

UNDERSTANDING BARRIERS AND ENABLERS OF CARBON DATA MANAGEMENT FOR CARBON ASSESSMENT IN THE SRI LANKAN CONSTRUCTION INDUSTRY *A STAKEHOLDER PERSPECTIVE*

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Abstract: Accurate carbon assessment is essential for reducing emissions in the construction industry, as it ensures reliable decision-making, compliance with sustainability targets, and identification of effective reduction strategies. Yet several challenges related to data management hinder its effective implementation in Sri Lanka. A mixed approach was used, involving 18 expert interviews and a questionnaire survey with 69 responses from professionals experienced in carbon assessment and sustainable construction. The analysis revealed that the highest-ranking barriers include the lack of national databases (RII = 0.93), dependence on international datasets, and incomplete or unavailable project-specific data. Additional, challenges related to embodied energy estimation, verification of self-reported data, and inadequate stakeholder coordination were also highlighted. On the other hand, the study identified several enablers, including the use of digital tools such as Building Information Modelling and estimating software, national databases, integration of carbon data during early design stages, and increased awareness among stakeholders. The research emphasises the need for a national database, structured data-sharing practices, government support to overcome prevailing challenges. The findings contribute valuable insights for policymakers, professionals, and academics aiming to enhance the reliability and consistency of carbon assessments in Sri Lankan construction projects.

Keywords: *Barriers, Carbon assessment, Data management, Enablers, Stakeholders*

1. Introduction

With the global economic growth and population increase, emissions of greenhouse gases (GHGs) like carbon dioxide have steadily increased (Xiong et al., 2024). Among the major contributors, the construction industry consumes one-third of the world's total energy and accounting for 39% of CO₂ emissions from energy use (Jayathilaka et al., 2023). In response to this challenge, several international policies and guidelines have been established for quantifying the carbon footprint (Kumari et al., 2022). However, the accuracy of carbon assessments is highly dependent on the quality of data and the precision of the applied methods (Xu & Macaskill, 2024). In practice, data reliability is often compromised due to inefficient data collection techniques, fragmented databases, and non-standardised reporting formats (Xu & Macaskill, 2024). These shortcomings introduce uncertainties into the assessment process and impact decision-making process in reducing emissions from construction (Lai et al., 2023). Moreover, stakeholders across the construction project life cycle play a vital role in managing data for accurate carbon assessments (Xu & Macaskill, 2024).

Most importantly, many countries face challenges in collecting, storing and reporting data and information related to carbon assessment (Chau et al., 2015). While many scholars continue to emphasise the importance of accurate carbon assessments, there is a noticeable gap in research addressing the specific enablers and barriers of data management in carbon assessment, particularly in developing countries like Sri Lanka. Addressing this gap is essential for developing effective strategies to improve the reliability of carbon assessment outcomes. Therefore, this study aims to explore and analyse the key data enablers and barriers influencing carbon assessment data management practices in the Sri Lankan construction sector. It will be achieved through 3 objectives as, identifying data enablers for data management in carbon assessment, identifying barriers faced during the carbon data management and assessing the most impactful enablers and barriers in each stakeholder perspective. The literature review will explore the existing literature to identify the existing barriers for management of data related to carbon calculations. In order to assess the current situation with the barriers in Sri Lanka, primary data were collected following the method which is explained in the methodology. The subsequent findings leading to barriers and enablers are provided in the finding section.

Carbon Data Management (CDM) is defined as the systematic process of collecting, validating, storing, processing, and reporting greenhouse gas (GHG) emissions data to ensure the integrity and reliability of carbon footprint calculations (Xu & Macaskill, 2024). Within the Life Cycle Assessment (LCA) framework (ISO 14040/44), effective CDM is critical across all four stages: (1) Goal & Scope Definition, (2) Life Cycle Inventory (LCI), (3) Life Cycle Impact Assessment (LCIA), and

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DOI: <https://doi.org/10.31705/FARU.2025.20>

(4) Interpretation. It involves managing two primary data classes: background data from commercial or public LCA databases (e.g., Ecoinvent, ICE) and user-entered foreground data specific to the project, such as material quantities, transport distances, and energy consumption (Kumanayake & Luo, 2018; Andreux & Henrysson, 2023). In the context of building assessments, most practitioners, including respondents in this study, primarily focus on cradle-to-gate system boundaries (covering raw material extraction to factory gate) for embodied carbon calculations due to data availability. However, cradle-to-grave (including use and end-of-life phases) is recognised as the ideal lifecycle scope which covers all the LCA stages (Dong et al., 2023; Giesekam et al., 2016).

2. Literature Review

According to the World Cities Report 2022, the global urban population was 56% in 2021 and projected to reach 68% by 2050 will drive increased city construction, thereby significantly amplifying carbon emissions from the construction industry (Jayathilaka et al., 2023). The industry is a major contributor to global emissions due to its heavy use of materials, energy, and machinery (Lu et al., 2016; Nguyen & Sharmak, 2021). Life Cycle Carbon Emissions (LCO₂), which include Operational Carbon (OC) and Embodied Carbon (EC), are now recognised as key indicators of a building's environmental performance (Alotaibi et al., 2022). OC contributes around 28% of emissions, while EC accounts for 12%, indicating the need to address both in climate policies. In response, global agreements such as the Kyoto Protocol and the Paris Agreement have prioritised emission reductions from the built environment (Hung et al., 2019; Liu et al., 2022). Carbon neutrality, therefore, has become a central target for sustainable development goals (Huang & Zhai, 2021).

2.1. CARBON ASSESSMENT IN CONSTRUCTION PROJECTS

Carbon assessment provides a foundation for reducing emissions in buildings by quantifying and reporting embodied greenhouse gas emissions throughout a product's lifecycle (Lokupathirage & Seneviratne, 2022). Life Cycle Assessment (LCA) is the most commonly used method in this context. It measures both direct and indirect environmental impacts from resource extraction to disposal commonly referred to as "cradle to grave" (Liu et al., 2022). Studies by Xiong et al. (2024) and Zhang et al. (2019) confirm LCA's dominance in building carbon analysis. Sri Lankan researchers Kumanayake and Luo (2018) also argue that LCA is the most suitable approach for evaluating a building's CO₂ impact.

However, LCA implementation is not without challenges. It demands significant time and effort, especially during data collection and processing (Xiong et al., 2024). The reliability of the results depends heavily on the quality and source of the data used (Wang et al., 2023). Standardised and accurate carbon emission calculation methods are essential for effective LCA in construction projects (Dong et al., 2023). Without consistency and accuracy, LCA results may misguide decision-makers and hinder carbon reduction efforts (Hong et al., 2016). Regional factors such as construction technologies, materials, energy sources, and socio-economic conditions can lead to large variations in outcomes (Dixit, 2017). This reinforces the need for location-specific data to ensure relevant and precise results, especially in countries like Sri Lanka (Kumanayake & Luo, 2018).

2.2. THE IMPORTANCE OF DATA IN CARBON ASSESSMENT

Accurate data is central to the success of carbon assessments. In LCA, poor data quality can lead to either overestimation or underestimation of emissions, ultimately affecting policy and project decisions (Andreux & Henrysson, 2023). Several studies highlight that data collection remains one of the most persistent challenges in LCA practice (Yeo et al., 2016). For example, using international emission factors for materials such as concrete or steel can distort the results when applied to a local context (Waldman et al., 2020). Sri Lanka faces difficulties due to a lack of local studies and national databases. As a result, researchers often rely on international sources, which may not reflect reliable outcomes (Kumanayake & Luo, 2018). Without reliable data, stakeholders like governments, developers, and builders risk making incorrect assumptions, setting unrealistic targets, and implementing ineffective policies, potentially undermining net-zero goals (Xu & Macaskill, 2024).

Different types of input data are required in LCA. According to Kumanayake and Luo (2018), these include data stored in databases (e.g., material properties, energy sources) and user-entered data (e.g., quantities, energy use, project details). Although many databases and standards are available, their relevance to the local context remains a concern in Sri Lanka. Without localised and reliable data, carbon assessments risk being inaccurate and ineffective. However, there are some issues in the application of LCA in Sri Lanka, even though LCA is preferred. Because of a lack of local data, researchers tend to use international data sources, which might not be relevant to the local environment (Kumanayake & Luo, 2018).

2.3. STAKEHOLDER ROLES IN DATA COLLECTION AND MANAGEMENT

Stakeholders play a vital role in the adoption and implementation of net-zero carbon building strategies and policies (Falana et al., 2024a). Their engagement is essential to ensure that these strategies are effectively integrated throughout all stages of the building life cycle. As highlighted by Kaya and Scolaro (2023), stakeholder involvement is key in reducing the carbon impact of construction activities. In green building projects, stakeholders such as contractors, architects, engineers, material manufacturers, and government agencies contribute significantly to managing carbon emissions across the building's life cycle (Falana et al., 2024b). Table 1 presents the stakeholder involvement identified by multiple studies in different phases of the life cycle of green buildings.

Table 1 : Stakeholders involved in green buildings

No.	Stakeholder	[1]	[2]	[3]	[4]	[5]
01	Client	√	√	√	√	
02	Architect	√	√	√		
03	Contractor	√	√	√	√	√
04	Developers	√		√		√
05	Consultants		√	√	√	√
06	Industry practitioners	√				
07	Designers	√		√		
08	Sub-contractors		√		√	
09	Academics			√	√	√
10	Government	√		√	√	√
11	Facilities managers		√	√		
12	Green accreditation professionals		√			
13	Public	√			√	
14	Manufacturers			√		
15	End-users/customers			√	√	
16	Suppliers			√	√	
17	Non-government organisations (Eg:Green Building Council of Sri Lanka (GBCSL))				√	

[1] (Wuni et al., 2019), [2] (Ferme et al., 2018), [3] (Darko et al., 2017), [4](Yang et al., 2016), [5] [9] (Kordi et al., 2021), [5] (Berawi et al., 2019)

2.4. DATA ENABLERS IN CARBON ASSESSMENT

Effective carbon assessment depends heavily on data availability and management. Zanni et al. (2019) emphasised the need for a standardised data framework that connects various technological approaches and systems. Among these, Building Information Modelling (BIM) stands out as a powerful tool that centralises data on materials, energy use, and emissions, ensuring smooth information flow throughout project phases (Yang et al., 2018). This integration minimises manual data entry, thereby reducing errors and increasing accuracy (Zhang et al., 2023). Additionally, BIM supports Life Cycle Assessment (LCA) by facilitating quicker extraction of material quantity data (Palumbo et al., 2020).

Digital databases also serve as critical enablers, offering access to region-specific carbon factors that align with local environmental conditions (Blay-Armah et al., 2022). National-level databases, such as the ICE and INIES databases, provide essential embodied carbon values used for accurate CO₂e assessments (Wolf et al., 2017). Furthermore, frameworks such as ISO 14040/44 and EN 15978/804, along with voluntary rating systems like LEED and BREEAM, act as both regulatory drivers and data enablers in the carbon assessment process (Wolf et al., 2017).

2.5 BARRIERS IN DATA COLLECTION

Understanding the barriers to data collection in carbon assessment is crucial for improving the accuracy and reliability of emissions calculations across the building life cycle. While prior research has emphasised the significance of carbon accounting, limited attention has been given to the practical challenges faced in gathering and managing relevant data, especially within developing countries. Identifying these barriers not only helps uncover the root causes of data inconsistencies but also supports the development of more effective frameworks and digital solutions. Table 2 outlines the key data collection barriers reported across recent studies, addressing this overlooked area in existing literature.

Table 2 : Barriers in data collection for carbon assessment

No.	Barriers	Sources
01	Lacks national databases	[1]
02	Rely on international databases	[1]
03	Data acquisition is very difficult	[2], [6]
04	Results depend on second-hand data from suppliers	[2]
05	Determining embodied energy is more complex and time-consuming	[3], [6]
06	Unavailability of timely and complete data	[4], [10]
07	Incomplete scopes of emissions from supply chains	[5]
08	Complex supply chain	[5]
09	Self-reported data lacks independent verification	[5]
10	Need professional and resources	[5], [6]
11	Uniqueness of different buildings	[6]
12	Accuracy and reliability difference of one database to another.	[7]
13	Requires large amounts of data	[8]
14	Insufficient information on materials from manufacturers	[1]
15	geological relevance of data	[9]
16	human errors and time consuming in data extraction from BOQ.	[9]

[1] (Kumanayake & Luo, 2018), [2] (Liu et al., 2020), [3] (Yeo et al., 2016), [4] (Andreux & Henrysson, 2023), [5] (Andreux & Henrysson, 2023), [6] (Yang et al., 2018), [7] (Blay-Armah et al., 2022), [8] (Palumbo et al., 2020), [9] (Kumanayake & Luo, 2017), [10] (Giesekam et al., 2016)

Despite technological advancements, several barriers hinder accurate data collection for carbon assessments. These barriers are summarized in Table 2. One major issue is the absence of local databases, which forces practitioners to rely on international data sources that may not reflect local contexts. Challenges in obtaining accurate, project-specific data and the frequent use of secondhand or outdated data further reduce the reliability of assessments. Additionally, inconsistencies across different databases, extensive data requirements, and the risk of errors in manual calculations also present significant obstacles.

3. Methodology

Research is a systematic approach that discovers new knowledge, verifies existing facts, analyses their relationships, and formulates theories to explain phenomena (Bhagyamma & Ramesh, 2023). Research approach can be categorised into three types as qualitative, quantitative and mixed approaches considering the data types used (Taherdoost, 2022). The most suitable research approach for a particular study is chosen based on the research aim and the objectives, while considering the nature of available information (Pandey, 2016). Therefore, to achieve this aim, a mixed-methods approach was adopted, integrating both qualitative and quantitative methods. The qualitative approach involves in identifying data enablers and barriers while the quantitative approach is suitable for identifying patterns and rank the impact of data enablers and barriers according to each stakeholder perspective.

3.1 DATA COLLECTION

In the first phase of data collection, semi-structured interviews were conducted to gather in-depth qualitative insights. The interviews aimed to identify the existing data related barriers, enablers. 18 experts participated to this data collection under three categories as academia, carbon analysts and construction professionals. The selection criteria were having more than 5 years of experience in both construction and carbon assessment. Therefore, the purposive sampling and snowball sampling technique was employed in selecting experts. Table 3 presents the experts’ profiles who were given their contributions.

Table 3 : Expert Profile

Int. code	Designation	Experience		Qualifications
		Cons.	Carb.	
E1	Senior Lecturer	12+	5+	GREEN SLAccP, Research publications in carbon assessment
E2	Senior Professor	0	12+	Research publications, Founder of carbon calculating software
E3	Senior Professor	25+	15+	Research publications in Carbon assessment, GREEN SLAccP
E4	Researcher	7+	5+	Research publications in carbon assessment, GREEN SLAccP
E5	Senior lecturer	11+	5+	Research on embodied carbon-related emissions in buildings
E6	Lecturer	6+	5+	Facilities manager, Health and Safety officer manufacturing
E7	Researcher Assistant	5+	7+	PhD in sustainable built environment, Research publications
E8	Lecturer	10+	5+	Research publications
E9	Senior lecturer	8+	6+	Research publications, GREEN SLAccP,
E10	Sustainability Manager	-	10+	Verification, certification, and advisory services
E11	Green Building Analyst	5+	5+	Masters in sustainable construction, IGBC AccP
E12	Project Lead	8+	7+	Visiting Lecturer, Former General Manager at GBSL, External Carbon Consultant, GREEN SLAccP, Civil Engineer
E13	Acting chief executive officer	-	10+	Carbon verification in organisations and services, GHG auditing
E14	Executive Envir. Sustainability	5+	4+	LEED & Green Building Certification and Rectification
E15	Senior Engineer (Green projects)	9+	6+	Involved in Carbon footprint assessment and LCA of buildings, LEED Green Associate, IGBC Accredited Professional
E16	General Manager	25+	5+	Green auditing, GREEN SLAccP
E17	General Manager	30+	-	green accreditation practices
E18	Senior QS	30+	5+	Involved in sustainable construction practices

The second phase of the study employed a questionnaire survey to collect quantitative data from a broader sample. This method allowed respondents to rate and rank the barriers and enablers identified during the interview phase, providing a clearer understanding of their significance from different stakeholder perspectives. The respondents represent the main groups of stakeholders identified through the literature and there were 69 responses for the quantitative data collection. A potential limitation of this study's sampling approach is that the use of purposive and snowball sampling, although appropriate for identifying experts, may result in selection bias and affect the extent to which the findings can be generalised to the wider population of construction professionals in Sri Lanka.

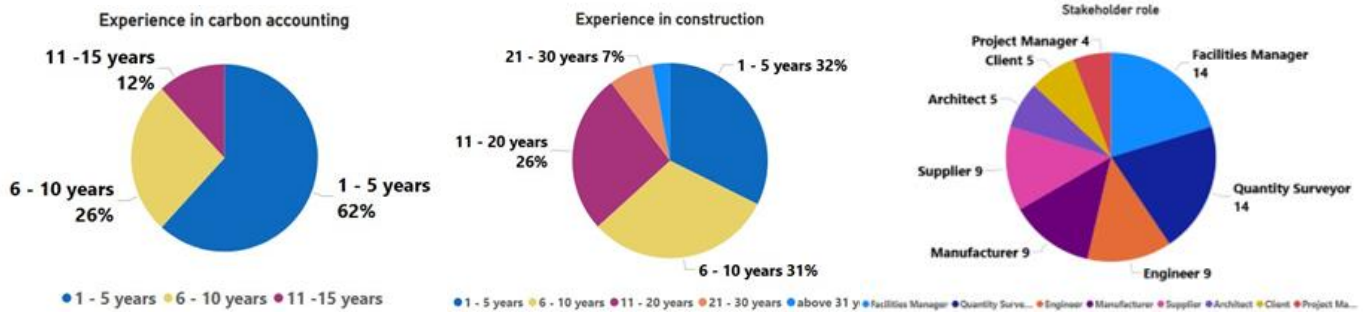


Figure 1 : Respondents' profile of the questionnaire survey

3.2 DATA ANALYSIS

Data analysis involves processing collected information to identify patterns, summarise key insights, and draw meaningful conclusions (Kothari, 2004). The data collected through 18 expert interviews were analysed using thematic analysis, facilitated by NVivo software. The process involved generating initial descriptive codes, developing broader themes, and finally reviewing and defining these themes to produce a code structure. Figure 2 below illustrates the number of interview respondents who resonated with the enablers and barriers identified from the literature. Further, # mark demonstrates the new barriers suggested by one interviewee, while ## represents the barriers confirmed by two or more experts.

Data Enablers		18	125	Barriers		18	305
○ National databases	15	16	○ Uniqueness of different buildings	12	12		
○ Green certification systems (e.g., LEED, B	15	17	○ Unavailability of timely and complete	17	17		
○ Digital databases	18	19	○ Self-reported data lacks independent	17	17		
○ Building Information Modeling (BIM)	17	17	○ Results depend on second-hand data	16	16		
○ Building codes	15	15	○ Requires large amounts of data	18	18		
○ ## Standards formats	5	8	○ Rely on international databases	18	18		
○ ## Manually formulated excel sheets	2	3	○ Need of experts	15	16		
○ ## Material databases	2	2	○ Lack of tools and resources	12	12		
○ ## LCA software	8	11	○ Lack of national databases	18	20		
○ ## GBCSL	2	2	○ Insufficient information on materials	17	18		
○ ## EPD certificates	2	2	○ Incomplete scopes emissions from	17	17		
○ ## Energy modeling	3	3	○ human errors and time consuming in data	17	17		
○ ## Digital tools (e.g., CostX, Revit)	2	2	○ geological relevance of data	17	17		
○ # Power BI	1	1	○ Determining embodied energy is more	17	18		
○ # Hardware like sensors	1	1	○ Data acquisition is very difficult	16	16		
○ # GRIHAR Rating system	1	1	○ Complex supply chain	16	16		
○ # Government regulations	1	2	○ Accuracy and reliability difference of	16	17		
○ # Blue green SL guideline	1	1	○ ## Not having a standardised framework	2	3		
○ # ASHRAE	1	1	○ ## No structured carbon calculation in demolition phase	2	3		
			○ ## No incentives, tax reduction or reward system	2	2		
			○ ## No government support	4	4		
			○ # Traditional mindset of people	1	1		
			○ # Practice monitoring is difficult	1	1		
			○ # Not having structured carbon footprint tracking in SL	1	1		
			○ # Less manufacturer logs	1	2		
			○ # Green accreditation focuses only on sustainable materi	1	1		
			○ # Converting foreign data	1	1		

Figure 2 : Coding structures for enablers and barriers identified from the literature and interviews

The themes emerging from qualitative analysis, specifically the identified barriers and enablers, were directly synthesised into the quantitative survey questionnaire. The survey presented respondents with two lists: 17 enablers and 20 barriers. Participants rated the importance of each item using a standard five-point Likert scale anchored from 1 (Very Low Importance) to 5 (Very High Importance). The quantitative data were then analysed using the Relative Importance Index (RII) method to rank the factors based on stakeholder perceptions.

$$Relative\ important\ Index\ (RII) = \frac{\sum W \times A}{N} \quad (1)$$

W – Weights given to each factor (range = 1 – 5); A – Highest weightage; N – Frequency of the responses

This study used RII solely for prioritisation, non-parametric tests and effect-size analyses were not applied, as identifying overall impact was the intended analytical focus. A limitation is that the RII analysis does not measure effect sizes or the statistical uncertainty around the ranks. Therefore, reported differences between stakeholder groups indicate trends in perception rather than statistically quantified differences.

4. Findings and Discussion

This section presents the findings of the study, which aimed to explore and analyse the key data enablers and barriers influencing carbon assessment data management practices in the Sri Lankan construction sector. Findings of both qualitative and quantitative data collections are discussed in relation to the research objectives.

4.1 DATA ENABLERS FOR DATA MANAGEMENT IN CARBON ASSESSMENT

While most experts agreed with the literature findings, they also proposed additional tools, standards, and practices to improve carbon assessment processes. Experts widely emphasised the importance of BIM for integrating carbon data (E9, E10), though its effectiveness depends on input quality (E14, E16, E17). Digital tools such as CostX and Revit were highlighted, with E13 recommending Power BI, and E7 noting the use of sensor hardware for emission tracking. Energy modelling was supported by three experts, and LCA software like One Click LCA, SimaPro, and OpenLCA was recommended, though E3 and E6 mentioned that Excel-based tools can also be effective. The lack of Sri Lanka-specific carbon databases was a major concern raised by 15 experts. Current practices rely on international databases such as EcoInvent and ICE, which lack local relevance. E4 suggested using conversion factors for local adaptation, though such data are not yet available. E9 stressed the value of Environmental Product Declarations (EPDs), with E15 stating that “EPDs contain LCA information over a product’s lifespan, making them more reliable.”

Green certifications and standards were also seen as enablers. LEED and BREEAM were mentioned for encouraging low-carbon practices, though they don’t directly measure carbon emissions (E5, E7). LEED is more commonly used in Sri Lanka (E1, E3, E15, E16, E17), while GBCSL’s Green Rating System was noted as a local enabler (E1, E8), including for awareness and training. The GRIHA system from India, based on ISO standards, was suggested for adoption in Sri Lanka (E11, E15). Finally, government regulations were identified as essential for driving carbon assessments. E17 and E7 emphasised regulatory importance, with E7 referencing global mandates such as using prefabricated components. Although Sri Lanka currently lacks such regulations, E1, E3, and E8 pointed to early efforts like the Urban Development Authority (UDA)’s Blue Green Economy Guidelines and Construction Industry Development Authority (CIDA) material databases as promising initiatives.

4.2 BARRIERS FOR DATA MANAGEMENT IN CARBON ASSESSMENT

Through the expert opinions, literature findings were confirmed and identified new barriers related to carbon assessment. New ten barriers were suggested by the experts which create a significant impact data management in achieving accurate and reliable carbon assessment. The most impactful barriers to accurate carbon assessment, confirmed by 18 experts, include the lack of national databases, the dependency on international data sources, and the need for large volumes of data for calculations. The survey and interview responses indicated that practitioners in Sri Lanka predominantly work with cradle-to-gate system boundaries for carbon assessment, focusing on the embodied carbon of materials and construction processes up to the point of project completion. This focus is largely driven by the complexity of obtaining reliable operational and end-of-life data, aligning with common challenges in developing economies (Kumanayake & Luo, 2018). Many experts also agreed on challenges such as difficulties in calculating embodied energy, data that lacks geographical relevance, and the absence of verification for self-reported data. Additional concerns raised were the unavailability of timely and complete data, insufficient material information, limited emission scope from the supply chain, and human errors in extracting data from BOQs.

E3 emphasised that the carbon coefficient is more crucial than material quantities, highlighting the need for accurate emission factors. To address geographical relevance, E18 and E7 proposed using Indian databases for Sri Lankan assessments due to similar climate conditions, which was supported by E11, an Indian expert who confirmed that India already maintains such databases. However, E8 pointed out that the absence of standardised norms for embodied carbon emissions and incomplete datasets often restrict calculations to fuel-related emissions during the construction phase.

A lack of government support and clear regulatory frameworks was also identified as a significant barrier. E17 noted there are no legal obligations to submit carbon footprint data, while E8 stressed that, as a UN member country, Sri Lanka is expected to align with SDG goals and therefore should mandate such assessments. The lack of incentives or tax benefits further discourages industry participation. Moreover, the absence of a structured data responsibility framework was highlighted by E16 and E17 as a critical gap. Additional barriers identified by E6, E7, and E17 included the traditional mindset among professionals, inadequate data tracking mechanisms, the low priority given to green accreditations, and uncertainty around demolition-phase data, all of which collectively hinder effective and accurate carbon assessments.

4.3 IMPORTANCE OF DIFFERENT ENABLERS TO VARIOUS STAKEHOLDERS INVOLVED IN CARBON ASSESSMENT

To prioritise key data enablers for stakeholders, a Likert-scale survey was analyzed using the RII method. While the importance varied by stakeholder, all enablers were found to support reliable carbon assessment. National databases, BIM, and LCA software were consistently ranked highest, highlighting their critical role across all project stages. Figure 3 presents each enabler’s significance and ranking.

No.	Enablers	Contractor		Consultant		Client		Manufacturer		Supplier		FM		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank
1	National databases	0.8933	3	0.9467	2	0.9600	1	0.9538	1	0.9556	1	0.9167	2	0.9333	1
2	Green certification systems (eg: LEED, BREEAM)	0.8533	6	0.8533	7	0.8000	7	0.8769	5	0.7778	9	0.7167	11	0.8203	6
3	Digital data bases	0.6400	13	0.8000	12	0.6800	13	0.9385	2	0.6889	11	0.8167	7	0.7710	11
4	Building Information Modeling (BIM)	0.9733	1	0.9067	4	0.8400	4	0.7692	10	0.7111	10	0.8833	3	0.8609	4
5	Building codes related to LCA	0.7067	11	0.8933	5	0.8000	7	0.8923	4	0.9111	4	0.6333	13	0.8029	8
6	##Standard formats	0.8000	9	0.8133	8	0.7200	11	0.8462	7	0.8222	7	0.6333	13	0.7797	10
7	##LCA software	0.8267	7	0.9467	2	0.9200	2	0.9231	3	0.9556	1	0.8667	4	0.9014	2
8	##Energy modeling	0.5200	14	0.8133	8	0.7200	11	0.7692	10	0.6222	14	0.8167	7	0.7101	12
9	##Manually formulated excel sheets	0.8000	9	0.3600	16	0.5200	15	0.5077	17	0.4889	15	0.5000	17	0.5362	16
10	##Material databases	0.8667	4	0.8800	6	0.6400	14	0.8154	9	0.8667	6	0.5667	15	0.7913	9
11	##GBCSL	0.5200	14	0.5600	14	0.8000	7	0.7077	12	0.6889	11	0.8000	10	0.6551	13
12	##EPD certificates	0.8667	4	0.8133	8	0.8400	4	0.8308	8	0.9333	3	0.6500	12	0.8174	7
13	##Digital tools	0.9200	2	0.7067	13	0.9200	2	0.7077	12	0.8222	7	0.9833	1	0.8319	5
14	#Censoring hardware	0.3867	17	0.5067	15	0.3200	17	0.5692	15	0.3556	16	0.8500	5	0.5188	17
15	#Government regulations	0.8133	8	0.9733	1	0.8400	4	0.8769	5	0.9111	4	0.8333	6	0.8783	3
16	#Blue green SL guideline	0.6800	12	0.8133	8	0.8000	7	0.5385	16	0.2667	17	0.5500	16	0.6145	14
17	#ASHRAE standards	0.5067	16	0.3200	17	0.4800	16	0.6615	14	0.6889	11	0.8167	7	0.5710	15

Figure 3: Significance of each enabler for different stakeholders and ranks based on the RII values

According to Figure 3, the highest-rated data enabler is the “National database” (RII = 0.93), highlighting the need for its development in Sri Lanka. “LCA software” (RII = 0.90) ranks second, ensuring reliable and efficient calculations. Other key enablers include “Digital tools,” “Government regulations,” and “EPD certificates,” all scoring above 0.80. Of the 17 enablers, 14 scored above 0.60, showing their relevance in carbon data management. The least impactful were “ASHRAE standards” (0.57), “Excel sheets” (0.53), and “Sensor hardware” (0.51). Focusing on top-ranked enablers can enhance carbon calculations across the project lifecycle.

The study found that while literature identifies key enablers like national databases, BIM, and building codes, expert insights added several context-specific enablers relevant to Sri Lanka. National databases ranked highest (RII = 0.93), confirming their critical role. Experts also emphasised LCA software, digital tools, and strong government involvement as essential. NGOs like the Green Building Council were noted for their support through training and certifications. Overall, expert input expanded on literature findings, highlighting practical enablers that can enhance carbon data management and reduce barriers in the Sri Lankan construction sector.

4.4 IMPACT OF DIFFERENT BARRIERS FOR VARIOUS STAKEHOLDERS IN CARBON ASSESSMENT

As carbon assessment is still emerging in Sri Lanka’s construction industry, various barriers were identified through literature and expert interviews. The analysis focused on how these barriers affect different stakeholders across project stages. Barriers were ranked based on stakeholder perspectives and overall impact using RII values to prioritise them. Figure 4 shows the identified barriers, their RII scores, and stakeholder-specific rankings.

Survey results show that the most critical barrier for all stakeholders is the “Lack of national databases” (RII = 0.93), highlighting the urgent need for one in Sri Lanka. The second is “No government support” (RII = 0.89), with several government-related issues ranking high. Other key barriers, including “Difficult data acquisition,” “No carbon tracking,” and “Lack of a standard data framework,” all scored above 0.80, confirming their significance. Perspectives varied for example, clients saw a lack of experts, while professionals did not. All barriers except one scored above 0.60, underscoring their overall impact. This analysis helps prioritise the most pressing issues for effective carbon data management.

Barriers identified through literature and interviews were validated and ranked using RII analysis. The most critical, consistently highlighted across all sources, was the lack of a national carbon database (RII = 0.93), underscoring the need for its development and standardised assessment methods. The second most impactful barrier was the absence of government support, repeatedly emphasised by experts as a key issue in the Sri Lankan context.

As the final synthesised output of this study, this Sankey diagram visualises stakeholder priorities by mapping the top five enablers and top five barriers specific to each stakeholder group based on their Relative Importance Index (RII) scores.

No.	Barriers	Contractor		Consultant		Client		Manufacturer		Supplier		FM		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank
1	Lacks national databases	0.9600	1	0.9867	1	0.8800	5	0.8462	5	0.9333	1	0.9500	1	0.9333	1
2	Rely on international databases	0.6800	19	0.8667	3	0.5200	24	0.8308	6	0.7111	16	0.7833	11	0.7594	13
3	Data acquisition is very difficult	0.8400	5	0.8667	3	0.9600	1	0.7846	9	0.9333	1	0.9500	1	0.8754	3
4	Results depend on second-hand data from suppliers	0.6400	23	0.6533	21	0.6400	21	0.6615	22	0.8889	5	0.7333	15	0.6957	19
5	Determining embodied energy is more complex and time-consuming	0.7333	13	0.8000	10	0.7600	13	0.6923	19	0.7778	13	0.8667	5	0.7710	11
6	Unavailability of timely and complete data	0.8000	8	0.8400	7	0.9600	1	0.7692	12	0.8444	8	0.8333	7	0.8261	6
7	Incomplete scope emissions from supply chains	0.8267	7	0.8400	7	0.5200	24	0.7538	13	0.6889	19	0.9167	3	0.7913	8
8	Complex supply chain	0.7733	9	0.7867	11	0.8400	7	0.7538	13	0.8222	11	0.8667	5	0.8000	7
9	Self-reported data lacks independent verification	0.7200	14	0.7200	17	0.7600	13	0.8000	8	0.7333	15	0.7500	14	0.7449	16
10	Need of experts	0.7200	14	0.7467	16	0.9600	1	0.7077	18	0.8667	7	0.7667	12	0.7681	12
11	Uniqueness of different buildings	0.6000	25	0.6267	24	0.7600	13	0.6000	26	0.6667	24	0.6833	20	0.6406	23
12	Accuracy and reliability difference of one database to another	0.7467	11	0.7600	13	0.7200	16	0.7385	16	0.7111	16	0.6667	23	0.7275	17
13	Requires large amounts of data	0.7200	14	0.7600	13	0.7200	16	0.6615	22	0.6889	19	0.6833	20	0.7072	18
14	Insufficient information on materials from manufacturers	0.7733	9	0.7867	11	0.4800	27	0.7538	13	0.8444	8	0.7667	12	0.7594	13
15	Geological relevance of data	0.6533	22	0.6533	21	0.5200	24	0.5846	27	0.8889	5	0.7000	18	0.6696	22
16	Human errors and time consuming in data extraction from BOQ	0.6800	19	0.6933	20	0.7200	16	0.6462	25	0.7556	14	0.6833	20	0.6899	20
17	Lack of tools and resources	0.7467	11	0.7600	13	0.8400	7	0.7846	9	0.8222	11	0.8167	8	0.7855	9
18	Not having standardized data framework	0.8533	3	0.8400	7	0.8800	5	0.8615	3	0.7111	16	0.8167	8	0.8290	5
19	No structured carbon calculation in demolition phase	0.5067	26	0.5200	26	0.6400	21	0.6923	19	0.4667	25	0.7333	15	0.5884	27
20	No incentives, tax reduction or reward system	0.7200	14	0.7200	17	0.8400	7	0.8923	1	0.8444	8	0.7167	17	0.7768	10
21	No government support	0.8933	2	0.8933	2	0.9600	1	0.8615	3	0.9111	4	0.8833	4	0.8928	2
22	Traditional mindset of people	0.7200	14	0.7200	17	0.8000	11	0.8308	6	0.4222	26	0.5667	26	0.6812	21
23	Practical monitoring is difficult	0.8400	5	0.8533	5	0.8000	11	0.7231	17	0.6889	19	0.5833	25	0.7536	15
24	Not having structured carbon footprint tracking in SL	0.8533	3	0.8533	5	0.8400	7	0.7846	9	0.9333	1	0.8167	8	0.8435	4
25	Less manufacturer logs	0.4400	27	0.4533	27	0.7200	16	0.8769	2	0.6889	19	0.7000	18	0.6232	25
26	Green accreditation focuses only on sustainable materials	0.6267	24	0.5733	25	0.6000	23	0.6615	22	0.6889	19	0.6667	23	0.6348	24
27	Converting foreign data	0.6800	19	0.6533	21	0.7200	16	0.6769	21	0.3778	27	0.5333	27	0.6116	26

Figure 4 : Significance of each barrier for different stakeholders and ranks based on the RII values

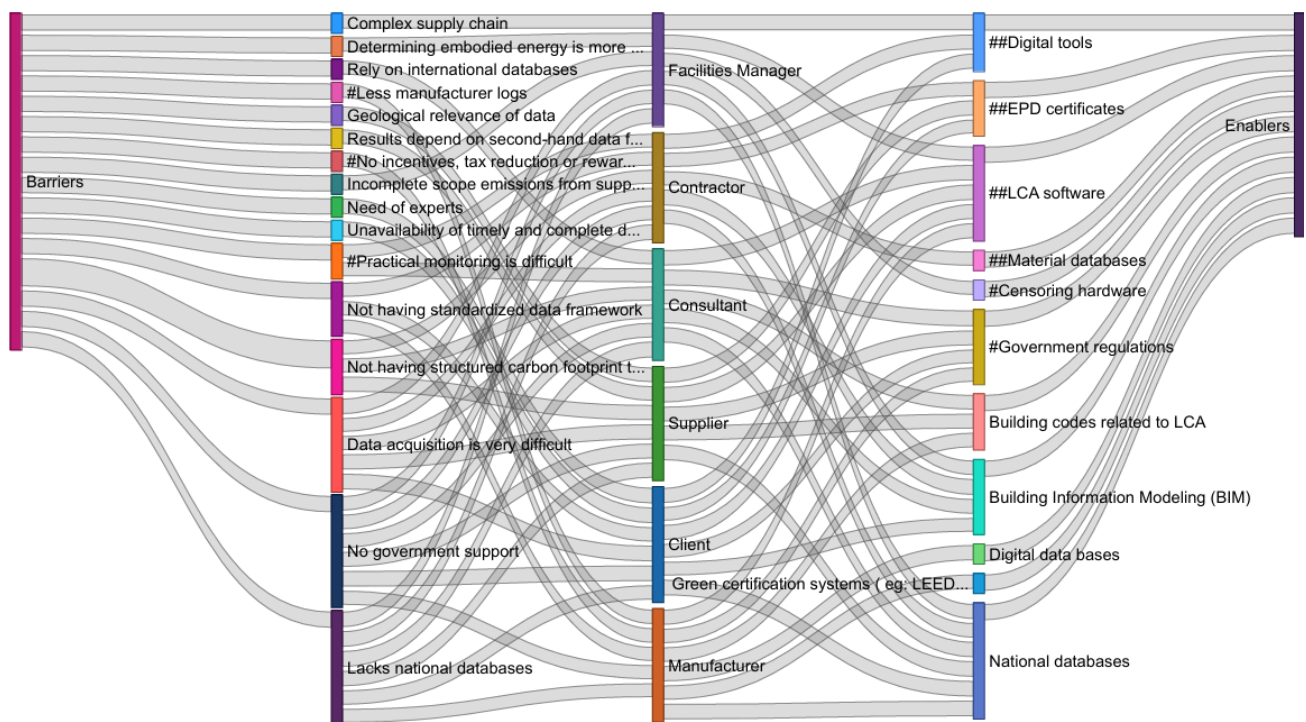


Figure 5 : Summary of important enablers and barriers from each stakeholder perspective

5. Conclusion

This study addresses the critical gap in understanding carbon data management within the emerging context of Sri Lanka's construction industry by identifying key enablers and barriers through literature review, expert interviews, and a stakeholder survey. The findings reveal that while national databases, LCA software, BIM, digital tools, and government regulations are vital enablers, the absence of a national carbon database and the lack of government support remain the most significant barriers hindering reliable carbon assessment. This highlights the urgent need for government-led initiatives to develop standardised databases and frameworks. Limitations include the focus on a limited sample size and reliance on self-reported data, suggesting future research should expand stakeholder involvement and explore implementation strategies. Overall, strengthening enablers and addressing identified barriers are essential steps toward effective carbon management in Sri Lankan construction projects.

6. Acknowledgement

Sincere gratitude is extended to the research supervisor, Department of Building Economics staff, and contributing industry professionals for their invaluable guidance, support, and insights that greatly strengthened this study.

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