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Toward a preliminary research agenda for the circular economy adoption in Africa

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Circular economy (CE) research plays an important role in accelerating the
CE transition globally and is an essential tool to contribute to climate change
adaptation. However, prior CE research is primarily focused on countries in
the Global North, whereas CE research in the Global South has been largely
unexplored, especially in African countries and contexts. Therefore, this study aims
to develop a preliminary research agenda for CE development in African countries
by identifying the current body of knowledge on CE, the existing CE research gaps
and barriers to conducting CE research in African countries. This research applied a
mixed method research design, whereby this study reviewed a total of 275 English
and French articles from Google Scholar through a scoping literature review
and carried out a quantitative and qualitative survey with 38 CE industry experts
working on CE projects in African countries. The findings suggest that South Africa
is the front-runner in CE research, with the most relevant publications and ongoing
research projects conducted by CE experts. The dominant focus on CE research in
South Africa is an urgent call for scholars to conduct country-specific research for
additional African countries, especially since a significant number of publications
do not distinguish between countries. Based on findings, this study concludes
that the current body of CE knowledge is primarily focused on one aspect of CE,
circulating materials and products (keep products and materials in use), while there
is consensus from published journal papers that there are meaningful gaps in other
CE principles such as designing out waste and pollution and regenerating natural
systems. Therefore, this paper suggests a list of research topics that can be further
investigated. To the authors' knowledge, this study is the first attempt to establish
a preliminary research agenda for CE across African contexts and countries.

KEYWORDS

circular economy (CE), Africa, bio-economy, Global South, sustainable development goal
12, responsible consumption and production, waste

1. Introduction

With the threat of the global challenges of the unstainable traditional linear economy
focused on "take-make-dispose", there is an urgent need for an alternative economic model
(Geissdoerfer et al., 2017; Sariatli, 2017; Oduniyi, 2022, p. 2022). A circular economy (CE)
model provides an alternative to the linear economy that seeks to prevent environmental

degradation, including biodiversity loss, accelerated climate change, waste and pollution (Su et al., 2013; Oduniyi, 2022). Kirchherr et al. (2017) concluded after analyzing 114 different CE definitions that Schut et al. (2015) and Geissdoerfer et al. (2017) identified that the Ellen MacArthur Foundation formulated the most prominent and employed definition. The Ellen MacArthur Foundation (2013, p. 7) defines a CE as "an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts toward 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 CE model targets achieving the sustainability of production and consumption through the implementation of closed cycles for restoration and regeneration and the combination of processes for maintenance, reuse, reparation, remanufacturing, renovation, and recycling of waste (Parida and Wincent, 2019).

CE research plays an important role in accelerating the global CE transition and is a tool to contribute to climate change adaptation (Muchangos, 2021). However, prior CE research is mainly focused on countries in the Global North, also recognized as high-income countries, such as Germany, and Japan, which are known for their immersive inclusion in CE practices and reforms (Greyson, 2007; Ministry of the Environment and Minister's Secretariat, Waste Management and Recycling Department Policy Planning Division, Office of Sound Material-Cycle Society, 2014; Muchangos, 2021). For example, the EU adopted an Action Plan for the CE (EU, 2020), followed by Germany, which developed a CE act (Ogunmakinde, 2019), Finland, which established a National Roadmap for CE (Cairns, 2018), and China adopted the "Circular Economy Promotion Law" to promote the CE (Greyson, 2007; UNEP, 2008). Earlier literature reviews concluded that more than half of the academic studies on CE from 2004 to 2017 are focused on the Asian region, especially China, and the other remainder concentrates on European countries (Merli et al., 2018). A similar conclusion can be drawn from a bibliometric review that evaluated studies related to sustainability and CE, whereby most of the authors and cited publications are focused on China, the UK, the Netherlands, the USA, and Italy (Geissdoerfer et al., 2017). The dominant focus on the Global North highlights the importance of studying CE development in the Global South.

In contrast, CE research in the Global South is mainly unexplored (Muchangos, 2021), even more so in African countries and contexts (Mhlanga et al., 2022). Despite this, CE practices and initiatives exist in African countries at different levels of society. A good example is the establishment of the African Circular Economy Alliance (ACEA), which is an intergovernmental initiative to promote CE among African nations (ACEA, n.d.). Another example is the initiative of the Rwandan government, among others, to host the World Circular Economy Forum (WCEF) for the first time in Africa in 2022 (WCEF, 2022).

At this moment, CE research in Africa is conducted by different organizations, such as a study carried out by the African Development Bank (AfDB) and African Circular Economy Alliance (ACEA) about the five big bets for CE in Africa. This study highlights five priorities for the CE for Africa: food waste conversion, plastic waste recycling, E-waste recycling, recycled

garments, and mass timber (ACEA, 2021). Other research is conducted on topics such as the impact of E-waste on Public Health by the University of Port Harcourt in Nigeria (Orisakwe et al., 2019), the barriers and drivers of applying CE to food systems in East Africa by individual scholars (Nijman, 2020), and studies on the framework of Sustainable E-waste management in Manufacturing and processing industries in Nairobi by Kenyatta University (Muhani, 2012). Also, reports have been developed on the CE for Africa by the Ellen MacArthur Foundation on policy (Ellen MacArthur Foundation, 2021a), plastics (Ellen MacArthur Foundation, 2021b), and built environment (Ellen MacArthur Foundation, 2021c), among others.

However, to the authors' best knowledge, there is no in-depth analysis previously conducted on the existing CE literature and research gaps for African countries and contexts at the moment that this study is conducted. This is a significant missed opportunity since many African and other emerging economies have the opportunity to leapfrog (Preston and Lehne, 2020) to a CE model due to comparatively limited norms or infrastructure for linear economy processes.

Therefore, this study applies a mixed method research design (triangulation) through a scoping literature review and a survey. This research carries out a scoping literature review that includes 198 peer-reviewed and 77 non-academic publications to identify existing CE publications and research gaps. This is followed by a qualitative and quantitative survey with CE industry experts active in African countries to identify the existing CE research gaps. This study is done with the objective of creating a preliminary research agenda for African countries and contexts. This research can encourage CE innovation and accelerate CE adoption in African nations and contexts.

With this research, we aim to identify research gaps with the objective to develop a preliminary research agenda for CE development in Africa. In order to do so, this study answers the following research questions:

- What is the scope of existing literature on CE development in African countries?
- What are the research gaps on CE development in African countries?
- What are the identified barriers to conducting CE research in African countries?
- What are the identified opportunities for CE research in African countries?

The contributions of this research are as follows. First of all, this study creates an in-depth understanding of how research can contribute to CE adoption in African countries and contexts by developing a preliminary research agenda. Secondly, it provides evidence of why research is important for CE adoption. Lastly, the study supports CE practitioners and scholars by taking, to our knowledge, a first attempt through academic research to create a preliminary CE research agenda for African countries and contexts which can be used for future research and innovation.

The rest of the article is organized as follows. After the introduction, Section 2 provides an overview of the methodology used during this research. Section 3 presents the research findings of the systematic literature and the survey, followed by the

FIGURE 1
Overview of the methodology that is used to identify the different research papers.
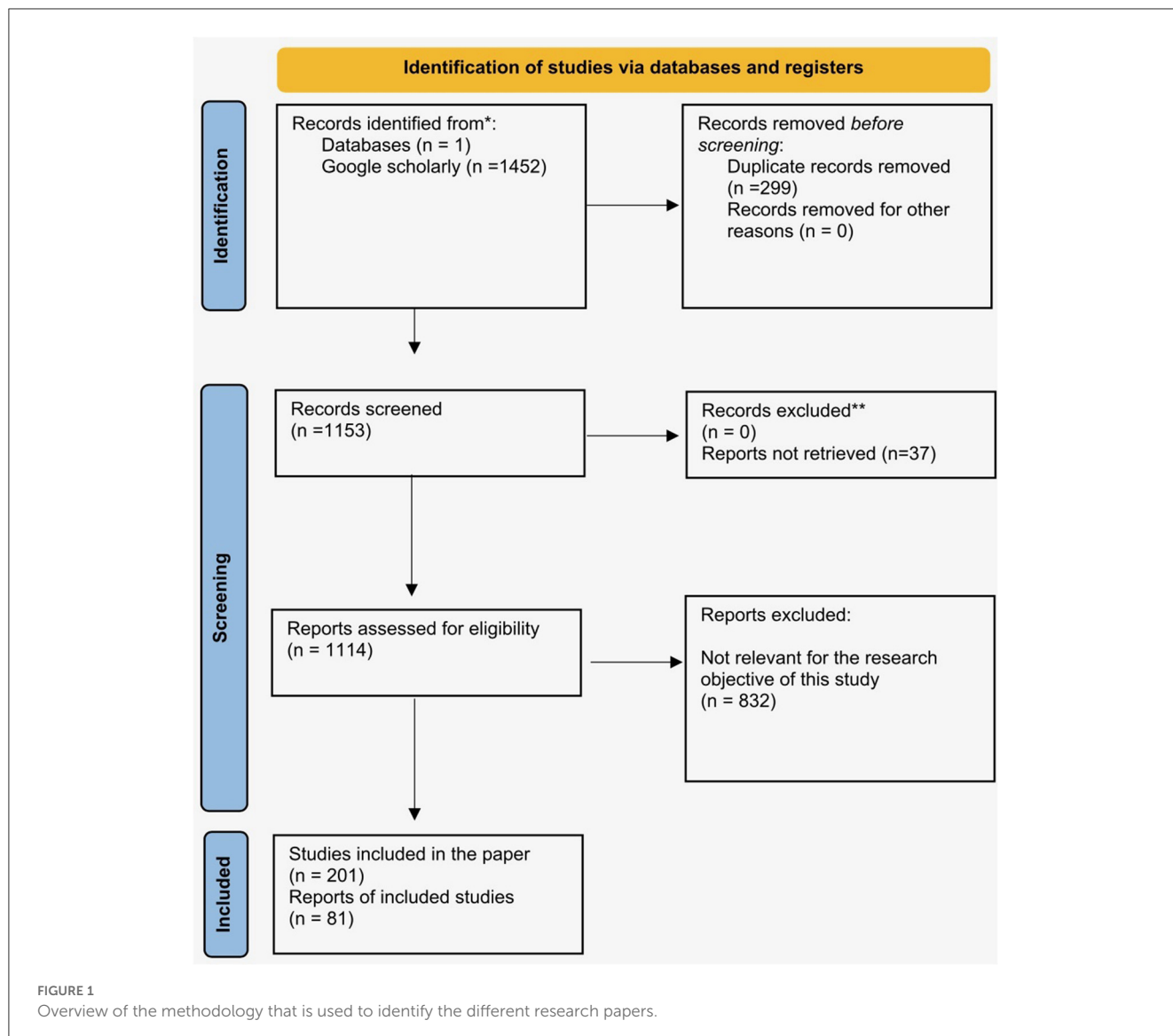
discussion and conclusion that highlights the research gaps and the CE agenda for African contexts and countries in future research to accelerate CE adoption in African countries.

2. Methodology

This research aims to develop a preliminary research agenda for CE in African countries. In order to do so, this study applied a mixed method research design (triangulation), whereby the authors collected and analyzed data simultaneously from two different resources to make the study more comprehensive. This study includes a survey with qualitative and quantitative questions answered by CE industry experts active in African countries with aim to identify existing research gaps (Section 2.2). Furthermore, this study conducts a scoping literature review to identify the existing relevant literature and its gaps (Section 2.1) (Figure 1). This section explains, for each data source, how data is collected and analyzed.

2.1. Scoping literature review

2.1.1. Data-collection

To the authors' best knowledge, no known published scoping or systematic review reviews are aimed at identifying the existing literature and its research gaps about the CE for African countries and contexts. Therefore, in this study, we conducted a scoping literature review to identify the existing CE literature and its research gaps, focusing on African countries and contexts. A scoping review is the precursor of a systematic literature review and has identified appropriate methodology to identify gaps where no research has been conducted (Arksey and O'Malley, 2005). Further, it has been identified as an appropriate methodology to identify and analyze research gaps in the existing literature, which is the purpose of this study (Munn et al., 2018). Also, scoping reviews are known to be able to analyze a large field of studies and as a stand-alone review (Macvean et al., 2017), which seems to be appropriate for the CE due to its holistic scope of applications on different levels of the systems (Kirchherr et al., 2017). For this study, a scoping literature

review was conducted using the Prisma flow diagram (Fink, 1998), as illustrated in Figure 1. The literature view was carried out to gather knowledge about the existing CE literature across contexts and African countries by identifying, evaluating, and synthesizing a comprehensive set of credible CE research literature for Africa published to date.

As part of the scoping literature review, this study developed an electronic database to map relevant CE literature for African countries and contexts. The database includes information such as the research topic, publication title, authors' names, a link to the article, research locations of the study, the identified CE research and relevant policy gaps highlighted by the authors. In order to identify the academic literature, this study used Google Scholar (GS) and targeted keyword searches to identify the most relevant and credible academic literature. This study used GS since it is open access database, one of the most popular academic search engines (Gusenbauer, 2018). GS is likely to be primarily used and accessible by CE scholars and practitioners in African low-income countries due to limited financial resources for research. A recent study concludes that the rate of open-access publications is the highest among low-income countries, especially in Sub-Saharan Africa. This is most likely due to factors such as the difficulties that scholars face in low-income countries to access pay-to-view academic publications, which motivates researchers to make their work freely available (Iyandemye and Thomas, 2019). This highlights the importance of open access search engines as GS for low-income and African countries and our study. GS has been identified as a commonly used web-based academic search engine, a source that can find three times as many articles free of charge than other databases such as PubMed (Shariff et al., 2013). Further, most articles identified through the Web of Science have also been identified through GS (Haddaway et al., 2015). On top of that, different studies emphasized that GS has been underestimated. Recent research has identified GS as the most comprehensive academic search engine, with 389 million records (Gusenbauer, 2018) and a sensitive enough database to be used alone for systematic reviews (Gehanno et al., 2013). However, this study did collect data through not only the literature, but also the survey as a comprehensive data source (Section 2.2). For GS, this study identified the most relevant publications written in English and French on the first 5 pages of GS for each keyword to identify the most relevant studies and narrow the scope of the literature research.

In the first step of the scoping literature review, this study identified papers linked to the selected keywords relevant to CE research in African countries and contexts (Figure 1). Since CE research is still new for African countries, and it is captured under different terms, this paper did not only focus on the keyword CE but also other relevant terms. This includes terms scholars/researchers, or organizations use to capture CE or part of the CE. In order to select the relevant keywords, this study consulted CE researchers based in Africa on which keywords could be used for this study and selected the keywords with the most relevant articles and records for CE by running the keywords through GS. This study used the following English keywords: circular economy Africa/Sub-Saharan Africa, recycling Africa/Sub-Saharan Africa, waste valorization Africa/Sub-Saharan Africa, e-waste Africa/Sub-Saharan Africa,

green economy Africa/Sub-Saharan Africa, circular practices Africa/Sub-Saharan Africa, bio-economy Africa/Sub-Saharan Africa, circular business model Africa/Sub-Saharan Africa and waste management Africa/Sub-Saharan Africa. Since English is not the only scientific language used in academic publications on this topic, this study also reviewed French academic literature relevant to CE principles by translating the identified English keywords into French. This research used the following French keywords in combination with Africa and Sub Saharan Africa: économie circulaire Afrique/Afrique sub-saharienne, recyclage Afrique/Afrique sub-saharienne, e-déchets Afrique/Afrique sub-saharienne, sous-produits Afrique/Afrique sub-saharienne, gestion des déchets Afrique/Afrique sub-saharienne, pratiques circulaires Afrique/Afrique sub-saharienne, economie verte Afrique/Afrique sub-saharienne, business models circulaires Afrique/Afrique sub-saharienne, valorisation des déchets Afrique/Afrique sub-saharienne and bio-économie Afrique/sub-saharienne. Only articles relevant to the CE and the research objective have been included in the database, which is explained in the second step of this section.

In the second step of the scoping literature review, articles were selected by three criteria (Figure 1). First, this study could not access 38 articles due to payments or other reasons. Therefore, these publications could not be included in the database. In order to overcome this challenge, the authors reached out via email and Linkedin to the first author of the paper to get full access to the identified paper so that the paper could still but used for literature research. The 38 publications that the authors still need access to despite contacting the authors of the paper have been excluded from the review (Figure 1). Secondly, publications not relevant to the research objectives were not included in the database. It is important to address that only articles relevant to the CE in African countries are included in the database. For instance, for keywords such as *"waste management Africa"* only papers are included if they incorporate CE principles. In the scoping literature review, four junior researchers screened the literature on the three criteria for different keywords, followed by a senior researcher that checked and supervised the screening process of the four junior researchers. This review included studies with both qualitative and quantitative methods.

In this paper, we used the three principles formulated by the Ellen MacArthur Foundation (EMF) since the CE definition has been identified as the most prominent and employed definition after the analysis of 114 different definitions by Kirchherr et al. (2017) and several other studies (Schut et al., 2015; Geissdoerfer et al., 2017). For these scientific reasons, this study adopted the CE concept and principles of the EMF for this study. Furthermore, for this study, the authors identified that these CE principles and concepts fit both technical and biological processes (Ellen MacArthur Foundation, n.d.). In contrast, other CE principles, such as the 10-Rs (Reike et al., 2018), might fit better studies with a different scope, such as material and product-focused studies. The three principles applied to this study include (1) to eliminate waste and pollution, (2) circulating products and materials, and (3) regenerative natural systems (Ellen MacArthur Foundation, n.d.).

These principles are applied by scanning the entire article to identify if the article reflects any of the CE principles. If the papers

reflect one or more CE principles, the article is considered relevant for the CE research for Africa. If articles do not reflect one or more CE principles, the article is not considered relevant. Lastly, since CE is a holistic concept that requires a system change (Kirchherr et al., 2017), it can be implemented in infinite. Therefore, the researchers have narrowed the scope of the preliminary study by including additional criteria for the literature review. Since this is a preliminary study with limited resources, the researchers decided to leave out technical studies related to chemistry, which are, in most cases, not restricted to geographical areas of Africa (e.g., laboratory research and experiments) and could be conducted elsewhere. Therefore, these studies do not directly contribute to relevant research gaps for the geographical area of African countries, and this study recommends that this will be investigated for future research.

It is essential to address, that this study did not only include 198 peer-reviewed papers but also 77 non-peer reviewed publications such as reports, book chapters, books and non-peer-reviewed papers (e.g., conference, work papers, and pre-prints). The non-peer-reviewed publications are identified through the same keywords, methodology and criteria that are used to select academic papers. The inclusion of non-peer-reviewed publications is appropriate since the documentation of the CE concept, and even more, CE research in African countries and contexts is still very new, which means that the number of publications relevant to this study is limited. Therefore, this study wanted to allow the inclusion of relevant non-peer-reviewed publications. Also, including peer-reviewed and non-peer-reviewed publications allows this study to integrate academia and practice to create a more comprehensive research agenda with preliminary findings. Furthermore, a scoping literature review also encourages being as comprehensive as possible in identifying primary studies and reviews that are central to the study's objective (Arksey and O'Malley, 2005).

In the third step of the scoping literature review, this study analyzed the different papers on the CE and research gaps by scan reading the full text of each of the publications with a specific focus on the abstract, discussion and conclusion. Research gaps are only included in our analysis if gaps were identified and described explicitly in the papers we reviewed. This study formulates a research gap as an opportunity or recommendation for further CE research in African countries or contexts. For example, publications addressed research gaps in the text of the abstract, results, discussion or conclusion of the paper by using sentences such as "more research is needed on" or "it is recommended that further research is conducted on", "there is a lack of research on" or other recommendations for future research. Various papers included general statements of the research gaps for developing countries; therefore, this study only included CE research gaps that are specific to African countries and contexts. The search gave 756 English and 696 French articles, without the inclusion of duplicates, which have been reduced for relevance and scope to 275 total articles, including 200 English articles and 75 French articles (Figure 1). The articles that are identified as relevant are included in a database created in Excel. Given that the objective of this study is to conduct a scoping review, the scholars primarily focused on providing an overview of the existing literature and its research gaps.

2.1.2. Data-analysis

After selecting the relevant articles for each keyword through the literature review, the total number of articles for the same keyword was calculated and represented in a bar chart. For example, for the keyword "circular economy Africa" the total number of relevant articles has been calculated and represented in a bar chart (Figure 4).

Secondly, this study calculated the total number of identified articles per African country or region that has been identified through the literature review on the CE. A map of Africa was generated to illustrate the number of articles in each country. This study used Jupyter Notebook with Python software to analyze the data and to generate the map for Africa due to the simple visualization and understanding of the developed codes to analyze the data. After loading the inbuilt map of Africa, it is customized to represent the data collected from the research.

2.2. Survey

2.2.1. Data-collection

In order to collect comprehensive data from multiple data sources, this study did not only collect data through the literature review but also through a survey that includes both qualitative and quantitative questions. The survey aims to identify existing research gaps and to build a database of different organizations and researchers that conduct CE research in African countries and contexts. Therefore, this study developed a survey simultaneously with the literature review.

The questionnaire has been developed in collaboration between African Leadership University (ALU), the Circular Economy Innovation Partnership (CEIP), and the African Circular Economy Network (ACEN), which is a network of CE industry experts working on CE in Africa. ALU played an important role in developing the survey, while CEIP and ACEN played a critical role in validating and reviewing the survey questions. After the validation, suggested improvements have been incorporated into the survey, such as improvements in the settings to ensure all respondents have access to the online survey. As part of the validation process, the researchers added additional questions, such as the research domain of the respondents. Also, the survey included examples to explain the questions to the respondents to ensure the answers' reliability and validity. Also, the examples by the questions of the survey have been validated.

The survey includes qualitative and quantitative questions that integrate topics such as the demographics of the respondents, the current involvement in CE research in Africa, types of research gaps they have identified, and the barriers the respondents have identified for conducting CE research in Africa. For the demographics, this study covered questions such as the respondent's location, the type of organization they are working for, the position of the respondent within the organization, and the research domain. As part of the survey, the respondents are informed that their inputs will be used for the purpose of this study and by completing the survey, they consent that data is used for research. Also, the study complied with the research ethics of the Circular Economy Research Program at ALU.

TABLE 1 Sample size of various actor segments across different African countries.

Actor segment	South Africa	Cameroon	Rwanda	Other African countries	European countries, incl. UK	Other	Sample size
Academia	2	1	2	2	6	0	13
Consultant/freelancer	1	0	0	1	3	0	5
Founder/co-founder	1	0	0	1	0	0	2
Retired Minister	1	0	0	0	0	0	1
Waste/CE specialist	0	1	0	1	0	1	3
Executive Secretary	0	0	0	1	0	0	1
Environmental engineer	0	0	0	0	0	1	1
Marketer	0	0	0	1	0	0	1
Associated program officer	0	0	0	0	1	0	1
Post graduate student	1	0	0	0	0	0	1
Researcher/analyst	3	0	0	2	3	1	9
Sample size per country	9	2	2	9	13	3	38

ALU Circular Economy Program.

The survey aims to collect additional data from CE researchers and experts conducting CE research or projects in African countries to make this study more comprehensive (Table 1). For this study, the researchers made use of a snowballing sample technique to identify the survey respondents. CE researchers and experts have been directly invited to the survey by email through the networks of CEIP, ACEN and ALU, who are directly working with circular economy experts in Africa. Also, researchers and experts active in Africa have been invited to complete the survey through Linkedin (groups) with a special focus on CE in Africa, and the ACEN newsletter was shared with a community interested in CE in Africa. The use of social media (Linkedin) and newsletters also allowed others to share the survey in their networks to increase the number of respondents.

38 respondents accepted and completed the survey. The respondents are based in different countries, whereby about 24% of the respondents are located in South Africa (Table 1).

2.2.2. Data-analysis

After collecting the data of 38 different CE researchers and industry experts through a survey (Table 1), this study analyzed the survey data to identify the indicated CE research gaps, research barriers and current research countries of the respondents.

In order to analyze the CE research gaps, this study followed three different steps. First, the responses that indicated similar research gaps are clustered into a group, which is called a category. After clustering the research gaps into categories, the categories were given a name. Lastly, after grouping the responses into different categories, a bar chart has been developed to illustrate the percentage of occurrence per category based on the inputs of the survey respondents.

Furthermore, an analysis of the CE research barriers has been conducted with the survey data to understand the current research barriers to conducting CE research in African countries and contexts. In order to do so, the total number of respondents

that indicated a challenge (barrier) for CE research was calculated in numbers and percentages. After that, this study developed a chart, as illustrated in Figure 6 to demonstrate the percentage of occurrence of each CE research barrier. Lastly, this study also analyzed the research focus countries of the different respondents by calculating the total number of respondents that conducted research for each African country. For each country, the percentage of the occurrence was calculated and represented in a pie chart (Figure 3).

3. Results

In this section, this study discusses the findings of both the literature review and the survey. The survey has been shared directly via email through the networks of ALU, ACEN and CEIP to 94 CE researchers and experts conducting research and projects in African countries. Furthermore, the researchers and experts conducting CE research and projects in Africa have been invited to complete the survey through Linkedin and the ACEN newsletter. The Linkedin post received 5,786 impressions. The ACEN newsletter has been shared with a community of 1,324 people interested in ACEN's work on CE in Africa. The survey has been accepted and completed by 38 respondents, whereby about 24% of the respondents are located in South Africa (Table 1). The following paragraphs highlight the survey results in more detail, followed by the literature review findings.

3.1. Research countries

From the findings of the literature review, South Africa has the highest number of relevant publications for the CE (105 out of 275 publications), followed by Sub-Saharan Africa as a region (31), Africa as a continent (29), Nigeria (35), Ghana (32), Kenya (22), Benin (22), Cameroon (14), Senegal (13), Ivory Coast

FIGURE 2
Overview of the relevant number of publications that have been published for each African country.

TABLE 2 Overview of the number of publications published for each region, whereby the authors of the identified publications did not specify the African countries but only the region.

Region	Number of publications
Sub-Saharan Africa	31
West Africa	6
Africa (the continent)	29
North Africa	2
East Africa	1
Central Africa	1
Total number of publications	70

(13), DRC (10), Ethiopia (10) and Rwanda (7). The other 39 African countries only have a few relevant publications for the CE, as shown in Figure 2. Burundi, Tunisia, South Sudan, Libya, Eritrea, Equatorial Guinea, Djibouti, Comoros, Seychelles, and the African island São Tomé and Princip do not have any relevant CE publications for Africa (represented as zero value on the map) (Figure 2). This study identified 70 publications (25%), whereby the authors do not specify the African countries in the publications; this includes Africa as a continent, Sub-Saharan Africa, West Africa, North Africa, and East Africa. The region Sub-Saharan Africa (31 publications) and Africa (29 publications) have the highest number of publications (Table 2). From the survey findings, it was discovered that researchers are only active in a few of the 54 African countries in CE research projects. Among the countries this study surveyed, South Africa has the highest percentage of published CE research projects, with about 33%. Kenya follows this with 19%; Malawi with 11%; Zambia with 11%; Rwanda with 11%. The "other" category in the chart comprises countries with 7% and below. The countries are Algeria, Ghana, Cameroon, Nigeria, Namibia, Mozambique, and Zimbabwe. Also, this included Africa as a continent (Figure 3).

3.2. Keywords

As the methodology explains, this study used different keywords to identify relevant publications for the CE. This study analyzed the number of relevant publications for each keyword to identify which keywords have the highest number of relevant publications. From the analysis, it is visible that the keywords *waste management (Sub Saharan) Africa* (48 publications), *E-waste (Sub Saharan) Africa* (46 publications) and *recycling (Sub) Saharan Africa* (38 publications) avails to be keyword widely used. From English keyword analysis, it is visible that the keywords *E-waste (Sub Saharan) Africa* (39 publications), *recycling (Sub Saharan) Africa* (34 publications), and *waste management (Sub Saharan) Africa* (29 publications) are the keywords mainly used. The French keyword *Gestion des déchets Afrique (sub-saharienne)*, also translated as waste management (Sub Saharan) Africa has the highest number of publications (19) in the French literature, as illustrated in Figure 4.
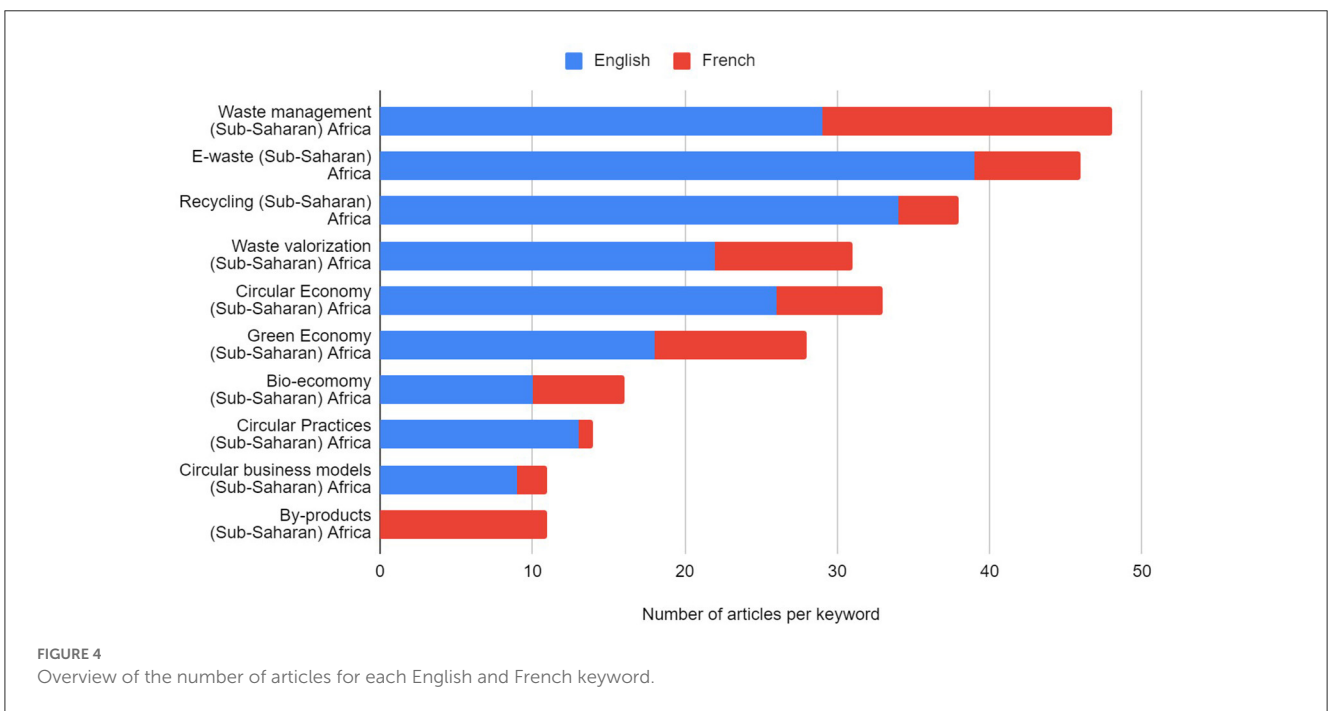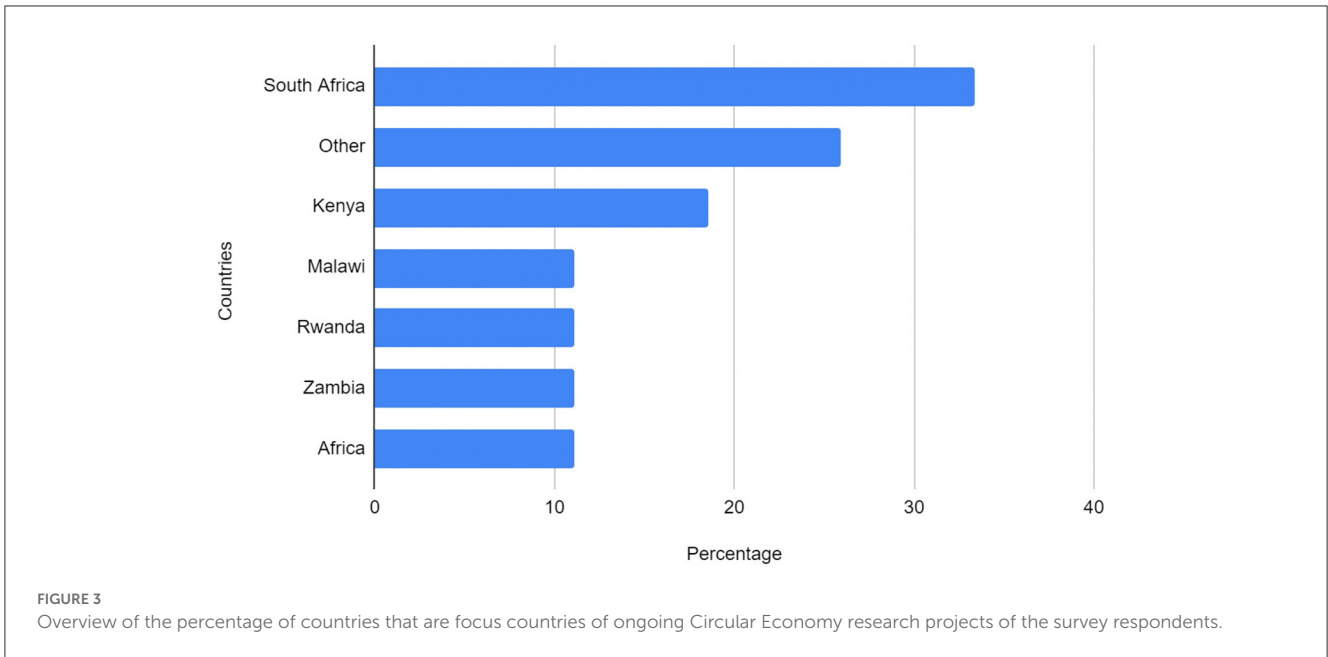
3.3. Research gaps

3.3.1. Research gaps identified in the literature

The findings of this study have identified several research gaps that can be categorized into four main categories, as illustrated in Figure 5. These categories include: (1) private-sector driven research (Table 3), (2) policy and governance (Table 4), (3) monitoring and evaluation (Table 5), (4) E-waste (Table 6), (5) food and agriculture (Table 7). These findings are discussed and represented in detail in the text below.

3.3.1.1. Private-sector driven research

It can be observed from the research findings, as illustrated in Table 3, that 7 studies suggest the need for CE pilots and demonstration projects intending to upscale CE innovation. This is followed by the suggestion of 5 studies to carry industry-academia

FIGURE 3
Overview of the percentage of countries that are focus countries of ongoing Circular Economy research projects of the survey respondents.

FIGURE 4
Overview of the number of articles for each English and French keyword.

collaborations for CE research and innovations. 6 studies indicated the need for further research on CE business opportunities in sectors such as agriculture, human settlements, transport, (rail) manufacturing, demanufacturing, and E-waste recycling. 6 studies indicate the need for research on benefits and other (success) factors for the private sector to be part of the CE transition, how products and innovations can be designed following a CE model, feasibility research on renewable energy projects such as biogas and bio-briquette making. 5 studies highlighted the importance of feasibility research on renewable energy such as biogas, briquette making, ethanol and other waste-to-energy solutions. This is followed by 4 studies that indicated the need for

feasibility studies of CE product design at a (commercial) scale (Table 3).

3.3.1.2. Policy and governance

Relevant to the category of policies, governance and waste management, 17 articles address the need for further research on waste management challenges for the informal sector, vulnerable groups, and local/rural communities (Table 4). 9 studies suggested further research on the drivers and barriers influencing recycling behavior, and existing practices among stakeholders and communities. 8 different studies highlighted the importance of critical analysis of existing policies related to topics that are

FIGURE 5
Overview of the number of identified research gaps per category.
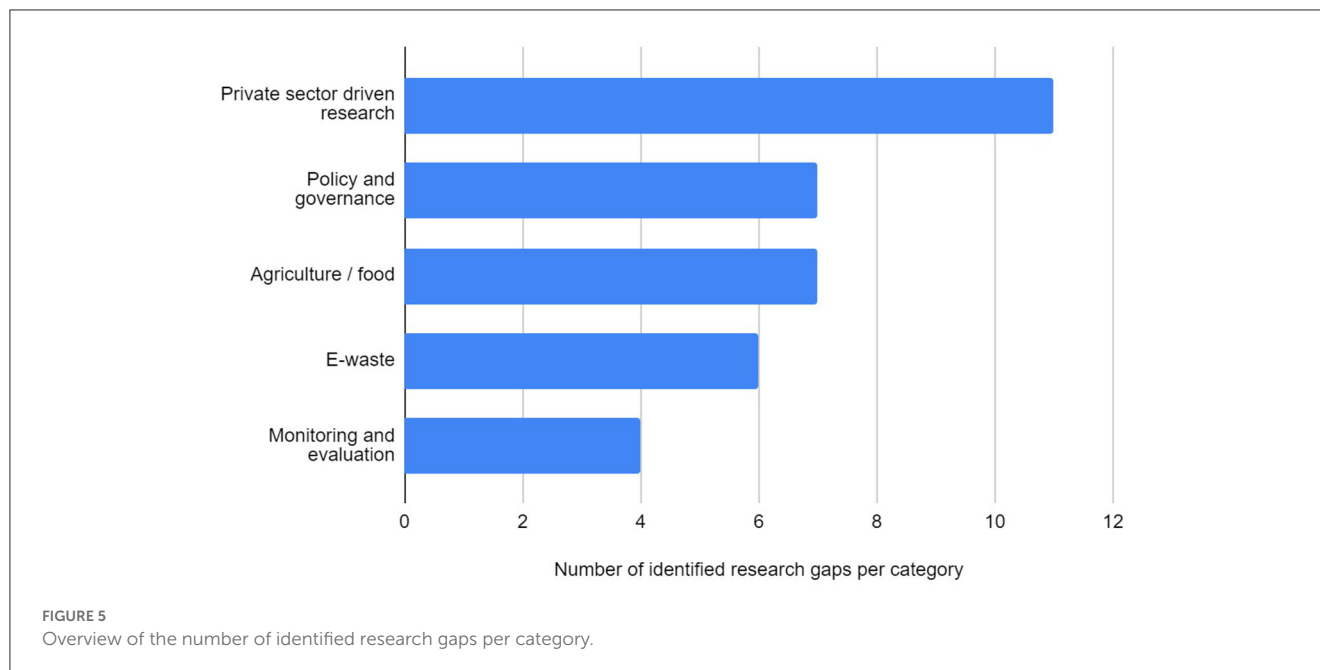
connected with CE, such as waste management, recycling, green economy, and energy. This analysis supports identifying of how CE can embed in existing and new policies and strategies (Table 4).

3.3.1.3. Monitoring and evaluation

Building on the results of policy and governance, this study also identified 4 different research gaps relevant to monitoring and evaluation, as illustrated in Table 5. 21 studies identified the need for reliable data on waste management, including the informal sector and industrial waste management data. 6 studies addressed the need to monitor and evaluate interventions or projects related to CE (Table 5).

3.3.1.4. E-waste

Relevant to research findings related to E-waste, as shown in Table 6, 9 studies suggested the need for further research on the health impact of E-waste—an in-depth study on the impact of E-waste recycling and disposal on the informal sector and local communities, and the environment. Also, 12 publications suggest the need for data collection to overcome the lack of data on E-waste -lack of reliable data on E-waste management, including the quantification. On top of that, 5 studies highlight the need to identify global and domestic E-waste flows of electronic products that end up in Africa (Table 6).

3.3.1.5. Food and agriculture

It can be observed from the findings that 7 different research gaps are identified that are related to food and agriculture, as illustrated in Table 7. 14 studies indicated the need for further research on how different types of organic waste and agricultural by-products can be upcycled. 8 studies emphasize the need to investigate the impact and performance of organic inputs (vermicomposting, composting, bio-fertilizers, fly-larvae composting, bio-char) on agricultural productivity and its benefit and opportunity compared to conventional farming.

3.3.2. Research gaps identified through the surveys with CE industry experts working in Africa

A total of 48% of the respondents indicated a lack of knowledge on how to reuse/upcycle different waste streams for circular innovation through transforming waste into new products, as illustrated in Figure 6. Examples include CE innovation research on the utilization of food residues in new commercial products as well as the innovation on how to reuse organic waste at the household level, or how to utilize waste from off-grid solar systems. Respondents across different African countries have addressed this research gap. More than 20% of the respondents addressed that the lack of monitoring and evaluation of CE interventions is a significant research gap since the impact of the CE needs to be studied and monitored. This may contribute to explanations for why more than 20% of respondents indicate that there are no measuring tools available for African countries to measure CE performance or how assess circularity. Following that, about 7% indicate a lack of data and research, on how to make informed decisions for policymakers. About 19% addressed a lack of understanding and research on how to create practical policies that promote and enforce the CE for the African context. Furthermore, about 15% stressed that there needs to be a focus on the role of marginalized groups, but also the inclusion of the informal sector, or how rural communities can be included in the CE research. Lastly, about 7% addressed a lack of understanding of how CE business models can be upscaled in Africa, and there is an analysis of CE business models (Figure 6).

3.3.3. Research barriers to conducting research on the CE in Africa

A total of 79% of the survey respondents are currently conducting research on the CE. Greater than 70% of the respondents indicated that the lack of funding to conduct CE research is a barrier to conducting research. In some cases, the

TABLE 3 Overview of the author's contribution to each identified research gap related to the private sector.

Research gap	Frequency	Authors contribution
CE pilot and demonstration projects to upscale CE innovation through research	7	Njenga et al., 2010; Montcho et al., 2016; Fletcher et al., 2017; Mugodo et al., 2017; Idowu et al., 2019; Callo-Concha et al., 2020; Oguntuase, 2020
(Sectoral) CE opportunities and challenges, e.g., agriculture, human settlements, transport, (rail) manufacturing, demanufacturing and E-waste recycling at the country level	6	Mäkelä, 2017; Ntsonde and Aggeri, 2017; Charles et al., 2018; Phuluwa et al., 2020; Schoeman et al., 2021
Feasibility research on renewable energy, such as biogas, briquette making, ethanol and other waste-to-energy (WTE) solutions	5	Parawira, 2009; Amegah and Agyei-Mensah, 2017; Dlamini et al., 2018; Tabasso et al., 2020; Chen et al., 2021
Feasibility research of manufacturing CE products at (commercial) scale	4	Semiyaga et al., 2015; Mombo and Bigirwa, 2017; Feleke et al., 2021; Gatune et al., 2021; Tapsoba et al., 2022
Study how products/innovations can be designed in a CE way	6	Liebenberg, 2007; Charles et al., 2018; Oguge, 2019; Pfukwa et al., 2019; Oruko et al., 2020; Ghosh and Ghosh, 2022
Determinants (barriers and drivers) and benefits of CE transition for the private sector	6	Musyoki, 2012; Mativenga et al., 2017; Pathak and Endayilalu, 2019; Miranosava, 2020; Hassim, 2021; Oyinlola et al., 2021
Industry - academia collaboration for CE research and innovation projects	5	Fletcher et al., 2017; Bambo and Pouris, 2020; Gatune et al., 2021; Oguntuase and Adu, 2021; Ghosh and Ghosh, 2022
Feasibility of waste management and sorting waste	4	Nahman and Godfrey, 2010; Kakeu and Christelle, 2018; Salguero-Puerta et al., 2019; Ddiba, 2020
The development of measuring, assessment tools/documentation of greening among private sector	2	Mativenga et al., 2017; Andersen et al., 2021
Recycling technologies for the textile and apparel industry	1	Larney and van Aardt, 2009
Lack of research on CE for construction and green building	2	Addy et al., 2021; Mhlanga et al., 2022

respondents even indicated that they had research funds to start the research, but did not have enough resources to complete the research. Remarkably, 75% of the respondents indicated noting challenges with lack of finance for CE research are representing organizations based in Africa, as illustrated in Figure 7.

4. Discussion

This study aims to uncover insights to inform the development of a preliminary research agenda for the circular economy (CE) adoption in African countries by identifying the current body of knowledge on CE, the existing CE research gaps and barriers to conducting CE research in African countries and contexts.

It can be concluded from the literature review and the survey findings that South Africa is currently the front-runner in CE research, with the most relevant published publications (Figure 2) and ongoing research projects conducted by CE experts (Figure 3). Furthermore, Kenya has also been identified by the survey respondents as an active country in the CE research (Figure 3). The dominant focus on CE research in South Africa is an urgent call for scholars to investigate other African countries on the status quo of CE development and country-specific potentials for CE. On top of that, it is important to address that about 26% of the studies generalize CE findings for the African continent or particular African regions without making a distinction between African countries. Therefore, more country-specific research is needed to unlock CE opportunities for different countries. In order to do so,

it is necessary to make sufficient financial resources available for African institutions to conduct CE research for African countries and contexts. The survey respondents have identified the lack of funding as a significant barrier, especially for institutions based in the continent in conducting CE research (Figure 7). A similar trend can be observed by AUDA-NEPAD (2019), whereby South Africa, out of 23 African countries, has allocated the highest amount of resources to Gross Domestic Expenditure on Research and Development (GERD). However, the contribution of South Africa, with 0.7% on the GERD, remains low compared to other western countries, such as Finland, which spends about 3.28% on the GERD (AUDA-NEPAD, 2019). Europe spends about 530 million USD on research per year, while Africa allocates about 25 million on research and development despite being the fastest-growing continent (NSF, 2019). The lack of research funds emphasizes the urgency of making research funds available to accelerate the CE transition in Africa. It can be derived from the results of this study that CE research in Africa primarily focuses on waste management, E-waste, and recycling (132 publications). Therefore, this study concludes that most of the CE publications in Africa are focused on the second principle of the CE, which aims to keep materials in use or also called circulate materials and resources (Ellen MacArthur Foundation, n.d.). The current body of knowledge is primarily focused on research topics such as waste management, E-waste and recycling (Figure 4) with a limited focus on other CE principles such as opportunities for regenerative natural systems and designing out waste as a solution in the first place (Ellen MacArthur Foundation, 2013). Therefore, there is an urgent need

TABLE 4 Overview of the author's contribution to each identified research gap related to policy, governance and waste management.

Research gap	Frequency	Authors contribution
Study the current waste management challenges for the informal sector, vulnerable groups and local/rural communities	17	Njeru, 2006; Gbinlo, 2010; Godfrey et al., 2013; Mondesir et al., 2013; Nzeadibe, 2013; Sotamenou, 2013; Kinobe, 2015; Ngambi, 2016; Daouda, 2017; du Toit and Wagner, 2018; Kakeu and Christelle, 2018; Sotamenou, 2018; Sossou et al., 2019; Adrien, 2021; Dabire and Gango, 2021; Viljoen et al., 2021; Volschenk et al., 2021
Study the drivers and barriers that influence recycling behavior, existing practices among local stakeholders and communities, and lessons learned from stakeholder participation in other projects such as environmental waste management	9	Oelofse and Strydom, 2010; Mtutu and Thondhlana, 2016; Strydom and Godfrey, 2016; du Toit et al., 2017; Strydom, 2018a,b; Viljoen et al., 2021; Volschenk et al., 2021; Owojori et al., 2022
Critical analysis of existing policies related topics such as waste management, recycling, green economy, and energy—and identify how CE can be best integrated into policies and strategies	8	Nahman and Godfrey, 2010; Borel-Saladin and Turok, 2013; Nhamo, 2013; Dieng et al., 2018; Desmond and Asamba, 2019; Mutezo and Mulopo, 2021; Rweyendela and Kombe, 2021
Study how the informal sector/communities and their (indigenous) knowledge can be included in policies, guidelines and frameworks, especially in waste management, green economy and bio-economy	5	Nzeadibe, 2013; Sentime, 2013; Moyo, 2014; Simatele et al., 2017; Gatune et al., 2021
Study the impact of air pollution on human health to convince governments about the urgency to invest in clean energy and asses the (indoor) air quality for the use FS (fecal sludge) fuel briquettes	2	Semiyaga et al., 2015; Amegah and Agyei-Mensah, 2017
Sustainability-focused research—study how CE can consider sustainability issues, e.g., SDGs, environmental quality vs. economic growth	2	Gbinlo, 2010; Rosa and Martius, 2021

TABLE 5 Overview of the author's contribution to each identified research gap related to monitoring and evaluation of CE.

Research gap	Frequency	Authors contribution
Lack of reliable quantitative data on waste management, informal sector, industry waste management data, illegally dumped and recycled waste	21	Nahman and Godfrey, 2010; Couth and Trois, 2012a; Feldt et al., 2014; Kinobe, 2015; Kinobe et al., 2015; Komakech et al., 2015; Mohee and Simelane, 2015; Scarlat et al., 2015; Gnassou, 2017; Godfrey et al., 2017; Regassa et al., 2017; Charis et al., 2019; Critoru et al., 2019; Kabera et al., 2019; Orhorhoro and Oghoghorie, 2019; Dibba, 2020; Adeleke et al., 2021; Ezeudu et al., 2020; Schoeman et al., 2021; Muheirwe et al., 2022; Obsa et al., 2022
Monitoring and evaluation of interventions/projects/initiatives to understand (project) interventions and their impact on improving (future) interventions and planning	6	Oduro-Appiah et al., 2013; Kinobe, 2015; Oyekale, 2017; Kakeu and Christelle, 2018; Mbiadjeu-Lawou, 2019; Moumbe et al., 2020
Lack of data for policy development/investments of CE and its related CE topics such as WEEE data, green and bio-economy	4	Klein and Reiher, 2016; Albagoury, 2020; Godfrey et al., 2021; Oguntuase and Adu, 2021
Monitoring and evaluation for (e) waste management and recycling policies	2	Sebola et al., 2018; Lebbie et al., 2021

to widen the scope of CE research in Africa, which is vital in advancing to a CE model.

Building on the previous point, the literature review findings suggest a drastic need to conduct CE research on the themes such as private-sector-driven research, policy and governance, monitoring and evaluation, E-waste, and food and agriculture (Figure 5). One of the cross-cutting research topics identified through the survey and 14% of studies of the literature review is the lack of data on waste management and E-waste, including the quantification of different waste streams to upcycle waste residues hampers CE research and data-based decision-making. Therefore, this should be an urgent call for scholars to develop solutions to overcome the challenges of the data collection for the CE applicable to African countries and contexts. A similar conclusion is made in the literature, Oyinlola et al. (2021) investigated the role of

technological innovations in accelerating the transition to circular plastic value chains in Africa. The study suggested that digital solutions could be a significant aid in collecting and analyzing data on topics for complexities around waste management and material flows. On top of that, the need for more data also impacts local policymakers, monitoring and evaluation of (government) interventions for CE. For instance, 22% of survey respondents indicate a need for more monitoring and evaluation on the impact and benefits of (policy) interventions and how to upscale successful interventions (Figure 6). This can be explained by the fact that the survey respondents also indicate a need to develop CE development measurement tools applicable to African countries and contexts. Also, developing a CE measurement tool that applies to Africa and proper monitoring and evaluation through research can help understand how to create practical policies

TABLE 6 Overview of the author's contribution to each identified research gap related to E-waste.

Research gap	Frequency	Authors contribution
Lack of reliable E-waste data, including quantification	12	Nolet, 2012; Akormedi et al., 2013; Bisschop and Walle van de, 2013; Lawhon, 2013; Schluep et al., 2013; Lepawsky, 2014; Ledwaba and Sosibo, 2017; Adejonwo-Osho, 2019; Orisakwe et al., 2019; Effebi et al., 2020; Maphosa and Maphosa, 2020; Ayeleru et al., 2021
Impact of E-waste recycling and disposal on the health of informal workers, local communities and the environment	9	Caravanos et al., 2011; Muhani, 2012; Feldt et al., 2014; Amankwah-Amoah, 2016; Srigboh et al., 2016; Asante et al., 2019; Lebbie et al., 2021; Wachinou et al., 2022
Identify global and domestic E-waste flows of electronics products that end up in Africa	5	Breivik et al., 2014; Akpan and Olukanni, 2020; Bimir, 2020; Ondiek and Onyango, 2021; Maes and Preston-Whyte, 2022
Identify existing and the best E-waste practices in Africa	3	Akpan and Olukanni, 2020; Bimir, 2020; Maphosa and Maphosa, 2020
Investigate the (social-economic) background of E-waste producers and stakeholders, and ensure their inclusion	2	Oteng-Ababio, 2012; Akpan and Olukanni, 2020
Limited E-waste policy studies for emerging economies	2	Borthakur, 2020; Lebbie et al., 2021

TABLE 7 Overview of the author's contribution to each identified research gap related to food and agriculture.
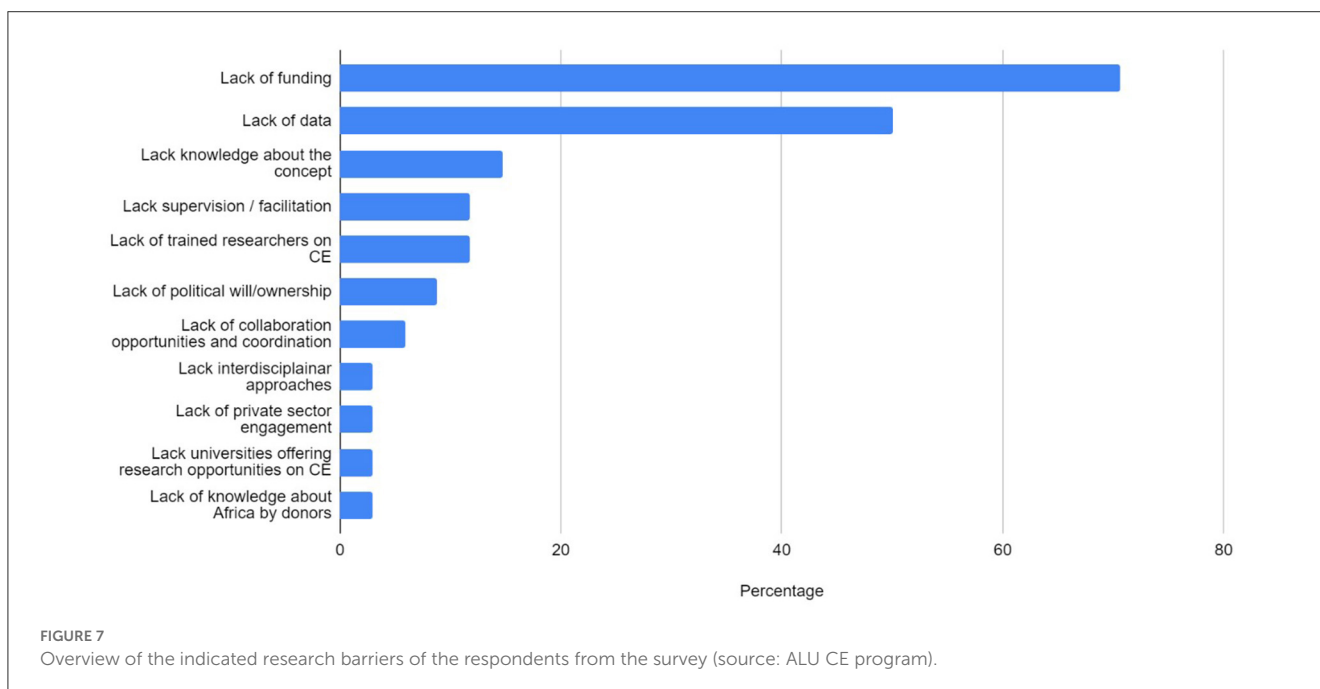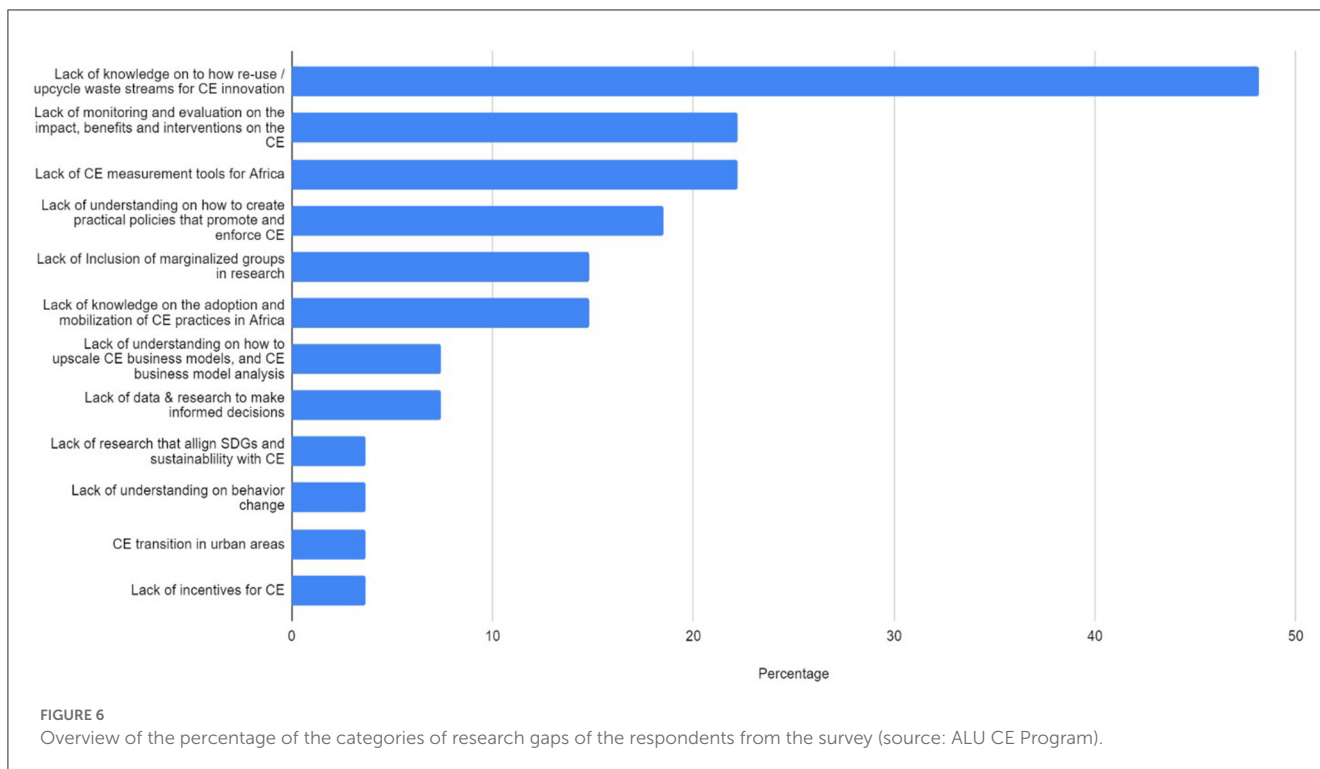
Research gap	Frequency	Authors contribution
Investigate how different types of waste and agricultural by-products can be upcycled, and study the (economic) benefit of the valorization.	14	Courard, 2020; Baffes, 2010; Semiyaga et al., 2015; Montcho et al., 2016; Nzila et al., 2016; Ousseini et al., 2017; Derouiche and Ben Amor, 2019; Pfukwa et al., 2019; Anagonou et al., 2020; Ayeleru et al., 2020; Browning et al., 2020; Dibba, 2020; Munubi and Lamtane, 2021; Sekabira et al., 2021b
Impact of compost, biofertilizers and other techniques on the soil, productivity, and study its challenges, (cost) benefits, and opportunities compared to conventional farming and over landfill disposal	8	Kaboré et al., 2010; Couth and Trois, 2012b; Longanza et al., 2015; Semiyaga et al., 2015; Temple and de Bon, 2020; Terfa, 2021; Obsa et al., 2022; Duponnis, n.d.
Adoption—study the factors that influence the adoption and engagement of farmers in applying CE practices	4	Musvoto et al., 2014; Smith et al., 2015; Sekabira and Kantengwa, 2021; Sekabira et al., 2021a
Study the safety of organic waste/human excreta for utilization in compost, energy or (food) products for human use	3	Parrot et al., 2009; Smith et al., 2015; Pfukwa et al., 2019
Study the status quo on the application of CE practices by farmers and the specific farming situation, including the soil fertility	3	Parrot et al., 2009; Musvoto et al., 2014; Boon and Anuga, 2020
The acceptance, safety and optimization of the performance of black soldier fly by using different types of waste streams	3	Semiyaga et al., 2015; Nyakeri et al., 2017; Chia et al., 2019
Investigate the status quo of existing composting practices	2	Parrot et al., 2009; Tshala et al., 2017

to promote and enforce CE, which the survey has emphasized as a critical research gap. In addressing these research gaps, both research, policymakers and other stakeholders must take an inclusive approach, whereby essential stakeholders such as the informal sector, local communities and marginalized groups should be included as suggested by the survey. A similar conclusion is made in the literature; for instance, Nzeadibe (2013) highlighted the importance of the inclusion of the informal sector in research and the formulation of policy on sustainable and inclusive solid waste management.

Lastly, it can be concluded from the findings that there is an urgent need for private-sector-driven research on CE in African countries since this study identified the highest number of research gaps on this topic. For example, almost 50% of the survey respondents (Figure 6) and 14 publications address the urgent need to identify opportunities for future research and partnerships on how different types of waste, especially organic waste and

agricultural by-products, can be upcycled into new products or uses. For instance, Semiyaga et al. (2015) highlight the need for research on simple technologies of converting fecal sludge into forms of mineral fertilizers with or without nutrient enhancement for urban-slum areas in Sub-Saharan Africa. Another example that highlights the importance of private-sector-driven research is a publication by Munubi and Lamtane (2021) that emphasizes the need for public-private research partnerships on the potential of valorizing agricultural by-products in Sub-Saharan Africa.

Also, there is a direct need for private-sector driven CE research for business opportunities for Africa in sectors such as agriculture, human settlements, transport, (rail) manufacturing, demanufacturing, and E-waste recycling. In addition, research findings of the literature suggest the direct need to establish CE demonstration and pilot projects to upscale CE innovation. Not only CE demonstration and pilot projects are highlighted as necessary, but also several studies highlighted the importance of

FIGURE 6
Overview of the percentage of the categories of research gaps of the respondents from the survey (source: ALU CE Program).

FIGURE 7
Overview of the indicated research barriers of the respondents from the survey (source: ALU CE program).

academia-industry projects. For instance, Fletcher et al. (2017) stressed that West African countries could adopt the Silicon Valley model to encourage innovation and creativity among universities, investors and start-ups. Industry-academia collaborations can play an important role in answering unsolved research questions and piloting innovations with the private sector, which has also been identified as essential solutions by several studies.

4.1. Recommendations for future research

This study has identified several research gaps based on the need to accelerate the CE transition in Africa. Based on this study, future research can be funded for the exploration of the following topics:

Private sector-driven research to accelerate the CE transition in Africa

1. Private-sector-driven CE research for business opportunities in sectors such as agriculture, human settlements, transport, (rail) manufacturing, demanufacturing, E-waste recycling and renewable energy (e.g., biogas and bio-briquettes). 8 different publications have indicated this research gap and further country-specific research can help to unlock new CE business opportunities (Table 3).

2. Study drivers, barriers and benefits for the private sector to transition to a CE in Africa. This research helps understand what is needed for CE adoption in the private sector and which incentives can be created to engage the private sector on the CE. 6 different studies have addressed this research gap, and about 7% of the respondents of the survey also indicated the need to understand how to upscale CE business models (Table 3).

3. Study the valorization and upcycling of different types of waste into new products and uses, especially regarding agricultural by-products. This has been addressed by almost 50% of the survey respondents (Figure 6), and 14 publications. Most of the publications especially highlight the potential for the valorization of agricultural by-products. Since agriculture is a dominant sector across different African nations, there is a high potential to study how to utilize by-products in new products and uses for the African context (Table 7).

4. Investigate how products and innovations can be designed in a CE way, e.g., by improving the recyclability of products and materials or innovations to prevent plastics from rising that can be applied in Africa. 6 studies addressed this research gap.

5. Establish CE demonstration and pilot projects to upscale CE innovations in African countries. The potential of demonstration and pilot projects helps to pilot business solutions with the private sector, which can be combined with point 6. Seven publications identified this research gap (Table 3).

6. Establish industry-academia collaborations for research and innovation projects, whereby the academia supports the private sector to solve unanswered questions through testing, demonstration and pilot projects. This provides the opportunity to accelerate the CE transition in African countries hand in hand with the private sector, whereby research is a spinoff for innovation. 5 publications have addressed this.

Policy and governance

1. Study the current waste management challenges for the informal sector, vulnerable groups, and local and rural communities, followed by how these groups can be included in policies related to CE, incl. existing policies such as waste management and recycling. It became clear from the survey and literature review that informal workers and local communities are not always considered as important stakeholders. 17 different studies address the need to study challenges that are faced by the informal sector, vulnerable groups, local and rural communities (Table 4). Five publications indicate the need for research on how to include these groups in existing policies and research (Table 4). This has been further emphasized by 15% of the respondents, as illustrated in Figure 6. This address the importance of studying the challenges and the inclusion of the informal sector, rural communities and vulnerable groups for CE-related policies in African nations and contexts.

2. Investigate the drivers and barriers that influence CE and recycling behavior and adoption, existing CE practices and the perception of CE and recycling toward local stakeholders and communities. Understanding the drivers and barriers that influence CE behavior is crucial for adopting CE and for creating the right (policy) incentives to engage in CE. This research has been addressed by 9 different publications (Table 4).

3. Study how to integrate CE in policies that can be easily implemented and enforced and create incentives to promote a CE transition in African countries. It is essential to understand how CE can be integrated into policies, implemented and enforced to ensure a successful adaption of the CE adjusted to the local context. 22% of the survey respondents have addressed this research gap, as illustrated in Figure 6 and eight different studies (Table 4).

Data- collection and monitoring

1. Building on the previous point, the development and testing of a measurement and monitoring tool to monitor the impact, benefits, and interventions of CE applicable to African contexts have been identified as an important key for CE. This is essential to be able to measure and evaluate the CE performance of the private sector, project and policy interventions for African countries and contexts. This gap has been identified by 22% of the survey respondents, as illustrated in Figure 6.

2. Identify and pilot solutions (e.g., digitalization) to overcome the lack of reliable quantitative data on (e)-waste management, incl. informal sector, industry waste management data, illegally dumped and recycled waste, and CE at large. One of the studies in this literature review addressed the potential of digital innovations (DI) as a potential solution to overcome challenges toward data-collection for the CE for plastics (Oyinlola et al., 2021), which highly recommends exploring other CE topics. The lack of data for research and monitoring has been addressed as a significant challenge by 50% of the survey respondents (Figure 6), 33 publications of which 12 studies especially highlight the need to collect data for E-waste. This highlights the importance of identifying solutions such as digitalization to overcome this challenge and unlock new circular economy opportunities.

E-waste

1. Identify global and domestic E-waste flows (movements) of electronic products that end up in different African countries. The identified publications from this study clearly stated that the E-waste management and recycling situation is problematic

since African countries are used as a dumping ground for E-waste. E-waste from high-income countries is (illegally) exported to African countries, whereby E-waste disposal and recycling takes place through the informal sector due to the lack of E-waste legislation and infrastructure in African countries and the high costs for E-waste recycling in high-income countries (Amankwah-Amoah, 2016; Srigboh et al., 2016). It becomes clear that CE thought leaders cannot build a CE without including African countries and other developing countries. The CE requires global solutions with the inclusion of Africa. This calls for further research on the current international and domestic E-waste flows to identify solutions to tackle ongoing E-waste challenges in African countries. Also, it highlights the importance of CE research for African and other developing countries. This research gap has been identified by five publications (Table 6).

2. Building on the previous point, it is recommended to study the impact of E-waste recycling and disposal on the health of informal workers, local communities, and the environment. E-waste disposal and recycling are taking place through the informal sector due to a lack of E-waste regulation and infrastructure. 9 different studies indicated the need to investigate the impact of E-waste recycling on health and the environment, as illustrated in Table 6.

Food and agriculture

1. Investigate the impact and performance of organic inputs (vermicomposting, composting, bio-fertilizers, fly-larvae composting, bio-char) on agricultural productivity and its benefit and opportunity compared to conventional farming. Food security is high on the agenda of policy makers and smallholder farmers in many African nations. In order to introduce and improve agricultural practices through applying compost or biofertilizer techniques, it is essential first to understand the impact of these techniques on agricultural productivity. 8 studies have identified this research gap (Table 7).

2. Study the safety of utilizing organic inputs and human excreta. 3 publications highlighted the importance of investigating the safety and different treatments of the utilization of organic inputs and the use of human excreta as a fertilizer, as illustrated in Table 7. For instance, it is crucial to study the safety of applying community-made compost in urban and peri-urban areas.

3. Investigate the determinants of adopting organic practices, waste valorization and CE agriculture, and factors affecting the engagement of farmers applying CE practices. This research helps to understand how behavior of farmers can be changed by understanding which determinants play a crucial role in the adoption of applying CE practices among farmers. 3 publications have addressed this research gap (Table 7).

4. Building on the previous point, it is also necessary to study the status quo of farmers on applying CE agriculture practices and the farming situation, including soil fertility. This investigation will help to accelerate the movement toward circular agriculture

among African farmers. 3 studies addressed this knowledge gap (Table 7).

Lastly, to our understanding, this study is the first attempt to identify research gaps and develop a preliminary research agenda for Africa through academic research at the moment this study is conducted. We encourage other scholars to build on this study and continue the efforts to take the lead in solving unanswered research questions to accelerate the CE transition in African countries and contexts.

4.2. Study limitations

Several limitations should be taken into consideration in this study. First, this study focuses on 20 keywords for the English and French literature, with each keyword emphasizing an area of the CE in Africa to narrow the scope of the literature review. The limited number of other keywords might hinder the study from accessing information relevant to the CE in Africa. However, this study identified the keywords most relevant for CE in African countries and contexts. Second, this paper used GS as the search engine focusing on the first five pages of the database. Such consideration discouraged exploring other pages of GS that could contain relevant articles to the study. Third, this study focuses on African countries with enough data on the CE in Africa. This approach may have caused bias toward countries early in the CE development in Africa. However, this study assumes that in case scholars published articles for specific African countries, for instance, "circular economy Kenya", a high correlation of these publications would appear under the keyword search of "circular economy Africa" or "circular economy Sub-Saharan Africa". Fourth, the sample size (38 respondents) for this study's survey was small, with much attention given to African respondents as the paper only focuses on Africa's CE. The sample size of the CE industry experts in African countries is small since there is a lack of documentation of CE industry experts across Africa. However, in order to overcome the challenge, this study made the best use of available networks, such as the African Circular Economy Network (ACEN) and other CE initiatives in Africa, such as the Circular Economy Innovation Partnership (CEIP) (Section 2.2). Finally, this study builds on previous studies to determine the current "state of art" for CE in African countries and regions. This research assumes that collected data from previous research is correct and properly analyzed. This study used data from two sources, the scoping literature review and the survey with CE industry experts active in African countries, to reduce the potential bias.

5. Conclusion

Research plays a vital role in accelerating the global circular economy (CE) transition and is an essential tool to contribute to climate change adaptation. However, prior CE research primarily focuses on countries in the Global North, whereas CE research in the Global South has been largely unexplored, especially in African countries and contexts. Therefore, this study aims to uncover insights to inform the development of a preliminary research

agenda for CE adoption in African countries by identifying the current body of knowledge on CE, the existing research gaps and barriers to conducting CE research in African countries and contexts.

The findings of this study can be summarized into three main conclusions. First, the results suggest that South Africa is the front-runner in CE research, with the most relevant publications and ongoing research projects conducted by CE experts. The dominant focus on CE research in South Africa is an urgent call for scholars to conduct country-specific research for additional African countries, especially since a significant part of the publications do not distinguish between countries and only publishes for Africa at large or as a region despite Africa's 54 distinct countries. This is a crucial missed opportunity for building CE economy knowledge, expertise and innovation toward the needs and opportunities of the countries. Secondly, this study concludes that the current body of CE knowledge is primarily focused on one aspect of CE, circulating materials and products (keep products and materials in use), while there is consensus from published journal papers and the survey that there are meaningful gaps in other CE principles such as designing out waste and pollution and regenerating natural systems. Therefore, this study suggests a list of research topics that can be further investigated, which are included in the recommendations for future research. The major identified research topics are related to private sector-driven research, data collection and monitoring, policy and governance, E-waste, food and agriculture.

Lastly, to drive CE research and development agenda for African countries and contexts, international organizations, donors, investors, and governments need to make research funds available, especially for African-based institutions, which has been identified as a crucial barrier to CE research. Since many African countries are still developing their economies, research can influence the pathway to CE. Research is crucial in building CE knowledge, piloting and developing (business) innovations, and practical solutions applicable to African countries. This study identified an urgent need for private-sector-driven research with the highest number of research gaps found in private-sector-driven research. Therefore, partnerships, such as academia-industry pilot projects, are crucial in developing CE solutions and innovations applicable to African countries and their stakeholders.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Circular Economy Research Program at African Leadership University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

EN-R conceived the work and main concept of the article, edited the draft and final manuscript, and results of the article. EN-R supervised the work of JU, JT, DS, and WA that build the database of the literature, analyzed the results of the data base and the survey, and helped to write the first drafts of the manuscript. DR reviewed the manuscript and supported with the structuring, and editing support. All authors contributed to the article and approved the submitted version.

Conflict of interest

DR was employed by Stratera Capital.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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