frontiers | Frontiers in Sustainability

TYPE Original Research
PUBLISHED 17 January 2025
DOI 10.3389/frsus.2024.1455335

OPEN ACCESS

EDITED BY
Riccardo Boero,
Norwegian Institute for Air Research, Norway

REVIEWED BY
Giacomo Di Foggia,
University of Milano-Bicocca, Italy
Vinod Kumar,
Jawaharlal Nehru University, India

*CORRESPONDENCE
Daniel Agyapong
✉ dagyapong@ucc.edu.gh

RECEIVED 26 June 2024
ACCEPTED 02 December 2024
PUBLISHED 17 January 2025

CITATION
Agyapong D, Agyapong GKQ, Ofori D, Light O and Frimpong SE (2025) Implications of circular economy practices for firms in the integrated waste sector.
Front. Sustain. 5:1455335.
doi: 10.3389/frsus.2024.1455335

Implications of circular economy practices for firms in the integrated waste sector

Daniel Agyapong[1]*, Gloria K. Q. Agyapong[2], Daniel Ofori[2], Osman Light[2] and Stephanie Efua Frimpong[3]

[1]Wits Business School, University of the Witwatersrand, Johannesburg, South Africa, [2]Department of Marketing and Supply Chain Management, University of Cape Coast, Cape Coast, Ghana, [3]Department of Finance, University of Cape Coast, Cape Coast, Ghana

Introduction: This study examined the effects of circular economy practices on the integrated waste management industry, drawing on the stakeholder theory. This study examined how the performance of Ghanaian waste management companies is affected by circular economy strategies, particularly upcycling and was recovery.

Methods: About 7,190 firms registered with the Environmental Service Providers Association (ESPA) formed the population of the study, out of which the sample yielded 524 valid responses, which was analysed using PLS-SEM and Partial Correlation Analysis. PLS was adopted because it integrates factor and route analyses into significantly more rigorous statistical processes. In addition, the Partial Correlation network structure was adopted to explain how the nodes or variables are related to one another.

Results: The results demonstrate that upcycling has a favorable and considerable impact on the economic performance (β = 0.475, t = 4.495, p = 0.000), social performance (β = 0.403, t = 3.132, p = 0.002), and corporate governance performance (β = 0.455, t = 3.670, p = 0.000) of the firms. Furthermore, waste recovery improved the performance of waste management companies in terms of performance, specifically economic performance (β = 0.333, t = 3.183, p = 0.001), environmental performance (β = 0.583, t = 4.641, p = 0.000), social performance (β = 0.402, t = 3.157, p = 0.000), and corporate governance performance (β = 0.250, t = 2. 024, p = 0.048) indices.

Discussion: Finally, circular economy practices have a substantial impact on firms' financial stability and investment readiness. It was concluded that waste management companies that excel in undertaking circular economy activities such as remanufacturing, trash recycling, and refurbishing are more likely to draw clients who want green activities in addition to their current needs. Additionally, these actions increase efficiency, which lowers operational expenses and improves governance-related concerns, including management training on these procedures and implementation of policies in compliance with the law.

KEYWORDS

circular economy, waste management, upcycling, recovery, sustainable performance

Introduction

The escalating quantity of waste on a global scale, which may be linked to factors such as population growth, economic expansion, urbanization, and industrialization, poses a significant environmental and public health issue (Muthuraman and Ramaswamy, 2019).

In developing economies, however, most firms in the sector have resorted to landfilling as the most economical means of managing waste in urban areas. This concept contrasts with the traditional waste management hierarchy proposed by Schall (1992), which prioritizes the principles of reduce, reuse, and recycle (the 3Rs) as the preferred approach to managing waste. However, the 3Rs have since evolved into the 5Rs, incorporating repair and rot alongside the original principles of reduce, reuse, and recycle. This expanded framework further emphasizes minimizing waste and extending resource lifecycles, positioning the 5R principles as essential elements of sustainable environmental management (Phonthanukitithaworn et al., 2024).

Since then, these concepts have seen wide application in various approaches to waste management. And firms in the integrated waste management sector are integral to reviving the old age practice that characterized societies in the pre industrial revolution The sustainable development goals (SDGs) urge everyone to ensure the availability and sustainable use of resources. Ghana's medium- and long-term goals reaffirm these international and local objectives. For instance, approximately 70% of the SDGs and Agenda 2063 are included in Ghana's Medium-Term National Development Policy Framework (2014–2021). These policies include environmental management, circular economy (CE)-inspired green waste management practices (see Supplementary Figure S2), and sustainable consumption and production.

These objectives are made at a time when the world, including nations like Ghana, deals with issues such as deforestation, pollution, and climate change due to economic and resource shortages (Terragni et al., 2014; Kapur, 2016; Schwartz and Popovich, 2019). According to statistics, Ghana's annual deforestation rate between 2013 and 2015 was 794,214 ha. Between 2002 and 2023, Ghana lost 143,000 hectares of humid primary forest, accounting for 8.9% of its overall tree cover loss during that period. In 2010, Ghana had 6.97 million hectares of natural forest, covering 30% of its land area, but by 2023, it lost 110,000 hectares of natural forest, resulting in 76.3 million tons of CO_2 emissions. Furthermore, between 1950 and the turn of the century, the nation was reported to have lost 60% of its forest cover (FAO, 2010). Landfills, sewers, and open spaces in almost every nation are now completely covered with plastic debris. Several sustainability projects have been undertaken in Ghana to address the issues listed above. These include passing new legislation and amending existing legislation to consider the need for sustainable development. In 2016, Ghana enacted Act 917, a regulatory policy aimed specifically at addressing e-waste (Bimpong et al., 2023). More legislations and guidelines can be seen in Supplementary Figure S1.

Additionally, efforts have been made to include sustainable development in national development plans within the framework of the circular economy. Resources are kept in use through the CE method, which involves recycling, reclaiming, regeneration, and reinvestment to benefit society (Stahel, 2016; Jørgensen and Pedersen, 2018; Agyapong, 2020). It is anticipated that businesses that adopt CE principles will experience cost savings by recycling their waste. This shift toward a CE is not only beneficial for the environment but also for the economy, as it promotes resource efficiency and reduces waste.

It is crucial to understand how such activities affect economic agents, including corporations, as countries try to achieve sustainable development goals. Furthermore, as the nation transitions to a circular economy, it is important to determine how well-prepared businesses are for investment. The integrated waste management sector has limited data on the relationship between corporate performance and the circular economy. Research on this phenomenon in Ghana has not yet been conducted. Second, problems with systemic waste management have an impact on developing countries by exacerbating environmental deterioration and public health difficulties. These problems have the potential to worsen social inequality and impede economic growth in these nations (Ayeleru et al., 2020; Loukil and Rouached, 2020). However, the global shift toward circularity and the need to create a more sustainable and resilient society and economy is making CE practices such as upcycling and waste recovery a common policy response among governments and businesses worldwide (Ofori and Opoku Mensah, 2021).

CE is a systemic approach to economic development aimed at decoupling economic development from the consumption of finite resources (MacArthur, 2017). It is founded on the principle of designing out waste and pollution; keeping products and materials in use and developing regenerative natural cycles. In the circular economy, waste is a crucial source of raw material for companies (Awasthi et al., 2019; Qiu et al., 2020). However, this remains a significant issue for governments (Gbadamassi et al., 2020). It is important to emphasize the advantages of CE practices for businesses to adopt. However, Ghana has scanted empirical data on this subject.

To achieve the goal of transitioning into a CE and its associated benefits, all stakeholders such as the government, businesses, households and other economic agents must work together. The transition to a CE model demonstrates an increasing recognition of the limited availability of natural resources and the necessity for sustainable resource management methods (Hart, 1995).

The use of natural resource-based theory framework in the integrated garbage sector in Ghana is to highlight the significance of building capacities that promote sustainable development and resource effectiveness. Waste management organizations can reduce environmental impacts and improve resource utilization efficiency by implementing CE strategies including garbage recovery and upcycling. The theory offers useful perspectives on sustainable financing, investment, and CE practices in Ghana's waste management sector. Adanu et al. (2020); in their study found out that financial resources are the main issue facing waste management firms in Ghana and that the waste management firms need government support to subsidize cost of technologies. The study indicated that most people working in this sector are the youth who have recorded high cases of injuries due to the use of unsustainable equipment. Adanu et al. (2020) in their study did not stress on what calls for investment into the waste management sector and how these antecedents have implications in the sector in question.

Also, Mensah and Ampofo (2021) assessed waste management practices among hotel industries in Ghana. The study concluded that the environmental attitude of managers influences waste management practices among hotels in Accra. This implies that waste management practices, whether good or bad, depend on the attitude of hotel management. The focus of this study did not consider financial investments as some possible solutions to manage waste. Grant et al. (2019) in their study described the e-waste situation in Agbogbloshie, Accra coupled with urbanization issues. The study described the types of waste generated, management processes of the waste, potential hazards associated with the management processes and its impact on the environment. It is clear that issues of the implications of CE practices on the performance of waste management firms in Ghana has received less attention. The focus has, however, been on technology and the harm that such waste causes. This occurs at a time when there is strong evidence that garbage is a resource that is changing

(Sarfo-Mensah et al., 2019), sparking a lot of interest among businesspeople and entrepreneurs.

This study examines how CE principles may affect Ghana integrated waste management industry performance. Specifically, the paper assessed the effect of upcycling and waste recovery on the performance of integrated waste management firms; and as well as the effect of upcycling and waste recovery on the financial readiness and investment preparedness of integrated waste management firms.

Literature review

This section discussed literature relating to the purpose of the study. It includes theoretical reviews and empirical reviews for this paper.

Integrated waste management sector in Ghana

Integrated waste management (IWM) in Ghana is a multi-faceted approach requiring collaboration among government authorities, private sector players, and the general public (Nyamekye, 2020). This approach is based on the argument that solid waste menace is more than just a technical problem requiring a technical solution. IWM distinguishes three important components in waste management and recycling systems. These are the technological (technical) component, the sustainability aspect and the stakeholder (or key actors) component (Batista et al., 2021). This means that solid waste can be managed effectively and efficiently by involving all the above components.

Despite the progress made, several challenges hinder the effectiveness of IWM in Ghana. Infrastructure deficits, including a shortage of waste treatment and recycling facilities and outdated equipment, limit the efficiency of waste management services. Factors contributing to this include housing crises vis a vis increasing rural–urban migration. This issue is particularly acute in major cities and towns in Ghana (Nott, 2020). The challenges stem from poor waste management behaviors exhibited by households, and commercial establishments. Inadequate, ineffective, or unaffordable service delivery arrangements exacerbate these issues (Kassah, 2020). According to Lissah et al. (2021), waste transfer stations are often poorly located and insufficient in number, leading to irregular waste collection. Door-to-door collection services are prevalent, especially in metropolitan areas, but private sector providers tend to serve selectively due to ambiguous zoning regulations, leaving marginalized households underserved or resorting to informal waste disposal methods.

Most urban areas in Ghana rely on designated dump sites managed by local government contractors. However, there is a lack of widespread waste reduction, reuse, and recycling initiatives across the country (Gyeduaah, 2020). Occasionally, there are ad-hoc recycling activities primarily concentrated in urban centers in Ghana. Recyclables are often sent to these regions for processing due to limited recycling facilities nationwide. The waste management sector in Ghana mainly focuses on common recyclable materials such as single-use plastics, e-waste plastics, and other subtypes, cardboard, glass, and metals (Ministry of Sanitation and Water Resources, 2020). While there are various recycling facilities ranging from informal aggregation points to small-scale enterprises, there is little investment available for advanced and commercially sustainable recycling businesses capable of producing export-grade recyclables.

The natural resource-based theory

The resource-based view (RBV) emphasizes how an organization's internal and external resources, which are expensive, challenging to duplicate, and no substitutable, at least temporarily, provide the skills that support a firm's competitive edge (Wernerfelt, 1984; Barney, 1991). This research suggests that having control, possession, and efficient use of resources are strategically important for creating value and gaining a competitive advantage (Frimpong et al., 2022). Grant (1991) stresses the significance of assessing resources, analyzing capabilities, and recognizing resource constraints to gain a competitive advantage.

Within sustainability financing and investment, the RBV proposes that organizations strategically manage their resources to seek funding and investment for CE activities. This involves evaluating the presence of internal resources such as organizational capital, human capital, and physical capital (Barney, 1991), and integrating them with CE goals. Organizations can improve their appeal to investors and financing institutions by efficiently using their internal resources, which can help in securing CE finance and investment. The RBV theory frequently fails to consider the limitations imposed by external sources, such as the biophysical environment (Hart, 1995). When examining CE techniques in Waste Management Firms in Ghana, it is crucial to consider the environmental constraints and legal frameworks that impact resource utilization and waste management tactics. The transition to a CE model demonstrates an increasing recognition of the limited availability of natural resources and the necessity for sustainable resource management methods (Hart, 1995).

When the RBV framework is used in the integrated garbage sector in Ghana, it highlights the significance of building capacities that promote sustainable development and resource effectiveness. Waste management organizations can reduce environmental impacts and improve resource utilization efficiency by implementing CE strategies including garbage recovery and upcycling. The Resource-Based View (RBV) approach highlights the importance of aligning organizational capabilities with CE goals to accomplish sustainable development objectives. Ultimately, the RBV theory offers useful perspectives on sustainable financing, investment, and CE practices in Ghana's waste management sector. Organizations can support sustainable growth and promote CE concepts in Ghana's waste management business by utilizing internal resources, aligning capabilities with CE aims, and overcoming environmental restrictions.

The corporate sustainability principle

Within sustainability, the CE is a key notion that is driving significant disruptive change. The circular economy, as defined by the Ellen MacArthur Foundation, is a new approach focused on restoring natural resources, encouraging ongoing use of products and materials, and minimizing waste and pollution (Purwanto and Prasetio, 2021). This stands in sharp contrast to the linear economy's approach of extracting resources and disposing of them, providing a sustainable alternative (Lobova and Tyryshkin, 2021). The waste-to-resource paradigm is central to the circular economy, emphasizing the crucial function of waste management organizations. They exemplify the practical implementation of CE ideas through their actions to regenerate resources, minimize waste, and reduce pollution (Purwanto and Prasetio, 2021). The CE aligns well with the overall discussion on business sustainability as proposed by Kantabutra and Ketprapakorn (2020) and WCED (1987). Corporate sustainability theory proposes that corporations can provide lasting value by promoting moral, cultural, environmental, social, and economic well-being (Ashrafi et al., 2020). Furthermore, the shift to a CE relies on a diverse and comprehensive strategy. The concept encompasses internal operations inside companies, reactions from stakeholders, and the necessity of harmonious coexistence among businesses, society, and government (Ofori et al., 2021). The financial environment is crucial in this change. Hartley et al. (2020) argue that macroeconomic circumstances and regulatory frameworks play a crucial role in shaping the acceptance of circularity.

The waste-to-wealth concept emphasizes the interconnectedness of growth and sustainability, promoting a unified approach to circularity (Lacy and Rutqvist, 2015). The shift to circularity requires a comprehensive approach that considers regulatory, economic, and social aspects (Oliveira et al., 2021). The theoretical framework of sustainability financing and investment in the CE highlights the interdependence of economic, social, and environmental aspects. It is essential to comprehend the factors that lead to funding in the circular economy, the impact of the financial setting, and the consequences for CE practices to progress sustainable development goals, especially in regions like Ghana where these shifts show great potential.

Hypothesis development

This section of the paper reviewed literature on the implications of circular economy practices, which served as the basis for the hypotheses development.

Implications of circular economy practices of firms in the integrated waste management sector

Depending on the type of corporate social responsibility (CSR) activity investigated and the business performance measurement used, there was conflicting evidence connecting higher value (CSR) rankings. According to Dalal and Thaker (2019), businesses with good corporate governance, environmental, and social practices do better overall. Atan et al. (2018), on the other hand, had a different viewpoint. According to Schoenmaker (2019), financial institutions are starting to include social and environmental factors in their stakeholder models. He contends that when thinking about an investment, environmental, social, and governance (ESG) concerns must be taken into account. Apparently, financial institutions are now supporting sustainability.

By investing in sustainable companies, it is anticipated that they will be able to shift from avoiding risk to seizing possibilities for sustainability. As a result, they would put a greater emphasis on initiatives for sustainable development, such as funding for health care, environmentally friendly structures, wind turbines, electric vehicle manufacturers, upcycling, waste management practices, and programs for land reuse. This is because research by Scarpellini et al. (2020) discovered a favorable correlation between corporate social responsibility, environmental accounting procedures used by businesses, and CE strategies, including upcycling and trash recovery. Upcycling focuses on enhancing the value of materials that can be reintegrated into the system, not just as recycled or recovered entities, but also through the creation of advanced materials. These sophisticated materials are developed for their potential to achieve recuperative and restorative benefits (Mahabir et al., 2021; Horodytska et al., 2020). On the other hand, waste recovery refers to the process of collecting, processing, and converting waste materials into usable resources or energy. It is an integral part of waste management strategies aimed at reducing the environmental impact of waste by diverting it from landfills and finding productive uses for it (Shahrashoub and Bakhtiari, 2021; Wang et al., 2020).

Meanwhile, research suggests that a company might attain economic prosperity, environmental quality, and social justice by aligning its actions with the triple-bottom-line strategy (Elkington, 1998). According to Onyali (2014), the triple-bottom-line has an impact on corporate performance. According to the OECD (2019), sustainability financing strategies (e.g., Socially Responsible Investment) have benefits for both the social and financial spheres. The triple bottom-line theory (see Supplementary Figure S3) is used to measure sustainability with a focus on waste management companies' economic, environmental, social, and governance actions.

Research questions

The purpose of this work is to examine the effects of CE practices on the integrated waste management industry, drawing on the stakeholder theory, by assessing how the performance of Ghanaian waste management companies is affected by CE strategies, particularly upcycling and waste recovery. The following Research Questions (RQs) are investigated:

1. What is the effect of upcycling on the performance of firms in integrated waste management?
2. What is the effect of waste recovery on the performance of firms in integrated waste management?
3. How does upcycling influence the financial readiness of firms and investment preparedness in integrated waste management?
4. What is the effect of waste recovery on firms' financial readiness and investment preparedness in integrated waste management?

In line with these research questions, the following hypotheses are tested:

> H_{1a}: Upcycling has positive influence on the performance of firms in integrated waste management
>
> H_{1b}: Waste recovery has positive influence the performance of firms in integrated waste management

According to research, not all sustainability challenges are crucial from the standpoint of investments. Therefore, it's crucial to recognize material sustainability challenges, which can vary between businesses and industries (Khan et al., 2016). There is also the 'business case' or opportunities made possible by the demonstration that integrating sustainability criteria into investment decisions increases financial returns (Barros et al., 2021; UNEP FI and Mercer, 2007; Cadman, 2011). Borah and Kumar (2024) argued that the 7Rs—Rethink, Refuse, Reduce, Reuse, Repair, Recycle, and Rot—will promote a significant shift toward sustainable consumption and waste minimization. Borah and Kumar (2024) underscore the significance of adopting sustainable approaches, such as the 7Rs principle, nanomaterial and photocatalysis applications, zero waste management strategies, recycling and upcycling methods, and IoT-driven solutions. These incentives therefore lead to a greater emphasis on ESG indicator parameters in traditional corporate governance frameworks, such as shareholder 'impact on activism' and fiduciary duty, while making investment decisions (Waygood, 2011; Hachigan and McGill, 2012; Mora-Contreras et al., 2023).

The character of company activities draws investments following that nature. Sustainable responsible investing (SRI) has expanded as a result of the focus on sustainable development. Investors base their decision to invest in a company on its environmental policies. The importance of investments, particularly social investments, for sustainability practices is highlighted in studies by Widyawati (2020) and the OECD (2019). Yang et al. (2023) emphasized that although CE strategies can be applied across multiple sectors, including industry, waste, energy, buildings, and transportation, life cycle assessment is necessary to optimize these new systems. The study, therefore, hypotheses that:

> H_{2a}: Upcycling significantly influences the financial readiness of firms and investment preparedness in integrated waste management
>
> H_{2b}: Waste recovery significantly influences firms' financial readiness and investment preparedness in integrated waste management

Conceptual framework

The conceptual framework for this chapter was presented in Figure 1.

From the conceptual framework in Figure 1, waste recovery and upcycling were the CE practices, and were the independent variables for the study. Economic performance, environmental performance, social performance, corporate governance performance, investment preparedness, and financial readiness were the dependent variables. Framework in Figure 1 depicts that the study tested if waste recovery and upcycling had a significant effect on economic performance, environmental performance, social performance, corporate governance performance, investment preparedness, and financial readiness (Figure 2).

Empirical methodology

The empirical methodology discusses the data and methods including the research design, approach, population, sample and

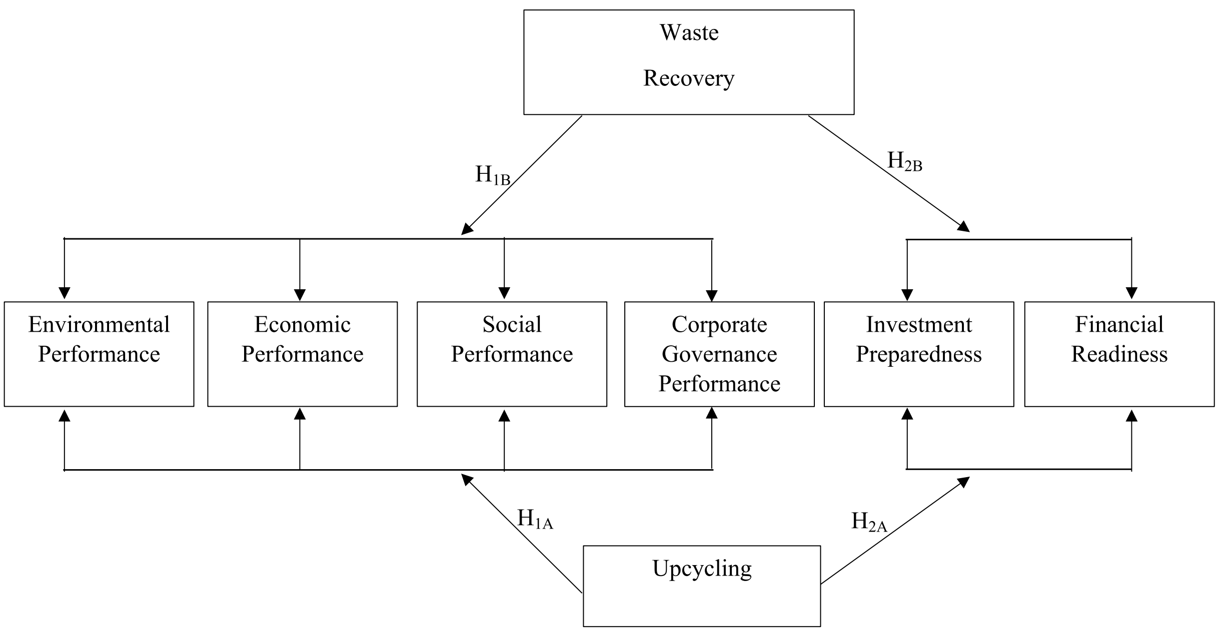

FIGURE 1
Implications of circular economy for waste management firms.

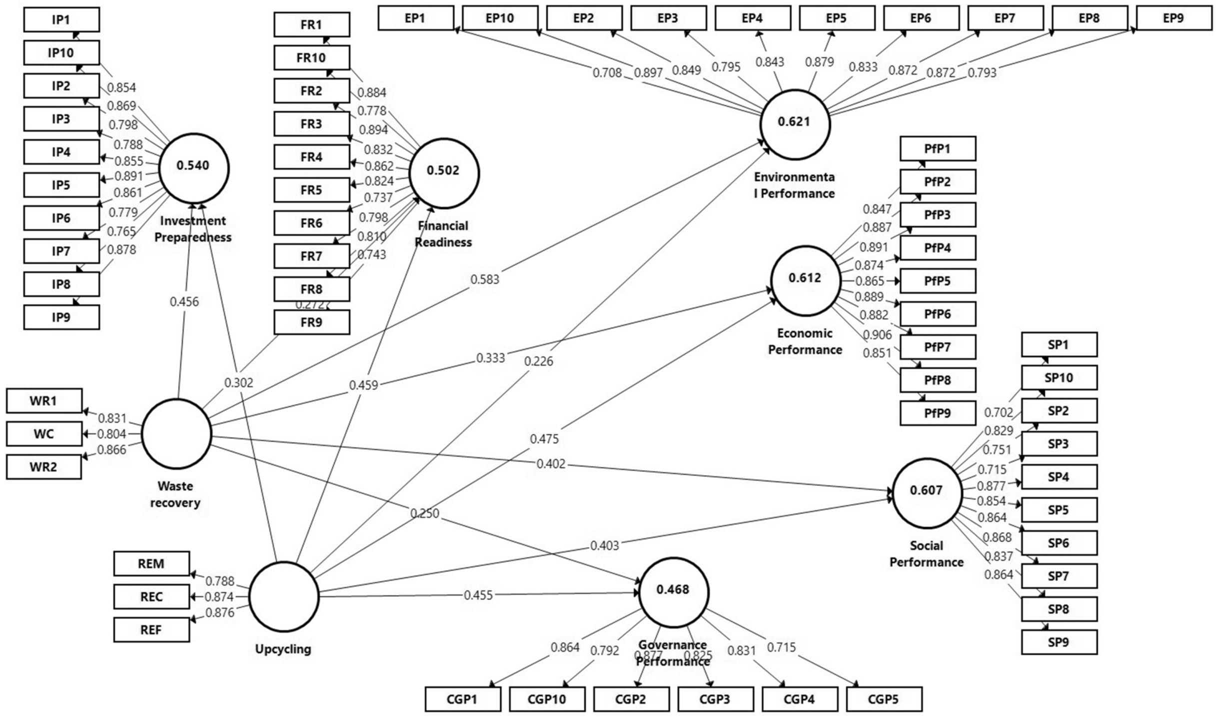

FIGURE 2
Structural model.

sampling technique. It also has the measures and the measurement of variables.

Data and methods

The study used a cross-sectional design and a quantitative research method. The target populations were the owner/managers of integrated waste management firms in the Environmental Service Providers Association of Ghana (ESPA) database. In all, there were 7,190 registered members of ESPA spread across the sixteen regions (16) of Ghana. Three hundred and sixty-seven (367) firms were selected using Kotrlik and Higgins (2001) Sample Size Determination formula. However, the sampling size is the minimum required based on assumptions of continuous data characteristics, 5 per cent margin of error, and significance level of 5%. However, an oversampling strategy was used to account for high non-response rate that characterizes primary data-based surveys, especially those involving actors in the waste management sector. This resulted in 524 responses obtained from the participants in the study. The objective of oversampling was to help better estimate the attributes of the firms. It was also to help inch closer to precision despite the delays and cost encountered (Vaughan, 2017).

Data was collected from integrated waste management firms using a questionnaire consisting of a 10-point Likert-like scale with closed-ended questions. The scale ranged from zero (0) at the lowest to ten (10) at the highest. The questions focused on investment preparedness, financial readiness, CE finance, investment supply, and the financial environment. The aim was to assess the determinants of CE finance and investment supply among integrated waste management firms in Ghana.

Partial least squares structural equation modeling (PLS-SEM) was used to analyze the data. Standard results evaluation criteria were employed, including reflective measurement, structural model, and goodness of fit (Lo et al., 2016). Confirmatory factor analyses (CFA) are assisted by this analytical method using the PLS approach. To gather fluctuations in the real-endogenous (observable) variable, PLS extracts the latent (non-observable) variable (Mateos-Aparicio, 2011). As a result of the connection between the exogenous and endogenous variables, it also estimates regression parameters to maximize the variance of the endogenous variable. PLS combines factor analysis and path analysis into a much more rigorous statistical tool (Kaplan, 2009; Hair et al., 2019). It is suitable for making measurements and predictions and testing complex models. The study used the SEM PLS approach.

Sampling procedure

The study used simple random sampling (SRS) technique. This technique is appropriate for populations that are homogeneous and permits uniform selection (Etikan and Bala, 2017) as in the case of the firms in the ESPA database. Furthermore, the approach offered every firm an equal chance of being included in the study (Noor et al., 2022; Berndt, 2020). Therefore, this approach has the benefit of producing an unbiased and representative sample (Stratton, 2021). To obtain the list of participants, the computerized randomization method in Microsoft Excel was used. This was done by importing the list of the integrated waste management firms in the sampling frame into

TABLE 1 Measurement of variables.

Upcycling	Upcycling focuses on enhancing the value of materials that can be reintegrated into the system, not just as recycled or recovered entities, but also through the creation of advanced materials. It was measured using the following constructs: re-manufacturing, reinvestment in CE activities, and recycling (Mahabir et al., 2021; Horodytska et al., 2020).
Waste recovery	Waste recovery refers to the process of collecting, processing, and converting waste materials into usable resources or energy. It was measured using the following constructs: waste collection and separation, material recovery and re-gift of suitable waste products (Shahrashoub and Bakhtiari, 2021; Wang et al., 2020)
Firm performance	The proxies for measuring firm performance with the CE framework, which includes social performance, economic performance, environmental performance and Governance performance (Thacker et al., 2019; Scarpellini et al., 2020)
Investment preparedness	The constructs for investment preparedness followed the elements in Mason and Kwok (2010), including equity aversion (dilution of control and ownership), investability (knowledge of the sector), presentational failings, functioning product and services, good corporate governance, experience of managers, quality of the board, NPD potential and assets quality. Financial Readiness This is measured by composite indicators including the understanding of the firm's risks, business survival potential, employee retention strategy of key personnel, understanding and mitigating costs, identifying other sources of potential funding, assessing liquidity needs, presence of loss response team and assessing insurance coverage (Melton, 2017)

Microsoft Excel. The list of waste management firms were coded (1, 2, 3….0.7190) before being imported. Then the RAND function was used to generate the list of participants for the data collection.

Operationalization of variables

The measurement of variables was presented in Table 1.

Analytical procedures

The data were analyzed using pairwise Markov random field (PMRF; Costantini et al., 2015, Van Borkulo et al., 2014) and partial least squares structural equation modeling (PLS-SEM) approaches. To corroborate the linear correlations proposed in the PLS-SEM model, further checks had to be made because numerous associations were being estimated. PLS-SEM is very useful for exploratory research because it maximizes the explained variance of a group of endogenous constructs in a model. Evidence from published works shows that PLS integrates factor analysis and route analysis into significantly more rigorous statistical processes (Kaplan, 2009; Hair et al., 2019). Latent variables were extracted to gather changes in the real endogenous variable (Mateos-Aparicio, 2011). Additionally, the correlation between the exogenous and endogenous variables is used to estimate the regression parameters to maximize the variance of the endogenous variable. It is appropriate for performing measurement and prediction tasks, as well as evaluating sophisticated models.

Making the measurement model is the first step in conducting data analysis using PLS-SEM. According to the reflective theory, the relationship between variables should be examined, considering how the measures reflect (or manifest) a construct. Before being included in the path model, the reflective measurement model estimate method includes a test of construct validity and reliability. Four reliability and validity tests—internal consistency, indicator, convergent, and discriminant reliability—were carried out. These tests examined the proportion of the indicator variables the latent variable accounted for as a diagnostic test using PLS-SEM. The idea was to eliminate indicators with loadings of less than 0.4 in the PLS model from the measurement model, as proposed by Hulland (1999). An evaluation of convergent validity was done in addition to the indicator reliability test. The degree to which one indicator positively connects with other indicators of the same construct was examined in this test. The indicators' outer loadings and the average variance retrieved were looked at during this process.

Results and discussion

The results of the hypotheses tested was presented with various diagnostic checks including validity, reliability and multicollinearity. The section also discussed the results and the implications from the findings.

Assessment of measurement model

The measurement model shows the connections between the constructs and the indicators. By reducing the residual variances of the endogenous constructs, the partial least squares-structural equation modeling (PLS-SEM) analytical approach combines factor analysis with multiple regression (Hair et al., 2011). The PLS-SEM is a useful technique for estimating complex models, including higher-order construct modeling, because the studies that follow use latent variable scores. An assessment of the measurement model is suggested as the first step before the structural model may be further examined to verify that the hypothesized relationships between structural models are accurately interpreted and presented (Hair et al., 2018). Prior to estimating the coefficients of the structural model, the PLS-SEM algorithm first optimizes the measurement model's parameters. The suggested techniques appropriate for the assessment of measurement model quality, include indicator reliability, internal consistency reliability, and convergent and discriminant validity. Table 2 displays indicator dependability and internal consistency dependability.

The results in Table 2 show recommended techniques such as AVE, composite reliability, factor loadings, etc., for assessing the model's convergent validity and reliability, as well as the reliability of the items (factor loadings). To analyze the reliability of indicators, factor loadings—where elements with loadings above 0.7 were

TABLE 2 Reliability and validity assessment.

Code	Latent constructs	Factor loadings	rho_A	Composite reliability	AVE
Economic performance			0.968	0.968	0.769
PfP 1	We have experienced increasing economic value-added	0.847			
PfP 2	Our return on equity has been improving	0.887			
PfP 3	The Firm's net income/revenue is increasing steadily	0.891			
PfP 4	Return on investment helps retain our investors	0.874			
PfP 5	We have experienced increasing earnings before tax	0.865			
PfP 6	Our management is efficient at using its assets to generate earnings	0.889			
PfP 7	Profit margins in this sector are often very high	0.882			
PfP 8	The firm has experienced growth in profit over time.	0.906			
PfP 9	We have low operating costs that improve our profit	0.851			
Environment performance			0.960	0.958	0.698
EP1	We have projects to improve/recover the environment	0.708			
EP10	Businesses and banks make a profit	0.897			
EP2	The firm has a low level of energy intensity (lower cost to convert energy)	0.849			
EP3	We use recyclable materials	0.795			
EP4	We reuse our residuals	0.843			
EP5	We monitor the volume of energy consumption	0.879			
EP6	The firm has not experienced any lawsuits due to its practices	0.833			
EP7	We use lesser water in our operations	0.872			
EP8	We have met all the environmental performance goals we set for the business.	0.872			
EP9	Businesses and banks make a profit	0.793			
Financial readiness			0.954	0.953	0.669
FR1	The firm has a high financial survival potential	0.884			
FR2	The firm has a strategy for retaining key personnel in the business.	0.894			
FR3	There is a strategy for identifying and mitigating financial and business risks	0.832			
FR4	The firm has other sources of potential funding	0.862			
FR5	The firm can determine its liquidity and financing needs	0.824			
FR6	There is the presence of a loss response team	0.737			
FR7	The firm has insurance coverage for projects it finances	0.798			
FR8	The firm has financed its projects previously from equity.	0.810			

(Continued)

10.3389/frsus.2024.1455335

TABLE 2 (Continued)

Code	Latent constructs	Factor loadings	rho_A	Composite reliability	AVE
FR9	Debt financing has been the means for financing the firm's projects	0.743			
FR10	Integrated waste management firms often engage in financial planning	0.778			
Corporate governance performance			0.927	0.924	0.671
CGP1	Our Board Size is comparable to that of similar firms	0.864			
CGP2	Our Board is free from any form of interference	0.877			
CGP3	We have directors who monitor executives to act in the interest of owners.	0.825			
CGP4	Managers have high share ownership	0.831			
CGP5	There is gender diversity on the Board	0.715			
CGP10	Customers purchase products in large volumes	0.792			
Investment preparedness			0.959	0.958	0.697
IP1	The business is open to large scale of investment	0.854			
IP2	The firm is willing to dilute its ownership and control	0.798			
IP3	The firm has managers who have knowledge of the sector and its dynamics	0.788			
IP4	The business has well-functioning products and services	0.855			
IP5	There are good corporate governance practices in the firm	0.891			
IP6	There are experienced managers in the firm	0.861			
IP7	The firm has a diverse board.	0.779			
IP8	There is new product development potential for the firm	0.765			
IP9	The firm boosts quality assets for its operations	0.878			
IP10	The firm has a good reputation in the industry	0.869			
Social performance			0.955	0.953	0.670
SP1	We employ more people from minority groups	0.702			
SP2	We have a number of social and cultural projects	0.715			
SP3	Our firm have not experienced any lawsuits	0.877			
SP4	We meet regulatory agencies' requirement	0.854			
SP5	We engage in fair trade	0.864			
SP6	We work to reduce vulnerability in our community	0.868			
SP7	The business has good relations with the community	0.837			
SP8	Our operations do not affect the people	0.864			

(Continued)

10.3389/frsus.2024.1455335

TABLE 2 (Continued)

Code	Latent constructs	Factor loadings	rho_A	Composite reliability	AVE
SP9	We are a diverse business	0.715			
SP10	Society need trees	0.829			
Upcycling			0.886	0.884	0.718
REM	The firm undertakes re-manufacturing.	0.874			
REC	Waste recycling is an integral part of the firm's activities	0.876			
REF	The firm re-invest in CE activities	0.788			
Waste recovery			0.874	0.873	0.696
WC	The firm engages in waste collection and separation	0.804			
WR1	The firm undertakes material recovery as part of waste management	0.831			
WR2	The firm engages in re-gift of suitable waste products	0.866			

retained—were employed. Factor loadings show how well something captures the conceptual space of a construct. Because factor loadings above 0.7 are advised, items with low factor loadings (0.60) were excluded from the measurement model (Becker et al., 2023). Internal consistency quantifies the degree to which test items measure the underlying constructs. It highlights a test's capacity to generate reliable results by employing a range of objects to gage a range of constructs. The study evaluates internal consistency and dependability using two diagnostic methods (Cronbach's alpha and composite reliability).

In addition to the Cronbach alpha, composite reliability—which is a more accurate measure of reliability in a PLS-SEM setting—was reported as an additional check on construct dependability (Hair et al., 2018). The total scale score variance is contrasted with the true score variance (Brunner, 2005). It assesses the shared variance among the observed variables and acts as a latent construct indicator (Fornell and Larcker, 1981). The composite reliability score (C.R.) must be more than 0.708 to pass this test. If the C.R. is 0.60–0.70, exploratory research may be considered appropriate.

Test for convergent and discriminant validity

The percentage of the indicator variables that the latent variable could explain was examined by the indicator reliability test. Although writers of flexible criteria propose factor loadings over 0.6, Hulland (1999) highlighted that the standard practice was to eliminate reflected indicators with loadings of less than 0.708 from the measurement model. The latent variable must account for at least 50% of the variance in the indicators. It was anticipated that the outer loading would be greater than 0.708, or 0.5 squared. The concept of convergent validity shows how to scale items for the same construct in relation to scale items of a similar nature. The final score of the average variance derived is influenced by the factor loadings' dependability (AVE).

The measuring criteria were cross-loading, Fornell-Larcker criterion (FLC), and Heterotrait-Monotrait Correlation Ratio (see Supplementary Table S1–S3) (HTMT). Henseler et al. (2014) claim that the cross-loading approach to discriminant validity is established by a construct indicator's low connection with all other constructs other than the one to which it is theoretically related. The PLS algorithm technique is used to generate cross-loadings (See Supplementary Table S1), which may then be tested for discriminant validity. The results show that indicators leaned more heavily on their parent components than on other constructs. A construct is regarded as discriminant valid by the Fornell-Larcker criterion if its square root of the AVE is higher than its correlations with other indicators (Fornell and Larcker, 1981). Values in bold indicate the AVE's squared root (see Supplementary Table S2). A list of correlations between the latent constructs is shown below the square root of the AVE. Any construct that demonstrates discriminant validity, which is indicated by having a squared root of the AVE higher than the construct with the highest correlation to other components, is valid.

The Heterotrait-Monotrait ratio of correlations (HTMT) (see Supplementary Table S3) is described as a more trustworthy way for assessing discriminant validity in variance-based SEM in comparison to cross-loadings and the Fornell Larcker criterion (Henseler et al., 2014). The HTMT's ultimate result near one, which is more credible, denotes a lack of discriminant validity.

10.3389/frsus.2024.1455335

TABLE 3 Explanatory power indices: R square, F square.

	Adj. R^2	Upcycling f^2	Waste recovery f^2
Economic performance	0.611	0.139	0.068
Environmental performance	0.620	0.032	0.214
Financial readiness	0.500	0.101	0.035
Governance performance	0.466	0.093	0.028
Investment preparedness	0.538	0.047	0.108
Social performance	0.606	0.099	0.098
Upcycling	0.611		
Waste recovery	0.620		

Source: Field data (2024).

Discriminant validity is present if latent ratios are smaller than the threshold value of 0.85 (Kline, 2011) or 0.9 (Gold et al., 2001). According to HTMT, which again demonstrates that indicators significantly perform well in differentiating between unrelated constructs and loading highly on the parent constructs. After the measurement model's quality has been established, the structural model is further evaluated based on collinearity diagnostics, significance tests of hypothesized correlations, and the model's explanatory and predictive power.

Assessment of the structural model

Additional structural model fit concerns were resolved throughout the structural model analysis. Collinearity, relevance and significance of structural models, effect size, the cumulative effect of the exogenous factors, and the predictive utility of the route model were some of these concerns. Before estimating the path model, collinearity should be tested as a fundamental step. The structural model's path coefficient is based on OLS regressions of each endogenous latent indicator on the constructs it preceded.

A variance inflation factor (VIF) score of 5 or above with a tolerance of 0.2 or below denotes a collinearity issue, according to Hair et al. (2017, 2019). Next, based on the study's theoretical and empirical foundations, the structural model relationship (path coefficients) or hypothesized link was determined. When estimating the path coefficient, the significance test was also be calculated for the relationships in the structural model. Using the t-values and p-values, the significance level of the path coefficient connections would be calculated. The coefficient of determination (R^2), the effect size (f^2), and the predictive relevance (Q^2) were used to further assess the structural model and its results. The amount of variance in the dependent variable that the independent variables could account for was assessed by the coefficient of determination (R^2) between zero (0) and one (1) for R^2 (1).

The two statistical methods (f^2) for assessing a model's predictive power are R^2 and effect size. According to Cohen (2013), the general guideline for calculating the f^2 Small, medium, and big were designated by values of 0.20, 0.15, and 0.35, respectively. The predictive power and combined significance of a model are measured by the coefficient of determination (R^2). It displays the amount of variation in the endogenous construct that can be explained by all conceptually significant external factors. The range of R^2 values is 0 to 1, with higher values indicating more precise predictions. Adjusted R^2 is advised because it takes model complexity into consideration and facilitates model comparison because R^2 values rise with the number of predictors (Table 3).

The results of the hypotheses test are displayed in Table 4. Two key circular activities of firms in the waste management sector were examined based on the theoretical and empirical evidence supporting them. Environmental, social, economic, and governance performance indicators were used to model waste recovery and upcycling. Additionally, the effect of upcycling and waste recovery on financial readiness and investment preparedness was tested. For hypothesis H_{1a} it was found that upcycling had a positive and significant effect on economic performance ($\beta = 0.475$, $t = 4.495$, $p = 0.000$). Increased upcycling activities may lead to better economic performance for waste management firms. Upcycling activities may include recycling, which enables firms to find new uses for waste. Thereby, increasing their access to cheaper raw materials and consequently reducing their cost of operation may lead to better economic performance (Mahabir et al., 2021; Horodytska et al., 2020). The findings also implied that waste management companies are better positioned to compete for investments and finance if they engage in CE practices like upcycling. That is the engagement in upcycling by waste management firms may attract socially responsible investors. According to the findings of Atan et al. (2018) upcycling has a considerable impact on waste management firms' ability to secure funding and investments, especially from socially responsible investors. This will lead to an increase in capital for their operations.

Furthermore, it was observed that upcycling had a positive and significant effect on social performance ($\beta = 0.403$, $t = 3.132$, $p = 0.002$). Upcycling activities may lead to a better social performance. This implies that once these firms engage in better waste management practices (e.g., re-manufacturing), they receive higher social acceptance as they may not experience lawsuits and social resistances (Dalal and Thaker, 2019; Scarpellini et al., 2020). This would obviously impact on their social activities within the community. Also, upcycling had a positive and a significant effect on governance performance ($\beta = 0.455$, $t = 3.670$, $p = 0.000$). This implies that an increase in upcycling activities by waste management firms would enhance their governance performance. When firms engage in upcycling activities (e.g., recycling and remanufacturing), it enables them to improve their operations (Scarpellini et al., 2020). This would enable the firm to attract better management and investors. This is because these individuals would want to receive a better return on

TABLE 4 Coefficients.

	Original Sample (O)	Standard deviation (STDEV)	*t* statistics (|O/STDEV|)	*p* values	95% B.C.I 2.5%	97.5%
Upcycling - > Economic performance	0.475	0.106	4.495	0.000	0.258	0.675
Upcycling - > Environmental performance	0.226	0.130	1.736	0.083	−0.041	0.461
Upcycling - > Financial readiness	0.459	0.122	3.755	0.000	0.208	0.691
Upcycling - > Governance performance	0.455	0.124	3.670	0.000	0.202	0.694
Upcycling - > Investment preparedness	0.302	0.127	2.388	0.017	0.030	0.533
Upcycling - > Social performance	0.403	0.129	3.132	0.002	0.140	0.646
Waste recovery - > Economic performance	0.333	0.105	3.183	0.001	0.130	0.547
Waste recovery - > Environmental Performance	0.583	0.126	4.641	0.000	0.352	0.835
Waste recovery - > Financial Readiness	0.272	0.123	2.212	0.027	0.031	0.516
Waste recovery - > Governance Performance	0.250	0.123	2.024	0.043	0.010	0.496
Waste recovery - > Investment Preparedness	0.456	0.126	3.624	0.000	0.229	0.717
Waste recovery - > Social performance	0.402	0.127	3.157	0.002	0.161	0.664

Source: Field data (2024).

investment and be associated with the success story of such firms (Dalal and Thaker, 2019).

However, the effect of upcycling on environmental performance was positive but not significant ($\beta = 0.226$, $t = 1.736$, $p = 0.083$). For upcycling to be attractive to waste management firms, they need to collect large volumes of appropriate waste before recycling or further processing. Meanwhile, low levels of waste segregation among households and other waste generators make it difficult for waste management firms to collect or obtain large quantities of segregated waste for their operations (Ofori et al., 2021). Therefore, the few firms that engage in upcycling, given the increasing levels of waste generated, are not able to make a significant impact on the environment. Regarding hypothesis H_{1b} waste recovery had a positive and significant effect on economic performance ($\beta = 0.333$, $t = 3.183$, $p = 0.001$). This implies that when waste management firms are able to collect and separate more material waste, it would lead to improved economic performance. Effective processes lead to more efficient use of resources. By recovering materials that would otherwise be discarded, firms reduce their reliance on raw materials, lowering costs associated with material procurement (Atan et al., 2018). Also, recovered materials can be sold or repurposed, creating new revenue streams. For example, recycled metals, plastics, or glass can be sold to manufacturers, while organic waste can be converted into compost or bioenergy, generating additional income for these waste management firms. Firms that demonstrate commitment to sustainability through waste recovery can enhance their brand value and reputation. This can attract environmentally conscious customers and investors, providing a competitive edge (Scarpellini et al., 2020). Engaging in waste recovery can stimulate innovation, leading to the development of new products or services. This not only diversifies the business but also opens up new markets. Also, from the results, it was found that waste recovery had a positive and significant effect on EP ($\beta = 0.583$, $t = 4.641$, $p = 0.000$). This outcome suggests that effective waste recovery practices enhance environmental performance among waste management firms. By effectively recovering, firms are able to reduce landfilling, thereby mitigating harmful emissions and environmental degradation (Shahrashoub and Bakhtiari, 2021; Wang et al., 2020). Also, the recovery of waste materials contributes to the conservation of natural resources, further reinforcing environmental benefits. The findings also suggest that for waste management firms, investment in and focus on waste recovery processes are not merely regulatory compliance or corporate social responsibility initiatives but are indeed integral to their core mission of enhancing EP (Favi et al., 2016; Yazdani et al., 2021). The result affirms that waste recovery is an important aspect of sustainable waste management, contributing significantly to improved environmental outcomes.

It was found that waste recovery had a positive and significant effect on governance performance ($\beta = 0.250$, $t = 2.024$, $p = 0.048$). This finding indicates that adopting waste recovery practices enhances governance within waste management firms. The significance of this relationship can be attributed to several factors. First, effective waste recovery practices require robust management and operational systems, which in turn foster better organizational governance. This includes transparent decision-making processes, accountability, and adherence to regulatory standards, all of which are crucial aspects of governance (Dubey et al., 2019; Shahbazi et al., 2016; Bressanelli et al., 2018). All these could be achieved by implementing monitoring and reporting mechanisms to improve data accuracy and transparency, an essential feature of strong governance. Second, the environmental responsibility demonstrated through effective waste recovery can enhance a waste management firm's compliance with environmental regulations and policies, which is a key component of good governance. It reflects a waste management firm's commitment to legal standards and ethical practices.

It was also found that waste recovery had a positive and significant effect on social performance ($\beta = 0.402$, $t = 3.157$, $p = 0.002$). This result indicates that waste recovery among integrated waste management firms promotes social welfare. Effective waste recovery initiatives often lead to reduced environmental hazards, promoting healthier and safer communities (Raimonda et al., 2020; OECD, 2019). By reducing waste and its associated negative impacts, firms are actively participating in the betterment of the living conditions in areas they operate in. Additionally, waste recovery processes can create job opportunities, particularly in recycling and processing activities. This not only contributes to economic wellbeing but also fosters community engagement and development (Wang et al., 2020). Moreover, firms that actively engage in waste recovery are often viewed positively by the public, enhancing their social image and standing. This can lead to better community relations and corporate social responsibility, thereby improving their social performance (Shahrashoub and Bakhtiari, 2021).

For hypothesis H_{2a} upcycling had a positive and significant effect on the financial readiness ($\beta = 0.459$, $t = 3.755$, $p = 0.000$) of waste management firms in Ghana. This finding implies that upcycling enhances the financial readiness of these waste management firms. This suggests that upcycling, as a strategic initiative, goes beyond mere waste reduction; it strengthens the cashflows of waste management firms (Khan and Haleem, 2020; Bag et al., 2019). This is because upcycling adds value to waste materials, thereby creating new revenue streams and reducing costs associated with waste processing and disposal (Govindan and Hasanagic, 2018). The transformation of waste into higher-value products through upcycling not only contributes to environmental sustainability but also aligns with economic gains, underpinning the financial viability of these waste management firms.

Also, upcycling had a positive and significant effect on investment preparedness ($\beta = 0.302$, $t = 2.388$, $p = 0.017$) of waste management firms in Ghana. This finding implies that upcycling enhances the investment preparedness of these waste management firms. First, upcycling can lead to the development of innovative products and processes, which in turn can open up new markets and revenue streams (De Angelis et al., 2018; Luthra and Mangla, 2018). This diversification strengthens the financial stability of firms, making them more appealing to potential investors and lenders. Second, engaging in upcycling can improve these firms' reputations in the market, given current consumers' and investors' interest in sustainable business practices. This enhanced reputation can make it easier for waste management firms to attract appropriate investment.

Furthermore, upcycling demonstrates a firm's strategic approach to resource innovation, an essential quality for investors. Concerning hypothesis H_{2b} waste recovery had a positive and significant effect on the financial readiness ($\beta = 0.272$, $t = 2.212$, $p = 0.027$) of waste management firms in Ghana. This means that waste recovery promotes financial readiness among waste management firms. This implies that waste recovery, as a component of sustainable practices, contributes not only to environmental stewardship but also to the economic health of waste management firms. These findings suggest that the more efficient a firm is at recovering waste, the better equipped it is financially (Genovese et al., 2017). This is because waste recovery can lead to more efficient use of resources, reducing costs associated with raw material procurement and waste disposal. Recovered materials can be sold or repurposed, creating additional streams of income (Maqbool et al., 2020). This enhances the financial capacity of the firm to invest in other areas or cushion against financial uncertainties.

Moreover, it was observed that waste recovery had a positive and significant effect on investment preparedness ($\beta = 0.456$, $t = 3.624$, $p = 0.000$) of waste management firms in Ghana. This finding implies that waste recovery enhances the investment preparedness of these waste management firms. The result suggests that as these firms enhance their capacity to recover and process waste, they increase their preparedness to undertake new investment initiatives. Efficient waste recovery enables optimal utilization of resources, leading to cost savings. These savings can be reallocated to investment opportunities, thereby enhancing these firms' growth. Firms' efficiency in waste recovery demonstrates a commitment to sustainable practices, which is increasingly valued in the market (Granz et al., 2020; Capizzi et al., 2022). This reduces coercive investment risks and make the firms more attractive to potential investors. Effective waste recovery positions firms favorably within the market, potentially leading to increased business opportunities and the ability to investment avenues.

Partial correlation

When numerous variables interact with one another, it may be important to assess the true relationship between these variables without taking another factor into account. It was evaluated whether there is a partial association between CE practices, financial readiness, investment preparedness, and performance indicators. Pairwise Markov Random Fields (PMRF; Costantini et al., 2015; Van Borkulo et al., 2014) are a well-liked network model for predicting psychological networks that was applied in this investigation. Psychological networks are made up of nodes that represent the observed variables and edges that represent the statistical correlations between the nodes. An estimated parameter in psychological networks is the degree of connectivity between two nodes. The parameters are approximated more precisely

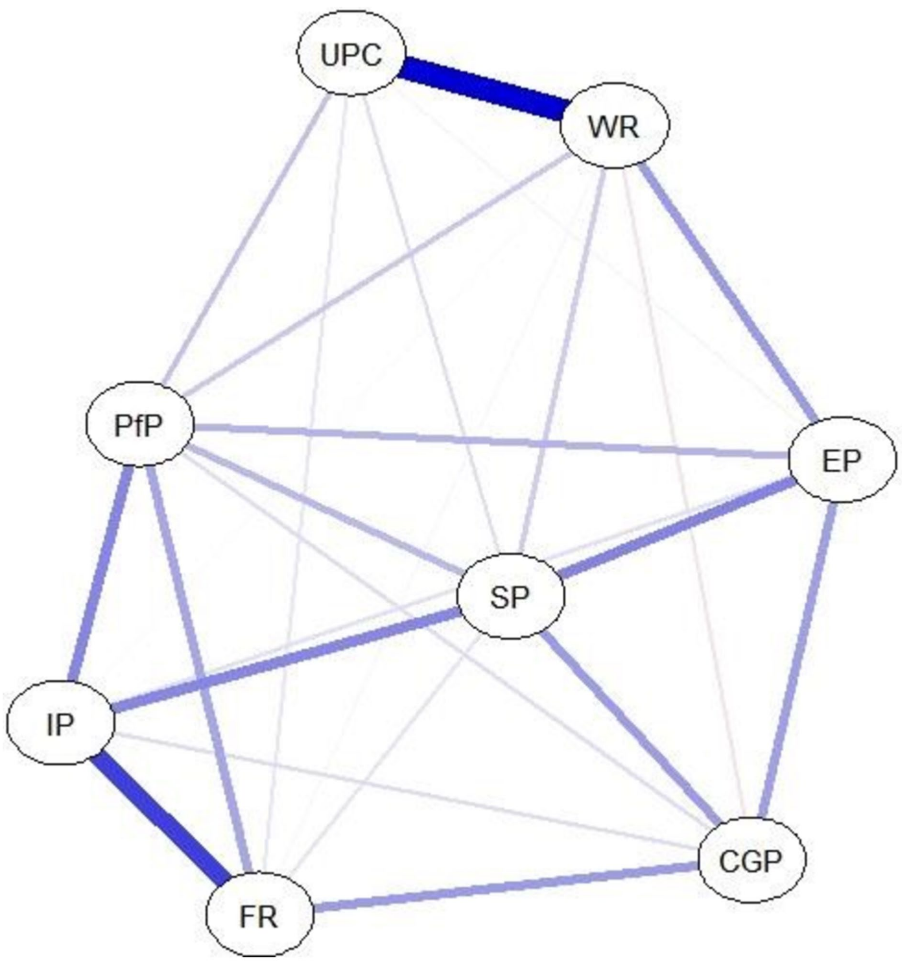

FIGURE 3
Estimated network structure. UPC, Upcycling; WR, Waste recovery; EP, Environmental performance; SP, Social performance; PfP, Economic performance; CGP, Corporate governance performance; IP, Investment preparedness; FR, Financial readiness.

with a larger sample size (close to the true value). Typically, a network structure is created to explain how the nodes, or variables, are related to one another. The network structure is shown in Figures 3, 4, and the post-hoc stability analysis and tests for substantial differences.

Figure 3 displays the connections (regularized partial correlations) between network nodes (for all connections, $p < 0.003$). Shorter, thicker lines with positive links shown in green and negative associations in red represent the strength of the connections between the nodes. The network topology shows strong ties between upcycling, waste recovery, financial readiness, and investment preparedness (positive in blue color). The marginal links between investment preparedness and economic performance, investment preparedness and social performance, social performance and environmental performance, corporate governance performance, and others may be shown in addition to the strong linkages. Additionally, there were weak linkages between several concepts, such as environmental performance, waste recovery, and upcycling. Upcycling activities and waste recovery were strongly correlated, as shown by the strongest relationship between upcycling and waste recovery. Upcycling entails cyclic processes like inventive repair and reuse techniques.

Figure 4 (right panel) shows how the nodes differ in terms of their estimates for centrality indices. The most statistically significant connections to other nodes in the network are made by a central node. Strength, betweenness, and closeness are the three primary centrality estimations produced throughout the estimation process (Epskamp et al., 2012). A node's strength describes how well it is directly coupled to other nodes. The total of the absolute weights (regularized partial correlations) connecting that node to other nodes is calculated (Di Cerbo and Taylor, 2021). A node's relevance in the typical path connecting two other nodes is indicated by its betweenness.

Also, how crucial a specific node is to linking other nodes. A node's closeness to other nodes in the network is determined by how well they are directly or indirectly connected to them. Using the R package bootnet, which examines variations in node strength, node centrality tests—i.e., statistical tests to assess whether any nodes in the network are considerably more central than other nodes—were carried out (Epskamp, 2016). The correlation of the stability coefficient, another bootnet calculation, was used to assess the accuracy of the strength values for the nodes and their links or edges (Epskamp et al., 2018).

We see a significant variation in the nodes' centrality indices (betweenness, strength, and closeness). The node with the greatest strength is waste recovery, whereas environmental performance indicated the greatest betweenness and proximity. These findings indicate the value of waste recovery and its bearing on environmental

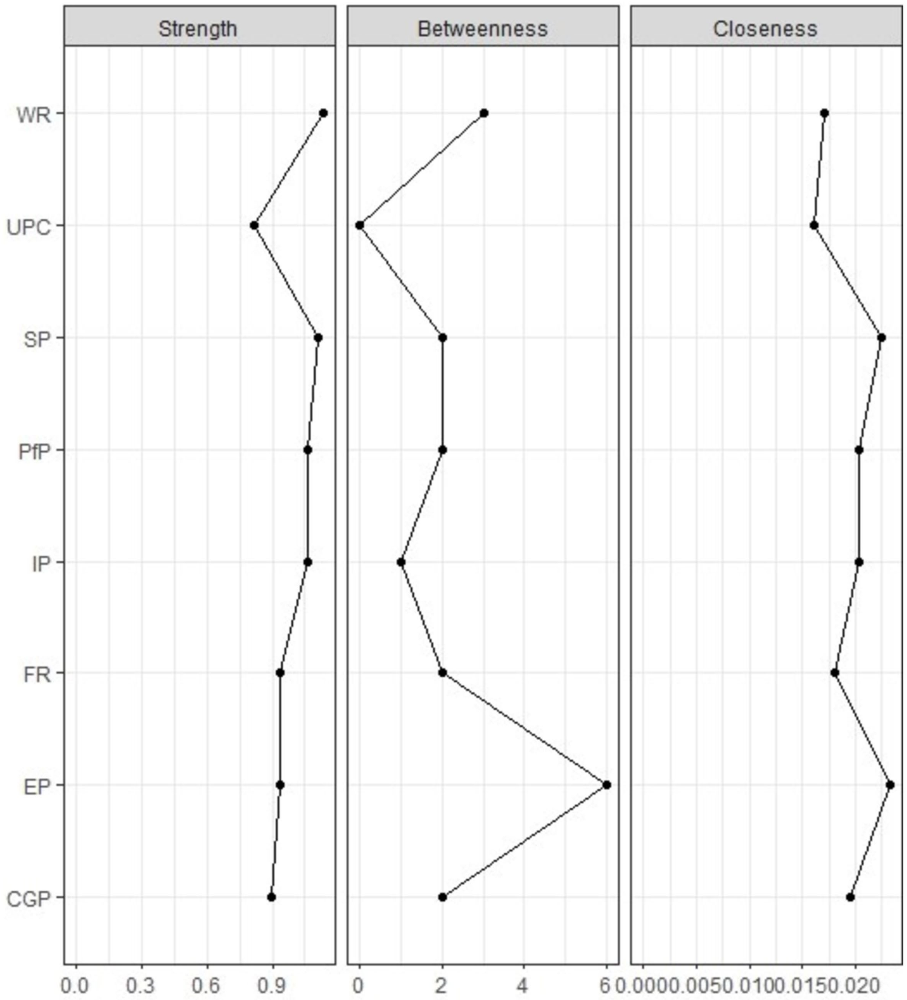

FIGURE 4
Centrality indices. UPC, Upcycling; WR, Waste recovery; EP, Environmental performance; SP, Social performance; PfP, Economic performance; CGP, Corporate governance performance; IP, Investment preparedness; FR, Financial readiness.

performance. Every node, including upcycling, environmental performance, social performance, economic performance, corporate governance performance, investment preparedness, and financial readiness, is directly connected to waste recovery. However, environmental performance is also the variable that is connected to all other variables most tangentially (closeness). In the average path between two other variables, it is the most significant variable (betweenness).

Discussion

The study's goals were to evaluate the effects of upcycling activities on waste management firms' performance, evaluate the effects of waste recovery on waste management firms' performance, examine the effects of upcycling on firms' finance readiness and investment preparedness, and finally examine the significant effects of waste recovery on these firms' financial readiness and investment preparedness.

The statistically significant effect of upcycling on economic performance ($\beta = 0.475$, $t = 4.495$, $p = 0.000$) reinforces the economic advantages that firms can gain through these activities. Upcycling enables waste management firms to reuse materials as raw inputs, leading to reduced operational costs and additional revenue streams. This finding aligns with Mahabir et al. (2021) and Horodytska et al. (2020), who indicate that CE practices in waste management promote cost efficiencies and profitability by reducing dependence on external materials. Daddi et al. (2019) similarly suggest that upcycling activities, by lowering material procurement costs, contribute to overall economic stability. Additionally, these practices appear to improve a firm's attractiveness to socially responsible investors (SRI), as noted by Atan et al. (2018), who argue that firms engaging in sustainable activities are more appealing to SRIs, thereby boosting capital and investment inflows. However, while the observed relationship is strong, the analysis could further benefit from addressing causality limitations by suggesting longitudinal or experimental studies that track economic outcomes over time to confirm that these practices directly influence profitability.

In addition to economic benefits, upcycling shows a positive effect on social performance ($\beta = 0.403$, $t = 3.132$, $p = 0.002$), suggesting that waste management firms adopting CE practices receive higher levels of social acceptance and community support. This correlation aligns with research by Scarpellini et al. (2020) and Dalal and Thaker (2019), who found that firms implementing sustainable practices encounter fewer legal challenges and experience stronger public trust. These outcomes are often attributed to reduced pollution and enhanced environmental responsibility, which foster better community relations and social capital (Daddi and Iraldo, 2018). Moreover, engaging in upcycling may create job opportunities and community involvement in waste management processes, as indicated by Liao and Yao (2022), further boosting a firm's social reputation. While the connection between upcycling and social performance is robust, a more granular look at how specific community engagement strategies influence social performance metrics could enrich the analysis.

The analysis also confirms a positive relationship between upcycling and governance performance ($\beta = 0.455$, $t = 3.670$, $p = 0.000$), indicating that firms engaged in sustainable practices improve their governance frameworks. Effective governance structures—marked by accountability, transparency, and regulatory compliance—are often necessary to implement upcycling practices successfully. These practices necessitate systematic monitoring and reporting, which inherently strengthen governance standards (Bressanelli et al., 2018). Dalal and Thaker (2019) further note that responsible management practices, such as those fostered through upcycling, attract higher-quality management and board members due to the perceived stability and ethical commitment of the firm. Although the link between upcycling and governance performance is compelling, specifying which governance mechanisms (e.g., enhanced ESG reporting, sustainable procurement policies) contribute to these improvements could provide a more detailed understanding for practitioners.

However, the effect of upcycling on environmental performance was positive but not statistically significant ($\beta = 0.226$, $t = 1.736$, $p = 0.083$). One plausible explanation for this finding is the ongoing challenge of low waste segregation, as Ofori et al. (2021) note that inadequate waste sorting at the source restricts the volume of waste suitable for upcycling, thereby limiting its environmental impact. This result suggests that upcycling alone may not be sufficient to generate substantial environmental benefits without supportive policies and infrastructure enhancements that facilitate effective waste segregation. Lieder and Rashid (2016) argue that increased environmental performance in upcycling may only be achieved once infrastructure and regulatory frameworks support large-scale waste recovery. Future research could explore how complementary policy measures, such as improved waste segregation practices, could enhance the environmental impact of upcycling in the waste management sector.

The positive and significant effect of waste recovery on economic performance ($\beta = 0.333$, $t = 3.183$, $p = 0.001$) emphasizes the economic advantages associated with effective resource recovery. Waste recovery processes allow firms to reduce their dependency on virgin materials and cut costs related to raw material procurement, thereby improving profitability. These findings align with Atan et al. (2018) and Maqbool et al. (2020), who found that waste recovery activities contribute to cost savings and improved operational efficiency, particularly when recovered materials, such as metals and plastics, can be repurposed or sold. Furthermore, waste recovery practices bolster a firm's brand and reputation, attracting environmentally conscious customers, as noted by Scarpellini et al. (2020). However, while this analysis highlights the financial benefits of waste recovery, it could be enhanced by suggesting methods for firms to quantitatively track economic returns from specific recovery activities to strengthen the causal interpretation of these benefits.

The data also reveal that waste recovery positively and significantly impacts environmental performance ($\beta = 0.583$, $t = 4.641$, $p = 0.000$), supporting the role of waste recovery in reducing landfill usage, emissions, and environmental degradation (Shahrashoub and Bakhtiari, 2021; Wang et al., 2020). Favi et al. (2016) found that waste recovery contributes to resource conservation, reinforcing its value in sustainable waste management practices. These findings suggest that waste recovery aligns with the core mission of waste management firms to contribute to environmental stewardship. This outcome is consistent with Genovese et al. (2017), who argue that waste recovery practices create significant environmental benefits by minimizing harmful emissions and reducing waste disposal needs. Including longitudinal data in future studies could further illuminate the impact of waste recovery on environmental metrics, enhancing the understanding of how these activities contribute to long-term environmental outcomes.

Regarding governance, waste recovery was found to positively and significantly affect governance performance ($\beta = 0.250$, $t = 2.024$, $p = 0.043$). Waste recovery initiatives necessitate structured operational systems, fostering transparency, regulatory compliance, and improved decision-making processes (Dubey et al., 2019; Shahbazi et al., 2016). Robust governance structures, as emphasized by Bressanelli et al. (2018), ensure compliance with regulatory standards and ethical practices, which are critical for maintaining investor and stakeholder trust. Strengthening governance through waste recovery also reflects a commitment to environmental responsibility, which aligns with regulatory requirements and reduces compliance risks. Expanding this section by discussing specific governance mechanisms, such as board oversight of sustainability practices, could clarify how waste recovery practices directly reinforce governance quality.

Social performance also benefits significantly from waste recovery ($\beta = 0.402$, $t = 3.157$, $p = 0.002$), suggesting that these practices contribute to community welfare by reducing environmental hazards. By actively recovering waste, firms can prevent pollution and minimize health risks, thereby fostering better living conditions within their operational areas (Raimonda et al., 2020; OECD, 2019). Waste recovery also supports job creation, particularly in recycling and repurposing activities, thereby contributing to community economic development (Wang et al., 2020). Firms engaging in waste recovery initiatives are often viewed favorably by the public, which positively impacts their social image and corporate social responsibility efforts. A more detailed look at how waste recovery affects specific social dimensions, such as local employment and health outcomes, could provide further insight into the social benefits of these practices.

The financial readiness ($\beta = 0.459$, $t = 3.755$, $p = 0.000$) and investment preparedness ($\beta = 0.302$, $t = 2.388$, $p = 0.017$) observed for firms engaging in upcycling imply that these activities enhance a firm's financial stability. By creating new revenue streams and reducing waste processing costs, upcycling strengthens cash flow, making firms more resilient to economic fluctuations (Khan and Haleem, 2020; Bag et al., 2019). Moreover, Govindan and Hasanagic (2018) argue that upcycling aligns with investors' expectations for sustainable practices, enhancing firm appeal. In addition, waste recovery's positive effect on financial readiness ($\beta = 0.272$, $t = 2.212$, $p = 0.027$) and investment preparedness ($\beta = 0.456$, $t = 3.624$, $p = 0.000$) suggests that these practices not only reduce costs but also make firms more attractive to investors (Granz et al., 2020; Capizzi et al., 2022). Firms that demonstrate efficiency in resource use and recovery are likely to be perceived as lower-risk investments, enhancing their market competitiveness.

The study limitations emanated from factors beyond the control of the researcher. This research employed a self-administered questionnaire and the tendency that an owner/manager may not have answered the questionnaire herself cannot be controlled by the researcher. The study relied on self-report questionnaires. In this case, there's the risk of response bias due to participants' subjective interpretation or the unwillingness to provide accurate information. Despite the quality control measures and validation of the instrument, there still may be inherent limitations in the accuracy and reliability of the data collected.

Conclusion

This study focused on assessing the effects of CE practices, specifically upcycling and waste recovery, on the integrated waste management sector in Ghana, utilizing stakeholder theory as a conceptual framework. The findings reveal that upcycling positively impacts economic, social, and governance performance among waste management firms, although its effect on environmental performance is minimal. The structural equation modeling (SEM) and partial correlation analyses confirmed that upcycling has an insignificant relationship with environmental metrics, possibly due to limitations in reducing pollution, lowering water consumption, and minimizing energy use. Conversely, waste recovery significantly enhances performance across economic, environmental, social, and governance parameters, suggesting that effective waste recovery practices allow companies to operate sustainably, attract environmentally conscious clients, and optimize efficiency to reduce operational costs.

Furthermore, the study emphasizes the value of CE practices in enhancing governance quality by fostering adherence to environmental policies and regulatory standards. As firms engage in remanufacturing, recycling, and refurbishment, they gain operational efficiencies, attract clients supportive of eco-friendly practices, and demonstrate compliance with governance standards. These findings underscore the strategic importance of CE activities in bolstering social, economic, and governance performance within the waste management sector. Notably, the minimal environmental impact observed from upcycling suggests a gap in CE practices' effectiveness in achieving robust environmental outcomes, possibly due to insufficient reductions in energy use, pollution, and water consumption. Therefore, it is recommended that firms in this sector set targeted environmental goals and prioritize strategies to enhance their environmental performance.

The study also explored the implications of CE practices on financial and investment readiness. The findings indicate that CE initiatives significantly improve waste management firms' financial stability and preparedness for investment, equipping them to mitigate financial risks associated with CE adoption. These companies exhibit the ability to evaluate liquidity needs, secure funding, and allocate assets efficiently, reflecting a strong financial foundation for CE investments. Additionally, such firms attract investors who value sustainability, as demonstrated by their robust financial and governance practices, including having skilled management and a well-qualified board. Companies interested in adopting CE practices should thoroughly assess their financial and investment capabilities to ensure they can support and sustain these activities, thereby enhancing their attractiveness to potential investors.

For future research, several directions could provide a deeper understanding of CE practices' impacts in this industry. First, longitudinal studies could track how CE activities influence environmental outcomes over time, especially focusing on energy savings, pollution reduction, and resource conservation. Such studies may uncover delayed environmental benefits that were not immediately observable in the present study. Second, future research could investigate specific governance mechanisms, such as board oversight and ESG (Environmental, Social, Governance) reporting frameworks, to determine how these practices directly reinforce governance outcomes in CE-focused firms. Additionally, exploring the role of policy interventions, such as incentives for waste segregation and recycling, could clarify how supportive regulations may amplify CE practices' environmental impact. Lastly, comparative studies across regions or countries could provide insights into how different regulatory and economic environments affect the effectiveness of CE practices, allowing for a broader understanding of the global applicability of these findings. The use of a qualitative study to gather perspectives from significant stakeholders in waste management firms is advised to improve the study's results. The author suggested conducting additional research on industries like finance and investing to obtain a range of viewpoints. Studies could be conducted on how a company's non-financial environment influences the finance and investment opportunities available for the circular economy. As a result, it is advised that more research be done on Ghana's waste management industries' viability. Research might also be done on how to manage home waste in a way that promotes a circular economy. A simple cluster analysis should be recommended to consider specific themes in the integrated waste management sector can be carried out.

It is advised that waste management firms develop a solid alliance with financial institutions and green funding organizations in addition to formalizing corporate processes. The partnership may indicate that each sector will rely on the others to advance its operations in terms of monetary assistance, product patronage, etc.

Collectively, these industries could persuade decision-makers, including the government, to adopt beneficial policies that entice foreign investors. Incentives like tax breaks or subsidized taxes could also be provided by policymakers to investors and waste management owners who adopt sustainable development or CE practices. This study contributed to improving the understanding of waste management companies on CE financing and its determinants, which contributed to the corpus of knowledge. The paper goes into detail on how these companies' financial environments impact their CE efforts. The findings of this investigation serve as a guide for creating policy and implementing rules for CE practices in the integrated waste management industry.

Creating a supportive financial environment to support the conduct of CE activities is the important issue that demands policy intervention. Therefore, waste management firms are encouraged to collaborate with the municipal assemblies and other stakeholders to improve upon waste collection facilities. This collaboration could also help to encourage proper waste disposal among waste generators.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Human Research Ethics Committee (Non-Medical), University of the Witwatersrand, Johannesburg. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

DA: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. GA: Methodology, Validation, Writing – review & editing, Formal analysis. DO: Formal analysis, Methodology, Validation, Writing – review & editing. OL: Data curation, Formal analysis, Methodology, Writing – review & editing, Writing – original draft. SF: Methodology, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The 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.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsus.2024.1455335/full#supplementary-material

References

Adanu, S. K., Gbedemah, S. F., and Attah, M. K. (2020). Challenges of adopting sustainable technologies in e-waste management at Agbogbloshie, Ghana. *Heliyon* 6:e04548. doi: 10.1016/j.heliyon.2020.e04548

Agyapong, D. (2020). *Transition to circular economy: A strategic support for small and medium Enterprises in the Waste of American task force (NATF) of the United Nations environment program finance initiative*.

Ashrafi, M., Walker, T. R., Magnan, G. M., Adams, M., and Acciaro, M. (2020). A review of corporate sustainability drivers in maritime ports: a multi-stakeholder perspective. *Marit. Policy Manag.* 47, 1027–1044. doi: 10.1080/03088839.2020.1736354

Atan, R., Alam, M. M., Said, J., and Zamri, M. (2018). The impacts of environmental, social, and governance factors on firm performance. *Manage. Environ. Qual.* 29, 182–194. doi: 10.1108/MEQ-03-2017-0033

Awasthi, A. K., Li, J., Koh, L., and Ogunseitan, O. A. (2019). Circular economy and electronic waste. *Nat. Electr.* 2, 86–89. doi: 10.1038/s41928-019-0225-2

Ayeleru, O. O., Dlova, S., Akinribide, O. J., Ntuli, F., Kupolati, W. K., Marina, P. F., et al. (2020). Challenges of plastic waste generation and management in sub-Saharan Africa: a review. *Waste Manag.* 110, 24–42. doi: 10.1016/j.wasman.2020.04.017

Bag, S., Gupta, S., and Foropon, C. (2019). Examining the role of dynamic remanufacturing capability on supply chain resilience in circular economy. *Manag. Decis.* 57, 863–885. doi: 10.1108/MD-07-2018-0724

Barney, J. (1991). Firm resources and sustained competitive advantage. *J. Manag.* 17, 99–120. doi: 10.1177/014920639101700108

Barros, M. V., Salvador, R., do, G., de, A., and Piekarski, C. (2021). Circular economy as a driver to sustainable businesses. *Clean. Environ. Syst.* 2:100006. doi: 10.1016/j.cesys.2020.100006

Batista, M., Caiado, R. G. G., Quelhas, O. L. G., Lima, G. B. A., Leal Filho, W., and Yparraguirre, I. T. R. (2021). A framework for sustainable and integrated municipal solid waste management: barriers and critical factors to developing countries. *J. Clean. Prod.* 312:127516. doi: 10.1016/j.jclepro.2021.127516

Becker, J. M., Cheah, J. H., Gholamzade, R., Ringle, C. M., and Sarstedt, M. (2023). PLS-SEM's most wanted guidance. *Int. J. Contemp. Hosp. Manag.* 35, 321–346. doi: 10.1108/IJCHM-04-2022-0474

Berndt, A. E. (2020). Sampling methods. *J. Hum. Lact.* 36, 224–226. doi: 10.1177/0890334420906850

Bimpong, F. A. K., Asibey, M. O., and Inkoom, D. K. B. (2023). Ghana's recently introduced e-waste regulatory policy: a hope for a better e-waste sector? *Waste Manag. Res.* 42, 1031–1041. doi: 10.1177/0734242X231204457

Borah, S. J., and Kumar, V. (2024). "Fundamental principles of waste management for a sustainable circular economy" in Integrated waste management: A sustainable approach from waste to wealth. eds. A. Gupta, R. Kumar and V. Kumar (Singapore: Springer Nature Singapore), 1–11.

Bressanelli, G., Perona, M., and Saccani, N. (2018). Exploring how usage-focused business models enable circular economy through digital technologies. *Sustain. For.* 10:639. doi: 10.3390/su10030639

Brunner, R. D. (2005). Adaptive governance: Integrating science, policy, and decision making. New York: Columbia University Press.

Cadman, T. (2011). Evaluating the governance of responsible investment institutions: an environmental and social perspective. *J. Sustain. Finance Invest.* 1, 20–29. doi: 10.3763/jsfi.2010.0004

Capizzi, V., Croce, A., and Tenca, F. (2022). Do business angels' investments make it easier to raise follow-on venture capital financing? An analysis of the relevance of business angels' investment practices. *Br. J. Manag.* 33, 306–326. doi: 10.1111/1467-8551.12526

Cohen, J. (2013). Statistical power analysis for the behavioral sciences. Abingdon: Routledge.

Costantini, V., Crespi, F., Martini, C., and Pennacchio, L. (2015). Demandpull and technology-push public support for eco-innovation: the case of the biofuels sector. *Res. Policy* 44, 577–595. doi: 10.1016/j.respol.2014.12.011

Daddi, T., Ceglia, D., Bianchi, G., and de Barcellos, M. D. (2019). Paradoxical tensions and corporate sustainability: a focus on circular economy business cases. *Corp. Soc. Responsib. Environ. Manag.* 26, 770–780. doi: 10.1002/csr.1719

Daddi, T., and Iraldo, F. (2018). The effectiveness of waste management policies in the EU: a cross-country comparison. *J. Environ. Plan. Manag.* 61, 1041–1060.

Dalal, K. K., and Thaker, N. (2019). ESG and corporate financial performance: a panel study of Indian companies. *IUP J. Corporate Gov.* 18, 44–59.

De Angelis, R., Howard, M., and Miemczyk, J. (2018). Supply chain management and the circular economy: towards the circular supply chain. *Prod. Plan. Control* 29, 425–437. doi: 10.1080/09537287.2018.1449244

Di Cerbo, L. F., and Taylor, S. (2021). Graph theoretical representations of equity indices and their centrality measures. *Quant. Financ.* 21, 523–537. doi: 10.1080/14697688.2020.1822539

Dubey, R., Gunasekaran, A., Childe, S. J., Papadopoulos, T., Luo, Z., Wamba, S. F., et al. (2019). Can big data and predictive analytics improve social and environmental sustainability? *Technol. Forecast. Soc. Chang.* 144, 534–545. doi: 10.1016/j.techfore.2017.06.020

Elkington, J. (1998). Partnerships from cannibals with forks: the triple bottom line of 21st-century business. *Environ. Qual. Manag.* 8, 37–51. doi: 10.1002/tqem.3310080106

Epskamp, S. (2016). *Brief report on estimating regularized gaussian networks from continuous and ordinal data*. arXiv.

Epskamp, S., Cramer, A. O., Waldorp, L. J., Schmittmann, V. D., and Borsboom, D. (2012). Qgraph: network visualizations of relationships in psychometric data. *J. Stat. Softw.* 48, 1–18. doi: 10.18637/jss.v048.i04

Epskamp, S., Waldorp, L. J., Mõttus, R., and Borsboom, D. (2018). The Gaussian graphical model in cross-sectional and time-series data. *Multivar. Behav. Res.* 53, 453–480. doi: 10.1080/00273171.2018.1454823

Etikan, I., and Bala, K. (2017). Developing questionnaire base on selection and designing. *Biometr. Biostat. Int. J.* 5, 1–3. doi: 10.15406/bbij.2017.05.00150

FAO (2010). Report on technical workshop- biodiversity in sustainable diets. Rome: FAO.

Favi, C., Germani, M., Mandolini, M., and Marconi, M. (2016). PLANTLCA: a lifecycle approach to map and characterize resource consumptions and environmental impacts of manufacturing plants. *Proc. CIRP* 48, 146–151. doi: 10.1016/j.procir.2016.03.102

Fornell, C., and Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *J. Mark. Res.* 18, 39–50. doi: 10.1177/002224378101800104

Frimpong, S. E., Agyapong, G., and Agyapong, D. (2022). Financial literacy, access to digital finance and performance of SMEs: evidence from central region of Ghana. *Cogent Econ. Finance* 10:2121356. doi: 10.1080/23322039.2022.2121356

Gbadamassi, M., Adéchian, S. A., Baco, M. N., and Tossou, R. C. (2020). Waste Management in Cosmopolitan West African Cities: towards the need for environmental education of populations. *Asian J. Educ. Soc. Stud.* 1, 17–25. doi: 10.9734/ajess/2020/v7i130188

Genovese, A., Acquaye, A. A., Figueroa, A., and Koh, S. L. (2017). Sustainable supply chain management and the transition towards a circular economy: evidence and some applications. *Omega* 66, 344–357. doi: 10.1016/j.omega.2015.05.015

Gold, A. H., Malhotra, A., and Segars, A. H. (2001). Knowledge management: an organizational capabilities perspective. *J. Manag. Inf. Syst.* 18, 185–214. doi: 10.1080/07421222.2001.11045669

Govindan, K., and Hasanagic, M. (2018). A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective. *Int. J. Prod. Res.* 56, 278–311. doi: 10.1080/00207543.2017.1402141

Grant, R. M. (1991). The resource-based theory of competitive advantage: implications for strategy formulation. *Calif. Manag. Rev.* 33, 114–135. doi: 10.2307/41166664

Grant, R., Oteng-Ababio, M., and Sivilien, J. (2019). Greater Accra's new urban extension at Ningo-Prampram: urban promise or urban peril? *Int. Plan. Stud.* 24, 325–340. doi: 10.1080/13563475.2019.1664896

Granz, C., Henn, M., and Lutz, E. (2020). *Research on venture capitalists' and business angels' investment criteria: a systematic literature review*. Contemporary Developments in Entrepreneurial Finance: An Academic and Policy Lens on the Status-Quo, Challenges and Trends, pp. 105–136.

Gyeduaah, C. (2020). *Examining solid waste management practices in food service sector of Ghana*. A case study of Sunyani municipality (Doctoral Dissertation).

Hachigan, H., and McGill, S. M. (2012). Reframing the governance challenge for sustainable investment. *J. Sustain. Financ. Invest.* 2, 166–178.

Hair, J. F., Hult, G. T. M., Ringle, C. M., and Sarstedt, M. (2017). A primer on partial least squares structural equation Modeling (PLS-SEM). *2nd* Edn. Melbourne: Sage Publications.

Hair, J. F., Ringle, C. M., and Sarstedt, M. (2011). PLS-SEM: indeed a silver bullet. *J. Mark. Theory Pract.* 19, 139–152. doi: 10.2753/MTP1069-6679190202

Hair, J. F., Risher, J. J., Sarstedt, M., and Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *Eur. Bus. Rev.* 31, 2–24. doi: 10.1108/EBR-11-2018-0203

Hair, J. F., Sarstedt, M., Ringle, C. M., and Gudergan, S. P. (2018). Advanced issues in partial least squares structural equations Modeling (PLSSEM). Thousand Oaks, CA: Sage.

Hart, O. (1995). Corporate governance: some theory and implications. *Econ. J.* 105, 678–689. doi: 10.2307/2235027

Hartley, K., van Santen, R., and Kirchherr, J. (2020). Policies for transitioning towards a circular economy: expectations from the European Union (EU). *Resour. Conserv. Recycl.* 155:104634. doi: 10.1016/j.resconrec.2019.104634

Henseler, J., Dijkstra, T. K., Sarstedt, M., Ringle, C. M., Diamantopoulos, A., Straub, D. W., et al. (2014). Common beliefs and reality about PLS: comments on Rönkkö and Evermann (2013). *Organ. Res. Methods* 17, 182–209. doi: 10.1177/1094428114526928

Horodytska, O., Kiritsis, D., and Fullana, A. (2020). Upcycling of printed plastic films: LCA analysis and effects on the circular economy. *J. Clean. Prod.* 268:122138. doi: 10.1016/j.jclepro.2020.122138

Hulland, J. (1999). Use of partial least squares (PLS) in strategic management research: a review of four recent studies. *Strateg. Manag. J.* 20, 195–204. doi: 10.1002/(SICI)1097-0266(199902)20:2<195::AID-SMJ13>3.0.CO;2-7

Jørgensen, S., and Pedersen, L. J. T. (2018). RESTART sustainable business model innovation. Berlin: Springer Nature, 253.

Kantabutra, S., and Ketprapakorn, N. (2020). Toward a theory of corporate sustainability: a theoretical integration and exploration. *J. Clean. Prod.* 270:122292. doi: 10.1016/j.jclepro.2020.122292

Kaplan, D. (2009). Structural equation Modeling: Foundations and extensions. *2nd* Edn. London: Sage Publication.

Kapur, M. (2016). Examining productive failure, productive success, unproductive failure, and unproductive success in learning. *Educ. Psychol.* 51, 289–299. doi: 10.1080/00461520.2016.1155457

Kassah, S. (2020). *A study of factors influencing development of unofficial waste disposal sites in developing countries: A case study of Minna, Nigeria* (Doctoral Dissertation, University of Central Lancashire).

Khan, S., and Haleem, A. (2020). Assessing sustainability in manufacturing processes: an approach to green economy. *J. Clean. Prod.* 249:119176. doi: 10.3389/frsus.2022.837016

Khan, M., Serafeim, G., and Yoon, A. (2016). Corporate sustainability: first evidence on materiality. *Account. Rev.* 91, 1697–1724. doi: 10.2308/accr-51383

Kline, R. B. (2011). "Convergence of structural equation modeling and multilevel modeling" in The SAGE handbook of innovation in social research methods (Thousand Oaks, CA: SAGE Publication), 562–589.

Kotrlik, J. W., and Higgins, C. C. H. (2001). Organizational research: determining appropriate sample size in survey research appropriate sample size in survey research. *Inf. Technol. Learn. Perform. J.* 19:43.

Lacy, P., and Rutqvist, J. (2015). Waste to wealth: The circular economy advantage, vol. *91*. London: Palgrave Macmillan.

Liao, G., and Yao, W. (2022). Upcycling of waste concrete powder into a functionalized host for nano-TiO_2 photocatalyst: binding mechanism and enhanced photocatalytic efficiency. *J. Clean. Prod.* 366:132918. doi: 10.1016/j.jclepro.2022.132918

Lieder, M., and Rashid, A. (2016). Towards circular economy implementation: a comprehensive review in context of manufacturing industry. *J. Clean. Prod.* 115, 36–51. doi: 10.1016/j.jclepro.2015.12.042

Lissah, S. Y., Ayanore, M. A., Krugu, J. K., Aberese-Ako, M., and Ruiter, R. A. (2021). Managing urban solid waste in Ghana: perspectives and experiences of municipal waste company managers and supervisors in an urban municipality. *PLoS One* 16:e0248392. doi: 10.1371/journal.pone.0248392

Lo, M. C., Wang, Y. C., Wah, C. R. J., and Ramayah, T. (2016). The critical success factors for organizational performance of SMEs in Malaysia: a partial least squares approach. *Rev. Bras. Gestão Negócios* 18, 370–391.

Lobova, S. V., and Tyryshkin, V. V. (2021). *Is it possible to change to a circular economy based on waste recycling? An overview of the situation, opportunities, and barriers for the Altai Krai*. In: IOP conference series: Earth and environmental science, no. 670. IOP Publishing, p. 12060.

Loukil, F., and Rouached, L. (2020). Waste collection criticality index in African cities. *Waste Manag.* 103, 187–197. doi: 10.1016/j.wasman.2019.12.027

Luthra, S., and Mangla, S. K. (2018). When strategies matter: adoption of sustainable supply chain management practices in an emerging economy's context. *Resour. Conserv. Recycl.* 138, 194–206. doi: 10.1016/j.resconrec.2018.07.005

MacArthur, E. (2017). Beyond plastic waste. *Science* 358:843. doi: 10.1126/science.aao6749

Mahabir, J., Koylass, N., Samaroo, N., Narine, K., and Ward, K. (2021). Towards resource circular biodiesel production through glycerol upcycling. *Energy Convers. Manag.* 233:113930. doi: 10.1016/j.enconman.2021.113930

Maqbool, A., Khan, S., Haleem, A., and Khan, M. I. (2020). "Investigation of drivers towards adoption of circular economy: a DEMATEL approach" in Recent advances in mechanical engineering: Select proceedings of NCAME 2019. ed. A. Maqbool (Singapore: Springer), 147–160.

Mason, C., and Kwok, J. (2010). Investment readiness programmes and access to finance: a critical review of design issues. *Local Econ.* 25, 269–292. doi: 10.1080/02690942.2010.504570

Mateos-Aparicio, G. (2011). Partial least squares (PLS) methods: origins, evolution, and application to social sciences. *Commun. Stat. Theory Methods* 40, 2305–2317. doi: 10.1080/03610921003778225

Melton, A. (2017). *The importance of financial disaster preparedness*. Available at: http://www.rmmagazine.com/2017/05/01/the-importance-offinancial-disaster-preparedness/ (Accessed July, 2020).

Mensah, I., and Ampofo, E. T. (2021). Effects of managers' environmental attitudes on waste management practices in small hotels in Accra. *Int. Hosp. Rev.* 35, 109–126. doi: 10.1108/IHR-08-2020-0032

Ministry of Sanitation and Water Resources (2020). National solid waste management strategy for Ghana. Ghana: Republic of Ghana.

Mora-Contreras, R., Torres-Guevara, L. E., Mejia-Villa, A., Ormazabal, M., and Prieto-Sandoval, V. (2023). Unraveling the effect of circular economy practices on companies' sustainability performance: evidence from a literature review. *Sustain. Prod. Consum.* 35, 95–115. doi: 10.1016/j.spc.2022.10.022

Muthuraman, L., and Ramaswamy, S. (2019). *Solid waste management*. MJP Publisher.

Noor, S., Tajik, O., and Golzar, J. (2022). Simple random sampling. *Int. J. Educ. Lang. Stud.* 1, 78–82.

Nott, D. (2020). The COVID-19 response for vulnerable people in places affected by conflict and humanitarian crises. *Lancet* 395, 1532–1533. doi: 10.1016/S0140-6736(20)31036-9

Nyamekye, A. B. (2020). *Towards a new generation of climate information systems: Information systems and actionable knowledge creation for adaptive decision-making in rice farming systems in Ghana*. (Doctoral dissertation, Wageningen University and Research).

OECD (2019). Social impact investment: The impact imperative for sustainable development. Paris: OECD Publishing.

Ofori, D., Appiah-Nimo, C., Dapilah, J. N., and Agyekumhene, A. (2021). A tri-party approach towards sustainable plastic waste management: a developing economy perspective. *Respons. Manage. Emerg. Markets* 273–296. doi: 10.1007/978-3-030-76563-7_11

Ofori, D., and Opoku Mensah, A. (2021). Sustainable electronic waste management among households: a circular economy perspective from a developing economy. *Manage. Environ. Qual.* 33, 64–85. doi: 10.1108/MEQ-04-2021-0089

Oliveira, M. L., Neckel, A., Pinto, D., Maculan, L. S., Zanchett, M. R. D., and Silva, L. F. (2021). Air pollutants and their degradation of a historic building in the largest metropolitan area in Latin America. *Chemosphere* 277:130286. doi: 10.1016/j.chemosphere.2021.130286

Onyali, C. I. (2014). Triple bottom line accounting and sustainable corporate performance. *Res. J. Finance Account.* 5, 195–209.

Phonthanukitithaworn, C., Srisathan, W. A., and Naruetharadhol, P. (2024). Revolutionizing waste management: harnessing citizen-driven innovators through open innovation to enhance the 5Rs of circular economy. *J. Open Innov.: Technol. Mark. Complex.* 10:100342. doi: 10.1016/j.joitmc.2024.100342

Purwanto, E., and Prasetio, T. (2021). *Changing the paradigm of a linear economy into a circular economy in residential waste*, IOP Conference Series: Earth and Environmental Science, No. 945. p. 12054.

Qiu, R., Lin, M., Ruan, J., Fu, Y., Hu, J., Deng, M., et al. (2020). Recovering full metallic resources from waste printed circuit boards: a refined review. *J. Clean. Prod.* 244:118690. doi: 10.1016/j.jclepro.2019.118690

Raimonda, R., et al. (2020). Social impacts of circular economy and waste management. *Soc. Impact Rev.* 2, 45–58.

Sarfo-Mensah, P., Obeng-Okrah, K., Arhin, A. A., Amaning, T. K., and Oblitei, R. T. (2019). Solid waste management in urban communities in Ghana: a case study of the Kumasi metropolis. *Afr. J. Environ. Sci. Technol.* 13, 342–353. doi: 10.5897/AJEST2019.2713

Scarpellini, S., Marín-Vinuesa, L. M., Aranda-Usón, A., and PortilloTarragona, P. (2020). Dynamic capabilities and environmental accounting for the circular economy in businesses. *Sustain. Account. Manage. Policy J.* 11, 1129–1158. doi: 10.1108/SAMPJ-04-2019-0150

Schall, J. (1992). Does the solid waste management hierarchy make sense? A technical, economic and environmental justification for the priority of source reduction and recycling. School of Forestry and Environmental Studies. New Haven: Yale University.

Schoenmaker, D. (2019). A framework for sustainable finance. Rotterdam School of Management. Rotterdam: Erasmus University, CEPR.

Schwartz, J., and Popovich, N. (2019). It's official: 2018 was the fourth warmest year on record, vol. *6*. New York: New York Times.

Shahbazi, S., Wiktorsson, M., Kurdve, M., Jönsson, C., and Bjelkemyr, M. (2016). Material efficiency in manufacturing: Swedish evidence on potential, barriers and strategies. *J. Clean. Prod.* 127, 438–450. doi: 10.1016/j.jclepro.2016.03.143

Shahrashoub, M., and Bakhtiari, S. (2021). The efficiency of activated carbon/magnetite nanoparticles composites in copper removal: industrial waste recovery, green synthesis, characterization, and adsorption-desorption studies. *Microporous Mesoporous Mater.* 311:110692. doi: 10.1016/j.micromeso.2020.110692

Stahel, W. R. (2016). The circular economy. *Nature* 531, 435–438. doi: 10.1038/531435a

Stratton, S. J. (2021). Population research: convenience sampling strategies. *Prehosp. Disaster Med.* 36, 373–374. doi: 10.1017/S1049023X21000649

Terragni, L., Garnweidner, L. M., Pettersen, K. S., and Mosdøl, A. (2014). Migration as a turning point in food habits: the early phase of dietary acculturation among women from south Asian, African, and middle eastern countries living in Norway. *Ecol. Food Nutr.* 53, 273–291. doi: 10.1080/03670244.2013.817402

Thacker, S., Adshead, D., Fay, M., Hallegatte, S., Harvey, M., Meller, H., et al. (2019). Infrastructure for sustainable development. *Nat. Sustain.* 2, 324–331. doi: 10.1038/s41893-019-0256-8

UNEP FI and Mercer. (2007). *Demystifying responsible investment performance*. UNEP. Available at: http://www.unepfi.org/.

Van Borkulo, C. D., Borsboom, D., Epskamp, S., Blanken, T. F., Boschloo, L., Schoevers, R. A., et al. (2014). A new method for constructing networks from binary data. *Sci. Rep.* 4:5918. doi: 10.1038/srep05918

Vaughan, R. (2017). Oversampling in health surveys: why, when, and how? *Am. J. Public Health* 107, 1214–1215. doi: 10.2105/AJPH.2017.303895

Wang, R., Liao, C., He, H., Hu, C., Wei, Z., Hong, Z., et al. (2020). COVID-19 in hemodialysis patients: a report of 5 cases. *Am. J. Kidney Dis.* 76, 141–143. doi: 10.1053/j.ajkd.2020.03.009

Waygood, S. (2011). How do the capital markets undermine sustainable development? What can be done to correct this? *J. Sustain. Finance Invest.* 1, 81–87. doi: 10.3763/jsfi.2010.0008

Wced, S. W. S. (1987). World commission on environment and development. *Our Common Future* 17, 1–91.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strateg. Manag. J.* 5, 171–180. doi: 10.1002/smj.4250050207

Widyawati, L. (2020). A systematic literature review of socially responsible investment and environmental social governance metrics. *Bus. Strateg. Environ.* 29, 619–637. doi: 10.1002/bse.2393

Yang, M., Chen, L., Wang, J., Msigwa, G., Osman, A. I., Fawzy, S., et al. (2023). Circular economy strategies for combating climate change and other environmental issues. *Environ. Chem. Lett.* 21, 55–80. doi: 10.1007/s10311-022-01499-6

Yazdani, M., Gonzalez, E. D., and Chatterjee, P. (2021). A multi-criteria decision-making framework for agriculture supply chain risk management under a circular economy context. *Manage. Decis.* 59, 1801–1826. doi: 10.1108/MD-10-2018-1088