

# Social Indicators for Integrating the Circular Economy into Infrastructure Projects in Malaysia

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**Abstract:** The adoption of the circular economy (CE) in infrastructure projects has grown in recent years, significantly contributing to sustainable development. However, the integration of the CE into Malaysia's infrastructure projects has social aspects that remain underexplored. This study aimed to, first, identify key social indicators that define the integration of CE principles into infrastructure development and, second, propose strategies to enhance the inclusion of these social dimensions. Thematic analysis was conducted on data collected through in-depth interviews with 18 respondents from diverse sectors of the infrastructure industry, including clients, consultants, contractors, and suppliers. Three main social indicators were identified: engagement, quality of life, and attractiveness. Strategies such as integration, regulatory policy, and transparency were found to be crucial for advancing the inclusion of social aspects in CE practices. The findings offer insights on integrating social factors into CE frameworks, promoting more inclusive and sustainable infrastructure development.

**Keywords:** Circular economy, infrastructure projects, social impact, social indicators, social sustainability

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## 1. Introduction

Circular economy (CE) principles are increasingly applied to infrastructure projects, aiming to minimise waste, conserve resources, and maximise the value of materials throughout the life cycles of the projects. This topic has garnered increased attention owing to its restorative and regenerative nature, which replaces the traditional 'take-make-dispose' of the linear economic system with practices such as restoration, recycling, and reuse (Neves and Marques, 2022). The CE enhances resource efficiency and reduces waste, significantly lowering greenhouse gas emissions and supporting climate change mitigation (Korhonen et al., 2022).

In the case of Malaysia, the government has demonstrated its commitment in the Twelfth Malaysia Plan (12th MP), with digital transformation being one of the key elements to be adopted in developing better infrastructures and connectivity. Adopting sustainable approaches and CE principles is a way to minimise the global greenhouse gas effects and the increasing scarcity of the world's natural resources caused by infrastructure developments (Mustaffa et al., 2023).

Even though the concept has still not been widely developed in current practices in Malaysia's infrastructure projects fraternity, CE is becoming a new model that focuses on achieving the targeted Sustainable Development Goals (SDG). The government, through its roadmap on long-term sustainable growth, continues to offer ways to generate value for not only stakeholders but also society at large (Sandoval et al., 2018).

To date, integrating CE principles into infrastructure projects offers a holistic approach to cost saving throughout the project life cycles by conserving natural resources and decreasing the environmental impact of waste disposal. Studies

conclusively demonstrate that embracing CE principles in infrastructure projects contributes to a more sustainable and resilient economy while safeguarding the environment.

However, there are no significant findings on how the CE has delivered the expected social value for the infrastructure industry in making the transition from linear to circular approaches, particularly those which affect society. This is supported in a recent study (Tomic and Schneider, 2020), where CE is viewed as a driver of both regional economic development and the preservation of environmental and natural resources but with very implicit gains in terms of social aspects. The silence and lack of focus on the social aspects of CE have led to growing criticism, and discussions on how CE could contribute to equitable societies are generally absent, indicating that social implications are a significant gap in the literature (Murray et al., 2017)

## **2. Literature Review**

### **2.1. Malaysia's Infrastructure**

The government of Malaysia has channelled substantial funds, approximately US\$13 billion or 3.66% of its gross domestic product (GDP), to be invested in infrastructure development to stimulate economic expansion and social progress (Davidson et al., 2020). In general, the complexity of infrastructure development consumes over 40% of global energy, 40% of solid waste, and 30% of carbon emissions, thus having a significant impact on the surrounding ecosystems (Krajangsri and Pongpeng, 2017). Similarly, for Malaysia, infrastructure development imposes a high social cost due to a lack of efficiency, a reduced quality of life, and increased safety and health risks. These costs arise from various factors, including inefficiencies in project planning, poor project implementation, inadequate consideration of social and environmental aspects, and insufficient investment in maintenance upkeep. As a result, infrastructure projects have a range of negative consequences that affect the well-being and quality of life of Malaysian citizens (Alaloul et al., 2022). The massive investment and development in the infrastructure industry in Malaysia have attracted numerous research interests, who aim to measure the policy tools and framework, especially those related to sustainability approaches.

### **2.2. Circular Economy in Infrastructure**

As a developing nation, Malaysia has started to introduce the CE model as a sustainable approach to its infrastructure projects. The government's endeavours to encourage influential stakeholders to construct environmentally friendly infrastructure have escalated with the establishment of this assessment tool and framework. At the time of writing, a blueprint for circular cities in Malaysia is on its way to be developed by the Government of Malaysia. This initiative underscores Malaysia's commitment to fostering sustainable urban development and building smart cities that prioritise environmental stewardship, resource efficiency, and social inclusivity.

This blueprint for circular cities also aims to integrate CE principles into urban planning, infrastructure development, and governance frameworks. By adopting a holistic approach that considers the interconnection of social, economic, and environmental factors, the Government of Malaysia seeks to create resilient and livable cities.

In essence, the transformation of the flow model from the traditional linear to cyclical is not solely to address the sustainability issue but also to minimise the consumption of natural resources, address material-energy-related issues, inspire new business prospects, and create value for the practitioners, societies, and other stakeholders (Sandoval et al., 2018)

### **2.3. Social Sustainability in CE**

Social sustainability has always been neglected by policymakers when addressing the sustainability concept in the CE model (Rivera et al., 2020). Despite the emphasis on economic and environmental aspects, the social impacts of the CE have often remained unclear, with a lack of the inclusion that would promote socio-economic benefits, social well-being, the paybacks that CE brings to society, and an understanding of the broader societal implications of CE initiatives. Furthermore, the lack of clarity in defining social sustainability has contributed to the knowledge gaps in this area (Zapata and Munoz, 2018). The absence of a universally agreed-upon definition and the fact that every author and policymaker describes social sustainability according to their individual perspective has complicated efforts to incorporate social sustainability into CE frameworks and policies.

To address these challenges, Vijakumar et al. (2022) suggested that rather than probing the theoretical definitions, the main dimensions and key indicators that operationalise the social dimensions in the CE should be discussed. By identifying and examining specific dimensions such as community engagement, job creation, social inclusion, and equitable distribution of benefits, policymakers and practitioners could better understand the social implications of CE initiatives and develop targeted strategies to maximise the positive social outcomes. Additionally, establishing clear indicators and measurement tools for assessing social sustainability within CE projects could facilitate monitoring and evaluation efforts, enabling stakeholders to track progress and make informed decisions.

The study by Mies and Gold (2021) also underscores the importance of integrating the social dimension into CE discourse and practice. They highlighted that this dimension is equally vital in the CE since it can indicate how policies and actions impact or benefit society.

### **2.4. Knowledge Gap and Study Positioning**

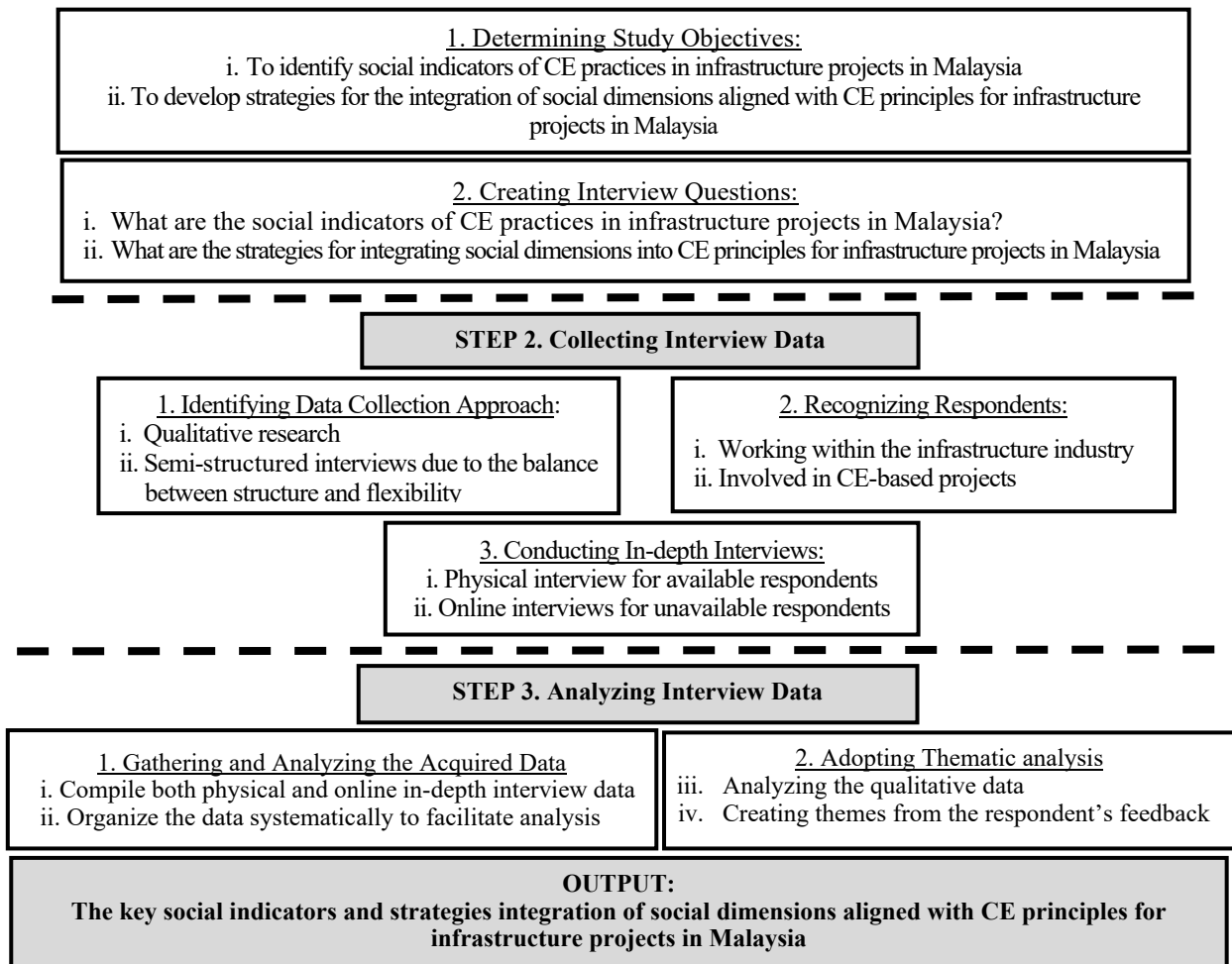
The current body of knowledge regarding CE is notably deficient in several key areas. Firstly, there is a lack of research specifically focusing on Malaysian infrastructure projects as a case study within the broader setting of the CE. This gap is not solely due to the challenges of researching the CE in this context, but it does reflect a broader issue of emphasis and prioritisation, leading to a limited understanding of how CE principles are applied to Malaysian infrastructure developments. Furthermore, much of the research on the CE in Malaysia primarily focuses on its implementation challenges and the economic and environmental benefits (Agamuthu and Mehran, 2019). While there is literature on the CE, its application and

impact on Malaysia's infrastructure development projects, particularly in relation to social sustainability—such as community impact, equity, social inclusion, and quality of life—have received less attention.

To address this issue, it is imperative to conduct further research that specifically focuses on the CE within infrastructure developments in Malaysia and develop comprehensive sustainability assessment frameworks that integrate and incorporate the full range of social impacts associated with CE infrastructure projects. By adopting these frameworks, stakeholders can promote the development of CE infrastructure projects that not only achieve economic and environmental objectives but also contribute positively to social well-being and equity.

### 3. Research Methodology

The research methodology encompasses the systematic approach used in this study, including the techniques, procedures, tools, data analysis, and interpretation. Figure 1 depicts the methodological flow, from establishing the interview protocol to analysing the collected data.



**Figure 1:** Research Methodology Progression of the Study

#### 3.1. Data Reliability and Validity

To ensure the reliability and validity of the data collected, several steps were taken during the research process. First, the study employed in-depth interviews with a carefully selected group of 18 industry practitioners, including clients, consultants, contractors, and suppliers, to gather diverse perspectives. A standardised interview protocol was used to minimise variability and ensure consistency in the responses. The data was then analysed using thematic analysis, with recurring themes being cross-checked for consistency and reliability. To further validate the findings, peer debriefing and triangulation with the existing literature were utilised, enabling the cross-verification of the identified themes and indicators. This approach enhanced the credibility of the results and strengthened the conclusions drawn from the data.

#### 3.2. Data Collection: Semi-Structured Interview

This research employed a data collection approach that is commonly used in qualitative research. As suggested by Mustaffa et al. (2023), the semi-structured interview was employed to measure the key social indicators and the strategies that policymakers can explore to incorporate social aspects into the CE of infrastructure project practices. The semi-structured interview offers a balance between structure and flexibility by using a pre-determined set of questions or topics.

To gather the necessary data and information for this study, two methods of data collection were adopted: physical and online in-depth interviews. For the physical in-depth interviews, potential respondents were contacted based on specific criteria. The focus was on individuals experienced in adopting the CE in project practices and those who were not but were

still working on infrastructure development projects. Once the respondents had been identified, mutually convenient interview dates were arranged.

Following the suggestion by Mao et al. (2015), the non-probability sampling technique was adopted to define the sample population and select the potential respondents who would take part in the study. This technique has been extensively used in construction management. Early respondents were requested to recommend contacts who were well-versed in the study area, who might then participate and become respondents themselves. If a subsequent respondent fulfilled the criteria, they were asked to complete the survey questionnaires. Alternatively, to reach a broader range of participants, online in-depth interview questions were also distributed via email to individuals unable to attend in person.

As suggested by Mustaffa et al. (2023), to obtain in-depth information and analytical capabilities, the number of interviews would ideally be between 10 and 15. For this study, the sample group consisted of 18 respondents with diverse backgrounds, including key players and relevant stakeholders such as members of the authorities, developers, consultants, contractors, suppliers, non-governmental organisations, and those from society who were directly affected. These respondents were among the stakeholders directly involved in the infrastructure industry in Malaysia.

Next, the questions were designed by displaying the study objectives on the front page to give the respondents a brief overview. During the interviews, the respondents' background information such as the nature of the business in which they were involved, their position level in their organisation, and their years of experience was promptly collected to ensure the relevance of the data to the study objectives, as demonstrated in Table 1, which shows the respondent demographics and profile.

**Table 1.** Respondent Demographic and Profile

No of Respondent	Stakeholder	Current Position	Years of experience
R1	Client / Developer	Asst.Manager	12
R2	Client / Developer	Senior Engineer	6
R3	Contractor	Senior Engineer	8
R4	Contractor	Project Manager	15
R5	Consultant	Resident Engineer	13
R6	Client / Developer	Design Manager	14
R7	Contractor	Head of Asset Management	16
R8	Client / Developer	Project Manager	9
R9	Consultant	Senior Engineer	8
R10	Contractor	Asst.Manager	5
R11	Contractor	Technical Engineer	6
R12	Contractor	Asst.Site Manager	7
R13	Consultant	Senior Engineer	12
R14	Authorities	Asst. Director	11
R15	Client / Developer	Project Manager	13
R16	Consultant	Principle Engineer	10
R17	Consultant	Principle Engineer	16
R18	Contractor	Project Manager	11

### 3.3. Data Analysis: Thematic Analysis

At this stage, the information was gathered and analysed. In this research, thematic analysis was adopted for the qualitative study. Thematic analysis was used for analysing the qualitative data that had been gathered through the physical semi-structured interviews and online in-depth interviews. The themes were created by looking for patterns in the respondents' answers. This dynamic procedure of reflexivity involved identifying, organising, and offering insights into obtaining themes from across a dataset (Braun and Clarke, 2006). This method allowed a focus on the data in numerous ways, by analysing across the whole dataset or focusing on specific parameters in depth. Several stages of the thematic analysis adopted in the current study are defined as follows and illustrated in Figure 2.

### 3.4. Ethical Clearance

This study did not require formal ethical clearance as it involved in-depth interviews with industry practitioners, with no sensitive information collected. All the participants were informed of the study's purpose, and they provided oral consent prior to participation. Given that the study focuses on professional insights and did not involve sensitive data, ethical clearance was not deemed necessary. However, the study adhered to ethical research practices, ensuring the participants' confidentiality and voluntary participation.

## 4. Results and Discussion

This chapter analyses the collected data and discusses how it aligns with the research aims and methodology. It focuses on two key subjects that explore the social dimension of infrastructure projects in a CE context. These subjects are crucial for identifying key social indicators and developing strategies to better integrate social aspects with CE principles.

#### 4.1. Social Indicators of Integrating CE into Infrastructure Projects in Malaysia

From the data gathered, a total of three (3) themes were created to address the social indicators in the CE framework of an infrastructure project, as illustrated in Figure 3. These themes were derived from several processes of reading and reviewing to ensure the relationship between the research questions and objectives was addressed. The three themes were engagement, quality of life, and attractiveness. These themes were derived from the several sub-themes identified under the categorisation phase as highlighted in Figure 3. All three themes are discussed in detail in the following sections. Additionally, the data analysis of the interview survey is presented in Table 2. The primary themes were derived from a series of subthemes analysed from respondents' statements as depicted in Table 3.

**Fig. 2.** Stages of Thematic Analysis of The Study

<b>STAGE 1: Data</b>	i. Reviewing the data, translating, and marking down the prime ideas. ii. Key ideas were zoomed in and recorded from each respondent's answer.
<b>STAGE 2: Generate Code</b>	i. Element and parameters were coded. ii. Identifying key and important ideas. iii. Codes were classified, and labels were provided for potential and relevant answers related to the research questions.
<b>STAGE 3: Searching Themes</b>	i. The data were repeatedly read and reviewed to zoom down into areas of similarity. ii. Identifying specific codes before grouping the data into identifiable themes. iii. Codes appear to have some unifying element and parameters were then reflected and described as a comprehensible outline in the data.
<b>STAGE 4: Reviewing Themes</b>	i. The developed themes were reviewed against the gathered extracts of data and checked if they met the research objectives and questions. ii. The reviewing process was repeatedly done to ensure distinctive and comprehensive themes were captured from the overall data set.
<b>STAGE 5: Defining Themes</b>	i. Exclusive and specific statements were the key to defining the themes. ii. Contains a clear focus, purpose, and scope.
<b>STAGE 6: Producing Report</b>	i. The final analysis of selected themes extracted from the entire data set. ii. The extracted themes were linked to the research question and literature. iii. The themes were connected reasonably by building the relation between each theme and it is important to present the data in the form of ideas and feelings, to provide the visualization of interconnections between the generated codes (Braun & Clarke, 2006).

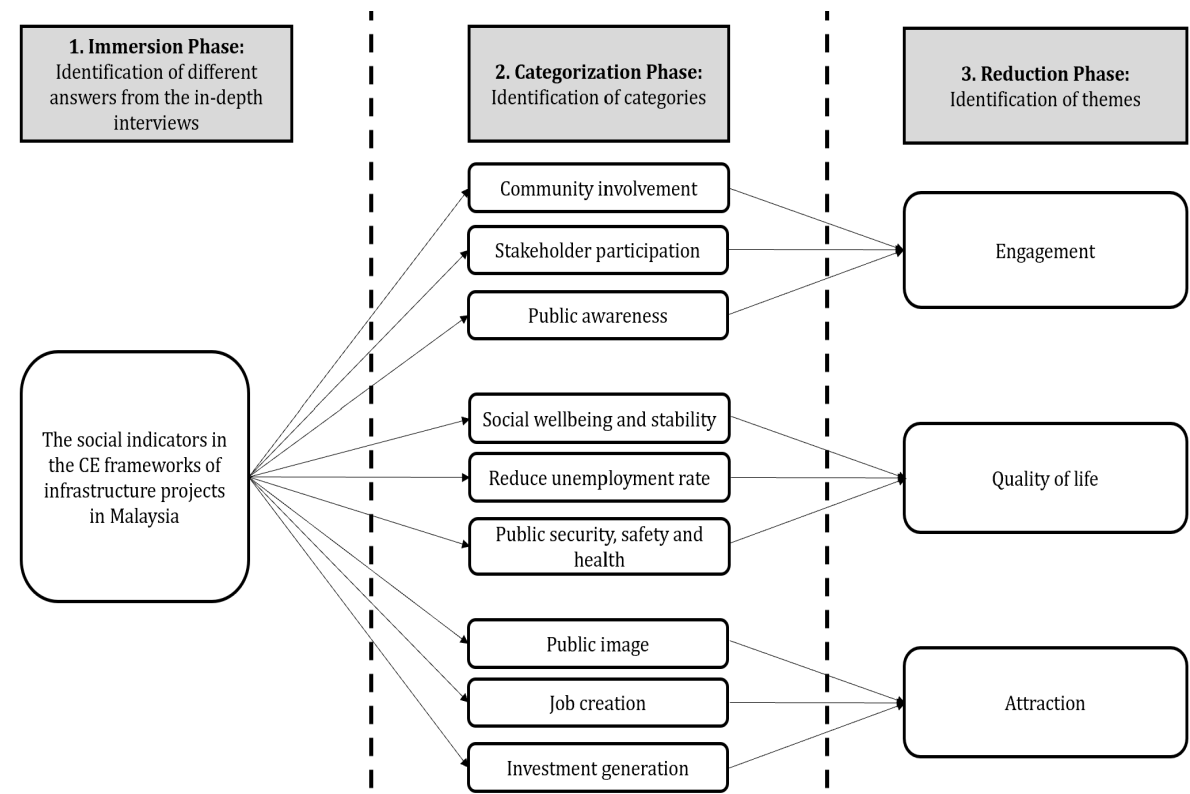
**Table 2.** Social indicators in the CE frameworks of infrastructure projects in Malaysia

No.	Theme	Subtheme	Respondents																		Total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	Engagement	Community involvement	√		√	√		√	√	√	√			√	√	√	√				11
		Stakeholders' participation	√	√	√	√		√	√	√	√			√	√	√	√	√	√	√	15
		Public awareness	√								√	√								√	4
2	Quality of life	Social wellbeing and stability		√															√		2
		Reduce unemployment rate						√					√	√	√			√		√	6
		Public security, safety, and health	√					√								√		√		√	5
3	Attractiveness	Public image		√	√				√		√										4
		Job creation					√					√	√	√			√		√		6

		Investment generation	√	√ √	3
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**Table 3.** Respondents' statements on social indicators in the CE frameworks of infrastructure projects in Malaysia

Attributes	Respondents Statements
Community involvement	"It's about engaging local communities into the sustainable practices." (R8)
Stakeholders' participation	"Relevant stakeholders need to participate actively in the planning and decision-making processes to ensure the CE principles are integrated into the projects. Do not work in silos." (R15)
Public awareness	"To hold more events as initiatives to promote CE for the public such as community recycling programs or green infrastructure that promote CE sustainability principles at the local level." (R17)
Social wellbeing and stability	"Positive impacts on communities, enhancing social wellbeing and stability in several ways." (R2)
Reduce unemployment rate	"Job created through the adoption of CE can lead to a reduction in the unemployment rate and also minimize crime rate, especially in the urban city center such as Klang Valley and Penang." (R12)
Public security, safety, and health	"Sustainable infrastructure has shown results to positively impact the community's health and wellbeing. For example, green infrastructure in the latest infrastructure developments promotes physical activity and enhances social cohesion." (R13)
Public image	"Able to improve public perception towards sustainability." (R2)
Job creation	"Open job opportunities in lifecycles of infrastructure projects including recycling, remanufacturing, design sectors." (R5)
Investment generation	"Attracting investment and partnership into CE initiatives." (16)

**Fig. 3.** The phases of identifying the themes and sub-themes for social indicators in the CE frameworks of infrastructure projects in Malaysia

#### **4.1.1. Engagement**

Based on the analysis of Tables 2 and 3, engagement was measured as one of the main social indicators in this study. Engaging stakeholders, including government agencies, contractors, suppliers, and the public seems to have a significant impact on the successful implementation of the circular economy principles in infrastructure projects. Partnerships between these parties can facilitate knowledge sharing, innovation, and the development of new technologies and business models that support circularity.

In the context of infrastructure in Malaysia, stakeholder participation and community involvement are crucial, especially in the decision-making process. Therefore, engagement between project stakeholders and community groups will ensure diverse perspectives, leading to more sustainable solutions and providing valuable insights into how challenges and opportunities can be identified when implementing CE-based projects. It also offers a degree of unity, cooperation, and social integration, whereby values are shared, mutual support is given, and harmonious interaction occurs, with positive relationships demonstrated between individuals from diverse backgrounds. Moreover, involving Malaysia and its communities throughout an infrastructure project's life cycle will give those in the community a sense of belonging, trust, and connection, which would then lead to a more resilient and supportive social environment. This view is supported by Vivas et al., (2014) in their study on community cohesion.

The engagement highlighted earlier can be realised through public awareness initiatives. Public awareness is equally important in determining the social indicators in this study. Public awareness became evident through the initiatives of certain groups of communities stimulating CE reactions among the public. Rivera et al., (2020) highlighted that the comprehension and results that stem from society engagement are significant in fostering innovations for a circular system. In addition, education through engagement is also key to enabling the public to become part of the decision-making community regarding the CE. Xue et al., (2010) highlighted in their study that one of the main barriers to CE development is weak public awareness. This initiative generally progresses through the replication of well-established networks. In this way, initiatives can be diffused into and followed by the community at large, with major impacts on sustainability in the social and behavioural dimensions.

#### **4.1.2. Quality of life**

Based on the feedback received from the interviews, other crucial elements of the social indicators when implementing the CE in infrastructure projects in Malaysia is the standard of living and the quality of life in society. In general, the adoption of the CE in infrastructure projects elevates people's social status and offers opportunities for better social interactions and developments.

The adoption of the CE in infrastructure projects has proven to provide access to quality income and improve serviceability among the stakeholders. As mentioned by Karji et al. (2019), the changes made by the CE have improved the living conditions of the surrounding communities and affected stakeholders. For example, since CE-based infrastructure projects in Malaysia are rarely new, the need for a significant amount of manual labour for tasks such as deconstruction, salvage refurbishment, and recycling has reduced the unemployment rate by creating jobs across various skill levels, including general construction workers, technicians, engineers, and waste management professionals. It has also contributed to skills development and upskilled the workforce in society through investment in training programs and education initiatives, making the workforce more employable in not only infrastructure projects but also sectors embracing sustainable practices. Ultimately, this can lead to a more adaptable and resilient workforce who are better equipped to navigate changes in the economy.

Other prominent social indicators categorised under the quality of life were the improvements in health and the establishment of a secure environment. For example, the CE contributed to a better range of cost-saving public healthcare services by creating supportive environments and resilient communities through the reduction of air pollution (Pei et al., 2018). It was also highlighted by the respondents that CE practices in Malaysia prioritise the safe handling and disposal of materials throughout their lifecycle by implementing strict safety protocols for workers involved in deconstruction, salvage, and recycling activities. Furthermore, using recycled materials in construction can reduce the carbon footprint of infrastructure projects and improve their capacity to withstand temperature fluctuations.

#### **4.1.3. Attractiveness**

The subsequent indicator that was deliberated upon was attractiveness. In circular economy infrastructure projects, attractiveness refers to the appeal and desirability of these projects to various stakeholders, including investors, policymakers, and communities. Attractiveness is also measured by the equal opportunities and resources that the CE provides to an individual or group. It also acknowledges different situations and provides opportunities and resources to obtain equal outcomes (Konow et al., 2016). This indicator is vital to minimise the drawbacks for certain groups while ensuring equal access to resources, well-being, and essential facilities for all community members.

In Malaysia, the sustainability credentials of an organisation are often perceived as a good image by stakeholders and the public. The prioritisation of resource efficiency, waste reduction, and environmental protection attracts environmentally conscious investors, policymakers, and consumers who prioritise projects with positive social and environmental impacts. It was also noticed that policymakers in Malaysia have committed to introducing several incentives for those investing in implementing the CE in infrastructure projects. As mentioned by Davidson et al., (2020), policies that offer incentives for public investment can assist Malaysia to achieve the sustainability development goals, delivering positive signals to the industry and enabling access to alternative funding sources. This initiative is one way to tackle the issue of ensuring a smooth transition from the linear economy to the circular economy in implementing infrastructure projects (Munyasya and Chileshe,

2018). In addition, the social indicators related to the policymakers' decisions are remarkable with improved social well-being attained through job creation and investment opportunities.

Taking Building Information Modelling (BIM) as an example, this concept has created many job opportunities (Sofiat et al., 2021) for industry players. These include the software developers, consultants, contractors, and project developers who were required to adopt this new approach throughout the life cycles of government infrastructure projects when they were being implemented. Similar to the impacts of improving social well-being, the CE in infrastructure in Malaysia has created business opportunities for industry players. As highlighted by Beccera et al. (2020), the CE brings opportunities to reshape our socio-economic development pathways towards social equity and environmental goals. These opportunities have also created more stakeholder collaboration in terms of maximising and leveraging the implementation of the CE in infrastructure projects in Malaysia. This social indicator is referred to as the investment generation. One element of investment generation is to share economies by allocating goods, services, or other resources among multiple individuals. Simultaneously, a sharing economy also promotes objectives such as fostering a sense of community, enhancing economic empowerment, facilitating creative expression, and optimising resource management.

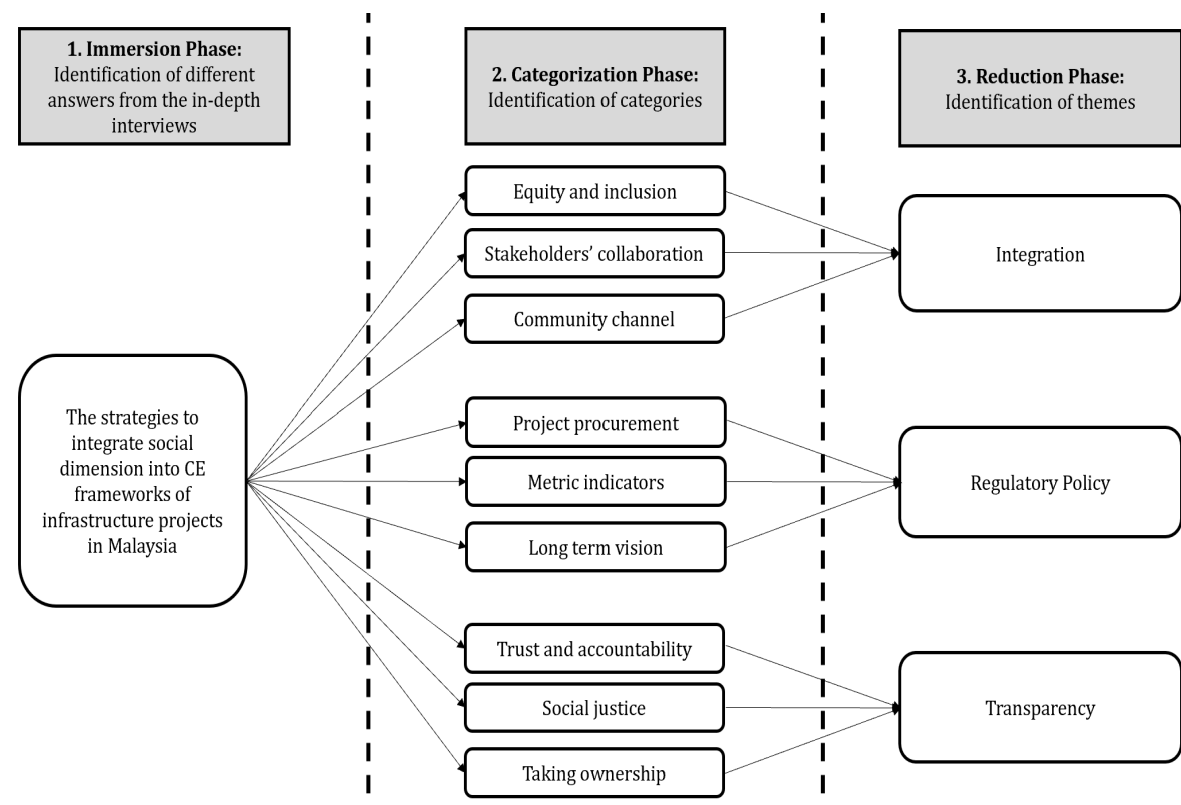
#### 4.2. Strategies for Incorporating the Social Dimension into the CE Frameworks of Infrastructure Projects in Malaysia

At the time of writing, while the concept of circularity strategies has been widely accepted, there were no clear guidelines on how to define social aspects and their strategies. To develop a clear guideline for incorporating social aspects into circularity strategies of infrastructure projects in Malaysia, all the stakeholders' experts must be committed to interdisciplinary collaboration.

From the data gathered, a total of three (3) themes were constructed. These were again derived from several rounds of reading and reviewing to ensure the relationship between the research questions and objectives was addressed. The three themes were integration, regulatory policy, and transparency. These were derived from the several sub-themes identified in the categorisation phase, as highlighted in Figure 4. Table 4 presents the data analysis of the interview survey on the strategies to be incorporated. Together, the primary themes were also derived from a series of subthemes analysed from respondents' statements as depicted in Table 5.

##### 4.2.1. Integration

Based on the analysis of Tables 4 and 5, several strategies can be approached when pursuing the inclusion of the social dimension in the CE frameworks of infrastructure projects in Malaysia. One of these is integration strategies. The study suggests that a thorough analysis should be conducted to identify all relevant stakeholders involved in or affected by an infrastructure project. This would map everyone's interests, concerns, and level of influence in order to tailor the integration strategies accordingly. The integration strategies for circular principles not only involve rethinking traditional linear models of resources and waste generation but also ensure social inclusion, with all members of society having equal access to and benefits from CE initiatives.



**Fig. 4.** The phases of identifying the themes and sub-themes in integrating the social dimension into the CE frameworks of infrastructure projects in Malaysia

Once the stakeholders have been identified, early engagement at the beginning of the project lifecycle is initiated. Open communication channels should be maintained throughout the process by seeking input at key decision points, listening to feedback, and incorporating stakeholder perspectives into project planning, design, and implementation. By having this communication platform, stakeholder partnerships, and collaboration can be created among industry associations, academic institutions, NGOs, and community groups to create solutions and drive innovation. The communication platform should also ensure diversity and inclusion and not neglect underrepresented groups such as women, minorities, indigenous peoples, and marginalised communities. It also acts as an inclusive space in which all voices should be heard and respected.

**Table 4.** Strategies for integrating social indicators into the CE frameworks of infrastructure projects in Malaysia

No.	Theme	Subtheme	Respondents																		Total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	Integration	Equity and inclusion	√		√		√	√				√									5
		Stakeholders' collaboration	√	√	√	√	√	√	√	√	√			√	√	√	√	√	√	√	15
		Community channel						√								√					2
2	Regulatory Policy	Project procurement		√				√				√									3
		Metric indicators					√				√	√	√			√		√			6
		Long term vision					√							√							2
3	Transparency	Trust and accountability	√	√			√		√	√		√									6
		Social justice	√				√				√			√							4
		Taking ownership					√								√						2

**Table 5.** Respondents' statements on strategies for integrating social indicators into the CE frameworks of infrastructure projects in Malaysia

Attributes	Respondents Statements
Equity and inclusion	"Circularity should also prioritize fairness and accessibility for all stakeholder's involved. It is essential to engage with diverse communities and ensure their needs and perspectives are taken into account" (R6)
Stakeholders' collaboration	"We need to ensure ongoing collaboration throughout the project lifecycle to address any concerns and adapt to changing circumstances." (R17)
Community channel	"Community channel as platform where members of the community and the stakeholders come to discuss and address social issues related to circular economy practices." (R8)
Project procurement	"When it comes to selecting suppliers and contractors, we should consider their commitment to social responsibility." (R3)
Metric indicators	"Metric indicator could be the number of jobs created, training opportunities and the investment generated from the project." (R5)
Long term vision	"The long-term vision is to ensure that our circular economy infrastructure projects not only promote benefits to economic and environmental areas but also contribute to social progress and equity." (R6)
Trust and accountability	"Building trust and partnerships with all stakeholders is key to creating infrastructure that truly serves everyone." (R10)
Social justice	"Promoting social justice in creating a more suitable and equitable future for all is when everyone has a voice and access to opportunities." (R11)
Taking ownership	"When the communities feel that their voices are heard, it fosters a sense of trust and ownership." (14)

#### 4.2.2. Regulatory policy

Regulatory policy strategies are another way to incorporate a social dimension into CE practices in Malaysia. They play a crucial role in promoting and supporting the adoption of CE principles in infrastructure projects. As indicated during the interviews, these strategies will be able to provide regulatory frameworks, incentives, and guidance for driving systematic change and encouraging sustainable practices. To begin with, a clear policy objective is to be defined that promotes CE principles in infrastructure projects. These may include reducing resource consumption, minimizing waste generation, promoting resource efficiency, and fostering innovation in design and construction.

Once the objectives have been set, it is suggested that they should be incorporated into the life cycle of an infrastructure project. One example is, project procurement. CE principles should be one of the main criteria included in project procurement documents such as tender specifications, pre-qualification, and request for proposal. The documents must clearly outline the requirements related to the use of sustainable materials, resource efficiency, waste reduction, and end-of-life considerations. Furthermore, the selection of suppliers, and contractors, along with their ability to contribute to the CE, also form part of the project procurement strategies.

The next strategy is implementing the metric indicators. Metric indicator strategies are essential for monitoring and evaluating the effectiveness of CE practices in infrastructure projects by providing a quantitative measure of performance, allowing stakeholders to track progress, identify areas of improvement, and make informed decisions. Although several rating tools are already established within the Malaysian construction industry, such as the Sustainable Infrastructure Rating Tools (INFRASTAR), the focus is always inclined towards economic and environmental benefits, as well as minimum impacts on society.

Therefore, the respondents suggested including social aspects in the current metrics such as resource efficiency metrics, waste reduction metrics, circularity metrics, and lifecycle assessment metrics. These need to be established with a baseline, targets, and benchmarks in order to evaluate the CE performance in infrastructure projects in Malaysia, especially where this concerns the social aspects. By implementing these metric indicator strategies, infrastructure projects can effectively be measured, managed, and optimised in line with the CE principles of promoting sustainability, resilience, and long-term value creation.

Long-term sustainability vision is another strategy that was briefly explained during the setting of a clear policy objective, as discussed earlier. To elaborate, this study emphasises the long-term strategies that can be adopted when incorporating social dimensions into CE frameworks. The elements and areas to consider in establishing these strategies include visionary goals and targets, holistic planning and integration, innovation and technology adoption, circular design and construction practices, circular business models, education and capacity building, monitoring, evaluation, and adaptation.

#### **4.2.3. Transparency**

Based on the analysis of the in-depth interviews, most respondents agreed that transparency in decision-making processes with comprehensive communication between all relevant stakeholders is crucial in fostering trust and accountability related to the social impacts of CE initiatives in Malaysia. Transparency involves providing clear, accessible, and timely information about project processes, decisions, impacts, and outcomes to stakeholders and community groups. For example, data sharing and reporting can provide an understanding of project performance, resource use, waste generation, and comparability across different infrastructure projects. Disclosing the lifecycle assessment results and findings would also offer insights into the sustainability performance of infrastructure projects thus identifying opportunities for improvement. Committing to this, could cultivate a sense of ownership among stakeholders and hold project owners, developers, and government agencies accountable for their commitments to CE principles in infrastructure projects.

#### **4.3. Study Implications**

This research highlights the limited adoption of social dimensions in the CE frameworks used Malaysia's infrastructure projects, with greater emphasis placed on economic and environmental benefits. To address this, strategies such as integration, regulatory policies, and transparency are essential for incorporating social impacts into CE practices.

Although this study focuses on Malaysia, its findings have broader implications. Social indicators like stakeholder engagement, public awareness, and policy integration are universally relevant and can be adapted to various contexts. By tailoring these indicators to local needs, policymakers and practitioners worldwide can use this framework to advance CE integration in infrastructure and promote sustainable development.

#### **4.4. Limitations and Future Directions**

This study identifies the social indicators of the CE in infrastructure projects in Malaysia. Certain limitations could represent valuable subjects for further investigation. First, the current study investigated and focused only on mega infrastructure projects in the major cities of Malaysia. Social sustainability is context-dependent and varies based on factors such as project scale, geographical location, and scope. Secondly, the sustainability rating tools available were not explored when evaluating and addressing the social indicators. Thirdly, the number of respondents could be increased further to obtain a better data set. It is advisable to explore various platforms including LinkedIn, and Telegram, to obtain answers from respondents.

#### **5. Conclusion**

This paper successfully identifies and analyses key social indicators related to the CE within the context of infrastructure projects in Malaysia. The findings reveal that the CE is a relatively new concept to Malaysia, and few studies have examined its impact on infrastructure development. A review of the existing literature shows that, in comparison to economic and environmental factors, social dimensions often receive less attention in CE initiatives. Through in-depth interviews with industry practitioners, this study identified several key social indicators and provided a detailed explanation of their significance. From a practical standpoint, these indicators offer valuable insights for industry practitioners, helping them address critical social aspects when implementing CE principles. Moreover, these findings can inform the development of strategies that integrate social dimensions into CE practices within Malaysia's infrastructure sector. Policymakers must prioritise the inclusion of these social aspects in the existing CE frameworks and policies, ensuring that each social indicator is properly evaluated. By doing so, social dimensions will be considered alongside economic and environmental factors, promoting a more balanced and sustainable approach to infrastructure development. This research contributes to scientific

understanding by emphasizing the importance of social sustainability in the CE, ultimately fostering a more holistic view of sustainable development.

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### Author Contributions

The authors collaborated to conduct research on the social dimensions of construction engineering (CE) frameworks within Malaysia's infrastructure projects. Rafiee contributed to the conceptualization of the study framework, data collection and analysis, and interpretation of findings to highlight the significance of integrating social aspects into CE practices. Yong Siang Lee, Ahmad Rizal Alias, and Rahimi A. Rahman reviewed the methodology, provided critical feedback, and contributed to refining the analysis and discussion. Furthermore, all authors collaborated on drafting, revising, and finalizing the manuscript, ensuring a comprehensive exploration of the topic and its broader implications.

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### Institutional Review Board Statement

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