

**Digitally enabled business models for a circular plastic economy in Africa.**

KOLADE, Seun <<http://orcid.org/0000-0002-1125-1900>>, OYINLOLA, Muyiwa, OGUNDE, Wunmi, ILO, Celine and AJALA, Olubunmi

Available from Sheffield Hallam University Research Archive (SHURA) at:

<http://shura.shu.ac.uk/33674/>

---

This document is the author deposited version. You are advised to consult the publisher's version if you wish to cite from it.

**Published version**

KOLADE, Seun, OYINLOLA, MUYIWA, OGUNDE, Wunmi, ILO, Celine and AJALA, Olubunmi (2024). Digitally enabled business models for a circular plastic economy in Africa. *Environmental Technology & Innovation*: 103657.

---

**Copyright and re-use policy**

See <http://shura.shu.ac.uk/information.html>

Digitally enabled business models for a circular plastic economy in Africa

Oluwaseun Kolade, Muyiwa Oyinlola, Wunmi Ogunde, Celine Ilo, Olubunmi Ajala



PII: S2352-1864(24)00133-0

DOI: <https://doi.org/10.1016/j.eti.2024.103657>

Reference: ETI103657

To appear in: *Environmental Technology & Innovation*

Received date: 30 December 2023

Revised date: 26 April 2024

Accepted date: 30 April 2024

Please cite this article as: Oluwaseun Kolade, Muyiwa Oyinlola, Wunmi Ogunde, Celine Ilo and Olubunmi Ajala, Digitally enabled business models for a circular plastic economy in Africa, *Environmental Technology & Innovation*, (2024) doi:<https://doi.org/10.1016/j.eti.2024.103657>

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

© 2024 Published by Elsevier.

**Title: Digitally enabled business models for a circular plastic economy in Africa**

Oluwaseun Kolade<sup>1\*</sup>, Muyiwa Oyinlola<sup>2</sup>, Wunmi Ogunde<sup>3</sup>, Celine Ilo<sup>2</sup>, Olubunmi Ajala<sup>4</sup>

<sup>1</sup> Sheffield Business School, Sheffield Hallam University

\*Corresponding author: seunkolade2014@gmail.com

<sup>2</sup> Institute of Energy and Sustainable Development, De Montfort University, Leicester, UK , LE 1 9BH

<sup>3</sup> School of Engineering, University of Warwick, Coventry, UK CV4 7AL

<sup>4</sup> School of Economics, Finance and Accounting, Coventry University

**Abstract**

In recognition of the need for an economic logic that complements and reinforces the ecological imperative for the circular plastic economy, this paper explores the importance and impact of digitally enabled circular plastic business models across retailing and distribution systems. The paper draws from 16 focus group discussions, complemented by 17 semi-structured interviews of frontline organisations incorporating digital innovations in their businesses to enable the management of plastic waste in Africa. The study finds that, across African countries, the transition to a circular plastic economy has been hampered by the limited uptake of circular products by consumers. In order to accelerate the transition, innovative business models are required to invigorate the ecosystem and simplify the logistics of retailing and distribution systems. The paper proposes a new conceptual framework that explicates the impact of digital innovations in the processes of value creation and value capture across a whole spectrum of circular economy reverse logistics activities: recycling, redistribution, and remanufacture. The study also highlights two important social and policy implications of digitally-enabled circular business models: Firstly, the creation of new employment opportunities through the empowerment of a new labour force for the circular plastic economy; secondly, the heightened opportunity to enact an innovative sharing economy in typically resource-constrained contexts in which otherwise idle products and resources are more efficiently used in a process of collaborative consumption.

**Keywords**

Circular economy; Circular plastic economy; Digital technologies; Business models; Sharing economy; Reverse logistics

**1. Introduction**

Global conversation about the merits and imperative of a circular economy has gained significant traction over the past decade. Along with this, scholars and stakeholders are focusing attention on market arguments for the circular economy, recognising this as a key factor in challenging, and changing, the entrenched production systems and consumption habits associated with the linear economy paradigm of make-take-dispose. In other words, the global circular economy campaigns need to be backed up by circular business models that effectively create, deliver and capture value through the creation and distribution of circular products and services. On the African continent, discussions about circular business models are in relatively earlier stages of development. Yet the continent arguably offers the most promising opportunities for creation and expansion of new markets for circular products and services. The

reasons for this are two-fold. Firstly, because African countries are still in relatively earlier stages of industrialisation, they are not locked in to old, “dirtier” technologies, and are therefore relatively less susceptible to lock-in mechanisms of sunk investment, economies of scale, economies of scope, network externalities and technology inter-relatedness, among others (Kolade et al., 2022). Secondly, widespread unemployment and poverty across the continent paradoxically offer new opportunities to create an inclusive economy that empowers new economic actors through the implementation of innovative, circular business models (Morais et al, 2022).

The present study focuses on the pressing challenge of plastic pollution and the market opportunities offered by the circular plastic economy in Africa. Plastic pollution is a major environmental challenge of the 21<sup>st</sup> century (Hildago-Crespo et al, 2022), and African countries are especially vulnerable because of limited institutional capacities and policy attention to mitigate the deleterious impacts of plastic waste (Oyinlola et al, 2022). Across the coasts of Africa, millions of tonnes of plastics are being dumped annually, a significant portion of which originates from outside the continent’s shores. In examining the complex and escalating plastic waste crisis in Africa, it is imperative to consider the entire value chain, including production, usage, and disposal stages (Kolade, 2023; Schröder and Oyinlola, 2023; Hildago-Crespo et al, 2020). The continent grapples with a critical challenge: less than 5% of its plastic waste is recycled, leaving the vast majority to be managed through unregulated means such as landfills, open burning, and water body disposal (UNEP, 2018; Babayemi et al., 2019). This issue is examined through comparative analyses of plastic waste management practices in Rwanda, Kenya, and South Africa, shedding light on the variances and commonalities across national strategies (Uche, 2023).

While Sub-Saharan Africa currently contribute the least to global plastic waste, its burgeoning population, evolving consumption patterns, and rapid urbanisation are projected to significantly increase plastic waste generation (Moyen Massa and Archodoulaki, 2024). Current insights into Africa's plastic value chain are sparse, yet it is known that the continent’s plastic production is considerably lower than in other regions, accounting for merely 7% of global output in conjunction with the Middle East (Babayemi et al., 2019; Mofo, 2020). To satisfy local demand, a substantial number of polymers and plastics are imported, with an estimated 172 million tonnes brought in from 1990 to 2017 across the 54 African countries (Babayemi et al., 2019).

Initiatives like Rwanda's prohibition of single-use plastics, with similar bans implemented by 36 African countries (Attafuah-Wadee and Tilkanen, 2020), highlight the pressing necessity for all-encompassing strategies that not only aim to minimize waste but also promote recycling and sustainable consumption habits. The 2018 ban on plastic waste imports by China has significantly impacted the global flow of such materials, resulting in a marked increase in the amount of plastic waste being imported into African countries. Regarding consumption, data indicates that per capita plastic usage was around 16 kilograms in 2015. Moreover, the United Nations has reported that approximately 99% of plastics are used for less than six months (Ayeleru et al., 2020; Babayemi et al., 2019). Amidst these challenges, the last decade has seen the emergence of numerous small-scale enterprises that collaborate closely with the informal sector. These entities are pioneering the reclamation of plastic waste as a valuable economic resource, marking a significant step towards addressing the continent’s plastic waste problem (Oyinlola et al., 2022). However, much of these efforts continue to be driven by sheer necessity

and survival imperatives, and little is known about emerging circular business and innovation ecosystems and associated market opportunities that can accelerate the transition to a circular plastic economy in Africa.

Furthermore, much of the extant scholarship and current campaigns for circular plastic economy, globally and within the African continent, have focused mainly on the environmental and sustainability imperative. These will continue to have compelling and critical relevance in the global conversation. Within Africa, the pertinence of the environmental and sustainability imperative is accentuated by the wide-ranging and far-reaching social and economic impacts of plastic pollution. The increasing volume of plastic waste in Africa has upended community livelihoods and induced poverty through the deleterious effects of plastic wastes on the natural ecosystem and the entire marine habitat. Still, the challenge of plastic wastes has persisted due to the overriding economic logic and lock-in mechanisms that drive the linear plastic economy, making it a source of profit and wealth for many in the linear ecosystem.

Digital technologies can play a key role in the drive to upend the lock-in to linear economy and promote new habits of production and consumption (Kolade et al, 2022). With regard to circular design and manufacturing, digital technologies are essential in advancing the development of recyclable and sustainable products. These innovations support the creation of goods designed with their lifecycle in mind, ensuring that they can be reused, repurposed, or recycled effectively, in line with the objectives of a more sustainable and environment-friendly circular economy. Some frontier technologies, like 3D printing, are also well suited for re-manufacturing using recyclable products. In terms of consumption, digital innovations enable the mobilisation of an inter-sectoral network of consumers and stakeholders to popularise circular products and generate new economic opportunities for other actors in the circular value chain. For example, digital platforms that facilitate product tracking and materials passports can empower consumers and stakeholders to participate actively in the lifecycle of products. Similarly, innovations like blockchain technology can create transparent supply chains, ensuring that materials can be traced back to their origins (Kolade, 2023). This enhances accountability and provides new economic opportunities for other actors in the circular economy ecosystem.

Given this background, this paper makes two important contributions to the extant literature: firstly, it underlines and explicates the importance of a market driven approach to circular plastic economy on the African continent, an underexplored area that has not attracted significant attention among scholars. It also highlights the possibilities and opportunities for digital transformation of the African informal circular plastic economy and the concomitant empowerment of otherwise invisible informal actors such as waste pickers. In terms of policy implications and practical applications, the paper explores a market case for circular plastics as a potential game changer, in terms of its capacity to focus the minds of stakeholders, create demands and empower otherwise economically invisible actors to harness the new opportunities offered by a circular plastic economy.

Thus, in order to drive the transition from a linear to a circular plastic economy, there is a need for an economic logic that complements and reinforces the ecological imperative. Profit and sustainability need not be a zero-sum game. The circular economy has to be “good” business, economically and ecologically, in order to harness the enlightened self-interest and commitment of stakeholders towards innovative models of responsible production and new

habits of sustainable consumption. Such socio-technical transition requires a combination of innovative circular business models and digital innovations to promote it. This paper therefore raises two related research questions: firstly, in what ways can digital technologies enable new business model innovations in the circular plastic economy in Africa? Secondly, what are the impacts of digitally enabled circular business models across the supply and value chains for employment generation and market growth? The first research question is conceptual; the second empirical. The research questions will help to unpack the processes through which digital innovations enable stakeholders to create, deliver and capture new forms of value in the circular plastic economy; and the impacts of these innovations for retailing and distribution of circular plastic products.

The rest of the paper is organised as follows: first, we begin with a review of the literature on circular business models, before narrowing down to the circular plastic economy and the relevance of digital technologies. This is followed by an outline of the methodological approach, and the presentation of findings from a recent qualitative study of circular plastic innovators across the African continent. The results are then discussed in the light of their impact on retailing and distribution systems. The paper concludes with critical reflections, implications for policy and practice, and recommendations for future research agenda.

## **2. Literature review**

### *2.1 Circular Business Models*

In recent times, scholars have acknowledged the necessity for significant shifts in conventional business strategies, value chain operations, and ultimately, business models toward advancing global circular economy ambitions (Rosa, Sassanelli and Terzi, 2019; Ferasso *et al.*, 2020; Toth-Peter *et al.*, 2023). According to Bican and Brem, (2020), the business model concept is understood as a firm's fundamental logic and preferred strategic approach for generating and capturing value across its business operations. Similarly, Ferasso *et al.*, (2020) surmise that the business model approach facilitates the holistic examination of an organisation's value creation process by outlining certain complementary activities, decisions, functions, and systemic elements that are all interconnected. Early definitions of the concept highlight three main value areas including: value proposition (Berman, 2012; Baden-Fuller and Haefliger, 2013), value creation (Beattie and Smith, 2013; Bocken *et al.*, 2014), and value capture (Teece, 2010; Zott and Amit, 2001). The business model paradigm evolved simultaneously with an increasing requirement for faster and more efficient strategies for systematically analysing, organising and disseminating complex business ideas tailored towards a boost in organisational performance and increased competitive advantage (Lopes de Sousa Jabbour *et al.*, 2019). In addition, businesses are currently under rising pressure to evolve beyond the current firm-centric mode of operation to systemic/network-centric methods involving engagement with diverse actors, society, and the environment. Such transformation requires innovative re-evaluation and redesign of existing business models, making business model innovation an essential competency for business firms and organisations (Pieroni, McAloone and Pigosso, 2019; Moktadir *et al.*, 2020). The business model innovation concept suggests substantial purposive transformation to the structure and fundamental components of business models (Bican and Brem, 2020). Business model innovation entails the development of new business models, diversifying into distinct types of business models, the procurement of new business

models or the conversion from one business model to another Geissdoerfer, Vladimirova and Evans, (2018). It also incorporates social and environment objectives alongside economic outcomes in what has been described as. triple-layered model of economic, social and environmental value creation (Kolade et al, 2021).

Fogarassy and Finger (2020) highlight 'linear risks' in business-as-usual procedures that contribute to adverse trends. These include the scarcity of primary resources, price instability, reduced efficiency in supply chains, lower renewable energy costs, and restrictions on waste trading. Scholars have also argued that the economic benefits of linear industrial systems have become threats to modern businesses (Salvador *et al.*, 2020; Andersen and Wicken, 2021). This necessitates the adoption of proactive measures to promote sustainable resource utilisation by virtue of more sustainable business models.

The incorporation of circular economy principles in business models offers an opportunity to achieve enhanced resource efficiency, dynamic competitive advantage and value chain productivity (Bocken and Geradts, 2020). It proposes a new model of resource flow i.e., 'extract-use-waste-renew' distinct from the conventional linear pattern of resource flow i.e., extract-use-waste. This is achieved through a disruption from existing linear resource cycles towards closed-loop resource flows, such that the utility and environmental value of resources is sustained whilst economic value is concurrently extended (Urbinati, Chiaroni and Chiesa, 2017; Rehman Khan *et al.*, 2022). Research in the field of manufacturing suggests that the principles of the circular economy are ideally suited to business model innovation strategies. The incorporation of these principles into well-known business models defines what is known as the circular business model paradigm (Pieroni, McAloone and Pigosso, 2019).

Circular business models are business models that help to minimise resource consumption, waste and emissions from an organisational unit through the processes of cycling (recycling measures), extending (prolonged usage), intensifying (more intense use and value maximisation) and dematerialisation (replacement of physical commodities and service with software-based solutions) of energy and material cycles (Geissdoerfer *et al.*, (2020). However, in the domain of business models and industrial operations, experts have grappled with the impracticality of a completely "circular" system, devoid of any material or energy loss/leakages (Centobelli *et al.*, 2020; Geissdoerfer *et al.*, 2020; Salvador *et al.*, 2020). Accordingly, circular business model innovation describes the design and implementation of new or diversified business models in alignment with circular economy principles and practices. This may significantly impact the entire value chain, the business model and its components or the relationships between its elements (Geissdoerfer *et al.*, 2020; Guldmann and Huulgaard, 2020). It targets a disruption in the way economic value and product development are approached, to promote resource efficiency i.e., narrowing, slowing and eventually closing material and energy cycles (Pieroni, McAloone and Pigosso, 2019).

Urbinati, Chiaroni and Chiesa, (2017) suggest three modes of adapting circular economy principles into existing business models. Firstly, the *upstream circular* process which entails introducing adjustments to the value proposition and value creation aspects of business models. These include circular product and process design i.e., design for X(DfX) and development to enable reverse logistics (redistribution and reuse, remanufacturing, and recycling) subject to

the influence of various stakeholders, including investors, manufacturers, producers, and suppliers. Secondly, the *downstream circular* processes which encompasses value capture and delivery through the implementation of novel revenue schemes and innovative customer engagement strategies, such as product dematerialisation and servitisation (pay-per-use models), involving the activities of retailers, customers, and end users. And lastly, *the fully circular* which integrates both upstream and downstream circular economy processes and business stakeholders, with the ultimate objective of achieving a balance in benefits accrued for the environment and the economy (Urbinati, Chiaroni and Chiesa, 2017; Centobelli *et al.*, 2020; Urbinati, Franzò and Chiaroni, 2021).

Effective management for reverse logistics requires greater expertise and resources, compared to forward logistics, thus novel technologies, infrastructure and platforms must be in place to facilitate the exchange of relevant information between internal and external associates as well as the overall system efficiency (Moktadir *et al.*, 2020; Rasool *et al.*, 2023). For example, plastic retailers, as major stakeholders in the downstream value chain occupy a strategic position in the drive towards the circular economy because they are the link between producers/wholesalers and consumers (Butt, Ali and Govindan, 2023). They can be critical conduits of awareness campaigns and public education in a committed drive to shape public opinion and re-orientate consumers towards the adoption of circular habits of consumption (Vadakkappatt *et al.*, 2021). In addition, sustainable retailing is increasingly seen as a competitive imperative, as plastic companies seek to differentiate themselves from others, and thereby attract new and loyal customers, by emphasising their sustainability values (Alzoubi *et al.*, 2020).

## 2.2 *The business case for circular plastics*

In contrast with traditional linear business models, circular business models aim to extract greater value from every unit of resource (Maio and Rem, 2015). They can be rightly seen as an industrial model that facilitates the decoupling of economic growth from material input. Extant scholarship has recognised the vital role that circular business model can play within the plastic industry. For example, the application of the circular business model can contribute to slowing and closing the plastic material loop (Whalen, 2019) The escalating demand for plastic has increasingly highlighted the critical issues associated with excessive use and reliance on plastic materials in developing African countries (Klemeš, Fan and Jiang, 2020).

African countries are progressively exploring and adopting circular plastic business models as they navigate the complexities of sustainable materials management. There is therefore an auspicious opportunity to shape the future of the market for circular plastic products. Circular plastic business model are promising business strategy that can promote economic benefits while also promoting environmental conservation, economic opportunities and ensuring sustainable impact (Khan, Razzaq, *et al.*, 2021) circularity activities such as recycling, reuse, repurposing, retailing and remanufacturing, redistribution of plastic materials can have directly or indirectly social impact when it comes to managing plastic waste challenges (Maione, Lapko and Trucco, 2022; Oyinlola *et al.*, 2022). For example, Nielsen, Holmberg and Stripple, (2019) concluded that plastic bags have become an indispensable companion to many consumers, and this is despite intensified conversations around single-use plastics awareness (Evide *et al.*,



2021). This makes an important case for the adoption of a more sustainable supply chain through circular plastic business models as a substitute for the current methods of managing plastic waste (Geissdoerfer et al., 2020).

The push for long-term sustainability plans must operate alongside detailed policies to guide supply chain optimization; consumer education to promote engagement and innovation to ensure collaboration for a successful circular plastic system to drive economic growth in Africa (Maione *et al.*, 2022). In addition, the business model simply ensures full maximisation of the plastic material and product (Khan, Zia-ul-haq, et al., 2021). The plastic industry supply chain can benefit from policies such as the Extended Producer Responsibility (EPR). The introduction of the Extended Producer Responsibility (EPR) principle in most developed countries has also emerged as a vital tool promoting the actualisation of a circular economy for plastic products. Similarly, Schröder et al., (2023) suggested that the introduction of plastic policies on a national level is a critical component that has the potential to shape the circular plastic economy, especially in Africa. For example, the EPR policy has encouraged recycling and upcycling start-ups businesses in Nigeria to valorise post-consumer plastics which has become a massive business opportunity, advancing the concept of circularity to create and capture value across the plastic value chain (Dijkstra, Beukering and Brouwer, 2020). Furthermore, it is characterised by an economic instrument that offers product manufacturers financial rewards to enact the EPR policy through a variety of means. These include advance disposal fees (ADF), which are charges levied on specific items at the point of sale according to the estimated costs of waste collection and treatment with the intention for use in meeting the financial demands of EoL management of the purchased product (Pouikli, 2020). However, the full potential is yet to be attained as a strict enforcement of this policy is lacking (Oyinlola et al., 2022). Nonetheless, there are promising opportunities for these policies to ensure businesses that operate within the plastic sector rethink its mode of operation and contribute to optimising inventory, forecasting, logistic scheduling, thereby improving the efficiency and effectiveness of retailing and distribution system within the plastic industry (Sylvester and Ikudayisi, 2021)

Consumer education plays a vital role in driving the circular plastic economy. Raising the awareness of circular plastic business model and its potential environmental and social benefits can promote consumer engagement and rapid adoption. For example, the launching a recycling awareness program can incentives consumers will increase recycling rate and promote behavioural change and minimize plastic pollution (Soares et al., 2021).

Collaboration plays a key role for the circular plastic business model to create shared value. A close collaborative system can contribute to scaling up the operations within circular business model (De Angelis, Howard and Miemczyk, 2018). For example, initiatives such as Africa Circular Economy Network facilitate partnerships between various stakeholders to foster mutually beneficial relationships for material redistribution that will enhance supply chain operations (Desmond and Asamba, 2019). The success of a circular business model requires the coming together of many companies and stakeholders within the eco-system to close the loop within the plastic industry (Antikainen, Uusitalo and Kivikytö-Reponen, 2018) .

According to (Dijkstra, Beukering and Brouwer, 2020), digital innovations are also essential for the effective implementation of the circular business model. The objective of the circular

business model is to maintain the value of plastics in the economy and keep them in circulation (Getor, Mishra and Ramudhin, 2020). In addition, it also offers a chance to guarantee a seamless supply chain management, provide consumers with real-time information, and co-create by facilitating collaboration among stakeholders.

### *2.3 Digital innovations for circular plastic business models*

Digital Innovations are at the heart of business model innovations in the 21<sup>st</sup> century where the ubiquity of the internet and the rapid pace of digital transformation offer new vistas of opportunities for businesses to create, deliver and capture value. This is arguably more important for the circular economy, where the opportunities for creative destruction and disruption of the linear economy lend themselves to the innovative deployment of digital technologies. The application of digital technologies in the circular plastic economy is highlighted by the development of mobile apps to mobilise and connect a wide range of stakeholders, the deployment of digital finance to incentivise plastic waste collection, the application of blockchain solutions for traceability and transparency of circular plastic supply chains, and the application of 3D printing to create new products, thereby delivering value for consumers, and elongating plastic lifecycle.

Firstly, the development of mobile apps has played a key role in the implementation of innovative business models in the circular plastic retail markets. Mobile apps can help facilitate a more efficient collection of plastic waste, thereby mitigating resource constraints for upcyclers (Shan, Neo and Yang, 2021). They can also serve as effective platforms for the open exchange of upcycling know-how. Furthermore, the deployment of mobile payment technologies has enhanced the value of mobile phones, transforming them into financial platforms (Kurniawan et al., 2022). This potentially brings millions of consumers and regular households into the circular plastic market, enabling them to undertake online transactions of recycled products. In this respect, mobile apps can be integrated with blockchain solutions via blockchain tokens that can be used to mobilise and incentivise households, especially in low-income communities to be actively involved in plastic waste collection and sorting (Verma et al., 2022). These integrated mobile apps have also been used to organise deposit refund systems (Reloop Platform, 2022).

In addition to their integration into payment technologies and applications in digital tokens, blockchain technology can enable the transformation of linear supply chains into circular supply chains in order to optimise resource allocation and promote sustainability. It harnesses the three key principles of trust, traceability and transparency to integrate three supply chain reverse processes- recycle, redistribute and remanufacture (Centobelli et al., 2022). This enables recyclers and other stakeholders to easily access and monitor key product information such as quality, quantity, location and ownership (Huang et al., 2022). In addition to these information transparency features, blockchains also offer new pathways for value creation and value capture by facilitating open innovation and knowledge exchange about novel, sustainable plastic production processes using, for example, cloud-based knowledge sharing systems (Li et al., 2018)(Li et al., 2018)(Li et al., 2018)(Li et al., 2018)(Li et al., 2018)(Li et al., 2018)(Li et al., 2018)(Li et al., 2018). Furthermore, blockchains can drive process optimisation in the logistics of plastic manufacturing process, including optimisation of transportation route maps and schedules, and the use of smart contracts to manage the interaction between traders, thereby avoiding cheating that is often associated with manual systems (Xu and He, 2022).

For remanufacturing, 3D printing offers highly promising potential as an enabler of innovative circular economy business models (Chaudhuri, Subramanian and Dora, 2022). By favouring the economy of one in place of the economy of scale that underpins traditional, subtractive manufacturing, 3D printing upends the structural and resource advantage of big manufacturers, bringing SMEs and local microenterprises into play (Kolade, Adegbile and Sarpong, 2022). It also removes the need for centralised high-volume production and large inventory stocking. These characteristics are well suited to a circular plastic economy, as local SMEs can use plastic wastes to make filaments for 3D printing of new products (Oyinlola et al., 2023). Partly as a result of the economy of one and the unique opportunities for customised products, 3D printed products from plastic wastes have been shown to be cost-effective, in one reported example costing 10% less than traditionally manufactured products (Heikkinen et al., 2018).

Bringing the above discussions together, we introduce a conceptual framework to highlight the key mechanisms through digital innovations can drive value creation and value capture across the three key supply chain reverse processes: recycle, redistribution and remanufacture (Figure 1).

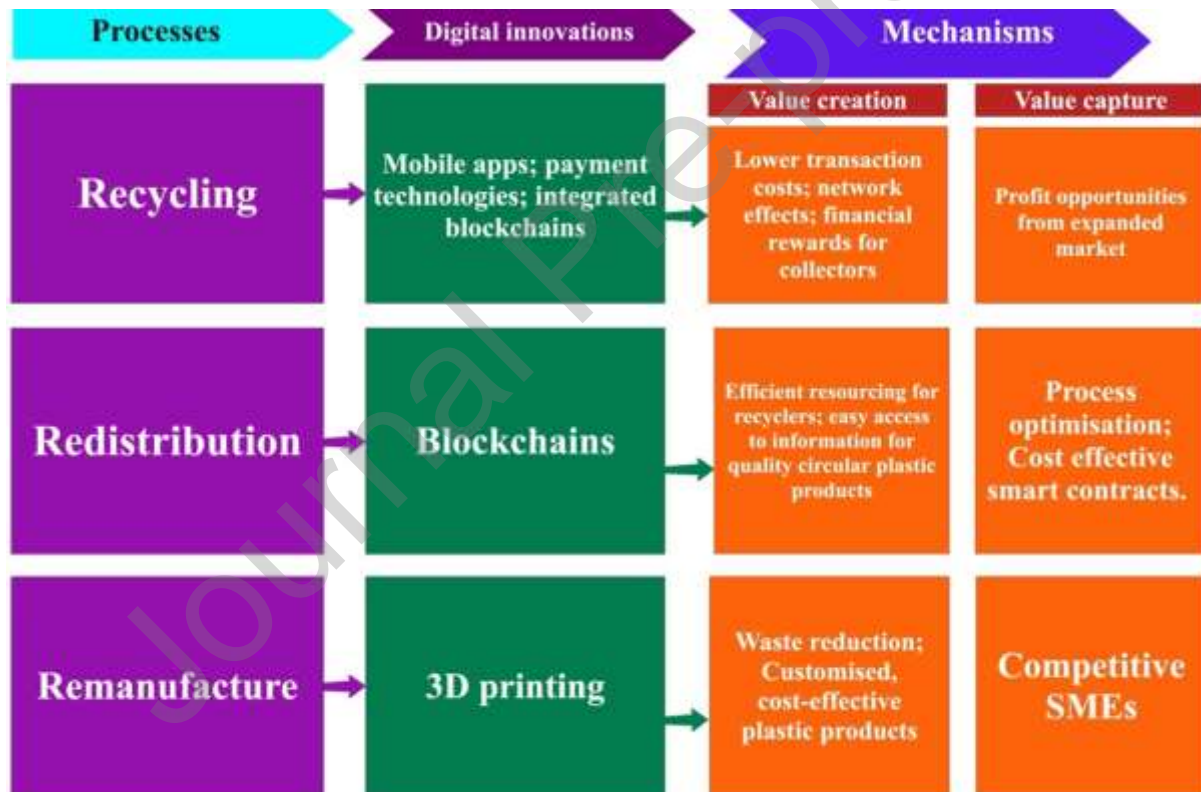


Figure 1. Digital innovations for value creation in CPE

### 3. Methodology

#### 3.1 Focus group discussions and semi-structured interviews

To gather in-depth qualitative data on the circular plastic economy and the use of digital innovations for managing plastic waste in Africa, a series of focus group discussions was conducted. Stakeholders from Southern, Western, and East African regions, including Namibia, Zambia, Nigeria, Kenya, Uganda, and Rwanda, were engaged from June to October 2020. The discussions involved participants from five distinct categories: innovators and start-

ups, academic researchers, government representatives, civil society members, and investors. This diverse mix ensured a comprehensive view from all sectors involved in plastic waste management and yielded a total of 16 focus group sessions. The selection of these locations was strategic, aimed at capturing a wide array of insights representative of the entire African continent. By incorporating opinions from these varied regions, the research aimed to reflect the continent's diverse challenges and innovations in plastic waste management.

Complementing these discussions, a tailored semi-structured questionnaire was sent electronically to 39 organisations identified through literature reviews and databases as key players deploying digital innovation in waste management practices on the continent. Of these, 17 organisations completed the semi-structured questionnaire, providing additional nuanced data. The instruments for both the focus groups and the questionnaire were meticulously crafted to align with established concepts and principles from existing literature, ensuring that the data collection process was both rigorous and relevant to the study's overarching goals. Full profiles of the organisations were described in Oyinlola *et al.*, 2022).

### 3.2 Thematic analysis

The transcripts of the focus group discussions and electronic semi-structured interviews were cleaned and then fed into NVivo 12 for processing and thematic analysis. In line with the six-step procedure recommended by Braun and Clarke, (2006), we first read and re-read the transcripts, noting down initial ideas captured in a series of vignettes. These vignettes were mapped, in the third step, against first order themes. In the fourth step, the first order themes were reviewed to generate a thematic map of the analysis. In the fifth step, the themes were refined and defined against aggregate dimensions, as outlined in Figure 2. In the final step, compelling extract examples were selected from the themes to explicate the key ideas in relation to the extant literature.

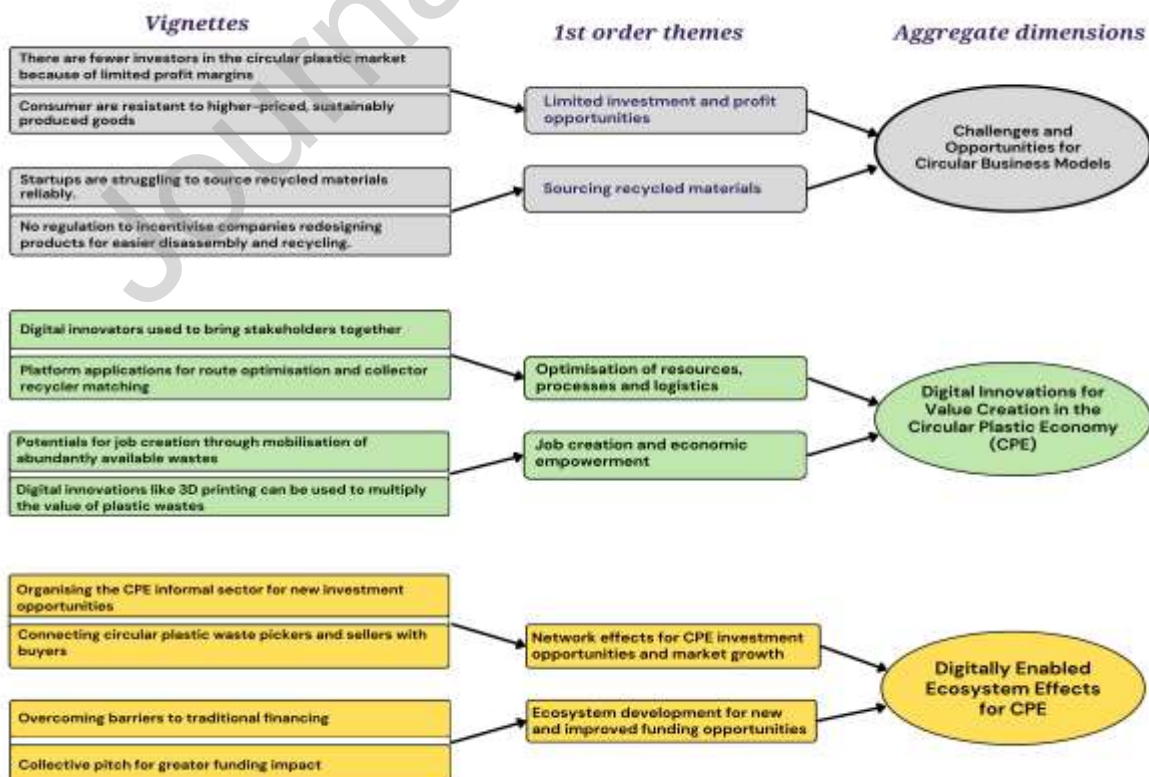


Figure 2. Vignettes, first order themes and aggregate dimensions

The Tables 1 and 2 below provide an overview of focus group participants and a profile of 17 organisations engaged in circular plastic innovations across African countries. In the next section, the excerpts from the themes are highlighted with initial descriptive commentaries. This is then followed by a more detailed discussion in the light of previous studies and in relation to the study's research questions.

Table 1. Overview of focus group sessions

Stakeholder Group	Country/Region	Number of Participants	Date
Academia	Nigeria	4	Thurs, 15th Oct 2020
	Namibia	4	Wed, 7th Oct 2020
	Rwanda	3	Thurs, 15th Oct 2020
Civil Society	Nigeria	4	Tue, 29th Sep 2020
	Namibia	5	Thurs, 1st Oct 2020
	Rwanda	2	Fri, 16th Oct 2020
Digital Innovators and Start-ups	Namibia	8	Thurs, 1st Oct 2020
	East Africa	4	Fri, 16th Oct 2020
	Southern Africa	6	Thurs, 22nd Oct 2020
Government and Policy makers	Rwanda	3	Tue 13th Oct 2020
	Namibia	3	Wed, 14th Oct 2020
Parastatals and projects within government	Namibia	3	Wed, 14th Oct 2020
Investors/Funders	Africa	3	Wed, 14th Oct 2020
	Namibia	4	Wed, 14th Oct 2020
Waste Management Organisations	Nigeria	4	Tue, 29th Sep 2020
	Rwanda	6	Tue 13th Oct 2020
	Namibia	3	Fri, 2nd Oct 2020

Table 2. Profile of circular plastic organisations

S/N	Innovators	Location	Value from digital technologies	Regulation facilitating innovations	Success narratives
-----	------------	----------	---------------------------------	-------------------------------------	--------------------

1	Bianca and Scofield Trading (B&S Trading)	Namibia	Help to do research, promote business and networking	Regulations of solid waste management	Successfully established the business in a way that we can turn waste into pavers.
2	Chanja Datti Ltd	Nigeria	Streamlining process	Not applicable	Won numerous awards.
3	ComeRecycle	Nigeria	Seamless interaction with users	Crowdfunding.	N/A
4	Epupa Cleaning Services cc	Namibia	Faster communication methods and increase productivity	Proper waste disposal. Legislative action to restrict single use plastic distribution is an effective way to decrease plastic pollution.	Achieving a milestone of 15 years as women in tackling sustainable environmental management and recycling, facilitating job security and contributing to the countries objective on minimising the unemployment rate.
5	FMK Motor design	Namibia	Helps to promote the business	Not applicable	I am happy with the results from the experiment, and I am confident that it will work successfully
6	GIVO	Nigeria	Transparency and verifiable data	Not applicable	In last 10 months, collected over 5 tonnes and made over 10,000 units of consumer goods from recyclables. created jobs, improved environment, provided financial inclusion
	GreenAxis	Nigeria	Broad market view and larger brand audience	None	We post prototype and already developing supply chain network
8	Libe Green Innovation	Tanzania	Networking	Business regulations authority a lot of process	Recognized by UNDP Indonesia and as a 100 top young leader in conservation Africa but also partnership with DANSIC21 and WWCA winner Award 2021. And also, Tony Elumelu alumni Grants 2019
9	Mckingtorch Africa	Ghana	A lot of value. Operating mostly online	-	Partnerships with University of Michigan and Brighton, won 3 grants, exhibited to Prince of Wales, build two waste segregation houses for two schools, trained over 3000 people in Ghana and Nigeria, contributed to Ghana, Aô's National Waste Management Policy document, public space bin installations
10	RecycleGarb Hub Ltd	Nigeria	Easy tracking of subscribers. Saves time and energy	None in Ibadan Oyo State.	Top100 Global recycler 2020. Winner of Under40 Green Award.

11	RecyclePoints	Nigeria	Digital Technologies drive efficiency and supports our scaling up	Logistics Optimization and Human Capital Management	RecyclePoints won maiden Aso Villa Demo Day Award
12	Recycling Lab	Namibia	It highlights the complete picture of the problem we are trying to solve		Won the Africa Youth in Tourism Innovation Award from Africa Tourism Leadership Forum 2020. Also selected for the EIF Sustainable Development Award in May
13	Robur Foundation: Environment ECHO	USA	Visibility, credibility, feedback from customers, broader reach to potential customers, seamless workflow	Deposit return scheme requires regulation.	None for now
14	Salubata	Nigeria	Major acquisition channel	No part	Won the silver prize at Princeton Africa Summit 2020. Overall winner of Africa innovation week. To represent the African region at Silicon Valley at the start up world cup in 2021. Winners of the extreme tech challenge. to represent the African region at the global final presented by TechCrunch. Winners of the Circularity award in 2021.
15	Street Waste Company Limited/waste for income	Nigeria		.	.
16	Tonge Engineering Limited	Zambia	Identifying hotspots for plastics	Tax exemptions on imports that are meant to help us process plastics Collection is facilitated by regulation. Color and grades of plastic is facilitated as well.	None yet
17	Trash Monger	Nigeria	Larger client base, access to cleaner and higher quality waste materials	Production and recycling process are not facilitated by regulation.	About 25 people have gained employment through Trashmonger. Over 350 tonnes of plastic have been recovered

## 4. Results

Three higher order themes were identified from the transcribed data: challenges and opportunities for circular business models; digital innovations and value capture in CPE; and the ecosystem effects.

### 4.1 Circular business models: challenges and opportunities

The focus group participants highlighted a number of issues relating to the viability of circular business models and the struggle enterprises have faced with investment opportunities and market traction. In the focus group for *Zambian start-ups*, participants highlighted the challenge of scalability and the concerns investors have about profit margins:

I feel like those are the barriers to scaling because most business models in the recycling sector do not attract investment because of the flaws they have. Because if I'm an investor looking to put money in a recycling business, I need to know what my margins are. We need to be very honest with ourselves that developing a business model in the waste recycling sector is quite difficult I would tell you (Speaker 3, *Zambian Start-ups Focus Group, Lusaka, October 2020*).

I think the biggest challenge is making the business models in waste recycling more attractive to scalability or to attract funding, and if there's a way to improve their margins, you know around profits because I feel like that's the biggest challenge. Everybody is kind of like "We do waste recycling." What are we investing in? What is the cost of what? What is the cost of actually collecting this waste? OK, what is the cost of us selling it to the recycler because your business model is not refined (Speaker 4, *Zambian Start-ups Focus Group, Lusaka, October 2020*).

In order to address this identified flaws and gaps in business models, university researchers are stepping into the space to offer consultancy services for businesses and public sector organisations. In *Namibia*, researchers are working with local councils and other stakeholders to help undertake evaluations and refine the business case for circular plastic, as the following focus group participant surmised:

So, we worked with the Oshakati Town Council. And we talked about that, and we started different research. So, we quantified the waste in Oshakati, then we sort of did the business case, what is the economic potential of recycling and how much. What's this volume of business that can be generated? Then we've done a study on various models, cooperative models, or should we go with big factories and things like that? We've done that. (Speaker 4, *Namibia Academia Focus Group, Windhoek, August, 2020*)

Other stakeholders and smaller enterprises are tackling the challenge of market traction by actively seeking partnership with larger corporations with environmental values. These include partnership with companies who have a strong commitment to designing products for easier disassembly and recycling, and those who use recycled material in their production activities. In *Nigeria*, an umbrella organisation of circular enterprise owners formed a partnership with a cement company:

One of the major things we have also done is we've had a partnership with Lafarge. Lafarge is a cement company that uses alternative forms of fuel to for their cement processing. So, there is a process that they've just initiated which is called coprocessing. They use alternate fuel derived from another source of fuel that may not be coal or fossil fuels (Speaker 3, *Nigeria Start-ups, Lagos, October 2020*).

### 4.2 Digital innovations for value creation in CPE

Partly in response to the challenges of viability and scalability associated with circular business models, focus group and interview respondents have identified the critical importance of digital



innovations as key drivers of value creation and value capture in the circular plastic economy. One of the key impacts for circular enterprises is the deployment of digital innovations to lower costs through optimisation of resources, processes and logistics. Through digital platforms, innovators are able to bring together key stakeholders such as waste pickers, transporters and recyclers in a more efficient collaborative synergy, as these focus group participants highlight:

Our primary focus is on optimising Uh, processes and workflows for organizations and in the waste management sector. We basically help companies that are engaged in recycling and disposal optimize their logistics and recovery of materials from source to final disposal (Speaker 8, Zambian Start-ups Focus Group, Lusaka, October 2020).

“...they can also engage with consumers and say, informal waste pickers out there on a digital platform. They can then have much more better-informed insights into their operation as a whole, and we feel that if such companies become profitable. It essentially means that the waste pickers can then supply more waste. If the transporters are more efficient, more waste can be recovered, and so more waste can be sold to processors and so more revenue can be generated in the market and so we see the application of digital technology and the transportation of Waste materials weather for the driver to scale in the sector” (Speaker 8, Zambian Start-ups Focus Group, Lusaka, October 2020).

One example of these digital platform applications was set up by Yo Waste, a Ugandan circular Start-up. It has gone on to achieve considerable success through its deployment of various features including route optimisation and collector-recycler matching features. Altogether these enhance the efficiency of the waste collection and recycling processes, as this FG participant describes:

We have an application for customers whereby. This application gets the exact location of a customer and helps connect them to a reliable, affordable waste collector in the area, right? So, these people don't really have to rely on that front collector was to check out the problem of inefficiency. What we do is that this person signs up with Yo Waste and they say I want a collection (Speaker 3, East African Start-ups and Innovators, Virtual Interview, August 2020)

Imagine a system whereby a person, uh, that has a smart form right, can download an application. Application can be able to pick their, uh, their geo location, let it be their home or their office, and ...this person can be able to search for a collector in their vicinity and when they find this collector, this collector will be able to come and collect at no extra cost...So imagine something like that and then go ahead and add in something like this waste collector is also given a mobile application that allows him to manage jobs from other clients. Because we didn't only talk to customers, but we also went ahead to talk to these west collectors' haulers because customers had problems like inefficiency (Speaker 3, Rwandan Start-ups and Innovators, Kigali, August 2020)

Others highlighted the potentials for job creation by deploying digital technologies to mobilise and sort abundantly available disused resources for value creation and value capture, though, for example, the re-use of plastic wastes in additive manufacturing. This can play a key role in the economic empowerment of informal sector workers:

I mean Zambia, has a population of about 18 million people and 35% of that population is the youth. And among the youth, there's a 16% unemployment rate. So now you wonder to say look, there's an industry here in which resources are largely available. And then you, you wonder to say OK, why isn't there public and private sector engagement? Because this is actually an industry...if I can put it to you honestly, that if we were to mobilize ourselves as a sector and the players in charge, we could reduce unemployment rate significantly (Speaker 6, Zambian Start-ups Focus Group, Lusaka, October 2020).

from a technical perspective, when we look at the collection of waste materials, whether for disposal or reuse, or perhaps recycling. One of the challenges we're experiencing almost on a daily basis and where we see digital technology helping to a great extent is in the discovery of materials. First that is: how can you as a Waste collector who is involved in recycling find materials within your community that are

ready for pickup, for example, or that have been separated and properly classified? So, discovery is a huge challenge, not only for us as a platform provider but also for the players, the aggregators, the buyers and also the waste collectors. (Speaker 8, *Zambian Start-ups Focus Group*, Lusaka, October 2020).

When it comes to plastic in particular, we see digital technology and particularly additive manufacturing or commonly known as 3D printing being one of those. Technologies that could emerge from the use of digital technology to actually help reduce and hopefully eliminate plastic. The beauty with 3D printing is that you can actually add 100 \* 1000 times value to plastic, so we see that as a huge opportunity for all the players in the value chain (Speaker 8, *Zambian Start-ups Focus Group*, Lusaka, October 2020).

#### *4.3 Digitally enabled ecosystem effects for CPE*

Given the fact that the circular plastic economy is a new paradigm that aims to upend the established linear paradigm of production and consumption, the network effects of digital innovations is especially important for successful transition. Interviewees and focus group participants highlighted the different ways digital innovations has enabled greater value creation and value capture by bringing many stakeholders together and thereby grown the market for circular plastic products. Here again, Yo Waste offers a prime example of the network impacts of digital innovation for CPE in Africa:

Yo-Waste is a technology-based start-up in Kampala, Uganda that helps communities and businesses manage their waste by connecting them to different waste management players. It started in 2017 as a class project but became fully registered as a company in 2019. The company currently has 7 employees (including the 5 cofounders) who handle software development, communications etc. There are about 50 registered clients and 200 one-off subscribers who use their services every month (Yo waste Co-founder, In-depth Interview, Kigali, November 2020)

In other words, the more clients, subscribers and stakeholders are connected to the network, the better and greater the value created and captured by individual actors. The informal sector, including waste pickers, constitute a critical building block of the CPE ecosystem. Unsurprisingly, investors are focusing increasing attention to organise the informal sector:

A lack of investable private projects, and sometimes this is complicated, complicated by the involvement of the informal sector being so important. So, organizing that informal sector seemed like a challenge that the investors were interested in.

And maybe then you also encourage the informal sector to collect more waste, and also it's a very important fact to understand that most of the people that are in the informal sector are just unemployed people and also very poor usually ...I think maybe if you do it in this way that you also have maybe a return back scheme for maybe the bigger plastics, maybe that could also benefit these informal sectors somehow

Aside from informal sector workers, innovators and start-ups are also able to reap greater benefits by coming together and organising themselves into groups. This includes the increased ability of the collective to overcome traditional barriers and constraints to funding- such as deposits and collateral requirements- faced by individual start-ups and enterprises:

So, from a bank perspective, I can clearly see that the network can maybe assist by engaging like the Green Climate Fund and see how we can, you know, establish a type of funding fund that specifically focuses on this sector. That can assist any project that is actually not bankable due to a limited deposit or collateral requirements as a bank or any financial institution we're providing loans will require. So, I think if we can maybe try to schedule or, you know, established a small partnership with these federal funding facilities that can provide a type of ground facility to kickstart some of these Start-up companies and also take it to a bankable level (Speaker 6, *Namibia Investors Focus Group*, Windhoek, October 2020).

Coming together in a network also enable actors to share best practices, and support and scale complementary activities for the benefit not only of individual network members but the network as a collective:

OK, if you want to change behaviours and you want to get innovation into certain places that's funded. If you want to have policies...especially in Africa, you need a kind of system to hold all that together, and so it's a multi sectoral interdisciplinary network...We have members from Southern Africa, East Africa, West Africa and we're trying to collaborate and share knowledge across that platform so it could be anyone who's trying to solve this issue who's trying to drive the transition so it could be a Start-up or even a private person or a government agency... How are we serving the different Members of this network? Ultimately, we can apply for some follow-on funding to scale this whole thing up and the people that are part of the network are going to be part of us creating this pitch to get the follow-on funding and we hope that people will get leverage of the network (Speaker 1, Rwandan Investors Focus Group, Kigali, August 2020)

## 5. Discussion

### 5.1 Digital innovations and network effects for circular transition

As noted in the introduction, arguably the biggest barrier to the circular economy, is the lock-in to the linear paradigm of production and consumption. In order to upend this trajectory, circular products and practices need to break the linear lock-in mechanisms by, among other things, creating new network externalities. This is where innovative circular business models, enabled by digital technologies, are of critical importance. The findings from this study indicate that start-ups and innovators across Africa have identified the digitalisation gap and are deploying digital technologies to drive the transition towards a circular plastic economy on the continent.

First, there is evidence of multi-channel and omni-channel practices by innovators and start-ups. These are critical to value creation and value capture in the circular plastic economy. Omni-channels offer the customer the opportunity to interact with several channels offered by a provider in a seamless experience that optimises logistics and minimises costs (Costa Climent, Haftor and Chowdhury, 2022; Salviotti et al., 2022). For example, the Ugandan Startup, Yo Waste provides channels for haulers, recyclers, municipalities, and households. It also offers services across multiple industries, including hotels and hospitality, restaurants and food services, grocery stores, and medical facilities. This not only optimises experiences for users but also provides an auspicious opportunity for providers to aggregate customer data insights to create better value and improve user experience.

The provision of multi-channel and omni-channel services by African digital innovators has also, crucially, enabled the creation of new network externalities necessary to break the lock-in to the linear economy. As the result shows, mobile apps are being used to mobilise tens of thousands of households and thousands of informal waste pickers into the circular economy ecosystem, where recyclers and other circular plastic enterprises can connect with them, and big corporations can also engage in more meaningful and impactful ways. As more and more actors connect within and across national boundaries, circular plastic enterprises are better able to create and capture value (Kolade et al., 2022). Furthermore, as other studies have reported, network effects can help lower the cost of switching from linear to circular plastic products; raise demand for, and value of, circular plastic products, and support stakeholder pressures for enabling policies and institutional innovations for a circular plastic economy (Czajkowski and Sobolewski, 2016; Weiergraeber, 2022).

These network effects can have a pathbreaking impact on the circular plastic economy in Africa, driving market growth, job creation, and economic empowerment, particularly within the informal sector. As more entities join the circular plastic initiative, the value of the network increases, attracting additional stakeholders and resources, thus accelerating market expansion. This is in line with the findings of other scholars who highlighted the importance of network externalities on market growth for green products (Liu, 2024; Muzamwese et al., 2024). This growth catalyses the creation of new jobs, ranging from collection to processing and remanufacturing of plastic waste, which can absorb a considerable portion of the unemployed and underemployed population.

In particular, the informal sector, which is often the backbone of waste management in many African countries, can see a transition from marginalisation to economic empowerment. As the network expands, informal workers gain access to more robust systems, training, and financial incentives, aligning with formal economic activities and contributing significantly to the industry's productivity.

This scenario presents a dual opportunity: it harnesses the untapped potential of the unemployed and underemployed population, effectively turning labour waste to productive economic purposes. In the same breadth, it simultaneously transforms the abundance of plastic waste into valuable products. Thus, by creating a structured and inclusive recycling ecosystem, network effects foster a self-reinforcing cycle where plastic waste becomes a resource, jobs are created, and communities thrive, leading to a sustainable and prosperous economy.

### *5.2 Digital transformation of retailing and distribution logistics for CPE*

Finally, digital innovations play key roles in strengthening and simplifying the logistics of retailing and distribution systems for a circular plastic economy. Logistics infrastructure is the missing link and has been identified by industry stakeholders as one of the major factors affecting the transboundary movement of plastic waste within the circular plastic economy industry. Digitally enabled reverse logistics is being effectively deployed to close the loop for more efficient collection. These include the adoption of AI-based reverse logistics by small and medium scale enterprises to monitor products as they move through the supply chain (Mukherjee et al., 2024). Yet, scaling of these innovations remain a challenge on the African continent. These technologies are critical success factors for the circular plastic economy and plastic enabling actors to optimise value creation and value capture (Julianelli et al., 2020).

Therefore, to achieve an effective logistics network, digital innovations supporting communication, knowledge and data sharing should be introduced to the existing reverse logistics system. This will ensure a more effective and efficient infrastructure network for value creation, delivery and capture. The value will include but not be limited to the timely collection of scheduled plastic waste, route mapping and logistics resource maximisation.

### *5.3 Theoretical contributions and practical implications*

Given the foregoing, this paper makes two important contributions. Firstly, it proposes a new conceptual framework that explicates the mediating roles of digital innovations in the processes of value creation and value capture across a whole spectrum of circular economy reverse logistics activities: recycling, redistribution and remanufacture. Secondly, the paper highlights the double-sided challenges and opportunities of the African context regarding the circular economy. The limited industrial development of the African continent, and the associated

limited sunk investment in old technologies, is a blessing in disguise with regards to new opportunities to leapfrog developed countries in innovative green technologies and achieve market leadership in the circular economy. Similarly, the problem of unemployment and underemployment, especially in the informal economy, is also an opportunity to empower a ready and otherwise under-used labour force for the circular economy. Furthermore, the resource constraints in African economies, in terms of finished products, is an opportunity to enact an innovative sharing economy in which otherwise idle products and resources are more efficiently used in a process of collaborative consumption.

Africa's relatively untapped industrial progress presents a unique opportunity for policymakers to drive green growth by leapfrogging to advanced green technologies. This approach can position the continent as a front-runner in the circular economy. The prevalent unemployment and underemployment, especially within the informal sector, offers a potential workforce ready to be engaged in this sustainable economic model. Policymakers can further utilise the continent's resource scarcity by promoting a sharing economy, ensuring efficient use of available products and resources through community-led initiatives. Together, these steps can create an economy that not only conserves resources but also fosters equitable wealth distribution and inclusive growth.

#### *5.4 Limitations and future research agenda*

We highlight two limitations of the present study. Contextually, while a cross-country study like this provides valuable insights on common challenges and opportunities shared across countries, it is limited in its ability to grapple with the peculiar characteristics and nuances of individual countries and the specific opportunities for a circular plastic economy. While our study is broad enough in its reach of Southern Africa, East Africa and West Africa sub-regions, we acknowledge that the selected countries may not be sufficiently representative of each sub-region, let alone the entire sub-Saharan Africa. Future studies can focus on specific country case studies. Secondly, while the qualitative method is well suited for this present research design, there is a need for longitudinal studies and data collection from African countries over a sustained period of time, to offer valuable data for researchers interested in digging up important new insights about the circular plastic economy in Africa.

## **6. Conclusion**

This paper focuses on the imperative of a business case for a circular plastic economy, in order to drive a successful transition from a linear to circular paradigm of production and consumption. The ecological case for a circular plastic economy has been well made over the past few decades. However, transition has been slowed by limited uptake of circular products by consumers, and an inadequate synergy among actors in the circular plastic ecosystem. In order to invigorate and accelerate transition, innovative business models are required to expand the ecosystem and simplify the logistics of retailing and distribution systems through the deployment of appropriate digital innovations. The circular plastic economy has won hearts but now needs to win the market. The new network externalities created by the popularisation of circular products in the consumer market can play a key role in breaking the lock-in to otherwise entrenched linear habits of consumption.

## References

- Alzoubi, H., Ahmed, G., Al-Gasaymeh, A., Kurdi, B., 2020. Empirical study on sustainable supply chain strategies and its impact on competitive priorities: The mediating role of supply chain collaboration. *Management Science Letters*. 10(3), pp. 703-708.
- Amit, R., Zott, C., 2001. Value creation in E-business. *Strategic Management Journal*. 22(6-7), pp. 493–520. <https://doi.org/10.1002/smj.187>.
- Antikainen, M., Uusitalo, T., Kivikytö-Reponen, P., 2018. Digitalisation as an Enabler of Circular Economy. *Procedia CIRP*. 73, pp. 45-49. doi: 10.1016/j.procir.2018.04.027.
- Attafuah-Wadee, K., Tilkanen, J., 2020. Policy approaches for accelerating the circular economy in Africa. *Circulareconomy.earth*. ChathamHouse.<https://circulareconomy.earth/publications/accelerating-the-circular-economy-transition-in-africa-policy-challenges-and-opportunities> (accessed 12 December 2020).
- Ayeleru, O.O. et al., 2020. Challenges of plastic waste generation and management in sub-Saharan Africa: A review. *Waste Management*. Elsevier. 110, pp. 24–42. <https://doi.org/10.1016/j.wasman.2020.04.017>
- Babayemi, J.O., Nnorom, I.C., Osibanjo, O., Weber, R., 2019. Ensuring sustainability in plastics use in Africa: consumption, waste generation, and projections. *Environmental Sciences Europe*. Springer. 31 (1), pp. 1–20.
- Berman, S.J., 2012. Digital Transformation: Opportunities to Create New Business Models. *Strategy & Leadership*. 40, pp. 16-24. <https://doi.org/10.1108/10878571211209314>.
- Baden-Fuller, C., Haefliger, S., 2013. Business Models and Technological Innovation. *LongRange Planning*. 46, pp. 419-426. <http://dx.doi.org/10.1016/j.lrp.2013.08.023>.
- Beattie, V., Smith, S.J., 2013. Value Creation and Business Models: Refocusing the Intellectual Capital Debate, *British Accounting Review*. 45 (4), pp. 243-254.
- Bican, P.M., Brem, A., 2020. Digital Business Model, Digital Transformation, DigitalEntrepreneurship: Is There A Sustainable “Digital”? *Sustainability*. 12, e5239. <https://doi.org/10.3390/su12135239>.
- Bocken, N.M.P., Short, S.W., Rana, P., Evans, S., 2014. A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*. 65, pp. 42–56. doi: 10.1016/j.jclepro.2013.11.039.
- Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*. 3(2), pp. 77–101. <https://doi.org/10.1191/1478088706qp063oa>.
- Butt, A., Ali, I., & Govindan, K., 2023. The Role of Reverse Logistics in a Circular Economy for Achieving Sustainable Development Goals: A Multiple Case Study of Retail Firms. *Production Planning & Control*. doi: 10.1080/09537287.2023.2197851.

- Centobelli, P. et al., 2022. Blockchain technology for bridging trust, traceability and transparency in circular supply chain. *Information & Management*. 59(7), e103508. <https://doi.org/10.1016/j.im.2021.103508>.
- Centobelli, P., Cerchione, R., Chiaroni, D., Del Vecchio, P., Urbinati, A., 2020. Designing business models in circular economy: A systematic literature review and research agenda. *Business Strategy and the Environment*. 29(4), pp. 1734-1749.
- Chaudhuri, A., Subramanian, N. and Dora, M. 2022. Circular economy and digital capabilities of SMEs for providing value to customers: Combined resource-based view and ambidexterity perspective. *Journal of Business Research*. 142, pp. 32–44. <https://doi.org/10.1016/j.jbusres.2021.12.039>.
- Costa Climent, R., Haftor, D.M., Chowdhury, S., 2022. Value creation through omnichannel practices for multi-actor customers: an evolutionary view. *Journal of Enterprising Communities*. 16(1), pp. 93–118. <https://doi.org/10.1108/JEC-07-2021-0100>.
- Czajkowski, M., Sobolewski, M., 2016. How much do switching costs and local network effects contribute to consumer lock-in in mobile telephony? *Telecommunications Policy*. 40(9), pp. 855–869. <https://doi.org/10.1016/j.telpol.2015.10.001>.
- Dijkstra, H., Van Beukering, P., Brouwer, R., 2020. Business models and sustainable plastic management: A systematic review of the literature. *Journal of Cleaner Production*. 258, e120967. <https://doi.org/10.1016/j.jclepro.2020.120967>.
- Di Maio, F., Rem, P., 2015. A robust indicator for promoting circular economy through recycling. *Journal of Environmental Protection*. 6, pp. 1095-1104. <https://doi.org/10.4236/jep.2015.610096>.
- Ferasso, M., et al., 2020. Circular economy business models: the state of research and avenues ahead. *Business Strategy and the Environment*. 29 (8), pp. 3006–3024. <https://doi.org/10.1002/bse.2554>
- Geissdoerfer, M., Pieroni, M.P., Pigosso, D.C., Soufani, K., 2020. Circular business models: A review. *Journal of Cleaner Production*. 277, 123741. doi: 10.1016/j.jclepro.2020.123741.
- Geissdoerfer, M., Vladimirova, D., Evans, S., 2018. Sustainable business model innovation: A review. *Journal of Cleaner Production*. 198, pp. 401–416. <https://doi.org/10.1016/j.jclepro.2018.06.240>.
- Getor, R. Y., Mishra, N., Ramudhin, A., 2020. The role of technological innovation in plastic production within a circular economy framework. *Resources, Conservation and Recycling*. 163, e105094. <https://doi.org/10.1016/j.resconrec.2020.105094>
- Guldmann, E., Huulgaard, R.D., 2020. Barriers to circular business model innovation: A multiple-case study. *Journal of Cleaner Production*. 243, e118160. <https://doi.org/10.1016/j.jclepro.2019.118160>.
- Heikkinen, I.T.S. et al., 2018. Chemical compatibility of fused filament fabrication-based 3-D printed components with solutions commonly used in semiconductor wet processing. *Additive Manufacturing*. 23, pp. 99–107. <https://doi.org/10.1016/j.addma.2018.07.015>.

- Hidalgo-Crespo, J., Moreira, C. M., Jervis, F. X., Soto, M., Amaya, J. L., Banguera, L., 2022. Circular economy of expanded polystyrene container production: Environmental benefits of household waste recycling considering renewable energies. *Energy Reports*. 8, pp. 306-311. <https://doi.org/10.1016/j.egy.2022.01.071>.
- Hidalgo-Crespo, J., Jervis, F. X., Moreira, C. M., Soto, M., Amaya, J. L., 2020. Introduction of the circular economy to expanded polystyrene household waste: A case study from an Ecuadorian plastic manufacturer. *Procedia CIRP*. 90, 49-54. <https://doi.org/10.1016/j.procir.2020.01.089>.
- Huang, L. et al., 2022. Blockchain implementation for circular supply chain management: Evaluating critical success factors. *Industrial Marketing Management*. 102(99), pp. 451-464. <https://doi.org/10.1016/j.indmarman.2022.02.009>.
- Klemeš, J. J., Fan, Y.V., Tan, R.R., Jiang, P., 2020. Minimising the present and future plastic waste, energy and environmental footprints related to COVID-19. *Renewable and Sustainable Energy Reviews*. 127, e109883. <https://doi.org/10.1016/j.rser.2020.109883>.
- Desmond, P., Asamba, M., 2019. Accelerating the transition to a circular economy in Africa. *The Circular Economy and the Global South*. Routledge, London. pp. 152-172.
- Julianelli, V., Caiado, R.G.G., Scavarda, L.F., Cruz, S.P., de M.F., 2020. Interplay between reverse logistics and circular economy: Critical success factors-based taxonomy and framework. *Resources, Conservation and Recycling*. 158. <https://doi.org/10.1016/j.resconrec.2020.104784>.
- Kolade, O., 2023. Blockchains for circular plastic value chains, in: Kolade, O., Oyinlola M., (Eds.), *Digital Innovations for a Circular Plastic Economy in Africa*. Routledge Studies in Sustainability. pp. 106-119.
- Kolade, O., Atiase, V., Murithi, W., Mwila, N., 2021. The business models of tech hubs in Africa: implications for viability and sustainability. *Technology Analysis & Strategic Management*. 33(10), pp. 1213-1225.
- Kolade, O. et al., 2022. Technology acceptance and readiness of stakeholders for transitioning to a circular plastic economy in Africa. *Technological Forecasting & Social Change*. 183. <https://doi.org/10.1016/j.techfore.2022.121954>.
- Kolade, O., Adegbile, A., Sarpong, D., 2022. Can university-industry-government collaborations drive a 3D printing revolution in Africa? A triple helix model of technological leapfrogging in additive manufacturing. *Technology in Society*. 69, e101960. <https://doi.org/10.1016/j.techsoc.2022.101960>.
- Kurniawan, T.A. et al., 2022. Unlocking digital technologies for waste recycling in Industry 4.0 era: A transformation towards a digitalization-based circular economy in Indonesia. *Journal of Cleaner Production*. 357. <https://doi.org/10.1016/j.jclepro.2022.131911>.
- Liu, X., 2024. The introduction and market expansion effects of green products considering network externalities. *Omega*. 124, e103017. <https://doi.org/10.1016/j.omega.2023.103017>.
- Maione, C., Lapko, Y., Trucco, P., 2022. Towards a circular economy for the plastic packaging sector: Insights from the Italian case. *Sustainable Production and Consumption*. 34, pp. 78-89. doi: 10.1016/j.spc.2022.09.002.



- Mofu, L., 2020. Future-Proofing the Plastics Value Chain in Southern Africa. WIDER Working Paper. <https://doi.org/10.35188/UNU-WIDER/2020/905-1>
- Morais, J., Corder, G., Golev, A., Lawson, L., Ali, S., 2022. Global review of human waste-picking and its contribution to poverty alleviation and a circular economy. *Environmental Research Letters*. 17(6), e063002. doi: 10.1088/1748-9326/ac6b49
- Moyen Massa, G., Archodoulaki, V.-M., 2024. An Imported Environmental Crisis: Plastic Mismanagement in Africa. *Sustainability*. MDPI. 16(2), p. 672. doi:10.3390/environments10030044.
- Mukherjee, S., Nagariya, R., Mathiyazhagan, K., Baral, M.M., Pavithra, M.R., Appolloni, A., (2024). Artificial intelligence-based reverse logistics for improving circular economy performance: a developing country perspective. *International Journal of Logistics Management [Preprint]*. <https://doi.org/10.1108/IJLM-03-2023-0102>.
- Muzamwese, T. C., Franco-Garcia, L., Heldeweg, M. A., 2024. The role of sustainable business networks in promoting a Circular Economy in Africa—A systematic literature review. *Wiley Interdisciplinary Reviews: Energy and Environment*. 13(1), e506. <https://doi.org/10.1002/wene.506>
- Moktadir, M.D., Anil B., Mithun, A. S., Sanjoy, P., Razia, S., 2020. Critical success factors for a circular economy: Implications for business strategy and the environment. *Business Strategy and the Environment*. 29, pp.3611–3635. doi: 10.1002/bse.2600.
- Oyinlola, M. et al., 2022. Digital innovations for transitioning to circular plastic value chains in Africa. *Africa Journal of Management*. 8(1), pp. 83–108. <https://doi.org/10.1080/23322373.2021.1999750>.
- Oyinlola, M. et al., 2023. The potential of converting plastic waste to 3D printed products in Sub-Saharan Africa. *Resources, Conservation and Recycling Advances*. 17, e200129. <https://doi.org/10.1016/j.rcradv.2023.200129>.
- Pironi, M., McAloone T., Pigosso, D., 2019. Business Model Innovation for Circular Economy: Integrating Literature and Practice into a Conceptual Process Model. *Proceedings of the Design Society: International Conference on Engineering Design*. 1, pp. 2517-2526. doi: 10.1017/dsi.2019.258.
- Reloop Platform, 2022. Digital Deposit Return Systems - What you need to know. <https://www.reloopplatform.org/digital-deposit-return-systems-what-you-need-to-know/>.
- Rosa, P., Sassanelli, C., Terzi, S., 2019. Towards circular business models: A systematic literature review on classification frameworks and archetypes. *Journal of Cleaner Production*. 236, e117696. <https://doi.org/10.1016/j.jclepro.2019.117696>.
- Salvietti, G. et al., 2022. Omnichannel retailing and post-pandemic recovery: building a research agenda. *International Journal of Retail and Distribution Management* 50(8–9), pp. 1156–1181. <https://doi.org/10.1108/IJRDM-10-2021-0485>.
- Sylvester, O., Ikudayisi, O., 2021. An overview of solid waste in Nigeria: challenges and management. *Jordan Journal of Earth and Environmental Sciences*. 12(1), pp. 36–43.

- De Angelis, R., Howard, M., Miemczyk, J., 2018. Supply chain management and the circular economy: towards the circular supply chain. *Production Planning & Control*. 29 (6), pp. 425-437. <https://doi.org/10.1080/09537287.2018.1449244>
- Schröder, P., Oyinlola, M., 2023. From polymers to microplastics: Plastic value chains in Africa. *Digital Innovations for a Circular Plastic Economy in Africa*, Routledge. pp. 63–75. doi: 10.4324/9781003278443-5.
- Shan, X., Neo, V.Z.Y., Yang, E.H., 2021. Mobile app-aided design thinking approach to promote upcycling in Singapore. *Journal of Cleaner Production*. 317. <https://doi.org/10.1016/j.jclepro.2021.128502>.
- Soares, J., Miguel, I., Venâncio, C., Lopes, I., Oliveira, M., 2021. Public views on plastic pollution: Knowledge, perceived impacts, and pro-environmental behaviours. *Journal of Hazardous Materials*. 412, e125227. <https://doi.org/10.1016/j.jhazmat.2021.125227>.
- Teece, D.J., 2010. Business Models, Business Strategy and Innovation. *Long Range Planning*. 43, pp. 172-194. <http://dx.doi.org/10.1016/j.lrp.2009.07.003>
- Urbinati, A., Chiaroni, D., Chiesa, V., 2017. Towards a new taxonomy of circular economy business models. *Journal of Cleaner Production*. 168, pp. 487-498. <https://doi.org/10.1016/j.jclepro.2017.09.047>.
- Uche, O.L., 2023. Plastic Waste Regime in Rwanda, Kenya and South Africa: A Comparative Case Study. *American Journal of Law*. 5 (2), pp. 54–85. doi: 10.47672/ajl.1652.
- UNEP, 2018. Africa Waste Management Outlook, Nairobi. <https://www.unep.org/ietc/resources/publication/africa-waste-management-outlook> (accessed 12 February 2024).
- Vadakkapatt, G.G. et al., 2021. Sustainable Retailing. *Journal of Retailing*. 97(1), pp. 62–80. <https://doi.org/10.1016/j.jretai.2020.10.008>.
- Verma, D. et al., 2022. Blockchain technology and AI-facilitated polymers recycling: Utilization, realities, and sustainability. *Polymer Composites*. pp. 1–15. <https://doi.org/10.1002/pc.27054>.
- Whalen, K. A., 2019. Three circular business models that extend product value and their contribution to resource efficiency. *Journal of Cleaner Production*. 226, pp. 1128-1137. <https://doi.org/10.1016/j.jclepro.2019.03.128>.
- Weiergraeber, S., 2022. Network effects and switching costs in the U.S. wireless industry. *International Economic Review*. 63(2), pp. 601–630. <https://doi.org/10.1111/iere.12543>.

## Appendices

### Appendices

#### Appendix 1 - Focus Group Questions

1. Overall information about the organization you represent (Location, size, turnover, number of staff, plastics collected and processed, etc.)
2. What are the main challenges for transitioning to a circular economy?
3. What are the opportunities for transitioning to a circular economy?
4. How can Digital innovations help solve the challenges?
5. What innovations for plastic waste management are you aware of?
6. How do you (stakeholders) use digital technologies?
7. What are opportunities and barriers of scaling up? (prompt for technical, social, political and economic factors)

#### Appendix 2 - Electronic survey to organisations incorporating digital innovation

The questions below were inputted into type form - <https://www.typeform.com/> and sent to startups managing plastic waste

#### A. Background

1. What's the name of your company/innovation
2. What year was your organization founded?
3. Location (city, Country)
4. Total quantity of Plastic waste processed till date (in kg)
5. Quantity of Plastic waste processed in the last 12 months (kg)
6. Which of these areas does your work focus on [ Reuse, Reduce, Recover/collection, Upcycle, Recycle] multiple answer

#### B. Business

7. How has your business been funded [Bootstrapping (savings, friends or family), Grants, Loans (bank, microfinance, convertible etc.), Crowdfunding, Venture Capitalist, Business incubator/accelerator, other please specify multiple answer option
8. In your opinion, after how many years can a start-up in this sector be deemed ready for scale up investment i.e. sustainable profits and not dependent on grants. [0-1 year, 1-2 years, 3-5 years, 5-7 years, other please specify
9. What unique opportunities in terms of circular plastic management exist in your sector [ Unsaturated Market, Government Incentives, Market Demand, Inadequate Infrastructure
10. How are digital innovations used in your business?
11. What are opportunities for scaling up?
12. What are the barriers for scaling up?

13. Please rank these barriers to scaling (beginning with 1 as the most significant barrier)

Barrier	1 (Most significant)	2	3	4	5 (least significant)
Funding					

Regulation					
Local Capacity					
Saturated Market					
other - please specify					

14. Please rank these barriers to mass adoption of digital tools in plastic waste management (beginning with 1 as the most significant barrier)

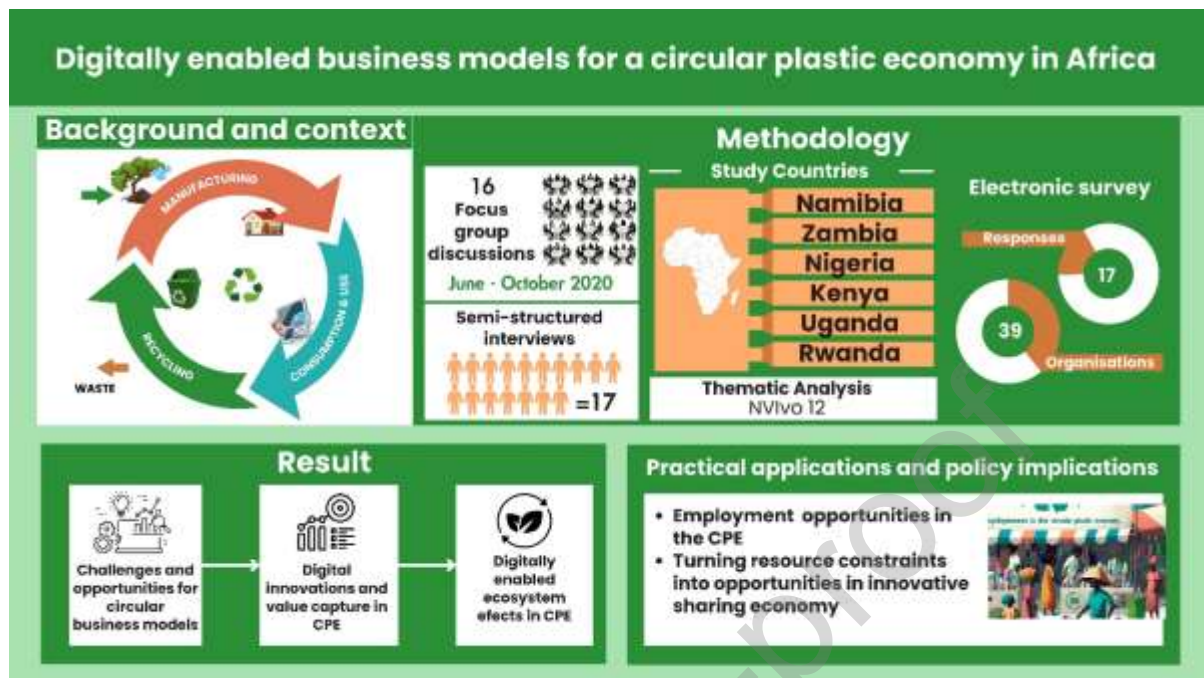
Barrier	1 (Most significant)	2	3	4	5 (least significant)
Technical (e.g. not tech savvy or literate)					
Economic (e.g. tools are not affordable)					
Political (regulation and policy are not supportive of digital tools)					
Socio-cultural (e.g. communities do not					

usually prioritise things like this)					
other - please specify					

### C. Policy

15. What forms of government support have you received for your business? I did not receive any support, training, tax breaks, financial support, other please specify multiple answer
  16. What are the socio-cultural factors affecting engagement between digital firms, waste management institutions and local waste collectors
  17. Are you aware of any government (Local or foreign) policy or regulations on digital innovations that support entrepreneurs and start-ups? If yes: Which policy?
  18. What are the key policies in your country that has enabled your innovation
  19. Are there any regulations which are obstacles to your business adopting digital innovations for better recycling, plastics collection, processing, etc.? If yes: which ones?
  20. what new government policies/regulations would you recommend that could be helpful to scale up your business and/or support plastic waste management
  21. In terms of policies, what matters the most to your business? What enabler policies can promote your business better?
  22. What are new skills needed among the staff/workforce?
- 
8. How are digital innovations used?
  9. How was the digital innovation financed?
  10. What are new skills needed among the staff/workforce?

## Graphical abstract

**Author Agreement Statement**

We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We understand that the Corresponding Author is the sole contact for the Editorial process. He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

**Declaration of interests**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

### Highlights

- Digital business models enhance recycling, creating jobs in African economies.
- Limited consumer interest hinders Africa's shift to circular plastic economy.
- Innovative digital business models vital for efficient recycling logistics.
- Proposed framework ties digital technology to circular economy's logistics success

Journal Pre-proof