Sustainable Production and Consumption

Modeling the principal success factors for attaining systemic circularity in the building construction industry: An international survey of circular economy experts

--Manuscript Draft--

Manuscript Number:	
Article Type:	Full Length Article
Keywords:	circular economy; critical success factors; waste management; building construction industry
Corresponding Author:	Benjamin I. Oluleye HONG KONG
First Author:	Benjamin I. Oluleye
Order of Authors:	Benjamin I. Oluleye
	Daniel W.M. CHAN
	Prince Antwi-Afari
	Timothy O. OLAWUMI
Abstract:	To achieve zero waste and cumber the acute environmental effect of the building construction industry (BCI), circular economy (CE) implementation is pertinent. Such implementation requires the incorporation of certain actionable factors that are critical to its success. However, investigating these factors considering the individualistic variations of developed and developing economies is rarely conducted in the literature. Therefore, this study evaluated the critical success factors (CSFs) for attaining systemic circularity in the BCI of both developed and developing economies. The methodological framework adopted comprises a literature review and a questionnaire survey of 140 CE experts across 39 developed and developing economies. The data collected was analyzed using exploratory factor analysis (EFA), rank agreement analysis (RAA), and fuzzy synthetic evaluation (FSE) techniques. The EFA analysis revealed four principal success factors (PSFs): data-driven digital tools and circularity plan, capacity building and pre-demolition auditing, systemic circularity guidelines and commitment, and circular metric and secondary market development. The RAA results showed that consensus and non-consensus exist between the two groups (developed and developing economies) on the PSFs. The FSE method revealed that all the PSFs are paramount in achieving a successful CE implementation in the two economies. However, the top two in developed economies are systemic circularity guidelines and commitment, and circular metric and secondary market development, while data-driven digital tools and circularity plans, and capacity building and demolition monitoring are the top two in developing economies. The RAA findings underscore the need to be context conscious while adopting the CSFs for CE implementation in the BCI. The FSE findings and the PSF models developed would guide the government and management teams in resource allocation during CE implementation. This study contributes to existing knowledge by providing essential insights into the CSFs that would promote systemic circularity attainment in the BCI of developed and developing economies.
Suggested Reviewers:	
Response to Reviewers:	
Additional Information:	

Modeling the principal success factors for attaining systemic circularity in the building construction industry: An international survey of circular economy experts

*****Benjamin I. OLULEYE
benjamin.oluleye@connect.polyu.hk
Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China
*Corresponding author

Daniel W.M. CHAN
daniel.w.m.chan@polyu.edu.hk
Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China

Prince ANTWI-AFARI
pantwiaf@connect.hku.hk
Department of Civil Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong, China

Timothy O. OLAWUMI
t.olawumi@napier.ac.uk
School of Engineering and the Built Environment, Edinburgh Napier University, Edinburgh, Scotland, United Kingdom

Modeling the principal success factor for attaining systemic circularity in the building construction industry: An international survey of circular economy experts.

Abstract

To achieve zero waste and cumber the acute environmental effect of the building construction industry (BCI), circular economy (CE) implementation is pertinent. Such implementation requires the incorporation of certain actionable factors that are critical to its success. However, investigating these factors considering the individualistic variations of developed and developing economies is rarely conducted in the literature. Therefore, this study evaluated the critical success factors (CSFs) for attaining systemic circularity in the BCI of both developed and developing economies. The methodological framework adopted comprises a literature review and a questionnaire survey of 140 CE experts across 39 developed and developing economies. The data collected was analyzed using exploratory factor analysis (EFA), rank agreement analysis (RAA), and fuzzy synthetic evaluation (FSE) techniques. The EFA analysis revealed four principal success factors (PSFs): data-driven digital tools and circularity plan, capacity building and pre-demolition auditing, systemic circularity guidelines and commitment, and circular metric and secondary market development. The RAA results showed that consensus and non-consensus exist between the two groups (developed and developing economies) on the PSFs. The FSE method revealed that all the PSFs are paramount in achieving a successful CE implementation in the two economies. However, the top two in developed economies are systemic circularity guidelines and commitment, and circular metric and secondary market development, while data-driven digital tools and circularity plans, and capacity building and demolition monitoring are the top two in developing economies. The RAA findings underscore the need to be context conscious while adopting the CSFs for CE implementation in the BCI. The FSE findings and the PSF models developed would guide the government and management teams in resource allocation during CE implementation. This study contributes to existing knowledge by providing essential insights into the CSFs that would promote systemic circularity attainment in the BCI of developed and developing economies.

Keywords: Circular economy; critical success factors; waste management; building construction industry

Nomenclature

EFA	Exploratory factor analysis
RAA	Rank Agreement Analysis
CSFs	Critical Success Factors
PSFs	Principal Success Factors
FSE	Fuzzy Synthetic Evaluation
BCI	Building Construction Industry
BCDW	Building construction and demolition waste
CBM	Circular Business Model
CE	Circular Economy
MF	Membership Function
MCDM	Multi-criteria decision-making
BREEAM	Building Research Establishment Environmental Assessment Method

1. Introduction

The building construction industry's (BCI) acute environmental impacts, such as natural resource depletion, high energy consumption, and unsurmountable waste production, are well-known and documented in the literature (Oluleye *et al*., 2022). For instance, Yeheyis et al. (2013) opined that the BCI contributes about 30% to all-natural resource extraction. Setaki and van Timmeren (2022) revealed that BCI is responsible for 38 % of CO_2 emissions globally. The effects of the BCI are also evident in the 10 billion tons of building construction and demolition waste generated annually (Mahpour, 2018). Extant studies have been developed to overcome these effects and enhance the implementation of total/systemic circularity to achieve zero waste and lead toward sustainable development. For example, developing environmental design guidelines to achieve circular construction and lead to high environmental performance (Eberhardt et al., 2020), integrating circular economy(CE) into modular buildings to enhance buildings' reusability at end-of-life (Wuni & Shen, 2022), and developing methods and guidelines to ensure systemic circularity in the construction industry (Antwi-Afari et al., 2022a).

Despite the ongoing means of reducing the effects of the BCI on the environment, a keen understanding of the critical success factors (CSFs) needs to be upheld to achieve zero waste and lead the BCI to a total/systemic circularity and sustainable development. Existing studies such as Rios et al. (2021) considered the barriers and enablers for circular building design in the United States construction industry. Shooshtarian et al. (2022b) investigated the barriers and enablers for CE in the Australian construction sector. Also, Wuni and Shen (2022) proposed CSFs for integrating circular economy in modular construction projects in Hong Kong, while Ababio and Lu (2023) looked at barriers and enablers for implementing circular economy in the construction industry through a multi-system perspective. Although several barriers and enablers have been identified and proposed in the literature linking different dimensions and systems levels to enhance the circularity of the BCI, their practical implementation to propel the BCI to achieve zero waste and attain sustainable development is lacking. Therefore, there is the need to identify the actionable factors which stakeholders in the BCI should adopt to achieve total / systemic circularity.

Achieving systemic implementation of CE principles in the BCI transcends national or regional agenda to incorporate differences in both developing and developed economies towards creating a model to enhance the sustainability of the construction sector (Giorgi et al., 2022). Nonetheless, the individualistic differences and convoluted agreements between different economies (developed and developing) should be observed to provide an overhaul of CSFs for attaining a systemic circularity in the BCI at the global level. CSFs in this study are the pertinent managerial areas that must be given exceptional attention, which, when adopted, will ensure a successful systemic circularity in the BCI.

Unsurprisingly, different economies may exhibit distinct perceptions of implementing CE in their BCI. This study evaluates the CSFs for attaining CE towards zero waste in BCI of developed and developing economies to acknowledge this consideration. In this sense, this study raises several research questions: (i) What are the CSFs for CE in BCI of developed and developing economies, and how can these CSFs be categorized for better understanding (ii) What is the level of agreement of respondents from BCI of developed and developing economies on the categorized CSFs (iii) How can the CSFs for CE in BCI be prioritized and evaluated. A multi-stage research framework was adopted to address the research questions. First, potential CSFs that could enable systemic circularity attainment were determined in extant studies and validated through a pilot study. Second, questionnaire data was collected from circular construction professionals in developed and developing economies. Third, the CSFs were categorized into concise groups using exploratory factor analysis (EFA). Fourth, the level of consensus between the two groups of respondents (developed and developed economies experts) was analyzed using rank agreement analysis (RAA). Finally, the fuzzy synthetic evaluation (FSE) approach was adopted to determine the significance indices of the CSFs groups for the two economies.

2. Literature review

This section presents the theoretical framework for the study on CE in the BCI, the critical success factor for attaining CE in the BCI and draws a research gap and a significant contribution of the study.

2.1. Circular economy in the building construction industry

The objective of systemic circularity or CE in the BCI is to guarantee that the building's product system is properly circularly designed and has the necessary system conditions, reverse cycles, and business models to facilitate zero waste and ease of reusability of building materials at the end of their life (Oluleye et al., 2023b). In contrast to the linear economy model, where products are discarded at the end of life, the CE provides a framework where resources are kept in loops to create regenerative values for more extended periods(Oluleye et al., 2022b).In the BCI, CE principles such as design for disassembly, recycling, reuse, recovery, and remanufacturing are integrated into the construction process to ensure efficient resource consumption and decoupling of resources from depletion (Oluleye et al., 2022a; Shooshtarian et al., 2022b). Thus, CE implementation in BCI is grounded in sustainable production and consumption theories, industrial symbiosis, reverse logistics, cleaner production, and closed-loop materials flow.

Researchers have indicated that implementation of CE practices in the BCI could offer a considerable opportunity, such as a reduction in environmental pollution, promotion of sustainable consumption of environmentally friendly materials, promote economic growth (GDP increase), improvement of a quality ecosystem, and reduction in waste and virgin materials consumption (Mohammadiziazi & Bilec, 2023). Furthermore, Wuni (2022a) argues that CE could offer opportunities beyond the traditional triple bottom line of sustainability (environmental, social, and economic) to include business, technological, and legislative benefits.

Due to the potential of CE in BCI, notable studies on reducing construction and demolition waste in a CE have been conducted. For example, López Ruiz et al. (2020) developed a theoretical model to assess CE in construction and demolition activities. (Shooshtarian et al., 2022a) investigated the transition towards a CE in the construction and demolition sector at various stages of the construction materials lifecycle. Guo et al. (2022) developed an evolutionary game model for promoting sustainable development in construction and demolition waste recycling. Furthermore, Bao et al. (2019) developed an innovative procurement approach for construction and demolition waste circularity. Oluleye et al., (2022a) examined the implementation of CE principles for managing all kinds of waste in the construction industry and identified key themes and strategies in extant studies. Akanbi et al. (2020) developed a deep-learning model for enabling pre-demolition auditing in a CE. Also, Sharma et al. (2022) developed a framework to attain CE in construction and demolition waste using lifecycle thinking. Ghisellini et al. (2018) explored the applications of CE's crucial principles in construction waste management. In the BCI, Christensen et al. (2022) developed an approach for looping materials from demolition to new construction to close the materials loop. Other studies have also identified the issues affecting CE adoption in the BCI(Mahpour, 2018; Oluleye et al., 2022b; Wuni, 2022b).

Despite the rapid interest of CE research in the BCI, its practical implementation seems relatively slow and delusive. Extant studies have argued that the waste produced and resource consumption in BCI is still increasing in volume over the years globally (Oluleye et al., 2023; Volk et al., 2023; Zhang et al., 2022). Precisely, Zhang and Ahmed (2022) submitted that the BCI still generates over 10 billion tons of waste annually across the globe, which is not different from the submission of other past studies. Also, among other sectors of the world, the BCI is responsible for over 40% of total solid waste production. This large volume of building construction and demolition waste (BCDW) could be attributed to the lack of practical CE initiatives to manage materials flow from the beginning of the product lifecycle to the end of life. As indicated by Shooshtarian et al. (2022a), the growth in BCDW emerges from low resource efficiency in the BCI and inappropriate initiatives to guide CE adoption globally. Thus, the initiatives in extant studies do not satisfactorily fulfill a systemic circularity implementation.

According to Giorgi et al. (2022), CE practices in managing resource production and consumption in the BCI towards zero waste require international effort and commitment from which local institutions can learn. Also, establishing a performing CE in the BCI requires several prerequisites to be fulfilled. One of these is the analysis of proper management techniques to support its implementation at an international level (developed and developing economies) which is still missing in extant studies (Oluleye et al., 2022a). Based on these considerations and to enable zero waste, it is imperative to investigate the critical success factors (CSFs) for attaining CE in the BCI based on developed and developing economies' perspectives. This step would guide BCI worldwide in integrating CE practices to reap its full benefits. It will also strengthen sustainable production and consumption of resources and zero waste in the BCI.

2.2 Critical success factors for attaining CE in the BCI

The few areas in which things must go right for any organization or business to flourish are known as critical success factors (CSFs) (Oluleye et al., 2021). In this study, CSFs are robust management support tools that must be understood and, if integrated into the production and consumption of materials in the BCI, would enable a successful systemic circularity. A systematic literature review was conducted to gather the potential CSFs suitable for this study. Extant studies discovered from both developed and developing economies were discussed accordingly.

In developed economies, Akinade et al, (2017) submitted that the CSFs for promoting design for disassembly in UK BCI include stringent legislation, deconstruction design process, and design for building flexibility. While predicting the demolition waste in a CE in the United Kingdom, Akanbi et al. (2020) submitted that demolition auditing using advanced technology is a veritable technique for CE in the BCI. Rios et al. (2021) interviewed USA architects on the enablers for circular building design and found that implementing materials tracking technologies, target for salvage materials, and increasing landfill taxes are major CE enablers. Also, in USA, Guerra and Leite (2021) submitted that the enabling factors for transitioning to a CE model in the construction industry include education data availability, policies, and incentives. Wuni and Shen (2022) conducted an empirical study on the CSFs for circular modular construction in Hong Kong. The study discovered that information sharing and effective collaboration among experts are critical for circular modular construction. Shooshtarian et al. (2022c), in a semi-structured interview with construction stakeholders in Australia found that creating and stimulating a market for recycled construction and demolition waste is a veritable intervention to divert construction waste from landfill sites. Also in Australia, Shooshtarian et al., (2022b) found out that the prime enablers of CE in the Architecture Engineering and Construction industry include the integration of enabling technologies, the promotion of circularity education, and the proving CE value and benefits. Sohal and De Vass (2022) revealed that leadership commitment is the main factor for the successful implementation of CE in Australia. Giorgi et al. (2022) found out that barriers and drivers for circular economy in the building sector showed that CE policy development, data-driven digital circularity, traceability, and expert training are critical drivers for CE promotion in developed European countries (Belgium, Netherlands, United Kingdom, Denmark, and Italy).

In developing economies, Mangla et al. (2016) found that global competitiveness and regulatory and economic factors are credible factors for enabling reverse logistics In Iran. Yuan (2017) argued that the measures for enhancing effective construction waste management in a CE in China include enforcing construction waste management regulations, collecting and documenting demolition waste, and implementing waste disposal charging fees. Also, Huang et al. (2018) suggested that the 3R CE principles, the development of an efficient CE model, innovative technologies adoption, and the development of targeted economic incentives for the circularity of waste are enablers of CE in China BCI. Mahpour (2018), while investigating the barriers to CE in waste management in Iran, recommended veritable strategies to promote CE adoption. Essential strategies in the study include the execution of more research projects in CE, adoption of advanced technologies, enactment of guidelines for CE in BCI, allocation of sufficient funds for the adoption of CE, mandating construction and demolition waste reporting, familiarization of decision-makers with the benefits of CE, engagement of all stakeholders with responsibilities toward the shift to CE, and clear national actions plans for CE. Bao and Lu (2020) in China posited that the promotion of circularity of concrete and masonry waste in China BCI would be feasible by developing a thriving market for secondary materials and introducing advanced recycling technologies for construction and demolition waste management and certification of secondary materials. Moktadir et al. (2020) identified and prioritized several CSFs for business sustainability in Bangladesh. Still, the study found that leadership and top management commitment are the most important CSF for CE development. Bilal et al., (2020) posited that the promotion of CE workshops, development and guidelines, and CE reward systems are veritable approaches for CE implementation in the construction sector. In India, Yadav et al. (2020) in India on the indicators for promoting SCI.

The study identified big data analytics within any organization as crucial to spreading CE adoption. Salmenperä et al. (2021) showed that the essential factors for enhancing CE in waste management in Finland are illustrating the benefits, sharing of waste-related data, collaboration among key players, and harmonizing CE regulations. Liu et al. (2022) submitted that clinical drivers for waste management in construction include the development of infrastructures for sorting construction and demolition waste in China.

In a systematic review, Wuni (2022) discussed 51 CSFs for circular construction and classified them into 6 clusters: technological, organizational, stakeholders, institutional, management, and supply chain. Hina et al. (2022) discovered that integrating internal and external factors is necessary for a successful circular business model. Another review conducted by Ababio and Lu (2022) classified the enablers of CE into 4 clusters: CE framework development, technology and innovation, policy education and awareness, and financing and market development. Further, Govindan and Hasanagic (2018) review found that CE implementation requires government commitment and regulatory policies.

The above literature highlights previous research on CE implementation drivers, facilitators, and CSFs. These are mainly empirical research and reviews. The empirical studies primarily examine country-specific drivers, facilitators, or CSFs for CE adoption, which limits their applicability to global CE implementation in the BCI. Despite the contributions of extant studies, we can argue that no studies focus on the CSFs for CE implementation based on international professionals' perspectives (developed and developing). Hence investigating the CSFs for attaining CE in the BCI by focusing on the view of experts from developed and developing countries is necessary to enrich the CE body of knowledge.

2.3 Existing research gaps and significant contributions

The opportunities and benefits of CE adoption in BCI are yet to be holistically realized in major world economies (Oluleye et al.,2022). Actualization of CE benefits and establishing a CE that works in the BCI requires several prerequisites. Extant studies have expressed and analyzed the leading CE barriers, indicators, and drivers, from a contextual, review, and international perspective. Also, to understand the condition to promote successful CE, a few studies have analyzed the CSFs for CE adoption in the BCI (Wuni et al., 2021; Hina et al.,2022). The limitations of these studies include i) they are merely confined to identifying CSFs in specific cultural settings, and ii) they failed to consider successful CE application in the construction sector beyond national ambitions to variations between developed and developing countries. Therefore, they are not satisfactory in enabling a successful systemic circularity attainment that could boost BCI's sustainable production and consumption.

As CE has become an international strategic agenda, Giorgi et al (2022) emphasized that its successful implementation requires the joint effort of international professionals (developed and developing economies) in practices and enabling factors to realize the circular flow of materials in a close loop. Nevertheless, comprehensive evaluation of CSFs for CE in BCI based on international experts' perspectives from developed and developing economies is still unexplored. Furthermore, objective quantification of the CSFs from the two economies is barely done in the literature, and evaluation of the consensus in experts' opinions from the two economies is still missing in extant studies. Therefore, these are regarded as the main literature gaps that require investigation.

The main contribution of this study, in comparison with previous studies, is that it modeled the actionable factors that stakeholders in developed and developing economies could adopt when implementing and managing CE in the BCI and evaluated the level of consensus between the two groups (developed and developing) on the CSFs. This research provides a valuable opportunity for organizations and individuals seeking to enter the CE domain to learn from the perceptions of international CE professionals on the checklist of CSFs required for attaining CE in the BCI. To actualize these contributions and meet the highlighted research gap, the EFA, RAA, and FSE approaches were used to analyze the CSFs (Table 1). The details about the methods are provided in the next section.

Table 1: Potential CSFs for attaining CE in the BCI

Codes	Potential Critical Success factors (CSFs)	References
CSF1	Establishment of relevant guidelines for CE adoption in BCDW management	(Bilal et al., 2020; Mahpour, 2018; Yuan, 2017)
CSF2	Effective budget allocation for systemic circularity in BCI	(Ababio & Lu, 2023; Guerra & Leite, 2021; Mahpour, 2018; Mangla et al., 2016)
CSF3	Integrating CE principles into university program curriculums and launch of more CE-based research	(Bilal et al., 2020; Mahpour, 2018)
CSF4	Development of a circular business model and decision support system for BCDW management.	(Hina et al., 2022; Huang et al., 2018; Wuni & Shen, 2022)
CSF5	Avoidance of the use of complex building materials	(Akinade et al., 2017; Mahpour, 2018)
CSF6	Promotion of waste classification and sorting	(Liu et al., 2022)
CSF7	Development of CE metrics and indicators	(de Oliveira et al., 2021; Khadim et al., 2022; Tokazhanov et al., 2022)
CSF8	Tracking the conditions of materials and waste	(Giorgi et al., 2022)
CSF9	Secondary market establishment	(Bao & Lu, 2020; Guerra & Leite, 2021; Shooshtarian et al., 2022c)
CSF10	Mandating construction stakeholders to use secondary materials	(Bao & Lu, 2020; Mahpour, 2018)
CSF11	Development of digitalization initiatives and materials passport promotion for circularity promotion	(Aslam et al., 2020; Bao & Lu, 2020)
CSF12	Clear national plans on CE goals and vision in the BCI	(Mahpour, 2018)
CSF13	Adequate storage of BCDW to avoid degradation	(Yuan, 2017)
CSF14	Mandating reporting and documentation for prediction	(Akanbi et al., 2020; Mahpour, 2018)
CSF15	Familiarization of decision-makers with the benefits of CE principles in BCI	(Govindan & Hasanagic, 2018; Shooshtarian et al., 2022b)
CSF16	New role creation in skills necessary for adopting CE in BCDW management	(Akinade et al., 2017; Mahpour, 2018)
CSF17	Pre-demolition auditing promotion	(Akanbi et al., 2020)
CSF18	Government regular site inspection and supervision of demolition projects toward circularity	(Aslam et al., 2020)
CSF19	Rewards for the BCI that promotes CE adoption and awareness	(Bilal et al., 2020; Huang et al., 2018)
CSF20	Design for disassembly to enhance value creation at EoL	(Akinade et al., 2017)
CSF21	Development of data management tools and valuable insights for value creation at EoL	(Giorgi et al., 2022; Wuni & Shen, 2022; Yadav et al., 2020) and Expert
CSF22	Promotion of workshops among experts on CE principles and implementation	(Bilal et al., 2020; Giorgi et al., 2022; Wuni & Shen, 2022) and Expert
CSF23	Penalties for illegal dumping of BCDW	(Rios et al., 2021) and Expert

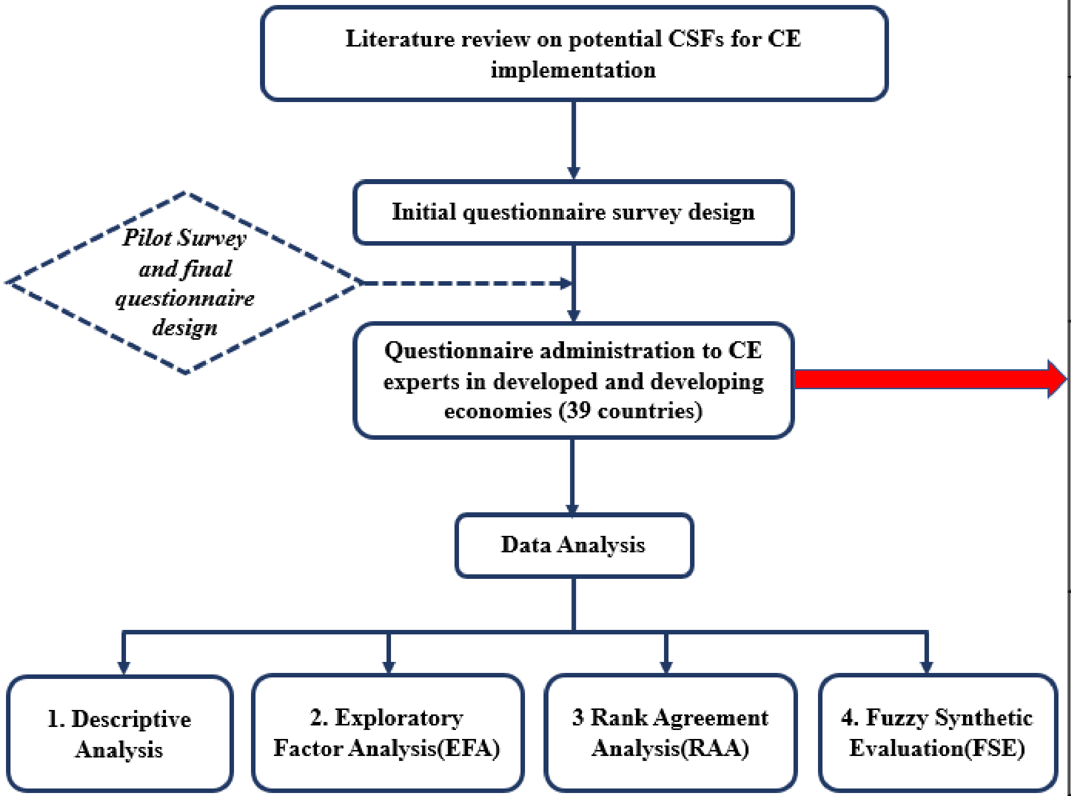
3. Methods

The study used a quantitative research design grounded on a positivist epistemology, with experts serving as the basis for evaluating the CSFs. The research used a multistage methodological framework that included a thorough review of the literature, an expert pilot review, the design and administration of questionnaires, and data pretesting and analysis. The summary of these stages is presented in Figure 1.

3.1 Identification of potential CSFs for attaining CE in the BCI and Pilot survey

To identify the potential CSFs, a review of extant literature was conducted. Consequently, a list of 20 potential CSFs was compiled. The sources for this review are secondary materials such as academic articles and reports. The identified potential CSFs (20) were subjected to a pilot survey.

The study conducted a pilot study with eight construction experts knowledgeable in the research topic to check that the factors were appropriate and comprehensive. They were carefully chosen to reflect the perspectives of many stakeholders and specialists involved in BCI, CE, sustainability, and waste management. Various refinements to the variables' names suggested during the pilot survey were implemented. Also, a validation question for the variables in the questionnaire showed that all the potential CSFs are relevant to the subject based on the pilot study participants' opinions. Also, Additional columns were added to the questionnaire where the pilot study participants (academics and industry experts) can add any other vital factors missing. As a result, three additional factors (now CSFs 21, 22, and 23) were proposed by pilot study participants. The resultant 23 potential CSFs presented in Table 1 form the basis for the data collection.



Respondents' profile			
Categories	**Attributes**	**Frequency**	
		Developed Economies (61)	**Developing Economies (79)**
Continent Distribution	Africa	36	
	Asia	60	
	Europe	29	
	North America	7	
	South America	4	
	Australia/Oceania	4	
Type of Organisations	Public client	14	8
	Private client	7	14
	Project consultant	5	12
	Main contractor	13	6
	Trade contractor	2	1
	Academic and Research institutions	20	38
Years of experience in BCI	1-5 Years	5	
	6-10 Years	7	22
	11-15 Years	15	10
	16-20 Years	10	15
	Above 20 Years	24	10
Years of CE related experience	1 Years	31	42
	2 Years	13	15
	3 Years	6	8
	4 Years	5	2
	Above 4 years	6	12

Figure 1: Methodological framework adopted for this research and the respondents' profile

3.2 Data collection

The primary data source for this study is CE experts in the BCI of developed and developing economies. This study adopted a purposive sampling approach to select experts from industry and academics from the two economies with credible hands-on experience in CE, sustainable construction, and waste management. Academic experts from top construction management and environmental science journals focusing on CE were identified. The industrial practitioners were identified through a LinkedIn search and selected relevant institutes and associations such as Building Research Establishment Environmental Assessment Method (BREEAM)-affiliated members with CE experience. After two months of rigorous search, about 420 experts were identified from developed and developing economies. There are no formulae for selecting sample size in purpose sampling. It all depends on the types of experts needed, the cost, time, and resources available for the study. Due to the selected experts' profiles, cost, and time constraints, it is assumed that the sample size would be appropriate and representative of the population. It is important to note that the diversity in sampling adopted in this study has been established in extant studies, especially in the construction domain; for instance, Saka and Chan (2021) analyzed 228 responses collected from 26 countries, Darko et al. (2017) analyzed 104 experts responses from 20 countries, and recently, (Yevu Sitsofe et al., 2022) analyzed 94 expert opinions from 23 countries. These surveyed sample in extant studies justify the appropriateness of diversity in sample collection from various economies conducted in this current study.

Emails with a weblink and fillable word documents for the survey were sent to the experts to increase the response rate. Further, to enable participation, it was communicated to the respondents that the study's outcome could be made available to them upon request. They were asked to express their professional opinion on the CSFs for implementing a circular economy in the building construction industry towards zero waste using a five-point Likert scale (5 = very significant, 4= Significant, 3 = uncertain, 2 = less significant, and 1 = not significant). The Likert scale is a popular technique in construction management research for rating the relative significance of individual variables based on experts' perceptions.

The potential respondents were also requested to forward the form and link to colleagues who meet the predefined criteria. A period of 3 months was allowed for the data collection. After a series of reminder emails, 277 responses were received, out of which 140 responses (from 39 developing and developed economies) were deemed suitable for this analysis after a series of data cleaning. The response rate was relatively low but acceptable because it is above the minimum threshold of 30 responses required for the central limit theory to make a credible conclusion.

3.3 Respondents' Profile

The analysis of the respondents' profiles showed that the reliability and credibility of the results from this study are high because most of them are engaged by various organizations that participate in circular construction. From the standpoint of developing countries, professionals and specialists working with public clients, private clients, principal contractors, project consultants, and academic/research institutions provided the most responses. In contrast, experts such as project consultants, academics, and clients offered the most responses in developed nations. 75% of respondents from developing countries and 80.33% from developed countries had at least 11–15 years of BCI experience, making them more competent and appropriate to evaluate the CSFs for CE in BCI. Additionally, the responders had substantial years of CE experience in the BCI. The profile distribution of the experts is summarized in Figure 1. Also, the experts' country distribution is provided in the Appendix for reference.

1

3.4 Data analysis

3.4.1 Pretesting of collected data

The collected data were analyzed using IBM SPSS Statistics (v26). All statistical pretesting was done at a 95% confidence interval to guarantee consistency. The Cronbach's Alpha value was used to measure the responses' internal consistency and reliability of the questionnaire. The reliability analysis yielded a Cronbach's Alpha value of 0.978 for the 23 CSFs. Although the value is greater than 0.90, the survey form is not long as it contains 23 variables. Therefore, the constructs are discriminately valid. The Shapiro-Wilk test was conducted to ascertain normality in the data distribution based on the null hypothesis that the sample is normally distributed.

The Shapiro-Wilk test is widely used for normality testing and is considered one of the most potent and reliable tests available (Saka & Chan, 2022). It has higher statistical power and is more robust to outliers and skewness than other normality tests like Anderson-Darling, Lilliefors, or Kolmogorov-Smirnov (Oluleye et al., 2023). The Shapiro-Wilk test is also computationally simpler than other normality tests, such as the Lilliefors test or the Anderson-Darling test, and can be easily implemented in various statistical software packages (Ruxton et al., 2015). Based on these considerations, it was adopted in this study. For this research, the Shapiro-Wilk test was significant at the $\rho<0.05$ significance level, suggesting that the data was not normally distributed (Table 2).

The non-normality of the data implies that further analysis must be less sensitive to the distribution of the data. As a result, rank agreement analysis, exploratory factor analysis, and fuzzy synthetic evaluation analyses were conducted on the data collected. These methods are known to be relatively insensitive to non-normality. By using techniques insensitive to non-normality, we can be more confident in the results of our analysis, even if the data is not normally distributed.

3.4.2 Determining the relative importance of the underlying CSFs for attaining CE in the BCI

The relative importance of the CSFs for implementing CE in BCI was initially assessed using descriptive statistical analysis such as mean, standard deviation, and the mean normalization approach. The mean normalization was conducted to remove variables that may not be considered critical factors in the further analysis if their normalized value is less than 0.5 normalization benchmark. Also, the mean analysis results were deployed as the basis for assigning weights to the CSFs categories (PSFs) using the FSE technique.

3.4.3 Categorizing the CSFs using exploratory factor analysis.

CSFs are few, usually less than 8 (Freund, 1988). Thus, organizing the long list of the CSFs in Table 1 into representative categories for easy handling is reasonable. To unravel the underlying categories of the 18 significant CSFs, exploratory factor analysis (EFA) was conducted. The EFA suitability was examined using various metrics such as sample size to CSF ratio, Kaiser-Mayer-Olkin (KMO) value, anti-image correlation, and Bartlett's Test of Sphericity. The suitability test revealed that the sample size ratio to the CSF is 7:1(140/18), meeting the acceptable EFA threshold. The KMO result of 0.948 was also above the required benchmark of 0.80. The anti-image correlation metrics between the CSFs range from 0.896 to

0.980, more significant than the 0.50 minimum benchmark. Thus, the results of the various metrics demonstrated the fitness of the data for EFA.

Moreover, the EFA was carried out using the principal component analysis as the extraction technique, while Varimax and Kaiser's normalization was used as the rotation method. The rotation converged in 11 iterations and resulted in a 4-factor solution explaining about 79.130% of the variance of CSFs. This forms the basis for the fuzzy synthetic evaluation. The results of the EFA are presented in Table 3. Hereafter, the CSFs were categorized into principal success factors (PSFs) to reduce the cognitive complexity of managing the numerous CSFs.

3.4.4 Determining the agreement level of experts from developed and developing economies Using Rank agreement analysis

The rank agreement analysis (RAA) was conducted to determine the degree of consensus between the two groups of respondents (developed and developing economies). Since the data was not normally distributed, the Mann-Whitney *U* test could also be appropriate. However, the rank agreement analysis was adopted in this study because it can quantitatively reveal the percentage consensus and non-consensus between the two groups, which is quite impossible using the Mann-Whitney U test (Oluleye et al., 2023). In addition, the RAA is quite a popular technique in extant studies (Oyetunji et al., 2022). Using the RAA in this study, the rank agreement factor (RAF) provides information on the degree of consensus in ranking between the two groups (Table 4). RAF near zero implies similar ranking consensus and, if otherwise, suggests high differences in ranking agreement between the two groups within a cluster. The agreement level between the developed and developed countries' contexts in this study was computed using the following steps:

a) Determine the summation of the rank of each CSFs for developed and developing economies within each category(PSF). This is illustrated as:

$$R_a = R_{a1} + R_{a2} \quad (1)$$

Where R_a = Summation of the rank of each CSFs for developed and developing economies within each category(PSF); R_{a1} = rank of each CSF within a PSF for developed economies; R_{a2} = rank of each CSF within a PSF for developing economies.

b) Determine the summation of R_a calculated in (i) for each PSF. This is illustrated as

$$R_b = \sum_{a=1} R_a \quad (2)$$

Where $R_b = summation\ of$ R_a

c) Determine the average mean value of the summation of the rank between the two groups within a component. This is computed using equation (3):

$$R_c = \frac{1}{n}\ x \sum_{a=1}^{n} R_b \quad (3)$$

R_c
$= Summation\ of\ the\ CSFs'\ rank\ within\ a\ group(R_b) divided\ by\ the\ number\ of\ item(n)$

d) Calculate the rank agreement factor(RAF) using its absolute value. The RAF is illustrated with equation (4)

$$\text{RAF} = \frac{\sum_{a=1}^{n} |R_{a1} - R_{a2}|}{n} \quad (4)$$

e) Calculate the maximum rank agreement factor (RAF_{max}) using its absolute value. The RAF max is computed using equation (5)

$$RAF_{max} = \sum_{a=1}^{n} |R_a - R_c| \quad (5)$$

f) Compute the percentage of disagreement(PD), which is given as:

$$PD = \frac{\sum_{a=1}^{n} |R_{a1} - R_{a2}|}{\sum_{a=1}^{n} |R_a - R_c|} X\ 100 \quad (6)$$

g) The agreement percentage (AP) is finally computed as =100 – PD

3.4.5 Determine the level of criticality of the PSFs using the Fuzzy synthetic Evaluation Approach

To evaluate and prioritize CSFs for decision-making, scholars have developed and adopted various fuzzy evaluation methods, including the fuzzy synthetic evaluation (FSE) method and fuzzy multi-criteria decision-making (MCDM) approaches such as Fuzzy AHP, Fuzzy ANP, Fuzzy TOPSIS, Fuzzy VIKOR, etc. The advantage of FSE is that it can evaluate a single object; meanwhile, Fuzzy MCDM approaches depend on a pairwise comparison between multiple variables, leading to selective reversal (Zhang et al., 2019). Moreover, practitioners find it easier to evaluate CSFs in a linguistic rating scale terms (e.g., 5=Very significant, 4=significant, 3=Uncertain, 2=Less Significant, 1=not significant), this scale was adopted for the data collection in this study, and FSE analysis is more suitable in such situation because it gives a precise result. This study adopted the FSE method to evaluate the CSFs for attaining CE in BCI to avoid the acute issues of selective reversal.

Furthermore, the FSE method was adopted to quantify the CSFs categories objectively. This method is suitable because multi-experts and stakeholders are involved in rating the CSFs, and their perceptions are generally tagged with subjectivity and fuzziness. Therefore, the FSE approach is suitable for handling such fuzziness and subjectivity in response to multivariate CSFs. Through the FSE method, the linguistic rating scale (5-point Likert scale) adopted was converted into fuzzy numbers to determine the magnitude of criticalities(FSE index) of the CSFs categories(Wuni & Shen, 2022). The FSE in this study was conducted in six phases, in line with the established protocol put forward in extant studies(Adabre et al., 2022a; Ameyaw & Chan, 2015).

a) Set up the FSE index system for the CSFs and the CSFs categories (hereafter, Principal Success Factors, PSFs) i.e., Q = (q_1, q_2, q_3…q_n);

Q stands for FSE index for level one(PSFs); q_n stands for FSE index system for level two(CSF) and *n* stands for the number of CSFs within a particular PSFs.

b) Establish a set of grade alternatives. The set of grade alternatives is the measurement scale adopted for this study. The grade alternative used(5-point rating scale) to assess the CSFs was defined as R= {1, 2, 3, 4, 5} comprising *R_1 (Not significant), R_2 (less significant), R_3(uncertain), R_4(Significant), and R_5(Very significant).*

c) Calculate the weighting functions of the CSFs and the PSFs. The weightings for each CSFs and PSFs can be computed from the mean scores using equation 7

$W_i = \frac{\mu i}{\sum_{i=1}^{5} ui}$, $0 < w_i < 1$, $\sum_{i=1}^{5} wi = 1$ and $W_i = (w_1, w_2, w_3, \ldots w_n)$ (7)

Where W_i = weightings function of the CSFs/PSFs, and μ_i= mean value of a particular CSF

d) Establishment of the fuzzy evaluation matrix (membership function) for each set of CSFs. The matrix is expressed as $MF_{q_{in}} = \frac{X_{1_{qin}}}{R_1} + \frac{X_{2_{qin}}}{R_2} + \frac{X_{3_{qin}}}{R_3} + \ldots + \frac{X_{j_{qin}}}{R_j}$ (8)

where qin = the n[th] CSF in a given PSF; $MF_{q_{in}}$= MF of a particular CSFs; $X_{j_{qin}}$(j =1, 2, 3, 4,5) denotes the percentage of experts who scored j for the significance of a particular CSF, which measures the degree of membership; $\frac{X_{1_{qin}}}{R_j}$ $denotes\ the\ relationship\ between\ X_{j_{qin}}$ and its grade alternatives.

e) Determine the results for the FSE through the weighting vector and the fuzzy evaluation matrix using equation 9

$D = Wi * T_i$ (9)

Where D = Final fuzzy evaluation matrix(MF of each PSF); W_i represents the weightings function of all CSFs in a PSF; T_i denotes the membership function of all CSFs in a given PSF; "*" indicates the fuzzy composition operator.

f) The final fuzzy evaluation matrix is normalized to determine an objective level of criticalities of the PSFs by using equation 10.

Significance index=$\sum_{i=1}^{n}(D_i\ x\ \ R_i)$ = (D_1, D_2, D_3, D_4, D_5) x (R_1, R_2, R_3, R_4, R_5) (10)

Where D_i = (D_1, D_2, D_3, D_4, D_5) is the fuzzy evaluation matrix or MFs for the PSFs; R_i = (R_1, R_2, R_3, R_4, R_5) is the grade alternatives.

(Detailed sample results of the FSE method are presented in the results section).

4. Results

4.1 Mean ranking of the CSFs for attaining CE in the BCI

The means, standard deviations, and normalization values were calculated for the 23 CSFs based on the responses from developed and developing economies (Table 3). For the developed economies, the top three CSFs include CSF1, "establishment of relevant guidelines for CE adoption in BCDW management (4.08)," CSF23, "penalties on illegal dumping of BCDW (4.05)," and CSF 4, "development of a workable circular business model and decision support system for BCDW management (4.02)." The developing economies have CSF12 "clear national plans on CE goals and vision in the BCI (4.10)," CSF22 "promotion of workshops among experts on CE principles and implementation (4.09)," and CSF23 "penalties on illegal dumping of BCDW (4.05) as the top three CSFs."

Generally, the normalized mean analysis of the overall response revealed 18 significant CSFs for enhancing SCI toward BCDW reduction with values > 0.50 significance benchmark. Thus, it implies that these 18 CSFs should be carefully given attention and integrated to ensure a successful SCI toward BCDW reduction. Therefore, based on the overall mean and normalized values, the top three significant CSF for SCI toward zero BCDW are CSF23 "penalties on illegal dumping of BCDW (4.05)"; CSF22 "promotion of workshops among experts on CE principles and implementation (4.09)," and CSF12 "clear national plans on CE goals and vision in the BCI (4.10)."

Table 2: Mean ranking results of the CSFs for attaining CE in the BCI of developed and developing economies

	Overall					**Developed economies**			**Developing economies**		
Code	μi	δ	Norm.V	Rank	ρ-value	μi	δ	Rank	μi	δ	Rank
CSF1	4.01	1.025	0.86	5	0.00	4.08	0.822	1	3.96	1.160	13
CSF2	3.89	1.030	0.54	17	0.00	3.95	0.865	8	3.85	1.145	21
CSF3	3.97	0.929	0.76	10	0.00	3.97	0.836	5	3.97	1.000	10
CSF4	3.99	0.906	0.81	7	0.00	4.02	0.846	3	3.96	0.953	12
CSF5	3.69	0.997	0.00*	23	0.00	3.69	0.958	23	3.68	1.032	23
CSF6	3.94	0.904	0.68	11	0.00	3.95	0.865	8	3.94	0.938	15
CSF7	3.90	0.962	0.57	16	0.00	3.89	0.968	16	3.91	0.963	16
CSF8	3.92	0.937	0.62	14	0.00	3.89	0.915	14	3.95	0.959	14
CSF9	3.99	0.941	0.81	8	0.00	3.93	0.929	11	4.04	0.953	4
CSF10	3.86	0.979	0.46*	20	0.00	3.82	0.992	21	3.89	0.974	17
CSF11	3.87	0.912	0.51	18	0.00	3.90	0.831	13	3.85	0.975	19
CSF12	4.03	0.952	0.92	3	0.00	3.93	0.854	10	4.10	1.020	1
CSF13	3.83	0.897	0.38*	21	0.00	3.80	0.749	22	3.85	1.001	20
CSF14	3.81	0.974	0.32*	22	0.00	3.89	0.915	14	3.75	1.019	22
CSF15	3.92	0.914	0.62	13	0.00	3.84	0.820	20	3.99	0.980	8
CSF16	3.93	0.870	0.65	12	0.00	3.87	0.885	17	3.97	0.862	9
CSF17	3.91	0.839	0.59	15	0.00	3.84	0.778	19	3.96	0.884	11
CSF18	3.86	0.891	0.46*	19	0.00	3.85	0.792	18	3.87	0.966	18
CSF19	4.02	0.993	0.89	4	0.00	4.02	0.957	4	4.03	1.025	7
CSF20	4.00	0.914	0.84	6	0.00	3.95	0.825	7	4.04	0.980	5
CSF21	3.98	0.877	0.78	9	0.00	3.92	0.843	12	4.03	0.905	6
CSF22	4.03	0.889	0.92	2	0.00	3.95	0.762	6	4.09	0.977	2
CSF23	4.06	0.927	1.00	1	0.00	4.05	0.865	2	4.06	0.979	3

4.2 Principal groupings of the CSFs for attaining CE in the BCI

The EFA detected four structural components of the CSFs for implementing CE practices towards zero waste in BCI. The EFA reduces the complexity of handling the long list of CSFs for CE in BCI and may provide easy-to-understand decision support in allocating scarce resources. It also provides a systematic framework for quantifying the significance of each CSFs and identifying those that contribute the most to CE success in BCI using the FSE approach.

The EFA generated a four-factor solution consisting of PSF1- Data-driven digital tools and circularity plan; PSF2- capacity building and demolition monitoring; PSF3- Systemic circularity guidelines and commitment; and PSF4- Circular metric and secondary market development (Table 3). The PSFs have a stronger association with the CE implementation success in BCI and explain about 79.130% of the total variances in the CSFs for CE implementation towards zero waste in BCI.

Table 3: Factor loading, and eigenvalues of the principal success factors for attaining CE in the BCI of developed and developing economies

Code	PSFs/CSFs	Factor loading				Eigen values	Variance explained (%)
		1	2	3	4		
PSF1 Data-driven digital tools and circularity plan						**4.565**	**21.738**
CSF12	Clear national plans on CE goals and vision in the BCI	0.749	-	-	-		
CSF19	Rewards for the BCI that promotes CE adoption and awareness	0.735	-	-	-		
CSF11	Development of digitalization initiatives and materials passport promotion for circularity of BCDW	0.578	-	-	-		
CSF4	Development of circular business model and decision support system for BCDW management.	0.548	-	-	-		
CSF21	Development of data management tools and useful insights for value creation at EoL	0.526	-	-	-		
CSF20	Design for disassembly to enhance value creation at EoL	0.521	-	-	-		
PSF2: Capacity building and demolition monitoring						**4.496**	**21.411**
CSF23	Penalties for illegal dumping of BCDW	-	0.644	-	-		
CSF22	Promotion of workshops among experts on CE principles and implementation	-	0.592	-	-		
CSF16	New role creation in skills necessary for adopting CE in BCDW management	-	0.591	-	-		
CSF15	Familiarization of decision-makers with the benefits of CE principles in BCI	-	0.509	-	-		
CSF17	Pre-demolition auditing promotion	-	0.508	-	-		
CSF6	Promotion of waste classification and sorting	-	0.503	-	-		
PSF3: Systemic circularity guidelines and commitment						**4.337**	**20.653**
CSF2	Effective budget allocation for circularity of BCDW by the government	-	-	0.793	-		
CSF1	Establishment of relevant guidelines for CE implementation	-	-	0.752	-		
CSF3	Integrating CE principles into university program curriculums and launch of more CE-based research	-	-	0.674	-		
PSF4: Circular metric and market development						**3.219**	**15.329**
CSF8	Tracking the conditions of materials and waste	-	-	-	0.740		
CSF7	Development of CE metrics and indicators	-	-	-	0.727		
CSF9	Secondary market establishment	-	-	-	0.593		
	Total variance explained (%):	-	-	-			**79.130**

4.3 Rank agreement analysis of the principal success factors for attaining CE in the BCI

The clusters generated by the EFA were adopted in enhancing the agreement analysis to ascertain the consensus level between the two groups (developed and developing economies) considered in this study, as presented in Table 5. Using the equations detailed in section 4.4 on the rank agreement analysis, the PD (percentage disagreement) was first computed before determining the agreement percentage (AP) of each cluster (PSFs). Recall Equation (5); the disagreement percentage is illustrated as.

PD = $\frac{\sum_{a=1}^{n} |R_{a1} - R_{a2}|}{\sum_{a=1}^{n} |R_a - R_c|} \; X \; 100$

Thus, for *data-driven digital tools and plan,* and using the corresponding values in Table 4, PD =$\frac{12}{12} \; x \; 100$ =100%

Hence PA is illustrated as, recall equation (6)

AP =100- PD

AP = 0%

Using a similar approach, the AP for capacity building and demolition monitoring (PSF2), systemic circularity guidelines and commitment (PSF3), and circular metric and secondary market development (PSF4) were calculated as 54.5%, 50%, and 100%, respectively as shown in Table 4.

Regarding the PSF1-*data-driven digital tools and circularity plan*, there exists a high degree of divergence in the rank of the two groups of experts (developed and developing countries). *CSF11-development of digitalization initiatives and materials passport promotion for circularity of BCDW* was ranked 6th by the two economies. The other five CSFs (CSF12, CSF19, CSF4, CSF 21, and CSF 20) within this group have a vast mean difference indicating a lack of consensus on the ranking of the two groups. Based on this consideration, the RAA (see Table 4) resulted in a 0% agreement percentage between the two groups(developed and developing countries). Regarding the PSF2-*capacity building and demolition monitoring category*, CSF16-*new role creation in skills necessary for adopting CE in BCDW management* was ranked fifth by the two groups, while CSF17-*pre-demolition auditing promotion* was ranked sixth by the two groups. This relative ranking implies that any nation in the world needs CE-related skills such as pre-demolition auditing-related skills and design for circularity skills.

Moreover, the two groups closely rank other variables under this category. As a result, the rank agreement analysis computed resulted in a 54.50% consensus level between developed economies and developing economies (See Table 5). Concerning PSF3-*Systemic circularity guidelines and commitment*, the two groups of experts ranked CSF2 *effective budget allocation for circularity of BCDW by the government* 3rd. The two groups of experts closely ranked the other two CSFs (CSF1 and CSF3) under this category. As a result, a 50% consensus level was computed to exist between developed and developing economies on this component. This indicated a relative or average agreement level on the need for systemic circularity guidelines and commitment towards CE implementation in any economy. With attention to the *PSF4-circular metric and secondary market development*, the experts from developed and developing countries had a perfect consensus. The two groups ranked CSF9-*secondary market* *establishment, CSF*- tracking of the conditions of materials and waste, and CSF7- *development of CE metrics and indicators* 1st, 2nd, and 3rd under this category, respectively (See Table 4). Due to the equal ranking of these CSFs by the two groups of experts, a 100% consensus level was computed. This indicates a perfect agreement on developing a circular economy metric and secondary market to promote CE in BCI of developed and developing economies.

Table 4: Rank agreement analysis result of the principal success factors for attaining CE in the BCI of developed and developing economies

Code	CSF/PSF	Developed economies			Developing economies			Agreement analysis			
		Mean	SD	R_{a1}	Mean	SD	R_{a2}	R_a	$\|R_{a1}-R_{a2}\|$	$\|R_a-R_c\|$	AP
CSF12	Clear national plans on CE goals and vision in the BCI	3.93	0.854	4	4.10	1.020	1	5	3	2	
CSF19	Rewards for the BCI that promotes CE adoption and awareness	4.02	0.957	2	4.03	1.025	4	6	2	1	
CSF11	Development of digitalization initiatives and materials passport promotion for circularity of BCDW	3.90	0.831	6	3.85	0.975	6	12	0	5	
CSF4	Development of a workable circular business model and decision support system for BCDW management.	4.02	0.846	1	3.96	0.953	5	6	4	1	
CSF21	Development of data management tools and useful insights for value creation at EoL	3.92	0.843	5	4.03	0.905	3	8	2	1	
CSF20	Design for disassembly to enhance value creation at EoL	3.95	0.825	3	4.04	0.980	2	5	1	2	
PSF1 Data-driven digital tools and plan								**R_c = 7**	$\sum_{i=1}^{n} R_{a1} - R_{a2}$**=12**	**Sum =12**	**=0%**
CSF23	Penalties for illegal dumping of BCDW	4.05	0.865	1	4.06	0.979	2	3	1	5	
CSF22	Promotion of workshops among experts on CE principles and implementation	3.95	0.762	2	4.09	0.977	1	3	1	5	
CSF16	New role creation in skills necessary for adopting CE in BCDW management	3.87	0.885	5	3.97	0.862	5	10	0	2	
CSF15	Familiarization of decision-makers with the benefits of CE principles in BCI	3.84	0.820	7	3.99	0.980	4	11	3	3	
CSF17	Pre-demolition auditing promotion	3.84	0.778	6	3.96	0.884	6	12	0	4	
CSF6	Promotion of waste classification and sorting	3.95	0.865	3	3.94	0.938	7	10	4	2	
PSF2: Capacity building and demolition monitoring								**R_c = 8**	$\sum_{i=1}^{n} R_{a1} - R_{a2}$**=10**	**Sum =22**	**=54.5%**
CSF2	Effective budget allocation for circularity of BCDW by the government	3.95	0.865	3	3.85	1.145	3	6	0	**2**	
CSF1	Establishment of relevant guidelines for CE implementation	4.08	0.822	1	3.96	1.160	2	3	1	1	
CSF3	Integrating CE principles into university programme curriculums and launch of more CE-based research	3.97	0.836	2	3.97	1.00	1	3	1	1	
PSF3: Systemic circularity guidelines and commitment								**R_c = 4**	$\sum_{i=1}^{n} R_{a1} - R_{a2}$**=2**	**Sum =4**	**=50%**
CSF8	Tracking the conditions of materials and waste	3.89	0.915	2	3.95	.959	2	4	0	0	
CSF7	Development of CE metrics and indicators	3.89	0.968	3	3.91	.963	3	6	0	2	
CSF9	Secondary market establishment	3.93	0.929	1	4.04	.953	1	2	0	2	
PSF4: Circular metric and secondary market development								**R_c = 4**	$\sum_{i=1}^{n} R_{a1} - R_{a2}$**=0**	**Sum =4**	**=100%**

4.4 Result of the Fuzzy Synthetic Evaluation of the CSFs for attaining CE in the BCI

4.4.1 Weightings of the CSFs and the PSFs

The weightings of the CSFs denote their relative mean value within each PSFs and are computed using equation 7.

$$W_i = \frac{\mu i}{\sum_{i=1}^{5} ui}, \quad 0 < w_i < 1, \text{ where } \sum_{i=1}^{5} wi = 1 \qquad (7)$$

Where W_i denotes the calculated weightings functions of a CSF in its category. W_i is derived by dividing the mean score represented as μi by the summation of all the mean scores of CSFs within the PSFs. For example, using the PSF1 (*data-driven digital tools and plan),* for developed economies, the weightings of the underlying CSFs "*development of digitalization initiatives and materials passport promotion for circularity of BCDW"* is computed as:

$W_i = \frac{3.9}{3.93+4.02+3.9+4.02+3.92+3.95} = 0.164$ (as presented in Table 5)

Likewise, the weightings of PSF is calculated by dividing their mean score (derived by summing the mean values of all the CSFs in a PSF) by the sum of the mean values of all the PSFs categories. For example, the weightings of *Data-driven digital tools and plan* -PSF1 for developed economies is calculated as:

W_i (*Data-driven digital tools and plan* -PSF1) = $\frac{23.74}{23.74+23.50+12+11.71}$ =0.335 (as presented in Table 5)

Using a similar approach, the weightings of other CSFs and PSFs are calculated (see Table 5)

4.4.2 The membership function of the CSFs and the PSFs

The membership function (MF) refers to the degree of an element's membership in a fuzzy set. It usually ranges between 0 and 1. The MF of each CSFs (level 2) and PSFs (level 1) can be generated using fuzzy mathematics. The MFs of level 2 are first computed before the MFs of level 1. Recall the grade alternatives for evaluating the CSFs defined as R_1 (Not significant), R_2 (less significant), R_3(uncertain), R_4(Significant), and R_5(Very significant). Therefore, the MF of each CSFs is computed as:

$$MF_{q_{in}} = \frac{X_{1_{qin}}}{R_1} + \frac{X_{2_{qin}}}{R_2} + \frac{X_{3_{qin}}}{R_3} + \frac{X_{4_{qin}}}{R_4} + \frac{X_{5_{qin}}}{R_5}$$

Where qin = the nth CSF in a given PSF; MF_{qin}= MF of a particular CSFs; $X_{j_{qin}}$(j =1,2,3,4,5) denotes the percentage of experts who scored *j* for the significance of a particular CSF, which measures the degree of membership; and $\frac{X_{j_{qin}}}{R_j}$ denotes the relationship between $X_{j_{qin}}$ *and its grade alternative*.

Using this approach, the MF for all the CSFs can be computed. So, for example, *development of digitalization initiatives and materials passport promotion for circularity of BCDW (CSF11)* for developed economies, 3.3% rated it to be not significant, 3.3% rated it to be less significant, 9.8% were uncertain, 67.2% rated it significant, and 16.4% rated it very significant, then, MF(CSF11) of *development of digitalization initiatives and materials passport promotion for circularity of BCDW* could be expressed as:

$MF_{CSF11} = \frac{0.03}{R_1} + \frac{0.03}{R_2} + \frac{0.01}{R_3} + \frac{0.67}{R_4} + \frac{0.16}{R_5}$, Alternatively, the MF for CSF11 is written as:

(0.03, 0.03, 0,01, 0,67, 0,16)

After obtaining the MFs of the CSFs, the MFs of the PSFs (also known as the final fuzzy evaluation matrix) could be determined using equation 9..

Recall that $D = W_i * T_i$

Where D = Final fuzzy evaluation matrix(MF of each PSF); W_i= Weightings of a CSFs within a PSF, and T_i =is the fuzzy evaluation matrix (membership function of the CSFs in each PSF as presented in Table 5).

Therefore, considering PSF1*(Data-driven digital tools and plan*) for developed economies, the weightings of all its underlying CSFs (i.e. CSF12, CSF19, CSF11, CSF4, CSF21, and CSF20) under this PSF1 can be expressed as:

W_i= (0.166, 0.169,0.164,0.169,0.165,0.166)

Also, MFs of the CSFs within the group are presented in a matrix and expressed as:

$$T = \begin{pmatrix} 0.03 & 0.02 & 0.15 & 0.59 & 0.21 \\ 0.05 & 0.00 & 0.15 & 0.49 & 0.31 \\ 0.03 & 0.03 & 0.01 & 0.67 & 0.16 \\ 0.03 & 0.12 & 0.10 & 0.61 & 0.20 \\ 0.02 & 0.02 & 0.13 & 0.59 & 0.22 \\ 0.03 & 0.00 & 0.16 & 0.59 & 0.21 \end{pmatrix}$$

From these, the membership function (final fuzzy evaluation matrix) for PSF1 is computed as

$$D1 = (0.166, 0.169, 0.164, 0.169, 0.165, 0.166) \quad X \quad \begin{pmatrix} 0.03 & 0.02 & 0.15 & 0.59 & 0.21 \\ 0.05 & 0.00 & 0.15 & 0.49 & 0.31 \\ 0.03 & 0.03 & 0.01 & 0.67 & 0.16 \\ 0.03 & 0.12 & 0.10 & 0.61 & 0.20 \\ 0.02 & 0.02 & 0.13 & 0.59 & 0.22 \\ 0.03 & 0.00 & 0.16 & 0.59 & 0.21 \end{pmatrix}$$

= (0.03, 0.03, 0.12, 0.59, 0.22) as presented in Table 5.

Using the same approach, the MFs for the rest of the PSFs were computed and presented in Table 5. The MFs of all the PSFs enabled the computation of the criticalities of the PSF for CE in BCI.

4.4.3 Criticalities indices of the PSFs for attaining CE in the BCI

After determining the MFs for each PSFs in developed and developed economies, the criticalities index for each PSFs for the two economies was computed (See Table 6). This is computed using the MFs of the PSFs and the grade alternatives. This is achieved using the formulae (Recall equation 10)

Criticality index=$\sum_{i=1}^{n}(D_i \ x \ R_i)$ = (D1, D2, D3, D4, D5) x (R_1, R_2, R_3, R_4, R_5)

Where D_i = (D_1, D_2, D_3, D_4, D_5) is the fuzzy evaluation matrix or MFs for the PSFs and $R_i =$ (R_1, R_2, R_3, R_4, R_5) is the grade alternatives. Therefore, the *criticality indices of the PSFs from the developed economies* are computed as follows:

PSF1= (0.03, 0.03, 0.12, 0.59, 0.22) * (1, 2, 3, 4, 5) = 3.91

PSF2 = (0.03, 0.01, 0.15, 0.59, 0.19) *(1, 2, 3, 4, 5) = 3.81

PSF3= (0.03, 0.02, 0.12, 0.61, 0.24) *(1, 2, 3, 4, 5) = 4.07

PSF4= (0.20, 0.02, 0.13, 0.59, 0.22) *(1, 2, 3, 4, 5) = 4.09

Likewise, *the criticality indices of the PSFs from the developing economies*

PSF1= (0.03, 0.05, 0.15, 0.44, 0.34) * (1, 2, 3, 4, 5) = 4.04

PSF2= (0.03, 0.03, 0.17, 0.45, 0.32) * (1, 2, 3, 4, 5) = 4.00

PSF3= (0.07, 0.04, 0.14, 0.42, 0.34) * (1, 2, 3, 4, 5) = 3.95

PSF4= (0.03, 0.05, 0.16, 0.47, 0.29) * (1, 2, 3, 4, 5) = 3.94

The PSF's criticality indices indicate their prioritization and level of significance to the success of systemic circularity attainment in BCI and ranking the benefits of systemic circularity execution in the BCI. Table 6 shows the criticality indices of the PSFs and their rankings. From Table 6, all the criticality indices for PSFs in developed and developing economies are above 3.50 based on the 5-point Likert scale used. Hence, they are all considered significant to systemic circularity attainment in the BCI.

Table 5: FSE (Weightings and membership functions) of the CSFs for attaining CE in the BCI of developed and developing economies

PSFs/CSFs	Developed countries				Developing countries			
	Mean	**Wi**	**MF for level II**	**MF for level I**	**Mean**	**Wi**	**MF for level II**	**MF for level I**
PSF1: Data-driven digital tools and plan	**23.74**	**0.335**		**(0.03,0.03,0.12,0.59, 0.22)**	**24.01**	**0.335**		**(0.03,0.05, 0.15, 0.44, 0.34)**
CSF12	3.93	0.166	(0.03, 0.02, 0.15, 0.59, 0.21)		4.10	0.171	(0.04, 0.04, 0.13 ,0.38,0.42)	
CSF19	4.02	0.169	(0.05, 0.00, 0.15, 0.49, 0.31)		4.03	0.168	(0.04, 0.04, 0.17, 0.38, 0.38)	
CSF11	3.90	0.164	(0.03, 0.03, 0.01, 0.67, 0.16)		3.85	0.160	(0.04, 0.05, 0.18, 0.49, 0.24)	
CSF4	4.02	0.169	(0.03, 0.12, 0.10, 0.61, 0.25)		3.96	0.165	(0.03, 0.06, 0.13, 0.50, 0.29)	
CSF21	3.92	0.165	(0.03, 0.02, 0.15, 0.61, 0.20)		4.03	0.168	(0.03, 0.03, 0.17, 0.47, 0.32)	
CSF20	3.95	0.166	(0.03, 0.00, 0.16, 0.59, 0.21)		4.04	0.168	(0.03, 0.05, 0.15, 0.41, 0.37)	
PSF2: Capacity building and demolition monitoring	**23.5**	**0.331**		**(0.03,0.01, 0.15, 0.59, 0.19)**	**24.01**	**0.335**		**(0.03,0.03, 0.17, 0.45, 0.32)**
CSF23	4.05	0.172	(0.03, 0.00, 0.15, 0.53, 0.30)		4.06	0.169	(0.03, 0.05, 0.14, 0.41, 0.38)	
CSF22	3.95	0.168	(0.03, 0.00, 0.12, 0.69, 0.16)		4.09	0.170	(0.04, 0.01, 0.17, 0.39, 0.39)	
CSF16	3.87	0.165	(0.03, 0.03, 0.16, 0.57, 0.20)		3.97	0.165	(0.03, 0.03, 0.15, 0.54, 0.25)	
CSF15	3.84	0.163	(0.03, 0.00, 0.23, 0.57, 0.16)		3.99	0.166	(0.04, 0.03, 0.18, 0.43, 0.33)	
CSF17	3.84	0.163	(0.03, 0.03, 0.10, 0.74, 0.10)		3.96	0.165	(0.03, 0.01, 0.22, 0.47, 0.28)	
CSF6	3.95	0.168	(0.03, 0.02, 0.15, 0.57, 0.23)		3.94	0.164	(0.03, 0.05, 0.17, 0.48, 0.28)	
PSF3:Systemic circularity guidelines and commitment	**12.00**	**0.169**		**(0.03, 0.02, 0.12, 0.61, 0.24)**	**11.78**	**0.164**		**(0.07,0.04, 0.14, 0.42, 0.34)**
CSF2	3.95	0.329	(0.03, 0.03, 0.10, 0.62, 0.21)		3.85	0.327	(0.08, 0.04, 0.17, 0.41, 0.32)	
CSF1	4.08	0.340	(0.03, 0.00, 0.10, 0.59, 0.30)		3.96	0.336	(0.08, 0.05, 0.08, 0.43, 0.38)	
CSF3	3.97	0.331	(0.03, 0.02, 0.12, 0.62, 0.21)		3.97	0.337	(0.04, 0.04, 0.17, 0.43, 0.33)	
PSF4:Circular metric and market development	**11.71**	**0.165**		**(0.20, 0.02, 0.13, 0.59, 0.22)**	**11.90**	**0.166**		**(0.03,0.05, 0.16, 0.47, 0.29)**
CSF8	3.89	0.332	(0.05, 0.02, 0.13, 0.61, 0.20)		3.95	0.332	(0.04, 0.03, 0.18, 0.49, 0.29)	
CSF7	3.89	0.332	(0.05, 0.03, 0.13, 0.56, 0.23)		3.91	0.329	(0.03, 0.06, 0.17, 0.47, 0.28)	
CSF9	3.93	0.336	(0.50, 0.02, 0.12, 0.59, 0.23)		4.04	0.339	(0.03, 0.05, 0.13, 0.46, 0.29)	

4.4.4 Developing the overall PSF model for attaining a systemic circularity in the BCI of developed and developing economies.

The final step in the FSE modeling process is developing a PSFs model for developed and developing economies. A linear model was chosen due to its simplicity and ease of understanding for industry professionals and other stakeholders (Olawumi & Chan, 2022). Before creating the composite linear model, the criticalities index of the PSFs was normalized to ensure that the sum of the coefficients equaled unity. Normalizing the PSF is logical and valid, as it helps to illustrate better the relative activity between the criteria in the linear equation (Osei-Kyei & Chan, 2017). In addition, it allows the differing scale of measurements to be used when assessing the CSFs for attaining systemic circularity in the BCI.

The PSF model for attaining systemic circularity in developed economies is expressed as:

$$Y = 0.246 (PSF1) + 0.240 (PSF2) + 0.246 (PSF3) + 0.258 (PSF4) \quad (11)$$

Also, the PSF model for attaining systemic circularity in developing economies is expressed as:

$$Y = 0.254 (PSF1) + 0.251 (PSF2) + 0.248 (PSF3) + 0.247 (PSF4) \quad (12)$$

Where Y = The PSF model for attaining systemic circularity in the BCI of developed/developing economies

Table 6: Criticalities indices and coefficients of the PSFs for attaining systemic circularity in the BCI of developed and developing economies

Codes		Developed economies			Developing economies		
	PSFs	Criticality index	Rank	[a]Coefficient	Criticality index	Rank	[a]Coefficient
PSF1	Data-driven digital tools and circularity plan	3.91	3	0.246	4.04	1	0.254
PSF2	Capacity building and pre-demolition monitoring	3.81	4	0.240	4.00	2	0.251
PSF3	Systemic circularity guidelines and commitment	4.07	2	0.256	3.95	3	0.248
PSF4	Circular metric and secondary market development	4.09	1	0.258	3.94	4	0.247
	Total	15.88		1.00	15.93		1.00

Note: [a]Coeffcient = criticality index for a given PSF/Summation of the criticality index

5.0 Discussion

This section elaborates vital research findings of this study by comparing the findings with past studies. It also provides information on the study's implications to management science and environmental experts. Finally, it draws interesting areas that should be considered in future research toward promoting sustainable production and consumption in BCI via a CE.

5.1 Principal success factors for attaining systemic circularity in the BCI of developed and developed economies

The EFA categorized the significant CSFs for attaining a systemic circularity in the BCI of developed and developing economies into four principal success factors (PSFs). They include PSF1(*data-driven digital tools and circularity plan,* PSF2 (*capacity building and pre-demolition auditing),* PSF3 (*systemic circularity guidelines and commitment),* and PSF4 (*circular metrics and secondary market development*).

5.1.1 Data-driven digital tools and circularity plan

Data-driven digital tools and circularity plan (PSF1) for attaining a systemic in the BCI ranked 1st and 3rd by developing and developed economies experts with fuzzy criticality index of 4.04 and 3.91, respectively. The result of FSE indicated that although the two economies have varied rankings regarding the PSF1, the factor is significant for a successful CE in the two groups. Therefore, attaining a systemic circularity in the BCI requires integrating data-driven technologies and a circularity plan. This approach is the future of a successful CE implementation as it can reshape waste management practice in the BCI.

This component (PSF1) explains 21.738% of the total variance with six underlying CSFs. One of the significant factors within this category is the development of digitalization initiatives and materials passport promotion for the circularity of BCDW(CSF11), highlighting the need to integrate digital technologies to promote various aspects of the CE. This factor (CSF11) has a more decisive influence on all other ingredients of CE implementation. Rios et al. (2022) argued that data-driven tools involve design, production, distribution, and business models. Therefore, CSF11 can promote the development of data management tools (CSF21), enabling value creation at EoL of materials in the BCI.

Most importantly, a data-driven approach with a faster agile learning process and iterative cycles of designing and prototyping, such as artificial intelligence, blockchain, and computer vision, is a crucial prerequisite to achieving a meaningful CE implementation in the BCI (Oluleye et al., 2023b). It can further enable data collection and interpretation more effectively as the basis for circular business model innovation (CSF4) for redesigning circular products and a more objective circular assessment of products in the BCI. According to Wuni and Shen (2022), CBM innovation is a critical mechanism for implementing the CE at the organizational level, as it allows for a systematic change in the underlying logic of firms and the alignment of incentives of various stakeholder groups.

Furthermore, integrating these initiatives will influence the BCI's overall production and consumption pattern through digitalized circular design promotion, especially the promotion of design for disassembly (CSF20). The ease of disassembly of materials at the end of life in the BCI is a crucial prerequisite to guarantee the effective recovery or parts in a CE. This supports the arguments of Akinade et al. (2017) that deconstruction, or the disassembly of buildings piece by piece, allows for the recovery of building materials and components once buildings reach the end of their useful lives and promotes economic and ecological sustainability. However, digital technology is imperative to make sense of the design process for disassembly. Moreso, within the PSF1, clean national plans on CE goals and vision in the BCI (CSF12) and rewards for the BCI that promotes CE adoption (CSF19) are other important factors for enabling CE in BCI of developed and developing economies. This implies that to achieve digitalization and other CSF within this group, proper planning and vision set aside with rewards for the organization pushing this CE frontier forward must be given attention. Bilal et al., (2020) submitted that one of the key actionable factors to enable CE development is motivating the BCI that advocates for CE through rewards in the form of subsidies for eco-friendly materials.

The findings of this study agreed with the study conducted in developed economies (USA, Australia, Belgium, Netherland, United Kingdom, Germany, and Italy) by; Rios et al. (2021), Shooshtarian et al. (2022b); Giorgi et al. (2022) and Neligan et al. (2022) that digitalization, data management, and effective circularity plan are decisive, actionable factors necessary to be given attention to achieve a circular economy. Also, regarding extant studies conducted in developing economies, this study supports the findings of Huang et al. (2018) in China and Mahpour (2018) in Iran that the 3R principles of CE can be implemented successfully in management of BCDW if innovative technologies and circular business model are linked with CE practices in BCI.

5.1.2 Capacity building and pre-demolition auditing

Capacity building and pre-demolition auditing (PSF1) were ranked 2nd and 4th by developing and developed economies experts with FSE indexes of 4.00 and 3.81, respectively. The FSE index indicated that the development of capacities for CE and pre-demolition auditing is significant in the two economies investigated but with varied allocative functions during integration. This component (PSF2) explained about 21.411% of the variance in the CSFs with six significant underlying CSFs. Among the various CSF within PSF2 include penalties for illegal dumping of BCDW (CSF23). This highlights the need to force the construction industry to adopt CE by imposing high penalties on waste dumping at landfills. According to a study conducted by Rios et al. (2021), imposing fines in the form of very high landfill taxes and sanctions are viable enablers of CE which will trigger BCI to develop capacities to minimize waste at the end-of-life of material to avoid the increased penalties.

Furthermore, to promote CE attainment in developed and developed economies, the promotion of workshops among experts on CE principles and implementation (CSF22) should be given full attention. For example, improving the competencies of the management team, such as for architects and design engineers, designers, demolition contractors, and engineers on the various key aspect of CE are necessary to achieve a systemic circularity in the BCI(Giorgi et al., 2022; Wuni & Shen, 2022). Moreover, since many construction stakeholders are still not adequately versed in the issues surrounding CE implementation, it is fundamental to support them by creating new roles necessary for adopting CE in BCDW management (CSF16). This will increase CE expertise in the BCI and prepare them for the rigor behind CE adoption (Bilal et al.,2018).

Also, familiarizing decision-makers with the benefits of CE principles in BCI(CSF15) is another significant actionable factor for CE implementation in developed and developing economies. According to a study conducted by (Salmenperä et al., 2021; Shooshtarian et al., 2022b), CE promotion can be actualized if its benefits and added value are evident to the stakeholders. This will drive them to develop the necessary competencies to promote CE adoption. Promoting waste classification and sorting (CSF6) is another significant factor within this cluster. This highlights that in any nation, effective sorting of waste in the BCI during construction or deconstruction is a practical approach to determining the circularity potential of the materials. The final significant factor within this category is the promotion of pre-demolition auditing (CSF17), with a mean value of 3.95 and 3.94 based on the opinion of developed and developing economies, respectively. Effective CE in the BCI requires accurately estimating the quantity of materials from deconstruction. This often facilitates adequate planning for materials reuse at the end of life. Pre-demolition auditing is a valuable factor that gives helpful information to stakeholders such as clients, architects, planners, and engineers in the BCI to optimize existing buildings as part of the deconstruction process (Akanbi et al., 2020). Promoting this would guide stakeholders to predict the quantity of materials that will be reused, recycled, remanufactured, and recovered before the deconstruction of a building which is a critical step in CE implementation (Martinez et al., 2022).

The findings based on this category (PSF2) are in tandem with previous studies conducted by (Akanbi et al., 2020; Akinade et al., 2017) where it was submitted that pre-demolition auditing promotion, capacity building through training and improving the competencies of professionals connected with CE implementation in the BCI with the necessary skills are fundamental to zero waste attainment in the BCI. Hence, training on circular design, design for waste prevention, sorting and classifying construction waste, and the pre-demolition auditing process should be reinforced to reap the full benefits of CE in BCI.

5.1.3 Systemic circularity guidelines and commitment

PSFs was ranked 3rd and 2nd by developing and developed economies experts with a FSE index of 3.95 and 4.07, respectively. Systemic circularity guidelines and commitment are significant to the success of CE attainment in developed and developing economies based on the FSE index computed. This component constitutes three CSFs with an Eigenvalue of 4.337 and explained 20.653% of the total variance in the CSFs. Establishing relevant guidelines for systemic circularity implementation (CSF1) is one of the significant factors within this category, with a mean value of 4.08 and 3.96 based on the opinion of developed and developing economies, respectively. According Antwi-Afari et al. (2022a), guidelines for recycling, reuse, and recovery of materials along the building lifecycle are a powerful management tool for CE implementation in BCI. These guidelines could be presented as policies and circularity requirements at each stage of the building lifecycle, enabling accurate assessment of materials' recovery potentials (Eberhardt et al., 2020).

Another important CSFs within this category is the government's effective budget allocation for circularity of BCDW (CSF2) with a mean value of 4.08 and 3.96 based on the opinion of developed and developing economies, respectively. This indicates that government commitment to CE through adequate funding is a significant backbone for CE implementation in the BCI (Guerra & Leite, 2021). This is imperative due to the capital-intensive nature of CE implementation. The last factor within this group is integrating CE principles into university program curriculums and launching more CE-based research (CSF3). This implies that the development of CE should begin in academic institutions through the improvement of curriculum to incorporate CE initiatives and support for more novel CE research by the government (Mahpour 2018).

From the developed economies context, this finding concurs with the study conducted by Sohal and De Vass (2022) in Australia where it was stated that appropriate guidelines and total commitment from the government via funding for CE promotion usually enable the successful implementation of CE in developed economies. Also, the studies conducted in Bangladesh by Moktadir et al. (2020) and in Iran by Mahpour (2018) agree with the findings of this study that the development of practical guidelines supported by a commitment from the government is veritable actionable factors for enabling effective CE implementation in developing economies.

5.1.4 Circular metrics and secondary market development

The circular metric and secondary market development (PSF4) was ranked 4th and 1st by developing and developed economies experts with FSE index of 3.94 and 4.09, respectively. PSF4, with an eigenvalue of 3.219, explained 15.329% of the variance in the CSFs. Within this category are three CSFs (CSF8, CSF7, and CSF9). Based on the perspectives of developed and developing economies, the most significant among them is the secondary market establishment (CSF9), with mean values of 3.93 and 4.04. The findings of this study based on the developed support the arguments of Shooshtarian et al. (2022c) in Australia and Bao and Lu (2020) in China that the development and promotion of a market for recycled building and demolition waste have emerged as a targeted intervention to divert waste from landfill sites, offer waste materials a second life and motivated the demand for and the supply of secondary materials.

The next significant CSF within PSF4 is tracking the conditions of materials and waste (CSF8), ranked 2nd by developed and developing economies with mean values of 3.89 and 3.95, respectively. Tracking the condition of materials or their circularity is very important for decision-making. For example, the study conducted by Giorgio et al. (2022) in European countries confirmed that to successfully implement CE in the building sector, attention must be paid to tracking the condition of materials to guide decision-making.

The last factor within this category is the development of CE metrics, tools, and indicators (CSF7), ranked 3rd by developed and developing economies with mean values of 3.89 and 3.91, respectively. According to Khadim et al. (2022), measuring and reporting CE progress is helpful in any economy's CE transition. The study of Tokazhanov et al. (2022) agrees with this finding that the development of methods, tools, and key performance indicators, is pertinent in CE implementation in BCI as it allows the evaluation of progress towards the CE targets. de Oliveira et al. (2021) argued that a holistic indicator covering the various scales/levels of CE, such as macro (city and region), meso (industrial symbiosis), micro (building), and nano(materials), needs to be developed to promote a standardized circularity measurement and assessment. This will further enable performance benchmarking against sustainable and circular ambition towards formulating an equitable pathway in aching for zero waste.

5.2 Rank agreement analysis of the PSFs for attaining systemic circularity in the BCI of developed and developed economies

Regarding the rank agreement analysis, findings revealed varied levels of consensus and non-consensus among the PSF. For example, regarding data-driven tools and circularity plan (PSF1), a total non-consensus in the opinion of the two groups (developed and developing). Also, RAA revealed a consensus on the ranking of the two groups on capacity building and pre-demolition auditing (PSF2). Furthermore, the study found that an average level of agreement exists between the two groups on systemic circularity guidelines and commitment (PSF3). Concerning circular metrics and secondary market development (PSF4), a perfect level of consensus was computed for the two groups investigated based on the ranking of the underlying CSFs. These findings indicate that implementing CE in BCI of developed and developing economies requires different mix ratios of the underlying CSFs within the PSFs. A CSF may require more proportion in the developed economies but less ratio in the developing economies, even though it is significant to the success of CE implementation. Therefore, the findings echo the need to be context conscious in adopting the CSFs for CE implementation. These findings support the argument of Oluleye et al. (2023a) that CE practice must consider cultural differences and contextual variations to achieve a practical implementation in the BCI. Also, CircleEconomy (2023), CE execution does not always look the same in all contexts. Some contexts need to reduce materials extraction radically, while others need to stabilize and grow.

5.3 Implications of the study

The CSFs identified and evaluated in this study based on the perspective of developed and developing economies CE professionals have substantial implications for promoting resource-efficient consumption practices and achieving a zero-waste environment in the construction sector. Theoretically, this study contributes to the existing body of literature by focusing on the diverse perspectives of experts from different regions instead of limiting the analysis to a single country. Furthermore, the evaluated CSFs provide an effective theoretical framework of actionable factors critical to achieving CE in the BCI of both developed and developing economies.

This study also provided an easy-to-handle structure of the long list of CSFs into PSFs for attaining CE in BCI. The PSF model result could serve as a resource allocation function for stakeholders when implementing CE in the BCI. Understanding and implementing the required PSFs would eliminate waste in the BCI and promote the continual use of construction materials. This will eventually protect the depletion of the finite construction resources in the environment and improve the quality of biodiversity. Furthermore, this study established that although CE is a global initiative, the mix of the actionable factors required for its successful implementation is not usually the same in developed and developing economies. This understanding will guide practice on the need to be context conscious in integrating the CSFs for CE implementation in the BCI.

Also, the findings from the FSE analysis conducted have immense managerial implications for the torchbearers of circular economy in BCI, such as deconstruction engineers, designers, architects, builders, government and regulatory agencies in developed and developing economies on the relevant actionable factors that must be incorporated to promote sustainable consumption of resources in a CE in their BCI. The study can guide the government to pay more attention to developing practical systemic circularity guidelines with total commitment to boosting the environmental consciences of stakeholders in the BCI. It also highlights the need for government to support CE development through funding for CE research to realize systemic circularity agenda. Further, it provides actionable factors that can guide regulatory agencies in developing integrated regulations and policies to promote design for disassembly, reverse logistics, reuse, recycling, industrial symbioses, and recovery. This study offers CE stakeholders a more precise understanding that if we do not measure, we cannot track progress meaningfully, nor can we ultimately locate the most impactful avenues. Hence it provides sound evidence that measuring and tracking circular performance will enable actors to set goals, peer review, measure, and benchmark performance. It will also allow them to track progress against their sustainable and circular ambitions or goals and formulate practical pathways aligned to local contexts.

The study documents the need for the government and concerned torchbearers of CE to consider the development of the secondary market for circular products as one of the actionable areas that, if achieved, will lead to the realization of CE in the BCI by encouraging secondary products consumption and reduction of virgin materials consumption. Also, due to the slow pace of CE implementation in most developing countries, data-driven digital tools and plans are essential. This study provides all stakeholders with information on the contribution of digital technology, such as artificial intelligence and blockchain, in realizing the mission of CE in BCI from the beginning of life to the end of life of materials. For example, in design for disassembly, selection of circular materials, materials strength prediction, reverse logistics, and effective end-of-life management in a CE to avoid value loss in materials. The study also provides BCI stakeholders in the CE domain insight into how optimization of circular business model will lead to successful circular materials pricing, demand prediction, and trading platform development.

This study provides insight to guide the deconstruction and demolition team on the need for pre-demolition auditing to predict the material's end of life in a CE. It also provides information for all stakeholders on the need to promote capacity building in the domain of CE. Notably, the competencies of designers, demolition contractors, and all stakeholders would be improved through sustainability education and workshop for the circular economy. Finally, this study's findings can benefit various nations that intend to implement CE in their BCI towards zero waste production. They can learn from the opinions of experts worldwide analyzed in this study on the CSFs required to enable a successful CE implementation in their respective countries.

5.4 Future research directions

This research is based on quantitative data from experts across developed and developing economies. Future researchers should adopt a qualitative or semi-structured interview approach on the CSFs for CE adoption in the BCI. Also, this study adopted the FSE approach to determine the significance of the PSFs for CE implementation in the BCI, but the method has limitations. Therefore, similar analytical tools, such as a Pythagorean fuzzy analytic hierarchy process (AHP) and best-worst-method (BWM), could be adopted in future studies. Furthermore, this study is limited to the BCI; the context may be extended to other industrial sectors. Future studies could develop a more rigorous decision support system for CE adoption in the BCI based on the CSFs investigated. Also, research on the influence of the CSFs on CE adoption in the BCI could be conducted in the future. In addition, future studies could use the PSFs to develop a pathway model for zero waste via a CE in the BCI. Finally, future research may be conducted on predicting CE adoption in the BCI.

6.0 Conclusions

The need for CE implementation in the BCI is uncontested due to its significant contribution to the growing scarcity of natural resources, municipal waste, and adverse environmental impact. However, enabling the widespread implementation of a successful CE goes beyond the national agenda to incorporate both developing and developed economies' perspectives, especially on the critical success factors (CSFs) that need to be upheld to achieve zero waste and lead the BCI to a systemic circularity and sustainable development. Therefore, this study attempted to evaluate the CSFs for attaining systemic circularity in the BCI by soliciting the view of 140 CE experts (developed and developing economies) across 39 countries rather than experts in a particular country. The data collected were analyzed using EFA, RAA, and FSE techniques. The EFA helps organize the long list of CSFs into comprehensive and representative categories for easy handling and the FSE approach. The RAA helps to understand the degree of consensus between the two groups (developed and developing economies respondents) on the PSFs. The FSE helps to establish the level significance indices of the PSFs for the two groups.

The EFA resulted in 5 PSFs, including data-driven digital tools and circularity plans, capacity building and pre-demolition monitoring, systemic circularity guidelines and commitment, and circular metric and secondary market development. The findings of the RAA showed that the two groups (the developed and developing economies) have no consensus on data-driven digital tools and circularity plans and a relative consensus on capacity building and pre-demolition monitoring. Also, the RAA result showed that the two groups have an average level of agreement on systemic circularity guidelines and commitment; and have a perfect consensus on circular metrics and secondary market development. The FSE analysis results show that all the PSFs are significant in the two economies. However, in developed countries, systemic circularity guidelines and commitment, circular metrics and secondary market development are more significant PSFs. In developing economies, data-driven digital tools and circularity plans, and capacity building and demolition monitoring are the most important categories.

The findings of this study have significant contributions and implications for management and practice. First, the study contributes to the body of knowledge by considering the view of international CE experts on the required CSFs for attaining CE in the BCI rather than experts from a particular country. Second, the findings of the EFA show a few actionable factors (PSFs) that could guide construction teams and other stakeholders in attaining systemic circularity in the BCI. The 4 PSFs derived in this study add to the building block of the theory of CSFs for CE in BCI. Third, the findings of the RAA demonstrated contextuality in the CSFs for enabling CE implementation in BCI. This shows that experts from developed and developing economies with hands-on experience in CE in BCI could have varied or similar preferences on the CSFs that could enable CE implementation. This will guide government and project teams to be context conscious while integrating the CSFs into construction activities. Fourth, the study prioritized the few areas where a satisfactory result can improve the success of CE in BCI using the FSE approach. Therefore, it contributes to the practitioners and experts in BCI knowledge on how best to implement CE in their BCI of developed and developing economies. Also, the FSE results and PSF models developed serve as an allocative function that will help the government of developed and developing economies who wish to focus on relevant aspects of the PSFs for attaining a systemic circularity. Despite the contributions of this study, there are limitations, especially in the methodology adopted. These limitations are perceived as opportunities to enhance future studies (see section 5.3) to consolidate the findings of this study and strengthen the development of CE practices in the construction industry.

Acknowledgments

The authors would like to thank the Department of Building and Real Estate of The Hong Kong Polytechnic University for funding this research study which forms part of a large-scope PhD study on the development of a hybrid model for systemic circularity implementation in the building construction industry (BCI).

Appendix I: Country distribution of the 140 international experts

Africa (36 experts)	Asia (60 experts)	Europe (29 experts)	North America (7 experts)	South America (4 experts)	Australia (4 experts)
Nigeria (12)	Hong Kong (33)	Spain (2)	USA (4)	Chile (3)	Australia (4)
South Africa (12)	Saudi Arabia (1)	United Kingdom (8)	Canada (2)	Brazil (1)	
Algeria (1)	Pakistan (3)	France (1)	Mexico (1)		
Cameroon (2)	Malaysia (5)	Italy (2)			
Egypt (2)	China (10)	Norway (2)			
Ghana (2)	Kazakhstan (1)	Russia (1)			
Malawi (1)	Indonesia (1)	Belgium (1)			
Burkina Faso (1)	India (3)	Turkey (6)			
Congo (2)	Sri Lanka (1)	Austria (3)			
Chad (1)	Vietnam (1)	Poland (1)			
	Bangladesh (1)	Czech Republic (1)			
		Hungary (1)			

References

Ababio, B. K., & Lu, W. (2023). Barriers and enablers of circular economy in construction: a multi-system perspective towards the development of a practical framework. *Construction Management and Economics*, *41*(1), 3-21. https://doi.org/10.1080/01446193.2022.2135750

Adabre, M. A., Chan, A. P. C., Edwards, D. J., & Mensah, S. (2022a). Evaluation of symmetries and asymmetries on barriers to sustainable housing in developing countries. *Journal of Building Engineering*, *50*, 104174. https://doi.org/https://doi.org/10.1016/j.jobe.2022.104174

Akanbi, L. A., Oyedele, A. O., Oyedele, L. O., & Salami, R. O. (2020). Deep learning model for Demolition Waste Prediction in a circular economy. *Journal of Cleaner Production*, *274*, 122843. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.122843

Akinade, O. O., Oyedele, L. O., Ajayi, S. O., Bilal, M., Alaka, H. A., Owolabi, H. A., Bello, S. A., Jaiyeoba, B. E., & Kadiri, K. O. (2017). Design for Deconstruction (DfD): Critical success factors for diverting end-of-life waste from landfills. *Waste Management*, *60*, 3-13. https://doi.org/https://doi.org/10.1016/j.wasman.2016.08.017

Ameyaw, E. E., & Chan, A. P. C. (2015). Evaluation and ranking of risk factors in public–private partnership water supply projects in developing countries using fuzzy synthetic evaluation approach. *Expert Systems with Applications*, *42*(12), 5102-5116. https://doi.org/https://doi.org/10.1016/j.eswa.2015.02.041

Antwi-Afari, P., Ng, S. T., & Chen, J. (2022a). Developing an integrative method and design guidelines for achieving systemic circularity in the construction industry. *Journal of Cleaner Production*, *354*, 131752. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.131752

Aslam, M. S., Huang, B., & Cui, L. (2020). Review of construction and demolition waste management in China and USA. *Journal of Environmental Management*, *264*, 110445.

Bao, Z., & Lu, W. (2020). Developing efficient circularity for construction and demolition waste management in fast emerging economies: Lessons learned from Shenzhen, China. *Science of the total environment*, *724*, 138264. https://doi.org/https://doi.org/10.1016/j.scitotenv.2020.138264

Bao, Z., Lu, W., Chi, B., Yuan, H., & Hao, J. (2019). Procurement innovation for a circular economy of construction and demolition waste: Lessons learnt from Suzhou, China. *Waste Management*, *99*, 12-21. https://doi.org/https://doi.org/10.1016/j.wasman.2019.08.031

Bilal, M., Khan, K. I. A., Thaheem, M. J., & Nasir, A. R. (2020). Current state and barriers to the circular economy in the building sector: Towards a mitigation framework [Article]. *Journal of Cleaner Production*, *276*, Article 123250. https://doi.org/10.1016/j.jclepro.2020.123250

CircleEconomy. (2023). *The circularity gap report*. A. C. Economy.

Darko, A., Chan, A. P. C., Owusu-Manu, D.-G., & Ameyaw, E. E. (2017). Drivers for implementing green building technologies: An international survey of experts. *Journal of Cleaner Production*, *145*, 386-394. https://doi.org/https://doi.org/10.1016/j.jclepro.2017.01.043

de Oliveira, C. T., Dantas, T. E. T., & Soares, S. R. (2021). Nano and micro level circular economy indicators: Assisting decision-makers in circularity assessments. *Sustainable Production and Consumption*, *26*, 455-468. https://doi.org/https://doi.org/10.1016/j.spc.2020.11.024

Eberhardt, L. C. M., van Stijn, A., Rasmussen, F. N., Birkved, M., & Birgisdottir, H. (2020). Development of a life cycle assessment allocation approach for circular economy in the built environment [Article]. *Sustainability (Switzerland)*, *12*(22), 1-16, Article 9579. https://doi.org/10.3390/su12229579

Freund, Y. P. (1988). Critical success factors. *Planning Review*, *16*(4), 20-23. https://doi.org/10.1108/eb054225

Ghisellini, P., Ripa, M., & Ulgiati, S. (2018). Exploring environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector. A literature review [Article]. *Journal of Cleaner Production*, *178*, 618-643. https://doi.org/10.1016/j.jclepro.2017.11.207

Giorgi, S., Lavagna, M., Wang, K., Osmani, M., Liu, G., & Campioli, A. (2022). Drivers and barriers towards circular economy in the building sector: Stakeholder interviews and analysis of five European countries policies and practices. *Journal of Cleaner Production*, *336*, 130395. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.130395

Govindan, K., & Hasanagic, M. (2018). A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective. *International Journal of Production Research*, *56*(1-2), 278-311. https://doi.org/10.1080/00207543.2017.1402141

Guerra, B. C., & Leite, F. (2021). Circular economy in the construction industry: An overview of United States stakeholders' awareness, major challenges, and enablers [Article]. *Resources, Conservation and Recycling*, *170*, Article 105617. https://doi.org/10.1016/j.resconrec.2021.105617
Guo, F., Wang, J., & Song, Y. (2022). How to promote sustainable development of construction and demolition waste recycling systems: Production subsidies or consumption subsidies? *Sustainable Production and Consumption*, *32*, 407-423. https://doi.org/https://doi.org/10.1016/j.spc.2022.05.002
Hina, M., Chauhan, C., Kaur, P., Kraus, S., & Dhir, A. (2022). Drivers and barriers of circular economy business models: Where we are now, and where we are heading. *Journal of Cleaner Production*, *333*. https://doi.org/10.1016/j.jclepro.2021.130049
Huang, B., Wang, X., Kua, H., Geng, Y., Bleischwitz, R., & Ren, J. (2018). Construction and demolition waste management in China through the 3R principle [Article]. *Resources, Conservation and Recycling*, *129*, 36-44. https://doi.org/10.1016/j.resconrec.2017.09.029
Khadim, N., Agliata, R., Marino, A., Thaheem, M. J., & Mollo, L. (2022). Critical review of nano and micro-level building circularity indicators and frameworks. *Journal of Cleaner Production*, *357*, 131859. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.131859
Liu, J., Chen, Y., & Wang, X. (2022). Factors driving waste sorting in construction projects in China. *Journal of Cleaner Production*, *336*, 130397. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.130397
López Ruiz, L. A., Roca Ramón, X., & Gassó Domingo, S. (2020). The circular economy in the construction and demolition waste sector – A review and an integrative model approach [Review]. *Journal of Cleaner Production*, *248*, Article 119238. https://doi.org/10.1016/j.jclepro.2019.119238
Mahpour, A. (2018). Prioritizing barriers to adopt circular economy in construction and demolition waste management [Article]. *Resources, Conservation and Recycling*, *134*, 216-227. https://doi.org/10.1016/j.resconrec.2018.01.026
Mangla, S. K., Govindan, K., & Luthra, S. (2016). Critical success factors for reverse logistics in Indian industries: a structural model. *Journal of Cleaner Production*, *129*, 608-621. https://doi.org/https://doi.org/10.1016/j.jclepro.2016.03.124
Martinez, P., Mohsen, O., Al-Hussein, M., & Ahmad, R. (2022). Vision-based automated waste audits: a use case from the window manufacturing industry. *The International Journal of Advanced Manufacturing Technology*, *119*(11), 7735-7749. https://doi.org/10.1007/s00170-022-08730-2
Mohammadiziazi, R., & Bilec, M. M. (2023). Quantifying and spatializing building material stock and renovation flow for circular economy. *Journal of Cleaner Production*, 135765. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.135765
Moktadir, M. A., Kumar, A., Ali, S. M., Paul, S. K., Sultana, R., & Rezaei, J. (2020). Critical success factors for a circular economy: Implications for business strategy and the environment [https://doi.org/10.1002/bse.2600]. *Business Strategy and the Environment*, *29*(8), 3611-3635. https://doi.org/https://doi.org/10.1002/bse.2600
Neligan, A., Baumgartner, R. J., Geissdoerfer, M., & Schöggl, J.-P. (2022). Circular disruption: Digitalisation as a driver of circular economy business models [https://doi.org/10.1002/bse.3100]. *Business Strategy and the Environment*, *n/a*(n/a). https://doi.org/https://doi.org/10.1002/bse.3100
Olawumi, T. O., & Chan, D. W. M. (2022). Developing project evaluation models for smart sustainable practices implementation in construction projects: a comparative study between Nigeria and Hong Kong. *Engineering, Construction and Architectural Management*, *29*(3), 1522-1552. https://doi.org/10.1108/ECAM-11-2020-0906
Oluleye, B. I., Chan, D. W. M., & Antwi-Afari, P. (2023b). Adopting Artificial Intelligence for enhancing the implementation of systemic circularity in the construction industry: A critical review. *Sustainable Production and Consumption*, *35*, 509-524. https://doi.org/https://doi.org/10.1016/j.spc.2022.12.002
Oluleye, B. I., Chan, D. W. M., & Olawumi, T. O. (2022b). Barriers to circular economy adoption and concomitant implementation strategies in building construction and demolition waste management: A PRISMA and interpretive structural modeling approach. *Habitat International*, *126*, 102615. https://doi.org/https://doi.org/10.1016/j.habitatint.2022.102615
Oluleye, B. I., Chan, D. W. M., Olawumi, T. O., & Saka, A. B. (2023). Assessment of symmetries and asymmetries on barriers to circular economy adoption in the construction industry towards zero waste: A survey of international experts. *Building and Environment*, *228*, 109885. https://doi.org/https://doi.org/10.1016/j.buildenv.2022.109885

Oluleye, B. I., Chan, D. W. M., Saka, A. B., & Olawumi, T. O. (2022a). Circular economy research on building construction and demolition waste: A review of current trends and future research directions. *Journal of Cleaner Production*, *357*, 131927. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.131927
Oluleye, I. B., Ogunleye, M. B., & Oyetunji, A. K. (2021). Evaluation of the critical success factors for sustainable housing delivery: analytic hierarchy process approach. *Journal of Engineering, Design and Technology*, *19*(5), 1044-1062. https://doi.org/10.1108/JEDT-06-2020-0232
Osei-Kyei, R., & Chan A., P. C. (2017). Developing a Project Success Index for Public–Private Partnership Projects in Developing Countries. *Journal of Infrastructure Systems*, *23*(4), 04017028. https://doi.org/10.1061/(ASCE)IS.1943-555X.0000388
Oyetunji, A. K., Oluleye, B. I., Olukolajo, M. A., & Chan, D. W. M. (2022). Is green good: Unveiling the latent benefits of sustainable housing delivery. *Cities*, *129*, 103809. https://doi.org/https://doi.org/10.1016/j.cities.2022.103809
Rios, F. C., Grau, D., & Bilec, M. (2021). Barriers and Enablers to Circular Building Design in the US: An Empirical Study. *Journal of Construction Engineering and Management*, *147*(10), 04021117. https://doi.org/doi:10.1061/(ASCE)CO.1943-7862.0002109
Rios, F. C., Panic, S., Grau, D., Khanna, V., Zapitelli, J., & Bilec, M. (2022). Exploring circular economies in the built environment from a complex systems perspective: A systematic review and conceptual model at the city scale. *Sustainable Cities and Society*, *80*, 103411. https://doi.org/https://doi.org/10.1016/j.scs.2021.103411
Ruxton, G. D., Wilkinson, D. M., & Neuhäuser, M. (2015). Advice on testing the null hypothesis that a sample is drawn from a normal distribution. *Animal Behaviour*, *107*, 249-252. https://doi.org/https://doi.org/10.1016/j.anbehav.2015.07.006
Saka, A. B., & Chan, D. W. M. (2021). BIM divide: an international comparative analysis of perceived barriers to implementation of BIM in the construction industry. *Journal of Engineering, Design and Technology*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/JEDT-07-2021-0348
Saka, A. B., & Chan, D. W. M. (2022). A contextualist perspective to drivers of BIM in the architecture, engineering and construction (AEC) industry. *International Journal of Construction Management*, 1-11. https://doi.org/10.1080/15623599.2022.2056806 (in press).
Salmenperä, H., Pitkänen, K., Kautto, P., & Saikku, L. (2021). Critical factors for enhancing the circular economy in waste management [Article]. *Journal of Cleaner Production*, *280*, Article 124339. https://doi.org/10.1016/j.jclepro.2020.124339
Setaki, F., & van Timmeren, A. (2022). Disruptive technologies for a circular building industry. *Building and Environment*, *223*, 109394. https://doi.org/https://doi.org/10.1016/j.buildenv.2022.109394
Sharma, N., Kalbar, P. P., & Salman, M. (2022). Global review of circular economy and life cycle thinking in building Demolition Waste Management: A way ahead for India. *Building and Environment*, *222*, 109413. https://doi.org/https://doi.org/10.1016/j.buildenv.2022.109413
Shooshtarian, S., Caldera, S., Maqsood, T., Ryley, T., Wong, P. S. P., & Zaman, A. (2022c). Analysis of factors influencing the creation and stimulation of the Australian market for recycled construction and demolition waste products. *Sustainable Production and Consumption*, *34*, 163-176. https://doi.org/10.1016/j.spc.2022.09.005
Shooshtarian, S., Hosseini, M. R., Kocaturk, T., Arnel, T., & T. Garofano, N. (2022b). Circular economy in the Australian AEC industry: investigation of barriers and enablers. *Building Research & Information*, 1-13. https://doi.org/10.1080/09613218.2022.2099788
Shooshtarian, S., Maqsood, T., Caldera, S., & Ryley, T. (2022a). Transformation towards a circular economy in the Australian construction and demolition waste management system. *Sustainable Production and Consumption*, *30*, 89-106. https://doi.org/https://doi.org/10.1016/j.spc.2021.11.032
Sohal, A., & De Vass, T. (2022). Australian SME's experience in transitioning to circular economy. *Journal of Business Research*, *142*, 594-604. https://doi.org/https://doi.org/10.1016/j.jbusres.2021.12.070
Tokazhanov, G., Galiyev, O., Lukyanenko, A., Nauyryzbay, A., Ismagulov, R., Durdyev, S., Turkyilmaz, A., & Karaca, F. (2022). Circularity assessment tool development for construction projects in emerging economies. *Journal of Cleaner Production*, *362*, 132293. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.132293
Volk, R., Steins, J. J., Kreft, O., & Schultmann, F. (2023). Life cycle assessment of post-demolition autoclaved aerated concrete (AAC) recycling options. *Resources, Conservation and Recycling*, *188*, 106716. https://doi.org/https://doi.org/10.1016/j.resconrec.2022.106716

Wuni, I. Y. (2022a). Burden of proof beyond the triple bottom line: Mapping the benefits of circular construction. *Sustainable Production and Consumption*, *34*, 528-540. https://doi.org/https://doi.org/10.1016/j.spc.2022.10.006

Wuni, I. Y. (2022b). Mapping the barriers to circular economy adoption in the construction industry: A systematic review, Pareto analysis, and mitigation strategy map. *Building and Environment*, *223*, 109453. https://doi.org/https://doi.org/10.1016/j.buildenv.2022.109453

Wuni, I. Y., & Shen, G. Q. (2022). Developing critical success factors for integrating circular economy into modular construction projects in Hong Kong. *Sustainable Production and Consumption*, *29*, 574-587. https://doi.org/https://doi.org/10.1016/j.spc.2021.11.010

Yadav, G., Mangla, S. K., Bhattacharya, A., & Luthra, S. (2020). Exploring indicators of circular economy adoption framework through a hybrid decision support approach [Article]. *Journal of Cleaner Production*, *277*, Article 124186. https://doi.org/10.1016/j.jclepro.2020.124186

Yeheyis, M., Hewage, K., Alam, M. S., Eskicioglu, C., & Sadiq, R. (2013). An overview of construction and demolition waste management in Canada: a lifecycle analysis approach to sustainability. *Clean Technologies and Environmental Policy*, *15*(1), 81-91. https://doi.org/10.1007/s10098-012-0481-6

Yevu Sitsofe, K., Yu Ann Tit, W., Nani, G., Darko, A., & Tetteh Mershack, O. (2022). Electronic Procurement Systems Adoption in Construction Procurement: A Global Survey on the Barriers and Strategies from the Developed and Developing Economies. *Journal of Construction Engineering and Management*, *148*(1), 04021186. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002213

Yuan, H. (2017). Barriers and countermeasures for managing construction and demolition waste: A case of Shenzhen in China. *Journal of Cleaner Production*, *157*, 84-93.

Zhang, C., Hu, M., Di Maio, F., Sprecher, B., Yang, X., & Tukker, A. (2022). An overview of the waste hierarchy framework for analyzing the circularity in construction and demolition waste management in Europe. *Science of the total environment*, *803*, 149892. https://doi.org/https://doi.org/10.1016/j.scitotenv.2021.149892

Zhang, L., Xin, H., & Kan, Z. (2019). Sustainability Performance Evaluation of Hybrid Energy System Using an Improved Fuzzy Synthetic Evaluation Approach. *Sustainability*, *11*(5), 1265. https://www.mdpi.com/2071-1050/11/5/1265

Zhang, X., & Ahmed, R. R. (2022). A queuing system for inert construction waste management on a reverse logistics network. *Automation in Construction*, *137*, 104221. https://doi.org/https://doi.org/10.1016/j.autcon.2022.104221

Declaration of interest

The authors declare that they have no known competing financial interest or personal relationship that could have appeared to influence the work reported in this paper.