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Circularity and sustainability in the waste value chain in Ghana

Resilience, opportunities, and barriers

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Circularity and Sustainability in the Waste Value Chain in Ghana: Resilience, Opportunities and Barriers

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Abstract

The mismanagement of plastic waste has caused several economic, health, environmental, and social consequences to both human and aquatic lives. This is particularly serious in the Global South where most plastics are for single use and only about 9% of plastic waste has been recycled. This study examined how the plastic waste circular economy contributes to resilience and sustainability as well as the opportunities and barriers to the informal circular economy in the Global South using Ghana as a case study. Quantitative and qualitative data were collected from 365 informal plastic circular economy actors and 30 key informant interviews with local and central government stakeholders. The findings showed that the informal plastic waste circular economy sector is fast growing in Accra, dominated by plastic waste recyclers, crushers, collectors/pickers, melters, sorters, dryers, pallet makers and washers. Also, the findings showed that the circular economy had a significant relationship with resilience and ecological sustainability. Furthermore, it was found that the circular economy has several prospects and opportunities for cities in the Global South. Again, the study revealed that informal plastic circular economy actors encounter challenges and barriers. Finally, the improper recycling methods adopted by informal plastic waste circular economy actors pose significant negative impact on the environment, human health and climate change. Recommendations for policy and research have been proposed based on the findings of this study.

Keywords: Circular Economy; Plastics; Sustainability; Resilience; Informality

1. Introduction

Plastics have become part of everyday modern life because of their low cost, durability, light weight and variety of usage (Saha et al., 2023; Tran-Nguyen et al., 2024). Whereas commercial production of plastics started in the 1950s (Lebreton & Andrady, 2019; Tran-Nguyen, 2024), it has increased to almost 400 million metric tons per year in 2021 (Alvis, 2024; Plastic Europe, 2022). If the current trend continues, this figure is projected to triple by 2060 to a staggering one billion metric tons (Alvis, 2024). In Ghana, there has been an increase in plastics production and high annual importation due to the higher demand for the packaging of products sold into the market (MESTI, 2020).

Whereas plastics are used for both industrial and domestic purposes, the pollution that is caused by plastic leaking into the environment has raised global concerns (Lobelle et al., 2024; Wang et al., 2023). Many cities, especially in the Global South are increasingly experiencing many plastic waste products and their associated littering (Babayemi et al., 2019). Thus, it has been found that whereas cities in the Global South are inundated with large amounts of plastic waste, only about 9% has been recycled. Another 12% have been incinerated, while the rest (79%) have been dumped into the environment (Hira et al., 2022). Jambeck et al. (2015) contend that South Asia, Southeast Asia, and Sub-Saharan Africa are regions of particular concern, with 80%–90% of plastic waste being mismanaged.

Data shows that Ghana generates approximately one million metric tons of plastic waste per year and approximately 9.5% of that is collected for recycling. According to Chico-Ortiz et al. (2020), Ghana like most developing countries is experiencing environmental pollution with plastic emissions being the major one. Accordingly, they added that more than 3000 tons of plastic waste are generated daily. This situation has a devasting range of environmental issues such as pollution and flooding as well as social and economic problems (Debrah et al., 2021).

Traditionally, plastics have been produced, used and dumped into the environment. This situation is no longer sustainable, requiring the adoption of a paradigm known as a "circular economy". The idea of the circular economy is based on designing out waste and pollution, keeping products and materials in use as well as regenerating natural systems (Morlet, 2018). According to Ghosh (2020), a circular economy promotes the upcycling of waste plastic into useful products while simultaneously reducing the amount of waste plastic that pollutes the environment. Therefore, the idea of a circular economy has generated

several research (e.g., Pires & Martinho, 209; Ko et al., 2020; Yamamoto & Eva, 2022; Erdiaw-Kwasie et al., 2023).

For instance, research has concentrated on the potential of circular economy to mitigate the detrimental consequences of traditionally linear economies and the amount of waste in the environment (e.g., Bening et al., 2021). Other strands of circular economy research have looked at the policies on circular economy (e.g., Hartley, van Santen & Kirchherr, 2020; de Melo et al., 2022) while some have examined circular economy practices (e.g., Barros et al., 2020; Gedam et al., 2021). Yet others have developed indicators of the circular economy (e.g., Luttenberger, 2020). Again, studies have delved into the barriers and challenges to the circular economy (e.g., Bening et al., 2021; Siltaloppi & Jahi, 2021) as well as reviews on various aspects of the concept of circular economy (e.g., Ranjbari et al., 2021).

However, there is a paucity of empirical research focusing on the relationship between circularity, resilience and sustainability. In addition, despite several studies that have been conducted on the circular economy in Ghana (e.g. Tulashie et al, 2022; Hira et al, 2022; Doe et al., 2022), there is limited research on how the emerging informal plastic circular economy in Ghana has contributed to resilience and sustainability. The purpose of this study is twofold. First, to examine the relationship between circularity, resilience and sustainability in the informal plastic circular economy. Second, to explore the opportunities and barriers in the informal plastic circular economy. Thus, this study aims to examine how circularity contributes to resilience and sustainability and the opportunities and barriers to the informal plastic circular economy in the Global South.

This study is relevant for different reasons: first, studies that examine the relationship between circular economy, resilience and sustainability are generally untapped; therefore, the margin of their contribution to the extant literature is quite missing considerably. Similarly, this study brings evidence from informal plastic circular economy actors in developing contexts who are often unrecognised and less studied. The rest of the paper proceeds as follows: section two provides an overview of the literature on plastics and circular economy. Section three explains the research design while section four contains the results and discusses the findings. Section five provides the policy and research recommendations, and the last section concludes the study.

2. Literature Review

2.1 Plastic Production and Waste

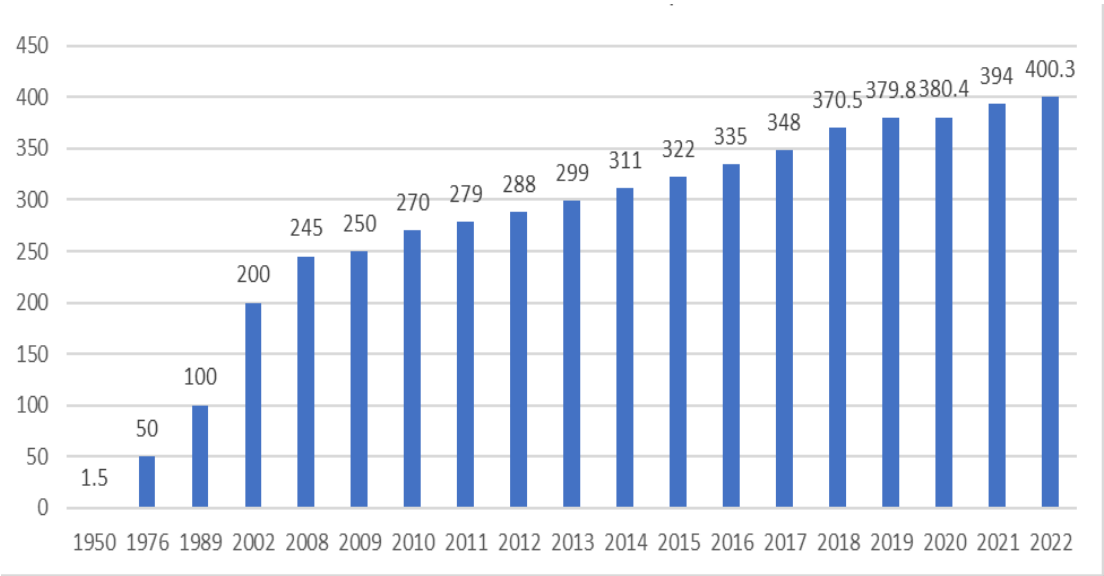
Plastics are generally synthetic polymers mostly made from petrochemical feedstocks (Shen & Worrell, 2024). Generally, plastics are divided into thermoplastics and thermosets (Shen & Worrell, 2024; Hale, King & Ramirez; 2024). The difference between thermoplastics and thermosets is about how the process behaves during curing. Thus, thermoplastics do not undergo chemical changes when they are heated and therefore can be moulded again.

Thermoplastics are further subdivided into polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyvinyl chloride (PVC). Again, PE can further be subdivided into high-density polyethene (HDPE), low-density polyethene (LDPE), and linear-low-density polyethene (LLDPE), all based on how the polymer chains are distributed in the plastic (Shen & Worrell, 2024). Finally, unlike Thermoplastics, thermosets can melt and shape once, so they stay solid after solidification. This is because, during the process of melting, a chemical reaction occurs making it irreversible. Therefore, recycling thermosets is difficult and usually done in a chemical process. Largely polyurethane (PUR) is a commonly used thermoset (Shen & Worrell, 2024).

From the invention of plastic or polymer in the early 1900s and the development of polyethene in the 1930s, the production and uses of plastic have increased tremendously (Shen & Worrell, 2024; Hale, King & Ramirez; 2024). The use of plastics has become so popular because they offer several advantages including easy to shape, they do not corrode or decompose slowly and their ability to adapt to specific needs by composites or adding specific layers or additives (Shen & Worrell, 2024).

Globally, plastic production reach 400 million metric tons in 2022 and it is estimated to increase to 589.03 million metric tons by 2050 (Jaganmohan, 2024). The current rapid urbanisation, economic growth, and shift in consumption patterns have caused a corresponding change in the amount of waste. The quantity and complexity of waste in the current global economy pose serious risks to humans and ecosystems.

Figure 1: Annual production of plastics worldwide – 1950 to 2022 (million metric tons)



Source: Jaganmohan, 2024 (Statista)

The amount of waste generated globally is estimated to reach 2.59 billion annually by 2030 and eventually reach 3.40 billion tons worldwide by 2050 (Suchek et al, 2021). As a result of the high production of plastic, plastic waste has become the biggest challenge facing the planet today. Plastic waste can be found polluting the environment and the sea in addition to affecting human health, destroying ecosystems, and harming wildlife, especially marine species (Hale, King & Ramirez; 2024). Research evidence has shown that the abundance of disposal of plastic waste accelerated environmental challenges and caused severe damage to human health and the environment (Lobelle et al., 2024; Rochman et al., 2013).

According to UNEP (2019), an estimated 11.2 billion tons of waste is collected yearly across the globe. In particular, plastic waste is the key contributor to unsustainable levels of waste generated because is widely used across several industries in addition to its short lifespan. As a result, the plastic waste challenge has become a major challenge to many countries. While plastic has several uses and serves many purposes, its single use has brought several economic, health, environmental and social consequences to humanity. To address the pollution and environmental challenges caused by plastic waste, recycling has been one of the key adopted strategies (Lobelle et al., 2024) of which the circular economy is a part.

2.2 Circular Economy

The concept of circular economy has assumed center stage in the sustainability agenda. It has become popular in scholarly literature and among practitioners and consulting firms (Kirchherr, Reike & Hekkert, 2017). Despite its popularity and current usage, there is still a lack of consensus about its meaning as definitions have ranged from simple to complex. For instance, Kirchherr, Reike & Hekkert (2017: 224-225) have defined circular economy as "an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes".

Ellen MacArthur Foundation gave one of the earliest definitions of the circular economy. According to the Ellen MacArthur Foundation (2012: 7) circular economy is "an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models." The adoption and implementation of circular economy systems require the design and implementation of business models that seek to maximise values while at the same time using as few resources as possible. As a result, the circular economy is based on three key principles: circularity from design, keeping products and materials in use, and regenerating natural systems (Herrador & Van, 2024).

Therefore, the idea of circular economy is to reduce waste to the bearer's minimum as well as ensure that products and materials are in the economic cycle (Korhonen, Nuur, Feldmann, & Birkie, 2018). As noted by Salmenperä, Pitkänen, Kautto & Saikku (2021) circular economy is broadly aimed at simultaneously creating environmental quality, economic prosperity, and social equity. Furthermore, Santeramo (2022) added that the circular economy is a paradigm that seeks to reduce waste and pollution and ensure that products and materials are kept in use and regenerate natural systems. The overarching idea behind the concept of circular economy is to ensure that there is maximum extraction from the use of resources and to keep materials or resources in circulation for as long as possible (Herrador et al., 2020).

Extant literature has looked at the circular economy in three levels; what is called the three levels of the circular economy system - the macro, the meso and the micro system (Kirchherr, Reike & Hekkert, 2017). Whereas the macro-systems perspective of the circular

economy focuses on adjusting the industrial composition and structure of the whole economy, the meso-system concentrates on the eco-industrial parks systems. But the micro-systems take it from the lowest level focusing on individual enterprises, products and what needs to be done to increase their circularity and more importantly on consumers (Jackson et al., 2014).

Since the concept of circular economy attention, several studies have engaged in consolidating circular economy strategies (Rahman et al., 2021) popularly known as "R". According to Reike et al. (2018) 'R' stands for various terms starting with 're-' (from Latin: 'again'), such as 're-use', 're-manufacture', among others. Reike et al. (2018) in their review of different R imperatives found that R imperatives vary from 3Rs to 10Rs. These are R0 (Refuse), R1 (Reduce), R2 (Re-sell/Re-use), R3 (Repair), R4 (Re-furbish), R5 (Re-manufacture), R6 (Re-purpose/ReThink), R7 (Re-cycle), R8 (Recover/Energy) and R9 (Re-mine). They argued that 3-5Rs strategies are dominant with a clear hierarchy as against 10Rs strategy which is aimed at deeper nuances and maximizing value retention. Again, Reike et al. (2018) added that typologies of 4Rs and 6Rs typologies are nearly as popular, whereas the more nuanced typologies with 7Rs-10Rs are far less used.

Through employing efficient waste management systems, the circular aims to increase resource efficiency and mitigate the environmental impacts of waste generation. It has also been found that the circular economy is beneficial in job creation, cost savings, innovation, resource efficiency, and productivity in both developing and developed countries (e.g., Gower and Schroeder 2016). Similarly, it has been found that a circular economy is beneficial in reducing waste, reducing energy usage, reducing consumption, improving economic efficiency, reducing greenhouse gas emissions, improving competitiveness as well as generating employment opportunities (Lahane et al., 2021).

Similarly, Fratini, Georg & Jørgensen (2019) argued that a circular economy is essential in creating jobs at all skill levels and provides opportunities for social integration and cohesion. The circular economy has the potential to save energy and can help avoid irreversible damage caused by using resources at a rate that exceeds the earth's capacity (Fratini, Georg & Jørgensen, 2019).

Whereas the circular economy sounds like a good idea and provides an opportunity to use resources sustainably, there remain several challenges. The challenges range from operational to technological, economic, societal, or regulatory barriers (Siltaloppi & Jahi, 2021). The technological challenges have to do with the novel or inferior material properties

of both bio-based and recycled plastics (e.g. Dijkstra et al., 2020) as this sometimes creates problems for product designers and converters (e.g., Paletta et al., 2019). The other side of the technological barrier is the issue that there is the need for technological advancement for sorting and processing plastics into high-quality raw materials (e.g., Larrain et al., 2020). In their study, Gedam et al. (2021) found the challenges of the circular economy in the food value chain to a lack of technology and innovation, a lack of robust estimates of food waste, a lack of supply chain design and optimisation, and lack of economic benefits and high cost of investment in the adoption of circular economy.

Furthermore, studies have found a lack of collaboration, support, knowledge, awareness, and policies and technologies as the most prominent barriers to adopting a circular economy (Sharma et al., 2019). Dossa et al. (2020) found that financial uncertainty is a major barrier to the adoption of circular economy practices. Other studies have documented the following challenges lack of financial and government support, circular economy legislation, environmental culture, information deficits, administrative burdens, technical skills, and expertise (Govindan & Hasanagic, 2018). Additionally, the following challenges have been documented in the literature including a lack of capabilities and skilled people, culture, and social issues as well as technological issues (García-Quevedo et al., 2020).

2.3 Circular Economy, Resilience and Sustainability

Most cities across the world, especially in Sub-Saharan Africa, are already vulnerable to climate change, natural disasters, and associated risks. Thus, the idea of a circular economy is certainly connected with city resilience and sustainability as it will strengthen and build a city that is capable of withstanding shocks and stresses. The concept of urban resilience has generally emerged as a tool to build and improve the capacity of urban systems not only to cope and withstand but also to mitigate the impacts of urban vulnerabilities (Amegavi, Nursey-Bray & Su, 2024). Resilience is defined as the ability of a city to maintain its core functions and processes in the face of shocks, and stresses by resisting, recovering, adapting, and bouncing back even better (Giannetti et al., 2023).

The concentration of this research is on socio-ecological resilience, which can be defined as the ability of a system to adapt and positively transform itself as a response to a perturbation (Folke et al., 2010). Massari & Giannoccaro (2024) in their study made the case for the integration of resilience thinking in a circular economy. This is because the concept of

circular economy has the potential to support the reduction and elimination of pollution and waste and help mitigate climate change thereby ensuring resilience.

Sustainability on the other hand has to do with a balanced integration of economic performance, social inclusiveness, and environmental resilience, to the benefit of current and future generations (Geissdoerfer et al., 2017). The focus of sustainability here is socio-ecological sustainability with a strong emphasis on environmental sustainability. The circular economy is the optimal point of sustainability, given that it offers a set of practices capable of generating more sustainable operations, making sustainability feasible in organizations.

As indicated by Schöggl et al. (2020) researchers have indicated that the circular economy is an umbrella of sustainability as it seeks to address the environmental sustainability of the production-consumption system. Therefore, the circular economy generally incorporates the notion of environmental sustainability. One of the main complex features of social-ecological systems, resilience, has been considered a prerequisite for sustainability (Biggs et al., 2015). Thus, both the circular economy and resilience have been perceived as an essential requirement for sustainability as they help in the transformation of systems that threaten planetary resilience (Folke et al., 2010).

2.4 Overview of Plastic Waste and Circular Economic in Ghana

Whereas plastic waste is not new in Ghana, Akuoko et al. (2023) are of the view that the political landscape of plastics in Ghana has changed due to increased domestic use, involvement of global plastic trade as well as neoliberal governance solutions. Thus, plastics became popular as part of daily life in Ghana in 1990 as they replaced baskets for markets, and banana leaves while sachet water replaced refillable water glasses (Akuoko et al., 2023). According to the 2020 National Plastics Management Policy, 120 plastic producing companies in Ghana manufacture about 52000 plastic products annually. Similarly, Ghana imports about 3.2 million tonnes of plastic annually and this has resulted in unquantifiable plastic waste in the country (Abrokwa et al., 2021).

Whereas plastics may not be entirely bad, the single use nature of plastics in Ghana raises a major concern. Available data shows that Ghana generates about 0.84 million tonnes of plastic municipal solid waste annually, with an estimated annual growth of 5.4 per cent (NPAP, 2021). Out of this plastic waste, only 5 per cent is collected for recycling. According to NAP (2021), despite the efforts by both the government and partners, plastic leakage is

expected to grow by 190 per cent between 2020 and 2040 from approximately 78,000 tonnes per year to 228,000 tonnes per year.

Even though plastic recycling was initially low, it is currently gaining ground where not only many businesses become involved but also informal recycling actors (Keesman, 2019). It has been found that more than twenty-five small and medium-sized firms are recycling plastic waste into carrier bags, packaging bags, disposable food packs, dust bins, shoe soles, lorry and door mats, and pavement bricks, among others (Hervie et al., 2021). Some of these firms include Nelplast Eco Ghana Ltd, GP Waste Recycling Co. Ltd, Geocrest Co. Ltd, Universal Royal Paper Ltd, etc. According to Hervie et al. (2021), these plastic recycling companies process about 230 tonnes daily with an annual expense of about 1.15 million Euros. However, the biggest challenge is that many of the plastics in Ghana are considered the hardest to recycle and least valuable (Lerner, 2020). As such, little has been achieved in terms of plastic waste recycling in Ghana.

In recent years, informal actors have become increasingly engaged in the circular economy, especially plastic waste recycling. Therefore, informal collection and recyclers have become very important to the circular economy and plastic recycling sector in Ghana. Indeed, it is estimated that about 20% to 30% of plastic recycling is achieved through informal recycling (Hervie et al. 2021). According to Quartey et al. (2015), informal recycling plays a critical role in the plastic waste value chain by reprocessing waste into secondary raw materials, providing livelihoods and eventually making the city resilient and sustainable.

2.5 Consequences of Plastic Waste in Ghana

There is research evidence that plastic waste disposal into the environment has caused severe environmental consequences due to the prolonged degradation of plastics (Tulashie et al., 2022). The amount of plastic waste in Ghana over the years has had negative consequences on both the environment and human as well as aquatic lives. Plastic waste has caused flooding in major cities in Ghana by blocking drainage systems (Tulashie et al., 2019; Fobil & Hogarh, 2010).

Other negative consequences of plastic waste include the risk of transmission of vector-borne diseases such as malaria (Clapp & Swanston, 2009), and pollution of the land and waterways (Tulashie et al., 2022; Tulashie et al., 2019). In aquatic life, plastics break down into smaller fragments called “microplastics”. When these are ingested by fish or other marine life,

they can enter the food chain and eventually affect human life. Indeed, these microplastics have already been found in table salt and both bottled and tap water (Yang et al., 2015; Kosuth & Wattenberg, 2018).

There are several methods of disposing of plastic waste such as landfill, incineration, material recycling and chemical recovery, gasification, and bioconversion, among others (Wami et al., 2004; Njiribeako & Kathleen, 2003). However, these methods of plastic waste disposal pose a serious threat to the environment. For example, Tulashie et al. (2019) indicated that these can generate poisonous substances such as Polychlorinated Biphenyls (PCBs) which can cause serious health problems.

3. Methodology

3.1 Study Context.

The study was conducted in the Greater Accra Region, the capital of Ghana and shown in Figure 2. Accra is the economic hub of the country and has the highest population density in Ghana (GSS, 2014). The expansion of Accra started in the 1960s and by the 1980s, Accra's population growth rate was estimated at 4.3 per cent when at the national level it was 2.8 per cent. From a population of 970,000 in 1984 (Agyei-Mensah & Owusu, 2010), Accra's population is currently 5.4 million. This population growth and urbanization come with economic growth and shift in consumption patterns and a corresponding increase in waste.

With an estimated one million tons of plastic produced annually in Ghana, plastic waste constitutes about 16.5% of all the waste stream in the environment (MESTI, 2020). Therefore, waste has become a major challenge in the Greater Accra Region including pollution, outbreak of diseases, climate change and other environmental challenges. The fact that Accra is located on the shore of the Atlantic Ocean raises concern as most of these plastics end up in the sea. This has serious implications for both human and marine life. Therefore, it is worth researching the relationship between circularity, resilience, and sustainability as well as exploring the opportunities and barriers to the circular economy in the Greater Accra Region.

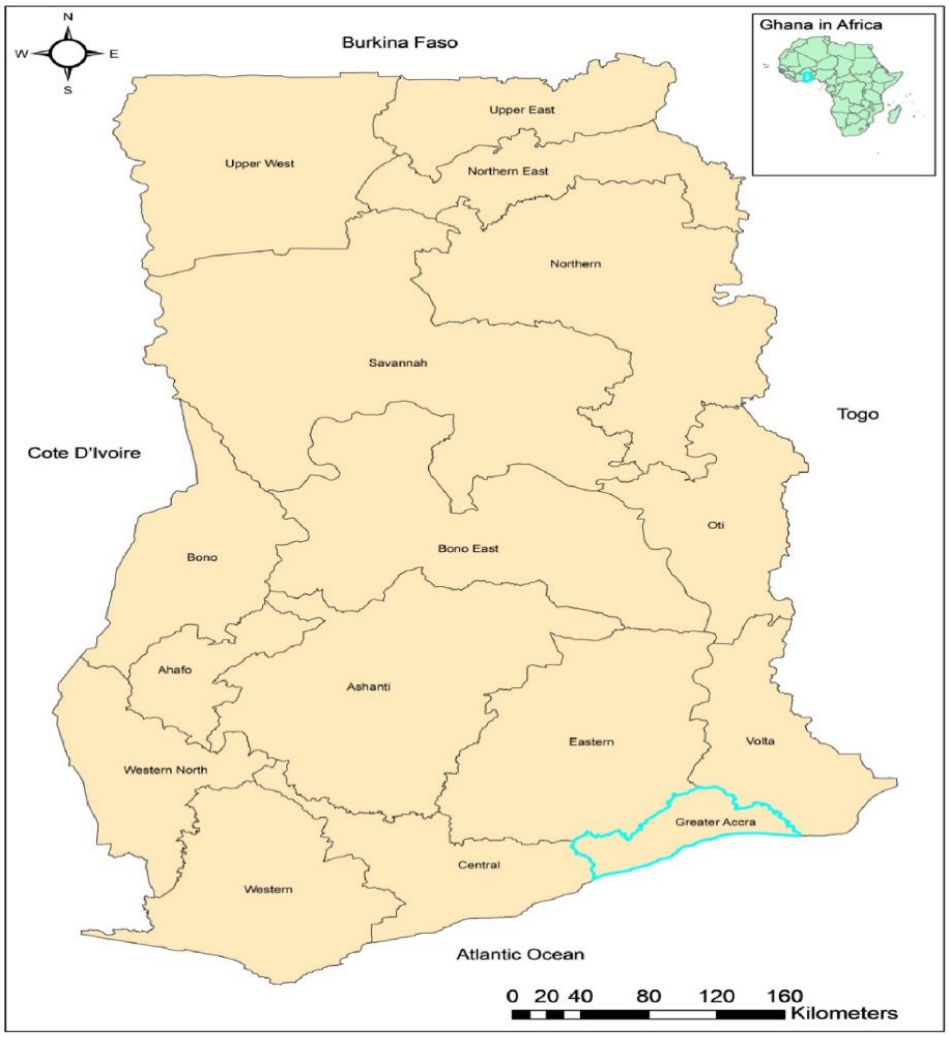


Figure 2: Map of Ghana indicating the study area in green colour

3.2 Research Design

The study utilizes mixed research design, which is defined as an approach of collecting, analyzing data, integrating the findings and drawing inferences using both qualitative and quantitative research designs. Therefore, the study employed a mixed research design using data from surveys and semi-structured individual interviews. This is imperative because employing a mixed research design enables the researcher to explore and understand complex aspects and relations of human behaviour (Malina, Nørreklit & Selto, 2011). Hence, mixed research was used because the study was interested in examining the relationship between circular economy, resilience, and sustainability quantitatively and exploring the opportunities and barriers to circular economy qualitatively.

3.3 Sample and Sampling Techniques

It was difficult to get the list of all actors in the informal plastic circular economy in Accra. We got a list from the Ministry of Environment, Science, Technology, and Innovation (MESTI), Ministry of Sanitation, Accra Metropolitan Assembly (AMA), Tema Metropolitan Assembly (TMA), and Korle-Klottey Municipal Assembly. Because of the scattered nature of actors in the circular economy in Accra, especially informal actors, none of the databases captured all of them. The list mostly captured those who are formally registered with either the Registrar Generals Department or with their respective Metropolitan/Municipal Assemblies and those in associations/cooperatives. Based on our interactions with MESTI, the Ministry of Sanitation and waste officials of the various Municipalities, we administered four hundred (400) questionnaires.

Table 1: Number of Respondents and their Organisation

Organisation	Number of Respondents
Ministry of Environment, Science, Technology & Innovation	3
Ministry of Sanitation	2
Accra Metropolitan Assembly	3
Tema Metropolitan Assembly	2
Korle Klotty Municipal Assembly	2
Ayawaso West Municipal Assembly	2
Ministry of Lands and Natural Resources	2
Madina LaNkwantanang Municipal Assembly	2
La Dade Kotopone	2
SESA Recycling	2
Kpone Katamanso	2
Nelplast	2
National Disaster Management Organisation	2
Ayawaso North Municipal Assembly	2
Total	**30**

Out of this number, 365 usable questionnaires were returned representing a 91.3 percent response rate. Respondents for the quantitative part include recyclers, crushers, processors, collectors/pickers, washers, pallet makers, aggregators and workers in organisations that recycle plastic waste in Accra. For the qualitative aspect, we conducted 30 key informant interviews with local and central government stakeholders in Accra as indicated in Table 1. We believe that this covered relevant stakeholders who can give enough information to arrive at valid conclusions.

3.4 Research Instrument and Data Collection

All the quantitative measures in this study allowed respondents to answer on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The circular economy was measured with seven (7) questions adapted from Geissdoerfer et al. (2017), Elia et al. (2017) and Kirchherr et al. (2017). Also based on Gunderson and Holling (2002), Walker et al. (2009) and Resilience Alliance (2012) eight (8) questions were drafted to measure resilience. Finally, the ecological sustainability questionnaire was designed based on Smit & Parnell (2012) and consists of five (5) questions. These items were pre-tested with a sample of thirty (30) respondents and subjected to further corrections before data collection.

The qualitative aspect used an interview guide as the data collection instrument. Each interview lasted between fifty (50) minutes to an hour. The interview guide covered questions related to circular economy practices, opportunities, and prospects in the circular economy as well as the challenges and barriers to the circular economy. We conducted these in-depth interviews to get detailed and firsthand information on circularity and resilience. The interviews were audiotaped while taking notes alongside. We recruited ten (10) research assistants to support the collection of the data.

3.5 Data Analysis

We analysed and tested the quantitative part of the study with the use of Structural Equation Modelling (SEM) via AMOS 25.0 and the Maximum Likelihood Estimation (MLE). It has been stated that SEM is effective for testing models that are path-analytic with mediating variables (Meyers et al., 2013). We followed the recommended two-step analysis procedure (Hair et al., 2010; Meyers et al., 2013). We validated the measurement model in the first step and the structural model in the second step.

For the qualitative aspect, the data was transcribed and analysed manually using both the content and thematic appraisal approach. The analysis followed the procedure prescribed by Braun and Clarke (2006). This approach helped in the systematic categorisation of large textual data, concentrating exclusively on those related to the study research questions and drawing inferences (Creswell & Poth, 2018). In the analysis, verbatim statements were used to substantiate the arguments made.

3.6 Ethical Consideration

First, we got ethical approval from the Ethics Committee for the Humanities (ECH), University of Ghana (ECH 204/22-23). Furthermore, we followed all ethical procedures, especially by ensuring that the consent of participants was sought, and their rights were explained as well as ensuring that their anonymity and confidentiality were protected. Indeed, participation was voluntary, and interviewees had the option to withdraw at any time they felt uncomfortable. Reporting of the data and analysis was done anonymously, and all identifiable data was removed from the analysis.

4. Findings of the Study

4.1 Demographics

Table 2 shows the demographic characteristics of the respondents. The data showed that the majority of respondents are males (63.6 per cent), more young people between the ages of 30-39 years (31.8 per cent) are engaged in the circular economy and 36.7 per cent of them had completed Senior Secondary School/Senior High School (SSS/SHS).

Table 2: Demographic Background of Respondents

Sex	Frequency	Per centage
Male	232	63.6
Female	133	36.4
Age		
18-29	96	26.3
30-39	116	31.8
40-49	87	23.8
50-59	40	11.0
60-69	22	6.0
70-79	3	0.8
80-89	1	0.3
Education		
None	35	9.6
Kingdagartin	1	0.3
Primary	43	11.8
JSS/JHS/Middle School	97	26.6
SSS/SHS	134	36.7
Voc/Tech/Comm School	13	3.6
Training – agric/nursing/teaching	3	0.8
Polytechnic	7	1.9
Bachelors	27	7.4
Postgraduate	4	1.1
Others	1	0.3

4.2 Designation and Position of Respondents

Table 3 below shows the designation and position of the respondents of this study. The informal plastic circular economy chain in Accra starts from the waste picker/collector and to the eventual recyclers. The full chain of the plastic circular economy will be captured later in this report. From the data, the leading actors in the sector include crushers (26.6%), machine operators (24.4%), CEOs (13.7%), recyclers (12.9%) and aggregators (8.2%).

Table 3: Designation and position of respondents

Designation	Frequency	Per centage
Aggregator	30	8.2
Plastic waste Buyer	5	1.4
Assistant Manager	2	0.5
CEO	50	13.7
Collector/pickers	8	2.2
Crusher	97	26.6
Recycler	47	12.9
Deputy manager	2	0.5
General manager	2	0.5
Human resource manager	3	0.8
Supervisor	7	1.9
Machine Operator	89	24.4
Waste transporter	18	4.9
Site engineer	3	0.8
Warehouse Assistant	2	0.5

4.3 Awareness of the Circular Economy

The idea of the circular economy has become popular because of the high production and usage of plastics and its consequences of environmental pollution and waste. The study sought to find out if respondents were aware of the concept of circular economy. The field data showed that 89.0 per cent of respondents are aware of the concept of circular economy. This data was collected from people in the plastic waste circular economy chain. Therefore, the 11.0 per cent who indicated their unawareness of the concept of the circular economy may be because they don't know that what they are doing is called circular economy.

4.4 Circular Economy Practices in Informal Plastic Waste

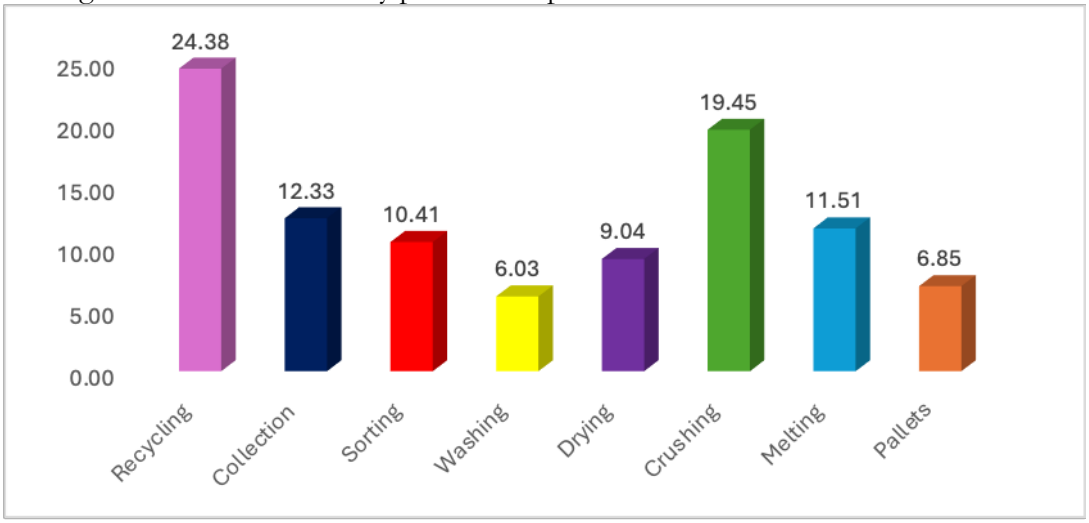
Whereas Accra continues to grapple with huge amounts of plastic waste, informal plastic circular economy practices are gradually establishing roots, especially in Accra and major cities in Ghana. Even though, the circular economy is not too new in Ghana, especially

in its traditional form. The idea of the circular economy manifested itself long ago in the form of wrapping takeaway food with leaves. However, there was a move away from the use of leaves to the use of plastics as the city continued to urbanise and modernise. The field data showed that the following informal plastic circular economy practices are dominant.

First, recycling. Recycling is basically about converting plastic waste into several new materials. After plastics are collected and sent to various recycling facilities where several recycling systems take place. Second, crushing plastic. After the collection of plastic waste, it is crushed into pieces by crusher machines. The crushing plastics are in several sizes depending on the crusher machine used, the type of plastic material used and the purpose for which the crushing material is to be used. Whereas crushing can be technically seen as part of recycling, it is the shredding process of plastic.

Third, the collection of plastics. The field data showed that a large number of people in Accra collect plastic waste. Indeed, figure 3 shows that 12.33 per cent of respondents are plastic waste collectors/pickers. Some of the collectors/pickers refurbish the plastics collected and sell them for further use by those who need them. Waste collection is an important part of the plastic circular economy, especially in developing countries where the concept is now gaining attention with limited infrastructure and resources in terms of a fully functioning circular economy system.

Figure 3: Circular economy practices in plastic waste



The fourth informal plastic waste circular economy practice is the production of pallets. The pallets are then used by the company or sold to other companies for the

production of new plastic products. The pallets are used to produce other plastics like bowls, food packs, plastic spoons, teacups, tables, chairs, and even wood and blocks. Another informal plastic waste circular economy practice is melting. The plastic waste is recycled into pallets through the process of melting the crushed plastic and cutting them into pieces as pallets. Other informal plastic circular economy practices are Accra as shown in Figure 4 include sorting of plastic waste and drying of washed and crushed plastic waste.

Figure 4: Plastic waste (left) and pallets in a machine to use to produce new products (right)

4.5 Informal Plastic Waste Circular Economy Model

The data from the field is produced in Figure 5 below. The informal plastic waste circular economy sector showed that plastic comes from both local production and foreign importation. Once the plastic is produced, it is then used and generated to waste. The model showed that plastic waste is generated in households, organisational settings (e.g., schools) and public places (e.g., markets). This plastic waste is then collected by individuals (from streets, homes, streets, etc). It is important to note that individual pickers in Ghana sometimes pick up plastic waste from dumping sites and at the seashore. This is because a lot of plastic waste is dumped at the landfill which makes it easy to generate large quantities of plastics. Also, a lot of plastic waste is accumulated at the seashore after rain, making it easy to gather enough plastics. The model also showed that plastic waste is collected by formal and informal waste collectors.

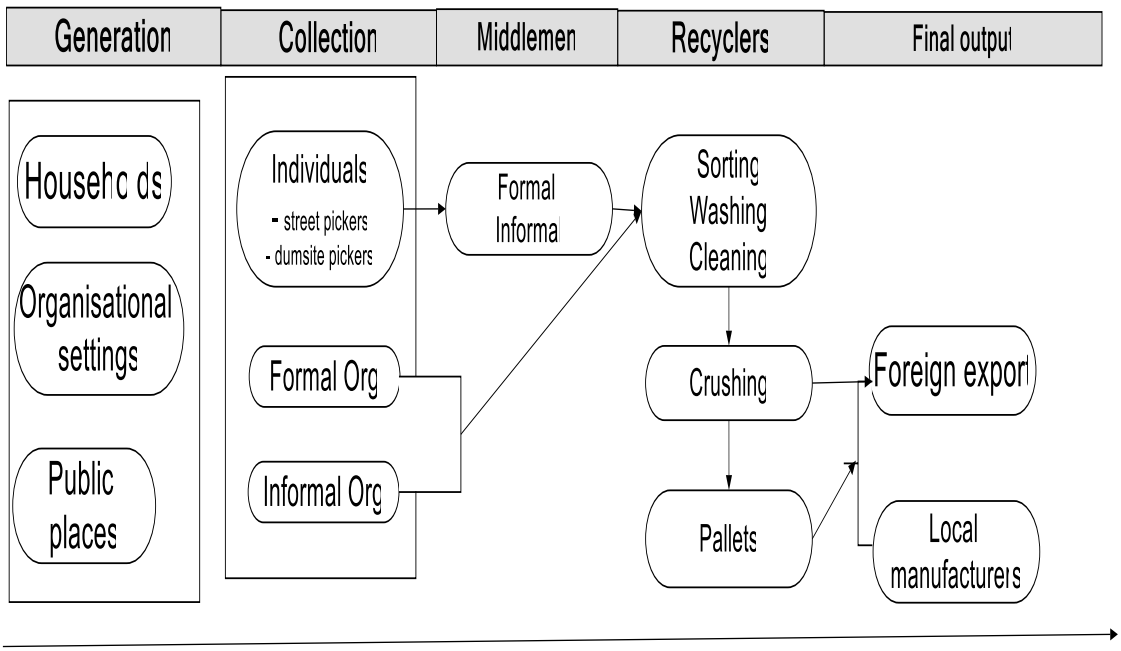


Figure 5: Informal plastic waste circular economy model

As depicted in the model, individual plastic waste collectors in most cases sell the waste to middlemen or aggregators. These middlemen are either formal or informal, most of them live within the areas and communities where these plastics are collected. These middlemen play an important role in the plastic waste value chain including the fact they individuals could get plastic to sell the waste that they collect and give people the indication that waste has value. Whereas, individual waste collectors sell to middlemen, formal and informal private waste collectors supply their plastic waste directly to recyclers. Thus, the model shows that recyclers get plastic waste from middlemen and formal and informal private waste collectors.

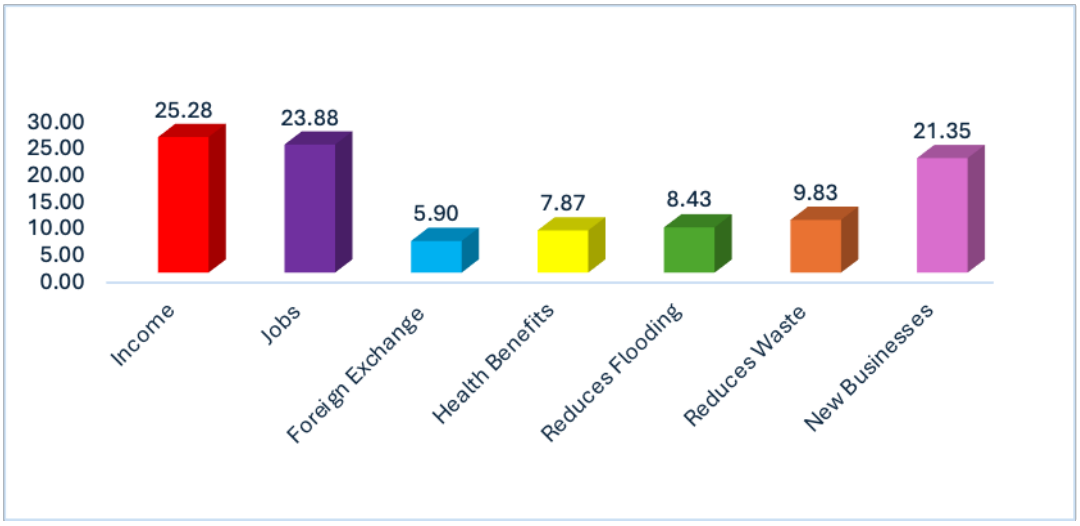
Once the plastics get to the recyclers they go through a series of processes before they are turned into raw materials. They are sorted out because in most cases they are contaminated and mixed with other waste. They are then washed and cleaned properly before they are crushed. The plastic waste is then crushed and shredded into pieces. The crushed and shredded plastics are either recycled in Ghana here into pallets or exported to companies outside the country. Similarly, the recycled pallets are either sold to companies in Ghana here for onward manufacturing of several plastic products or are exported to foreign companies outside this country.

4.6 Prospects and Opportunities in the Informal Plastic Waste Circular Economy

The circular economy holds several prospects and opportunities. Indeed figure 6 below shows some of the opportunities of informal plastic waste circular economy in Accra. First, 25.28 per cent of the respondents indicated that the informal plastic waste circular economy is a source of income for them. In our interactions with sanitation officers at the Metropolitan and Municipal Assemblies, they indicated that the majority of the youth are now engaged in plastic waste collection. A number of them are using tricycles to collect waste from homes and collect fees while at the same time selling the plastic waste to middlemen in the plastic waste value chain. The interactions further reveal that a lot of migrants from the Sub-Saharan African region in Ghana are engaged in plastic waste collection.

The second prospect and opportunity is the creation of jobs representing 23.88 per cent of the respondents. The circular economy has become an avenue for the creation of green jobs. According to the field data, the informal plastic waste circular economy has created jobs along the plastic waste value chain. Thus, in the value chain, there are plastic collectors and pickers from both the formal and informal sectors. During the recycling process, people are employed along the value chain. Therefore, the major opportunity and prospect in the circular economy is the creation of formal and informal jobs as well as direct and indirect jobs.

Figure 6: Prospects and opportunities in the informal plastic waste circular economy



Third, the informal plastic waste circular economy has prospects and opportunities to create new businesses in the areas of repair, reuse, and manufacturing among others. Thus, 21.35 per cent of the respondents indicated that the informal plastic waste circular economy has created new businesses in Accra. Such people now own their businesses, earn incomes and are able to live a decent life with their families. Also, 5.90 per cent of the respondents indicated that the informal plastic waste circular economy has the potential to boost the Ghanaian economy by bringing in more foreign exchange from the export of pallets and crushed materials from plastic waste. As indicated in Figure 5, some of the crushed plastics and pallets produced from plastic waste are exported to foreign companies outside the country. This is expected to bring in foreign exchange for the country.

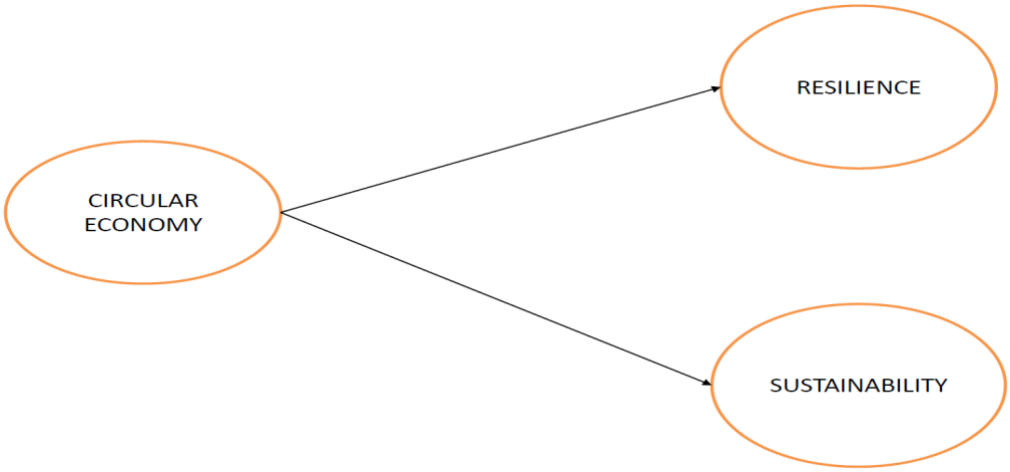
Again, 8.43 per cent of respondents noted that the informal plastic waste circular economy has the potential to help reduce disasters such as flooding caused by the accumulation of plastic waste in drains and gutters in the city. Major flood disasters in Ghanaian cities such as Accra, Tema, Kumasi and Takoradi are caused by human activities such as dumping of plastic waste in drains and gutters. The collection and use of plastic waste as a resource has the potential to help reduce this situation of flooding in cities.

Furthermore, 7.87 per cent of the respondents indicated the health benefits of the informal plastic waste circular economy to the inhabitants of the city. Plastic waste causes a lot of pollution in the environment, and this eventually has health impacts on the citizens. By adopting a circular economy in the plastic waste value chain by informal actors, they help in cleaning of the city and prevent the associated negative impact of plastic waste thereby improving not only the health of the environment but also humans. Therefore, the circular economy helps mitigate environmental hazards and threats to human lives.

4.7 Circular Economy, Resilience and Sustainability

This section concentrates on the relationship between circular economy, resilience and sustainability. The idea is that a circular economy has the potential to make a city resilient and eventually sustainable. Therefore, in this section, figure 7 was tested to examine the relationship between the variables.

Figure 7: Circular economy, resilience, and sustainability model



The relationship between circular economy, resilience, and sustainability was tested with the methodology of the Structural Equation Model (SEM) via Analysis of Moment Structures (AMOS 26), and the Maximum Likelihood Estimation (MLE). This approach was adopted because SEM is effective for testing models that are path analytic with mediating variables (Byrne, 2009). The assessment of the model followed the two-step procedures recommended by scholars (Meyers et al., 2013). First, to validate the measurement model and structural model in the second step. The fit of the model was assessed with the $\chi 2$ test [with critical insignificant level, $p < 0.05$], the Normed $\chi 2$ ratio [with critical level not more than three or at most five], the GFI, CFI, TLI, and IFI [with critical level not lower than 0.90] and the RMSEA [with critical level not more than 0.08] (Meyers et al., 2013).

Table 4: Parameter Estimates of the measures

			Estimate	S.E.	C.R.	P	Label
CE7	<---	F1	.707				
CE6	<---	F1	.998	.101	15.151	***	par_1
CE5	<---	F1	.643	.094	9.777	***	par_2
CE4	<---	F1	.921	.100	13.975	***	par_3
CE3	<---	F1	.680	.097	10.324	***	par_4
CE2	<---	F1	.666	.095	10.120	***	par_5
CE1	<---	F1	.911	.104	13.819	***	par_6
RES1	<---	F2	.603				

		Estimate	S.E.	C.R.	P	Label
RES2	<--- F2	.995	.154	11.464	***	par_7
RES3	<--- F2	.699	.125	9.097	***	par_8
RES4	<--- F2	.994	.155	11.457	***	par_9
RES5	<--- F2	.987	.152	11.413	***	par_10
RES6	<--- F2	.804	.145	10.038	***	par_11
RES7	<--- F2	.623	.134	8.334	***	par_12
RES8	<--- F2	.705	.129	9.149	***	par_13
SUST6	<--- F3	.615				
SUST5	<--- F3	.777	.129	9.181	***	par_14
SUST4	<--- F3	.847	.157	9.636	***	par_15
SUST3	<--- F3	.627	.148	7.728	***	par_16
SUST2	<--- F3	.610	.135	7.629	***	par_17
SUST1	<--- F3	.744	.133	8.922	***	par_18

When the measurement model was subjected to CFA, the results showed the following. First, all the parameter estimates were positive and within the logically anticipated range of values as can be seen in Table 4 while the CR values were greater than 1.96, which indicated that all the estimates were statistically different from zero. Second, the inter-correlations among the studied variables in the model are in the right direction with strong associations between the variables as can be seen in Table 5. Third, the measurement model showed a model fit as follows: $\chi 2/df = 1.955$, CFI = 0.925, IFI = 0.926, TLI = 0.914, and RMSEA = 0.053.

Table 5: Inter-correlation matrix

Variable	Mean	Alpha	AVE	1	2	3
1. Circular Economy	3.5	.80	.75	.27		
2. Resilience	3.7	.78	.83	.45	.41	
3. Sustainability	4.2	.88	.77	.51	.33	.33

4.8 Structural Model and Hypothesis Testing

Having subjected the structural model to CFA, the results are also given as follows: $\chi 2/df = 1.742$, GFI = 0.920, CFI = 0.963, IFI = 0.964, TLI = 0.956, and RMSEA = 0.057. This indicates that the data fits the model. The analysis further shows that resilience explains 24.3 per cent of the variance in sustainability (R^2 =24.3) while circular economy explains 27.6 per cent of the variance in resilience (R^2 =27.6). Finally,

the result of the hypothesis is as follows: the circular economy has a positive and significant relationship with resilience ($\beta = 0.212, p < 0.004$), sustainability ($\beta = 0.324, p < 0.001$), as well as a positive and significant relationship between resilience and sustainability ($\beta = 0.212, p < 0.001$).

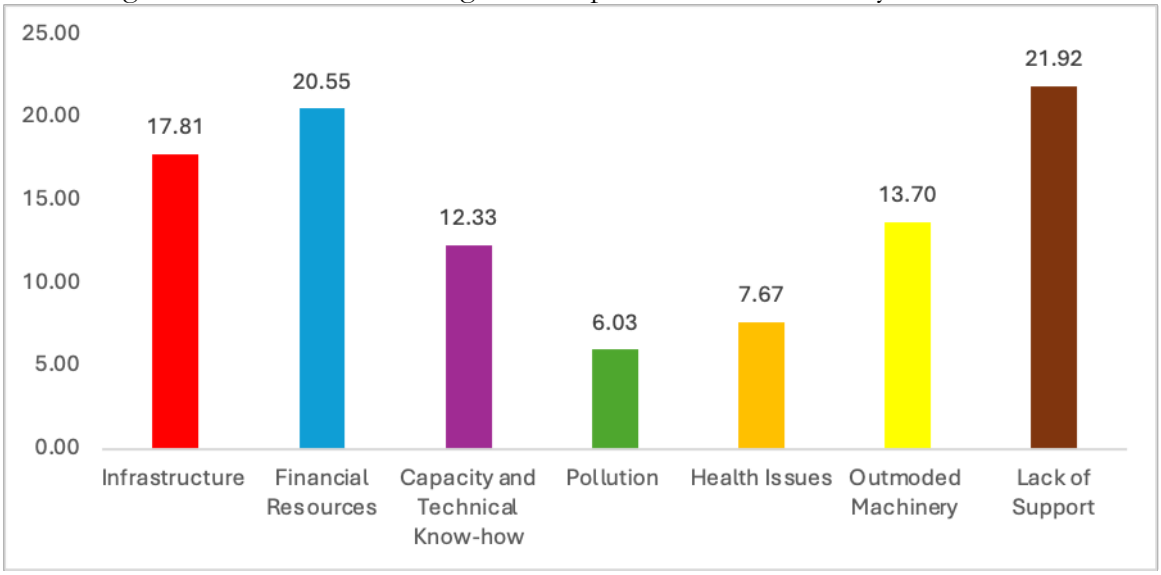
4.9 Barriers and Challenges of the Circular Economy

Despite the opportunities and prospects of the circular economy, there are barriers and challenges as presented in Figure 8. First, 21.92 per cent of respondents indicate a lack of support from the government. They indicated that even though they have met several government functionaries at the local and national levels, there hasn't been any concrete support from the government. According to them, whereas the government keeps talking about the circular economy, the local-level government seems not to give them the necessary support. There is no support from the government in terms of finance, equipment and machinery, capacity building, and other non-financial incentives to support informal plastic waste circular economy actors.

The second barrier and challenge mentioned by 20.55 per cent of the respondents is the lack of financial resources. Because they have limited resources, they often operate on a small scale and cannot buy the required modern equipment to convert the plastic to several other products. This is seen in the equipment they use, the working environment and their capital base. Third, 17.81 per cent of the respondents indicated a lack of the required infrastructure such as the land and factory setting. Indeed, almost all the informal plastic waste circular economy actors we interacted with have their factories on either government land or land owned by someone else.

The fourth challenge mentioned by 13.70 per cent of the respondents is about the lack of proper machinery. They often use crude and outmoded machinery and techniques in the sorting, washing, crushing, and recycling of plastic waste. Most of them use their hand in sorting, washing and drying the washed plastics. The crude techniques and machinery make it unhealthy for the workers. The nature of the equipment, lack of factory procedures and a lack of training in equipment use make the workers susceptible to accidents.

Figure 8: Barriers and challenges of the plastic circular economy



The fifth challenge stated by 12.33 per cent of the respondents is a lack of capacity and technical know-how. Most of the informal plastic waste circular economy actors do not have the technical know-how to convert plastic into several other usable materials. It appears that they are all doing the same thing such as crushing and converting them into pallets. As a result, they indicate that they don't earn much as what they do is considered the raw state of plastic waste. Thus, those formal companies who buy the pallets from them and turn them into finished products benefit more than the informal plastic waste circular economy actors.

Furthermore, environmental damage and pollution were indicated by 6.03 per cent of the respondents. In the field, we observed smoke, dust, and heat engulfing the recycling facilities. This improper way of recycling poses significant damage to the environment through releasing dangerous toxins and chemicals into the atmosphere. Lastly, connected to the pollution and environmental damage is the health issues associated with informal plastic waste circular economy. Thus, the factories are full of dust and smoke, unfortunately, the workers do not even put on protective clothes posing serious challenges to their health. The amount of smoke, dust and chemicals that is released into the environment also affects the health of people living close to the recycling facilities.

5. Discussions

The amount of plastic waste generated annually, and the implications thereof have generated concerns among urban managers and sustainable development scholars. The environmental impacts as well as the externalities associated with plastic waste are threatening to both human and ecological lives. Generally, this has triggered the need to rethink the production and sustainable use of plastic resources. Hence, the concept of circular economy has emerged as a sustainable way of minimising the impact of plastic waste on the environment and human lives. As a result, circular economy has attracted the attention of both scholars and practitioners (Kirchherr, Reike & Hekkert, 2017; Hartley, van Santen & Kirchherr, 2020; de Melo et al., 2022).

Despite much scholarly research on the concept of circular economy, there appears to be little research on the relationship between circularity, resilience and sustainability especially in the context of informal plastic waste circular economy value chain. This research therefore seeks to (1) examine the relationship between circularity, resilience and sustainability in the informal plastic waste circular economy; (2) explore the opportunities and barriers in the plastic waste informal circular economy. The study employed both quantitative and qualitative research designs where data was collected from 365 and 30 respondents respectively. The findings of the study are as follows:

First, the findings showed that despite all the respondents being in the circular economy about 11 percent of respondents indicated that they are not aware of the concept of circular economy. This is not too surprising because the educational level of most of the respondents is low and they may not perceive that what they are doing is a circular economy. It is imperative to state that respondents are familiar with the term recycling. Truly, their understanding of what they are doing as recycling appears to be right because plastic is crushed/shredded and converted to pallets so that they can be used in the manufacturing of the same or other entirely new products while the circular economy is aimed at keeping products in perpetual circulation. In the extant literature, it has been found that lack of awareness is a barrier to the adoption of a circular economy (Farooque et al., 2019; Sharma et al., 2019).

Second, the findings showed that the informal plastic waste circular economy manifests itself in the collection and refurbishment of plastic waste; sorting, washing, and crushing plastic waste; recycling and converting the plastic waste into new raw materials

such as pallets; and the use of the pallets to produce other plastics like bowls, food packs, plastic spoons, teacups, tables, chairs, and even wood and blocks. Studies in Ghana such as Hervie et al. (2021) have found that small and medium firms in Ghana are recycling plastic waste into carrier bags, packaging bags, disposable food packs, dust bins, shoe soles, lorry and door mats, and pavement bricks.

Third, the study developed an informal plastic waste circular economy model and the model showed that plastic waste is generated at a certain point such as markets; this plastic waste is collected by individuals at various locations (e.g., waste pickers); the collected waste is either sold to middlemen or recyclers. A number of things happen at the recyclers stage in the model which includes sorting, wasting, cleaning and crushing. The model showed that the crushed plastics are either processed in Ghana here to pallets or exported to foreign companies. Similarly, the pallets produced from the plastic waste are either used by manufacturers in Ghana to produce new products or are exported outside the country.

Fourth, the findings showed that the informal plastic waste circular economy has several prospects and opportunities for cities, especially in the Global South. The findings showed that the informal plastic waste circular economy in Accra has the potential to create jobs for the people, especially in the informal sector. This happens throughout the plastic waste value chain starting from waste collection to the final product of manufacturing. The informal plastic waste circular economy in Accra has the potential to bring in foreign exchange through the export of crushed plastic waste and pallets produced from the waste. The informal plastic waste circular economy has health and ecological benefits by reducing pollution, mitigating environmental hazards, and making the city clean. Thus, the literature showed that the circular economy is important and beneficial in the creation of jobs (Gower and Schroeder 2016; Fratini, Georg & Jørgensen, 2019), reducing waste, reducing greenhouse gas emissions, reducing harm to the environment, and promoting environmental tranquility (Lahane et al., 2021).

Fifth, the findings showed that the informal plastic waste circular economy had a significant relationship with resilience and ecological sustainability. Thus, the findings indicated the informal plastic waste circular economy contributes to 32.4 per cent of city resilience and 21.2 per cent of ecological sustainability. This is very important in the current dispensation where a lot of cities in the Global South are experiencing natural

disasters and shocks such as flooding and environmental changes. This gives some hope to city authorities that they can pay attention and invest or ensure the provision of the enabling environment to support informal plastic waste circular economy actors as their interventions have positive impact on city resilience and sustainability. As noted by Massari & Giannoccaro (2024) circular economy can improve the general environmental condition thereby leading to city resilience. Similarly, Schöggl et al. (2020) stated that the circular economy is an umbrella of environmental sustainability.

Finally, the study found that the informal plastic waste circular economy actors encounter challenges and barriers including a lack of the necessary infrastructure; lack of capacity and technical know-how; lack of financial resources; and lack of support from the government. These challenges impede the ability of informal plastic waste circular economy actors to fully benefit from circularity. The biggest challenge is the improper way of recycling, this releases harmful toxins and chemicals into the air. It affects both the workers who do not have protective equipment and people living around the facility and can cause climate change. Some of these challenges have been identified in the literature. For example, lack of financial and government support, technical skills, and expertise, technological challenges, and high cost of investment (Dossa et al., 2020; García-Quevedo et al., 2020; Gedam et al., 2021; Siltaloppi & Jahi, 2021).

6. Policy and Research Recommendations

Research on the circular economy, especially plastic waste, is of much importance to policymakers, practitioners and academics. This is because plastic has become part of daily life due to its unique characteristics, however, these characteristics in addition to its poor waste management also make it very challenging. The policy and research recommendations proposed here are based on the research findings.

6.1 Capacity Building

One of the major challenges of the informal plastic waste circular economy actors is the lack of the requisite skills, technical know-how and capacity. It is therefore recommended that actors in the informal plastic circular economy chain should be given the necessary training that would build their capacity to convert plastic waste to other usable materials. This is very essential because most of the actors in the informal plastic

waste circular economy have low educational levels and this requires that they are given some training in the whole value chain. Capacity building will help them to handle the plastics, machines, business management and available markets for their products. It is also recommended that future research should be conducted on the capacity needs and how to deliver this capacity to them.

6.2 Provision of the Necessary Infrastructure

Similarly, the findings show a lack of infrastructure for the proper functioning of the informal plastic waste circular economy. Circular economy infrastructure refers to the requisite infrastructure, equipment and machinery that enable circular economy activity such as recycle, reuse, recovery, etc to operate and function. Therefore, this study recommends that informal plastic waste circular economy actors should be supported to acquire crushing/shredding machines, plastics recycling washing machines, compactors and recycling pelletizing systems, among others. These machines are very important to support the informal actors in the plastic circular economy. Apart from the machinery, it was realised from the field that most of the actors were occupying lands illegally and were vulnerable to eviction. The national and local governments must support them by acquiring space outside the city center to accommodate them.

6.3 Financial Support

One of the major challenges mentioned by the informal plastic waste circular economy actors was the lack of finance. This has implications for their work as they are unable to buy the required and needed equipment. Indeed, their vulnerable financial situation is hampering their ability to process the plastic waste into other usable materials that would earn them good money. Therefore, most of them tend to just crush the plastics and sell either to local or international companies. It is therefore important to support these actors financially as this could help them broaden their operations and enjoy the full benefit of the circular economy. Research can also be conducted to find out the sources and what financial support is available to help informal plastic circular economy actors.

6.4 Environmental and Health Mitigation Measures

A major challenge that was discovered in the field was the environmental and health hazards of the people who work in the informal plastic waste circular economy chain. It is imperative on the part of policymakers to put in place a guide and policy on recycling, the requirements and standards for recycling as well as health and safety standards in plastic recycling for informal plastic waste circular economy actors. It is also recommended for a study to identify the various health and safety issues as well as the nature of environmental hazards and pollution caused by the activities of informal plastic waste circular economy activities.

7. Conclusions

The number of plastics produced annually and more importantly the amount of plastic waste generated has generated interest in finding solutions to this menace. Thus, the idea of a circular economy emerged as a possible alternative to dealing with the linear, single-use and mismanagement of plastics. The circular economy has therefore gained substantial attention among policy makers and practitioners. Several research and scholarly works have been conducted on the idea and concept of circular economy. The data on plastic and plastic waste in Ghana especially in urban areas is glaring. This study was conducted in Accra and data was collected from informal plastic waste circular economy actors and responsible public organisations in the waste sector. We draw the following conclusions.

First, the informal plastic waste circular economy sector is fast growing in Accra because of its flexibility of free entry and exit in any part of the value chain. Second, within the informal plastic waste circular economy chain, a lot of people are employed as aggregators/buyers, plastic waste collectors/pickers and crushers/shredders employing about 85.3 per cent of the people in the sector. Third, the circular economy practices in the informal plastic sector include plastic collection/picking, sorting, washing, drying, crushing, melting, and making pallets while conversion to the final product is done by formal private sector actors.

Fourth, a unique model of circular economy waste was identified in the informal plastic waste circular economy in Accra, starting from where the plastic waste is generated (in homes, public places, and organisational settings) to the collection (by formal organisations both private and public as well as individuals), to middlemen/aggregators

(both formal and individuals), to recyclers where all sought of conversion takes place to the final output. Again, the informal plastic circular economy has several opportunities and prospects for cities in the Global South such as job creation, boosting the economy, creating businesses, reducing waste, reducing flooding and promoting environmental well-being. Furthermore, the informal plastic circular economy is positively associated with city resilience and ecological sustainability. Finally, despite the benefits and potentials of the informal plastic circular economy, the sector is confronted with several challenges including finance, infrastructure, machinery, inadequate capacity and skills, lack of support and health-related challenges.

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