Whole Life Costing Awareness and Implementation Challenges in the Sri Lankan Construction Industry

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ABSTRACT

Construction industry is highly demanding, especially with regard to the project cost as a significant aspect. However, more informed cost advice can be produced considering the project's life cycle that begins with the conception and ends with its disposal instead of using a conventional initial capital cost basis. Thus, Whole Life Costing (WLC) and Life Cycle Costing (LCC) concepts are essential. Though many LCC research studies exist, WLC studies are minimal in the Sri Lankan construction industry context. Therefore, this study aims to explore WLC awareness and implementation challenges in the Sri Lankan construction industry. A literature review was conducted to search for the concepts. Empirical data were gathered using questionnaires by implementing a quantitative survey strategy. Findings depict that the awareness of WLC in the Sri Lankan construction industry is poor, preventing its benefits. Moreover, this research identified difficulty in identifying includes and excludes for calculating WLC, lack of details at early stages, lack of awareness of WLC benefits, lack of understanding of WLC tools, lack of reliable data and lack of expertise/knowledge on WLC as the primary challenges in implementing WLC in the Sri Lankan construction industry. Therefore, these challenges must be mitigated for the beneficial WLC implementation in the Sri Lankan construction industry while enhancing awareness and knowledge of the WLC concept among professionals, especially quantity surveyors, to facilitate responsible initiation of WLC practices in the Sri Lankan construction industry.

KEYWORDS: *Awareness, Benefits, Challenges, Construction industry, Life Cycle Costing, Sri Lanka, Whole Life Costing*

1 INTRODUCTION

1.1. Background

Construction industry is one of the world's most significant industries, contributing a considerable proportion of most countries' GDP (Horta et al., 2013) and 5%-6% of the nation's employment (Ruddock et al., 2011). However, construction cost is affected by several variables, namely labour, material, overheads and revenue-related variables, including taxation, repatriation restrictions and foreign exchange rates (Baloi & Price, 2003). Therefore, it is evident that cost performs a leading role in the growth of the construction industry. However, as per Higham et al. (2015), providing more knowledgeable cost advice is critical considering the project's whole life cycle rather than solely on a standard initial capital cost basis.

Whole Life Costing (WLC) is a tool supporting decision-making on construction projects considering the long-term view of costs and benefits involved (Manege and Kennedy, 2020). The primary purpose of WLC is to assess and optimize a building's whole life cost and help decision-making throughout the life of the structure (Opoku, 2013). However, a lack of uniform methodology is one of the main challenges in WLC deployment. In contrast, the absence of regular and trustworthy data on cost and performance, a general lack of demand and interest on the part of clients, and a shortage of knowledge of WLC are identified as other barriers (Opoku, 2013).

British Standards Institute (2008), defines Life Cycle Costs as the 'costs of an asset or its parts throughout its life cycle while fulfilling the performance requirements and Whole Life Costs as 'all

significant and relevant initial and future costs and benefits of an asset, throughout its life cycle, while fulfilling the performance requirements'. Accordingly, the Life Cycle Cost is a subset of the Whole Life Costs (Manege & Kennedy, 2020), even though Life Cycle Costs and Whole Life Costs are believed and treated as synonymous concepts by most construction industry practitioners.

Even though building construction consultants in Sri Lanka do not use the Life Cycle Costing (LCC) concept to its full potential as per Sandaruwan and Chandanie (2021), there are LCC research studies concerning the Sri Lankan Construction industry, e.g. barriers in practicing life cycle costing techniques experienced by Sri Lankan quantity surveyors (Sandaruwan and Chandanie, 2021), On-site renewable energy for industrial buildings in Sri Lanka: a life cycle cost analysis (Nanayakkara et al., 2021), Comparative life-cycle cost (LCC) study of green and traditional industrial buildings in Sri Lanka (Shanika et al., 2021), the impact of sustainable features on life cycle cost (LCC) of green buildings in Sri Lanka (Weerasinghe, 2018). However, the research studies examining WLC proceedings beyond LCC are seldom found in the Sri Lankan construction industry, showing that the awareness of WLC and its implementation are scarce is in the Sri Lankan construction industry. WLC is an all-inclusive exercise considering not only life cycle costs but also non-construction costs, income, and externalities (Manege and Kennedy, 2020). Hence, WLC implementation will help consultants make well-informed decisions with more benefits compared to LCC. Therefore, this study explores Whole Life Costing (WLC) awareness and implementation challenges in the Sri Lankan Construction industry.

2 LITERATURE REVIEW

2.1. Importance of WLC and LCC

A building project's life cycle starts with the conceptual idea and concludes with its disposal. When making decisions, investors or owners are used to focusing solely on the initial cost, overlooking future maintenance and operating costs (Davies,2004). However, a complete evaluation of building costs is needed due to the increased knowledge among stakeholders ranging from building owners and suppliers to building occupants and facility managers in modern construction projects (Opawole, 2020). Whole Life Costing (WLC) and Life Cycle Costing (LCC) are tools to support decision-making considering long-term costs and benefits involved in construction projects (Manege and Kennedy, 2020). In addition, these tools provide more informed cost advice at an early stage of projects rather than advising on cost using an initial capital cost basis (Higham et al. 2015).

2.2. Definitions of WLC and LCC

The literature provides several definitions for LCC and WLC to gain a better understanding of both concepts. Tables 1 and 2 provide some of the definitions/descriptions for LCC and WLC given by different authors.

Table 1: Definitions /descriptions for Life Cycle Costing

Ref.	Definitions/descriptions for LCC
[1]	LCC is a tool for calculating the total cost performance of a facility over time, which includes acquisition, operating, maintenance and disposal costs.
[2]	LCC has been defined as a technique which can measure all costs related to the construction, operation, and maintenance of a construction project over a particular timeframe.
[3]	LCC, as an asset management technique, allows the operating costs of premises to be evaluated at frequent intervals, which can also be recognized as its unique advantage.
[4]	LCC is an economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value.
[5]	LCC is constrained by a poor projection of future building operation and maintenance expenses and a lack of measurable risk assessment measures.
[6]	LCC is a technique used to estimate the total cost of ownership. It allows comparative cost assessments over a specific period, considering relevant economic factors regarding initial capital costs and future operational and asset replacement cost.

[1]Langdon (2007), [2]Heralova (2017), [3]Ashworth et al. (2013), [4]International Organization of Standardization ISO 12006-2 (2001), [5]Hunter et al. (2006), [6]Zakaria et al. (2020)

Table.2: Definitions /descriptions for Whole Life Costing

As depicted in Tables 1 and 2, literature includes definitions for WLC and LCC, where differences can be identified. Therefore, distinguishing between WLC and LCC is essential.

Ref	Definitions/descriptions for WLC
[1]	WLC it is a tool to assist in assessing the cost performance of construction work, aimed at facilitating choices where there are alternative means of achieving the client's objectives and where alternatives differ, not only in their initial cost but also in their subsequent operational costs
[2]	WLC consists of non-construction costs, income, externalities and life cycle costs (construction, operation, maintenance and end of life)
[3]	WLC is Rethinking Construction, Best Value and procurement routes, such as Public Private Partnerships and the Private Finance Initiative, which have led to clients and designers putting more emphasis on considering whole life costs.
[4]	WLC is value for money and is the optimum combination of whole-life cost and quality to meet the user's requirements.
[5]	WLC is a technique for examining and determining all the costs – in money terms – direct and indirect, of designing, building and facility management (operating, maintenance, support and replacement) of a building throughout its entire service life, including the disposal cost.
[1]Kishk et al. (2006), [2]Manege and Kennedy (2020), [3]Kirkham et al. (2004), [4]Office of Government Commerce (2003), [5]Horner (2002)	

2.3. WLC vs LCC

Even though LCC and WLC are used interchangeably in practice, they are not similar. WLC consists of non-construction costs, income, externalities and life cycle costs (construction, operation, maintenance and end of life) (Manege and Kennedy, 2020). Figure 1 illustrates the elements of WLC and LCC, showing the relationship between WLC and LCC.

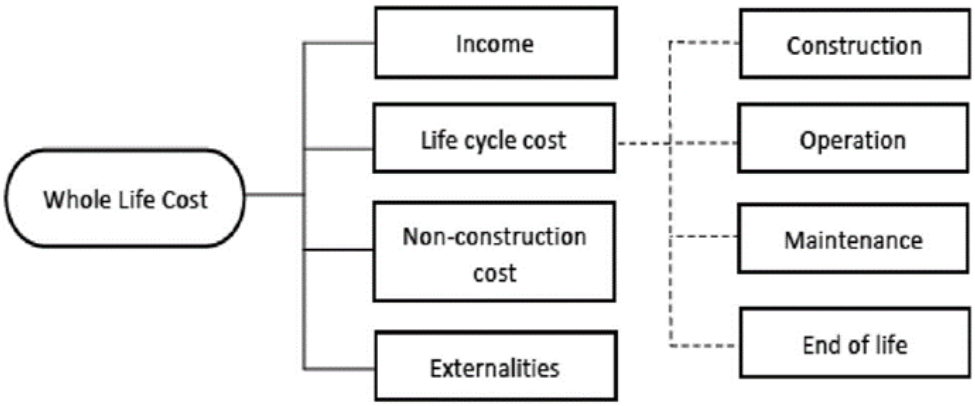

Figure 1: Elements of WLC and LCC

Source: Manege and Kennedy (2020)

As per Figure 1, LCC is one element of WLC. WLC is associated with several building-related costs and benefits for producing, operating, maintaining, and disposing of an asset, e.g. initial costs, fuel costs, operational, maintenance and repair costs, replacement costs, residual amounts, finance expenses

and non-monetary benefits (Fuller 2007). In addition, as per BSI (2008), WLC also includes non-construction costs, income, and externalities other than LCC, as shown in Figure 1. Therefore, implementing WLC provides benefits related to both WLC and LCC. Hence, stakeholders involved in construction projects must realize the advantages of using WLC, which also includes LCC.

2.4. Benefits of WLC

LCC may be used to foresee the cash flow of an asset for budgeting, cost planning, tendering, and cost reconciliation in a project (Sandaruwan et al., 2021). This is not restricted to the expense of inception and construction but extends during the building's entire duration. (Opawole, 2020). Since the LCC is a subset of WLC, all the benefits of LCC are also related to the WLC. Table 3 gives the benefits of LCC and WLC found in the literature.

Table 3: Benefits of WLC and LCC

Benefits of WLC and LCC	Ref
Analyse and optimise a building's whole life costs	[1]
Give a tool to guide decision-making throughout the building's life	[1], [2]
Involved in delivering early-stage project cost advice for a Project	[3]
The facility's total cost commitment can be effectively used to; reduce building ownership costs, evaluate economic aspects of a project, improve the risk management process, monitor project cost performance, control design development, identify project costs, increase cost transparency, recognize the various cost drivers	[4]
Clients can have a long-term connection with their built environment asset benefits Combined with a clear desire on the client's behalf to optimize ownership costs over the asset's entire life.	[5], [6]
Help in evaluating the environmental/economic aspects of a proposed building project at an early stage to design in a more sustainable manner	[7]
[1]Al-Hajj and Aouad (1999), [2] Kirkham (2005), [3]Higham et al. (2015), [4]Knauer et al. (2005), [5]Higham et al. (2015), [6]Opoku (2013), [7]Caplehorn et al. (2012)	

2.5. Barriers to implementing WLC

Hunter et al. (2005) considered the barriers to practice in the industry caused by a lack of past data on building elements and services.(., . Employers' and practitioners' shortage of understanding of LCC tools, inaccuracy of data, employers' desire to maintain budgets within short-term horizons, and a lack of shared techniques are all barriers to adopting LCC as an initial stage project in the UK as an evaluation tool according to Higham et al.(2015). Heralova (2017) reported that LCC deployment was hampered by a shortage of industrial requirements for reporting LCCs and past cost data Zakaria et al. (2020) identified that the absence of a standard method for calculating LCC and clients' reluctance to pay for LCC are significant barriers in Malaysian construction projects. The technological obstacles were recognized as software tools, laws and standards, data and information, strategy and technique. Chiurugwi et al (2000) identified a lack of procurement award incentives as a barrier when implementing LCC in the construction industry. Moreover, Horner (2002) recognized "the lack of trustworthy and reliable data on aspects of whole life cost (capital, facilities management, and disposal) and building element performance and services" as one of the significant barriers in WLC implementation . Sandaruwan et al. (2021), Kishk (2004), and Kishk et al. (2003) identified the critical issue that impacts the use of LCC in practice, is determining the quality of the data available to carry out an analysis of the initial costs, future running and maintenance costs, life cycles, and discount and inflation rates of a potential construction project.

Due to many obstacles, Sri Lankan quantity surveyors hesitate to use LCC procedures. The most common barriers preventing the usage of LCC practices in the local building construction industry are; a shortage of awareness of the LCC tool among employers and practitioners, nonexistence of knowledge about LCC, a lack of previous data, a lack of interest from employers and experts, a lack of a standard calculation method for LCC, a lack of recognized guidelines, and a lack of an industry standard for

reporting LCC (Sandaruwan and Chandanie, 2021). Sandaruwan and Chandanie (2021) further mentioned how recognized professional bodies (e.g. Construction Industry Development Authority (CIDA), Institute of Quantity Surveyors Sri Lanka (IQSSL), Sri Lanka Institute of Architects (SLIA), and the Institute of Engineers Sri Lanka (IES L)) could encourage the use of the LCC concept in the Sri Lankan construction industry. Accordingly, they suggest launching a new awareness campaign focusing on the advantages and applications of the LCC concept, enhancing LCC training, introducing user-friendly systems and applications, and including LCC as a module of education courses. In addition, government's involvement in regulations, standards, and guidelines will also help eliminate the obstacles mentioned above (Sandaruwan and Chandanie, 2021). Therefore, identifying the importance of WLC awareness in the Sri Lankan construction industry and barriers that hamper the usage of WLC is beneficial in ensuring value for money by considering not only LCC but also non-construction costs, income, and externalities.

3 RESEARCH METHOD

Quantitative research findings are representative of a population through a large data set and can be generalized (Saunders et al. 2009). Therefore, since this research aims to find Whole-Life Costing (WLC) awareness and implementation challenges in the Sri Lankan construction industry, this research was required to collect quantitative data to achieve its research aim. A quantitative survey strategy was implemented with a questionnaire developed based on findings from a comprehensive literature review. A sample of 60 Sri Lankan construction industry professionals was selected using a non-probability convenient sampling method due to the time restrictions of the study and the difficulty of finding a complete list of Sri Lankan construction industry professionals. The questionnaire prepared using "Google forms" was circulated among the sample.

Descriptive statistical approaches such as percentages and Relative Important Index (RII) were used to analyze the collected quantitative data.

The equation to calculate RII is shown in Eq (1).

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

Where 'W' is the rank given to each factor by the respondents (ranging from 1 to 5), 'A' is the highest rank (here, A=5), and 'N' is the total number of respondents. RII value has a range from 0 to 1. The higher value of RII gives higher significance to the usefulness of WLC implementation, benefits of WLC implementation, and barriers to WLC implementation.

4 DATA ANALYSIS AND DISCUSSION

Out of distributed questionnaires among 60 professionals, only 40 were returned, resulting in a response rate of 67%.

4.1. Demographic information about the respondents

Initially, the demographical data, including profession, experience and highest academic qualifications were analyzed. Respondents' profession, experience in the industry and educational background vary, resulting in different points of view related to the subject matter, as shown in Figures 2, 3 and 4.

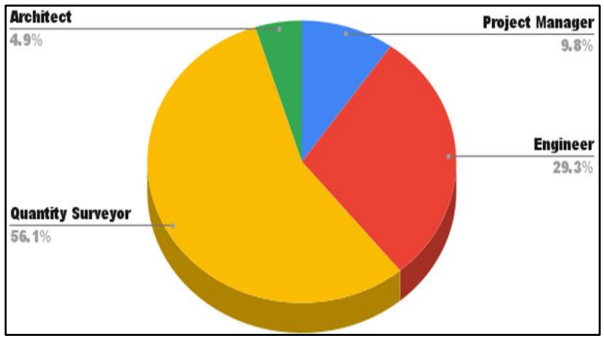

Figure 2: Respondents' Profession

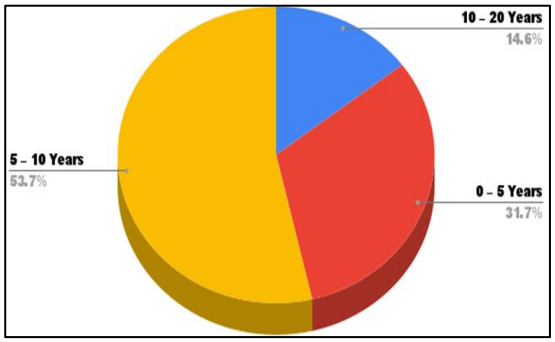

Figure 3: Respondents' work experience

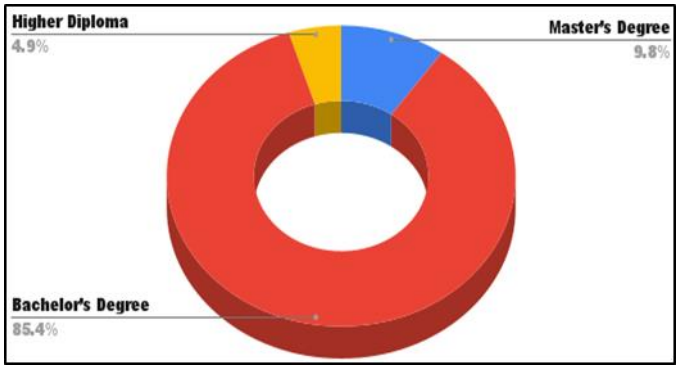

Figure 4: Highest Educational qualifications

As per Figure 2, 56.1% of quantity surveyors, 29.3% of engineers, 9.8% of project managers and 4.9% of architects responded to the questionnaires. In addition, as per Figure 3, 53.7% of respondents have 5 – 10 years of experience in the industry, while Figure 4 shows that 85.4% of respondents have a bachelor's degree as their highest academic qualification at the time of the survey.

4.2. Respondents' knowledge and awareness of the Whole Life Costing (WLC) and Life Cycle Costing

The contextual data was analyzed in quantitative forms, which directly affected the aim of the research. The first concern is whether the responders know WLC and LCC concepts. Accordingly, findings show that 92.7% of respondents know what LCC is, and 85.4% know what Whole Life Costing is. In addition, the research found that 85.4% of respondents have not been involved in the execution of WLC or LCC in construction projects. In contrast, only 14.6% of respondents mentioned that they had been involved in the LCC practices in building construction projects.

Furthermore, respondents were asked to select the best suit description related to WLC and LCC to identify their understanding of both concepts.

1. Opinion 1 - Whole Life costing (WLC) and Life cycle costing (LCC) are synonyms
2. Opinion 2 - Life cycle costing (LCC) is a subset of Whole life costing (WLC)
3. Opinion 3 - WLC is an investment appraisal and management tool that assesses an asset's total cost over its whole life. On the other hand, LCC is a tool to determine the most cost-effective option among competing alternatives to purchase, own, operate, maintain and, finally, dispose of an object or process when each is equally appropriate to be implemented on technical grounds.
4. Opinion 4 - Whole Life costing (WLC) and Life cycle costing (LCC) are two different concepts.

Accordingly, the majority (37.5%) of respondents think that WLC and LCC are synonyms, while 12.5% selected Option 3, which indicates the roles of WLC and LCC. Unfortunately, only 20% mentioned that LCC is a subset of WLC. Therefore, it is apparent that Sri Lankan construction industry professionals are not adequately aware of the roles and differences between LCC and WLC concepts.

Further, results show that most Sri Lankan construction industry professionals misunderstand the two concepts, i.e., they think WLC and LCC are synonyms.

Moreover, the awareness of the WLC elements among Sri Lankan construction industry professionals was found and presented in Figure 5.

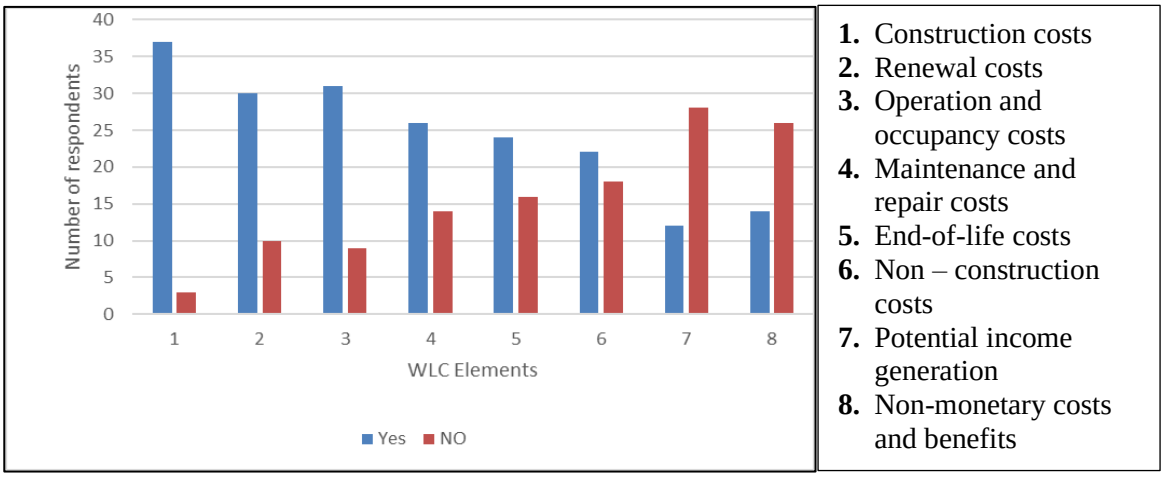

Figure 5: Awareness of the elements of WLC

Figure 5 demonstrates that most respondents know construction costs are a WLC element. In addition, renewal costs, maintenance and repair costs, operation and occupancy costs, end-of-the-life costs and non-construction costs are also elements of WLC, as mentioned by more than 50% of the respondents. Since these elements are related to LCC, a subset of WLC, it indicates the professionals' awareness of LCC rather than WLC. On the other hand, only a few respondents identified that potential income generation and non-monetary costs and benefits, e.g., social benefits and environmental damages, are elements of WLC. This result indicates some respondents' lack of knowledge and misunderstanding of the WLC concept.

4.3. Whole life Costing implementation in the construction industry

Party to initiate WLC practices

Figure 6 illustrates the respondents' answers to the question, "which party should initiate the Whole life costing practices in the construction industry?".

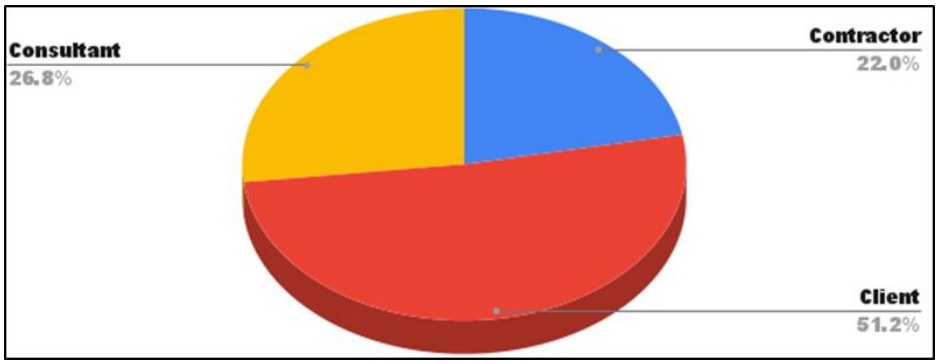

Figure 6: Respondents' opinion about which party should initiate WLC

According to Figure 6, 51.2% of respondents believe clients should initiate WLC practices in the industry, while 26.8% of respondents think consultants should do it. However, only 22% of respondents think the responsibility for initiating WLC practices rests with the contractors.

Responsible profession for initiating WLC practices

Further, respondents were asked which profession should take responsibility for initiating WLC practices, and the responses are illustrated in Figure 7.

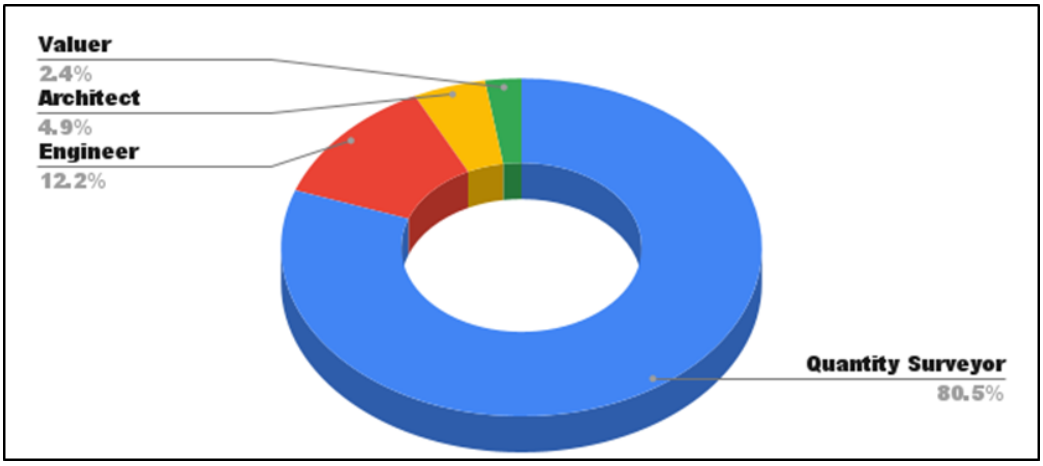

Figure 7: Respondents' opinion about Responsible profession for initiating WLC

Most respondents, 80.5%, selected quantity surveyors as the responsible profession for initiating WLC. On the other hand, 12.2% of the respondents said engineers should take responsibility for initiating WLC, while 4.9% and 2.4% of respondents selected architects and valuers, respectively, as responsible professions for initiating WLC.

Usefulness of implementing WLC in different sectors of projects

The usefulness of implementing WLC in the projects of different sectors in the Sri Lankan construction industry was found using a scale of 1-5, indicating; 1-not useful, 2-slightly useful, 3-moderately useful, 4-useful, 5-very useful. Data were analyzed by calculating RII and ranking from the most useful sector to the least useful sector to implement WLC. Accordingly, Table 4 depicts RII and the ranking of the sectors to implement WLC.

Table 4: RII values and ranks for Sectors to implement WLC

Sector	Usefulness RII	Rank
Private Sector Projects	0.795	1
Other, e.g., projects of NGOs	0.745	2
Public Sector Projects	0.710	3

Table 4 shows that WLC implementation is more useful for private sector projects with the first rank. Secondly, it is useful for other sector projects like projects of NGOs and, thirdly, for public sector projects. However, there is only a slight difference in the RII of all three sectors, with an RII of more than 0.7, indicating that WLC implementation is useful for projects in all sectors in Sri Lanka.

4.4. Benefits and Challenges for Whole Life Costing implementation in the construction industry

The significance of benefits the Si Lankan construction industry could gain from implementing WLC was found by analyzing data. Table 5 illustrates the RII and the ranking of those benefits.

Table 5: Significance of benefits from WLC implementation

Benefit	RII (Relative Importance Index)	Rank
Increasing long-term value	0.690	1
Developing the total cost of ownership	0.685	2

Forecasting the future operating cost of the building	0.680	3
Optimizing the selection of materials, equipment and components	0.681	4
Getting a better understanding of the risks in the early stage of the building	0.665	5
Providing increased certainty and transparency	0.660	6
Appraising the cost performance of design alternatives	0.655	7
Identifying non-construction costs, e.g., site costs, finance costs, and rental costs	0.645	8
Identifying the durability standards	0.640	9
Getting an idea about potential income generations	0.630	10
Increasing economic sustainability	0.620	11
Getting an idea about non-monetary costs and benefits, e.g., social benefits, environmental damages	0.610	12

As per Table 5, the Sri Lankan building construction industry can gain by increasing the long-term value of construction products, which is the most important benefit of WLC implementation. In addition, developing the total cost of ownership, forecasting the future operating cost of the building, optimizing the selection of materials, equipment and components, getting a better understanding of the risks in the early stage of the building, providing increased certainty and transparency and appraising the cost performance of design alternatives can be identified as other significant benefits of WLC implementation having more than 0.65 RII. On the other hand, getting an idea about non-monetary costs and benefits (e.g., social benefits, environmental damages) is considered the least significant benefit of WLC implementation, owing RII of 0,61. However, Table 5 indicates the importance of all the benefits, giving more than 0.6 RII for all the benefits.

In contrast, Table 6 presents the significance of challenges /barriers to implementing and using WLC in the Sri Lankan Construction industry.

Table 6: Significance of challenges for WLC implementation

Challenge/ Barrier	RII (Relative Importance Index)	Rank
Difficulty in identifying includes and excludes calculating WLC	0.675	1
Lack of details at early stages	0.665	2
Lack of awareness of WLC benefits	0.656	3
Lack of understanding of WLC tools	0.655	4
Lack of reliable data	0.654	5
Lack of expertise/knowledge on WLC	0.653	6
Unavailability of a standardized approach	0.630	7
Maintaining databases to obtain data for WLC elements is difficult and expensive	0.620	8
Difficulty in calculations	0.570	9
Lack of client interest	0.535	10

The ranking shows the most impactful challenge to the least impactful challenge. Challenges with more than 0.65 RII can be considered as significantly impactful challenges when implementing WLC in the Sri Lankan construction industry. They are difficulty in identifying includes and excludes calculating WLC, lack of details at early stages, lack of awareness of WLC benefits, lack of understanding of WLC tools, shortage of reliable data and lack of capability/knowledge on WLC. Since all the challenges have an RII of more than 0.5, all challenges can be considered to be impacting the Sri Lankan construction industry when implementing WLC.

5 CONCLUSION

A comprehensive literature review was conducted to understand WLC and LCC concepts clearly. As per literature findings, the WLC concept is used in many countries like the UK, proving the gain of many benefits via WLC implementation. However, even though research studies related to LCC are available in the literature related to the Sri Lankan construction industry, there is a scarcity of research studies about WLC. Therefore, this research study aimed to explore Whole Life Costing awareness and implementation challenges in the Sri Lankan construction industry. Accordingly, a quantitative survey strategy was followed, and data were collected using questionnaires. Due to the time restrictions, the sample was selected using a non-probability convenient sampling method. From the sample of 60 Sri Lankan construction industry professionals, 40 responded to the survey. Findings revealed that Sri Lankan construction industry professionals are unaware of the difference between the WLC and LCC concepts. In addition, they have disregarded the potential income generation and non-monetary costs and benefits are elements of WLC. Further, as per findings, when implementing WLC practices, the client party initiates, and the quantity surveying profession must take the responsibility for initiating as a construction industry professional.

The construction industry of Sri Lanka could mostly get benefits such as increasing the long-term value of construction products, developing the total cost of ownership, forecasting the future operating cost of the building, optimizing the selection of materials, equipment and components, getting a better understanding of the risks in the early stage of the building, providing increased certainty and transparency and appraising the cost performance of design alternatives through WLC implementation.

In order to gain the above advantages through WLC implementation, the identification of challenges is critical. Difficulty in identifying includes and excludes calculating WLC, lack of details at early stages, lack of awareness of WLC benefits, lack of understanding of WLC tools, lack of reliable data and lack of expertise/knowledge on WLC are the main challenges that prevent the implementation of WLC in the Sri Lankan construction industry. These challenges have to be mitigated for the effective implementation of the WLC concept in the Sri Lankan construction industry.

The study can be recommended to enhance awareness of the WLC concept among Sri Lankan construction industry professionals, especially quantity surveyors, via CPDs, seminars, workshops…etc., to take responsibility for practicing WLC in the Sri Lankan construction industry. On the other hand, the identified challenges of WLC implementation must be mitigated as much as possible. Therefore, future research can be conducted to identify strategies to mitigate such challenges.

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