

Introduction. A Digitally Enabled Circular Plastic Economy for Africa

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INTRODUCTION

A Digitally Enabled Circular Plastic Economy for Africa

Muyiwa Oyinlola and Oluwaseun Kolade

1 Plastic Pollution in Africa

Plastics have been around since the discovery of polystyrene in 1839. They come in different types such as polyethylene terephthalate (PET), low-density polyethylene (LDPE), high-density polyethylene (HDPE), polyvinyl chloride (PVC) and polypropylene (PP). Between 1950 and 2017, approximately 7 billion out of 9.2 billion tonnes of plastics produced ended up as wastes. They further approximated the recycling rate to be only 9% while 79% is disposed of in landfills and the oceans. Therefore, even though plastics are essential materials due to unique properties and extensive benefits, they now pose considerable environmental and health problems due to large quantities that have been mismanaged over the years (Sakthipriya, 2022).

This challenge is expected to worsen, as several reports indicate a steady increase in annual global production of plastics. Dasgupta et al. (2022) reported a growth rate of more than 8% per year, and in 2016, Drzyzga and Prieto (2019) estimated the production to be 335 million tonnes per annum, and Plastics Europe (2021) estimated global plastic production in 2020 to be 367 million tonnes. The latest estimates at the time of writing put production at about 381 million tonnes, of which 50% is single-use (Grodzińska-Jurczak et al., 2022; Phillips, 2022). Given the current growth rate, the total plastics produced is projected to grow to 33 billion tonnes by 2050 (Rochman et al., 2013; Jambeck et al., 2015). This trend has become a major concern as plastic is non-biodegradable, and microplastics are permeating into the environment and the food chain (Wright and Kelly, 2017).

Many countries in Africa have poor infrastructure and suboptimal waste management systems, which exacerbates the plastic pollution challenge. It is estimated that less than 5% of plastic waste is recycled in Africa (UNEP, 2018)

while the remaining are disposed of through open dumping, open burning, unregulated landfills, and dumping into drains, streams and rivers. The scale of the challenge is expected to increase as the continent is anticipated to experience almost 200% increase in waste generated by 2050, with much of this being plastic (Kaza et al., 2018).

2 The Circular Economy as a Viable Solution

The circular economy has been touted as a viable intervention for the plastic challenge (Geissdoerfer et al., 2017; Kirchherr et al., 2017). Its key approaches of reducing, reusing, recycling, redesigning, remanufacturing and recovering are expected to significantly contribute to better management of the high volumes of waste in the ecosystem (Leslie et al., 2016). These core ideals of the circular economy have gained increasing attention globally, including interest from governments and businesses (Korhonen et al., 2018). The circular economy empowers organisations to realise lasting productivity and economic growth (Cainelli, Evangelista and Savona, 2006), otherwise described as the “circular advantage”. The concept of the circular economy has been explored by several scholars such as Murray, Skene and Haynes (2017); Araujo Galvão et al. (2018); Berg et al. (2018); and Gall et al. (2020).

The circular plastic economy (CPE) is a system which employs the principles of the circular economy to the plastic value chain, including design, manufacture, use and end-of-life phase. Therefore, the CPE approach promotes innovative design, encourages recycling and incentivises the reuse of materials, thereby minimising issues arising from the use and disposal of plastic products (Völker, Kovacic and Strand, 2020). In other words, the CPE fosters a move to more sustainable interventions for the plastic challenge through innovation (Dedehayir, Mäkinen and Ortt, 2018).

While public awareness of the need for a CPE has grown, the African continent has not experienced corresponding development in terms of tangible actions and verifiable achievements. This is owing, in part, to the constraints presented by institutional frameworks in which national governments are frequently out of touch with global debate (Kolade et al., 2022), and public participation is frequently not matched by policy commitment and political resolve (Adetoyinbo et al., 2022). Furthermore, many private-sector stakeholders continue to work in silos, limiting the gains and effectiveness of current circular economy campaigns (Oyinlola et al., 2022b). According to Barrie et al. (2022), developing countries may be limited in taking advantage of the higher-value opportunities of the circular economy.

Against this backdrop, the central thesis of this book is that digital tools and technologies, which result in digital innovations (DIs), can be the game changer that positively disrupts the landscape by channelling and driving a multi-stakeholder approach that brings together digital innovators, researchers, policymakers and ordinary citizens together in the collective drive towards the CPE in Africa. DIs

can facilitate the creation of new multi-sided platforms and institutions that link existing stakeholders together for greater impact. They can also enable new actors and ordinary citizens to co-create innovative solutions and ideas to drive the CPE. This book therefore explores the challenges and opportunities of a digitally enabled circular economy in Africa.

3 Digitisation in the Circular Economy

DIs create and integrate new technologies into current systems to address issues and boost productivity, accessibility, dependability and sustainability (Ciriello, Richter and Schwabe, 2018; Kohli and Melville, 2019). Internet of things (IoT), smart mobile devices, big data, remote sensing, blockchain, cloud storage, artificial intelligence (AI) and three-dimensional (3D) printing are all examples of digital tools and technology for innovation. Several business sectors in Africa have benefited from DIs. For instance, “precision agriculture” based on sensors and satellites as well as AI-based agronomic solutions have been utilised to assist sustainable agriculture in Africa, providing smallholder farmers (SHFs) and their communities with a number of advantages (Syngenta, 2019). Another industry where DIs has been effectively applied is mobile finance, which has enabled low-cost money transfers and many creative forms of financing, such as crowdsourcing and peer-to-peer lending. These tools have completely changed the African payment environment, inspiring brand-new, cutting-edge methods of approaching the financial value chain. Additionally, digital technologies such as geospatial platforms and embedded systems have transformed the energy industry in Africa by enabling real-time demand monitoring, adjustment and smarter management of distributed power systems (Annunziata et al., 2015).

There are several factors catalysing the uptake of digital tools and technologies in Africa, for example, the demographic profile of the continent; almost 60% of Africa’s population is under the age of 25 (Statista, 2021). Furthermore, Africa has the fastest growing internet penetration (GSMA, 2020; Granguillhome Ochoa et al., 2022), and the continent has attracted significant investment in digital platforms such as Google AI hub in Ghana and Facebook hub in Kenya. In addition, several technology innovation hubs have sprung up across the continent (Atiase, Kolade and Liedong, 2020), giving several young people the opportunity to immerse themselves in technologies which result in innovations that can support development. The mushrooming of these tech-hubs, which offer space and technology support for budding digital entrepreneurs, is empowering young Africans to be more creative and more innovative in their use of DI. According to GSMA (Giuliani and Ajadi, 2019), the tech-hubs offer support as incubators, accelerators, university-based innovation hubs, maker spaces, technology parks and co-working spaces. The tech-hubs are instrumental in building DI start-ups and a robust digital ecosystem where entrepreneurs can learn from as well as share ideas with like-minded innovators. Furthermore, tech-hubs offer much-needed fast internet access and electricity (Giuliani and Ajadi, 2019).

DIs have also demonstrated the ability to contribute to Africa’s CPE by filling the vacuum left by insufficient waste collection and management infrastructure (Antikainen, Uusitalo and Kivikytö-Reponen, 2018). Several improvements have been implemented in a bid to transform the plastic value chain into a smart, innovative and sustainable value network through improved plastic identification, collection, transportation, sorting, processing and reuse. Alternative Energy Solutions (AES) in Kenya, for example, uses revolutionary technology to turn various types of plastic into oil (Horvath, Mallingu and Fogarassy, 2018). Pratap et al. (2019) propose an automated communication method based on IoT technology between households and waste collection agencies to help monitor and collect plastic waste, recycle and aid in centralised disposal. As IoT becomes more ubiquitous on the African continent, such a model could also be considered among other DIs. Mugo and Puplampu (2020) discuss how smart sensors as a technology innovation can be useful in addressing environmental pollution and waste management in Africa. Singh (2019) discussed how municipal waste management can make use of geographic information systems (GIS) and the layers available from remote sensing. Chidepatil et al. (2020) posit that AI and blockchain technology have the potential to make recycling more efficient. They suggest that using AI to segregate plastic waste will ensure effective and intelligent segregation, which could otherwise be a complex and inefficient procedure. Furthermore, they suggest that blockchain technology can be utilised as a “trust-based platform between plastic waste segregators, recyclers, and recycled feedstock buyers (manufacturers)”, so that information can be easily exchanged and validated between the various partners in the value chain, making it easy for partners to have relevant information on plastic waste and how best to reduce or recycle it. There are several start-ups utilising digital technology to tackle the plastic pollution challenge in Africa, Figure 1.1 presents some of these, and a comprehensive list is presented in Oyinlola et al. (2022).



FIGURE 1.1 Some start-ups utilising digital technologies for the circular plastic economy

4 DITCh Plastic Project

Despite a growing number of studies and start-ups focused on utilising digital tools and technologies for the CPE over the past decade. Progress has been slow, with most start-ups struggling to scale. In response to this, the United Kingdom Research and Innovation (UKRI), through the Global Challenges Research Fund (GCRF), funded the formation of a network in 2020, <https://gtr.ukri.org/projects?ref=EP%2FT029846%2F1>. The Digital Innovations for Transitioning to a Circular Plastic Economy in Africa (DITCh Plastic) Network, led by the partners in Figure 1.2, is a multisectoral, international and interdisciplinary network aimed at promoting and supporting DIs that can accelerate the transition to a CPE in Africa. The network targeted to characterise, cluster, synergise and optimise DIs that would support a transition to a CPE in Africa and had the following specific objectives:

- I. Identify and assess digital solutions and innovations that can support the transition to a CPE.
- II. Characterise technical, political, gender, socioeconomic and cultural factors that can influence the transition to a CPE.
- III. Identify policy, research questions and capacity building opportunities for promoting digital tools and innovations.
- IV. Promote digital tools and innovations for a CPE.

This book, in addition to Kolade et al. (2022), Oyinlola et al. (2022, 2022b) and Schroeder et al. (2023), is an output from the network. This book brings together interdisciplinary, multisectoral and multi-stakeholder perspectives exploring challenges and opportunities of utilising DIs to manage and accelerate the transition to a CPE in Africa. It provides both scholarly and practitioner perspectives on the role of DIs, such as web-based/mobile apps, blockchains and 3D printing, in the drive towards the CPE in Africa. These are reinforced with



FIGURE 1.2 DITCh plastic network partners (<http://ditch-plastic.org/>)

real-world examples, policy insights and country case studies spanning Western, Eastern and Southern Africa regions.

Along with a critical synthesis of the extant literature, DITCh Plastic has also engaged with hundreds of stakeholders from across the continent through focus groups, interviews, workshops and a conference as well as a cross-sectional survey of 1475 households across five countries which were selected to have a comprehensive representation of sub-Saharan Africa. Geographic diversity was ensured by a wide continental coverage (East, West and South): significant differences in economy size [Nigeria with a gross domestic product (GDP) of \$375.8 billion versus Rwanda with a GDP of \$9.137 billion], population (190 million in Nigeria to 2.5 million in Namibia) and literacy rates. Below are some insights from the extensive engagement activities.

Firstly, despite the numerous prospects in the sector, funding appears to be a significant barrier. This includes a lack of financing and/or a lack of understanding of funding sources to support research, innovation and development for the CPE. Although waste management initiatives are generally recognised as viable businesses in the medium to long term, start-ups in this sector are finding it difficult to access start-up capital to pilot their innovation until they can make a viable investment case for scaling. Digital platforms can be used to create virtual marketplaces which streamlines and optimises the plastic value chain. Government's ambitions should be to maximise the recycling (and recovery) of waste resources for productive use while reducing pollution. Despite creating online marketplaces being simple, a critical research question is how it functions with or without market regulation or support, and how this can promote good waste commodity governance.

Secondly, regulation is a significant obstacle that may slow the rate of transition. Addressing serious deficiencies and flaws in rules and regulations for sustainable plastic waste management is critical. This encompasses policy design, implementation and enforcement. It was observed that there are many excellent waste management policies across the continent; however, the majority of them might benefit from better coordination and enforcement. One example is the extended producer responsibility (EPR) scheme, in which plastic manufacturers contribute to post-consumer recovery. Another piece of helpful regulation will be on recycled content; for example, requiring plastic manufacturers to include recycled content will raise demand while also increasing recycling rates. Government incentives will be critical to success; therefore, striking the correct balance between rewards and penalties is critical. Governments must regularly examine their policies and procedures for effective waste management in their communities and industries.

It should also be noted that due to the intricacies of waste management as a regulated business with significant material flows, data will always be a critical requirement if the system is to perform properly. The lack of good data is now a major impediment to the transition to a CPE. It is difficult for industry participants and stakeholders to control something they cannot quantify. As a result, systems

and/or technologies for collecting and tracking waste data must be established. Types, location, distribution, quantity collected, quantity recycled and so on should all be included in this data. Digital technologies and advances can significantly aid in the collection and analysis of pertinent data, allowing for more successful research.

There is an urgent need for public awareness/education on sustainable waste management, particularly among youth, who constitute a substantial proportion of the population. Currently, most of the population does not consider waste to be a resource, and some collectors are still struggling to obtain enough plastics for recycling. Citizen education, community awareness activities, and behavioural change programmes will need to be established and implemented. These should be implemented in cooperation with relevant policies.

The transition to a CPE demands cross-sectoral cooperation. Collaboration and coordination among various stakeholders is currently minimal, which is a major hurdle in achieving considerable progress. There must be multi-stakeholder collaboration and synergy involving the government, corporations, universities, civil organisations, local governments and communities in both urban and rural areas. National platforms that can support this type of involvement are desperately needed. This could solve the issue of coordinating many stakeholders – waste producers, waste collectors, consumers and ministries – who may need to collaborate, sometimes outside of their apparent areas of responsibility.

Digital tools and technology can be utilised to scale up local projects at granularities appropriate for Africa's population and terrain, from rural to urban communities. DIs such as mobile applications can aid in the effective collecting and transport of waste plastics to aggregators, as well as technologies that allow for the efficient optical sorting of plastics to meet reprocessing requirements. This facilitates the “bottom-up” approach to waste management and the advancement of local pollution control strategies. However, the primary potential of DIs will be in the ability to support a systemic shift to circularity at scale. Taking this forward will require further study, which will be enabled by the creation of spatial and temporal data, which informs the assessment of the systems and processes underlying waste plastic management.

A considerable demand exists to develop skills that are relevant to the circular economy. For example, introducing training in various waste management methods, including behaviour interventions, can have a significant influence within and beyond industry sub-sectors.

Another issue that must be addressed is the sociocultural dynamics of waste management. It has been discovered, for example, that social standing influences how people approach reuse and recycling. Another important difficulty is stigma; plastic waste collection is primarily viewed as a dirty job for the poor. To successfully transition, stereotypes and stigma about waste management need to be eliminated.

While both genders actively participate in the CPE, it seems like macro-level projects/initiatives are mainly dominated by males and micro-level projects by females. Similarly, while women are highly involved on the ground, they have limited opportunities in the decision-making processes for policies and strategies.

These observed gender differences need to be addressed, and there should be mainstreaming of gender-balanced projects.

Across the continent, it seems like the invitation to invest in alternative packaging has not really gained much traction in spite of several innovations around the continent. For example, biodegradable packaging has been produced locally using banana leaves and water hyacinth. However, this and similar innovations have not diffused across the continent. Systems need to be in place to promote, celebrate and diffuse these sorts of innovations across the continent.

Finally, we observed that the majority of the initiatives and interventions are focused on recycling, i.e. collection and sorting, with not very much in terms of preventing plastic waste. Therefore, there needs to be increased activity on reducing and reusing plastics.

5 Introduction to Book Chapters

The issues in this book are explored within the framework of three thematic sections: the environment for digitisation in the circular economy; digitisation in action; a digitally enabled CPE. In Chapter 2, from a multilateral agency perspective, Leonard kicks off the first section on the environment for digitisation by discussing the barriers and enabling conditions across the regulatory and institutional; economic and financial; technology and capacity; and societal and cultural dimensions. The chapter illuminates the environment that needs to be in place for a successful CPE transition. It further highlights the importance of the systems thinking approach in developing solutions and the need for the government to play a leading role in this transition. In Chapter 3, Beinisch examines the sustainable plastics regime complex – an array of partially overlapping and non-hierarchical institutions governing a particular issue area (Raustiala and Victor, 2004). She highlights that transition to a CPE is a regime complex which involves national regulators, multilateral institutions, civil society organisations and advocacy networks, market-based regulators, multinational businesses, entrepreneurs and academia. She examines how Nigerian organisations are participating in the regime complex for sustainable plastics and highlight opportunities to use it to build local institutional strength. A successful transition to a CPE requires an understanding of plastic value chains. In Chapter 4, Schröder and Oyinlola provide an overview of the plastic value chain in Africa and illustrate how digital tools and technologies can help in minimising leakage and improving material flow in the value chain. They argue that a life cycle perspective and understanding of the plastic value chains from production to end of life is fundamental to finding systemic solutions for a CPE.

The first section is concluded with Chapter 5, where Tijani, Oyinlola and Okoya utilise a practitioner's perspective along with the sectoral systems of innovation framework to examine the CPE innovation ecosystem in Africa. They postulate that the CPE ecosystem is driven by a set of local and international actors,

networks and institutions, which include development organisations like the Africa Development Bank (AfDB), civil society organisations, research institutes, academic institutions, innovation intermediaries like technology hubs, investors and entrepreneurs. They propose a process that involves systematic interactions among a wide variety of actors to drive progress, activities, and the generation of knowledge relevant to innovation.

In recognition of the heterogenous, culturally and politically diverse nature of African states, Section 2, *Digitisation in Action*, explores specific country, regional and digital technology case studies in relation to the development and implementation of different innovative ideas to drive the CPE on the continent. The case studies discussed represent diverse socioeconomic, cultural, geographical and political landscapes, in order to adequately illuminate contextual peculiarities and common theoretical and practical insights that can inform policy and practice. The section opens with Chapter 6, where Oyinlola, Okoya and Whitehead focus on additive manufacturing, also known as 3D printing, which has been recognised as a leading frontier technology that has a significant role to play in international development (Ramalingam et al., 2016). They illustrate through case study examples how local plastic waste can be converted into filament for 3D printing and used in the creation of new, innovative, locally made products which meet specific local needs. They further highlight that utilising this frontier technology (3D printing) can result in leapfrogging traditional manufacturing, which is highly capital intensive, and the technology has the ability to create new businesses and support wealth generation. In Chapter 7, Kolade continues the discussion on plastic value chains, with a focus on blockchains. He reviews the relevance and application of blockchains in the circular economy. Utilising BanQu (a blockchain solution launched in partnership with Coca-Cola Africa to improve local recycling and drive a CPE in South Africa) as a case study, he discusses the distinct set of possibilities provided by blockchains to drive a major shift in thinking and approach. He opines that blockchains can drive a major shift in perception of plastics from wastes to assets and incentivise different behaviours by offering users the opportunities to capture value from end-of-life plastic products. He further argues that adopting blockchain in the plastic value chains in Africa can offer a more transparent and accountable system whereby information from the “molecular barcode” of plastics can be publicly tagged and tracked, but not altered, through the product life cycle. In Chapter 8, Odumuyiwa and Akanmu discuss initiatives and interventions using digital tools/innovations to tackle the plastic waste challenge in West Africa. They highlight various examples of how DIs have been used to advance the CPE in West Africa. They further identify the gaps that need to be addressed. In Chapter 9, Kolade, Oyinlola and Rawn draw on in-depth interviews and focus group discussions with key stakeholders to examine the many threads held by researchers, entrepreneurs and industrialists, investors and policymakers in East Africa. They explicate the collaborative synergy of stakeholders across sectors that play a critical role in the transition to a CPE in

East Africa. They also highlight the important contributions of DIs in lowering barriers and changing attitudes among consumers and producers alike. Section 2 ends with Chapter 10, where Lendelvo, Pinto, Amadhila, Kloppers, Samazaka, Hasheela and Sifani discuss case studies from Southern Africa. They draw on cross-sectional engagement with stakeholders to highlight six opportunity areas/drivers for DI and the use of technology for the CPE, including environmental sustainability, technological and DIs, economic significance, employment creation and enterprise, livelihood improvement and gender equality.

The final section of this book draws on contributions from both academia and practitioners to make proposals for a digitally enabled CPE. In Chapter 11, Ilo, Oyinlola and Kolade draw on the extant literature to propose the BIG-STREAM framework, which highlights digital functions and strategies for a digitally enabled CPE. They highlight big data, AI, IoT, mobile applications, GIS and remote sensing as critical digital functions. In Chapter 12, Ogunde, Oyinlola, Coles make a contribution to the discourse on the global plastic crisis with particular emphasis on how plastic management in Africa can be enhanced with adequate data. They highlight that effective data collection and usage will be facilitated by a multi-stakeholder, multi-process and multisectoral approach and, therefore, argue for a plastic data exchange (PDE) platform which will facilitate collaboration between stakeholders. In Chapter 13, Okoya, Oyinlola, Schröder, Kolade and Abolfathi investigate how small- and medium-sized enterprises (SMEs) are utilising digital technology for decentralised plastic waste management solutions. They showcase case studies from around the continent and emphasise which technologies are currently employed. They observe that these start-ups' activities are focused on one or more of three key areas: subscription, collection, and processing. They add that the decentralised method used across Africa provides considerable social, environmental and economic benefits to stakeholders.

In Chapter 14, Ajala utilises machine learning for text analysis of policy description. He finds the continent's efforts ineffective at directing the continent towards a circular economy due to shallow regulations, exclusion of the informal recycling sector, enforcement problems, and lack of awareness of policies, among others. He presents some broad propositions on how digital and technological tools can be used to redirect the continent from linear to circular economy and how they can also aid in plastic waste policy effectiveness.

In Chapter 15, Wakunuma and Lendelvo interrogate the gender inequalities in the CPE and examine how DI can reduce these disparities to provide opportunities for both men and women to participate and benefit equally. They note that although some innovative approaches to the CPE have been initiated by women, generally more women still work in the lower echelons of the CPE as plastic waste pickers. They further discuss how the gender gap could be reduced when looking at DI in the CPE in Africa. They propose a gender mainstreaming approach which will result in an informative and transformative change in the CPE in as far as gender and DI are concerned.

Overall, the chapters across these three sections offer a unique insight into complex, multilayered issues of transitioning to the CPE and highlight how DIs can drive the transition to the CPE in a continent where progress has been decidedly slow. As well as identifying threads of common challenges and practices, this book weaves a promising narrative of a circular economy powered by an integrated combination of DIs, policy innovations and market processes.

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