Construction Innovation

Strategies for sustainable financing of circular infrastructure projects – a systematic review

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Abstract

Purpose – The transition to circular infrastructure projects already encounters several barriers; however, access to funding has emerged as a critical barrier. Stakeholders within the infrastructure sector are seeking strategies to offset this financial challenge while maintaining financial performance. The purpose of this study is to explore sustainable financing strategies for circular infrastructure projects.

Design/methodology/approach – Using Scopus as the main search engine, 31 relevant studies were selected based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocol.

Findings – The study identified and grouped sustainable financial strategies based on the life cycle stages into access to funds, quality of financial resources, cost management practices, government financial support, technology and innovation and project organizational initiatives. The strategies were aligned with the 10R framework of circular economy and the United Nations Sustainable Development Goals. Subsequently, the study proposed a conceptual framework of sustainable financing strategies that could be adopted by relevant stakeholders to promote circular infrastructure projects.

Originality/value – The study underscores the significance of circularity in infrastructure projects, and by implementing the sustainable financing strategies presented, this study promotes sustainability in the infrastructure sector. The study provides a conceptual framework that serves as a guide to stakeholders on circular infrastructure projects, enabling them to attain greater financial performance.

Keywords Circular economy, Circular infrastructure projects, Sustainable financing strategies, Financial performance, Project life cycle, SDGs

Paper type Literature review

1. Introduction

The infrastructure industry has a crucial role to play in achieving the global objectives regarding decarbonization due to its dominant contribution to global greenhouse gas emissions (79%) and consumption of global materials (60%) (Rissman *et al.*, 2020). According to Fisch-Romito (2021), transitioning to decarbonization and sustainability

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demands alterations in the global infrastructure industry. In this regard, researchers and practitioners across the globe have directed attention to circular economy (CE) as a potential solution to the infrastructure sector's sustainability issues (Lei *et al.*, 2021; Merli *et al.*, 2018). CE holds the promise of addressing several long-term challenges of the global economy (MacArthur, 2015).

While the linear model depletes resources in the long term, pollutes and incurs losses of habitat and biodiversity, threatens ecosystems, and increases risks to human health and economic welfare (Xu and Zhao, 2023), the CE model, on the other hand, is focused on enhancing resource efficiency through the reuse, remanufacture and recycling of materials. CE model accomplishes this by reframing and reorganizing materials, information and recycling of materials (Ghisellini and Ulgiati, 2020; Martin *et al.*, 2023). In this regard, the Global Infrastructure Hub described circular infrastructure as any infrastructure that supports CE activities by limiting or eliminating the number of raw materials used across its life cycle, reducing the embodied carbon of infrastructure assets as a result and securing the supply of critical materials (Global Infrastructure Hub, 2021).

CE model has attracted a number of stakeholders in the construction industry. Key stakeholders in circular infrastructure include governments, who consider it vital to policy and environmental targets, and the private industry, who perceive opportunities in spite of the financial and logistical challenges involved. There is also academia, which focuses on researching innovative models and performance. Consumers/users are also increasingly demanding sustainable solutions in built environment. While governmental and academic perspectives often highlight the environmental and long-term systemic benefits, industry views are frequently shaped by economic viability and implementation complexities, while communities emphasize social equity and local impact (Osei-tutu *et al.*, 2024; Lampinen *et al.*, 2024; Bostanci *et al.*, 2025). These varied perspectives underscore the need for collaborative frameworks to reconcile differing priorities and accelerate the transition. Charef *et al.* (2021) asserted that obtaining the commitment of stakeholders to circularity is the most challenging task in circular construction.

Nonetheless, CE remains a key enabler in the integration of deconstruction and carbon finance that improves sustainability and resilient in the construction industry (Murali *et al.*, 2024). In their study, the authors uncovered nine enablers that enhanced the integration of deconstruction and carbon finance. However, CE approach with a closed-loop emerged as the most crucial enabler due to its significant influence on each of the other enablers such as strengthening stakeholder engagement and developing robust carbon accounting. CE approach to construction also offers a feasible mechanism through which corporate stakeholders can earn revenue within the carbon finance architecture (Wang *et al.*, 2025, 2025). This potential is realized by implementing circular strategies that produce measurable reductions in carbon emissions, enabling the generation and monetization of carbon credits (Zhaoi and Ma, 2025). Despite these potential benefits of circular infrastructure, it receives inadequate attention and investment (Global Infrastructure Hub, 2021; Kara *et al.*, 2022). This incidence is attributed to the financial barriers faced by key stakeholders in the transition from linearity to circularity, among which difficulty accessing financial resources is a major financial barrier (Fischer *et al.*, 2023; Yuan *et al.*, 2020). Financial risk is one of the prominent and most cited challenges to circular infrastructure (Wuni and Abankwa, 2023; Agyekum and Amudjie, 2024). This risk entails high upfront investment cost, uncertain investment returns, unclear market demands for circular construction projects, shortage of funds, higher cost of eco-friendly materials, high production and transaction cost, and split financial incentive (Meili and Stucki, 2023; Wuni and Abankwa, 2023).

Historically, it has become evident that access to finance can significantly facilitate human progress (Kara *et al.*, 2021; van Niekerk, 2024). Therefore, access to financial resources can facilitate the transition from linear to circular infrastructure (Nogueira *et al.*, 2020). However, research focusing on circular infrastructure projects is inadequate, especially regarding the financial strategies that can scale up the transition from linear infrastructure to circular infrastructure (Mignacca and Locatelli, 2021). Several studies including Akomea-Frimpong *et al.* (2021) and Shibani *et al.* (2022) have explored the financial risks and strategies for linear infrastructure; however, the results of these studies are not applicable to circular infrastructure projects. Therefore, transitioning to circular infrastructure demands the identification of sustainable financing strategies that can improve the financial performance of circular infrastructure projects through assessing investment opportunities and the identification and mitigation of CE risks (Buyle *et al.*, 2019; Sassanelli *et al.*, 2019).

Awan *et al.* (2022) opined that, although circular projects have social, environmental and financial benefits, studies exploring financial strategies for implementing circular infrastructure projects are still scarce. Among the few available, Saarinen and Aarikka-Stenroos (2023) studied the drivers of CE and its financial barriers, as well as revealing few limitations to their study. First, there is difficulty generalizing the factors identified because the data collected stemmed primarily from European countries. Meanwhile, different factors may be the case in other regional contexts. In addition, the study presented the identified factors as financial inhibitors to CE but failed to clarify how these inhibitors can be overcome.

Other studies investigating financial aspects of CE business include Scarpellini (2021), who investigated the available types of financial resources for renewable self-consumption investments, and Aranda-Usón *et al.* (2019), who examined the characteristics of financial resources companies invested in circular activities. Ghisetti and Montresor (2020) studied correlation between the financial decisions made by small- and medium-sized enterprises and if and how they applied CE practices. Despite these studies exploring some financial aspect of CE projects, they lacked a comprehensive understanding of the financing-related strategies that shape it. Therefore, it is critical to identify sustainable financing strategies that can be adopted by key players when implementing circular infrastructure projects.

The limitations of the aforementioned studies call for the need to identify sustainable financing strategies that are applicable to implementing circular infrastructure projects to both overcome the financial barrier and attain future sustainability. The study therefore aims to conduct a systematic review of financial strategies for sustainable financing of circular infrastructure projects. The following objectives will aid to achieve the aim of the study: (1) to examine the annual publication trend on sustainable financing strategies; (2) to identify the leading contributing countries to studies related to sustainable financing strategies; (3) to identify the research approach adopted by studies regarding sustainable financing strategies; (4) to identify and categorize the sustainable financing strategies; and (5) to propose a conceptual framework for sustainable financing strategies for circular infrastructure projects.

2. Research methodology

2.1 Research strategy

Systematic literature review (SLR) was adopted as the primary method for the purposes of identifying, categorizing and conceptualizing the sustainable financing strategies of circular infrastructure projects. SLR has attained international recognition, contributing significantly to research synthesis in the academic circles and among policymakers (Tandon *et al.*, 2020). SLR has been adopted in various disciplines such as international development, engineering,

environmental science and education (Singh *et al.*, 2023). SLR's strength lies in its thorough, clear, rigorous and resilient nature, which makes it easier to synthesize information, evaluate existing knowledge, generate novel perspectives, discover patterns and develop theories (Akomea-Frimpong *et al.*, 2024; Wadsworth *et al.*, 2022; Wuni, 2023). Furthermore, SLR helps to highlight methodological issues in research projects, which improves related future research. SLR was utilized in this research to identify the sustainable financing strategies that are relevant to circular infrastructure projects.

Studies addressing the sustainable financing strategies for circular infrastructure projects were identified in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) technique to safeguard the integrity and validity of findings (Moher *et al.*, 2015; Sarkis-Onofre *et al.*, 2021). The PRISMA protocol involved the formulation of a research question, the selection of keywords, the retrieval of articles from specific databases, an examination of their eligibility and the finalization of the study list for data analysis (Sarkis-Onofre *et al.*, 2021; Stevens *et al.*, 2018). Figure 1 depicts the procedures required in gathering and analysing data.

2.2 Data collection

To find pertinent papers for the study, the researchers created keywords related to sustainable financing strategies and the circular infrastructure project life cycle. The search codes that were adopted in Scopus are as follows.

TITLE-ABS-KEY ("financial resources" OR "sustainable finance strategies" OR "circular financial strategies" OR "green finance"" OR "financial techniques" AND "circular economy" OR "circular businesses" OR "circular infrastructure" OR "circular project").

The Scopus database was the main search engine used to identify the sustainable financing strategies. Given its high degree of improvement in literature indexation and management databases in construction engineering and management, Scopus has been utilized extensively by scholars in CE-related research (Eshun *et al.*, 2021; Wuni, 2022; Wuni and Shen, 2020). Searching only English articles, 85 materials were found from Scopus database and an additional six articles were obtained from the grey literature, totalling 91 documents found.

The title/abstract/keywords of these documents were thoroughly scrutinized, and 29 documents unrelated to sustainable financing strategies were removed. The full text of the remaining 62 papers was downloaded for additional review. The downloaded papers were screened using the predefined exclusion and inclusion criteria. The inclusion criteria comprised of the following: (1) articles addressing questions about sustainable financing strategies; (2) articles with easily accessible complete text; (3) articles authored in English; and (4) articles relevant to the keywords selected. The exclusion criteria include the following: (1) articles without full text and (2) articles written in any language other than English. Of the 62 documents detected, 31 (23 articles and 8 reports) were deemed to be eligible for metadata extraction. Table 1 shows the 31 selected articles for the research.

2.3 Data analysis

The selected articles were subjected to a content analysis to glean out the sustainable financing strategies, year of publication, methods adopted and journal in which each article was published. Content analysis enabled identification and systematic examination of themes and patterns, or the frequency of concepts or ideas within the literature selected (Kleinheksel *et al.*, 2020). The sustainable financing strategies identified were recorded on an excel sheet and grouped under six main categories.

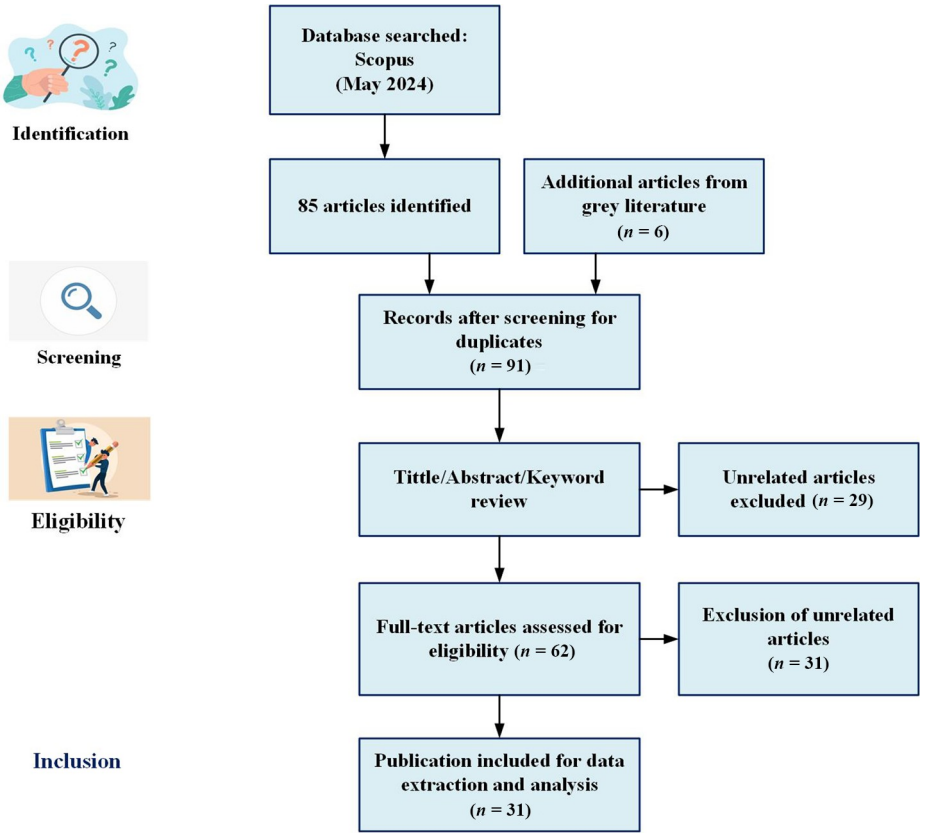

Figure 1. Flow diagram illustrating the literature sampling procedure
Source: Authors' own work

Each indicator identified was mapped with the frequency at which it was mentioned in the relevant articles. Further analysis was conducted to facilitate ranking of the indicators. Ranking is appropriate for ascertaining the most significant element within a data set (Schmid *et al.*, 2020), and in this study, ranking enabled the identification of the strategy with highest priority. First, each strategy within a category was assigned a weight, which was obtained by dividing the frequency of mentions of a strategy by the total frequency of mentions of the category it belongs. To ascertain the weight a strategy carries within the entire set of strategies, the frequency of mentions of that strategy was divided by the total frequency of mentions for all the strategies. This led to the ranking and prioritization of each strategy within the categories and the entire set of indicators. A high weight of a strategy depicts the high level of priority placed on that indicator. The formula used for calculating the weight is as follows:

$$W_i = \frac{\sum_{i=1}^{n} fi}{n}$$

Table 1. Details of the relevant articles

ID	Author full names	Title	Year	Source/journal
1	Scarpellini, Sabina; Marín-Vinuesa, Luz María; Portillo-Tarragona, Pilar; Moneva, José M.	Defining and measuring different dimensions of financial resources for business eco-innovation and the influence of the firms' capabilities	2018	*Journal of cleaner production*
2	Biancolin, Marta; Capoani, Luigi; Rotaris, Lucia	Reverse logistics and circular economy: a literature review	2023	*European transport*
3	Rapp, Lucien; Rhimbassen, Maria	Orbital debris mitigation: from vicious circles to circular economy	2022	*Proceedings of the international astronautical congress, IAC*
4	Werning, Jan Philipp; Spinler, Stefan	Transition to circular economy on firm level: barrier identification and prioritization along the value chain	2020	*Journal of cleaner production*
5	Meili, Rahel; Stucki, Tobias	Money matters: the role of money as a regional and corporate financial resource for circular economy transition at firm-level	2023	*Research policy*
6	Wang, Shanshan; Chen, Shih-Chih; Ali, Mohd Helmi; Tseng, Ming-Lang	Nexus of environmental, social, and governance performance in China-listed companies: disclosure and green bond issuance	2024	*Business strategy and the environment*
7	Qadri, Hussain Mohi Ud Din; Ali, Hassnian; Abideen, Zain Ul; Jafar, Ahmad	Mapping the evolution of green finance research and development in emerging green economies	2024	*Resources policy*
8	Kumar, Bhavesh; Kumar, Love; Kumar, Avinash; Kumari, Ramna; Tagar, Uroosa; Sassanelli, Claudio	Green finance in circular economy: a literature review	2023	*Environment, development and sustainability*
9	Agrawal, Rohit; Agrawal, Shruti; Samadhiya, Ashutosh; Kumar, Anil; Luthra, Sunil; Jain, Vranda	Adoption of green finance and green innovation for achieving circularity: an exploratory review and future directions	2023	*Geoscience frontiers*
10	Rizos, Vasileios; Behrens, Arno; Van Der Gaast, Wytze; Hofman, Erwin; Ioannou, Anastasia; Kafyeke, Terri; Flamos, Alexandros; Rinaldi, Roberto; Papadelis, Sotiris; Hirschnitz-Garbers, Martin; Topi, Corrado	Implementation of circular economy business models by small- and medium-sized enterprises (SMEs): barriers and enablers	2016	*Sustainability (Switzerland)*
11	Rao, Huacheng; Chen, Dongxu; Shen, Feichao; Shen, Yangyang	Can green bonds stimulate green innovation in enterprises? Evidence from China	2022	*Sustainability (Switzerland)*

(*continued*)

Table 1. Continued

ID	Author full names	Title	Year	Source/journal
12	Scarpellini, Sabina; Gimeno, José Ángel; Portillo-Tarragona, Pilar; Llera-Sastresa, Eva	Financial resources for the investments in renewable self-consumption in a circular economy framework	2021	*Sustainability (Switzerland)*
13	Xiaofei, Yan	Research on the action mechanism of circular economy development and green finance based on entropy method and big data	2022	*Journal of Enterprise Information Management*
14	Yaoteng, Zhao; Xin, Li	Research on green innovation countermeasures of supporting the circular economy to green finance under big data	2022	*Journal of Enterprise Information Management*
15	Van Niekerk, Arno J.	Economic inclusion: green finance and the SDGs	2024	*Sustainability (Switzerland)*
16	Kumar, Love; Nadeem, Farah; Sloan, Maggie; Restle-Steinert, Jonas; Deitch, Matthew J.; Ali Naqvi, Sohail; Kumar, Avinash; Sassanelli, Claudio	Fostering green finance for sustainable development: a focus on textile and leather small medium enterprises in Pakistan	2022	*Sustainability (Switzerland)*
17	Aranda-Usón, Alfonso; Portillo-Tarragona, Pilar; Marín-Vinuesa, Luz María; Scarpellini, Sabina	Financial resources for the circular economy: a perspective from businesses	2019	*Sustainability (Switzerland)*
18	Derhab, Neama; Elkhwesky, Zakaria	A systematic and critical review of waste management in micro, small- and medium-sized enterprises: future directions for theory and practice	2023	*Environmental Science and Pollution Research*
19	Albert, Martin	Sustainable frugal innovation - The connection between frugal innovation and sustainability	2019	*Journal of Cleaner Production*
20	AK Inwale, Yusuf Opeyemi	Awareness and adoption of circular economy in the consumption and production value-chain among MSMEs towards sustainable development	2023	*African Journal of Science, Technology, Innovation and Development*
21	Ezeudu, Obiora B.; Oraelosi, Tochukwu C.; Agunwamba, Jonah C.; Ugochukwu, Uzochukwu C.	Co-production in solid waste management: analyses of emerging cases and implications for circular economy in Nigeria	2021	*Environmental Science and Pollution Research*
22	Huda, S.S.M. Sadrul	Increasing green footprints: Indications of transformations in the socio-economic spaces of Bangladesh	2024	*Engineering Reports*

(*continued*)

Table 1. Continued

ID	Author full names	Title	Year	Source/journal
23	Kadhila, Timoteus; De Wit, Martin P.; Schenck, Rinie	A conceptual framework for sustainable waste management in small municipalities: the cases of Langebaan, South Africa and Swakopmund, Namibia	2023	*Environmental Science and Pollution Research*
24	Jiang, Chun; Qiu, Yihan	Dynamic relationship between green finance, environmental taxes, and CO_2 emissions in transition toward circular economy: what causes what?	2023	*Environmental Science and Pollution Research*
25	De la Cuesta-González, Marta; Morales-García, Manuel	Does finance as usual work for circular economy transition? A financiers and SMEs qualitative approach	2022	*Journal of Environmental Planning and Management*
26	PricewaterhouseCoopers; Global infrastructure Hub	Funding and financing infrastructure for a net zero future	2021	*Report*
27	United Nations Environment Programme-Finance Initiative	Principles for responsible banking	2019	*Report*
28	United Nations Environment Programme-Finance Initiative	Financing circularity: Demystifying finance for the circular economy	2020	*Report*
29	Ellen MacArthur Foundation	Financing the circular economy	2019	*Report*
30	Organization for Economic Cooperation and Development,	Financing the circular economy transition	2019	*Report*
31	Schroder, Patrick; Lawlor, Ellis	How to finance the transition to a circular economy	2021	*Report*

Source(s): Authors' own work

where *f* denotes the total number of occurrences of each strategy and *n* represents the total number of occurrences for all the strategies within a category when identifying the weight an indicator carries within its category. However, *n* also represents the total number of occurrences for all the strategies when assessing the weight an indicator carries within the entire set of strategies.

3. Results and discussion

3.1 Annual publication trend

Figure 2 represents the undulating annual publication trend of the 31 eligible documents used for the study. The documents were published between 2016 and 2024 with an average publication of 3.87 annually. This is an indication that the area of research is still emerging and needs to be explored. The publication of documents related to sustainable financing strategies of circular infrastructure projects began in 2016 with no publication in 2017 until 2018 when one article was published. In 2019, the number of publications shot up to five and declined in 2020. The publications began to incline in 2021 and peaked again in 2023 with eight articles. The results obtained show that researcher's interest in identifying sustainable

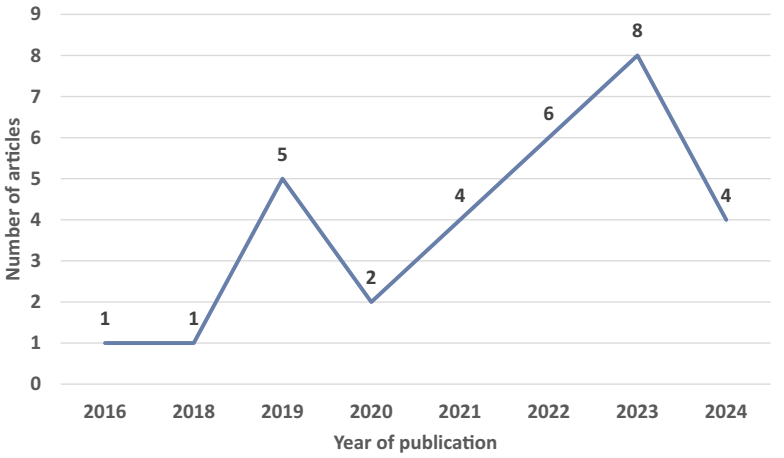

Figure 2. Yearly publication of included studies
Source: Authors' own work

financial strategies for implementing circular infrastructure projects is increasing in recent years. The trend could also be an indication that funding is being provided to support research in the said area.

3.2 Methodologies of included studies

The methodologies adopted for the eligible studies have been presented in Figure 3. A total of five methodologies including quantitative, qualitative literature reviews, reports, case

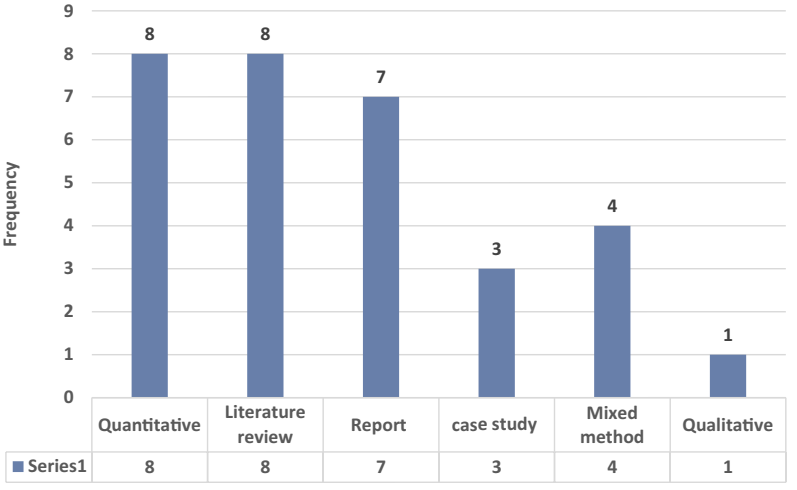

Figure 3. Research methodologies of included studies
Source: Authors' own work

studies and mixed method were adopted. The quantitaive and literature reviews were the most often adopted methodologies, employed in eight documents each. This is followed by the mixed method, employed in four documents, and case study and qualitative methods were used in three articles and one article, respectively. This result, therefore, calls for researchers to consider the less used methodologies, which may yield new insights.

3.3 Journal distribution of included studies

The 31 eligible articles used for the study were published in 15 multidisciplinary journals. As shown in Figure 4, about 50% of the articles were published in three journals, namely *Sustainability (Switzerland)*, *Environmental Science and Pollution Research* and reports. This is an indication of how productive these journals are, making them favourable choices for submission of manuscripts in circular infrastructure projects and its financial aspects. Also, the multidisciplinary nature of sustainable financing strategies is reflected in the different journals that has published these eligible documents.

3.4 Country of focus for relevant studies

This section discusses the countries in which studies related to sustainable financing strategies was conducted based on the 31 eligible documents. Figure 5 shows that 13 of the documents were conducted internationally. This may be attributed to the attention CE has garnered on the global front as a viable strategy to address challenges such a climate change, biodiversity loss and material extraction (Mhatre *et al.*, 2021). Apart from international studies, Spain and China contributed more to research on sustainable financing strategies. The Spanish government has been making efforts to address CE challenges. In June 2020, the Spanish government published "Espana Circular 2030," which outlines the new Strategy for Circular Economy in Spain until 2030 (Alonso *et al.*, 2022). China is also investing

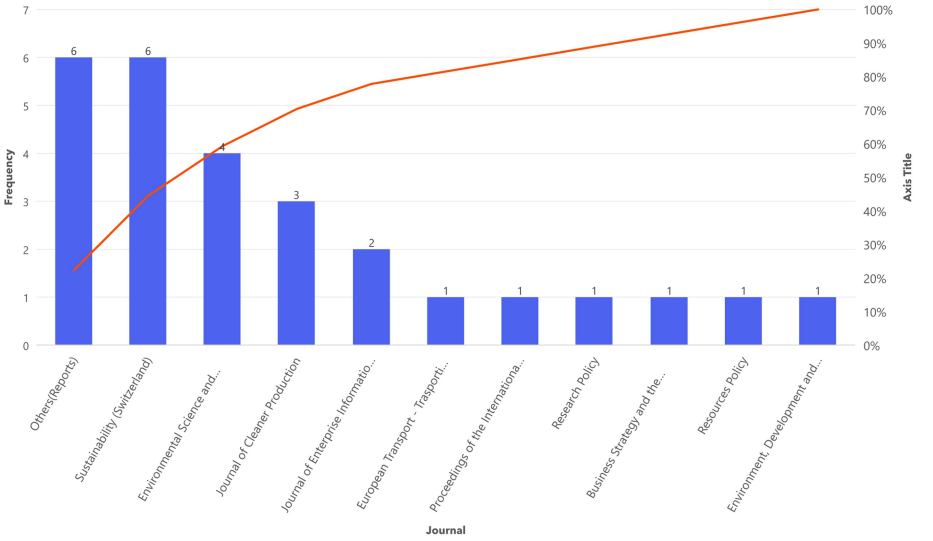

Figure 4. Pareto chart of journals of relevant articles
Source: Authors' own work

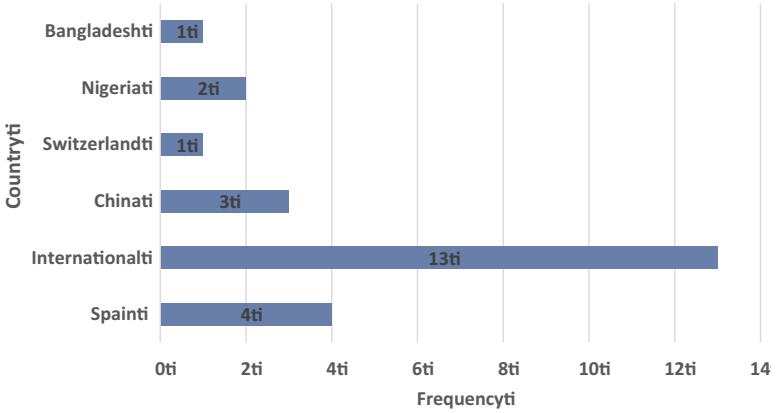

Figure 5. Country of focus for relevant studies
Source: Authors' own work

resources towards the promotion of economic advancement as well as enhancing resource efficiency to transition towards a CE while contributing to global sustainability (Wang *et al.*, 2022). Two studies came from Nigeria, while Bangladesh and Switzerland each produced a paper. This outcome could be attributed to inadequate financial support for CE-related projects or researchers not showing much interest in the subject matter.

3.5 Ranking analysis of sustainable financing strategies for circular infrastructure projects
Sustainable financing strategies are practices that enhances circular infrastructure project's financial performance as well as positively impacting the society and environment. The study identified 46 sustainable financing strategies, as shown in Table 2, while indicating the life cycle stages in which each strategy belongs. Subsequently, the sustainable financing strategies identified in this study were grouped into six categories, namely *access to funds*, *quality of financial resources*, *cost management practices*, *government financial support*, *technology and innovations*, and *project organizational strategies*. The category *access to funds* earned the highest number of strategies (16), which demonstrates the crucial role finances play in transitioning towards circular infrastructure. The category *project organizational initiatives* obtained the next highest number of strategies (ten), followed by the *cost management practices* (eight). Also, *government financial support* had six strategies, while *technology and innovation* recorded four strategies. Finally, *quality of financial resources* recorded only two strategies. According to Purchase *et al.* (2021), by taking a holistic view of circular infrastructure projects' life cycle, stakeholders of the infrastructure sector can unleash opportunities for resource optimization, waste reduction and mitigation of emissions. The strategies were assigned weights and computed based on the formula stated in Section 2.3, which facilitated ranking of the strategies in Table 3. These sustainable financial strategies are purported to aid in the achievement of financial performance of circular infrastructure projects (Sporri *et al.*, 2022). The ensuing section discusses the prioritized strategies within each of the categories.

3.5.1 Access to funds for circular infrastructure projects. Green bonds, innovative funding and finance, and green finance were the most mentioned under this category. Green

Table 2. Sustainable financing strategies for circular infrastructure project life cycle

No.	Sustainable financing strategies for circular infrastructure projects	References	No.	Circular infrastructure project life cycle stages					
				Design	Procurement	Execution	Completion	Operation	End of life
A	*Access to funds for circular infrastructure projects*								
1	Public equity funds	[1, 8,15 ,17 ,20]	5	√	√	√	√	√	√
2	Corporate bonds	[5, 26]	2	√	√	√	√	√	√
3	Private market funds	[26]	1	√	√	√	√	√	√
4	Innovative funding and finance	[8, 9, 10, 11, 13, 16, 17, 18, 19, 20, 26, 28,30]	13	√	√	√	√	√	√
5	Green bonds	[6, 7, 8, 9, 11, 12, 13, 16, 17, 18, 22, 23, 24, 25, 30, 31]	16	√	√	√	√	√	√
6	Credit institutions	[1, 12, 13, 15]	4	√	√	√	√	√	√
7	CE venture capital	[1, 8, 9, 10, 11, 17, 18, 19, 22, 31]	10	√	√	√	√	√	√
8	Company's internally generated funds	[1,5,12,17]	4	√	√	√	√	√	√
9	Green loan	[8, 7, 9, 12, 15, 18, 20, 25, 31]	10	√	√	√	√	√	√
10	Green finance	[8, 9, 11,12,13,14,15,16, 22, 24, 29]	12	√	√	√	√	√	√
11	Green climate fund	[8, 16 ,19 ,30]	4	√	√	√	√	√	√
12	Green credits	[8]	1	√	√	√	√	√	√
13	Sustainable/ green banking	[1, 12, 8, 16]	4	√	√	√	√	√	√
14	Sustainable finance	[7, 8, 12, 17, 22]	5	√	√	√	√	√	√
15	Environmental finance	[8]	1	√	√	√	√	√	√
16	Sustainability bonds	[8, 31]	2	√	√	√	√	√	√
B	*Quality of financial resources*								
17	Providing valuable collateral (guarantees) to secure funding for circular infrastructure projects	[1,17]	2	√	√	√	√	√	

(*continued*)

Table 2. Continued

No.	Sustainable financing strategies for circular infrastructure projects	References	Circular infrastructure project life cycle stages						
			No.	Design	Procurement	Execution	Completion	Operation	End of life
18	Access to external funds with reasonable interest rate and other cost associated with external funding	[1,17]	2	√	√	√	√	√	√
C	*Cost management practices*								
19	Cost reduction through resource efficiency or minimization of resource consumption	[3, 18, 19, 27, 28]	5	√	√	√	√	√	√
20	Reverse logistics practices	[3, 8]	2		√	√	√	√	
21	Waste reduction practices	[3, 18]	2		√	√	√	√	
22	Circular procurement financing	[7, 8, 9, 10, 13, 16, 17, 18, 20, 29, 31]	11		√				
23	Just in time delivery	[18]	1			√		√	
24	Funding circularity at the design phase	[8, 15]	2	√					
25	Financial risk assessment	[13]	1	√	√	√	√	√	√
26	Standardization and integration of circular metrics into financial reporting	[1, 3, 6, 7, 8, 10, 11, 13, 16, 18, 27, 29]	12	√		√			
D	*Government financial support*								
27	Green tax exemptions	[1, 4, 7, 8, 9, 10, 12, 17, 18, 20, 21]	11	√	√	√			
28	Import duties incentives	[1, 4, 8, 9, 10, 12, 17, 24]	8		√				
29	Subsidies/incentives	[1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 16, 17, 19, 20, 27]	15		√	√			
30	Soft loans	[1, 4, 7, 8, 9, 10, 12]	7	√	√	√			

(*continued*)

Table 2. Continued

No.	Sustainable financing strategies for circular infrastructure projects	References	Circular infrastructure project life cycle stages						
			No.	Design	Procurement	Execution	Completion	Operation	End of life
31	Financial policy formulation for circular infrastructure projects	[1, 2, 3, 4, 7, 8, 10, 12, 18, 20, 23, 27]	12	√					
32	Start-up financing and grants	[1, 4, 7, 9, 10, 11, 17, 19, 20, 31]	10	√					
E	*Technology and innovation*								
33	Investment in CE technology and innovation	[1, 2, 3, 4, 9, 13, 16, 17, 18, 20, 21, 22, 23, 26, 27]	15	√	√	√	√	√	√
34	Green innovation	[1, 2, 5, 9, 11, 14, 15, 18]	8	√					
35	Digital finance on green investment	[7]	1	√	√	√	√	√	√
36	Investment in energy efficiency and renewable energy	[1, 12, 13, 16, 17, 26,19]	7	√		√		√	
F	*Project organizational initiatives*								
37	Commitment and leadership of contractor and client toward achieving financial performance	[18, 20]	2	√	√	√	√	√	√
38	Adequate financial knowledge and experience of the project team	[2, 18, 27]	3	√	√	√	√	√	√
39	Knowledge and capacity building in life cycle cost management of circular infrastructure projects	[1, 2, 7, 9, 10, 11, 14, 15, 16, 18, 19, 20, 22, 21, 23, 27, 28, 29, 30]	19	√	√	√	√	√	√

(*continued*)

Table 2. Continued

No.	Sustainable financing strategies for circular infrastructure projects	References	No.	Circular infrastructure project life cycle stages: Design	Procurement	Execution	Completion	Operation	End of life
40	Awareness creation on cost reduction practices	[2, 7, 9, 18, 21, 22, 27]	7	√		√	√		
41	Competitive pressure towards circular infrastructure projects	[18, 20]	2				√		
42	Financial quality management	[1, 18, 27]	3	√					
43	Market orientation	[18, 28]	2					√	
44	Collaborative financing between relevant stakeholders	[2, 6, 8, 9, 10, 11, 12, 13, 16, 18, 22, 24, 25, 27, 28, 31]	17	√	√	√	√	√	√
45	Financial risk-sharing mechanisms	[3, 4, 7, 8, 9, 10, 12, 13, 19, 22, 24, 25, 28, 30]	14	√	√	√	√	√	√
46	Decent employment opportunities	[15, 27]	2	√	√	√	√	√	√

Source(s): Authors' own work

Table 3. Weight and ranking of sustainable financing strategies

Category	ID	Sustainable financing strategies	Weight(a)	Weight (b)	Rank(a)	Rank(b)
Access to funds for circular infrastructure projects	A1	Public equity funds	0.0532	0.0167	6	21
	A2	Corporate bonds	0.0213	0.0067	12	30
	A3	Private market funds	0.0106	0.0033	14	41
	A4	Innovative funding and finance	0.1383	0.0435	2	7
	A5	Green bonds	0.1702	0.0535	1	3
	A6	Credit institutions	0.0426	0.0134	8	24
	A7	CE venture capital	0.1064	0.0334	4	13
	A8	Company's internally generated funds	0.0426	0.0134	8	24
	A9	Green loan	0.1064	0.0334	4	13
	A10	Green finance	0.1277	0.0401	3	8
	A11	Green climate fund	0.0426	0.0134	8	24
	A12	Green credits	0.0106	0.0033	14	41
	A13	Sustainable/ green banking	0.0426	0.0134	8	24
	A14	Sustainable finance	0.0532	0.0167	6	21
	A15	Environmental finance	0.0106	0.0033	14	41
	A16	Sustainability bonds	0.0213	0.0067	12	30
Quality of financial resources	Q1	Providing valuable collateral (guarantees) to secure funding for circular infrastructure projects	0.0213	0.0067	1	30
	Q2	Access to external funds with reasonable interest rate and other cost associated with external funding	0.0213	0.0067	2	30
Cost management practices	C1	Cost reduction through resource efficiency or minimization of resource consumption	0.0532	0.0167	3	21
	C2	Reverse logistics practices	0.0213	0.0067	4	30
	C3	Waste reduction practices	0.0213	0.0067	4	30
	C4	Circular procurement financing	0.1170	0.0368	2	11
	C5	Just in time delivery	0.0106	0.0033	7	41
	C6	Funding circularity at the design phase	0.0213	0.0067	4	30
	C7	Financial risk assessment	0.0106	0.0033	7	41
	C8	Standardization and integration of circular metrics into financial reporting	0.1277	0.0401	1	8

(*continued*)

Table 3. Continued

Category	ID	Sustainable financing strategies	Weight(a)	Weight (b)	Rank(a)	Rank(b)
Government financial support	G1	Green tax exemptions	0.1170	0.0368	3	11
	G2	Import duties incentives	0.0851	0.0268	5	16
	G3	Subsidies/Incentives	0.1596	0.0502	1	4
	G4	Soft loans	0.0745	0.0234	6	18
	G5	Financial policy formulation for circular infrastructure projects	0.1277	0.0401	2	8
	G6	Start-up financing and grants	0.1064	0.0334	4	13
Technology and innovation	T1	Investment in CE technology and innovation	0.1596	0.0502	1	4
	T2	Green innovation	0.0851	0.0268	2	16
	T3	Digital finance on green investment	0.0106	0.0033	4	41
	T4	Investment in energy efficiency and renewable energy	0.0745	0.0234	3	18
Project organizational initiatives	P1	Commitment and leadership of contractor and client toward achieving financial performance	0.0213	0.0067	7	30
	P2	Adequate financial knowledge and experience of the project team	0.0319	0.0100	5	28
	P3	Knowledge and capacity building in life cycle cost management of circular infrastructure projects	0.2021	0.0635	1	1
	P4	Awareness creation on cost reduction practices	0.0745	0.0234	4	18
	P5	Competitive pressure towards circular infrastructure projects	0.0213	0.0067	7	30
	P6	Financial quality management	0.0319	0.0100	5	28
	P7	Market orientation	0.0213	0.0067	7	30
	P8	Collaborative financing between relevant stakeholders	0.1809	0.0569	2	2
	P9	Financial risk-sharing mechanisms	0.1489	0.0468	3	6
	P10	Decent employment opportunities	0.0213	0.0067	7	30

Source(s): Authors' own work

bonds obtained the highest weight of 0.1702. This was followed by innovative funding and finance with a weight of 0.1383 and, finally, green finance with a weight of 0.1277.

3.5.1.1 Green bonds. The past years have seen several innovations for sustainable finance emerge, and among them, green bond has become prominent (Maltais and Nykvist, 2020). Green bonds are a preferred financial strategy for most projects that are environmentally sustainable, particularly circular practices and green growth (van Niekerk, 2024). Green bonds are reputed to increase the liquidity of infrastructure assets, which appeals to institutional investors, ultimately increasing sustainable infrastructure investments. They were first issued in 2007 by the European Investment Bank (Frydrych, 2021). Although green bonds address more financing barriers to energy efficiency than other financing strategies, it has challenges needed to be unlocked to realize the full potential of the bond market (Kapoor *et al.*, 2020).

Bungau *et al.* (2022) opined that these challenges include the lack of experience by project sponsors to use green bonds due to their inability to create a green bond framework, the absence of an established green bond policy framework, the complex process of creating a green as an advanced bond market and green building certification schemes are required and finally the inconsistencies and ambiguities in green bond standards further complicate the process and increase costs (Hyun *et al.*, 2020). According to Banga (2019), the perceived high transactional costs are a significant deterrent for infrastructural firms considering the issuance of green bonds. However, these adoption barriers can be mitigated through the establishment of a strong institutional framework and by increasing the issuance of green bonds for circular infrastructure projects, which would help build local capacity and expertise (Debrah, 2024).

3.5.1.2 Innovative funding and finance. Innovative technologies and solutions that advance circularity attracts this type of funding, for example, advanced recycling technologies. Aranda-Usón *et al.* (2019) highlighted that technological innovations and solutions are indispensable to advancing circular infrastructure projects. The importance of innovative technology and solutions for CE projects was underscored by the United Nations Environment Programme Finance Initiative. In their report titled "Demystifying Finance for Circular Economy," accelerating the transition to circular infrastructure projects demands innovative financial solutions (United Nations Environment Programme-Finance Initiative, 2020). According to Fallahi *et al.* (2023), there are innovative funding and financing models that stakeholders can use to spring forward their financial growth. For instance, using the blended financing models, such as concessional financing, helps limit the risks attached to circular technologies (Fiorentino *et al.*, 2022). Also, smaller communities are benefiting immensely from microfinancing in their circular initiatives (Kandpal *et al.*, 2023).

3.5.1.3 Green finance. The goal of a more inclusive and sustainable economy is enabled by green finance, which can provide needed funds to finance projects in the infrastructure sector that foster sustainability (van Niekerk, 2024). This financial strategy provides access to resources for projects that focus on environmental protection and CE (Kumar *et al.*, 2022). Green finance funds renewable energy projects and circular infrastructure projects (Wang *et al.*, 2022). Green finance enables green growth by funding infrastructure projects that aim at reducing waste, enhancing resource efficiency and using renewable materials, all of which positively impacts the planet (Organization for Economic Cooperation and Development, 2019). In addition, innovative green finance strategies such as carbon financing incentivize stakeholders to reduce carbon emissions by rewarding such endeavours with carbon credits, which they can sell to earn revenue (Wang *et al.*, 2025).

3.5.2 Quality of financial resources. This category has two strategies, which include providing valuable collateral (guarantees) to secure funding for circular infrastructure

projects, access to external funds with reasonable interest rate and other cost associated with external funding. Each of these strategies obtained a weight score of 0.0213.

3.5.2.1 Providing valuable collateral to secure funding for circular infrastructure projects. According to Scarpellini *et al.* (2018), while the availability of financial resources influences the development of circular infrastructure projects, the quality of the financial resource influences its implementation and determines the choice of resources to finance the investment. As such, financial resources that are not explicitly penalized are preferred, with consequent impact on the differentials applied and the collateral demanded. In addition, importance is placed on public financial incentives that allow a reduction in the risk exposure and the provision of profitability to certain projects, which otherwise could not be developed by companies (Aranda-Usón *et al.*, 2019; Kim *et al.*, 2021; Polzin *et al.*, 2019).

3.5.2.2 Access to external funds with reasonable interest rate and other cost associated with external funding. Access to external funds is crucial for the implementation of circular infrastructure projects (Arsova *et al.*, 2022). By providing reasonable rate and other cost (such as lender services fees, legal fees, interest and tax implications) associated with external funding of circular infrastructure projects, the infrastructure sector can contribute to a more resilient and environmentally conscious future (Aranda-Usón *et al.*, 2019; Scarpellini *et al.*, 2018).

3.5.3 Cost management practices. In this category, the most mentioned strategies were standardization and integration of circular metrics into financial reporting (which obtained a weight of 0.1277), circular procurement financing (0.117) and cost reduction through resource efficiency or minimization of resource consumption (0.0532).

3.5.3.1 Standardization and integration of circular metrics into financial reporting. Informed strategic decision-making and the creation of organization values are few beneficial outcomes of financial reporting on circularity of infrastructure projects. Financial reporting also enables responsiveness to societal pressure and regulatory pressures, as well as facilitating access to talent and capital (Nazir and Doni, 2024). Circulytics is a common tool used in this regard to measure circularity. It was developed by the Ellen MacArthur Foundation, one of the leaders in the shift towards CE. Circulytics, therefore, is a useful tool project stakeholders can leverage to measure the degree of circularity in their operations (Immonen, 2023). The Sustainability Accounting Board is another available tool for rating agencies and stakeholders to access disclosure of environmental, social and governance information (Eng *et al.*, 2022).

3.5.3.2 Circular procurement financing. Circular procurement is a procurement process that contributes to closed energy and material loops within the supply chain, as well as limiting or avoiding waste generation and adverse impact on the environment throughout the whole life cycle (Xu *et al.*, 2022). Many countries in the European Union (EU) do have national policies on circular procurement that are active and that cover aspects such as environmental standards, market assessment, awareness raising and legal frameworks (Marino and Pariso, 2020). The advantages of circular procurement include fostering innovations in eco-friendly solutions, reducing greenhouse gas emissions and supporting sustainability goals. Therefore, circular procurement offers both environment benefits and financial savings when considered from life cycle perspective rather than just the purchase price (Xu *et al.*, 2022).

3.5.3.3 Cost reduction through resource efficiency or minimization of resource consumption. Circular infrastructure stakeholders are often concerned with cost reduction (Guerra and Leite, 2021). Effective cost management creates value and ensures that stakeholders get returns on their investment (Munaro and Tavares, 2023). According to Chen (2023), one way to do this is effectively allocating resources across the value chain by

adopting practices such as modularity, standardization and reusability. Moreover, resource consumption can be minimized and the cost of raw materials reduced by extending project life cycles through refurbishment, repair and remanufacturing (Cruz-Rios and Grau, 2020). In addition, the construction process can be streamlined to reduce costs through efficient supply chain management and waste prevention. Therefore, shifting to circular infrastructure projects can decrease resource inefficiency and reduce costs of waste disposal and landfill fees (Victar and Waidyasekara, 2022).

3.5.4 Government financial support. The government as a stakeholder plays a key role in circular infrastructure (Osei-Tutu *et al.*, 2024). Inadequate government support, however, remains one of the primary challenges of implementing circular infrastructure (Agyekum and Amudjie, 2024). Financial support from governmental bodies in a form of subsidies, green tax exemptions and financial policy formulation for circular infrastructure projects plays a key role in implementing circular infrastructure projects (Aranda-Usón *et al.*, 2019). In this category, subsidies/incentives obtained the highest weight (0.1596), followed by financial policy formulation for circular infrastructure projects (0.1277) and green tax exemptions (0.1170).

3.5.4.1 Subsidies/incentives. The capital intensiveness of circular infrastructure and its long payback periods demand sufficient capital investment. Targeted subsidies alleviate the financial burden on developers, enabling the integration of green technologies in circular infrastructure projects (Ding *et al.*, 2023). In addition, subsidies support decentralized renewable energy systems and resilient infrastructure, improving energy access and community resilience to climate impacts. In the long run, subsidies contribute to sustainable development goals and economic stability of circular infrastructure projects (Tan and Ye, 2024). Where capital is insufficient, it leads to underinvestment in circular projects, which ultimately adversely affects the CE transition (Aranda-Usón *et al.*, 2019). Government subsidies are therefore necessary to offset the exorbitant costs and potential risks in circular infrastructure, which historically have been barriers to executing such projects. This would improve profitability of circular infrastructure projects (Scarpellini *et al.*, 2018).

Subsidies, however, have challenges including difficulty in securing sufficient public funds for subsidies due to economic downturns, inconsistent and changing policies, which creates uncertainty for circular infrastructure developers and investors and makes long-term planning a huge challenge, and significant administrative efforts and costs involved in the management and distribution of subsidies, which burdens government resources among others (Han *et al.*, 2022).

3.5.4.2 Financial policy formulation for circular infrastructure projects. Extant literature indicates that government policies can be pivotal to promoting circular infrastructure (Bolger and Doyon, 2019). Such policies are critical to reducing risks associated with circular infrastructure projects as well as creating incentives for their financial investments (Toledano *et al.*, 2023). Therefore, a strong policy framework is necessary to de-risk and provide incentives. Such policy frameworks may include national action plans and roadmaps for circular infrastructure projects (Lukkarinen *et al.*, 2023). However, Agyekum and Amudjie (2024) stated that environmental and regulatory policies that foster circular infrastructure in developing countries like Ghana tend to fail, because the agencies that enforce such policies fail to perform.

3.5.4.3 Green tax exemptions. Tax policies are important to circular infrastructure projects by either incentivizing or deterring stakeholders (Vence and López Pérez, 2021). There have been significant studies on environmental tax instruments, specifically energy taxes and carbon taxes, with a broader debate revolving round carbon taxation (Pegels, 2016). Carbon tax has been commonly established in majority of organisation for economic

co-operation and development countries with the agreed aim of mitigating greenhouse emissions and global warming. Taxation, according to the 2019 Final Report of the Tax Working Group in New Zealand, can be used to alter behaviours and finance the shift towards CE. Countries such as China use taxation to promote CE by providing incentives such as value-added tax exemptions and refunds (Pernet, 2024). Therefore, governments play an important role in influencing resource efficiency of consumer choices. Through a taxation system that facilitates reductions in waste and improvement in project design and procurement policies, there will be incentives to innovate and invest in circular infrastructure projects (Fiedler *et al.*, 2021).

3.5.5 Technology and innovation. The global economy is challenged with the transition towards a lower carbon future and greater renewable energy infrastructure (Kabeyi and Olanrewaju, 2022). In the era of the fourth industry revolution, the global economy can rapidly adopt technologies and innovation to achieve the necessary decarbonization while attaining financial performance of circular infrastructure projects (Hoosain *et al.*, 2023). In this category, investment in CE technology and innovation was ranked highest (0.1596), followed by green innovation (0.851) and investment in energy efficiency and renewable energy (0.0745).

3.5.5.1 Investment in CE technology and innovation. Investments in innovation and technology are necessary to implement circular infrastructure, according to Scarpellini *et al.* (2020). The adoption of CE paradigm would be faster with available technology to streamline circular infrastructure processes (Oluleye *et al.*, 2022). Technology offers a viable way of circumventing the challenges to investment that circular infrastructure projects often encounter, and they are essential to scaling up circular infrastructure. Digital technologies and digitization include artificial intelligence, big data, blockchain and internet of things (Çetin *et al.*, 2022). Digitization can help streamline the financial processes of circular infrastructure projects by creating financial performance management models. It does this by centralizing data, customizing financial reports, providing real-time insights and providing risk mitigation features (Varaniūtė *et al.*, 2023). This assists project stakeholders to make data-driven decisions, improving financial performance of circular infrastructure (Gupta *et al.*, 2019). Moreover, investing in CE technology and innovation can additionally develop new markets, transform design of materials and processes, and provide investment funds, which are often cumbersome to obtain by stakeholders (Aranda-Usón *et al.*, 2019).

3.5.5.2 Green innovation. Green innovations describe creative solutions that aim at minimizing adverse environmental impacts of the infrastructure sector as well as maximizing sustainability (Bibri and Krogstie, 2020). Green innovations comprise products, processes and technologies that are environmentally friendly. Tu and Wu (2021) stated that green innovations have become a force advancing the implementation of circular infrastructure projects. Green innovations accomplish this by enhancing financial performance through cost reduction, increasing competitiveness and enhancing resource efficiency (Farza *et al.*, 2021).

3.5.5.3 Investment in energy efficiency and renewable energy. This strategy targets the financing of renewable energy and energy efficiency, both of which are key to ameliorating the issues of environmental and climate challenges (Yazar, 2023). This offers the advantage of ensuring sustainability as well as guaranteeing financial returns (Kandpal *et al.*, 2024a). Increased investment in renewable forms of energy, such as solar, wind and hydropower, can provide project organizations needed capital to innovate and create new technologies and limit greenhouse gas emissions (Lima *et al.*, 2020). For instance, the desolate northern communities of Scotland generate funds from wind energy, which is reinvested into local development initiatives such as communications, social services and circular infrastructure

projects. This strategic reinvestment employs ten times more people and generates more income than the wind power production itself (Okkonen and Lehtonen, 2016).

3.5.6 Project organizational initiatives. This category entails the initiatives taken by the project organization to equip their team members with necessary financial resources, skills and knowledge to enable them scale up circular infrastructure projects. Knowledge and capacity building in life cycle cost management of CE projects was the most prioritized strategy in this category with a weight of 0.2021, followed by collaborative financing between relevant stakeholders (0.1809) and financial risk-sharing mechanisms (0.1489).

3.5.6.1 Knowledge and capacity building in life cycle cost management of CE projects. According to Hadro *et al.* (2022), inadequate knowledge or financial training seems to be a common issue among non-financial employees with regard to managing life cycle cost of circular infrastructure projects. However, this gap in financial literacy can be closed by financial institutions, equipping non-financial stakeholders with the knowledge required to make informed decisions on sustainable investments and to effectively participate in CE activities (Demirgüç-Kunt *et al.*, 2017). Conversely, unlike the traditional linear models, many financial stakeholders lack in-depth understanding of circular business models (Wrålsen *et al.*, 2021). Capacity building efforts, such as workshops, will equip relevant stakeholders with the required understanding to make the shift from linear to circular infrastructure projects.

3.5.6.2 Collaborative financing between relevant stakeholders. According to Sepetis (2022), the transition towards CE requires collaborative efforts among EU, international organizations and national policies with the public and private sectors at the global financial and business level. Multilateral development banks and other financial institutions can generate greater momentum for circular infrastructure projects by exploiting their large network of stakeholders to advocate for favourable legal and policies changes (Loorbach *et al.*, 2020). This can be achieved through dialogue and knowledge exchange with key policy makers and actors in the financial sector. Moreover, progress in circular financing requires collaboration among financial institutions and strategic partnerships with regional coalitions (Ghisellini and Ulgiati, 2020). In addition, in circular infrastructure projects, collaborative efforts with suppliers, partners and other stakeholders create opportunities for learning, sharing and solving problems (Goodman *et al.*, 2017).

3.5.6.3 Financial risk-sharing mechanisms. There is greater complexity with circular infrastructure projects compared with linear projects, which increases the risk associated with such projects (Cziesielski *et al.*, 2024). Blended finance as a finance instrument can be used to decrease risk associated with circular infrastructure projects across various tranches of investment, which encourages investment and boosts investors' confidence (Moretti *et al.*, 2021). Blended finance mechanisms, therefore, attract private sector capital for circular infrastructure projects and serve as a viable solution for sustainability issues.

4. Conceptual framework

From Figure 6, the sustainable financing strategies have been aligned with the CE principles and the Sustainable Development Goals (SDGs). The most prioritized strategies were selected from each of the indicator categories and used for the development of the conceptual framework. Aligning the sustainable financing strategies with the CE principles, infrastructure project life cycle, and the United Nations (UN) SDGs promotes responsible project practices, attracts investors, allows for a holistic financial performance assessment, facilitates risk mitigation, enhances infrastructure resilience, enables long-term value creation and contributes to a more sustainable world (Niyommaneerat *et al.*, 2023; Valdivia *et al.*, 2021).

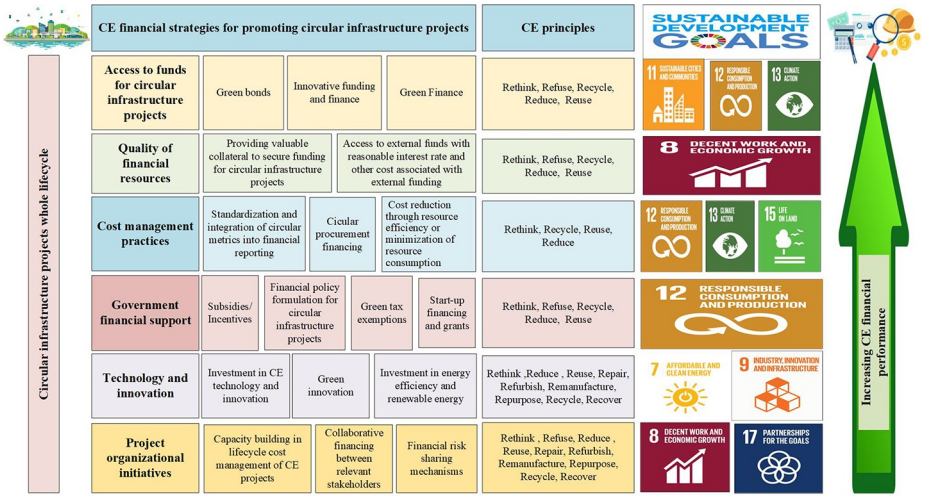

Figure 6. Conceptual framework for sustainable financing strategies of circular infrastructure projects
Source: Authors' own work

Access to funds such green bonds, innovative financing and finance and green finance aligns with the CE principles, *rethink, refuse, reduce and reuse*. In recent times, financial institutions and investors are looking to invest in circular infrastructure projects because it contributes to green growth and circular practices throughout the various life cycle stages (Joensuu *et al.*,2020). For circular infrastructure projects to make substantial contributions to the SDGs, there must be a significant increase in its financing (Ogunmakinde *et al.*, 2022). Access to funds aligns with SDG 11 titled *sustainable cities and communities*, providing funding for eco-friendly urban development, resilient infrastructure and sustainable transportation to promote inclusive cities. It also aligns with SDG 12, *responsible consumption and production*, providing funding to promote sustainable project practices and regenerative consumption of natural resources. SDG 13 titled *climate action*, which entails funding circular infrastructure projects that reduce carbon emissions, can promote green economy efficiency and respect limits (ecological ceiling).

Quality of financial resources aligns with CE principles *rethink, refuse, recycle, reduce and reuse*. These strategies contribute to SDG 8 to promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all. Cost management practices, such as standardization and integration of circular metrics into financial reporting, and cost reduction through resource efficiency or minimization of resource consumption, align with the CE principles, *rethink, recycle, reuse and reduce*. Consequently, these strategies contribute to SDGs 12, 13 and 15 (life on land: providing finance for projects focused on biodiversity conservation, sustainable land management, circular production and combating deforestation). Government financial support through the provision of subsidies/incentives, financial policy formulation for circular infrastructure projects, green tax exemptions and start-up financing and grants aligns with the CE principles *rethink, refuse, recycle, reduce, and reuse* while contributing to SDGs 12.

Technology and innovation strategies including investment in CE technology and innovation, green innovation and investment in energy efficiency and renewable energy align

with the 9R of CE and contribute to SDGs 7 and 9. SDG 7 is focused on providing affordable and clean energy: investment in renewable energy projects, making clean and sustainable energy sources more accessible and affordable. SDG 9 is focused on industry, innovation and infrastructure: investments in green technologies and sustainable infrastructure that enable circular industrial development methods and cost reduction through innovation.

Project organizational initiatives including capacity building in life cycle cost management of CE projects, collaborative financing between relevant stakeholders and financial risk-sharing mechanisms align with all the 10R CE principles while contributing to SDG 8 and SDG 17 –partnership for the goals: financial institutions, states, businesses and civil society collaborating to promote green finance and nurture communitarian networking. The application of CE principles throughout the entire life cycle of circular infrastructure projects is necessary to scale up the financial performance of circular infrastructure projects, as illustrated in Figure 6.

4.1 Explaining the linkage between the sustainable financing strategies, CE principles and the SDGs

In this section, the linkage between selected sustainable financial strategies presented in Figure 6 is further elaborated.

Under the category access to funds for circular infrastructure projects, *green bond* is one of the financial strategies identified. Green bonds provide the necessary capital to implement CE principles by financing circular infrastructure projects that **reduce** waste, promote **recycling** and **restore** natural systems (Shinde, 2021). In addition, green bonds fund initiatives promote **recycling**, **reuse** and **refurbishment** to keep products and material in use for as long as possible (Kandpal *et al.*, 2024b). This includes investments in circular supply chains and sustainable product design. These initiatives in the long run help in the attainment of SDGs 11, 12 and 13.

Considering the technology and innovation category, one of the identified sustainable financial strategies is *investment in CE technology and innovation*. Investing in CE technology can drive economic growth by creating new markets and job opportunities (Hysa *et al.*, 2020). Also, these investment helps to **reduce** environmental impact. Innovations in CE technology improve resource efficiency, **reducing** the need for virgin materials and minimizing waste from the implementation of circular infrastructure (Suchek *et al.*, 2021). CE technologies ensure that materials are efficiently **recycled** and reintroduced into the construction of a new circular infrastructure project, thus supporting the circulation of materials (Rahla *et al.*, 2021). These initiatives align with SDGs 7, 8 and 9.

It is worth nothing that the CE principles provided for each category in the framework is not limited to only the ones stated in the framework.

5. Implications and future research directions

5.1 Theoretical implications

Considering the scarcity of research on sustainable financing strategies and the concern raised by various stakeholders regarding the financial risk and viability of circular infrastructure projects, the result of this study bridges this gap by unveiling valuable insights that can aid scale up the transition to CE. Moreover, the results obtained add to knowledge on the financial aspects of circular infrastructure projects. The result of the study also aligns with CE principles as well as the SDGs, achieving a harmonious balance between economic viability, social responsibility and environmental stewardship within the operations of circular infrastructure projects. Finally, focusing on the life cycle of sustainable financing strategies provides an opportunity for stakeholders to achieve both short- and long-term financial goals.

5.2 Practical implications

The conceptual framework proposed by this study serves as a guide to stakeholders involved in the implementation of circular infrastructure projects. Also, based on the study's findings, it is anticipated that managers of circular infrastructure projects will be able to monitor and control financial risks associated with circular infrastructure projects. The results of this study can assist managers to identify and prioritize their financial objectives. The sustainable financing strategies presented in this study can also enable managers to both enhance financial performance and achieve their sustainability goals. The CE financial strategy framework will aid relevant stakeholders to make investment-related decisions regarding circular infrastructure projects and its financing.

Considering the societal impact of the sustainable financial strategies, green bonds and subsidies enable the development of eco-friendly and energy-efficient infrastructure. This leads to an improved quality of life for the occupants and users of the infrastructure project. In addition, the investment in climate-resilient infrastructure enhances the resilience of circular infrastructure to natural disasters as well as the impact of climate change. The shift towards the investment in circular infrastructure projects eventually creates new job opportunities while promoting skill development and employment.

Economically, the implementation of circular infrastructure projects facilitated by the sustainable financing strategies presents the advantage of long-term cost savings through reduced energy consumption and cost of maintenance. Moreover, sustainable financing strategies attract socially responsible investors and provide access to new funding sources. Another economic impact is that circular infrastructure firms can gain competitive advantage in the market.

5.3 Policy implications

The strategies suggested by the study can be adopted by various stakeholders of the infrastructure sector when formulating investment policies regarding circular infrastructure projects. The study provides a holistic approach to financing that incorporates not only financiers but also the whole value chain and ecosystem. Banks, insurers and investors can accelerate financing circular infrastructure projects through the management of circular risks and opportunities by applying the 10R principles in risk policies. National policies can be set to support the sustainable financing of circular infrastructure projects by simulating resource efficiency through various economic incentives such as setting waste reduction target or adjusted tax regime. Policies regarding green procurement will also ensure that eco-efficient products are used for circular projects. Also, governments can implement policies, laws and related instruments to address the barriers to implementing circular infrastructure projects while creating incentives.

5.4 Future research directions

The study identified sustainable financing strategies and proposed a conceptual framework for implementing circular infrastructure projects. However, further studies are required to address the limitations of the study by using both primary and secondary data sources as well as using exploratory factor analysis to categorize the identified strategies. While it is commendable to consider the sustainable financing strategies from the life cycle perspective, it is also necessary to group the strategies under the various stakeholders (client, contractors, suppliers, financiers, etc.) of the infrastructure sector needed to implement such strategies. This is because the transition from linear to circular infrastructure requires the cooperation of all relevant stakeholder groups. Although the number of articles used for the study is acceptable in SLRs, future studies should consider a larger sample size to ensure that the

findings are broadly represented validating the conceptual framework through expert forums and case studies to access how the financial strategies enhance the financial performance of circular infrastructure projects.

6. Conclusion

The study investigated the sustainable financing strategies for promoting circular infrastructure projects. SLR was adopted for searching, retrieving, evaluating and extracting relevant metadata of 31 eligible articles. The sustainable financing strategies were categorized and prioritized using thematic content analysis and weights. From the analysis, research interest in CE has been growing since 2016. Out of the 46 identified sustainable financing strategies identified from the study, the top five include: knowledge and capacity building in life cycle cost management of circular infrastructure projects, collaborative financing between relevant stakeholders, green bonds, investment in CE technology and innovation and subsidies/incentives. The identified strategies were grouped into six categories, namely access to funds for circular infrastructure projects, quality of financial resources, cost management practices, government financial support, technology and innovation, and project organizational initiatives. The prioritization of the strategies within the categories and the entire set of strategies was facilitated by the weights assigned to each of the strategies. Consequently, a conceptual framework for sustainable financing strategies was proposed based on the 10R framework, and it was aligned to the SDGs to attain financial performance of circular infrastructure projects. The theoretical, managerial and policy implications have been detailed in the discussion section of the study. The study recommends future studies to consider exploratory factor analysis to make the literature-based categorization of the sustainable financing strategies more credible. Finally, the conceptual framework should be validated through expert forums or case studies to ascertain how the identified strategies impact the financial performance of circular infrastructure projects.

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