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Circular Economy in the Building Sector: Investigating Awareness, Attitudes, Barriers, and Enablers through a Case Study in Saudi Arabia

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Abstract: The adoption of circular economy (CE) holds significant potential to mitigate the challenges posed by the conventional linear economic model. The building sector in Saudi Arabia continues experiencing rapid growth, often marked by a consistent annual rise in the number of projects. The incorporation of CE principles into this expansion presents opportunities to optimize resource utilization, minimize waste generation, and enhance overall environmental sustainability. This study explores the current levels of awareness, perception, and implementation of CE principles among local building sector stakeholders and assesses the potential for CE expansion in the region. Additionally, it seeks to rank the identified barriers and enablers while exploring the interconnected relationships between such barriers. A literature review was conducted to explore the CE barriers and enablers. This was followed by an online survey which was conducted amongst 139 respondents from diverse stakeholder groups. A relative importance index (RII) was employed to rank the barriers and enablers, and the findings were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS). The outcomes of this study highlight a significant lack of awareness regarding CE principles among stakeholders, with a very low implementation rate. To break this inertia and encourage the adoption of CE practices, this study suggests the need for CE- supportive policy and legislation, and the provision of financial incentives.

Keywords: circular economy; building; building sector

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1. Introduction

The construction industry significantly contributes to negative environmental impacts on the ecosystem. The building sector stands as a primary contributor to the emission of greenhouse gases (GHGs), which is responsible for global warming [1]. In addition, the building sector is a major consumer of natural resources, global energy consumption, and causes substantial waste generation [2]. Globally, the construction industry produces more than 10 billion tons of construction and demolition waste every year [3]. The adoption of sustainable energy sources in the sector remains limited, with only 6% of the total energy consumed originating from sustainable sources [4]. As the linear economy only involves one direction of movement for products and materials: from raw material to waste, it stands as an unsustainable practice that generates widespread environmental damage [5].

In contrast, the circular economy (CE) model offers a promising solution to the challenges that have arisen from the long-standing dominance of the linear economic model in the construction industry [6]. The Ellen MacArthur Foundation [7] defined the concept of CE as *"An industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models"*. In the CE model, the primary focus is on preserving the highest value of products and materials throughout their lifecycles, with the goal of effectively eliminating waste [8].

The adoption of CE principles holds promise in fostering industrial growth in nations while enhancing prosperity and diminishing the risk of resource price volatility [9]. The concept of CE presents a comprehensive approach that fosters economic renewal, drives innovation, and facilitates industrial transformation [10]. According to the Ellen MacArthur Foundation [7], implementing CE at the European Union level could result in significant annual material-cost savings, estimated to be between USD 520 to 630 billion per year. In addition, the adoption of CE practices in the built environment has the potential to enhance Europe's resource productivity by up to 3% annually, resulting in a primary resource benefit of around EUR 0.6 trillion per year by 2030, along with EUR 1.2 trillion in non-resource and externality benefits [11]. The World Economic Forum [12] stated that "adopting circular economy principles could significantly enhance global construction industry productivity, saving at least $100 billion a year".

Leising et al. [13] conceptualised the CE approach for circular buildings as "*a life-cycle approach that optimises the buildings' useful lifetime, integrating the end-of-life phase in the design and uses new ownership models where materials are only temporarily stored in the building that acts as a material bank*". Circular building design revolves around the core principles of adaptability, flexibility, and deconstruction [14]. Askar et al. [15] emphasised that designing buildings under the principles of CE necessitates a strong focus on the end-of-life phase of the building's components and materials. Within the CE paradigm, building components are maintained in a continuous cycle of utilisation, reuse, refurbishment, and recycling [8]. According to Eberhardt et al. [16], the CE approach is essential for achieving material sustainability in buildings.

The implementation of CE in the building sector faces several barriers that hinder its widespread adoption. The complexity of building materials and the lack of standardised methods and tools for assessing their circularity pose significant obstacles [17,18]. The initial costs associated with adopting circular practices deter stakeholders from embracing CE. Furthermore, the adoption of CE practices may be hindered by inadequate incentives embedded in existing regulations and policies [19,20], as well as a lack of stakeholder interest coming from insufficient awareness about the benefits of CE. The uncertainties in regulatory frameworks related to circular construction practices can create ambiguity and discourage stakeholders from investing in circular solutions. The absence of clear guidelines and regulatory stability can hinder the confidence of stakeholders, making it challenging for them make informed decisions regarding circular practices [21].

As a developing country, Saudi Arabia is acknowledged as the largest economy in the Middle East and North Africa, with a high growth domestic product (GDP) [22]. As a member of the Group of Twenty (G20), Saudi Arabia is recognized among the world's leading economies. Its position as the world's largest oil exporter further highlights its global economic significance. The Saudi Arabian economy is heavily reliant on petroleum products revenue, with this sector contributing an estimated 38.7% of the total GDP [23], and accounting for a remarkable 76.1% of total exports [24]. However, the Saudi government has strategic plans, as outlined in Vision 2030 [25], to have a more diverse economy, less dependence on oil, and plans for the private sector to participate in this transition. Such a transition cannot be achieved without substantial construction and infrastructure development.

The construction sector plays a significant role in the Saudi Arabian economy, contributing 4.8% of the overall GDP [23]. Additionally, the construction sector's annual GDP growth in 2020–2030 is expected to grow by 9.2% [26]. Saudi Arabia leads the largest share of building projects in the Gulf Cooperation Countries (GCC), accounting for approximately 43% of all building projects [27]. Saudi Arabia stands among the highest countries in the world in terms of per-capita energy consumption and environmental emissions, with the building sector playing a significant role in this regard [27]. The CE model can help Saudi Arabia to diversify its economy beyond its reliance on oil resources and reduce its high levels of waste, transforming waste into an economic resource. As of now, the Kingdom of Saudi Arabia has not established any formal laws or a nationwide strategy for CE [28]. There is a significant institutional fragmentation and insufficient attention to construction and demolition waste [29]. According to Ibrahim and Shirazi [30], neither Saudi Arabia nor the GCC have a holistic policy in place regarding CE.

To the best of the authors' knowledge, this study represents the first of its kind in the country that focuses on implementing the concept of CE in the context of the building sector. The primary objective of this study is to bridge the existing gap in the literature by investigating and comprehensively analysing the current state of CE awareness, implementation, perceptions, challenges, and enablers for greater adoption within the Saudi Arabian building sector. This research aims to contribute to the limited body of knowledge on CE in Saudi Arabia, addressing the lack of studies on the CE paradigm within the specific context of the Saudi building industry. The following four research questions are established for this study:

1. What is the current level of awareness of CE principles within the Saudi Arabian building sector?
2. How do different stakeholders in the building sector perceive CE concepts?
3. What are the main challenges faced by stakeholders in adopting CE practices in the building sector in Saudi Arabia?
4. What factors contribute to the successful adoption and integration of CE practices in the building sector in Saudi Arabia?

2. Methods

2.1. Research Design

This study adopted the quantitative research method of an online survey. The choice of an online survey offers a convenient and accessible method for collecting data from a broad and diverse sample, allowing for respondents to participate from various locations. This increases this study's reach and provides flexibility, as participants can complete the surveys at their convenience. According to Careswell [31], quantitative research encompasses a systematic and structured approach to investigating phenomena through collecting and analysing numerical data. The subject of the survey is the awareness, major challenges, and enablers of the successful adoption of CE principles in Saudi Arabia. Sukamolson [32] described quantitative research as the process of utilizing numerical data to discern patterns, attitudes, or perspectives gathered from an examined sample of the overall population. This study used the survey's quantitative data to assess CE awareness, perception, practices, barriers, and enablers among building stakeholders in Saudi Arabia's building sector, in addition to the authors' previous publication on the identified barriers and enablers [33].

2.2. Data Collection

A web-based format using Google Forms was employed to distribute the questionnaire effectively. Participants were provided with a link to the form, allowing them to access and complete the survey online conveniently. The survey was accessible for completion over a two-month period. At the beginning of the questionnaire, participants were presented with a brief overview of the fundamental principles of CE in the building sector. This introductory section aimed to familiarise respondents, including those who might not be experts or have practical experience in the field, with the key concepts of CE. The questionnaire utilised the Likert scale technique, employing a five-point rating scale ranging from '1' (indicating the lowest weight) to '5' (indicating the highest weight). This design was implemented to facilitate a seamless analysis of results through close-ended questions. The survey was drafted in accordance with the insights derived from the systematic literature review [33]. A random sampling technique was used to define a representative sample of individuals involved in building construction in Saudi Arabia. To maximise response diversity and avoid bias, the questionnaire was distributed to stakeholders in eight organisations, including semi-government and private entities, across three different provinces—Riyadh, Makkah, and the Eastern provinces. These regions were chosen due to their representation of major construction projects in the country. A pilot study was conducted prior disputing the questionnaire with a group of 13 respondents who have experience in building construction projects in Saudi Arabia. The group consisted of three consultants, three owners, four contractors, and three faculty members within the Civil and Construction Engineering department in Imam Abdulrahman bin Fisal University. The pilot study participants were asked to provide their opinions on the questionnaire's clarity, appropriateness of response options, and overall ease of completion. The feedback obtained from this pilot study was used to make necessary adjustments and improvements to the questionnaire before distributing the final version.

2.3. Questionnaire Sampling

Sampling is the process of selecting a subset of a population to represent the entire population [34]. For the present study, we used Yamane's [35] simplified formula, which is a widely used for calculating a sample size involving a large population [36]. The formula considers the total population size and the desired level of precision, as shown in the following equation:

$$n = \frac{N}{1 + N(e)^2}$$

where:

- n = Sample size.
- N = The overall population size.
- e = The desired precision level (expressed as a proportion).

This study comprised a population of 200 key stakeholders, including contractors, consultants, and clients. Additionally, researchers from educational institutions were included, all of whom possess a dual expertise in both practical field experience and research proficiency. Their inclusion brings a unique perspective, combining theoretical knowledge with practical understanding, enriching the overall depth of this study. Based on the Yamane's [35] formula, the sample size is:

$$\frac{200}{1 + 200(0.05)^2} = 134 \text{ participants.}$$

The questionnaire was completed with 139 valid responses out of the 200 questionnaires distributed, meeting the goal of obtaining at least 134 respondents and achieving a response rate comparable to similar studies. The response rate of this study was 69.5%, which is the number of completed questionnaires (139) divided by the number of questionnaires sent out (200). According to Fincham [37], researchers should aim to obtain a response rate of 60% or higher in most research.

2.4. Data Analysis

2.4.1. Relative Importance Index (RII)

The RII is a commonly used parameter to assess the importance or significance of various factors, in this case within the construction sector [38]. The RII offers a structured approach to prioritizing factors based on their perceived significance, making it a valuable tool for gaining insights into attitudes, practices, and preferences. This study utilized the RII to determine the main barriers and enablers influencing CE within Saudi Arabian's building sector. The RII for barriers and enablers were calculated using the method proposed by Kometa et al. [39] as follows:

$$\frac{\sum w}{A \times N} = \frac{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{A \times N};\ (0 \leq \text{RII} \leq 1)$$

where:

- w = The weighting given to each factor by the respondent, ranging from 1 to 5 where n_5 is "Critical" and n_1 is "Insignificant".
- A = Highest weight (in this study: 5).
- N = Overall number of respondents (in this study: 139).

2.4.2. Reliability Analysis

The reliability of a research instrument refers to the extent the results can consistently and dependably produce the same or similar results when the same methods and procedures are applied [40]. According to Litwin [40], reliability is commonly evaluated in three forms: test–retest reliability, alternate-form, and internal consistency reliability. Cronbach's alpha coefficient is the most used technique for evaluating internal consistency [41,42]. Cronbach's alpha values can range from 0 to 1 and a value of 0.7 or higher is generally considered acceptable for a multi-item construct, indicating good internal consistency [43,44]. This study employed Cronbach's alpha to evaluate the reliability of the quantitative data, revealing a strong level of internal consistency ranging from 0.7 to 0.9, indicating good-to-excellent reliability. As outlined by Cronbach [45], the Cronbach's alpha coefficient can be calculated using the following formula:

$$\alpha = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum_i V_i}{V_t}\right)$$

where:

- n = Number of items.
- V_t = Variance of test scores.
- V_i = Total variance of the scale.

2.4.3. Spearman's Correlation Test

Spearman's correlation is a non-parametric statistical measure used to assess the strength and direction of the monotonic relationship between two ranked variables [46,47]. The result is expressed as a value between -1 and 1, with -1 indicating a perfect inverse relationship, 1 showing a perfect direct relationship, and 0 suggesting no monotonic relationship between the variables. In this study, a Spearman's correlation was used with SPSS 27 software to examine the strength and direction of the associations to implementing CE among the various barriers.

3. Results

3.1. Overview

This section presents the findings of the questionnaire employed in this study, arranged into four sections. Section 1 concerns the demographic details about the participants, which the questionnaire addressed by answering five questions. Section 2 concerns the participants' level of awareness and their practice of CE, as well as their opinions regarding its future implementation. Section 3 provides an overview of the participants' ratings of 25 barriers that hinder the implementation of CE principles. Finally, Section 4 presents the participants' views concerning the importance of employing certain enabling strategies to promote the widespread adoption of CE in the building sector.

3.2. Demographic Details

3.2.1. Years of Experience in the Building Sector

The distribution of the participants' years of experience in the building sector is shown in Figure 1. Most of the participants had extensive experience, with 43% reporting that they had between 6 and 10 years of experience, and 20% that they had 2 to 5 years of experience. Meanwhile, 18.0% had fewer than 2 years of experience, 10% reported that they had between 11 and 15 years of experience, and 9% had more than 15 years of experience in the building sector.

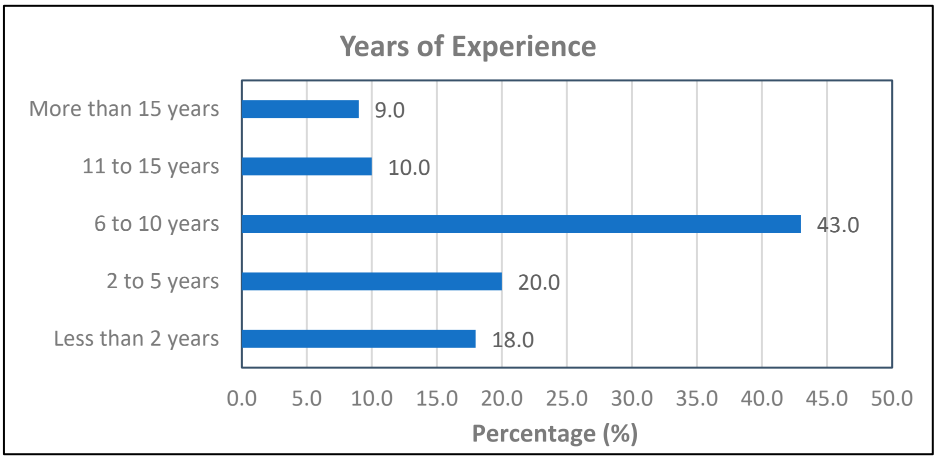

Figure 1. Participants' years of experience in the building sector.

3.2.2. Organisation Type

In building construction projects, three distinct categories of organisation typically play fundamental roles. According to the survey results, a significant number of the respondents (49%) had worked primarily in client organisations throughout their careers. Meanwhile, 22% had worked within consultant organisations, 22% had primarily been employed by contractor organisations, and 7% had primarily pursued careers in academia (Figure 2). The inclusion of participants with an academic background added a valuable perspective to this study, as their experience contributed to research-based knowledge regarding the understanding of circular building practices. The respondents' diverse career backgrounds reflected the varied experiences and expertise of construction project stakeholders.

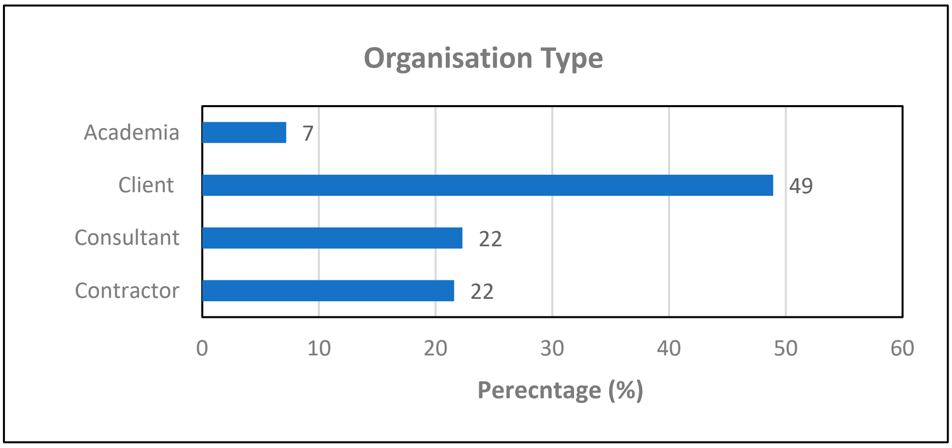

Figure 2. Participants' organisational type.

3.3. *Circular Economy Awareness, Practice, and Future Implementation*

3.3.1. Level of Awareness

The level of awareness of the concept of CE plays a crucial role in understanding the knowledge gap experienced by stakeholders within the building sector. Awareness of CE principles among stakeholders is also essential for accelerating its adoption, as it empowers individuals to make informed decisions in this regard.

As shown in Figure 3, more than half of the respondents (52%) had only a very basic understanding of CE and its principles, and were therefore unlikely to be familiar with the specific details of its implementation. Furthermore, 21% were unaware of the concept and its principles, while 20% reported having had significant awareness of CE, and were therefore likely to understand its core ideas and principles to a notable extent. A smaller proportion of the respondents (7%) indicated that they were fully aware of CE, which suggested they possessed a comprehensive understanding of the concept, its principles, and practical applications.

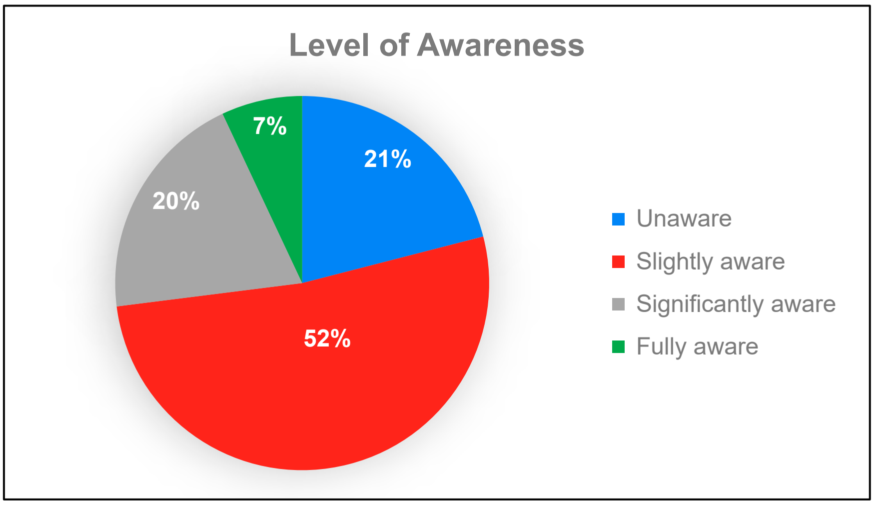

Figure 3. Participants' level of awareness of CE.

It was therefore apparent that a significant majority of the participants (73%) currently lack the knowledge to implement CE principles effectively, indicating the need for greater education and research on the subject, CE legislation, and campaigns to raise awareness on the subject, which could facilitate the adoption of CE practices among stakeholders in Saudi Arabia.

3.3.2. Level of Practice

This section of the questionnaire explored differing levels of practice regarding the integration of CE principles into building construction projects among the respondents' organisations (Figure 4). A significant percentage (32%) of the respondents indicated that their organisation rarely engaged with CE principles in their building construction projects, suggesting that these organisations have limited involvement with CE practices. Meanwhile, 27% of the respondents reported that their organisation sometimes incorporated CE principles, indicating a lack of full commitment. Remarkably, 22% revealed their organisation had never integrated CE principles into their building construction projects, a finding that indicated a big gap in the organisations' awareness of, or willingness to adopt, CE. In contrast, 16% of the participants reported that their organisation often integrated CE principles into their building construction projects, evidencing a stronger commitment to incorporating CE practices. However, only 3% of the respondents stated that their organisation always integrated CE principles into their building projects.

Organisations that always integrate CE principles can be seen as industry leaders in the transition towards circularity within the building sector. As the findings of this study have demonstrated that there is currently little engagement with CE practices in the building sector in Saudi Arabia, there is a need to promote an increased awareness of the subject, and to encourage its adoption.

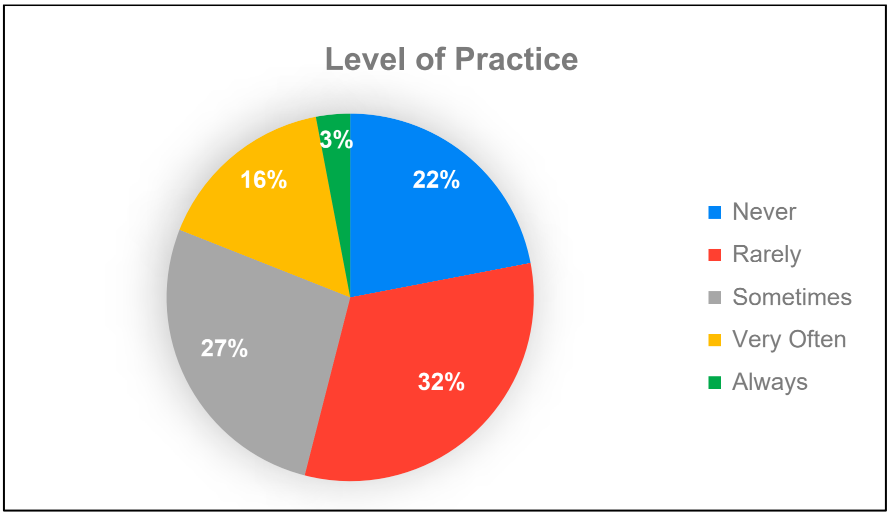

Figure 4. Participants' organisations' level of CE practice.

3.3.3. Future Implementation

This section examines the participants' views regarding their organisation's future implementation of CE. As shown in Figure 5, a significant proportion of the respondents (41%) believed that their organisation was likely to implement CE principles in their future building construction projects, evidencing a positive view of the adoption of circular practices. Moreover, 22% considered that it was highly likely their organisation would implement CE principles in future. However, 22% of the respondents were unsure whether their organisation would implement CE principles in future projects, and a significant number of the respondents (10% and 5%; very unlikely and unlikely, respectively) believed that their organisation was reluctant to adopt CE in future.

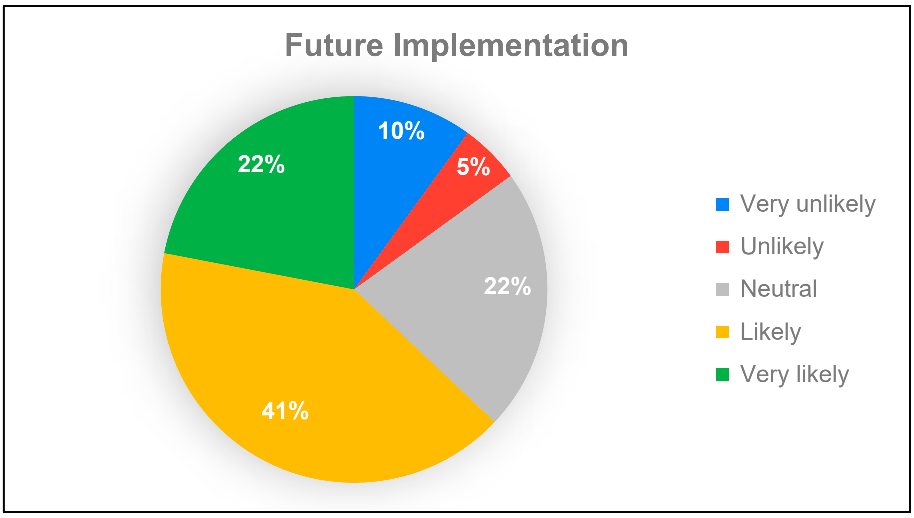

Figure 5. Participants' belief that CE would be implemented in future building projects.

In addition, the participants were asked to share their views of the following statement: "Your organisation should integrate more circular economy principles into future construction projects".

The survey results (Figure 6) revealed the presence of a generally positive outlook among the respondents regarding the future integration of CE principles, with over half (51%) agreeing with the statement, and a significant proportion (34%) strongly agreeing, which emphasized a high level of commitment to incorporating CE principles in the future. Only a small percentage (13%) remained undecided, neither agreeing nor disagreeing with the statement, while an even smaller percentage (2%) disagreed with, or strongly disagreed with, the need to integrate more CE principles into their organisation's future construction projects. These findings suggest the presence of considerable interest in CE practices, and willingness among the participants to embrace them if they see benefit of it.

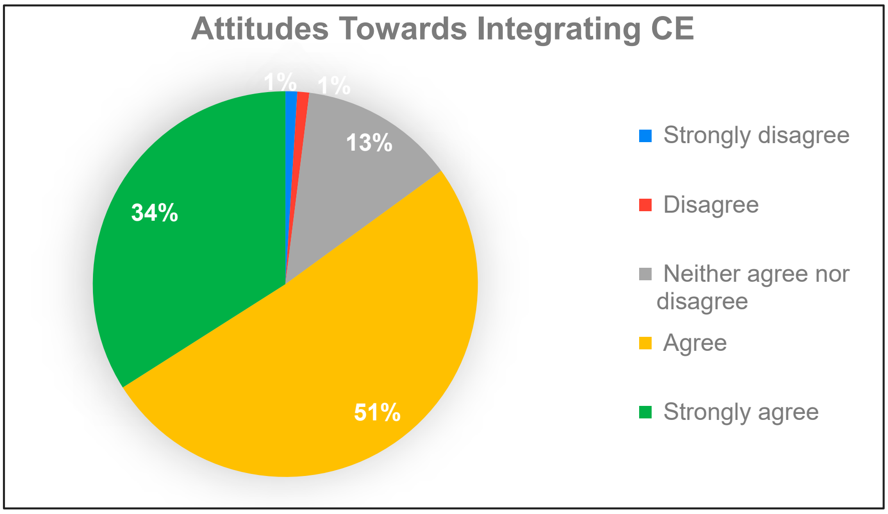

Figure 6. Participants' attitudes towards integrating CE practices.

3.4. Barriers Relative Importance Index Analysis

This study employed the relative importance index (RII) to rank each of the questions posed in the questionnaire according to their importance regarding the perceived barriers to implementing CE practices in the building sector. Understanding these barriers from a stakeholder's perspective is crucial for developing practical solutions to overcome them. To assess the significance of these barriers, the participants were asked to rate them using a five-point Likert scale.

Table 1 presents the results concerning the respondents' views of the significance of the barriers included in this study to the adoption of CE practices, ranked according to the RII. The top 10 barriers in order from highest to lowest were: (T4) Absence of certification, quality assurance, standardisation of reused materials (RII = 0.776), followed by (E1) Lack of market mechanisms for recovery (RII = 0.768); (S1) Negative perception of circular practices (RII = 0.765); (A3) Fragment supply chain (RII = 0.760); (E4) High upfront cost (RII = 0.757); (A5) Lack of adequate information/data about reused materials' availability (RII = 0.755); (E3) Unclear financial case (RII = 0.751); (T3) Policy and regulatory (RII = 0.750); (S2) Lack of interest in CE (RII = 0.745); and (A4) Lack of case studies (RII = 0.74).

According to Akadiri et al. [48], the RII value can be divided into five levels: High (H) ($0.8 \leq$ RII ≤ 1); High–Medium (H–M) ($0.6 \leq$ RII ≤ 0.8); Medium (M) ($0.4 \leq$ RII ≤ 0.6); Medium–Low (M-L) ($0.2 \leq$ RII ≤ 0.4); and Low (L) ($0 \leq$ RII ≤ 0.2). As shown in Table 1, all the barriers in this instance were of high–medium importance, demonstrating the perceived importance of these barriers to CE adoption by the building sector.

Barriers' Relative Importance Index Analysis per Stakeholder

Different stakeholders may possess distinct priorities and have diverse reasons for deciding not to implement CE practices. Within the building construction industry, numerous complex factors influence the decision making regarding the adoption of specific practices. These include the absence of data concerning the safe and effective reuse of materials, the high upfront costs associated with circular practices, the complexity of building structures, and a lack of financial incentives to encourage the adoption of circular practices [17–19,49]. Consequently, the RII values provided in Table 2 concern three distinct groups: contractors, clients, and consultants. To gain a broad range of insights and perspectives in these matters, input from academia was also sought.

Table 1. RII ranking of the barriers to CE adoption.

Category	Barrier Code	Barrier	RII	Ranking across Constructs	Overall Rank	Importance Level
Awareness	A1	Limited knowledge of CE	0.678	5	**20**	H–M
	A1	Lack of clearly defined national goals, targets, and vison for CE	0.691	4	**19**	H–M
	A3	Fragment supply chain	0.76	1	**4**	H–M
	A4	Lack of case studies	0.737	3	**10**	H–M
	A5	Lack of adequate information/data about reused materials availability	0.755	2	**6**	H–M
Technical	T1	Buildings complexity	0.702	5	**18**	H–M
	T2	Quality of materials at end of life	0.622	6	**25**	H–M
	T3	Policy and regulatory	0.75	2	8	H–M
	T4	Absence of certification, quality assurance, standardisation of reused materials	0.776	1	**1**	H–M
	T5	Lack of flexibility in the building codes and regulations	0.714	3	**14**	H–M
	T6	Lack of CE metrics/tool/design	0.705	4	**17**	H–M
Economic and market	E1	Lack of market mechanisms for recovery	0.768	1	**2**	H–M
	E2	Cost of virgin materials	0.656	6	**22**	H–M
	E3	A mismatch between supply and demand of reused materials	0.706	5	**16**	H–M
	E4	Unclear financial case	0.751	3	**7**	H–M
	E5	High upfront cost	0.757	2	**5**	H–M
	E6	Cost of removing contaminated materials	0.721	4	**13**	H–M
Implementation	I1	Lack of storage facilities	0.653	3	**23**	H–M
	I2	Site constraints	0.633	4	**24**	H–M
	I3	Inadequate CE infrastructure to support CE management	0.673	2	**21**	H–M
	I4	Conservative and non-collaborative industry	0.724	1	**12**	H–M
Support and promotion	P1	Lack of incentives	0.709	2	**15**	H–M
	P2	Insufficient support from governmental institutions	0.734	1	**11**	H–M
Social	S1	Unrealistic hypothesis/ Social flexibility	0.765	1	**3**	H–M
	S2	Lack of interest in CE	0.745	2	**9**	H–M

For the respondents who were contractors, the five barriers that ranked highest were, in order, (T4) Absence of certification, quality assurance, standardisation of reused materials; (E4) Unclear financial case; and (E1) Lack of market mechanisms for recovery.

Table 2. RII ranking of the barriers to CE adoption per stakeholder.

Category	B-Code	Barrier	Contractor		Consultant		Client		Academia	
			RII	Rank	RII	Rank	RII	Rank	RII	Rank
Awareness	A1	Limited knowledge of CE	0.633	**25**	0.626	**22**	0.712	**15**	0.740	**17**
	A1	Lack of clearly defined national goals, targets, and vison for CE	0.687	**19**	0.658	**17**	0.694	**18**	0.600	**20**
	A3	Fragment supply chain	0.780	**4**	0.716	**6**	0.765	**2**	0.800	**11**
	A4	Lack of case studies	0.747	**10**	0.697	**13**	0.741	**9**	0.800	**11**
	A5	Lack of adequate information/data about reused materials availability	0.740	**11**	0.742	**2**	0.759	**3**	0.820	**8**
Technical	T1	Buildings complexity	0.680	**21**	0.716	**6**	0.685	**19**	0.840	**7**
	T2	Quality of materials at end of life	0.673	**22**	0.587	**25**	0.612	**25**	0.640	**19**
	T3	Policy and regulatory	0.720	**15**	0.723	**5**	0.750	**5**	0.920	**1**
	T4	Absence of certification, quality assurance, standardisation of reused materials	0.853	**1**	0.716	**6**	0.747	**6**	0.920	**1**
	T5	Lack of flexibility in the building codes and regulations	0.767	**7**	0.690	**14**	0.676	**22**	0.880	**4**
	T6	Lack of CE metrics/tool/design	0.720	**15**	0.658	**17**	0.703	**17**	0.820	**8**
Economic and market	E1	Lack of market mechanisms for recovery	0.787	**2**	0.735	**4**	0.776	**1**	0.760	**15**
	E2	Cost of virgin materials	0.713	**17**	0.600	**24**	0.676	**22**	0.520	**23**
	E3	A mismatch between supply and demand of reused materials	0.727	**13**	0.716	**6**	0.709	**16**	0.600	**20**
	E4	Unclear financial case	0.787	**2**	0.710	**10**	0.735	**11**	0.880	**4**
	E5	High upfront cost	0.780	**4**	0.768	**1**	0.732	**12**	0.820	**8**
	E6	Cost of removing contaminated materials	0.740	**11**	0.703	**11**	0.729	**13**	0.660	**18**
Implementation	I1	Lack of storage facilities	0.653	**24**	0.632	**21**	0.682	**20**	0.520	**23**
	I2	Site constraints	0.673	**23**	0.619	**23**	0.638	**24**	0.520	**23**
	I3	Inadequate CE infrastructure to support CE management	0.687	**19**	0.665	**16**	0.682	**20**	0.600	**20**
	I4	Conservative and non-collaborative industry	0.713	**17**	0.671	**15**	0.747	**6**	0.760	**15**
Support and promotion	P1	Lack of incentives	0.727	**13**	0.639	**19**	0.724	**14**	0.780	**13**
	P2	Insufficient support from governmental institutions	0.753	**9**	0.639	**19**	0.747	**6**	0.880	**4**
Social	S1	Unrealistic hypothesis/Social flexibility	0.767	**7**	0.742	**2**	0.756	**4**	0.900	**3**
	S2	Lack of interest in CE	0.773	**6**	0.703	**11**	0.741	**9**	0.780	**13**

Meanwhile, the consultants ranked (E5) High upfront cost as the most significant barrier, followed by (A5) Lack of adequate information/data about reused materials' availability and (S1) Negative perception of circular practices. The barriers ranked highest by the respondents who had primarily worked in client organisations were, in order, (E1) Lack of market mechanisms for recovery, followed by (A3) Fragment supply chain and (A5) Lack of adequate information/data about reused materials availability. Finally, those who had primarily been associated with academia ranked (T3) Lack of circular economy-specific legislation highest, followed by (T4) Absence of certification, quality assurance, standardisation of reused materials, and last (S1) Negative perception of circular practices.

3.5. Correlation Test of the Barriers

A Spearman's correlation test was conducted to analyse the strength and direction of the associations to implementing CE among the various barriers. The Spearman correlation coefficients between barriers A1 to E3 are shown in Table 3, and those between barriers E4 to S1 are shown in Table 4.

Table 3. Results of the Spearman's Correlation test between barriers.

B-Code	A1	A2	A3	A4	A5	T1	T2	T3	T4	T5	T6	E1	E2	E3
A1	1													
A2	0.483 **	1												
A3	0.540 **	0.469 **	1											
A4	0.445 **	0.499 **	0.447 **	1										
A5	0.426 **	0.415 **	0.456 **	0.546 **	1									
T1	0.293 **	0.257 **	0.395 **	0.264 **	0.396 **	1								
T2	0	0.174*	0.182 *	0	0	0.270 **	1							
T3	0.249 **	0.310 **	0.311 **	0.256 **	0.357 **	0.243 **	0.207 *	1						
T4	0.231 **	0.225 **	0.268 **	0.229 **	0.195 *	0.217 *	0.263 **	0.495 **	1					
T5	0.220 **	0.215 *	0.205 *	0.201 *	0.272 **	0.237 **	0.204 *	0.448 **	0.452 **	1				
T6	0.266 **	0.338 **	0.260 **	0.299 **	0.389 **	0.289 **	0.182 *	0.399 **	0.403 **	0.418 **	1			
E1	0.214 *	0.204 *	0.257 **	0.280 **	0.288 **	0.337 **	0.252 **	0.381 **	0.346 **	0.248 **	0.516 **	1		
E2	0	0	0	0	0	0	0	0.186 *	0	0	0	0	1	
E3	0.168 *	0.195 *	0.224 **	0.168 *	0.203 *	0	0	0	0	0.216 *	0.180 *	0.232 **	0.458 **	1
E4	0.189 *	0.227 **	0.190 *	0	0.197 *	0	0.220 **	0	0.285 **	0.284 **	0.272 **	0.169 *	0	0
E5	0.196 *	0.315 **	0.355 **	0	0.299 **	0.273 **	0.231 **	0.198 *	0.345 **	0.225 **	0.306 **	0.289 **	0.217 *	0.180 *
E6	0	0	0	0	0	0	0	0	0.205 *	0	0	0.237 **	0.212 *	0.217 *
I1	0.222 **	0	0.206 *	0	0.284 **	0.252 **	0	0	0	0	0.246 **	0.394 **	0	0.170 *
I2	0	0	0	0	0.168 *	0.299 **	0	0	0	0.270 **	0	0.263 **	0.203 *	0.294 **
I3	0	0	0	0	0.218 **	0.209 *	0.251 **	0	0	0	0	0.228 **	0.313 **	0.225 **
I4	0.303 **	0.307 **	0.190 *	0.304 **	0.320 **	0.267 **	0	0.276 **	0.283 **	0.311 **	0.406 **	0.443 **	0.238 **	0.171 *
P1	0.307 **	0.297 **	0.223 **	0.173 *	0.175 *	0.216 *	0	0.285 **	0.173 *	0.293 **	0.329 **	0.212 *	0	0
P2	0.398 **	0.340 **	0.284 **	0.181 *	0.177 *	0.323 **	0	0.280 **	0.269 **	0.318 **	0.365 **	0.366 **	0	0
S1	0.223 **	0.258 **	0.213 *	0	0	0.169 *	0	0.193 *	0.315 **	0.279 **	0.311 **	0.247 **	0	0.223 **
S2	0.294 **	0.237 **	0.320 **	0.291 **	0.210 *	0.274 **	0	0	0.324 **	0.340 **	0.421 **	0.315 **	0	0.200 *

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 4. Results of the Spearman's Correlation test between barriers (continued).

B-Code	E4	E5	E6	I1	I2	I3	I4	P1	P2	S1
E4	1									
E5	0.425 **	1								
E6	0.364 **	0.385 **	1							
I1	0.241 **	0.211 *	0.387 **	1						
I2	0	0	0	0.526 **	1					
I3	0	0.244 **	0.172 *	0.201 *	0.467 **	1				
I4	0.323 **	0.352 **	0.214 *	0.244 **	0.316 **	0.243 **	1			
P1	0.252 **	0.331 **	0	0	0	0.198 *	0.483 **	1		
P2	0.309 **	0.463 **	0.185 *	0.250 **	0.231 **	0.260 **	0.513 **	0.639 **	1	
S1	0.242 **	0.315 **	0.262 **	0	0.179 *	0	0.309 **	0.303 **	0.455 **	1
S2	0.318 **	0.415 **	0.227 **	0.202 *	0.185 *	0.207 *	0.471 **	0.347 **	0.447 **	0.657 **

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Most of the barriers were associated positively with one another. (A2) Lack of clear vison for CE and (A3) Fragment supply chain had a statistically significant strong positive connection (r_s = 0.540), and this relationship was statistically significant at a very high level of significance ($p < 0.01$). A clear vision for CE initiatives often involves strategic planning and coordination throughout the supply chain. The positive correlation indicates that a lack of a clear vision may contribute to a fragmented supply chain. Without a cohesive and shared vision for circular practices, it becomes challenging to align and integrate different elements of the supply chain effectively.

The correlation observed between (T3) Lack of circular economy-specific legislation and (T4) Absence of certification, quality assurance, standardization, and grading systems for salvaged materials exhibited a strong positive correlation with a coefficient (r_s = 0.495, $p < 0.01$), indicating a strong positive relationship. Legislation provides the foundation, while certification and quality assurance systems ensure adherence to the principles outlined in the legislation. Without a specific legal framework guiding CE practices, there may be challenges in establishing and enforcing certification, quality assurance, and standardisation mechanisms for salvaged materials.

The barriers (E1) Lack of market mechanisms for recovery and (E3) Mismatch between supply and demand of reused materials were strongly correlated (r_s = 0.458, $p < 0.01$). The absence of market mechanisms for recovery can contribute to a situation where the supply and demand of reused materials are not effectively balanced. Without efficient recovery mechanisms, the supply of reused materials may not align with the market demand, leading to a mismatch.

The lack of interest in CE (S2) was significantly and strongly positively correlated with (S1) Negative perception of circular practices ($r_s = 0.657$, $p < 0.01$). Concerns among stakeholders regarding the quality and safety of reclaimed materials can lead to a general disinterest to adopt circular practices. Additionally, a lack of awareness about the advantages and suitability of circular design contributes to this negative perception, resulting in a lack of interest in adopting CE.

3.6. Enablers' Relative Importance Index

This section presents the RII of the ranking of the various enablers and their importance level, as perceived by the respondents. As shown in Table 5, the five which ranked highest, in order of highest to lowest, were as follows: "More materials yards and recycling facilities" (RII = 0.851), followed by "Use of Building Information Modelling (BIM)" (RII = 0.800), "Technology and Innovation for circular building tools" (RII = 0.797), "CE-Supportive Policy" (RII = 0.795), and "Standardisation and Assurance Certification for Reused Materials" (RII = 0.793).

Table 5. Collated RII ranking of the enablers of CE adoption.

Enabler	RII	Rank	Importance Level
More Materials Storage and Recycling Facilities	0.851	**1**	H
Use of Building Information Modelling (BIM)	0.800	**2**	H
Technology and Innovation for Circular Building Tools	0.797	**3**	H–M
CE- Supportive Policy	0.795	**4**	H–M
Standardisation and Assurance Certification for Reused Materials	0.793	**5**	H–M
Circular Business Models	0.791	**6**	H–M
Development of Reused Materials Market	0.788	**7**	H–M
Financial Incentives	0.784	**8**	H–M
Collaboration and Stakeholder Engagement	0.782	**9**	H–M
Design Guidelines for Circular Buildings	0.770	**10**	H–M
Circular Building Case Studies	0.770	**10**	H–M
Awareness Campaigns	0.761	**12**	H–M
Material Passport	0.752	**13**	H–M
Education and Research	0.723	**14**	H–M

In all, two of the enablers, namely, the establishment of more materials storage and recycling facilities and the use of BIM, were ranked as being at the highest level of importance, while the remaining 11 enablers had a high–medium importance level, clearly demonstrating the importance of all the enablers to the implementation of CE.

Enablers Relative Importance Index Analysis per Stakeholder

Table 6 presents the RII and ranking of enablers based on the perceptions and expertise of various stakeholders. This approach allows us to gain a deeper understanding of which enablers are crucial for different stakeholders and provides valuable insights into tailoring strategies and policies to facilitate the transition to a more circular construction industry.

For respondents who are contractors, the five highest-ranking enablers are "More materials yards and recycling facilities", followed by, both with the same ranking, Standardization and Assurance Certification for Reused Materials", and "Development of Reused Materials Market", followed by three enablers with the same ranking; "CE-Supportive Policy", "Design Guidelines for Circular Buildings", and "Financial incentives". On the other hand, the consultants ranked "More materials yards and recycling facilities" as the highest enabler, followed by "Use of BIM". Three enablers had the same ranking, which were "Collaboration and Stakeholder Engagement", "Financial Incentives", and "CE-Supportive Policy".

Table 6. RII ranking of the enablers of CE adoption by stakeholder.

Enabler	Contractor		Consultant		Client		Academia	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Design Guidelines for Circular Buildings	0.783	**4**	0.774	**8**	0.765	**11**	0.750	**12**
Circular Business Models	0.767	**7**	0.766	**10**	0.794	**3**	0.925	**2**
Standardisation and Assurance Certification for Reused Materials	0.792	**2**	0.798	**7**	0.787	**7**	0.825	**8**
Circular Building Case Studies	0.767	**7**	0.766	**10**	0.768	**10**	0.800	**9**
Use of Building Information Modelling (BIM)	0.758	**12**	0.831	**2**	0.794	**3**	0.875	**4**
More Materials Storage and Recycling Facilities	0.833	**1**	0.847	**1**	0.846	**1**	0.950	**1**
Awareness Campaigns	0.767	**7**	0.694	**14**	0.790	**6**	0.750	**12**
Financial Incentives	0.783	**4**	0.806	**3**	0.765	**11**	0.850	**6**
Education and Research	0.767	**7**	0.718	**13**	0.713	**14**	0.675	**14**
Collaboration and Stakeholder Engagement	0.742	**13**	0.806	**3**	0.772	**9**	0.900	**3**
CE-Supportive Policy	0.783	**4**	0.806	**3**	0.783	**8**	0.875	**4**
Development of Reused Materials Market	0.792	**2**	0.774	**8**	0.794	**3**	0.775	**11**
Technology and Innovation for Circular Building Tools	0.767	**7**	0.806	**3**	0.798	**2**	0.850	**6**
Material Passport	0.742	**13**	0.758	**12**	0.746	**13**	0.800	**9**

The enabler that received the highest ranking among the respondents who have primarily worked in client organisations was “More materials yards and recycling facilities”, followed by “Technology and innovation for circular building tools”. Three enablers have the same ranking: “Circular Business Models”, “Use of BIM”, and “Development of Reused Materials Market”, whereas, for respondents who have been primarily associated with academia in their career, the highest-ranking enablers are “More materials yards and recycling facilities”, followed by “Circular Business Models” and “Collaboration and Stakeholder Engagement”. Both the enablers “Use of BIM” and “CE-Supportive Policy” have the same ranking.

4. Discussion

4.1. Awareness and Attitudes

The built environment’s rising interest in CE necessitates the exploration of practical implementation mechanisms. The building sector plays a crucial role in achieving CE objectives. The notable finding that over 70% of stakeholders in the building sector in Saudi Arabia lack awareness of CE can be attributed to several factors. Cultural considerations can significantly impact attitudes and priorities within the building sector. If there exists a cultural resistance to change or a prevailing emphasis on traditional practices over sustainable approaches, stakeholders may be less motivated to prioritize CE initiatives. Stakeholders might be resistant to change if they are unfamiliar with the benefits and feasibility of adopting CE practices. This resistance is compounded by negative perceptions surrounding the quality and safety of reused materials and circular practices, which can hinder their acceptance. If there is a societal bias against adopting circular practices in construction industry, stakeholders may be reluctant to incorporate them into projects. Moreover, the absence of CE-specific regulation for adopting CE practices contributes to the prevailing lack of awareness among the stakeholders. Without requirements promoting CE practices, stakeholders may not perceive a compelling need to familiarise themselves with such principles. The regulatory framework is critical as it influences the establishment of industry standards that promote CE in construction and design, which will result in increasing knowledge and awareness of CE principles.

4.2. Barriers

Despite the growing interest in the CE model, several obstacles still hinder the full transition of the building sector towards a CE paradigm. As reported by the study participants, the five most notable challenges are related to the absence of certification and standardisation of reused material, a lack of market mechanisms for recovery, a negative perception of circular practices, supply chain fragmentation, and budget and upfront costs.

Material standardisation, classification, and certification are pivotal for creating uniform frameworks and guidelines that support circular practices. Stakeholders may express concern about the lack of established standards and certifications for reused materials. The absence of a clear framework for certifying the quality and safety of reclaimed materials can create uncertainty and hinder their widespread acceptance in construction projects. In addition, the lack of certification contributes to uncertainty regarding the performance and longevity of reclaimed materials. This uncertainty can discourage stakeholders from choosing these materials, particularly for projects where durability and performance are critical considerations.

The absence of market information regarding the supply and demand for recovered materials can hinder decision making among stakeholders, as the lack of efficient and effective market mechanisms for recovering materials and products contributes to limited opportunities for reclaimed materials. This limitation leads to unpredictable fluctuations in the unit cost of reclaimed components. Moreover, the lack of effective market mechanisms for material recovery makes it difficult to build profitable reuse and recycling models for construction materials. Therefore, a shift toward circularity requires favourable market conditions, including consumer demand and economic benefits [50].

Stakeholders prefer buildings constructed using new materials rather than those utilising recovered materials, as new materials are typically produced under controlled conditions, ensuring a level of standardisation and consistency in quality. This quality assurance is appealing to stakeholders who prioritise the reliability and durability of construction materials. Kanters [51] argued that building codes and regulations lack flexibility, typically showing a preference for specifying new materials in design codes. Therefore, stakeholders may prefer to adhere to established codes to ensure compliance, safety, and approval from regulatory authorities. The negative perceptions toward reclaimed materials have the potential to diminish their market demand in construction projects. This, in turn, restricts the economic feasibility of reusing and recycling materials, consequently impeding the advancement of CE. Furthermore, the lack of clear regulations regarding the use of reclaimed materials may contribute to negative perceptions.

The building sector involves various stakeholders, such as material suppliers, manufacturers, designers, contractors, engineers, and owners. The construction industry currently operates on conventional linear models. Shifting to a circular model requires a fundamental change in the mindset and practices of every part of the supply chain. Resistance to change from established norms can lead to a fragmented supply chain, which poses challenges in incorporating circular practices. According to Dunant [52], a rejection by a single participant in the supply chain to adopt a reused material has the potential to impede an entire project's progress. Therefore, efficient implementation of a CE requires effective communication and collaboration among all stakeholders in the supply chain.

Adopting circular practices often requires investments in new technologies and processes that may have higher initial costs [53,54]. Processing reclaimed materials and obtaining necessary certifications may cost additional expenses. Additionally, the absence of standardisation for reused materials contributes to increased construction costs, as these materials often necessitate additional testing and consultations to obtain the necessary certificates and permissions. This may lead stakeholders to perceive circular practices as more uncertain, particularly when they are unsure about the long-term benefits and returns on investment.

As explained in Table 2, the contractors' ranking of the absence of certification and standardisation of reused materials as a top barrier might be influenced by the uncertainty regarding the safety, reliability, and performance of such materials in construction projects. Without clear standards and assurances, contractors may fear potential liabilities and safety risks associated with using reused materials. From the academic perspective, recognition of the absence of certification and standardisation for reused materials as the highest-ranking barrier reflects the vital role of academics in shaping policies. Academics serve as key contributors to the policy-making process by providing expertise, research insights, and recommendations. Their influence is paramount in ensuring that policies align with best practices, addressing challenges such as the need for clear certification and standardisation for reused materials. Establishing clear certification and standardisation ensures reliability and credibility, which are essential for contributing to policy decisions.

Clients' ranking of a lack of market for recovered materials could be influenced by the economic viability of construction projects. The lack of established market mechanisms for the recovery of materials may raise concerns about the cost-effectiveness of circular practices. Clients may worry about potential additional costs associated with the recovery and reuse of materials without clear market mechanisms for such materials. Consultants ranked the high upfront cost associated with circular practices as a top barrier, recognizing the challenges posed by client's defined budgets for construction projects. Consultants recognise that higher upfront costs can strain the financial allocation by the client. They may perceive that a client is resistant to allocating additional funds for CE, especially if there is an immediate impact on upfront costs. The focus on adhering to client budgets could influence consultants' perspectives on this barrier.

4.3. Enablers

The analysis conducted in this study reveals that enabler strategies, including the need for more materials storage and recycling facilities, the use of BIM, the development of technology and innovation for circular building tools, CE- supportive policy, and standardisation and assurance certification for reused materials, emerged as the top five enablers to the wider adoption of CE.

Stakeholders in Saudi Arabia may see the need for more materials storage and recycling facilities as a strategic step to overcome barriers associated with the adoption of CE principles. Adequate materials storage and recycling facilities enable better management of resources, as well-designed storage and recycling facilities support the circular flow of materials. This means that materials can be collected, processed, and reintroduced into the construction cycle, aligning with the principles of a CE. Furthermore, the availability of storage and recycling facilities plays a significant role in fostering the growth of a robust market for reused and recycled construction materials. This, in turn, stimulates increased participation from new markets and attracts investments in circular practices.

The integration of BIM in the construction of circular buildings is important as BIM serves as a digital hub, allowing for better collaboration among stakeholders throughout a project's lifecycle [55]. Moreover, BIM allows for material tracking and management, which facilitates the identification, documentation, and potential reuse of materials [14,56]. BIM's design optimization features empower decision makers to analyse various scenarios, aiding in informed choices regarding material selection, resource utilisation, and waste reduction. Additionally, BIM facilitates a comprehensive evaluation of a building's lifecycle costs, including design, construction, operation, maintenance, and end-of-life costs [57]. This provides stakeholders with a comprehensive overview of the circular building costs, enabling a more informed and holistic understanding of the economic aspects associated with circular construction practices.

In the construction industry, the adoption of innovative technologies plays a crucial role in facilitating and accelerating the implementation of circular buildings, as technological advancements enhance the accessibility and applicability of CE principles in complex design. These advancements include incorporating design for manufacture and assembly (DfMA), digital fabrication (Dfab), and additive manufacturing (AM). These approaches often result in cost savings, reduced material waste, and optimised resource utilization [58]. Moreover, technological advancements in prefabrication and modular construction allow for the off-site manufacturing of building components in a controlled environment, and assembly of them on-site. This allows for faster construction times and easier modifications, expansions, or repurposing of buildings as needs evolve over time, which minimises on-site waste.

The presence of CE-supportive policies is a crucial enabler for the wider adoption of CE practices. Legislation oriented towards CE can establish standards that cover building design, construction, and operation. These standards may mandate the utilization of reused or recycled materials, emphasise energy efficiency, promote waste reduction strategies, and advocate for the integration of circular principles throughout building practices. Such policies provide a structured framework, guidelines, regulations, and incentives that promote the overall transition toward circular business models. Furthermore, policies help mitigate the risks associated with the transition to circular practices by providing guidelines and support. Therefore, stakeholders are more likely to embrace circularity when they have a clear understanding of regulatory expectations.

The concerns about the quality and performance of reclaimed materials in building construction are legitimate, and addressing these concerns is essential for the wider adoption of such materials. Recognized standards and certifications play a crucial role in building trust among stakeholders and ensuring the quality, safety, and durability of reclaimed materials. This helps in meeting specific performance criteria and ensures that the materials are suitable for their intended applications, as stakeholders need assurance that the materials will perform as expected over time. In addition, certifications of reclaimed materials can enhance market acceptance, as stakeholders are more likely to use these materials if they are assured of their quality and compliance with established standards.

As shown in Table 6, stakeholders identified "More Materials Storage and Recycling Facilities" as the top enabler. This consensus underscores the shared recognition among stakeholders of the paramount importance of enhancing infrastructure for materials storage and recycling in fostering CE practices within the Saudi Arabian building construction industry. This recognition indicates the need for investments and initiatives to enhance materials storage and recycling capabilities. The lack of adequate infrastructure can be a significant impediment to efficiently managing recycled and reused materials.

5. Conclusions

As the Kingdom of Saudi Arabia strives for economic diversity and environmental sustainability, embracing CE strategies in the building sector emerges as a critical pathway. This research shares the first findings of the awareness, attitudes, and implementation level of CE among the stakeholders of the built environment in Saudi Arabia. Additionally, it examined the primary obstacles to implementing circular strategies in building construction projects, along with the factors that facilitate a transition to the CE model. This study employed a quantitative method through an online survey with a total of 139 respondents from various stakeholder groups across major provinces, including Riyadh, Makkah, and the Eastern provinces, which are representative of significant construction projects in the country. This study utilised the relative importance index (RII) to rank barriers and enablers, conducted a reliability analysis using Cronbach's alpha, and employed a Spearman's correlation test to analyse the strength and direction of associations concerning the implementation of CE among various identified barriers.

This study's findings reveal a significant lack of awareness of CE among the stakeholders, as the majority of participants (70%) express unfamiliarity with CE principles. Furthermore, the results indicate a low implementation rate of CE principles in building construction projects, as only 19% of participants believe their organisations consistently or frequently incorporate CE practices in such projects. However, the participants showed a positive attitude toward implementing CE as 85% of the participants believe their organisation should adopt CE principles in future construction projects. This strong endorsement shows a willingness among the participants to embrace and integrate circular practices within their organisational frameworks.

This study ranked 25 barriers to the adoption of CE in the building sector. The analysis revealed that the primary challenges in adopting CE are the "Absence of certification, quality assurance, and standardization for reused materials"; "Lack of market mechanisms for recovery"; "Negative perception of circular practices"; "Fragmented supply chain";

and “High upfront costs”. Conversely, this study ranks a set of crucial enablers that can contribute to the current situation and facilitate the transition towards more circular buildings. According to the participants, the top five enablers are “More materials storage and recycling facilities”; “Use of Building Information Modelling (BIM)”; “Technology and innovation for circular building tools”; “CE-Supportive Policy”; and “Standardisation and Assurance Certification for Reused Materials”.

In order to promote the adoption of CE practices and raise awareness among the stakeholders, this study suggests two key measures: the implementation of CE-supportive policies and legislation that involve creating a regulatory framework promoting sustainable resource use, recycling, and responsible waste management; and the provision of financial incentives such as tax reductions for circular practices.

The study’s findings provide valuable insights into the current state of CE in the building sector in Saudi Arabia, empowering stakeholders to develop more effective strategies for successful CE adoption. These research outcomes play a crucial role in shaping pathways toward a more circular built environment. However, it is crucial to acknowledge this study’s limitations, as it lacks a qualitative method for validating survey results through the perspectives of CE experts. Additionally, this study is limited to surveying stakeholders in three specific provinces of Saudi Arabia. While these provinces provide valuable insights into the perceptions and challenges related to CE adoption in the construction industry, it is essential to acknowledge that the findings may not fully represent the entire industry. Future research should incorporate expert opinions and discussions to contribute to a deeper understanding and advancement of CE practices. Moreover, a more comprehensive understanding would require the inclusion of stakeholders from a broader geographic scope, encompassing all regions of Saudi Arabia.

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