focused EPR, UPR proposes waste prevention and introduces multiple value retention options to reduce exports of ecological and health harms currently associated with some transboundary shipments. Value-adding activities like reselling, repairing, refurbishing, remanufacturing, repurposing, and so forth, are prioritised before recycling and energy recovery. Cascading principle proposed by Campbell-Johnston et al. (2020) suggests incorporating quality and functionality and the triple P (planet, people and prosperity) to guide decisions for choosing between various value retention options. Cascading could serve as a starting point. In the Nigerian context, making EPR inclusive means including the hitherto marginalised but important circularity-enabling actors like the informal sector.

Ultimate producer responsibility (UPR) carefully adds circularity and just transitions globally to the existing UEEE and e-waste governance, currently primarily dominated by consideration solely for the market mechanism without much care for people, the planet, equity and (procedural, distributive, restorative justice, spatial) justice. Thus, UPR envisions a more transformational approach to CE with consideration for current inequity and harm (intended or otherwise) in faraway places associated with UEEE and e-waste shipment. UPR acknowledges that circularity and sustainability in one location are tied globally and proposes incorporating the longer-term spatial context. The principles of UPR could potentially be applied to other waste and product categories.

However, UPR can have limitations and rebound effects. For example, it does not tackle the crucial problem of EEE consumption and e-waste generation that instigates shipment of UEEE and e-waste. For UPR to function, fair international collaboration, transparency, and traceability are necessary and require openness, time and effort. Discourse and aspirations alone are insufficient; the political will, resources and actions are needed for just CE transition. UPR is susceptible to corruption, identified as a waste governance challenge in the literature and our research. UPR needs international solidarity to function, which also requires openness, time, effort and political will. Regulation implementation and enforcement will need to be dramatically increased compared to the present situation in both exporting and importing countries. UPR is not a solution to existing inequalities but a proposal to prevent further unequal exchange that exacerbates inequality and harm in the name of environmental performance in one part of the world. UPR is one of the solutions that

emerged in the research context, but there could be a plurality of ways towards a just, sustainable and circular solution.

6 | CONCLUSION

This research studied e-waste and UEEE exported from the EU and imports to Nigeria. It took stock of Nigeria's various practices, challenges and perceptions and co-created solution-oriented pathways guided by TDR principles. We find that current UEEE and e-waste shipment to countries without a capacity for sound e-waste management do not contribute to circularity or sustainability in the exporting and the importing countries but add to the global e-waste problem. It further obstructs a just transition and contributes to global-scale spatial inequality through an unequal global (ecological) exchange that causes harm elsewhere.

Existing policies, implementations, enforcements and policy loopholes in the EU and Nigeria govern UEEE and e-waste shipments. Unsustainable, uncircular and unjust shipping of non-functional or non-durable or soon-to-be e-waste UEEE to destinations without sound e-waste management and not making producers responsible for e-waste management is a global sustainability problem. We find that circular ambitions and policy solutions must explicitly incorporate just transition, especially in the context of increasing global inequality. With regards to circularity and just transition, there should not be any transboundary shipment of non-functional or non-durable UEEE. Our research shows that the EU aspiration for circularity is inexplicably tied with global circularity and global justice.

Currently, CE policy and discourse are focused on the material flow at the national level without sufficient consideration for international flows of materials and the implications for global equity. We propose revising the existing EPR to UPR by making producers responsible for managing waste globally, adding more value retention options and focusing on just transition. UPR builds on being inclusive, fair and collaborative to promote justice and equity, all concepts crucial in the CE transition. UPR emerged as a solution to the e-waste problem in a specific context guided by concepts of just transition, just sustainability, spatial equity, environmental justice and ethical consideration. Principles like justice, equity, transparency, circularity and sustainability inherent in UPR can be applied to other waste streams and geographies.

A solution-driven co-creative and adaptive methodology like TDR can integrate scientific and societal knowledge to facilitate a more nuanced understanding of the sustainability challenges by incorporating diverse societal actors to create solution-oriented knowledge with some built-in social legitimacy. This research could also bring fairness in the research process and thus in the created knowledge, especially in the context of spatial injustice. Future (TDR) research could focus on more equitable and socially just CE transitions.

ACKNOWLEDGMENTS

The authors would like to thank the many research participants who enabled this research. Many thanks to Linda Joy Mitchell from the Art of Hosting for helping design the workshops and to Kieran Campbell-Johnston, Katelin Opferkuch and Claudiu Eduard Nedelciu for helping facilitate the workshop. Many thanks to Nelson Obine (BCCC Nigeria) and Oluseun Badejo for their support during our stay in Nigeria and Ton Markus for the figures.

FUNDING INFORMATION

This study is part of the Circular Economy: Sustainability implications and guiding progress project (CRESTING), which received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement no 765198.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ORCID

Kaustubh Thapa https://orcid.org/0000-0002-5211-2640
Walter J. V. Vermeulen https://orcid.org/0000-0002-5947-8688
Pauline Deutz https://orcid.org/0000-0002-9165-5322
Olawale Olayide https://orcid.org/0000-0003-3151-0807

REFERENCES

Adesokan, M. D., Adie, G. U., & Osibanjo, O. (2016). Soil pollution by toxic metals near E-waste recycling operations in Ibadan, Nigeria. *Journal of Health and Pollution*, *6*(11), 26–33. https://doi.org/10.5696/2156-9614-6-11.26

African Development Bank Group. (2021). *Nigeria circular economy working group (NCEWG)*. Retrieved February 2, 2022, from. https://www.afdb.org/en/topics-and-sectors/topics/circular-economy/nigeria-circular-economy-working-group-ncewg

Agyeman, J. (2008). Toward a 'just' sustainability? *Continuum*, *22*(6), 751–756. https://doi.org/10.1080/10304310802452487

Akese, G. A., & Little, P. C. (2018). Electronic waste and the environmental justice challenge in Agbogbloshie. *Environmental Justice*, *11*(2), 77–83. https://doi.org/10.1089/env.2017.0039

Allen, C., & Clouth, S. (2012). *A guidebook to the green economy*. UN Division for Sustainable Development. https://sustainabledevelopment.un.org/content/documents/GE%20Guidebook.pdf

Amuzu, D. (2018). Environmental injustice of informal e-waste recycling in Agbogbloshie-Accra: Urban political ecology perspective. *Local Environment*, *23*(6), 603–618. https://doi.org/10.1080/13549839.2018.1456515

Aremu, S. A. (2020). Circular Economy: Global Perspective. In D. A. Olukanni, O. A. Mokuolu, O. A. Lasode, M. A. Ahove, & O. M. Ojowuro (Eds.), *Circular economy: Nigeria perspective* (1st ed. 2020 ed., pp. 279–299). Springer.

Atasu, A., & Subramanian, R. (2012). Extended producer responsibility for e-waste: Individual or collective producer responsibility? *Production and Operations Management*, *21*(6), 1042–1059. https://doi.org/10.1111/j.1937-5956.2012.01327.x

Awasthi, A. K., Zeng, X., & Li, J. (2016). Comparative examining and analysis of E-waste recycling in typical developing and developed countries. *Procedia Environmental Sciences*, *35*, 676–680. https://doi.org/10.1016/j.proenv.2016.07.065

Basel Action Network. (2018). Holes in the circular economy: WEEE leakage from Europe. http://wiki.ban.org/images/f/f4/Holes_in_the_Circular_Economy-_WEEE_Leakage_from_Europe.pdf

Basel Convention Coordinating Centre for the African Region. (2017, September 19). *Profile of Basel convention coordinating centre for*

training & technology transfer for the African region (BCCC-Africa). Basel Convention Coordinating Centre Retrieved February 3, 2022, from. https://www.basel.org.ng/index.php/about-hot-academy/2017-09-19-15-03-58/profile

Bauwens, T. (2021). Are the circular economy and economic growth compatible? A case for post-growth circularity. *Resources, Conservation and Recycling*, *175*, 105852. https://doi.org/10.1016/j.resconrec.2021.105852

Bressanelli, G., Pigosso, D. C., Saccani, N., & Perona, M. (2021). Enablers, levers and benefits of circular economy in the electrical and electronic equipment supply chain: A literature review. *Journal of Cleaner Production*, *298*, 126819. https://doi.org/10.1016/j.jclepro.2021.126819

Brown, V. A. (2010). *Tackling wicked problems: Through the transdisciplinary imagination* (1st ed.). Routledge.

Calisto Friant, M., Vermeulen, W. J., & Salomone, R. (2020). A typology of circular economy discourses: Navigating the diverse visions of a contested paradigm. *Resources, Conservation and Recycling*, *161*, 104917. https://doi.org/10.1016/j.resconrec.2020.104917

Calisto Friant, M., Vermeulen, W. J., & Salomone, R. (2021). Analysing European Union circular economy policies: Words versus actions. *Sustainable Production and Consumption*, *27*, 337–353. https://doi.org/10.1016/j.spc.2020.11.001

Campbell-Johnston, K., Lindgreen R., E., Mae De Waal, I., Maria Gulotta, T., Mondello, G., Salomone, R., & Vermeulen, W.J.V. (2022). Policy Brief on Critical Raw Materials and their integration in Extended Producer Responsibility and Eco-design Policy. https://doi.org/10.5281/zenodo.6444189

Campbell-Johnston, K., Munck, M., Vermeulen, W. J. V., & Backes, C. (2021). Future perspectives on the role of extended producer responsibility within a circular economy: A Delphi study using the case of The Netherlands. *Business Strategy and the Environment*, *30*(8), 4054–4067. https://doi.org/10.1002/bse.2856

Campbell-Johnston, K., Vermeulen, W. J. V., Reike, D., & Brullot, S. (2020). The circular economy and cascading: Towards a framework. *Resources, Conservation & Recycling: X*, *7*, 100038. https://doi.org/10.1016/j.rcrx.2020.100038

Carpenter, D. (2016). Recruitment by petition: American antislavery, French Protestantism, English Suppression. *Perspectives on Politics*, *14*(3), 700–723. https://doi.org/10.1017/s1537592716001134

Chatham House. (2020). *National Circular Economy Policies*. Retrieved February 2, 2022, from https://circulareconomy.earth/?policy=cep

Clapp, J. (2001). *Toxic exports: The transfer of hazardous wastes from rich to poor countries*. Cornell University Press.

Cotta, B. (2020). What goes around, comes around? Access and allocation problems in global north-south waste trade. *International Environmental Agreements: Politics, Law and Economics*, *20*(2), 255–269. https://doi.org/10.1007/s10784-020-09479-3

Dalkey, N., & Helmer, O. (1963). An experimental application of the DELPHI method to the use of experts. *Management Science*, *9*(3), 458–467. https://doi.org/10.1287/mnsc.9.3.458

D-waste. (2013). *Waste Atlas–Interactive map with visualised waste management data*. Retrieved February 2, 2022, from http://www.atlas.d-waste.com

D-waste. (2014). Waste Atlas–The world's 50 Biggest Dumpsites. http://www.atlas.d-waste.com/Documents/Waste-Atlas-report-2014-webEdition.pdf

Ellen McCarthur Foundation. (2015). *Stiftungsfonds für Umweltökonomie und Nachhaltigkeit, Deutsche Post Foundation, & McKinsey Centre for Business and Environment*. Growth Within: *A Circular Economy Vision for a Competitive Europe*. Ellen McCarthur Foundation. https://emf.thirdlight.com/link/8izw1qhml4ga-404tsz/@/preview/1?o

European Commission. (2020a). *2020 circular economy action plan: International aspects*. European Commission. https://doi.org/10.2779/603655

European Commission. (2020b). *Circular economy action plan*. Retrieved February 2, 2022, from https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en

European Commission. (2020c). *The just transition mechanism: Making sure no one is left behind*. European Commission Retrieved February 2, 2022, from. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en

European Parliament. (2021). *Circular economy: definition, importance and benefits*. Retrieved February 2, 2022, from https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

Eurostat. (2022). *Waste statistics - electrical and electronic equipment*. Eurostat. Retrieved February 7, 2022, from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics_-_electrical_and_electronic_equipment#Electronic_equipment_.28EEE.29_put_on_the_market_and_WEEE_processed_in_the_EU

Federal Republic of Nigeira. (2011). *Federal Republic of Nigeria official gazette–National Environmental (electrical/electronic sector) regulations, 2011*. The Federal Government Printer.

Franklin, K. K., & Hart, J. K. (2007). Idea generation and exploration: Benefits and limitations of the policy delphi research method. *Innovative Higher Education*, *31*(4), 237–246. https://doi.org/10.1007/s10755-006-9022-8

Genovese, A., & Pansera, M. (2020). The circular economy at a crossroads: Technocratic eco-modernism or convivial technology for social revolution? *Capitalism Nature Socialism*, *32*(2), 95–113. https://doi.org/10.1080/10455752.2020.1763414

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies* (1st ed.). SAGE Publications Ltd..

Gregson, N., Crang, M., Fuller, S., & Holmes, H. (2015). Interrogating the circular economy: The moral economy of resource recovery in the EU. *Economy and Society*, *44*(2), 218–243. https://doi.org/10.1080/03085147.2015.1013353

Gutberlet, J., & Carenzo, S. (2020). Waste pickers at the heart of the circular economy: A perspective of inclusive recycling from the global south. *Worldwide waste. Journal of Interdisciplinary Studies*, *3*(1), 6. https://doi.org/10.5334/wwwj.50

Hadorn, H. G., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C., Wiesmann, U., Zemp, E., & Jäger, J. (2007). *Handbook of transdisciplinary research* (2008 ed.). Springer.

Hale, S. A., Margetts, H., & Yasseri, T. (2013). Petition growth and success rates on the UK no. 10 downing street website. *Proceedings of the 5th Annual ACM Web Science Conference on–WebSci'13* (pp.132-138). Association for Computing Machinery.

Heacock, M., Kelly, C. B., Asante, K. A., Birnbaum, L. S., Bergman, K. L., Bruné, M. N., Buka, I., Carpenter, D. O., Chen, A., Huo, X., Kamel, M., Landrigan, P. J., Magalini, F., Diaz-Barriga, F., Neira, M., Omar, M., Pascale, A., Ruchirawat, M., Sly, L., … Suk, W. A. (2016). E-waste and harm to vulnerable populations: A growing global problem. *Environmental Health Perspectives*, *124*(5), 550–555. https://doi.org/10.1289/ehp.1509699

Hickel, J. (2018). *The divide: Global inequality from conquest to free markets* (1st ed. W. W. ed.). Norton & Company.

Hickel, J., Dorninger, C., Wieland, H., & Suwandi, I. (2022). Imperialist appropriation in the world economy: Drain from the global south through unequal exchange, 1990–2015. *Global Environmental Change*, *73*, 102467. https://doi.org/10.1016/j.gloenvcha.2022.102467

Hickel, J., & Kallis, G. (2019). Is green growth possible? *New Political Economy*, *25*(4), 469–486. https://doi.org/10.1080/13563467.2019.1598964

Hickel, J., Klu, K., & Read, R. (2021). *Less is more: How degrowth will save the world*. Windmill Books.

Hornborg, A., & Martinez-Alier, J. (2016). Ecologically unequal exchange and ecological debt. *Journal of Political Ecology*, *23*(1), 328–333. https://doi.org/10.2458/v23i1.20220

Hossain, M. S., Al-Hamadani, S. M., & Rahman, M. T. (2015). E-waste: A challenge for sustainable development. *Journal of Health and Pollution*, *5*(9), 3–11. https://doi.org/10.5696/2156-9614-5-9.3

Iles, A. (2004). Mapping environmental justice in technology flows: Computer waste impacts in Asia. *Global Environmental Politics*, *4*(4), 76–107. https://doi.org/10.1162/glep.2004.4.4.76

International Labour Organization. (2021). Frequently Asked Questions on just transition. https://www.ilo.org/global/topics/green-jobs/WCMS_824102/lang–en/index.htm

Kim, J. H. (2006). Management of natural resources, sustainable development and ecological hazards. In C. A. Brebbia (Ed.), *E-waste transboundary movement violating environmental justice* (pp. 95–103). WIT Press.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualising the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular economy: The concept and its limitations. *Ecological Economics*, *143*, 37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041

Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E. (2018). Circular economy as an essentially contested concept. *Journal of Cleaner Production*, *175*, 544–552. https://doi.org/10.1016/j.jclepro.2017.12.111

Lawhon, M. (2013). Dumping ground or country-in-transition? Discourses of e-waste in South Africa. *Environment and Planning C: Government and Policy*, *31*(4), 700–715. https://doi.org/10.1068/c1254

Leavy, P. (2011). *Essentials of transdisciplinary research: Using problem-centered methodologies (qualitative essentials)* (1st ed.). Routledge.

Lemille, A. (2020). *The Circular Humansphere*. Medium. Retrieved March 3, 2022, from. https://alexlemille.medium.com/the-circular-humansphere-2020-update-8b2df60a477

Lepawsky, J., Araujo, E., Davis, J. M., & Kahhat, R. (2017). Best of two worlds? Towards ethical electronics repair, reuse, repurposing and recycling. *Geoforum*, *81*, 87–99. https://doi.org/10.1016/j.geoforum.2017.02.007

Lin, C. K., Yan, L., & Davis, A. N. (2001). Globalisation, extended producer responsibility and the problem of discarded computers in China: An exploratory proposal for environmental protection. *Georgetown International Environmental Law Review*, *14*, 525–576.

Lipman, Z. (2015). Trade in hazardous waste. In S. Alam, S. Atapattu, C.G. Gonzalez, & J. Razzaque (Eds.), *International Environmental Law and the Global South*, 256–276. Cambridge University Press. https://doi.org/10.1017/cbo9781107295414.013

Makov, T., & Font Vivanco, D. (2018). Does the circular economy grow the pie? The case of rebound effects from smartphone reuse. *Frontiers in Energy Research*, *6*, 39. https://doi.org/10.3389/fenrg.2018.00039

Manhart, A. (2010). International cooperation for metal recycling from waste electrical and electronic equipment. *Journal of Industrial Ecology*, *15*(1), 13–30. https://doi.org/10.1111/j.1530-9290.2010.00307.x

Manhart, A., Oladele, O., Aderinto, A., & Prakash, S. (2011). *Informal e-waste management in Lagos, Nigeria – Socio-economic impacts and feasibility of international recycling co-operations*. Öko-Institut e.V. https://www.oeko.de/oekodoc/1371/2011-008-en.pdf

McAllister, L., Magee, A., & Hale, B. (2014). Women, E-waste, and technological solutions to climate change. *Health and Human Rights Journal*, *16*(1), 166–178.

McCauley, D., & Heffron, R. (2018). Just transition: Integrating climate, energy and environmental justice. *Energy Policy*, *119*, 1–7. https://doi.org/10.1016/j.enpol.2018.04.014

Ministry of Environment. (2018). *Fundamental plan for establishing a sound material-cycle society*. Government of Japan–Ministry of Environment. https://www.env.go.jp/en/recycle/smcs/4th-f_Plan.pdf

Murray, A., Skene, K., & Haynes, K. (2015). The circular economy: An interdisciplinary exploration of the concept and application in a global context. *Journal of Business Ethics*, *140*(3), 369–380. https://doi.org/10.1007/s10551-015-2693-2

Newell, P., & Mulvaney, D. (2013). The political economy of the 'just transition'. *The Geographical Journal*, *179*(2), 132–140. https://doi.org/10.1111/geoj.12008

Nnorom, I. C., & Odeyingbo, O. A. (2020). Electronic waste management practices in Nigeria. In M. Prasad, M. Vithanage, & A. Borthakur (Eds), *Handbook of Electronic Waste Management: International Best Practices and Case Studies*, (1st ed., pp. 323–354). https://doi.org/10.1016/b978-0-12-817030-4.00014-0

Nnorom, I. C., & Osibanjo, O. (2008). Electronic waste (e-waste): Material flows and management practices in Nigeria. *Waste Management*, *28*(8), 1472–1479. https://doi.org/10.1016/j.wasman.2007.06.012

Odeyingbo, O., Nnorom, U., & Deubzer, O. (2017). *Person in the port project: Assessing import of used electrical and electronic equipment into Nigeria*. United National University–ViE SCYCLE and Basel Convention Coordinating Centre Africa. https://collections.unu.edu/eserv/UNU:6349/PiP_Report.pdf

Ogungbuyi, O., Nnorom, I., Osibanjo, O., & Schluep, M. (2012). *E-waste country assessment Nigeria*. Basel Convention Coordinating Centre, Nigeria and Swiss Federal Laboratories for Materials Science and Technology. http://www.basel.int/Portals/4/Basel%20Convention/docs/eWaste/EwasteAfrica_Nigeria-Assessment.pdf

Ohajinwa, C., van Bodegom, P., Vijver, M., & Peijnenburg, W. (2017). Health risks awareness of electronic waste workers in the informal sector in Nigeria. *International Journal of Environmental Research and Public Health*, *14*(8), 911. https://doi.org/10.3390/ijerph14080911

Osibanjo, O., & Nnorom, I. (2007). The challenge of electronic waste (e-waste) management in developing countries. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, *25*(6), 489–501. https://doi.org/10.1177/0734242x07082028

Parrique, T., Barth, J., Briens, F., Kerschner, C., A, K.-P., A, K., & Spangenberg, J. H. (2019). *Decoupling debunked – Evidence and arguments against green growth as a sole strategy for sustainability*. European Environmental Bureau. https://eeb.org/library/decoupling-debunked/

Pelenc, J., & Ballet, J. (2015). *Weak sustainability versus strong sustainability*. United Nations. https://sustainabledevelopment.un.org/content/documents/6569122-Pelenc-Weak%20Sustainability%20versus%20Strong%20Sustainability.pdf

Pellow, D. N. (2008). The global waste trade and environmental justice struggles. In K.P. Gallagher (Ed.), *Handbook on Trade and the Environment*, (p. 368). Edward Elgar Publishing. https://doi.org/10.4337/9781848446045.00027

Perkins, D. N., Brune Drisse, M. N., Nxele, T., & Sly, P. D. (2014). E-waste: A global hazard. *Annals of Global Health*, *80*(4), 286–295. https://doi.org/10.1016/j.aogh.2014.10.001

Portas, P. (2016). Waste management and the green economy: Law and policy. In K. K. Peiry, A. R. Ziegler, & J. Baumgartner (Eds.), *Recycling and resource recovery under the Basel convention: Historical analysis and outlook* (pp. 56–79). Edward Elgar Publishing.

Reike, D., Vermeulen, W. J., & Witjes, S. (2018). The circular economy: New or refurbished as CE 3.0?—Exploring controversies in the conceptualisation of the circular economy through a focus on history and resource value retention options. *Resources, Conservation and Recycling*, *135*, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027

Sætre, A. S., & van de Ven, A. (2021). Generating theory by abduction. *Academy of Management Review*, *46*(4), 684–701. https://doi.org/10.5465/amr.2019.0233

Schnoor, J. L. (2012). Extended producer responsibility for E-waste. *Environmental Science & Technology*, *46*(15), 7927. https://doi.org/10.1021/es302070w

Schröder, P. (2020a). Promoting a just transition to an inclusive circular economy. Chatham House. https://www.researchgate.net/profile/Patrick-Schroeder-9/publication/344225649_Promoting_a_just_transition_to_an_inclusive_circular_economy/links/5f5dde59a6fdcc11640ee791/Promoting-a-just-transition-to-an-inclusive-circular-economy.pdf

Schröder, P., Lemille, A., & Desmond, P. (2020b). Making the circular economy work for human development. *Resources, Conservation and Recycling*, *156*, 104686. https://doi.org/10.1016/j.resconrec.2020.104686

Soja, E. W. (2010). *Seeking spatial justice (volume 16) (globalisation and community)* (1st ed.). Univ. of Minnesota Press.

Stevis, D., & Felli, R. (2020). Planetary just transition? How inclusive and how just? *Earth System Governance*, *6*, 100065. https://doi.org/10.1016/j.esg.2020.100065

Sullivan, J. (2014). Trash or treasure: Global trade and the accumulation of e-waste in Lagos, Nigeria. *Africa Today*, *61*(1), 89. https://doi.org/10.2979/africatoday.61.1.89

Temper, L., & Shmelev, S. (2015). Mapping the frontiers and front lines of global environmental justice: The EJAtlas. *Journal of Political Ecology*, *22*(1), 255-278. https://doi.org/10.2458/v22i1.21108

Terada, C. (2012). Northwestern. *Journal of International Human Rights*, *10*(3), 154–172. http://scholarlycommons.law.northwestern.edu/njihr/vol10/iss3/2

Thapa, K., Vermeulen, W. J., Deutz, P., & Olayide, O. (2022). Transboundary movement of waste review: From binary towards a contextual framing. *Waste Management & Research: The Journal for a Sustainable Circular Economy*. https://doi.org/10.1177/0734242x221105424

Thapa, K., Vermeulen, W. J. V., & Deutz, P. (2022). Science with society: Challenges of early-stage researchers engaging with transdisciplinary research in sustainability science. *Sustainable Development*. https://doi.org/10.1002/sd.2328

Thapa, K., Vermeulen, W. J. V., Olayide, O., & Deutz, P. (2022). *Policy brief: Blueprint for ultimate producer responsibility*. Copernicus Institute of Sustainable Development, Utrecht University. https://doi.org/10.5281/zenodo.5957809

UNEP. (2015). *Global waste management outlook*. United Nations Environment Programme. https://www.unep.org/resources/report/global-waste-management-outlook

UNEP. (2019). *Nigeria turns the tide on electronic waste*. UN Environment. Retrieved February 2, 2022, from. https://www.unep.org/news-and-stories/press-release/nigeria-turns-tide-electronic-waste

van Breda, J., & Swilling, M. (2018). The guiding logics and principles for designing emergent transdisciplinary research processes: Learning experiences and reflections from a transdisciplinary urban case study in Enkanini informal settlement. *South Africa. Sustainability Science*, *14*(3), 823–841. https://doi.org/10.1007/s11625-018-0606-x

van Yken, J., Boxall, N. J., Cheng, K. Y., Nikoloski, A. N., Moheimani, N. R., & Kaksonen, A. H. (2021). E-waste recycling and resource recovery: A review on technologies, barriers and enablers with a focus on Oceania. *Metals*, *11*(8), 1313. https://doi.org/10.3390/met11081313

Velicu, I., & Barca, S. (2020). The just transition and its work of inequality. *Sustainability: Science, Practice and Policy*, *16*(1), 263–273. https://doi.org/10.1080/15487733.2020.1814585

Vermeulen, W., Campbell-Johnston, K., & Thapa, K. (2022). Extended producer responsibility and circular economy: Three design flaws. *Ökologisches Wirtschaften–Fachzeitschrift*, *37*(1), 21–23. https://doi.org/10.14512/oew370121

Vermeulen, W. J. V., & Witjes, S. (2021). History and mapping of transdisciplinary research on sustainable development issues: Dealing with complex problems in time of urgency. In M. M. Keitsch & W. J. V. Vermeulen (Eds.), *Transdisciplinarity for sustainability* (1st ed., pp. 6–27). Routledge.

von Weizsäcker, E. U. (2014). Factor four: Doubling wealth—Halving resource use: A new report to the Club of Rome. In A. B. Lovins & L. H. Lovins (Eds.), *Springer briefs on pioneers in science and practice* (2014th ed., pp. 127–141). Springer. https://doi.org/10.1007/978-3-319-03662-5_11

Wang, F., Huisman, J., Meskers, C. E., Schluep, M., Stevels, A., & Hagelüken, C. (2012). The best-of-2-worlds philosophy: Developing local dismantling and global infrastructure network for sustainable e-waste treatment in emerging economies. *Waste Management*, *32*(11), 2134–2146. https://doi.org/10.1016/j.wasman.2012.03.029

Wang, X., & Lo, K. (2021). Just transition: A conceptual review. *Energy Research & Social Science*, *82*, 102291. https://doi.org/10.1016/j.erss.2021.102291

Wecyclers. (n.d.). *Home - Wecyclers*. Retrieved February 2, 2022, from https://wecyclers.com

Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D., Schnellmann, M., & Böni, H. (2005). Global perspectives on e-waste. *Environmental Impact Assessment Review*, *25*(5), 436–458. https://doi.org/10.1016/j.eiar.2005.04.001

Wijkman, A., & Skånberg, K. (2015). The circular economy and benefits for society jobs and climate clear winners in an economy based on renewable energy and resource efficiency. The Club of Rome. https://www.lagazettedescommunes.com/telechargements/etude-club-rome-eng.pdf

Wilson, D. C., Velis, C., & Cheeseman, C. (2006). Role of informal sector recycling in waste management in developing countries. *Habitat International*, *30*(4), 797–808. https://doi.org/10.1016/j.habitatint.2005.09.005

Witjes, S., & Vermeulen, W. J. V. (2021). Transdisciplinarity for sustainability. In M. M. Keitsch & W. J. V. Vermeulen (Eds.), *Transdisciplinary research approaches and methodological principles* (1st ed., pp. 27–49). Routledge.

Woggsborg, A., & Schröder, P. (2018). Nigeria's E-waste management: Extended producer responsibility and informal sector inclusion. *Journal of Waste Resources and Recycling*, *1*(1), 1–9. https://doi.org/10.15744/2766-5887.1.102

Wurster, S. (2021). Creating a circular economy in the automotive industry: The contribution of combining crowdsourcing and delphi research. *Sustainability*, *13*(12), 6762. https://doi.org/10.3390/su13126762

WWF & Global Footprint Network. (2019). *EU overshoot day: Living beyond Nature's limit*. World Wide Fund For Nature. https://www.wwf.eu/?346835/EU-Overshoot-Day-2019-If-EU-consumption-was-the-global-norm-the-Earths-yearly-budget-would-be-exhausted-on-10-May

Yousuf, M. I. (2007). Using experts' opinions through delphi technique. *Practical Assessment, Research, and Evaluation*, *12*(4). https://doi.org/10.7275/rrph-t210

Zink, T., & Geyer, R. (2017). Circular economy rebound. *Journal of Industrial Ecology*, *21*(3), 593–602. https://doi.org/10.1111/jiec.12545

How to cite this article: Thapa, K., Vermeulen, W. J. V., Deutz, P., & Olayide, O. (2022). Ultimate producer responsibility for e-waste management–A proposal for just transition in the circular economy based on the case of used European electronic equipment exported to Nigeria. *Business Strategy & Development*, 1–20. https://doi.org/10.1002/bsd2.222

APPENDIX A

Scenario I. Policy as usual scenario for EEE and e-waste	
Imports Only occasional import controls on e-waste and UEEE Presence of loopholes for undesirable imports No monitoring, no data and transparency	Domestic EEE usage Ratio of new imported EEE / re-usable imported EEE is unknown Curb side and informal sector collection, most e-waste ends up in dumpsite, very few to formal recycling
National policy • No specific national policy regulating EEE or e-waste, guidance from national waste management policy and environmental policy • Lack of implementation and enforcement • Weak coordination between implementing bodies • No national policies on value retention of EEE and e-waste	Extended producer responsibility • Normative visions of future EPR to be planned • Producer and importers not organised in PROs • Few formal sectors only dealing with small fraction of generated e-waste
Local policy • Very limited local government involvement in collection and inspection of e-waste when directed by national government • No active role of local government	Informal sector • Unorganised, polluting, and dangerous • No governmental support • Health, environment, and social problems for community • Unsystematic value retention of few EEE and e-waste like repair, reuse, resell and crude recovery but with high social and environmental cost
Scenario II. Policy as usual scenario for EEE and e-waste	
Imports Only occasional import controls on e-waste and UEEE Presence of loopholes for undesirable imports No monitoring, no data and transparency	Domestic EEE usage Ratio of new imported EEE / re-usable imported EEE is unknown Curb side and informal sector collection, most e-waste ends up in dumpsite, very few to formal recycling
National policy • No specific national policy regulating EEE or e-waste, guidance from national waste management policy and environmental policy • Lack of implementation and enforcement • Weak coordination between implementing bodies • No national policies on value retention of EEE and e-waste	Extended producer responsibility • Normative visions of future EPR to be planned • Producer and importers not organised in PROs • Few formal sectors only dealing with small fraction of generated e-waste
Local policy • Very limited local government involvement in collection and inspection of e-waste when directed by national government • No active role of local government	Informal sector • Unorganised, polluting and dangerous • No governmental support • Health, environment and social problems for community • Unsystematic value retention of few EEE and e-waste like repair, reuse, resell and crude recovery but with high social and environmental cost
Scenario III. Policy as usual scenario for EEE and e-waste	
Imports Only occasional import controls on e-waste and UEEE Presence of loopholes for undesirable imports No monitoring, no data and transparency	Domestic EEE usage Ratio of new imported EEE / re-usable imported EEE is unknown Curb side and informal sector collection, most e-waste ends up in dumpsite, very few to formal recycling
National policy • No specific national policy regulating EEE or e-waste, guidance from national waste management policy and environmental policy • Lack of implementation and enforcement • Weak coordination between implementing bodies • No national policies on value retention of EEE and e-waste	Extended producer responsibility • Normative visions of future EPR to be planned • Producer and importers not organised in PROs • Few formal sectors only dealing with small fraction of generated e-waste
Local policy • Very limited local government involvement in collection and inspection of e-waste when directed by national government • No active role of local government	Informal sector • Unorganised, polluting and dangerous • No governmental support • Health, environment and social problems for community • Unsystematic value retention of few EEE and e-waste like repair, reuse, resell and crude recovery but with high social and environmental cost

APPENDIX B

Make European producers responsible for the management of their e-waste internationally.

Petition to the Nigerian Government and European Commission on organising effective repair and recycling for imported second-hand electric and electronic equipment (EEE) and discarded electrical and electronic equipment (e-waste): implementing ultimate producer responsibility.

We welcome you to endorse this petition on implementing ultimate producer responsibility (UPR) for producers of electronic and electrical equipment that is exported from high-income countries towards low-income countries. UPR aims to reduce such exports' ecological and health impacts and create greater economic benefits associated with the transboundary movement of electrical and electronic equipment (EEE), both second-hand EEE and discarded EEE (e-waste).

This science-based petition is a product of the work of four researchers and 24 e-waste experts from 9 countries who have co-created a concrete domestic and international action plan to add circularity and sustainability in EEE management over the past 18 months.

The national and international solutions with specific actors and actions are laid out below:

1. We observe that

Second-hand electronics enter Nigeria in large volumes, mostly coming from European countries;

that the treatment and refurbishment mostly takes place in an informal and weakly regulated market;

that the consumer use of EEE is dominated by imported second-hand EEE in Nigeria;

that the remaining lifetime is mostly very short;

that the post-user phase collection and treatment is hardly organised, which causes severe health and environmental problems; and.

while in Europe, producers are held (financially) responsible for proper recycling of this post-consumer EEE; however, they are not held responsible for their products that leaks to African countries.

2. Therefore, we recommend the Nigerian government to implement a new national circular EEE policy, explicitly focusing on this international trade of EEE by introducing an international financial mechanism while simultaneously transforming the national EEE treatment sector in Nigeria

This includes both national and international collaborative actions.

These actions have been identified in a Delphi study with 24 experts in EEE trade and recycling in Nigeria and neighbouring counties.

Recommendations for the Nigerian government:

a. Enable a transformation of the informal sector, active in refurbishing and reselling imported second-hand EEE, by building capacity, awareness raising and training for specific roles that ultimately incorporate them into safe and well-paying jobs, including waste collectors and separators, repairing, refurbishing and recycling with qualified training. In this way, the government can recognise and reward the informal sector's crucial role, incorporate and empower them politically and economically, thus minimising the health and environmental harms to their communities and contributing to prosperity.

b. The National Waste Management Policies include an internationally oriented version of extended producer responsibility (EPR), instead of the currently promoted version, which lacks an orientation towards the international trade flow characteristics of the problems of managing second-hand EEE and illicit and illegal imports of WEEE. This new form of EPR, we term Ultimate Producer Responsibility, includes a financial transfer mechanism from EU-based EPR programmes dedicated to upgrading and the final treatment of imported second-hand EEE under international standards and sustainability guidelines in Nigeria (and other African countries). This enables adding value through repair and refurbishment to extend the equipment life and establishing sound end-of-life management systems for the large volume of second-hand EEE in usage.

c. Ensure that in the revised National Waste Management Policy, as a part of the ultimate producer responsibility, a permanent monitoring program is established, identifying the original equipment manufacturers and origin countries of imported EEE and periodically reports to measure performance and goal achievement.

d. Implement the "polluter pays principle" for imported EEE, both new or second-hand EEE, via the ultimate producer responsibility. This means making original equipment manufacturers and importers responsible for contributing their fair share for extending EEE's lifetime and sound management of recycling of e-waste. A financial mechanism is created for second-hand imported EEE, sourcing funds from the EPR programs under the EU WEEE Directive 2012/19/EU.

e. Implement a program supporting local governments in creating infrastructures for awareness-raising and collection for recycling of EEE, aiming to maximise the value of EEE for as long as possible. The local government creates infrastructures for repairs and refurbishment and facilitates the effective collection, sorting, recycling and disposal facilities that fit the needs of the local context. The financial resources for this are to be provided under the ultimate producer responsibility regulations by the original equipment manufacturers and importers.

f. The ultimate producer responsibility requires establishing a producer responsibility organisation, run by the producers and importers whose actions must follow the standards set by the United Nations Convention against corruption for transparency and corruption prevention.

Recommended collaborative actions for African countries:

a. Countries that are receiving second-hand EEE imports from Europe to ensure a new and appropriate funding for repair or end-of-life management by original equipment manufacturers and importers be transferred along with import/export of used EEE or e-waste. Existing domestic EPR mechanisms of importing countries incorporate the ultimate producer responsibility principles and connect these with the existing EPR mechanisms of exporting EU countries (under the EU WEEE Directive 2012/19/EU and Directive (EU) 2018/851) to facilitate financial and knowledge transfer for sound e-waste management.

b. Revisit international arrangements like the Basel Convention's Decision BC-12/5 to ensure all that UEEE exports accompany

certification of functionality and durability to prevent importation of e-waste in disguise or second-hand items with a short life span.

c. Negotiate with the European Union and its member states a revision to the EU WEEE Directive 2012/19/EU that includes financial responsibility for exported second-hand hand EEE to Africa in the regulations. This is discussed in the European Parliament; see question reference: (E-003034/2021 and its answer E-003034/2021(ASW)).

d. Support the Right to Repair law and negotiate with the European Union and its member states to extend the repair rights to all consumers who benefit from second-hand hand EEE from the European Union. This collective action should make repair and refurbishment for reuse easy, accessible and cost-effective to extend the lifespan of the European product everywhere. This action systematically tackles the problem of needless consumption and throw-way culture while promoting sustainable resource use and reducing toxic waste generation.

e. EU member states and African countries mandate and strengthen the collaboration of port authorities of the importing and exporting countries for regular knowledge sharing, monitoring and measuring the flows of imports/exports and its fate with greater accuracy and transparency. There should be more support for existing international bodies like the International Criminal Police Organisation, the European Union Network for the Implementation and Enforcement of Environmental Law and Ports Environmental Network–Africa, who already facilitate such collaboration.

3. Rationale for the petition.

The domestic consumption of EEE in Nigeria and elsewhere are increasing. Nigeria lacks a basic waste management infrastructure; handling e-waste is a significant challenge. There is also an influx of second-hand EEE in Nigeria – some of which are either non-functional (e-waste), non-durable or non-repairable (soon become e-waste). The Person in the Port Project in 2015/2016 found 71,000 tonnes of used EEE being imported to Nigeria, 77% of which arrived from the EU and 11% of it being e-waste. From our research in 2020, experts estimate 43% of all EEE used in Nigeria are second-hand, indicating a big market for second-hand products. About 35.7% of second-hand equipment are imported from Europe, of which 37.25% arrive in Nigeria disguised as e-waste. Of the remaining two-thirds of UEEE, they last only 2.3 years on average, after which they become e-waste. E-waste is hazardous and causes health and environmental harm. If managed right with proper knowledge and infrastructure, e-waste contains valuable resources and can bring financial gains. Nigeria is known as one of the e-waste hubs in Africa, where the informal sector primarily engages in collecting, repairing and crude recycling. Although these create jobs (repair, refurbishment, resell, collection and primitive recycling etc.) and provide livelihood, unsound practices like burning and acid leaching create harm. So far, there are only a few formal e-waste recycling facilities in Nigeria. The majority of e-waste undergo crude recycling and dumping. The problem of e-waste, both domestic and imported, have created sustainability challenges in Nigeria.

4. Blueprint for the ultimate producer responsibility

In EU countries with extended producer responsibility (EPR), producers are held responsible for end-of-life management of Electronic and Electric Equipment (EEE). However, the EPR systems are limited inside the national jurisdiction. In reality, many second-hand EEE are traded and reused globally. Our research finds 35.7% of all imported second-hand equipment in Nigeria are from Europe, with an average lifespan of 2.3 years, after which they become e-waste. The existing EPR system must transform to make the producers responsible for e-waste generation everywhere, not just nationally. We call this transformative EPR ultimate producer responsibility (UPR), which takes international trade in second-hand EEE into account and accounts for the ultimate fate of the EEE globally. UPR includes a financial transfer mechanism from EU-based EPR programmes to countries that import second-hand EEE from Europe. UPR is dedicated to upgrading and the final treatment of imported EEE following international standards and sustainability guidelines in second-hand importing countries. UPR system enables value-addition through repair and refurbishment to extend the equipment life and establish sound end-of-life management systems for the large volume of second-hand EEE usage.

To learn more about the ultimate producer responsibility, please visit: https://doi.org/10.5281/zenodo.5957809

To watch the video outlining the research, please visit: https://www.youtube.com/watch?v=dUfE_eUot68

The petition has been co-authored by:

Kaustubh Thapa, Utrecht University, Netherlands
Dr Walter Vermeulen, Utrecht University, Netherlands
Dr Olawale Olayide, University of Ibadan, Nigeria
Dr Pauline Deutz, University of Hull, United Kingdom
Ojo Olumide Alex, Harvest Recycling Limited, Nigeria.
Dr Chimere May Ohajinwa, MPHC-Circle Research, Nigeria.
Dr Vusumuzi Maphosa, Lupane State University, Zimbabwe.
Cajetan Okeke, Alamonk Recyclers Ltd, Nigeria.