Big-Stream. A Framework for Digitisation in Africa's Circular Plastic Economy

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BIG-STREAM

A Framework for Digitisation in Africa's Circular Plastic Economy

Celine Ilo, Muyiwa Oyinlola and Oluwaseun Kolade

1 Introduction

According to United Nations (2021), the world's population is predicted to rise to 8.5 billion by 2050 and 11.2 billion by year 2100. This rapid increase in population coupled with the versatility of plastics to be adopted in various sectors of society (Mrowiec, 2018) has resulted in corresponding increases in the demand for natural resources such as salt, crude oil, natural gas, cellulose and coal required for the production of plastics (Plastics Europe, 2022). This translates to major strain on the earth's natural resources as a result of increased consumption of non-renewable fossil-based materials (Payne and Jones, 2021).

Poor waste management practices across the globe have resulted in severe consequences such as pollution of freshwater resources, clogging waterways and permeating sub-aquatic space (Awoyera and Adesina, 2020). Approximately 4.8–12.7 million tonnes of waste is expelled into water bodies from coastal areas every year (Conkle et al., 2017; Mrowiec, 2018). Furthermore, it has been reported that plastics and microplastics (plastics considered to be smaller than 5 mm) currently account for a reasonable proportion of marine debris. This is alarming as microplastics pose a threat to the sustenance of life underwater Given that smaller sea creatures and those in their formation stages can easily ingest these materials, thus introducing microplastics into oceanic food chains (Conkle et al., 2017). In addition, terrestrial biodiversity is threatened with the risk of extinction as a result of discharges emanating from toxic elements constituting plastic wastes, which saturate and pollute the ecosystem. Improper plastic waste management also poses far-reaching threats to public health as microplastics are taken up through air inhalation, ingestion or absorption when plastic wastes are being incinerated in some communities. The particles released during this activity

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can be inhaled in the air, ingested when they settle on drinking water or absorbed through chemical transfer in food types consumed by humans (Marsden et al., 2019; Silva et al., 2022).

The non-biodegradable characteristic of plastics is attributable to its heavy molecular weight; hence, if not managed adequately at end of life, these will remain on the earth's surface for many years without decomposing or disintegrating (Sharuddin, Abnisa and Daud, 2016). This further underlines a requirement for the development of a sustainable solution aimed at the disruption of the prevalent linear economy for plastics and solid waste management in Africa.

Several scholars (e.g., Bakker et al., 2014; Rashid et al., 2013) posit that it is possible to address the global problem of poor plastic waste management by establishing a holistic system governed by the principles of the circular economy (CE), which regulates all phases in the plastic value chain (Kaur et al., 2018; Mrowiec, 2018). This system is referred to as the "Circular Plastic Economy (CPE)", and its rationale is hinged on transforming the methods of designing, producing and using plastic materials. In other words, the CPE aims to facilitate extended service life, value recovery and ecological compatibility for plastic resources. It entails a fundamental rethink of design and production approach which culminates in a closed-loop system for the life cycle of plastic resources (Payne and Jones, 2021).

Experts have highlighted the central roles of digital tools for the enhancement and efficacy of the CPE (Barrie et al., 2022; Oyinlola et al., 2022b; Rajput and Singh, 2019). Digital technologies enable strategic monitoring, predictive investigation, increased system performance and traceability through the material life cycle (Chauhan et al., 2019). Similarly, the efficient use of resources facilitated through data-informed regenerative designs improves the environmental and economic sustainability of plastic products. Instructional and predictive machine learning insights can hence be used to tailor the production processes as well as constituents of eco-friendly products (Bressanelli et al., 2018a; Garcia-Muiña et al., 2019).

Therefore, this chapter reviews the intersection between modern digital technologies and the CPE. It examines various models for optimising digital technologies for systemic changes in ecosystems. This leads to the conceptualisation of a framework for the digitisation of Africa's CPE. Accordingly, this chapter contributes to the body of literature as it targets the design of a holistic system for the intersection of digital innovations inspired by a significant range of digital functions and a CPE for Africa.

2 A Digitally Enabled CPE

Emerging digital technologies present great opportunities for the revolutionisation of critical sectors of the global economy. Digital technologies include Internet of things (IoT), artificial intelligence (AI), mobile applications, virtual reality (VR), augmented reality (AR), cloud computing, three-dimensional (3D) printing, geographic information systems (GIS) and remote sensing, blockchain technology and big data analytics (BDA). The integration of these digital technologies in the CE will enable the development of innovations addressing various social and economic issues currently experienced in different sectors and parts of the world (Oyinlola et al., 2022). In addition, digital innovations will allow for a seamless transition from the contemporary linear value network into a CE for plastic resources, as it fosters a shift from unsustainable methods of material sourcing, production and consumption (Liu et al., 2022). This is required to effectively address the plethora of ecological and climate-related problems plaguing our planet in recent times. Consequently, scholars have argued that accelerating the global shift to a CE is firmly tied to digitalisation (Ajwani-Ramchandani et al., 2021; Chauhan et al., 2022; Ingemarsdotter et al., 2019). Researchers have examined various technologies, for example, the application of AI as a digital tool capable of executing tasks in a manner synonymous to that of the human intellect in information assimilation and reasoning (Wilts et al., 2021). Digital innovations can be instrumental for the implementation of CE principles in various industries. As an illustration, the flow of products can be tracked by manufacturers' post-consumption in order to retrieve components and valuable parts for regeneration and design of value-added products (Lopes de Sousa Jabbour et al., 2018). Similarly, other scholars have shown that 3D printing can accelerate the transition to a CE (Oyinlola et al., 2023). Digital tools can be applied across the entire circular plastic value chain.

At present, the intersection of digital tools and the CE can be seen as a burgeoning field of research as there are a limited number of studies in this area. Recently developed literature draws upon ideas and analyses from domains such as competition-led sustainability in businesses, i.e., product service systems (PSS), industrial ecology and sustainable supply chain logistics (Pagoropoulos et al., 2017). Interestingly, conceptual research and reviews constitute the bulk of existing works as there are inadequate empirical studies illuminating the use of digital technology within the spheres of a CE, especially in developing regions like Africa. With the concept of a CE being often considered alongside other notions like decentralised manufacturing (Moreno and Charnley, 2016; Srai et al., 2016) and enterprise systems, some may argue that the area is still at a "pre-paradigmatic" stage (Pagoropoulos et al., 2017; Weichhart et al., 2016), such that it must be developed, while tailored to individual relevant disciplines.

According to recent estimates, 1 million plastic bottles are manufactured every minute, with single-use plastics accounting for 47% of total garbage (Fagnani et al., 2021; Payne et al., 2019). A sustainable plastic economy cannot be accomplished simply by renewable feedstock; there is a necessity for supplementation by extensive sustainable waste management strategies. This requires several digitally enhanced material recovery infrastructures in order to manage the massive amounts of plastic garbage produced per time and minimise any leakages from the sustainable network.

The fundamentals of a CE include eco-efficiency, material collection, sorting and recycling, sustainable design, production and redesign, life cycle assessment, cleaner production, carbon footprint reduction as well as other sustainable practices (Qi et al., 2016). Consequent to their multi-functional and long-lasting nature, the resourceful management of plastic products alongside the various processes involved in absolute value extraction from plastic wastes will be hardly achievable without digital technologies.

However, effective uptake of digital technologies for the CPE has been hampered by a number of barriers in Africa. These include inadequate information on how material resources and products traverse through the plastic value chain as well as their activities through their service life which will provide necessary details on their degradation processes and catalysts (Foschi et al., 2020). Another consideration is the lack of technological expertise for sustainable product design and how this expertise can be well inculcated into individual product development processes and projected service stages (Foschi et al., 2020). This will play a significant role in influencing general stakeholder (resource extraction companies, producers, manufacturers, retailers, customers and recyclers) behaviour in terms of levels of readiness and willingness to adopt required sustainable practices (Solomon and van Klyton, 2020). Dmitriev (2019) in a study enunciating the introduction of technologies for the logistics systems underlined challenges due to the lack of adequately defined legal framework, as well as the technical reticence of transport and logistics businesses to use modern digital technologies in the delivery of commodities. Therefore, it is impossible to disregard existing political and regulatory constraints such as the lack or misalignment of incentives, the absence of support from governmental institutions and hesitation on the path of business owners and product manufacturers (Bocken et al., 2016; Bressanelli et al., 2018b; Schirmeister and Mülhaupt, 2022; Schroeder et al., 2023). Foschi et al. (2020) further described how the public–private governance model, coupled with the growing number of disposal consortia and platforms, contributes challenges in product tracking. Olukanni et al. (2018) identified installation costs of a traditional material recovery facility(s) (MRFs) in low-income countries as well as a lack of significant technical skills, as a key impediment to the operationalisation of a CE for plastics.

A fundamental challenge for transitioning to a CPE in Africa is that the key actors (technical facilities, research bodies and governmental institutions) typically operate in silos (Oyinlola et al., 2022) with no strategic synergy and integration of approaches and methods by which the digital technologies are deployed to address various aspects of the CPE, such as collection, separation, sorting, sanitisation and recycling, to mention a few (Kolade et al., 2022; Olukanni et al., 2018; Oyinlola et al., 2022b). For example, many technology-driven initiatives and start-ups for the CPE in Africa have been seen to operate individually, effectively disconnected from one another (Oyinlola et al., 2022b). This makes it difficult to achieve significant changes as should be seen with a functional CPE. An efficient CPE across Africa will be unachievable with the current system of things which is characterised by the absence of unified participation of pertinent stakeholders (Awoyera and Adesina, 2020). As such, actualising the CPE calls for an amalgamation of consistent inputs from the diverse stakeholders involved. The CPE will benefit from a well-defined systemic change giving rise to a significant shift in societal values and norms (Chizaryfard et al., 2021).

Systemic changes that will accelerate the transition to a CPE cannot be facilitated by isolated digital innovations and disjointed CE strategies. There is a need for synergistic transformations across the entire value chain through the integration of multiple digital tools, strategically tailored to prevent leakage from the plastic value chain as well as track material flows (Truffer et al., 2008). In order to achieve this goal, a system thinking approach must be adopted. In a study highlighting the significance of digital technologies in the CE, Pagoropoulos, Pigosso and McAloone (2017) asserted that they have empowered the formulation of multiple PSS in the field of business. The concept of PSS is synonymous to the CE as it promotes a shift in business focus from selling things to selling utility via a combination of products and services that satisfies the same set of customer demands with less environmental effects (Lewandowski, 2016). Pagoropoulos, Pigosso and McAloone (2017) further evaluated the efficacy of digital technologies in the CE using a three-layer architectural framework namely, data collection, data integration and data analysis. Seven digital tools were identified and grouped into each layer based on individual functions: for data collection, radio frequency identification (RFID) and IoT; for data integration, relational database management systems (RDBMS), product life cycle management (PLM) systems and AI; and for data analysis, machine learning and BDA. An evaluation of the framework depicts that digital technologies play an essential role towards the CE by acting as a critical enabler in the optimisation of forward material flows and expedition of reverse material flows (Pagoropoulos, Pigosso and McAloone, 2017).

Chauhan, Sharma and Singh (2019) employed the situation, actor, process–learning, action, performance (SAP–LAP) interconnection model to examine the applicability of Industry 4.0 mechanisms in resolving difficulties in existing CE business models. This was achieved by analysing the cross-interaction and self-interaction linkages between the various components of the SAP–LAP framework, thus integrating both CE and Industry 4.0 streams in order to ascertain how issues regarding the CE parameters can be tackled. Research findings based on developed toolkits suggest that as regards the CE, senior managers (actors) have the most influence on the integration of Industry 4.0 to achieve sustainability. Additionally, smart technologies like IoT and cyber physical systems account for the most important Industry 4.0 activities that encourage the enhancement of CE performance metrics. However, the shortcoming of this research work is that the identification of ties between the main components of the SAP–LAP framework is based on the personal judgement of various experts; thus, it is susceptible to the writer's individual bias. The study will benefit from empirical validation and real-world implementation.

Furthermore, Liu et al. (2022) conducted a systematic review to inform the development of a framework – digital technologies for the circular economy(DT4CE). This framework is used to ascertain which digital functions are most relevant in the realisation of a functional CE. The study identified 13 different digital functions (Auto-plan, Auto-control, Sort and Classify, Optimise, Innovate, Forecast, Connect, Assess, Detect, Track and Trace, Monitor, Share and Collect) to be most effective in driving material circularity in line with the CE principles. It further hinges on seven mechanisms (Recycle, Repurpose, Remanufacture, Repair, Reuse, Reduce and Rethink and Refuse) for the implementation of the selected functions towards the enhancement of CE strategies. The framework also examines specifications and combinations of digital functions and CE strategies that have been widely studied, thereby revealing levels of technology maturity and existing gaps for application in the CE. Albeit the study is limited by its emphasis on just three digital technologies, namely IoT, BDA and AI. Reviews on a larger variety of CE technologies would offer greater understanding of the pertinence of digital technologies in the circular economy (CE-DT) integration.

Cwiklicki and Wojnarowska (2020) compared technologies such as AI, robotics, the IoT, autonomous vehicles, 3D printing, nanotechnology and biotechnology using the ReSOLVE model, 3R strategy and three other concepts. They concluded that the IoT and BDA were the most promising Industry 4.0 digitalisation tools for the CE. Ingemarsdotter et al. (2019), in their model, incorporated the 3R strategy with three operational strategies to point out the potentials of IoT. Tracking, monitoring, control, optimisation and design evolution were identified as main IoT capabilities, while circular in-service strategies are efficiency in use, increased utilisation and product service life extension. Circular looping strategies include reuse, remanufacturing and recycling. Furthermore, case studies on digital tools such as IoT, big data and data analytics were categorised by Kristoffersen et al. (2020) using the circular strategies scanner by Blomsma et al. (2019) which entails a comprehensive multilayered strategy mapping in accordance with the 9R strategies formulated by Potting et al. (2017).

3 A Framework for a Digitally Enabled CPE

As highlighted in the previous section, the application of multiple digital technologies in tandem, can perform a variety of essential functions. However, most of the studies have been focused on the Global West, with only a few fragmented studies focused on Africa which are not comprehensive enough to provide understanding on how digital technologies can accelerate a systemic shift in Africa's current plastic value chain (Aristi Capetillo, 2021). Desmond and Asamba (2019) also noted that African case studies stay "hidden" as they are yet to be documented through academic research. Therefore, this chapter makes a contribution by drawing on a review of the extant literature to develop

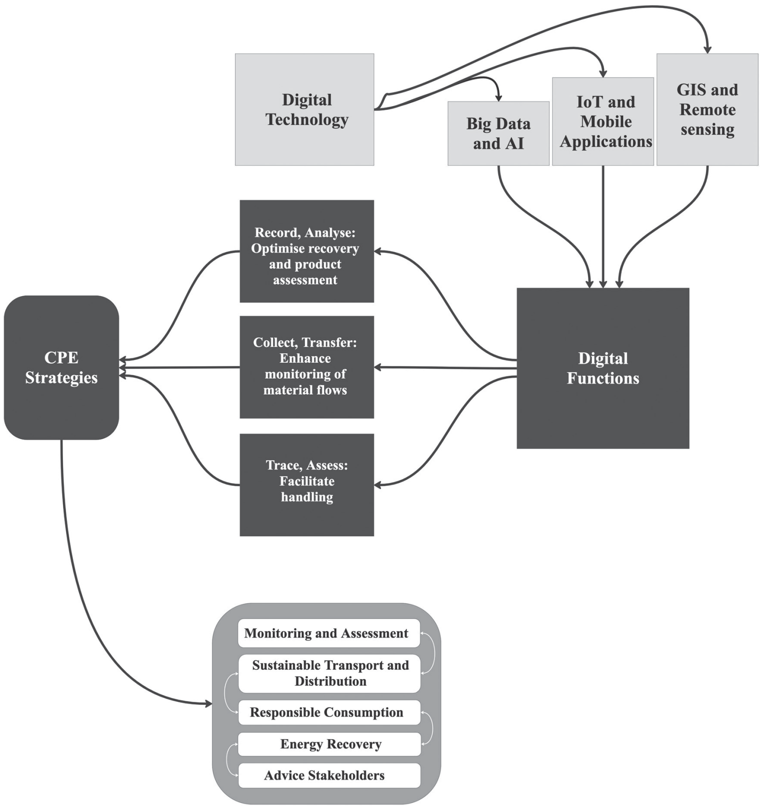

FIGURE 11.1 The BIG-STREAM CPE framework

a framework, the BIG-STREAM framework, which can accelerate the CPE transition in Africa.

This framework focuses on the following three main areas:

1. The core functions of digital technologies that are relevant to the CPE transition in Africa; Digital functions refer to using specific technologies to perform smart actions (Allmendinger and Lombreglia, 2005).
2. The strategies to be prioritised for the CPE transition in Africa.
3. The mechanisms by which highlighted digital functions can be leveraged for effective implementation of the CPE.

The elements of the BIG-STREAM framework (shown in Figure 11.1) are discussed below:

- B – big data and AI
- I – IoT and mobile applications

- G – GIS and remote sensing
- ST – sustainable transport and distribution
- R – responsible consumption; use, reuse, repair, remanufacture and repurpose, and recycle and recovery; identification, collection, separation, sorting, reprocessing
- E – energy recovery
- A – advice stakeholders; refrain, reuse, separate and garner
- M – monitoring and assessing of waste management systems for improved and more sustainable future product designs.

3.1 Digital Functions

3.1.1 BDA and AI

BDA is referred to as the analysis of large data sets using a variety of cutting-edge methodologies in order to draw inferences and valuable conclusions (Ghasemaghaei et al., 2015; Oztemel and Gursev, 2018). Similarly, in the scope of a CPE for diverse settings like Africa, BDA embodies a viable tool for leveraging information from multiple systems of record, such as sensors and IoT, to enhance decision-making. It is pertinent to highlight that big data is not generally treated as a concept in and of itself but rather as a method for analysing large amounts of data gathered from various data sources (Abideen et al., 2021). This is particularly relevant taking into consideration the regional and ecological complexity of Africa (Olukanni et al., 2018). AI has also lately received more attention in studies pertaining to the CE. It enables rapid and adaptive learning for data analysis (Haenlein and Kaplan, 2019; Kristoffersen et al., 2020), allowing for faster and more dynamic operations based on larger data sets and therefore opening up new opportunities for CE implementations (Ellen Macarthur Foundation, 2013). Relative to plastic waste management, the amalgamation of BDA and AI will enhance the tracing and sharing of material flows from the design and production to the end-of-service life stages which invariably facilitates waste recovery and connectivity between waste reduction practices. The integration of AI further introduces a smart and agile learning interface for data analysis and allows faster and more adaptable actions using large and dispersed data sets (Esmaeilian et al., 2018; Kristoffersen et al., 2020). IoT-affiliated technologies such as VR and AR are instrumental in the area of educating CPE stakeholders such as potential customers and governmental bodies on the imminence of environmental disaster if their quota is not rendered towards the CPE as well as the myriad of benefits to be recovered from existing plastic waste materials.

3.1.2 IoT and Mobile Applications

Digital tools such as IoT which are known to function by virtue of linking objects to enable the collection and transfer of information (Ghasemaghaei et al., 2015). On the other hand, mobile and web applications for cell phones and other devices have become vital tools for a wide range of applications in the context of the CE (Faria et al., 2020). They rely on various methods of connectivity such as near-field communication (NFC), Bluetooth low energy (BLE) and Wi-Fi, for short-range communications and technologies and general packet radio service (GPRS), universal mobile telecommunications system (UMTS) and 3G/4G/5G to support long-range connections (Marques et al., 2019). Thereby enabling practices such as electronic commerce and product exchange, based on the geolocation of neighbouring users, and material upcycling (where it serves as a traditional social network for acquiring used items), which are required in the handling of plastic resources and waste materials (Agrebi and Jallais, 2015).

In terms of the identified life cycle phases in a CE for plastics, sensor technologies such as RFIDs, which is a major tool on which the IoT technology depends, in conjunction with mobile applications as principal interface, may assist in closing the material loop for plastics. Synchronous incorporation of both digital functions will promote system resilience for the CPE within Africa as it presents a medium for seamless communication between CPE actors. In this scenario, the key emphasis is on the material "End of Life" (EoL) and its relationship with sustainable manufacturing and product redesign. One famous example is the employment of RFIDs in the development of useful information on how the customer or client handled the product; hence, the incorporation of functions such as data collection will facilitate monitoring of plastic material flows through their life cycle (Faria et al., 2020).

3.1.3 GIS and Remote Sensing

The development of new digital technologies like remote sensing and GIS have made municipal waste management assessments seamless to conduct in recent years. Critical processes involved in the management of solid wastes like plastics, including capturing, waste handling and the transmission of necessary information in a timely and error-free manner, have been enhanced through the employment of these technologies. These tools may also be used to gather information directly from a distant site at a reasonable cost. Remote sensing technologies are also applied in landfill and trash bin placement, as well as assessing the environmental effect of buried garbage. Techniques have also been used for locating landfills and waste stockpiles for disposal, as well as evaluating the ecological effects of buried debris (Singh, 2019). This technology will be instrumental in the operationalisation of the recycle and recovery strategy (identification, collection, separation, sorting and material reprocessing) for plastic material circularity, as its monitoring capabilities will facilitate ease of identification and collection of plastic waste for effective recycling and upcycling.

3.2 Strategies

3.2.1 Sustainable Transport and Distribution

The development of eco-packaging designs and environmentally friendly plastic substitution to facilitate material flows for plastic containers, and enhance packaging inventory is crucial as plastic packaging accounts for a huge percentage of overall plastic waste products in the environment today. This is also owing to the fact that in the contemporary mechanisms, they are designed to be single use, thereby causing their distribution to imply environmental depletion (Esmaeilian et al., 2018). Studies performed by Galindo et al. (2021) portrayed how the processing of raw materials to completed goods, raw material deployment and final product distribution can be sustainably optimised regardless of the extensivity and possible disjunction of existing suppliers' network, product units and consumers. The model targeted the reduction of overall costs, which include raw material acquisition costs, manufacturing expenses and transportation costs, leveraging information such as raw material supply, raw material prices, raw material needs, production capacities, production expenses, raw material and final product conversions, customer demand and transportation costs provided by the plastic manufacturing firm.

3.2.2 Responsible Production and Consumption

They predominantly include, but are not limited to, the Reduce, Reuse and Recycle strategies commonly referred to as the 3Rs of the CPE (Blomsma et al., 2019). Extrapolation of the 3Rs, in attempts to assess the CE strategies through a more comprehensive and circular perspective (cradle to cradle), led to the 9R strategy, R_0 – Refuse, R_1 – Rethink, R_2 – Reduce, R_3 – Reuse, R_4 – Repair, R_5 – Refurbish, R_6 – Remanufacture, R_7 – Repurpose, R_8 – Recycle and R_9 – Recover, which was developed by Potting et al. (2017).

Innovative solutions such as the reuse, repair, remanufacturing and repurposing of plastic products should be employed to prevent plastics and microplastics from leaking into the environment, reaching and settling into water bodies. The effective execution of these practices is also facilitated by the use of alternative sustainable feedstock for plastic production, compared to non-renewable options (Mrowiec, 2018).

Adopting clean methods in the sourcing of plastic feedstock is essential for maintaining an environmentally sustainable plastic economy. Bioplastics such as polylactic acid was introduced and promoted by Djukić-Vuković et al. (2019) as a potential substitute to improve the environmental efficiency of plastics, whereas Walker and Rothman (2020) claimed that the precise environmental impacts of bioplastics are yet to be defined. Payne et al. (2019) explored polylactic acid waste management strategies. Plant-based plastic necessitates the use of fertilisers, pesticides and land, accounting for further consumption of natural capital and the disruption of soil fauna (Atwood et al., 2018). Bioplastics can be made from waste, such as food waste, to produce polyhydroxyalkanoates (Rai et al., 2019), which has a lower environmental footprint. However, the economic viability of pre-treatment and the spillover impacts (requirement for food waste or unstable supply) must be carefully evaluated. Another option is biodegradable plastics (petroleum based with additives). However, they can still produce debris and pollution in a case where they are not properly collected, as they are not fully decayed under all conditions. Ultimately, the issues raised by plastic consumption would perpetuate if the waste management supply chain is not well developed and strongly adhered to (Klemeš et al., 2020).

The revision of current design and manufacturing techniques will allow for higher plastic recycling rates in all major applications. A myriad of plastic products, in fact, cannot be reused or recycled, in some cases relative to their method of initial design as well as material type. Thus, product redesign involves the utilisation of alternative available materials, for instance, the employment of natural alternatives to plastic microbeads in beauty products. In the same vein, it is important to consider the design of plastic products without the addition of toxic chemicals and colorants as this could result in ecological and health problems as well as minimises product capacity in secondary applications (Brink et al., 2018). This strategy will benefit from compliance on the path of managers in the adoption of eco-friendly product designs in a bid to avert the risk associated with customer's unwillingness to abandon traditional products (De Jesus and Mendonça, 2018; Ritzén and Sandström, 2017).

Increased rates of plastic recycling cut down reliance on the importation of fossil fuels and reduce CO_2 emissions. The processes of gathering, separation, sorting and recycling of plastic waste materials contribute to job opportunities and flexible income generation (Klemeš et al., 2020). It is a vital phase of the circular plastics loop and a determinant for the materialisation of plastic circularity.

3.2.3 Energy Recovery

Recycling and energy recovery are the final lines of defence in reshaping the linear system into a CE because they allow plastic products to have a longer lifespan and maintain resources in use for as long as possible, enhancing the sustainable management of post-consumer plastics which are at their end of life (Klemeš et al., 2020). The ultimate place of non-recyclable plastic should be incineration. Liu et al. (2022) argued that several factors influence the choice of an energy-based disposal technique, including energy efficiency, technical specifications, environmental laws, social acceptance and responsibility. Incineration, autoclaving, microwaving, plasma treatment, chemical treatment and steam treatment are examples of traditional techniques.

3.2.4 Advice Stakeholders: Refrain, Reuse, Separate and Garner

According to Wichai-utcha and Chavalparit (2018), fundamental hindrances to the recycling of plastic waste materials are three major factors. They include human behaviour, i.e., lack of awareness on plastic recycling processes and the various types of plastics available; regulations (presence of incentives, plastic resin identification codes and eco-labels on products, etc.); and, lastly, recovery infrastructures (availability and access to collection bodies, efficiency of operations and running costs). These factors further highlight the cost intensiveness of effective plastic waste management and the need for integration of digital tools to close existing gaps by increasing the awareness of plastic users, knowledge proliferation, encouraging waste reductions, government intervention and promoting flow and connectivity in the plastics economy (Olukanni et al., 2018). This further allows for the advancement of scientific knowledge and extensive adoption of sustainable practices (Bucknall, 2020; Liu et al., 2022).

3.2.5 Monitoring and Assessing Waste Management Systems

The incorporation of digital functions is pertinent in this area, various initiatives have recorded the use of tools like blockchain technology. The monitoring and evaluation of waste management systems is invaluable to the proliferation of the CPE concept. In order to collect longitudinal data on waste operations, blockchains are characterised as a data ledger, and as such, one of its basic features is the logging of events and transactions in blocks, allowing the provenance of resources and wastes to be made available and public, if required. This data is utilised in the monitoring and improvement of the efficacy and efficiency of waste management procedures (Steenmans et al., 2021).

In this study, the decision was made to harness three major technologies for optimising the CPE and some in clusters as they share an intersection of functions relevant to the proposed CE strategies. They include big data and AI, IoT and mobile applications, and GIS and remote sensing, thereby constituting the "BIG-STREAM" framework.

4 Conclusion

Given the environmental and public health challenges posed by plastics, the transition to a CPE in Africa is now imperative. This chapter illustrates that despite the potential for digital technologies to accelerate the transition, there is need for strategic synergy and integration of approaches and methods. Therefore, this chapter adopts a system thinking approach to develop the BIG-STREAM framework, which brings together digital functions, strategies and mechanisms for digital technologies to address various aspects of the CPE. This chapter also stresses the necessity for the incorporation of digital innovations to foster a sustainable and resource-efficient plastic value chain which will function in lockstep with a proactive atmosphere of collaboration among stakeholders. The framework underlines practical as well as research implications which includes a requirement for the stringent reform of business practices and a change of social behaviour alongside further research on how digitally optimised frameworks such as this could be closely tailored to specific plastic-affiliated industries, organisations and businesses. This will allow for clearer insights on how their management processes can be reconfigured as well as expose new opportunities for perpetual development. Finally, the limitation of this study includes that the digital functions discussed are nascent, and the CPE strategies were established based on a review of conceptual studies or systematic reviews of current relevant academic resources; hence, there is requirement for further validation of ideas through quantitative and practical case studies for a CPE.

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