

An Investigation on Importance and Adoption of Circular Economy Strategies in the Libyan Construction Industry

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دراسة حول أهمية واعتماد استراتيجيات الاقتصاد الدائري في قطاع البناء في ليبيا

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Abstract:

The idea of a circular economy (CE) has arose as an effective strategy for calling resource exhaustion, waste generation, and environmental challenges, offering a hopeful path toward a more sustainable future. This is specifically appropriate in the construction industry on account of the meaningful amounts of waste produce all the while construction and demolition processes. This study analyzes the perceived significance and adoption of 25 CE strategies within construction projects. Data were collected from professionals in the Libyan construction sector through a questionnaire, occupying their ideas of different actions. The results indicate that most strategies were seen as highly substantial, suggesting a strong knowledge of their significance among respondents. Strategies such as waste management, recycling, and designing for disassembly were specifically adored. However, the study discloses a meaningful gap between the perceived significance and the real adoption of these strategies, with overall adoption levels surplus approximately low. The findings also identify key barriers to CE implementation, generally stopping from young engineering technologies and a ignorance with professionals. This study provides valuable observations into the current state of the CE in the Libyan construction industry, highlight the need for target policies and interventions. The findings can help policymakers and industry stakeholders plan active development policies and practical plans to help along between knowledge and implementation, thereby supporting a more sustainable and flexible built environment.

Keywords: Circular economy (CE); Construction industry; Strategies; Importance-adoption analysis; Sustainability; Libya.

المخلص:

برز مفهوم الاقتصاد الدائري (CE) كاستراتيجية فعالة لمعالجة استنزاف الموارد وتوليد النفايات والتحديات البيئية، مما يوفر مسارًا واعدًا نحو مستقبل أكثر استدامة. وهذا أمر مهم بشكل خاص في صناعة البناء بسبب الكميات الكبيرة من النفايات التي تحدث أثناء عمليات البناء والهدم. تحلل هذه الدراسة الأهمية المتصورة لـ 25 استراتيجية من استراتيجيات الاقتصاد الدائري واعتمادها في مشاريع بناء المباني. تم جمع البيانات من المهنيين في قطاع البناء الليبي من خلال استبيان، لتسجيل تصوراتهم حول مختلف الاستراتيجيات. تشير النتائج إلى أن معظم الاستراتيجيات تم اعتبارها ذات أهمية كبيرة، مما يشير إلى وعي قوي بأهميتها بين المشاركين في الاستبيان. حظيت استراتيجيات مثل إدارة النفايات وإعادة التدوير والتصميم من أجل التفكيك بتقدير كبير بشكل خاص. ومع ذلك، تكشف الدراسة عن فجوة كبيرة بين الأهمية المتصورة والتطبيق الفعلي لهذه الاستراتيجيات، حيث تظل مستويات التطبيق الإجمالية منخفضة نسبيًا. كما تحدد النتائج العقبات

الرئيسية التي تحول دون تنفيذ الاقتصاد الدائري، والتي تنبع في المقام الأول من عدم نضج التقنيات الهندسية ونقص المعرفة لدى المهنيين. توفر هذه الدراسة رؤية قيمة حول الوضع الحالي للاقتصاد الدائري في قطاع البناء الليبي، وتسلط الضوء على الحاجة إلى سياسات وتدخلات موجهة. يمكن أن تساعد النتائج صانعي السياسات وأصحاب المصلحة في القطاع على صياغة سياسات تنموية فعالة واقتراحات عملية لسد الفجوة بين الوعي والتنفيذ، وبالتالي تعزيز بيئة بناء أكثر استدامة ومرونة.

الكلمات المفتاحية: الاقتصاد الدائري (CE)، صناعة البناء، الاستراتيجيات، تحليل الأهمية-الاعتماد، الاستدامة، ليبيا.

Introduction:

The construction industry (CI) plays a vital role in driving global economic expansion; however, it simultaneously generates substantial environmental pressures due to intensive resource consumption and large volumes of construction and demolition waste (C&DW) (Tafesse et al., 2022; Alazaiza et al., 2024). While infrastructure development is essential for meeting societal needs, it frequently results in significant quantities of waste materials such as concrete, metals, asphalt, brick, and various recyclable components including wood, glass, and plastics (Di Maria et al., 2016; Ferriz-Papi et al., 2024). In recent years, the sector has been undergoing a structural transition influenced by demographic changes, digital transformation, and economic challenges, all of which have intensified efforts to minimize environmental impacts (Tafesse et al., 2022; Idir et al., 2025).

The circular economy (CE) has emerged as an effective and contemporary framework for enhancing sustainability in the construction sector by improving resource efficiency, reducing waste, and promoting long-term material value retention (González et al., 2021; Alhawamdeh et al., 2024). CE strategies, including designing for disassembly, employing recycled materials, and prioritizing adaptability, have shown strong potential to mitigate environmental burdens while simultaneously generating economic and social advantages such as cost reductions, improved resilience, and innovation-driven performance (Ossio et al., 2023; Swarnakar & Khalfan, 2024). Implementing CE practices is especially crucial for addressing material scarcity and improving resource management in construction markets with limited recycling infrastructure.

Despite increasing global adoption of CE principles, their application within the Libyan construction sector remains underdeveloped, with limited awareness and inconsistent implementation across firms and practitioners (Lee et al., 2023; Alazaiza et al., 2024). Accordingly, this study explores the degree of CE adoption in the Libyan construction industry and examines the opportunities and barriers shaping the transition toward a more sustainable and circular built environment. The study is guided by the following research questions:

- Are construction industry practitioners and companies in Libya willing to adopt and promote circular economy practices?
- What challenges hinder the implementation of CE strategies in construction projects?

Material and methods:

Research Design:

This study employed a quantitative research methodology, which emphasizes structured inquiry, objective measurement, and the use of numerical evidence. Unlike qualitative approaches that rely on interpreting narrative or observational data, quantitative methods focus on quantifying variables and analyzing measurable patterns (Saunders, 2016). To obtain reliable insights from construction-sector specialists, a structured survey questionnaire was administered. This method was chosen due to its suitability for capturing standardized responses from a geographically dispersed group of professionals and for enabling statistical comparison of perceptions toward the proposed strategies.

Questionnaire Design and Sampling Process:

A structured questionnaire based on a five-point Likert scale was developed to assess participants' views regarding circular economy (CE) strategies. The instrument consisted of four major sections:

- **Part 1:** Background information on the respondents and the organizations they represent.
- **Part 2:** Evaluation of the perceived importance of each CE strategy, scored from 1 ("not important at all") to 5 ("extremely important").
- **Part 3:** Assessment of the extent to which CE-related practices have been applied in previous projects, using a scale from 1 ("never applied") to 5 ("implemented in nearly all projects").
- **Part 4:** Open-ended items that allowed respondents to describe challenges and practical barriers affecting the implementation of CE principles.

The questionnaire was distributed electronically through Google Forms to ensure accessibility and efficiency. Participants were selected from key professional groups, such as engineers, architects, builders, and quantity surveyors, who possess relevant knowledge and experience in construction activities. A total of 199 completed and valid responses were obtained and included in the analysis.

Data Collection and Analysis:

Collected data were processed using both descriptive and inferential statistical techniques with the support of Microsoft Excel and SPSS (Version 27). Findings were organized and displayed in tables to enhance clarity and interpretation. The statistical procedures applied included mean ranking, one-sample t-tests, and one-way ANOVA (Kruskal–Wallis) to examine differences in perceptions across respondent groups.

Results and discussion:

Reliability Statistics:

The reliability of the survey instrument was assessed using Cronbach's Alpha. The analysis revealed a very high degree of internal consistency across the questionnaire sections. The scale measuring the perceived importance of CE strategies (Part 2) achieved a Cronbach's Alpha of 0.916, which reflects excellent reliability. Similarly, the scale evaluating the extent of CE strategy adoption (Part 3) produced an Alpha coefficient of 0.872, also indicating a strong level of internal consistency. These high values demonstrate that the questionnaire is both dependable and stable for empirical use.

Demographic Profile:

The demographic data provides understandings into the characteristics of the respondents and their companies.

Table (1): Demographic Profile of Respondents

Variable	Categories	Frequency	Percent
Age	20-29 years	10	5.0%
	30-39 years	55	27.6%
	40-49 years	101	50.8%
	50-59 years	30	15.1%
	>60 years	3	1.5%
	Total	199	100%
Position	Engineer	116	58.3%
	Surveyor	31	15.6%
	Construction Technician	5	2.5%
	Construction Supervisor	39	19.6%
	Site Manager	6	3.0%
	Consultant	2	1.0%
	Total	199	100%
Company's Years in Business	Less than 1 year	2	1.0%
	Between 1 and 5 years	42	21.1%
	More than 5 years but less than 10 years	108	54.3%
	More than 10 years	47	23.6%
	Total	199	100%
Years of Experience	Below 5 years	10	5.0%
	5-10 years	91	45.7%
	11-15 years	38	19.1%
	16-20 years	48	24.1%
	Over 20 years	12	6.0%
	Total	199	100%

The Importance of CE Strategies:

The overall mean for the significance of CE strategies is 3.478, with a standard deviation of 0.503. This indicates that, approximately, professionals in the Libyan construction industry consider these strategies to be substantial.

Table (2): Importance of Circular Economy (CE) Strategies

Strategy	Mean	Std. Deviation
Design Stage		
Minimising recuperative maintenance with preventive maintenance	04.01	0.937
Use of a circularity tool to evaluate existing buildings	3.98	0.801
Using less hazardous and less toxic materials	3.95	0.963
Design with sustainable, climate-resilient, and eco-friendly concepts	3.94	0.743
Optimisation of resources to minimize excessive use of resources on-site	3.94	0.833
Using renewable energy	3.93	0.865
Design for an increased lifespan (durable design)	3.89	0.907
Design for manufacture and assembly (modular construction)	3.89	0.875
Procuring reused and recycled materials	3.89	1.002
Effective management of demolition waste	3.87	0.722
Design for preventing waste generation	3.85	0.903
Applying take-back and trade-in systems	3.84	0.946
Consuming services instead of products	3.82	0.901
Using recycled contents when manufacturing construction materials	3.80	0.859
Disassemble building structures and parts	3.77	0.950
Analysing the potential of reusing and recycling of building materials and components	3.65	0.861
Sharing spaces, facilities, and products	3.64	0.873
Design for adaptability and flexibility to change	3.63	0.863
Using prefabricated/offsite construction	3.59	0.823
Reusing secondary materials and components in new productions	3.46	0.737
Design for deconstruction	3.44	1.052
Design for disassembly of building into components	3.20	0.936
Preparing material passports	3.14	0.864

The Adoption of CE Strategies:

The overall mean for the adoption of CE strategies is 2.518, with a standard deviation of 0.403. This low mean score signifies that the adoption of these strategies is not yet widespread in the Libyan construction industry.

Table (3): Adoption of Circular Economy (CE) Strategies

Strategy	Mean	Std. Deviation
Construction Stage		
Consuming services instead of products	03.03	0.964
Optimization of resources to minimize excessive use of resources on-site	2.95	1.004
Reduction/prevention of construction waste at the site	2.92	0.962
Procuring reused and recycled materials	2.91	0.961
Using less hazardous and less toxic materials	2.66	0.805
Minimising recuperative maintenance with preventive maintenance	2.66	0.836
Effective management of demolition waste	2.66	0.760
Using prefabricated/offsite construction	2.63	0.798
Design with sustainable, climate-resilient, and eco-friendly concepts	2.62	0.699
Using renewable energy	2.54	0.744
Using recycled contents when manufacturing construction materials	2.54	0.723
Use of a circularity tool to evaluate existing buildings	2.51	0.797
Design for an increased lifespan (durable design)	2.46	0.863
Design for manufacture and assembly (modular construction)	2.44	0.742
Design for preventing waste generation	2.43	0.768
Lifespan extension of products and materials through repairing and upgrading	2.40	0.752
Sharing spaces, facilities, and products	2.35	0.679
Analysing the potential of reusing and recycling of building materials and components	2.32	0.663
Disassemble building structures and parts	2.27	0.891
Reusing secondary materials and components in new productions	2.25	0.639
Design for deconstruction	2.15	0.884
Preparing material passports	2.15	0.601
Applying take-back and trade-in systems	2.10	0.655
Design for adaptability and flexibility to change	2.41	0.773
Design for disassembly of building into components	1.93	0.739

Obstacles to Adopting CE Strategies:

The survey finds the basic obstacles hindering CE adoption.

Table (4): Obstacles to Adopting CE Strategies

Obstacle	Frequency	Percent
Immature engineering technologies	92	46.2%
Lack of knowledge	87	43.7%
Lack of government support	18	9.0%
High CE adoption costs	2	1.0%
Total	199	100.0%

Discussion:

The results of this research reveal a noticeable mismatch between how important circular economy (CE) strategies are perceived to be and the extent to which they are currently applied within the Libyan construction sector. Although industry professionals recognize the value of CE principles, as reflected in an overall importance mean of 3.478, the comparatively low adoption mean of 2.518 indicates that these practices have not yet been widely integrated into real-world projects. **Several key insights emerge from the detailed analysis:**

Disparity Between Perceived Importance and Actual Use:

A substantial gap exists between what respondents consider essential and what they actually implement. For example, measures such as reducing restorative maintenance through preventive maintenance ($X = 4.1$) and using safer, less hazardous materials ($X = 3.95$) were among the highest-rated in terms of perceived value. However, their implementation levels remain notably limited. This contrast suggests that professionals possess awareness and willingness, yet structural and operational constraints hinder the transition from intention to practice.

Most Highly Rated Strategies:

The strategies ranking highest in perceived importance primarily relate to waste reduction and environmentally friendly material usage. This corresponds with global trends that prioritize sustainability in construction. The results imply that Libyan professionals are aware of their sector's environmental impact. Nonetheless, the strategies most frequently implemented, such as shifting toward service-based consumption ($X = 3.03$) and optimizing resource use to avoid excess ($X = 2.95$), tend to be less complex and easier to integrate within existing workflows. This pattern suggests that the sector is gravitating toward straightforward, low-barrier CE practices rather than those requiring advanced technical capabilities.

Major Barriers to Implementation:

The low adoption levels are closely tied to the obstacles identified by respondents. The most commonly reported challenges include underdeveloped engineering technologies (46.2%) and insufficient professional knowledge (43.7%). This is significant because it indicates that the primary issue is not related to perceived cost, reported by only 1.0%, but instead to the absence of the technological infrastructure and technical competence necessary for implementing CE strategies. Limited government support (9.0%) also contributes to slow adoption, though to a lesser extent, which may help explain the lack of strong policy incentives compared with more advanced economies.

These observations are consistent with existing research, which also notes that knowledge gaps and technological limitations are among the most persistent barriers to CE implementation. The findings therefore suggest that enhancing CE adoption in Libya requires moving beyond awareness-raising and focusing on actionable capacity-building measures. This includes promoting local development of CE-related technologies, strengthening institutional support systems, and establishing comprehensive training programs to ensure that construction professionals are equipped with the expertise needed to apply CE strategies effectively.

Conclusion:

The adoption of circular economy (CE) practices is crucial for addressing resource limitations and enhancing economic performance in the construction sector. This study examined both the perceived importance and the actual implementation of various CE strategies within the Libyan construction industry. The findings confirm that CE principles, such as reducing material waste and extending the lifecycle of construction products, offer significant potential benefits. Professionals in Libya demonstrate a strong awareness of the value of these strategies; however, a considerable gap exists between this perceived importance and their practical application, indicating that CE adoption is still at an early stage of development.

The main barriers identified in this study are the lack of advanced engineering technologies and insufficient technical knowledge, highlighting that practical and educational challenges are more pressing than financial or regulatory issues at this stage. Based on these insights, **several recommendations can be made:**

- 1. Technological Development and Localization:** Both government and industry stakeholders should prioritize the development and local adaptation of CE-related technologies. This includes creating accessible tools for deconstruction, recycling, and material traceability that are suitable for the local context.
- 2. Knowledge Enhancement and Capacity Building:** Efforts should focus on equipping construction professionals with the necessary skills and knowledge through targeted workshops, training programs, and educational initiatives that emphasize the practical application of CE strategies in projects.
- 3. Policy and Incentive Support:** Although government support was not identified as the primary barrier, formal policies and economic incentives are essential to close the gap between recognition and practice. Policymakers should implement regulations and provide rewards to encourage firms to adopt CE strategies.

This study offers a preliminary understanding of CE adoption in Libya's construction sector. Future research should expand the sample to include a wider range of participants from diverse regions and professional backgrounds to improve the generalizability of results. Moreover, considering the rapid evolution of CE technologies, continuous refinement and updating of proposed strategies are necessary. Finally, future studies should incorporate cost-benefit analyses to provide practical guidance for companies seeking to implement these strategies effectively.

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