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Acknowledgement

IQSSL Technical Research Proceedings are published annually in parallel to the Annual Technical Sessions in order to disseminate novel knowledge to the construction industry stakeholders and as well us to encourage young researchers. In January 2020, the researchers were invited to submit their Research Papers on the general theme of "Rethinking Construction Industry: Future Envision." A total of 25 research papers were received and 15 of them were finally selected after a comprehensive review.

All submitted full papers were sent to at least two independent reviewers selected from the scientific committee for double-blind peer review. Reviewers provided constructive comments with respect to the originality, significance, reliability, quality of presentation and relevance to the remit of each paper. The Members of IQSSL Publication board, who are the editors of the symposium proceedings, were responsible for final decisions on accepting or rejecting the papers based on these assessments.

Even though the IQSSL Technical Sessions could not be held as planned due to the Covid-19 pandemic situation, its heartening to see the Technical Research Proceedings being published for open access on the IQSSL official web site. On behalf of IQSSL and the Board of Quantity Surveying Publications, I hereby acknowledge and highly appreciate the all the authors who submitted their valuable research papers. In addition, I thank all the members of the Scientific Review Panel for their untiring commitment and dedication in providing comprehensive reviews.

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THE MITIGATION MEASURES FOR MATERIAL SHORTAGE ISSUES IN CONSTRUCTION INDUSTRY

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THE MITIGATION MEASURES FOR MATERIAL SHORTAGE ISSUES IN CONSTRUCTION INDUSTRY

ABSTRACT

The construction industry is a highly material-intensive industry that requires a constant supply of materials during the entire construction period. The impact, causes, and mitigation of material shortage in the construction industry were identified by reviewing literature. However, it was emphasized that current mitigation methods cannot be effectively tackled in profitable manner with rapid economic fluctuations. Hence this research aimed to develop a framework to mitigate causes of material shortage. The data was gathered from the construction professionals through questionnaires using convenience sampling and analyzed through RII method. Findings revealed that external causes are extremely significant whereas contractor related causes are comparatively high significant. Proper logistics planning, proper material handling techniques and completed design details are revealed as some of the mitigation measures as per the developed framework.

Keywords: *Construction Industry; Construction Materials; Material Shortage, Mitigation measures.*

INRODUCTION

Raw materials can be identified as a major component in the construction industry (Elisa, et al., 2007), and the available variety of construction materials has recently been widened in the industry (Gulghane & Khandve, 2015). Construction projects can be viewed as assembling processes involved by various sub-assemblies of materials supplied to the site (Vidalakis, et al., 2013). When it comes to the cost of construction materials, it covers a significant portion and the overall cost of a project could be reduced by minimizing the expenses for material procurement (Patel & Vyas, 2011). Moreover, procuring materials should be managed well because any surplus or shortage can critically affect and putting project success at risk (Gulghane & Khandve, 2015). Further, material shortages can be considered as an external risk to the construction industry and which is affecting the economy as well (Assaf & Al-Hejji, 2006). Accordingly, the material shortage is identified to be one of the demanding causes of failures and delays in large construction projects (Bekr, 2015). Improper estimations, poor workmanship, quality issues, special materials and inconsistency in demand were identified as causes for material shortage (Rahman, et al., 2017). In the global context, material shortage is considered to be one of the main reasons causing cost variance while the rest are material damages by logistics, errors in applying and handling, poor supervisions causing material loss, improper tracking systems resulting longer material waiting, site layout issues making the materials roam around and materials being stolen on-site (Gulghane & Khandve, 2015). Sawchuk (2001) stated that there was a widespread shortage of principal materials such as reinforcing steel, Portland cement, aluminum and asphalt.

Hence, material shortage is one of the most adverse reasons among many causes of construction failures, which is made further positive by the recent identification of factors affecting the Saudi Arabian larger scale building project failures where it confirms the damages occurred to those projects mainly due to material shortage and delays (Rahman *et al.,* 2017). Shortages are categorized and reported as severe shortages, moderate and critical shortages by a number of projects which have been visible failures due to material shortage issues (Sawchuk, 2001). Thus, there is a necessity to mitigate material shortage issues in the construction industry. Material shortage issues have been one of the governing factors in overall project failures. Consequently, this research has been created to discuss shortage of construction materials and to identify long term approaches to minimise material shortages in the construction industry. Although, some studies have already been conducted to find mitigation measures to overcome the material shortages, still there is a gap as current mitigation methods cannot be tackled effectively to be profitable with rapid economic fluctuations of the present context. Therefore, this research study focuses on filling the gap by doing proper investigation in this regard.

Accordingly, this paper aims to develop a framework to mitigate foreseeable construction failures caused by material shortage issues in construction industry with achievement of following objectives;

- To identify factors affecting material shortage and its significance in the construction industry.
- To discover mitigation measures to overcome those material shortage issues in the construction projects.

This paper is structured in three sections Started with describing the method used for achieving the aim of the study and then, through the research analysis and findings validated the importance of this paper. Finally drew the conclusion with the framework of mitigation measures of material shortage issues.

METHODOLOGY

A research methodology is the somewhat systematic route taken to reach the answers for the research problem (Kothari, 2004). A quantitative research approach encompasses collecting and analysing numerical data subjected to statistical testing (Amaratunga, et al., 2002). Accordingly, a quantitative approach was adopted and a questionnaire was picked as the data collection tool which was included with the direct questions, questions with the Likert scale for the ranking purpose and several open-ended questions in order to collect further information as well. Questionnaire survey was conducted among contractors, clients and consultants. Then, the sample size of the survey was only 30, due to, the limitation of time for the research and in order to attain meaningful and relevant information, highly experienced professionals were only chosen for the study. Hence, the convenience sampling method was used to select the participants for the survey. Quantity surveyors (67%) are mostly utilized due to their significant involvement in material management activities and next site engineers (23%), who are directly involved in the material management activities in the site. Project managers (10%) were selected due to their knowledge of the overall management of materials. The sample contained respondents with 20% from 'less than 5 years', 70% from '5-15 years' and 10% from 'above 15 years' of experiences which they had with acquaintance in material shortage in the construction industry. Further, the respondents comprised of 60%, 30% and 10% respectively from contractor, consultant and client organisations. Since the descriptive questionnaire survey is used in this research, quantitative analysis was used for data analysis. Additionally, statistical analysis was used with the assistance of the RII technique. The responses related to the impacts of material shortage in the construction industry and factors affecting material shortage will be gathered from the questionnaire surveys and these responses will by analysing using RII,

$$\boldsymbol{RII} = \frac{\sum \boldsymbol{Wn}}{\boldsymbol{A \times N}} \qquad \text{(Eq: 01)}$$

where, W= Constant expressing the weighting given to each response, A= the highest weighting, n= the frequency of responses and N= Total Number in the Responses

DATA ANALYSIS AND FINDINGS

This section discusses the finding of the study under two sub sections namely causes of material shortage in construction industry and mitigation measures for material shortage in construction industry. In addition, third sub section as summary which carries a framework to mitigate material shortage in building construction.

Causes of material shortage in construction industry

Totally twenty-five different causes behind material shortage were identified through literature and which have been ranked in order to find its significance using RII. Moreover, those causes have been classified into 03 categories namely; contractor related causes, client related causes and external causes. The following sub sections clearly illustrate those 03 categories.

Contractor related causes

The contractor related causes have higher effect regarding material shortage in construction industry. Table 3-1 indicates the contractor related material shortage causes in accordance with their significance.

Table 3-1: Contractor Related Material Shortage Causes

Description	RII	Rank
Delays in procuring materials (Koushki, P. A & Kartam, 2004)	0.813	1
Poor estimation of materials quantity (Al-Kharashi & Skitmore, 2009)	0.800	2
Material delivery delays (Aibinu & Jagboro, 2002)	0.800	2
Lack of proper inventory control (Mansur, Abdul Hamid, & Yusof, 2016)	0.780	3
Improper coordination and planning during material transportation (Ameh, Soyingbe, & Odusami, 2010)	0.747	4
Poor workmanship (Dolage & Rathnamali, 2013: Mydin, Sani, Taib, & Alias, 2014)	0.740	5
Poor supervision of materials (Arditi & Mochtar, 2000).	0.733	6
Payment delay (Windapo, Odediran, Moghayedi, Adediran, & Oliphant, 2017).	0.720	7
Improper costing (Abd El-Razek, Bassioni, & Mobara, 2008).	0.713	8
Unavailability of onsite storage (Omoregie & Radford, 2006).	0.713	8
Wrong consumption calculation (Al-Kharashi & Skitmore, 2009).	0.693	9
Excessive machine stoppage (Rajaprabha, Velumani, & Jayanthi, 2016).	0.633	10

The more significant causes related to material shortage are due to the contractor's faults according to the analysis. Therefore, the contractor has to play a significant role in mitigating material shortage impacts for the successful completion of the project. According to both literature and survey, the late procurement of materials is a significant factor which has to be given more attention. In literature, it was identified that the supply chain has to be maintained in a proper manner where the procurement of materials is a key requirement to deliver the materials on time without affecting the project. Poor estimation of material quantity was identified as one of the key causes of contractor faults affecting the material shortage where it was justified by the respondents ranking it as the second highest cause of the material shortage. Maintaining an inventory is the contractor's own responsibility to ensure the supply and demand of materials in the site as identified in the literature where the respondents have ranked it as the third significant cause. Further, unavailability of on-site storage, improper costing, wrong consumption calculation and excessive machine stoppage were ranked at least significant items in both overall rankings and within contractor related causes category.

External causes

Most of the causes for the material shortage is related to the external causes. Moreover, the most significant cause is also related to the external causes from the overall ranking as well, which is special materials. Table 3-2 illustrates the external causes related to material shortage. Out of twenty-five causes, most of the external causes were ranked as the most significant causes while securing more places in the first ten places. As a whole, there were some least significant items in the special causes ranked at the bottom level of the causes of material shortage. Moreover, in literature, it was identified that inconsistent demand and heavy fluctuations in demand had a significant impact on the demand and supply of the materials.

Table 3-2: External Causes Related to Material Shortage

Description	RII	Rank
Special materials (Koushki & Kartam, 2004 ; Rahman M., Yap, Ramli, Dullah, & Shamsuddin, 2017).	0.827	1
Delays in manufacturing of special building materials (Faridi & El-Sayegh, 2006).	0.807	2
Quality of materials (Kazaz, Ulubeyli, & Tuncbilekli, 2012).	0.787	3
Damages caused to sorted material while they are needed urgently (Ihuah, 2015).	0.780	4
Origin or availability materials (Toor & Ogunlana, 2008; Doloi, Sawhney, Iyer, & Rentala, 2012).	0.767	5
Defective or damaged raw materials (Elkhalifa & Shaddad, 2011).	0.727	6
Inconsistent demand (Shanmugapriya & Subramanian, 2013; Abd El-Razek, Bassioni, & Mobara, 2008).	0.720	7
Policy matters, like custom (Dolage & Rathnamali, 2013).	0.703	8
Heavy fluctuations in demand (Mansur, Abdul Hamid, & Yusof, 2016).	0.700	9
Suppliers' turnover (Alonso, Gregory, Field, & Kirchain, 2007).	0.673	10
Natural disaster (Christopher, Logistics & Supply Chain Management, 2011).	0.647	11
Force major situations (Bysheim, Nyrud, & Strobel, 2016).	0.633	12

Client related causes

Material shortage in construction due to the client's fault directly or indirectly is very less. In the literature review, it was identified that the client has frequently changed the material types (Toor & Ogunlana, 2008), used due to the various reasons. The client has the potential to change his design requirements. However, as a whole client related causes have medium significance.

Mitigations Measures for Causes for the Material Shortage

Mitigation measures for material shortage were acknowledged in the literature review and those measures were questioned in the survey to identify the significance of those measures in each shortage of causes. Each measure in the same shortage category is separately ranked and the highest RII value in the same category was selected as the most suitable measure for each category. Additionally, few mitigation measures have been introduced by the professionals as well. Finally, two mitigation measures were suggested for each cause based on their significance. The following sub sections clearly illustrate those 03 categories.

Mitigation measures for contractor related material shortage

Table 3-3 illustrated the material mitigation measures can be adopted to mitigate the contractor related material shortages.

Table 3-3: Mitigation Measures for Contractor Related Material Shortage

Item No	Description	Mitigation Measures (Rank 01)	Mitigation Measures (Rank 02)
1	Poor estimation of materials quantity	Proper understanding of construction methodologies and scope of work	Proper estimation
2	Poor workmanship	Proper supervision	Proper training programs
3	Late procurement of materials	Proper logistic planning	Proper material planning
4	Delay in material delivery	Proper logistic planning	Considerable material storage
5	Poor supervision of materials	Keeping materials in a good condition	Proper security system

6	Improper costing	Available cost data	Proper estimation techniques
7	Wrong consumption calculation	Proper estimation techniques	Available cost data
8	Improper coordination, planning during material transportation	Proper logistic planning	Proper supervisory staff
9	Lack of proper inventory control	Skilled work force	Conducting audits
10	Excessive machine stoppage	Proper maintenance	Skilled operators
11	Payment delay	Feasible budget allocation	Additional bank facilities
12	Not availability of onsite storage	Proper supply chain of materials	Keeping allowances for onsite storage

Mitigation measures for external causes related to material shortage

This section focuses on the analysis of mitigation measures best suited for mitigating external causes related to material shortages as identified in the literature and ranked by respondents.

Table 3-4: Mitigation Measures for External Causes Related to Material Shortage

Item No	Description	Mitigation Measures (Rank 01)	Mitigation Measures (Rank 02)
1	Origin of availability materials	Proper logistic planning	Minimizing of wastage
2	Quality of materials	Proper material testing	Considerable budget allocation
3	Inconsistent demand	Proper material planning and using alternatives materials	
4	Special materials	Produce only when demand and minimizing of wastage	
5	Delay in manufacturing special building materials	Adequate lead time	Minimizing changes to the design
6	Damage of sorted material while they are urgently needed	Proper material handling techniques	Proper stores management
7	Defective or damaged raw materials	Keeping materials in a good condition	Proper material testing methods
8	Policy matters, like custom	Proper documentation in imports	Updating registrations
9	Heavy fluctuations in demands	Using alternatives materials	Proper material planning
10	Natural disaster	Proper insurance coverage	Proper evacuation plans
11	Suppliers' turnover	Proper customer relationships	Supply only demand
12	Force major situations	Proper insurance coverage	Proper customer relationships

Mitigation measures for client related causes of material shortage

Adopting proper material planning is the best suited alternative for minimizing material shortage cause of changes in material types during construction as suggested by the most respondents.

Summary

The below framework (Figure 1) shows the causes of ***material shortages and mitigation measures/tools for those in the construction industry***, especially in Sri Lanka in a single view as a summary.

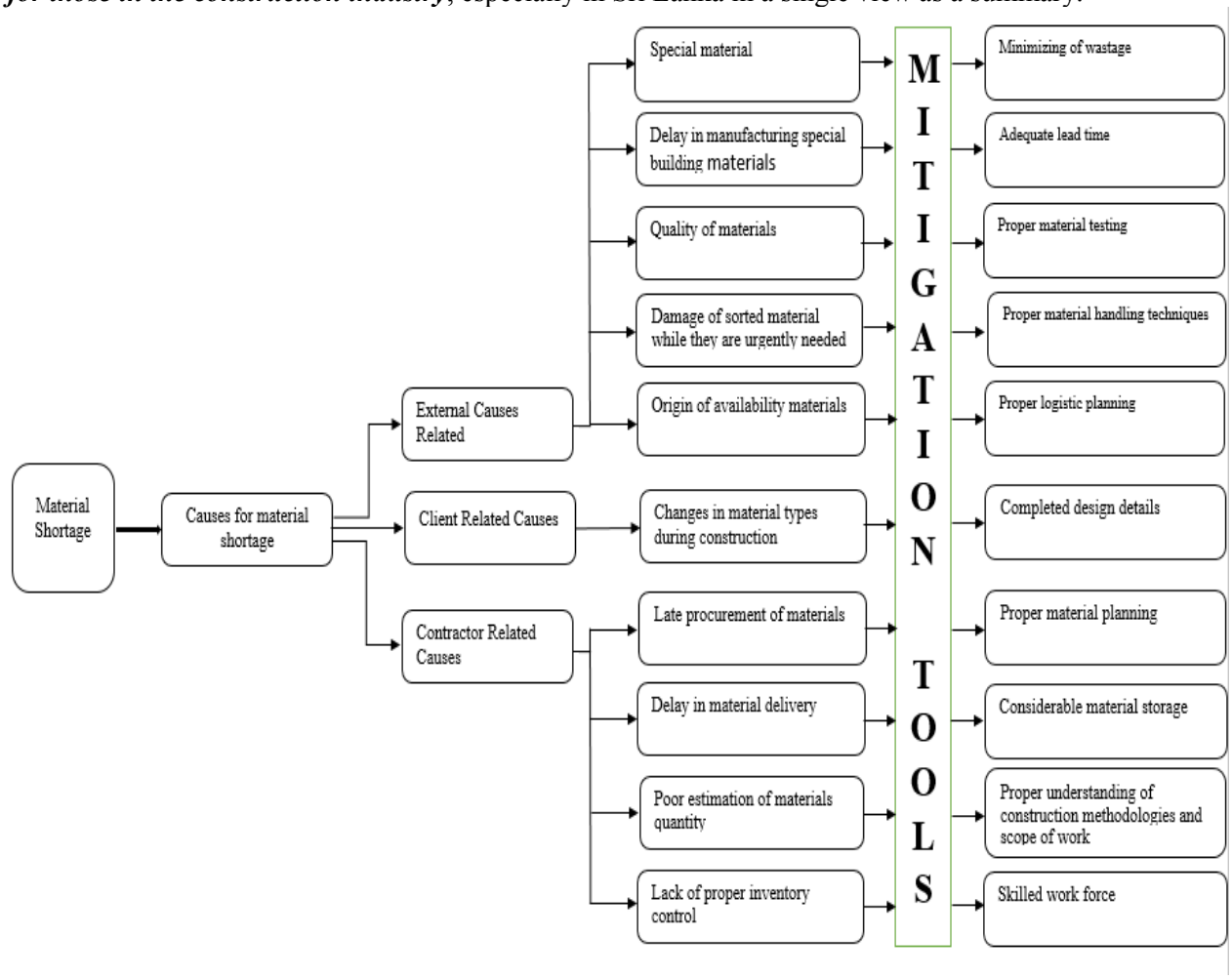

Figure 1: Framework to mitigate material shortage in the building construction industry

CONCLUSIONS

This research was aimed at addressing the impact of construction material shortage by mitigating them with the proper measures. According to the literature review carried out at the initial stage of the research, the several factors related to the material shortage have been identified which were then modernized through the survey carried out within the industry with the professional assistance including quantity surveyors, project managers and site engineers. All the data has been collected via literature available in the field and responses of the professionals related to the construction industry. The material shortage has been recognized as the crucial concern in the construction industry which has been directly affecting the construction. In terms of causes of material shortage, the external causes and the contactor related causes were recognized as more significant whereas the client related causes were identified as least significant out of three main categories of causes of material shortage. However, as far as the overall impacts are concerned, the external causes are the most significant material shortage causes. Therefore, industry

practitioners have to concern more on the external causes affecting material shortages as much as possible. After analyzing the material shortage causes, the requirement for mitigating those causes was emphasized with respective material shortage mitigation measures. Form the research findings, a framework was developed to overcome material shortage issues in the construction industry.

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APPLICATION OF LIFE CYCLE COSTING TECHNIQUE IN SRI LANKAN CONSTRUCTION INDUSTRY: ASSESSMENT BY QUANTITY SURVEYORS

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Application of Life Cycle Costing Technique in Sri Lankan Construction Industry: Assessment by Quantity Surveyors

ABSTRACT

Life Cycle Costing (LCC) is a tool, which can evaluate all the costs over a specified period of time. There is a number of benefits and applications of LCC. The aim of this research is to investigate the current application of LCC in the Sri Lankan building construction industry based on quantity surveyors' experience. Accordingly, data collection was executed through a questionnaire survey with 120 qualified quantity surveyors from different professional levels selected via purposive sampling method. Ultimately, 85 dully filled questionnaires were collected with a response rate of 70.83%. The research revealed the key applications of LCC are to find out the optimum alternative from series of alternatives, use as a decision tool, to comprehend the project maintenance process and to determine the retirement cost impact of a building.

Keywords: *Applications; Benefits; Life Cycle Costing; Quantity surveyors; Sri Lanka.*

1. INTRODUCTION

1.1 BACKGROUND

Various stakeholders are involved throughout the lifetime of a building from construction to demolition. While energy and maintenance costs during the operation stage are of concern to the occupants and owners of buildings, respectively, the capital cost is vital for investors. At present day, most of the investors are more concerned about both operation costs and maintenance costs rather than focusing entirely on capital cost. Therefore, LCC analysis is widely used to determine the costs associated with each stage of a building's life and understand how the costs are distributed among the stakeholders (Samani *et al.,* 2018). The LCC is defined as a technique which can evaluate all the costs over a specified period of time, as mentioned in the agreed scope (BS ISO 15686, 2008).

The main motivation for the implementation of LCC technique in the construction industry is being identified it as a tool for decision making (D'Incognito *et al.,* 2015). Many professionals use LCC technique for different applications leading to different purposes. Decision making at the design stage, to determine the performance impact throughout the life span of buildings, selection of most cost-effective project from a series of alternatives and assessment of new installation services against existing installation services can be recognised as some generic purposes of the application of LCC techniques in the construction industry (Dale, 1993).

Furthermore, an ultimate conclusions from LCC output represents the total cost commitment of a facility, evaluation of various alternatives leading to reduce the unnecessary costs, enhance the cost transparency, recognise the different cost drivers and identification of risk factors can be identified as benefits of using the LCC techniques (Knauer & Moslang, 2005).

Further, the consultants have an important role during the design stage and the bid development process. This stage has various risks (Swaffield & McDonald, 2008). Financial risks, legal risks, political risks, technological risks, environmental risks, and sociological risks can be identified as risks associated with the construction industry. Meanwhile, at the feasibility stage, the owner wants to minimise the total project cost (Liapis *et al*., 2014). According to Davies (2004), for every unit spent on capital cost, five units are spent on maintenance. Therefore, the consultants have to concern on the LCC of the project rather than the capital cost (Norman, 1990).

However, Kunaseelan and Perera (2011) revealed that Sri Lankan building construction consultants do not fully consider LCC techniques in their designs. Further, it was stated that the awareness of LCC should be improved in the local context (Kunaseelan and Perera, 2011). Hence, it is important to investigate the

applications of LCC technique which is assessed in this study based on the experience of the Sri Lankan Quantity Surveyors.

1.2. RESEARCH PROBLEM

Based on the background, LCC can be identified as a technique mainly used to select the best option from a number of competing proposals (Ashworth, 1996). Considering the construction industry, LCC could be very effectively used by consultants for; analysis of system concepts and options, identify cost drivers, identify warranty incentive schemes and identify cost reduction benefits, etc. (Norman, 1990).

Previous work has stated on the necessity of the industry to have a greater appreciation in focusing on the better value rather than the lowest price at the early stage of project valuation of construction projects (Wolstenholme, 2009). In addition, some other previous works state that it would be expected to have the involvement of construction professionals in delivering cost consultancy services in early stages with the use of evaluative tools such as LCC. LCC tools enable the proper assessment of the long-term implications of alternatives related to the proposed project's life cycle. LCC can be identified as a technique that assesses the total design life costs of components or materials which are parts of the proposed building project's design. It is obvious that the use of LCC technique in formulating price advice at the early stages of a project, would enable better financial decision making in the long-term design life of the proposed asset (Higham, Fortune & James, 2015).

All the above mentioned previous works stated the importance of using LCC technique in the built environment. Yet, in Sri Lanka, building construction consultants have been claimed to be backward in practicing LCC technique for early-stage project valuation (Kunaseelan and Perera, 2011). Hence it is important to investigate the applications of LCC technique in Sri Lankan construction industry through experience of the Sri Lankan Quantity Surveyors who deal with costs in construction projects.

2. LITERATURE REVIEW

2.1 LIFE CYCLE COST (LCC) TECHNIQUE

"LCC is an economic process for the evaluation of the total costs incurred in the commissioning and operation of a construction project" (Norman, 1990, p. 344). Therefore, the LCC technique helps to evaluate the organisations current assets, leading to making better decisions in the planning and constructing new facilities (Islam *et al.,* 2015). In addition, LCC has been also defined as a technique that can use to measure all costs related to construction, operation, and maintenance of a construction project over a particular timeframe (Heralova, 2017).

Accordingly, the LCC technique gives emphasis to a whole or the total cost approach consumed during the acquisition of a capital cost project or asset, rather than merely concentrating on the initial capital costs alone. Hence, LCC facilitates considering optional solutions for different variables involved and sets up hypotheses to test the confidence of the results achieved. Taking into account the initial capital costs, maintenance costs and replacement or the salvage costs and expressing these costs in comparable terms, this LCC as an asset management technique allows the operating costs of premises to be evaluated at frequent intervals, in which also can be recognised as its unique advantages (Ashworth, *et al.*, 2013).

2.2 BENEFITS OF APPLYING LCC TECHNIQUE

Every investor or owner expects his project to be a cost-effective construction development. Yet, one of the major barriers is, 'how to identify the benefits and the real cost of a particular construction development? In response to such a barrier, LCC technique is oftently used to determine the most cost-effective construction development pathways in the construction industry (Cole & Sterner, 2000).

Furthermore, an ultimate conclusions from LCC assessment output represents the total cost commitment of a facility which can be effectively utilise for reduction of building ownership cost, evaluating economic

aspects of a project, enhancing the risk management process, monitoring the cost performance of a project, control design development, identify the cost of project, enhance the cost transparency, and also in recognising the different cost drivers as key benefits of application of LCC technique (Knauer, Thorsten, Moslang & Katja, 2005).

The main benefits of LCC applications to the construction industry are summarised in Table 1.

Table 1: Benefits of LCC Applications in Construction Industry

Benefits	References
Help todetermine the life cycle cost of project	[1], [2], [7], [10] [12], [16], [17], [18], [19]
Help to monitor overall cost performance	[1], [2], [9], [10], [12]
Easy to evaluate economics aspects of a project	[2], [3], [4], [5], [6]
Identify different cost drivers	[2], [8], [18]
Offer control in design development	[2], [14], [15]
Assist to enhance cost transparency of project	[2], [7], [12]
Assist to improve risk management process	[3], [7], [8]
Assist to reduce building ownership cost	[11], [13], [14]
[1] Dale, (1993), [2] (Knauer, Thorsten, Moslang, & Katja, 2005), [3] (Heralova, 2017), [4] (Caplehorn, 2012), [5] (Zhang, 1999), [6] (Malmgren *et al.,* 2016), [7] (Norman, 1990), [8] (Sinisuka & Nugraha, 2013), [9] (Ashworth, 1996), [10] (Cole & Sterner, 2000), [11] (Rahim *et al.*, 2014), [12] (Mat, 2002), [13] (Sinisuka & Nugraha, 2013), [14] (Gundes, 2015), [15] (Dell'Isola & Kirk, 1981), [16] (Bruce-Hyrkas *et al*., 2018), [17] ((Moussatche & Languell, 2001), [18] (Akhlaghi, 1987), [19] (Woodward, 1997)	

2.3 APPLICATIONS OF LCC TECHNIQUE IN THE BUILDING CONSTRUCTION INDUSTRY

The LCC technique has been integrated into many research efforts and engineering applications. Its implementation has quite a broad range, as discovered in the literature review. This implementation of LCC is utilised in many fields, such as construction projects, infrastructures, buildings, facilities management (Akhlaghi, 1987).

Heralova (2017) conducted case studies to investigate the role of LCC analysis in the early stage (feasibility stage) of construction projects, in the public sector. The study identified the public sector investors' characteristics, such as they want to meet the sustainable dimensions within projects, fund limited financial resources and very strict procurement system. Hence, it is necessary to find the most financially efficient solution, in the feasibility stage to attract public investors (Heralova, 2017).

In Hong Kong, Yang and Kumaraswamy (2011) conducted a case study aiming to present the approaches towards improving infrastructure maintenance principles, models, strategic and practices based on a recent study of bridge management systems in Hong Kong, while focusing LCC techniques.

Many investors and building owners have more concern regarding reducing the energy consumption to save the national energy and to minimise the costs of heating, cooling and operation functions in buildings. Therefore, it is important to build cost-effective buildings while maintaining other parameters. Malmgren, *et al.* (2016) conducted a case study to show a clear comparison between various renovation alternatives from a sustainability perspective using the LCC technique (Malmgren, *et al.,* 2016).

The applications of the concept of LCC for the construction industry can be summarised in Table 2.

Table 2: Applications Of LCC Concept In The Construction Industry

Applications Of LCC Concept	References
Use as a decision tool	[1], [3], [5], [7]
Use as a resource allocation and optimization tool	[7]
Use as a technology selection tool	[7]
To improve the reliability & performance of a building	[7]
To comprehend the projects maintenance process	[4], [7]
To find out the optimum alternative	[2], [3], [6]
To determine the market demand	[7]
To provide design trade-offs	[7]
Determine ways of reducing the energy consumption of a building	[5], [7]
Determine the warranty incentive scheme	[7]
Determine the system integration and verification	[7]
Determine the retirement cost impact of a building	[7]
[1] (Dale, 1993), [2] (Wu, et al., 2006), [3] (Heralova, 2017), [4] (Yang & Kumaraswamy, 2011), [5] (Malmgren, et al., 2016), [6] (Moussatche & Languell, 2001), [7] (Norman, 1990)	

2.4 CONSTRUCTION CONSULTANTS' ROLE IN APPLYING LCC TECHNIQUE

As previously discussed in the background (refer to Section 1.1), there are various stakeholders involved in the construction sector at the project level. Among those stakeholders, construction consultants have a significant role to play throughout the project life cycle (Samani *et al*, 2018). As discussed in the benefits of LCC (refer to Section 2.2), the major aim of using LCC is to find out the most cost-effective project proposal from a series of optional project proposals (Dale, 1993; Wu *et al*., 2006).

According to Ashworth (1993), the main applications of LCC in a construction project are at many stages including; the inception stage, the design stage, the construction stage, the occupation stage, and for procurement and energy conservation. In addition, nowadays most of the construction professionals are concerned about achieving the sustainable development goals of construction projects. According to Hussin and Omran (2002), to successfully complete a project with sustainability concerns, it is essential to have a good construction consultant team with a whole life understanding of a particular project. It is proved by Higham *et al* (2015), stating the priority of construction professionals, who are using the LCC technique to evaluate the environmental sustainability in employing consultants as trendy.

At the inception stage of a construction project, LCC is used as a part of the investment appraisal. LCC assist to balance the construction cost and the maintenance cost with needed desires and within the rental value. Hence, the involvement of construction professionals is necessary during this stage to calculate the LCC (Ashworth, 1993).

3. RESEARCH METHODOLOGY

In the early stage of research, the background study and literature review were carried out to gain the knowledge from different sort of resources i.e. journal articles, conference proceedings, books, and electronic sources etc. The background study provided the basic idea of the knowledge gap and existing knowledge level related to the research problem. The literature review revealed the clear and deeper real scenario of the research problem.

According to Creswell (2014), there are three research approaches as quantitative, qualitative and mixed-method approaches. After considering the characteristic of this research, the quantitative approach to the research was identified as the best-suited approach.

Based on the findings of the literature review, to find out the LCC applications in Sri Lankan construction industry through experience of the Sri Lankan Quantity Surveyors, a questionnaire survey was carried out with a quantitative approach. A closed-ended questionnaire was carried out allowing both manual and e-based responding options. Accordingly, 120 qualified quantity surveyors from different professional levels were selected as the sample through personally made requests. Ultimately, 85 dully filled questionnaires were collected with a response rate of 70.83%. This 85 research sample contains various categories of quantity surveying professions and a range of quantity surveyors with different levels of experience in Sri Lanka construction industry to gather more accurate data. Consequently, 18 assistant quantity surveyors, 41 quantity surveyors, 14 senior quantity surveyors, and ten chartered quantity surveyors contributed with their input to the research. Further, 20 professionals out of 85 participated for this questionnaire are having more than ten years experience and 29 professionals out of 85 participated are having more than five years experience. Based on the 'Mean Weighted Rating' formula, quantitative data were analysed.

4. Analysis and Research Findings

4.1 Identification Of Applications of LCC Technique in Sri Lankan Building Construction Industry

Twelve LCC technique applications identified from the literature review and the questionnaire survey revealed that out of twelve applications, only six applications were visible in the Sri Lankan building construction industry context. Figure 1 presents the results of the questionnaire survey.

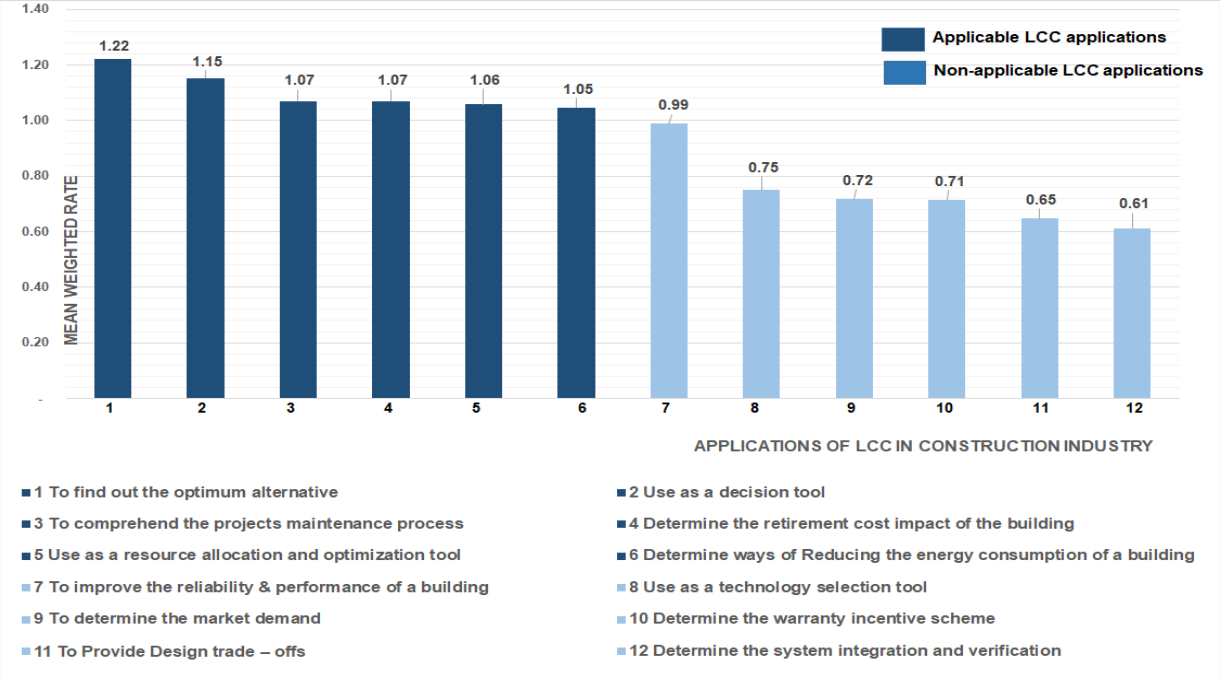

Figure 1: Applications Of LCC In Construction Industry

According to Figure 1, most of the respondents stated that the LCC technique can be mostly applied to find out the optimum alternatives and the use it as a decision tool was the second ranked application of the LCC technique in the local context. Further, these findings have previously proven by Malmgren *et al.* (2016), Heralova (2017) and Dale (1993) through their study in different contexts.

In addition to, using as resource allocation and optimisation tool, to comprehend the project maintenance process, to find out the best alternative from the series of alternatives, determine the ways of reducing the energy consumption of a building and determine the retirement cost impact of the building can be identified as comparatively fewer applications.

Further, to improve the reliability and performance of a building, use as a technology selection tool, to determine the market demand, determine the warranty incentive scheme, to provide design trade-offs and determine the system integration and verification are not visible in Sri Lanka context as applications of LCC.

The results of this analysis can be summarised as follows: (refer to Table 4)

Table 4 : Applications of LCC concept in the local context

Applications of LCC concept	References from Literature	Applicability in the considered context
Use as a decision tool	[1], [3], [5], [7]	Visible
Use as a resource allocation and optimization tool	[7]	Visible
Use as a technology selection tool	[7]	Not Visible
To improve the reliability & performance of a building	[7]	Not Visible
To comprehend the projects maintenance process	[4], [7]	Visible
To find out the optimum alternative	[2], [3], [6]	Visible
To determine the market demand	[7]	Not Visible
To provide design trade-offs	[7]	Not Visible
Determine ways of reducing the energy consumption of a building	[5], [7]	Visible
Determine the warranty incentive scheme	[7]	Not Visible
Determine the system integration and verification	[7]	Not Visible
Determine the retirement cost impact of a building	[7]	Visible
[1] (Dale, 1993), [2] (Wu, et al., 2006), [3] (Heralova, 2017), [4] (Yang & Kumaraswamy, 2011), [5] (Malmgren, et al., 2016), [6] (Moussatche & Languell, 2001), [7] (Norman, 1990)		

5. CONCLUSIONS, RECOMMENDATION, AND LIMITATIONS

5.1 CONCLUSIONS

Based on the research, it could be concluded that the LCC concept has various applications. However, in the international context's vivid practices of LCC technique could be identified and are limited in local context due to various reasons (refer Figure 1 and Table 4). The current LCC applications can be identified as; to find out the optimum alternative, use as a decision tool, to comprehend the projects maintenance process, determine the retirement cost impact of a buildings, use as a resource allocation and optimisation tool and, determine ways of reducing energy consumptions of buildings in Sri Lankan construction sector which were identified based on Sri Lankan quantity surveyors' assessment. It is evident that such applications of LCC help to reduce the project overall cost throughout its lifetime while focusing on different stages of building life cycle, i.e. feasibility phase, construction phase, operation phase, maintenance phase and, demolition phase. Moreover, many LCC applications are common in the global construction industry. Yet, international contexts' uses of LCC; to improve the reliability and performance of a building, use as a technology selection tool, to determine the market demand, determine the warranty

incentive scheme, to provide design trade-off and, determine the system integration and verification are not applied in Sri Lankan construction industry context.

5.2 LIMITATIONS

Lack of awareness of the LCC concept by practitioners and LCC practice is not established in the local construction industry become the highest barrier to implement research. Therefore, it is hard to gather information and data.

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KEY PERFORMANCE INDICATORS BASED PERFORMANCE MEASUREMENT MECHANISM FOR PUBLIC-PRIVATEPARTNERSHIP PROJECTS IN SRI LANKA

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KEY PERFORMANCE INDICATORS BASED PERFORMANCE MEASUREMENT MECHANISM FOR PUBLIC-PRIVATEPARTNERSHIP PROJECTS IN SRI LANKA

ABSTRACT

Key Performance Indicators (KPI) are essential elements in performance measurement and management of the project. It ensures the Value for Money (VfM) in the Public-Private Partnership (PPP) projects. In Sri Lanka, limited studies were addressed the PPP project performance measurement to get the project success even which was owned by most of the developed countries. Hence, this paper aims to presents a KPIs based performance measurement mechanism to evaluate the PPP project performance in Sri Lanka. Different indicators were found from Literature review and Delphi survey was conducted to gather data. Twenty indicators were used for further evaluation via survey findings. Data analysis was done using the Relative Important Index (RII) and Severity Index (SI). Construction time, construction cost, quality control system, productivity and resource management are some of the most significant performance measurement indicators in suggested performance measurement mechanism for PPP projects in Sri Lanka with 18 KPIs.

Keywords: *Key Performance Indicators; Performance Measurement; Public-Private Partnerships; Sri Lanka.*

INTRODUCTION

A Public-private Partnership (PPP) is created to increase the quality, efficiency and competitiveness of public sector services while solving macroeconomic problems. Therefore, PPP has become beneficial for developing countries to lift infrastructure development and improve the living standard of the people (Robert, et al., 2014). In Sri Lanka, the Government has recognized that the private sector can play a dynamic role in accelerating growth and developing infrastructure projects, hence it is committed to promoting PPP in the country (Stattel & Theresa, 2016). Accordance with the past decade literature, although, Sri Lanka has successfully implemented some PPP projects in enlightening services in highways, ports, power and telecom sectors, the project number has been decreased due to many constraints (Weththasinghe *et al*., 2016). Moreover, PPP projects are prominent in developing countries to get infrastructure development through less cost, high efficiency of construction and operation and improved service quality by incorporating the private sectors' knowledge, expertise, and capital (Robert *et al*., 2014). However, during the life cycle of PPP projects, many interactions could affect their performance and cause inefficiency and failure of projects (Yuan *et al.,* 2009), for instance cost escalation, delay in construction, faulty construction techniques, design failures and operating and maintaining cost (Grimsey & Lewis, 2000). Thus, performance measurement could be a better solution to overcome these issues and it would encourage the efficiency and effectiveness of the PPP projects (Yuan *et al.,* 2010). Moreover, KPIs are the essential elements in performance measurement and management of the projects as it ensures the Value for Money (VfM) in the PPP projects (Yuan *et al.,* 2009). Li and Akintoye (2003) stated VfM is the main goal of PPP projects, which concerns the cost savings to the government achieved through harnessing the economies of the private sector. Because the principal goal of PPPs is to achieve VfM (Broadbent & Laughlin, 2003). Furthermore, most of the developed countries had their own set of KPI for performance improvements. However, there is a lack of studies, which has not been conducted on project level performance measurement of PPP projects in Sri Lanka and that was recognized as a research gap.

Hence, this paper aims to develop a mechanism for measuring the performance of PPP projects in Sri Lanka based on KPIs through achieving the following objectives, such as

To identify the KPIs for improving the project performance, emphasizing the PPP Projects.
To evaluate the KPIs used in PPP Projects in Sri Lanka.

This paper is structured as follows. First, a literature review related to important concepts of the study. Then it is followed up with the method used in achieving the aim of the study and finally, finding analysis and discussion.

LITERATURE REVIEW

PUBLIC-PRIVATEPARTNERSHIP PROJECTS

PPPs can involve design, construction, finance, operation and maintenance of public infrastructure and facilities, or the operation of services, to meet public needs (Jefferies, 2006). There are major types of phases in the PPP project life cycle, such as selecting, building, operating and terminating (Appuhami, 2011). There are many different types of PPP project models applied by each country (Grimsey & Lewis, 2004). Government implementation of PPPs is based on two general approaches (Ahmed & Aziz, 2007). One represents a finance-based approach and the other is service-based, which is used mostly in Sri Lanka (Kumaraswamy & Morris, 2002). Eventhough, many countries and regions have been promoting PPP to overcome the traditional drawbacks of public procurement, thare are variety of risks that affect the performance of PPPs like political, legal, technological and commercial factors related to the external environment (Appuhami, 2011) and there is a poor interest of the partners in partnership (Koppenjan, 2005). Furthermore, there are other issues in PPP projects such as; poor supply arrangement, inefficient project company formation, and high construction (Algarni, Arditi & Polat, 2007), poor procurement incentives, lack of coordination, lack of skill, high transaction costs, lack of information (Sanghi, Sundakov & Hankinson, 2007).

PERFORMANCE MEASUREMENT

Performance measurement is the practice of measuring the efficiency and effectiveness of past actions and defined as a parameter that is used to quantify the efficiency and effectiveness of present actions (Neely *et al.,* 2002). Three levels of performance measurement techniques exist from 1998 based on the review of performance measurement studies in construction, including project level, company level and stakeholder level (Yuan, et al., 2010). At the project level, cost, schedule and quality have been the traditional main performance measurement areas in construction projects (McKim, Hegazy, & Attalla, 2000). However, performance measurement of the project level influenced the organizational level and stakeholder's level of interest as well (Yuan *et al.,* 2010). Thus, only the project level of performance measures was considered in this research. The performance measurement technique has become significant to get project success. Therefore, construction industry must periodically measure their performance and compare with their previous performance to find out what should be improved (Gupta, 2004). Many performance measurement frameworks and performance improvement initiatives exist in the construction industry are the KPI, Balanced Scorecard, EFQM Excellence Model, JIT and benchmarking (Bassioni *et al*., 2004). Furthermore, performance is multi-faceted and that each framework holds its advantages and limitations (Neely *et al.,* 2002). Thus, it is significant to decide on a proper performance measurement model under a specific condition. Accordingly, KPIs are the critical components in performance measurement and management of the projects, especially as it ensures the VfM in the PPP projects (Yuan *et al.,* 2009). Furthermore, many authors stated to measure the performance of any given change in the process of PPP projects, one must determine the appropriate KPIs to focus on and measure the impact. Exact analysis of performance can be reached only after the KPIs are determined and monitored. Hence, KPIs were selected as the best performance measurement technique and this study was done only considering that.

KEY PERFORMANCE INDICATORS

KPIs are the most critical measures in determining the overall success of the project by measuring the performance of the project and for applying the benchmarking approach (Ali *et al.,* 2013). Also, it is used for comparing actual performance against specified targets in terms of establishing the effectiveness and efficiency delivery (Robert & Behn, 2003). To measure the performance of any given change in the process of PPP projects, one must determine the appropriate KPIs to focus on and measure the impact (Yuan *et al.*,

2009). The performance indicators available at the project level from previous studies and their frequency of identification (F) by authors are presented in Table 1.

Table1: Performance indicators at project level

Performance Indicators	Source of Resources															F
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
Time	X		X	X	X	X		X			X	X	X	X	X	11
Cost	X	X	X	X	X	X		X		X	X	X	X	X	X	13
Client satisfaction			X					X			X	X	X	X		6
Defects			X	X									X	X	X	5
Profitability			X	X									X			3
Productivity			X	X						X			X			4
Environment												X	X			2
Safety			X	X		X		X				X	X		X	7
Quality control system	X	X			X						X	X				5
Team experience				X				X	X							3
Resource management				X		X		X								3
Financial stability				X												1
Cash flow				X												1
Labour efficiency				X												1
Transfer of experience				X												1
Benefit										X						1
Project status										X						1
Learning and growth				X												1
Generating future jobs				X												1
Pre-stated objectives				X												1
Predictability - cost, time													X	X		2
Variance cost, time													X			1
Contractor satisfaction													X			1
Decision effectiveness				X												1
Speed of construction					X											1
Health and safety											X					1
Business performance											X					1
Management capabilities										X						1
Mutual understanding							X									1
Accountability				X												1
Quality-assurance mechanism	X	X			X											3
Satisfaction-on stakeholders	X				X		X			X					X	5
Minimizes-construction aggravation		X														1
Quality-of-service-and work				X		X		X								3
Effectiveness of planning				X											X	2
Increase-the-level-of professional				X												1
Dispute-resolution process				X												1
Proper-communicating and reporting				X					X			X				3
Risk-and-opportunity management				X					X	X						3
Generated-positive reputation				X												1
Labour-utilization-and relaxation				X												1
Minimizing-of-any construct-claims-and proceedings							X									1

A-Kumaraswamy and Thorpe (1996), B-Songer and Moleenar (1997), C-Egan (1998), D-Takim and Akintoye (2002), E-Chan and Chan (2004), F-Wong (2004), G-Jin et al. (2007), H-Luu, Kim, Huvnh (2008), I-Haponava and Al Jibouri (2009), J-Pillai, Joshi, and Rao (2002), K- (KPI Working Group, 2000), L-Cheung, Suen, and Cheung (2004), M-Roberts and Latorre (2009), N-Skibniewski and Ghosh (2009), O-Toor and Ogulana (2010)

Different countries have different indicators to measure their performance based on their needs. Most of them are using the same measures, but somehow different. The main objective of this research is to evaluate the KPIs used in Sri Lankan PPP projects. Therefore, from the performance indicators in Table 1, twenty indicators were selected based on the greatest significant by considering survey findings of Delphi round 1. Those are then used for the evaluation as shown in Table 2. The summary of selected performance indicators at the project level from previous studies are listed below in Table 2.

Table 2: Selected Performance indicators

Item no	Performance Indicators	Explanation
01	Construction cost	The degree of compilation of construction work within the estimated budget (Lim & Mohamad, 1999).
02	Construction time	The degree of compilation of construction work within agreed/approved duration. (Chan & Chan , 2004)
03	Quality control system	The observation techniques and activities use to fulfil requirement for quality and the degree of conformity to all technical specifications. (Chovichien & Nguyen, 2013)
04	Quality assurance mechanism	The planned and organized activities applied in a quality system (Ali *et al*., 2013)
05	Effectiveness of planning	It specifies the percentage consistency by comparing the planned programme against the actual programme (Toor & Ogunlana, 2010)
06	Satisfaction of stakeholders	The degree of stakeholder satisfaction (Saunders & Turner, 2014)
07	Client satisfaction	The degree of satisfaction over the achievement of client's expectation in executing the project (Heravi & Ilbeigi, 2012)
08	Proper communication and reporting	Information exchange between members using the prescribed manner and terminology (Kagioglou *et al*., 2001)
09	Quality of service and work	Use to maximize the client or customer satisfaction through the high quality of services (Wong, 2004)
10	Cash flow	Expenses and incomes for a construction project (Heravi & Ilbeigi, 2012)
11	Financial stability	It manages adequate amount to succeed appropriately during the economic emergency, which a project bear (Takim & Akintoye, 2002)
12	Productivity	Labour productivity, machine productivity and materials consumption (Dawood, 2010).
13	Resource management	Monitoring labour and construction materials (Luu *et al*., 2008).
14	Risk and opportunity management	Manage the degree of risk due to the nature of construction activities, processes, environment (Pillai *et al*., 2002)
15	Construction safety	The amount to which the common circumstances endorse the completion of a project without major accidents or injuries (Chan & Chan , 2004)
16	Predictability-time	Between the actual construction time and the estimated construction time expressed as a percentage of the estimated construction time at Commit to Construct (Ali *et al*., 2013).
17	Team experience	Involvement of key stakeholder group, active and continuity of involvement (Dawood, 2010)
18	Profitability	Degree of financial success of the project (Takim & Adnan, 2008)
19	Predictability-cost	Measures the rate at which the actual construction costs with the anticipated construction cost (Cheung *et al*., 2004)
20	Defects	Atkinson (1999) divides the cause of building faults.

RESEARCH METHODOLOGY

This research aims is to develop a mechanism for measuring the performance of PPP projects in Sri Lanka. The quantitative research approach is collection of data to measure characters and analysing the data gathered by statistical procedures and hypothesis tests (Creswell, 2003). Accordingly, to evaluate the KPIs used in PPP Projects in Sri Lanka, a quantitative approach was selected. Once the research approach has been selected, appropriate research techniques must be recognized to carry on the research. A complete literature survey was carried out to identify the KPIs for improving the project performance, emphasizing

the PPP Projects. Questionnaires were chosen as the foremost data collection tool through two Delphi rounds and thirty-two respondents have been selected by using convenience sampling method due to the time limit of the study. Those respondents are involving in the Sri Lankan PPP projects and have more than 5 years of experience (53% more than 10 years & 47 % between 5 – 10 years) including Project Managers (7%), Structural Engineers(60%) and Chief Quantity Surveyors(33%). The level of importance and level of influence of the selected twenty-eight indicators which affect the PPP projects' performance related to the Sri Lankan industry were calculated using the rating for the indicators provided by respondents, which is a Likert 1-5 scale rating. The data analysis was done using the Relative Importance Index (RII) and Severity Index (SI).

$$\mathbf{RII} = \frac{\sum \mathbf{Wn}}{\mathbf{A} \times \mathbf{N}} \quad \text{(Eq: 01)}$$

where, W= Constant expressing the weighting given to each response, A= the highest weighting, n= the frequency of responses and N= Total Number in the Responses

$$SI = (\sum Wi * Fi) * 100\% / n \quad \text{(Eq: 02)}$$

where, i= Represent Ratings, Fi= Frequency of Responses, n= Total number of responses and Wi= Weight for each factor.

RESEARCH FINDINGS AND DISCUSSION

This session discusses the finding of the study under two sub sessions namely level of importance of the indicators and level of influence of the indicators.

LEVEL OF IMPORTANCE OF THE INDICATORS

According to the results, selected twenty factors have been ranked in which RII is greater than 0.6 and can be treated as statistically significant factors affecting the performance of the PPP projects. When analysing the level of importance of the indicators based on RII, which is above 50%, it was considered as the most significant value. Taylor (2010) stated that when RII takes 50% or above gives a negotiable and reasonable answer in research. Further, 100% of the expert panel has identified that all the indicators that were selected from the literature review were significant and scored above 60 % of importance as shown in Table 3.

Table 1: RII and Rank of significant selected indicators

No	Indicators	RII %	Rank	No	Indicators	RII %	Rank
1	Construction time	84.00	1	**11**	Financial stability	75.00	11
2	Construction cost	83.00	2	**12**	Productivity	75.00	11
3	Effectiveness of planning	81.00	3	**13**	Risk and opportunity management	75.00	11
4	Quality control system	79.00	4	**14**	Team experience	73.00	14
5	Quality assurance mechanism	79.00	4	**15**	Resource management	73.00	14
6	Proper communication and reporting	79.00	4	**16**	Construction safety	72.00	16
7	Cash flow	77.00	7	**17**	Predictability-time	71.00	17
8	Quality of service and work	77.00	7	**18**	Profitability	64.00	18
9	Client satisfaction	76.00	9	**19**	Predictability-cost	63.00	19
10	Satisfaction on stakeholders	76.00	9	**20**	Defects	61.00	20

LEVEL OF INFLUENCE OF INDICATORS

The respondents were asked to indicate the level of influence of the indicators related to Sri Lankan PPP projects to evaluate the KPIs used in PPP projects during the project construction using a simple 5 – level scale. Here, WMA was conducted to identify the significant factors and, above or equal to the interquartile

value (3) considered as statistically significant factors considered as the much higher impact. Below the interquartile range considered as a rejected factor. According to the results, out of 20 factors, 18 were considered as statistically significant factors during the performance of the project. Each of them maintained a severity Index between 60% - 95% as illustrates in Table 4.

Table 4: Level of influence on performance measurement indicators on PPP

No	**Indicators**	**Severity Index**	**Rank**	No	**Indicators**	**Severity Index**	**Rank**
1	Construction time	86.67%	1	11	Effectiveness of planning	69.34%	10
2	Construction cost	86.67%	1	12	Risk and opportunity management	68.00%	12
3	Quality control system	78.67%	3	13	Satisfaction on stakeholders	68.00%	12
4	Productivity	73.34%	4	14	Cash flow	66.67%	14
5	Resource management	73.34%	4	15	Financial stability	66.67%	14
6	Quality assurance mechanism	73.34%	4	16	Client satisfaction	62.67%	16
7	Quality of service and work	72.00%	7	17	Proper communication and reporting	61.34%	18
8	Construction safety	70.67%	8	18	Profitability	61.34%	18
9	Team experience	70.67%	8	19	Predictability-time	58.67%	20
10	Defects	69.34%	10	20	Predictability-cost	58.67%	20

CONCLUSIONS

This study primarily contributed to developing a mechanism for measuring the performance of PPP projects in Sri Lanka. The aim of the research was covered by identifying significant eighteen KPIs for the Sri Lankan PPP project which can be use as a mechanism for measuring performance of PPP projects in Sri Lanka. Twenty indicators were selected from the indicators identified through the literature review which were then used to evaluate the KPIs used in PPP projects in Sri Lanka. Finally, based on the analysis, eighteen indicators were concluded to measure the performance of the project, project management and to measure the project success after the project completion of Sri Lankan PPP Projects. It will be beneficial for the industry practitioners for improving the performance of PPP projects during the project phase. In order to materialize the research aim, a well-structured research procedure was followed. It was evidenced by the research findings where usage of those indicators can increase the performance of the PPP projects and get the project success. Further research could be conducted on broadening the assessment criteria by evaluating other guidelines in the Sri Lankan context, investigating on KPIs not only the project level but also in organizational and stakeholder level of the PPP projects and determine the KPIs separately according to project life cycle phased of the PPP.

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STUDY OF VALUE ENGINEERING CONCEPT APPLICATION ON ACHIEVING VALUE FOR MONEY IN SRI LANKAN CONSTRUCTION INDUSTRY

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Study of Implementation Issues in Value Engineering Concept on Achieving Value for Money in Sri Lankan Construction Industry

ABSTRACT

Value Engineering (VE) is a trending concept which is currently being used to get the maximum utility of resources and obtaining Best Value for Money (VFM) in the construction industry. The construction industry is an unpredictable industry where numerous unexpected changes and situations occur during all the stages of Design, Construction, and Operational. Therefore, implementation of VE concept where the unnecessary costs are eliminated and encourage for an effective and efficient Construction. This paper discusses the main requirement of assisting to adaptation of VE technology and other modern technologies in Construction industry compared to foreign industry that affects to the investment of the Employer as the main objective of this qualitative research study conducted through expert interviews.

Keywords: *Cost Elimination; Value Engineering; Value for Money.*

1. INTRODUCTION

Economy of both developed and developing countries can be defined along with the contribution of the country's economy to the construction industry (Moavenzadeh, 1978). During the past decade of time, in Sri Lanka (SL) the construction sector has served the economy with the thriving development and leads as the 4th largest sector with 6-7% contribution to GDP (Jayalath & Gunawardhana, 2017).

Among the Time, Cost, Quality factors the Quality can be defined as the compliance of the Employer's expectations or specifications where the concept of Value for Money preserves the Quality of the product while be within the limits of time and cost margin. Providing value for money (Jha & Iyer, 2006), while identifying the initiatives, would cause an extra cost elimination as mentioned by (Perera, et al., 2003) where the Cost factor is controlled accordingly.

Therefore, Value Engineering strategies are used as remedial tools that can improve and maintain the quality factor while reducing the expenditure in construction projects. (Ilayaraja & Eqyaabal, 2015). The identification of the necessary unnecessary items in the projects or finding alternative options to achieve quality outcome with lower cost investment is done with the use of these strategies. (Annappa & Panditrao, 2012). Techniques such as Value Management, Value Analysis, Value Engineering could provide the best Value for Money without compromising the cost factor in the Construction Industry. The Influence of the Value Engineering approach which is done at the Concept design stage of the project timeline, on the Quality factor that is considered as one of the main constraints in a construction project.

Currently Value Engineering (VE) is considered as a current requirement and a tool of construction management that can help companies to improve their procedures, services and final product regarding the client's needs as an end user, with respect to time, cost and quality (Ahmed & Pandey, 2013). This strategy is used to improve the Value without reducing the level of functional quality while eliminating the unnecessary costs embedded in the concept design stage.

The problem arrives mostly with the dissatisfaction of the clients with the final outcome of the project. Sole intention of clients is to obtain a final product orientated by VM towards providing the best possible manner. This process should ensure that providing optimum Value for Money while the functions and needs can be fulfilled at the most favorable cost.

Moreover, according to (Wilegoda, 2009) even though previous researchers have revealed that absence of a proper VE procedure is one of the main constraints for an effective VE practice in the Sri Lankan construction industry, the proper procedures are not in the current practice.

Therefore, even with the most satisfactory cost, it is necessary to have the expected quality level and the extent which the cost or the expenses can be reduced while preserving the quality factor. The Low quality of projects could be ensued as a result of the elimination of costs through VE and this problem is to be analyzed and discussed via this research.

The main objective of this research paper is to pertain Sri Lankan VE practices against foreign countries while identifying timely remedies to provide best Value for Money.

2. LITERATURE REVIEW

The origination of Value Engineering was with the attribution of Lawrence Miles, an Electric Engineer of General Electric Company (GEC) in the USA during Second World War. This concept was originally applied in a manufacturing and production process in materials and other resources shortage due to war effects. With the requisite, alternative materials and substitutions were used to improve the qualitative performance while reducing the expected cost. (Ashworth & Perera, 2015)

Thereafter, value methodology was used as an important technique to improve the value of projects which spread worldwide. Along with the attraction and attention drawn by the construction industry professionals, the society name was updated as "SAVE International" in 1996. (SAVE, 2007)

The concept of Value Engineering in UK arose in late 1980s and the RICS published a report named "Value Engineering and Quantity Surveying Practice" in 1987 which was another imperative incident in VE.

Value Engineering is a function oriented, intensive problem solving technique which is also a management tool to improve the functional requirement in a cost effective manner in construction projects. (Arivazhagan, et al., 2017). Intention of VE is to accomplish the objectives and targets of the project team while eliminating the unnecessary costs from the conceptual stage to project operational stage. (Ravish & Vinoth, 2016)

Generally, Value can be defined in a simple equation (Ravish & Vinoth, 2016);

$$Value = Function / Cost \qquad \text{(Eq1: Definition of Values)}$$

Simply the goal of VE is to achieve the excellence of the design while getting the optimum value for money spent. The VE should be done by a team appointed at the initial stage of the project generally including a designer or Architect, Structural Engineer, Quantity Surveyor, planner and members to apply VE through innovative approaches to the concept of the project (Department of Defence USA, 2011)

To proceed VE, the scope of the project should be aware by the VE team. Under the scope requirement of the Employer, the Structural Engineer's and Architect's designs, Consultants requirements should be clearly identified by the VE team (HDR Engineering, , 2013).

2.1 ISSUES IDENTIFIED IN VE APPLICATION

With reference to the past researches all over the world, the concept of Value Engineering is identified as a management technique to uplift quality and value of the final outcome. (Oke & Aigbavboa, 2017).

The past researchers have identified some issues regarding the implementation of Value Engineering practices to the Construction industry.

Lack of knowledge / awareness and wrong practices – Even though the concept of VE was introduced during early 1940s, the construction professional's knowledge regarding the practical application is considerably low. The wrong practices by the professionals in the industry instead of proper VE techniques and using ad-hoc methods which do not maintain the expected quality, consumes time in construction projects. (Ronald & Wijono, 2017) & (Fernando, 2018).

Lack of Senior Management support – In order to overcome the obstacles on implementation of VE, the support of consultant's services and engagement are lacking compared to the other countries. Senior Management's encouragement and involvement directly involves the VE implementation in Sri Lanka (Ahmed & Pandey, 2013)

Procurement strategies – The research papers of (Baker , et al., 2013), (kelly, et al., 2004) explains that the application of Value Engineering is more successive at the conceptual stage (Early design phase). The application of VE is omitted, unless the chosen procurement path is Design and Build which is another issue identified in VE adaptation. (Perera, et al., 2003)

No predefined way to apply VE techniques – The VE application in Sri Lankan construction Industry is done randomly and only with the requirement or the interests of the Employer. (Karunasena & Gamage, 2017)

Quality – The improvement of quality of the final outcome is the main intention of Value Engineering (Ahmed & Pandey, 2013). Even though, most of the Clients in Sri Lanka are considerate and pays their attention only for low budget within lower time duration (Wilegoda, 2009).

Short time scales – With the construction boom that occurred in 2004 after the Tsunami disaster, the requirement of the buildings was hassled, and therefore larger and more complex buildings were required to be constructed with shorter programs. With the limitation of time, the Stakeholders' intention on applying VE is diminished (Wilegoda, 2009).

Risk – Another identified issue on application of VE is the Risk factor that occurs along with the VE proposals of the Contractors. In order to develop the project quality, the stakeholders should have the capability of accepting the risk. (Karunasena & Gamage, 2017)

Stakeholder involvement – the Life Cycle Cost of Construction project is an important feature of a project and despite of the Employer, the other Stakeholders do not consider about the LCC after as their accountabilities limits until the end of the DLP (Wilegoda, 2009). Furthermore, the misunderstanding of stakeholders, that the Employer obtains the highest benefits led for the reluctance on practicing VE.

Lack of contractual Involvement by authorities – (Wilegoda, 2009) identified that the unavailability of proper standard procedure for VM/VE process in Sri Lanka and compared to other countries, the government involvement to implement this system to construction is low.

Even though there are several Value Engineering / Value Management studies which are conducted in both foreign and local environment, there is less encouragement to implement Vein to construction projects and that is identified as a gap. The past researchers have addressed the issues to be faced on not implementing VE, advantages of VE, etc. and still the constructional professionals are not very interested in VE. The main constraints are lack of awareness, lack of a proper guideline or strategic system, low involvement of government and authorities, reluctance due to risk were identified as the gaps which are ascertained to cover in order to implement VE in Sri Lanka.

3. METHODOLOGY

This research study is basically focused through Qualitative Analysis including with Structured and Semi structured Interviews. The interviews were conducted from a Purposive Sampling with the population of Construction professionals in Sri Lanka with an experience of more than five years. The selected sample of interviewees are 10 experts from the fields comprising Quantity Surveying, Engineering, Project Management, Planning and Architecture (Karunasena & Gamage, 2017), (Fernando, 2018), (Perera, et al., 2003).

The Interview questions were based on the issues identified through the literature review challenged by the Sri Lankan construction industry and structured and semi-structured interviews were conducted to grasp their experience and opinion regarding this matter of factor.

The interview was done with ten experts in the construction industry who possesses the experience of both local and foreign industry. The table 1 represents the details of the sample selected for the interview.

Ref	Job Title/Designation	Organization type	Experience (years)
I_1	Senior Project Manager/ Civil Engineer	Contractor	21
I_2	Project Coordinator/ Civil Engineer	Contractor	18
I_3	Ch. Quantity Surveyor	Consultancy	15
I_4	Ch. Quantity Surveyor	Contractor	13
I_5	Ch. Quantity Surveyor	Contractor	11
I_6	Planning Engineer	Contractor	10
I_7	Ch. Architect	Client	12
I_8	Ch. Engineer	Consultancy	11
I_9	Ch. Architect	Consultancy	14
I_{10}	Ch. Engineer	Consultancy	10

4. RESULTS and Discussion

The Qualitative data analysis is conducted through Frequency analysis and the indication of percentages which were obtained by the expert interviews conducted along with the suggestions and the opinions were tabulated and illustrated through bar charts.

This study explores about the implementation issues identified in Sri Lankan construction Industry compared to foreign industry. These identified issues for the implementation of VE are categorized according to the stages of construction projects as follows.

When considering about the Value Engineering pertinence at the stage of pre-contract, the initial and main step should be taken at this level in conception. According to the interviewees' responses, a team of VE should be appointed at the stage of conception with the approval of the Employer. Reference to the *Figure 1,* the highest frequency was obtained by the fact of Interface and flexibility of authorities and procurement involvement, where Sri Lanka possess considerably poor adaptation of trending construction concepts in construction. As discussed earlier, the international industry has already implemented this situation to maintain the quality of projects.

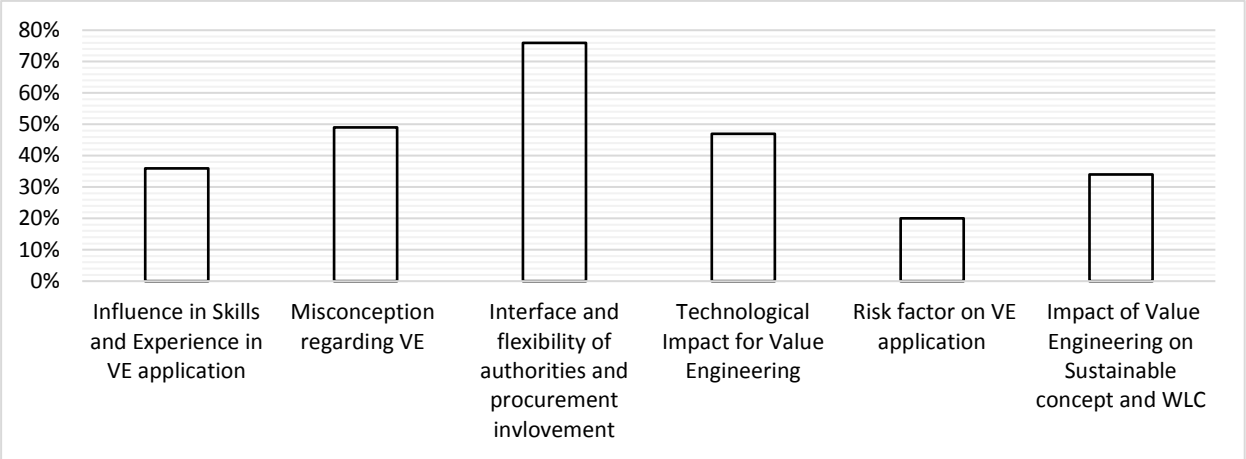

Figure 1: Summary of frequency analysis of interviewed opinions

This paper presented the important causes for not using proper VE in Sri Lanka even though the cost factor is highly considerable. The opinions obtained by the selected professionals representing the construction areas, through structured and semi-structured interviews.

With the results gained from the interviewees as per *Figure 1,* Introducing a proper procurement strategy to obtain the best results from VE is marked as an essential step to be taken. It is identified by the professionals that procurement strategy similar to Design & Built where the Contractor or any other specialized team could engage in VE during the entire process. Encourage the government and local authorities to implement a regulatory system and to increase the involvement. It is proven through the previous studies and expertise opinion that in SL the Government and relevant authorities do not provide the required attention for this matter. In foreign countries such as UK and Japan, they've introduced a method to encourage the Employer and Contractor to apply VE and optimize the value for money. Therefore, in order to encourage the general public, the government involvement is an essential step. A new professional body on behalf of VE is another important step that will ensure the liability or the responsibility to concern about the application of this concept. Originally, the application of VE will improve the Quality of the product while maintaining time and cost in range. Therefore a specific organization on VE implementation is essential to improve the requirement of the Investor with best VFM, increase the training experience to the newly appointed construction professional, educate the top level management on VE to encourage it in their projects is categorized under awareness programmes which will make the employers familiarized to the VE concept for a better outcome, improve the exposure to modern construction methods and the latest technology in construction which is used in the world which is also another identified requirement of Sri Lanka. Encourage to use new software and new technologies to make the work easy and to improve the accuracy and validity by minimizing the possible errors is another opinion provided by the respondents.

Moreover, the construction Industry professionals tend to migrate to foreign countries (Middle East, Australia, UK, etc.) for attractive offers and for newer experiences. Therefore, it is required to encourage the expert to establish in Sri Lanka by providing proper job opportunities to reduce the migration has been identified as another important requirement. Avoid the misconceptions and misunderstanding on VE, improve the education by the higher educational institutions, improve the inter relationship between the stakeholders specially during the pre and post contract stages, improve the inter relationship between the stakeholders specially during the pre and post contract stages which is another current problem for the reluctance of VE application. Encourage to conserve resources and reduce wastage through VE which will further improve the functionality of sustainable construction through VE concept such as reusing, recycle materials which will reduce the cost expected while maintaining the quality, encouraging the adaptation of

Green building concept to Sri Lankan construction industry are identified as mainly focused experts' opinions to improve the VE concept in Sri Lanka on achieving Value for Money at the required best quality while retaining the sustainability concept. Therefore, in this research study, it was able to identify VE application in SL compared to foreign countries and what are the loose ends to be solved.

5. CONCLUSION AND RECOMMENDATION

The sole intention of this research paper is to identify the factors which limits VE on application to Sri Lanka while achieving three main objectives. These objectives have compared the application of VE in foreign construction and to apply that technology to Sri Lanka while suggesting suitable remedies, which were obtained through professionals' opinion. Moreover, the said objectives were achieved successfully with professionals' guidance and solutions.

The Recommendations identified through the expert interviews are categorized as per the long run and short run where the Sri Lankan construction industry could obtain the best value for money paid. When considering the long run, improvement of VE involvement in sustainable construction, establishment of a separate professional organization on VE, introducing a rating system to improve the market value for VE projects, introducing suitable procurement strategy, increase the attention required by the government and relevant authorities. As short run recommendations, executing awareness programmes, establishing faster method of approaching modern Technologies to Sri Lankan Construction Industry and improve the interpersonal relationship among stake holders can be considered.

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IDENTIFICATION OF SIGNIFICANT FACTORS INFLUENCING COST OVERRUNS IN CONSTRUCTION PROJECTS OF SRI LANKA

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Identification of Significant Factors Influencing Cost Overruns in Construction Projects of Sri Lanka

ABSTRACT

Cost is a basic criterion which measures the success of a project. Projects rarely meet the pre-estimated budget. Cost overrun has been severely hit down the status of the Sri Lankan construction industry. Thus, this paper aims to identify the significant factors influencing cost overruns in construction projects in Sri Lanka. This research was assessed through detailed questionnaire survey and interviews. The number of distributed questionnaires were 60 and the response rate was 88% which added a positive mark on the research study. Relative index methods and content analysis were used to analyse the collected data. The findings highlighted the main causes for cost overruns as poor preliminary estimations, variations and delay of completion. It is recommended to have adequate contingency plans and modern cost reduction techniques in practice. While this research focused on the causes of cost overruns in private sector projects, in future researches can be developed to categorize the modern techniques to reduce the cost and time overruns in construction projects.

Keywords: *Causes; Cost control; Construction cost; Cost overruns; Sri Lanka.*

INTRODUCTION

Construction industry is one of the engines of national economy, which the over-all physical improvement of a country is achieved which confirmed it is one of the leading zones in Sri Lankan context which has contributed approximately 6.8% to the GDP (Annual Report 2018, Central Bank of Sri Lanka). Construction projects are termed as complex events in which most uncertain events can occur. Due to various internal and external issues, one of the key problems faced in the Sri Lankan construction industry is "Poor Cost Performance" in projects according to the professionals' view in the industry.

Customers demand a high-quality product/output with better service performances and at the same time the cost to be reduced. Construction industry always experiences cost variations during the process due to its complex nature. The completed cost is almost always higher than the anticipated cost which is estimated at the initial stage (Aljohani, et al., 2017). Cost overrun is a shared matter which happens in construction industries globally.

Poor cost control management may origin project failures to meet its objectives to complete the project successfully. Subsequently, proper cost control is an essential element in Sri Lankan construction industry. Construction cost performances can be enhanced by either eradicating factors having adverse effect or by taking a control over them. By using corrective cost regulatory measures, the over budgeting can be reduced.

Cost overrun has severely smashed down the economy and reputation of construction industries around the world. In common, construction projects practically exceeds their budget limits and time which was set out originally (Adam, et al., 2014). Cost overrun is a key barrier for contractors as it creates less profit or reduces the profit margins and causes problems to other parties which have negative impacts on the stakeholders who are involved in the project. This may cause projects to fail to meet their objectives. Projects which suffer from cost overruns, have a likelihood of being defaulted projects (Aljohani, et al., 2017). Though there were several studies on construction cost overruns, none of the studies have aided improvements on the issue and cost overruns over last 70 years period (Hedaya & Saad, 2017) which remark the need of researching on the matter subjected to cost.

LITERATURE REVIEW

CONSTRUCTION COST OVERRUNS

There is a need for understanding the causes of cost overrun and recognize the corrective actions that can be taken to mitigate the loss. Azhar (2008) noted cost as one of the greatest parameters and key driving factor of project success. Further, Aris (2013) confirmed the statement as the poor cost performance is a common problem worldwide. The causes will differ from country to country, therefore it wouldn't be sufficient to identify causes for a specific country from global literature (Aljohani, et al., 2017).

The cost overrun of a project will depend on project size, type and location. The statement was confirmed by Cantarelli (2012) and Jahren and Ashe (1990) that the connection between project size and cost overruns, when the project is in large scale, a greater percentage of cost overrun could happen. Le-Hoai (2008) described that it's a necessity to control the cost performance of a project, otherwise progress will be affected. Without keeping an eye on the real costs while progressing, successful completion will not be possible (Susana, 2012).

CAUSES FOR COST OVERRUNS

Ramabhadran (2018) identified the most vital causes of cost overruns in Pakistan as less control, delayed completion, insufficient pre-planning, price escalation, productivity issues and lack of resources. In Bahrain, construction industry ranked essential causes as inaccurate estimations, design changes and reworks due to mistakes (Hedaya & Saad, 2017). Consequent delays in construction, reworks and the practice of awarding the contract to the lowest bidder are the common causes for cost overruns which were identified in non-infrastructural Indian projects (Devi & Ananthanarayanan, 2017). Malkanthi (2017) investigated that 25% of projects in Sri Lanka are over budgeted. Some of the reasons are lack of monitoring, price fluctuations of raw materials, cost of plant and machinery, improper planning and high interest rates.

A study by Ramabhadran (2018) categorized cost overruns into two main parts as internal & external. External factors are more challenging to control than internal and has a low occurrence edge. He found out that only internal factors were extremely influencing the cost overrun.

However, authorities related to the construction industry of Sri Lanka have limited researches to addressing causes and taking mitigation measures of cost overruns which demonstrates by lack of literature. There is a need to find causes and mitigation measures for a successful project completion in Sri Lankan context.

RESEARCH METHODOLOGY

The main objective of the research is to identify the significant factors which cause cost overruns at different stages of the project in building construction in Sri Lanka which helps to recommend effective cost reduction methods for the betterment of the industry. To evaluate the factors causing cost in construction projects, a large range of community attached to the construction industry in Sri Lanka was targeted covering professionals and stakeholders in the Sri Lankan construction industry. The research was completely evaluated through questionnaire survey and interviews (mix method) with the concerned authorities. This was a combination of both qualitative (interviews) and quantitative (a predominant way via questionnaire survey) analysis to confirm and make concrete recommendations based on the views of different parties by several methods.

DATA COLLECTION METHODS

A detailed questionnaire (includes both open-end and close-end questions) was circulated among professional groups in construction industry of Sri Lanka. A web based questionnaire was also developed and sent through e-mails (Google forms) to the construction firms. Total number of questionnaires distributed were 60 to entities involved in large private construction projects and the response rate was 88.33% which includes 13 Contractors (C), 18 Cost Consultants (QS), 10 Engineers (Eng), 07 Consultants (CR) and 05 Project Managers (PM). A purposive sample was selected for the semi-structured interviews since the objective is to select the partakers who have better knowledge and industry experience in the area of research study.

Table 01: Summary of Data Collection and Data Analysis

Method of Data Collection	Target Population	Sample	Sample Techniques	Method of Data Analysis	Reason of Method of Data Collection & Data Analysis
1. Questionnaires	Quantity Surveyors (QS), Project Managers, Engineers, Contractors & Clients/ Client representatives (Consultants).	60 number of people	Stratified Random Sampling	Frequency index analysis	To rank the identified factors which cause cost overruns
2. Interviews	Quantity Surveyor (QS), Project Manager, Engineer & a Contractor.	04 number of people	Purposive Sampling	Content analysis	To make concrete recommendations & identify the effective methods to reduce cost overruns

DATA ANALYSIS METHODS

Data analysis was done with the use of frequency index analysis (data gathered through questionnaire survey) which expresses the frequency of occurrence of the factors responsible for cost overruns in the construction industry (Le-Hoai, et al., 2008), and the content analysis was done to analyse the data which were gathered through the interviews.

$$Frequency\ Index\ (FI) = \frac{\sum_{i=1}^{5} ai \times fi}{H \times N} \quad \text{(Eq:01)}$$

Where:

i = Score of the factor ranging from "Unimportant =1" to "Very Important =5"

ai = Weight of the response for the ith response

fi = The frequency of the ith response from all respondents

H = Highest ranking available, which is 5 in this survey

N = Total number of respondents who have answered the question

Presentation was in the forms of graphs and tables. A cording system was used to identify the factors separately for the easiness of understanding.

DATA ANALYSIS

The general information of respondents including their profession and experience in the industry were assessed as based on the perspective of different people, the answers to the questions may vary based on their thinking capacity and knowledge. The degree of responses are discussed below. The scope of works were limited to the private sector construction projects and the collected responses were 86.8% of professionals who work under private entities and 13.2% of professionals who work under public entities currently. They had experiences in private sector projects previously, which added a positive mark on the research study.

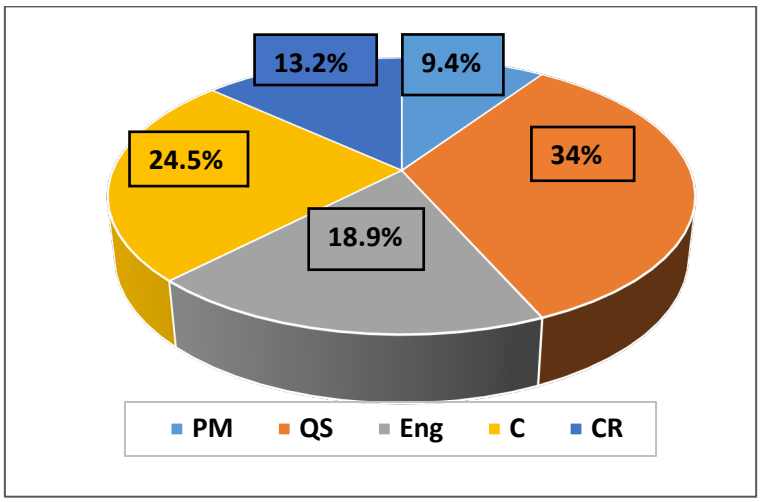

Figure 01: Respondent Based on Profession

It was targeted to find out whether these professionals experienced project cost overruns. More than 90% of respondents had experienced cost overruns at construction projects which highlighted it as a serious problem in the construction industry and the need for remedy to mitigate the cost overrun in projects.

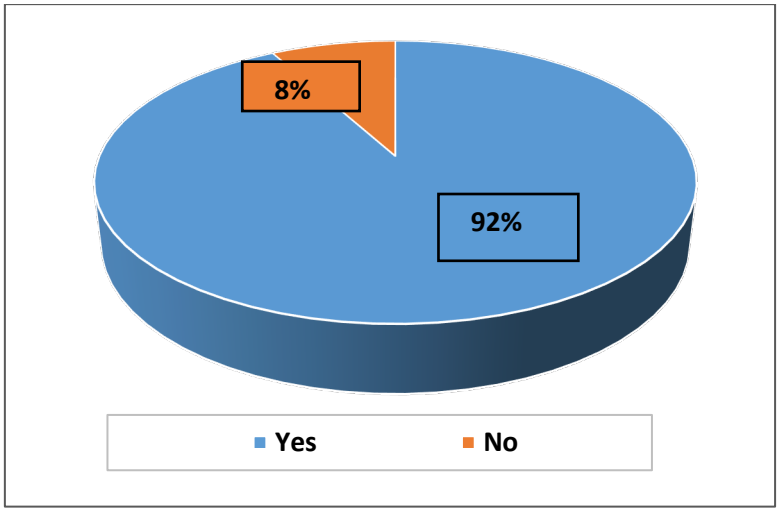

Figure 02: Experience in Cost Overruns

According to the research, there are 15 major causes which we can categorize by considering all factors affecting construction cost overruns in the construction industry of Sri Lanka. The causes for cost overruns

are identified from the literature survey and marked into 15 factors among them to rank according to the frequency of its occurrence. The scores gained by the respondents in the questionnaire were summed up for each factor. The frequency index was computed based on the degree of agreement of the respondents. The factors were identified based on a coding system for the ease of identification and ranked as tabulated below. The main 15 obstacles can be classified into two main categories.

They are,

- Pre-Contract Stage related
- Post-Contract Stage related

Table 02: Ranked Causes of Cost Overruns According to the Frequency Index Analysis

Code	Cause of Cost Overrun	Frequency Index	Rank	Categorized
COR10	Bid offer to the lowest bidder with lack of capacity & experience	0.815	1	Pre-Contract Stage
COR05	Poor preliminary estimations with use of inaccurate quantity take-offs	0.811	2	Pre-Contract Stage
COR04	Cost due to delay of completion	0.774	3	Post-Contract Stage
COR01	Variations & change orders	0.755	4	Post-Contract Stage
COR15	Insufficient knowledge on cost control techniques	0.743	5	Post-Contract Stage
COR12	Poor material management	0.721	6	Post-Contract Stage
COR13	Lack of skill work force & labour turnover	0.709	7	Post-Contract Stage
COR09	Lack of skill resources & shortage of technical members	0.683	8	Post-Contract Stage
COR03	Ambiguities or discrepancies in the contract documentation	0.658	9	Pre-Contract Stage
COR14	Lapse in project management strategies	0.657	10	Post-Contract Stage
COR02	Price fluctuation	0.654	11	Post-Contract Stage
COR11	Improper site management & supervision	0.653	12	Post-Contract Stage
COR06	Financial difficulties & funding problems of Contractors & Clients	0.650	13	Post-Contract Stage
COR07	Poor productivity	0.604	14	Post-Contract Stage

COR08	Insufficient early planning	0.604	14	Post-Contract Stage

Cost is a main item in every construction project. At the initial stage, the targeted budget for the proposed project was estimated based on the specifications and detailed drawings. Though every project itself has a pre-estimated budget, cost overrun is still a common phenomenal in every project all over the Sri Lankan construction industry.

According to Table 02, the first and second top ranks were identified in the pre-contract stage related causes for cost overruns. Bid offer to the lowest bidder with lack of capacity and experience (COR10) ranked as the top factor which caused cost overruns in projects, which was also confirmed by a similar study done by Devi & Ananthanarayanan (2017). The bidding stage of a project is the period which selects the most appropriate contractor for the proposed project. The entire success of project depends on the wise choice of selecting the best bidder as the future contractor. The normal practice is offering the bid to the lowest bidder. In this process, the pre-qualification assessment was not done in majority of the projects. Some bidders purposely price the Bill of Quantities (BOQ) with lower values with the intention of only to win the bid. This will lead to choosing the wrong bidder with less experience and it will lead to future cost overruns.

Poor preliminary estimations with use of inaccurate quantity take-offs (COR05) rank as the second most frequent occurrence in cost overruns which Aljohani (2017) also confirms by his research study as a main potential cause of cost overrun. Client will allocate very limited time for the initial stage of a project to make a timely completion of the project. The quantity surveyor gets a limited time period to make the preliminary estimations and it might lead to arithmetic errors when taking-off quantities. The errors in the estimation made initially will lead to wrong decisions at the construction stage of the project and overrun the cost.

The third and fourth top ranks were identified in the construction stage related causes for cost overruns. Cost due to delay of completion leads automatically to cost overrun of a project was identified as the major issue in Indian projects (Devi & Ananthanarayanan, 2017) which is the third most frequent factor (COR04) in this study. The projects have a specific date for the start and completion. If the project wasn't completed on time, liquidate damages (LD) were charged based on agreed rates in contract data. An Extension of Time (EOT) also will be applicable due to reasonable factors which almost lead to extra cost in the project. Variations and change orders (COR01) are the fourth frequent factor according to the ranking which comes as the most significant cost variation factor by a study done by Sooriyaarachchi, 2007. Every project has changes and variations due to its complexity. Variation is an extra workload for the scope which was not identified at the initial stage. Since it was not identified at the beginning, it wouldn't have been included at the preliminary estimations and occurrences of more variations in a project will lead to cost overruns.

The fifth frequent cost overrun factor is identified as insufficient knowledge on cost control techniques (COR15). Cost overrun happens continuously because people do not have proper knowledge on how to control cost in the project. Though there are strategies on controlling cost, cost overruns are still common in current practices due to unawareness of mitigation measures. All parties in project partake in different cost related activities, hence the knowledge on cost controlling needs to pan out through the management hierarchy.

The results accomplished from a survey done at Pakistan, revealed that the major cause of cost overrun is the price escalation of materials (Ejaz, et al., n.d.), however in this study in Sri Lanka, that particular cause (COR02) has a minor influence on the cost. Hedya & Saad (2017) revealed from a study done by Bahrain that schedule delays and planning errors are the most important factor which cause cost overrun. In this study insufficient early planning (COR08) comes as the least cause of cost overrun in the Sri Lankan context.

An interviewee listed causes for cost overruns as additional wastages, not utilizing materials properly, technical failures, defects in structures, lack of proper supervision and delay to ordering materials. He further stated that, "*The problems in storage are a common issue in every project. Not allocating proper security at stores and not allocating store keepers due to high cost may lead to more and more cost overruns than anyone expected*".

Another interviewee listed causes for cost overruns as wastage, improper resource allocations, and errors in documentation which leads to ambiguities and inflation in the country like Sri Lanka as prioritized factors, while another interviewee identified the shortage of labour supply as the main issue. He further stated that, "*Due to the high salary demand of the local labour, labour shortage and increase of labour turnover, we have to hire foreign labour for lower basic salaries. But in long-term, maintaining them will be costlier than hiring local labour force and it will negatively effect on cost of the project*".

An interviewee stated that, "*Unforeseen obstructions increase the project cost. The clients are not willing to do a risk analysis at the beginning of the project. Risk assessment will emphasize the unforeseen circumstances which can happen based on a proper feasibility study. According to assessments, certain percentage of contingency amount can be allocated to the preliminary estimation to mitigate cost overruns but client will refuse to pay extra time on these most critical items*".

The factors were ranked based on the responds of different parties in the construction industry according to their knowledge on construction cost overrun. Based on results, it was revealed that cost overrun is a major issue in projects and actions needs to be taken regarding cost controlling.

CONCLUSIONS

Based on a questionnaire survey, 15 significant causes for cost overruns were identified. It is essential to discuss the problems faced when controlling the cost of a project. An interviewee stated that, "Time, cost and quality are the main pillars of the construction". Change of any of those parameters will affect negatively or positively on the other two parameters. Quality has more chance of being damaged and that is the main cause for clients' not willing to implement cost control in projects, which was found from this research and confirmed by Hafez (2015).

Considering the data gathered and analysed above, it shows that there is an essential need of controlling cost overruns. The above analysed data clearly illustrates that there is a direct positive relationship with pre-contract and post-contract stages regarding cost overrun that needs to be administrated properly. Construction projects have a very poor performance record in completing the projects with pre-estimated budget. Corrective cost controlling is an essential necessity in the Sri Lankan construction industry (Malkanthi, et al., 2017). Karunakaran (2018) mentioned the need of study about identifying cost overrun factors and corrective actions for mitigation.

This gap was filled by the objective of this research. The study revealed that the minimization of cost at each stage of the construction is important. The causes for cost overruns were identified and the study revealed that there is still a need of controlling cost by identifying modern cost reduction techniques. The

study revealed that cost overruns occur in numerous phases of the project. Choosing the lowest bidder with lack of capacity and experience, poor preliminary estimations with use of inaccurate quantity take-offs, cost due to delay of completion and insufficient knowledge on cost control are ranked top three among the causes of cost overruns.

RECOMMENDATIONS

According to the analysis of data, the main causes of cost overruns were choosing to the lowest bidder with lack of capacity and experience, poor preliminary estimations with use of inaccurate quantity take-offs, cost due to delay of completion, variations and change orders and insufficient knowledge on cost control techniques. There is a need of controlling cost overrun in projects for a successful completion. Considering the nature of the problem and based on the experience gained from experts, the followings were strongly recommended.

- Should have adequate contingency plans.
- A well-defined, cost effective and practical plan at the initial stage is essential.
- The project managers should have tight control over the project budget.
- Continuous training programs should be provided to project stakeholders to update their knowledge on the importance of project cost control.
- Contractor, client and consultant should improve team spirit and make appropriate adjustments at every milestone of the project to avoid cost overruns.
- Conduct awareness programs on software (MS project, BIM) and new cost control approaches (Value Engineering, EVM) .
- Government should improve flexibility of loans regarding construction work and allocate proper funding plans for the project stakeholders.

RESEARCH LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This research is limited to the building construction projects, in the private sector in Sri Lankan construction industry excluding infrastructure projects. The respondents of the research were mostly from the private sector projects. The main reason for focusing on the private sector is due to the ease of collecting most accurate data within a short period of time. Hence the results obtained from this is more recommended for the cost control in private sector projects. Therefore, certain consideration is required while using these data in projects of government sector and in infrastructure projects because the causes for cost overruns and mitigation measures could differ depending on the type of the project.

While this research focused on the causes of cost overruns on private sector projects in Sri Lanka, a study can be done to validate the conclusion of this study considering the public sector projects. A similar study can be done to identify the modern techniques to reduce the cost overruns in construction projects. Further researches can be done to develop a framework to identify the proper contingency amount for different type of construction projects and measure the cost of training against the cost of saving from a proper training on the subject matter of “cost control”.

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IMPACT OF PHYSICAL ENVIRONMENTAL FACTORS ON COST OF THE CONSTRUCTION OF FOREIGN FUNDED RURAL WATER SUPPLY PROJECTS IN KEGALLE DISTRICT, SRI LANKA.

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Impact of Physical Environmental Factors on Cost of the Construction of Foreign Funded Rural Water Supply Projects in Kegalle District, Sri lanka.

ABSTRACT

Construction of foreign funded rural water supply projects affected from various factors. It is important to manage the impacts caused by various factors to ensure the sustainability of the project. Hence, the aim of this research is to investigate the physical environmental factors and their impact on Cost of the construction of foreign funded rural water supply projects in Kegalle District, Sri Lanka. Physical environmental factors were identified from literature review and available physical environmental factors were validated with expert personnel in the rural water supply sector. Following that questionnaire survey was used to get the required data. The collected data was analyzed and arrived that Rock conditions and unexpected geological conditions, elevation and slope equally cause highest impact on cost.

Key Words: *foreign funded rural water supply projects, Physical environmental factors, Impact on cost,*

INTRODUCTION

The Drinking water supply is a very significant problem in the current times in the light of health awareness among the rural public. Therefore one of the most significant objectives of the government is to cover up or to provide the rural public safe drinking water. According to the NWS&DB Annual Report (2017), there are 343 major, medium and small water supply schemes in operation under the NWS&DB's purview and out of these, 55 schemes cover major cities and 288 schemes cover townships and villages. According to statistics, 89.3% of the population of the country have access to safe drinking water of which 49.2% comes through the piped water supply schemes (NWS&DB, 2017). Since there's always a gap between the demand and the supply this gap growth through growing population and fast urbanization and increasing ability constraints at the deliver aspect (Imbulana et al. 2006).

According to NWS&DB Annual report (2017), there were 19 foreign funded water supply projects and 10 local bank funded water supply projects in progress, in addition to the many small and medium water supply projects at completion stage. Simultaneously, some CBO systems might be consolidated into the fundamental water supply conspire, in which case the quantity of CBO-managed rural water piped water schemes will be decreased. Experience proposes that around 25% of the CBO plans might be fused into enormous funneled water supply plans. Some other CBO schemes—estimated to be up to 15% of the total—are likewise liable to stop activity because of value issues. This infers up to 40% of the 550,000 existing CBO schemes may vanish. On the off chance that the national water supply inclusion figure of 10.5% that is directly given by CBOs is to be kept up, at that point a further 220,000 associations by CBO plans will be required (Fan, 2015).

The "Water Supply and Sanitation Improvement Project" will bolster advancement in the slacking districts and the homes division where access to water supply and sanitation is lower and destitution level is higher contrasted with the national normal. Water Supply and Sanitation Improvement project (WaSSIP) which is funded by World Bank currently on progress in Sri Lanka. One of the main aims of this project is to increase access to the piped water services in rural areas. This will cover up more than 64900 households in rural areas. The advancement targets of the task will be to expand access to funneled water benefits and improved sanitation, and to reinforce country administration conveyance courses of action, in chose Districts.

The project will be implemented in 7 high need locale, which have been chosen dependent on (a) percentage of individuals with access to unchanged/risky water (ii) percentage of family units with access to non-funneled water sources and (iii) area in the dry zone. Destitution, estimated by the neediness head tally, has a solid co-connection with access levels and is along these lines certainly caught in the area determination process. The districts are; Mullaithivu and Kilinochchi Districts in Northern Province, Nuwara Eliya District in Central Province, Badulla and Moneregala Districts in Uva Province, Kegalle and Ratnapura Districts in Sabaragamuwa Province.

The development business is in charge of the utilization of a pertinent piece of all created materials, in any case, as it were as of late has this industry begun to stress over its natural impacts (Pacheco-Torgal, 2014). Whereas traditional construction focuses on cost, schedule, and quality, sustainable projects must also consider environmental protection, users' health, low-carbon emissions, and low-energy consumption. The idea of construction project advancement might be debilitated without a decent information and effective administration of the effect of natural elements affecting the presentation of such extends.

PROJECT ENVIRONMENT

Akanni, Oke and Akpomiemie (2015) stated that the success of a construction project most probably depends on performance. Various researches had conduct studies and researches on the performance of construction project. The study of (Ling et al, 2007) in China disclose that architectural, engineering and construction (AEC) companies may face struggles managing construction ventures' performance for the reason of that they are not familiar with the new operating environment. According to (Akanni, Oke and Akpomiemie, 2015) construction environment is the aggregate of surrounding things, conditions or influences and tell of that this environment as all external influence on the construction process. Similarly (Lester, 2017) has stated that projects are impacted by a large number of variables which can be external or internal to the organization in charge of its administration and execution and these external and internal influences are indicated as project context or project environment. With striding forward in his literature he has indicated these influences as Political, Economic, Social, Technical, Legal, and Environmental. Similarly (Walker, 2015) and (Hughes, 1989) have identified factors represent the environment of the project and they are political, legal, institutional, cultural, sociological, technological resources, economic, financial and physical (infrastructure).

PHYSICAL ENVIRONMENTAL FACTORS

Akanni, Oke and Akpomiemie (2015) stated that the physical condition inside which a development project is cited may affect impressively on its improvement as development projects are constantly influenced by physical impacts. The geological area of a task, ground conditions furthermore, climate examples are the most widely recognized instances of physical impacts. Those influences are unforeseeable and no management actions had been able to overcome their occurrence. (Uher and Loosemore, 2004) opined that the higher level supervisors (Managers) of construction projects will take noteworthy thought of physical impacts when arranging the administration techniques to maintain a strategic distance from limits which can exploit accessible assets. (Lester, 2017) stated that the site location of the project obviously has a gigantic effect on the cost and completion time. Also he has pointed out to consider some factors that should be taken in to account when deciding or carrying out a project in a particular area of the world: Temperature (daytime and night time) in different seasons, Rainy seasons (monsoon), Tornado or typhoon seasons, Access by road, rail, water or air, Ground conditions and earthquake zones, Possible ground contamination, Nearby rivers and lakes, Is the project onshore or offshore?, Tides and storm conditions, Nearby quarries for raw materials, Does the project involve the use of radioactive materials?. Akanni, Oke and Akpomiemie (2015) have identified factors which are similar to factors identified by Lester (2017). The identified

physical factors are as follows: Hidden obstructions, climate condition/weather, natural disaster (e.g. storm, fire and land slide), unfavorable site conditions, unexpected geological conditions, high water table. Following are some of another physical environment factors identified: Geographical location, Climate and weather, waste disposal laws, energy consumption regulation, people's attitudes towards the environment (Contributor, 2019). Youker (1992) has identified elements that are relevant to physical. Identified physical elements are as follows: temperature range, evaporation, storm incidence, Natural pests, Land: slope, geology, soil, Rainfall, land: erosion, drainage, pests.

Consequently, most of researches have been done about the impact of construction projects to the environment but very less researches have been carried out regarding the impact of physical environmental factors on construction projects. Still there is very limited research carried out regarding impact of physical environmental factors on rural water supply construction projects. Therefore, considering industry need and the research gap, there is a need to do a research on assessing the impact of physical environmental factors on the construction of foreign funded rural water supply projects.

2. OBJECTIVES

Main objective of this Research paper is to investigate the physical environmental factors and their impact on Cost of the construction of foreign funded rural water supply projects in Kegalle District, Sri Lanka.

3. METHODOLOGY

LITERATURE SURVEY

An extensive literature survey and review will be executed by analyzing and going through the peer reviewed journal articles; theses and Researches; periodicals (printed and electronic); reports; project reports; text books (printed and electronic); newsletters; web pages and other online study materials; and unpublished articles and journals.

FACTOR VALIDATION TOOL

The identified physical environmental factors in the literature review will tabulated and sent to 15 experts in rural water supply sector in Sri Lanka and experts involve in water supply and sanitation improvement project to validation process.

QUESTIONNAIRE SURVEY

A systematically prepared and organized questionnaire was submitted to the stakeholders and gather information and required data for the following research work. The inquiries were deliberately stated, requested and sorted under four segments: General Information, awareness of the factors, whether the factors impacted or not and impact to the cost of the construction of foreign funded rural water supply projects. The main question of the questionnaire was to investigate the respondent's opinion on the impact of the physical environmental on the cost of the construction of foreign funded rural water supply projects and in below section shows how the opinions were obtained and scaled.

SAMPLE SELECTION

In this study only Project Managers are included. The targeted responders are from 16 local contractors that they are currently involved in rural water supply projects in Kegalle districts of the ''Water Supply and Sanitation Improvement project". The only recent project is the project stated above and sample size is based on the actual construction projects not on the population. All the selected projects for the study have

completed 120 days of construction period. The project managers got their experiences through their extended career in construction companies.

DATA MEASUREMENT

The level of measurement can influence type of analysis. There are four levels of measurement associated with the quantitative data and these measurements are as follows:

- Nominal
- Ordinal
- Interval
- Ratio (scale)

This data is continuous and has a logical order and data has standardized differences between values, but no natural zero. Items measured on a Likert scale – rank your satisfaction on a scale of 1-5.

- 1 = Negligible
- 2 = Minor
- 3 = Moderate
- 4 = Major
- 5 = Severe

ANALYSIS TECHNIQUES

The quantitative data are being used in this Research. Quantitative analysis is "concerned with numerical measurement and mathematical models to the test hypotheses, support the view of the positivist paradigm that there is an objective reality that can be accessed and measured (Saunder et al, 2006). Data will be investigated by using the SPSS-16 windows program and Microsoft Excel 2013 operating system.

Due to sample size limitations, the forms of quantitative methods in this research area are limited. The questionnaire quantitative data analysis was done by using the following the quantitative data analysis procedures defined below.

1) Data tabulation (frequency distributions & percent distributions)
2) Descriptive data

DATA TABULATION

These strategies give a thorough picture of what the information resembles and helps the researcher in identifying patterns. The most ideal approaches to do this are by building frequency and percent distributions. A frequency circulation is a sorted out classification of the quantity of people or scores situated in every classification. This will decide:

- If scores are entered correctly
- If scores are negligible or severe
- How many are in each category
- The spread of the scores

DESCRIPTIVE DATA

A descriptive denotes to calculations that are used to "describe" the data set. The most frequently descriptive used are:

- Mode- the most occurred numerical value of scores for a particular variable

- Mean – the numerical average of scores for a particular variable
- Minimum and maximum values – the highest and lowest value for a particular variable
- Median – the numerical middle point or score that cuts the distribution in half for a particular variable

Similarly, questionnaire surveys were executed to fulfill the main aim of the research as required. The data gathered from questionnaire survey were discussed broadly and analyzed using SPSS 16 software. Impacts caused on cost by physical environmental factors were analyzed.

RESULTS AND DISCUSSION

FINDINGS OF THE FACTOR VALIDATION TOOL

So as to empower support, potential validators were sent brief figure of the research objectives and key discoveries from the literature study. All the fifteen experts responded to the factor validation tool basing their expertise on the relevant field. Table 4-1 shows the responses of the validators and illustrates some interesting facts about what factors impacts the construction of foreign funded rural water supply projects and which facts don't impact the construction works. In the table ''✓'' refers to impacting and ''X'' refers to not impacting. Sixteen factors were included for the factor validation tool and all the experts had responded to above sixteen factors. It can be seen that all the validators had responded to four factors as impacting to the construction works of foreign funded rural water supply projects. The above four factors are rainfall, landslides, flood, Rock conditions and unexpected geological conditions. Out of fifteen validators more than ten validators had marked for nine factors as impacting to construction of foreign funded rural water supply projects. Rainfall, flood, landslide, slope elevation, issues related with removal of trees, access related and material transportation problems, rock conditions and unexpected geological conditions, Lack of natural resources (related with material quality and quantity) are the above factors. Same as, more than ten validators marked as, not impacting for seven factors. Wind, temperature, wildfires, biodiversity related problems, water level related problems, anthropogenic activities, vector borne diseases are the factors which, more than ten validators marked as not impacting to the construction of foreign funded rural water supply projects. Therefore, above seven factors were eliminated from the selected list and nine factors were took in to the account for the study.

Table 2: Factor Validator's responses

Physical Environmental Factor	Validator Codes															No of Responses	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Impacting	Not Impacting
Rainfall	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	15	-
Wind	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓	3	12
Temperature	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	15
Flood	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	15	-
Landslides	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	15	-
Wildfires	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	15
Slope	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	13	2
Elevation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	14	1
Issues related with removal of trees	✓	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓	x	x	x	10	5
Biodiversity related problems	x	x	x	x	x	x	x	x	x	✓	x	✓	✓	✓	✓	5	10
Water level related problems	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓	3	12
Access related and material transportation problems	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	14	1
Rock conditions and unexpected geological conditions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	15	-
Lack of natural resources (related with material quality and quantity)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓	x	12	3
Anthropogenic activities	x	x	x	x	x	x	x	✓	✓	✓	✓	x	x	x	x	4	11
Vector borne diseases	x	x	x	x	x	x	x	x	x	x	x	x	✓	✓	✓	3	12

IMPACT OF THE PHYSICAL ENVIRONMENTAL FACTORS ON CONSTRUCTION COST

This question is aimed to get the overviews of project managers regarding with the impact of physical environmental factors on construction cost. The respondent answered and evaluated the important level of the factors based on their empirical experiences and the results are as in the below table 2 and table 3. Furthermore, impact of the physical environmental factors is briefly described using the frequency graphs in next sections.

Table 3: Frequency Distribution of Factors Impact on Cost

Scale	Rainfall	Flood	Landslides	Slope	Elevation	Removal of trees	Access related and material transportation	Rock conditions and unexpected geological conditions	Lack of natural resources (related to material quality and quantity)
Negligible	12.5%	50.0%	31.2%	25.0%	25.0%	68.8%	25.0%	12.5%	25.0%
Minor	12.5%	18.8%	25.0%	12.5%	12.5%	18.8%	6.2%	18.8%	43.8%
Moderate	43.8%	6.2%	31.2%	6.2%	6.2%	12.5%	25.0%	31.2%	25.0%
Major	25.0%	25.0%	12.5%	37.5%	37.5%	*	31.2%	18.8%	*
Severe	6.2%	*	*	18.8%	18.8%	*	12.5%	18.8%	6.2%

Table 4: Statistics distribution of factors: impact on cost

Statistics		Rainfall	Flood	Landslides	Slope	Elevation	Removal of trees	Access related and material transportation	Rock conditions and unexpected geological conditions	Lack of natural resources
N	Valid	16	16	16	16	16	16	16	16	16
	Missing	4	4	4	4	4	4	4	4	4
Mean		3.00	2.06	2.25	3.12	3.12	1.44	3.00	3.12	2.19
Std. Error of Mean		.274	.322	.266	.386	.386	.182	.354	.328	.262
Median		3.00	1.50	2.00	4.00	4.00	1.00	3.00	3.00	2.00
Mode		3	1	1[a]	4	4	1	4	3	2
Std. Deviation		1.095	1.289	1.065	1.544	1.544	.727	1.414	1.310	1.047
Variance		1.200	1.662	1.133	2.383	2.383	.529	2.000	1.717	1.096

a. Multiple modes exist. The smallest value is shown

SLOPE AND ELEVATION

Ohtake, Kimiyasu, & Ohmachi, Tatsuo. (2006) have conducted a research on damage estimation of the water supply pipelines buried in artificially altered ground. Researchers have identified ground slopes is a cause for the damaging the underground laid pipes. Also they have stated that on account of the slow inclined ground, the harm happened where the peak time of the H/V spectral ratio is long. About the lofty slanted ground, harm were found in the focuses where the peak time of the H/V spectral ratio is short.

Figure 1 & Figure 2 plots the impact of the slope and elevation on construction cost. Most of the responders has given their opinion that, impact of the slope and elevation on construction cost is major. Considering the impact on cost, mean values falls in the range of moderate to major.

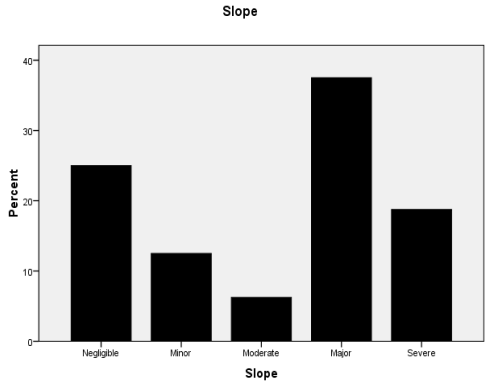

Figure 1: Impact of Slope on Cost

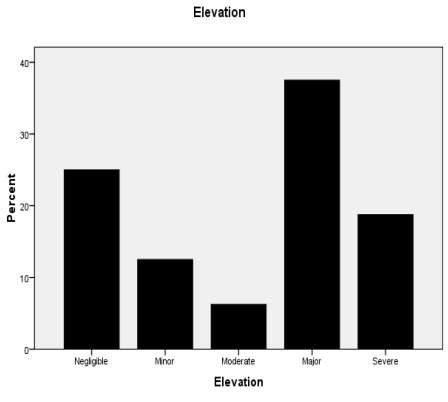

Figure 2: Impact of Elevation on Cost

Considering the impact of the slope and elevation impacts acts parallel. Most of intakes are situated in streams and rivers. To take a gravity flow, intakes are located in the higher levels. And to access those intakes, no roads are available. Most of the times nature of the access is uphill foot path. Pipe network shall lay along the uphill foot path. It is not convenient as laying pipes along a motor able plane path because no machinery could be used to lay pipes. Pipes weight are extremely high and to hold and handle pipes may need additional labours compared to laying pipes in plane path. Unexpected situations like falling rocks and falling trees can be happened while working. Therefore, working on a sloppy land may be risk to life. Considering those situations, labour wages may be high appropriate to the risk taken. The efficiency of the workers might be less comparing to pipe laying in urban projects due to the sloppy conditions and workload for the labours are much higher than labours in urban projects. So, the production rate decreases and will delay the works. The steeper the slope, the larger volume of soil can be lost. As the soil erodes downhill, it increases the slope degree, which in turn, creates further erosion. The soil quality, structure, stability, and texture are also affected, which in turn affect the holding capacity of the soil. This may damage structures like reservoirs and treatment plant. And will incur additional labour and cost to rectify those damages.

Most of the sites are located in elevated areas and elevation difference is changed rapidly. This rapid change of elevation is the one of the reason for low percentage of full treated pipe born water supply coverage in Kegalle district in currently. Due to community request some scenarios planned pipe laying path had to lay in a different route through sloppy and elevated lands. Due to that sudden elevation changes pressure level of the pipes increase. Therefore suitable pipes have to lay for the extents like those and need to supply additional pipes. That may be take reasonable cost. Therefore slope and elevation cause major impact on construction time cost.

ROCK CONDITIONS AND UNEXPECTED GEOLOGICAL CONDITIONS

Panthi and Nilsen (2007) stated that, where much poorer rock quality than expected have caused significant impact on the overall cost of construction. Hwang and Leong (2013) stated that unforeseen site conditions include underground obstructions, hard rock barriers and poor soil condition.

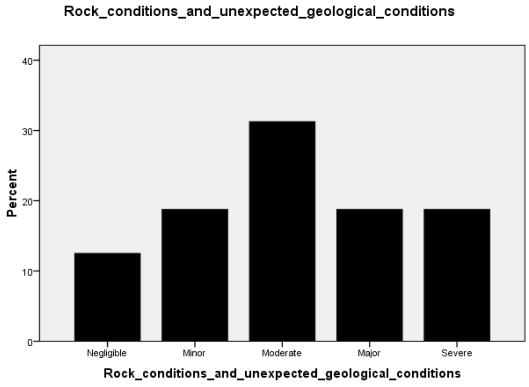

Figure 3: Impact of Rock Conditions and Unexpected Geological Conditions on Cost

Figure 3 deals with the impact caused by the rock conditions and unexpected geological conditions to the construction cost. Considering the opinions of the interviewers, majority of the interviewers have

mentioned that, impact of rock conditions to the time and cost both are moderate. As per the interviewers' responses, mean value of impact cost falls in the range of moderate to major.

This may be due to numerous reasons and causes. Geotechnical site investigation could not be carried within the allocated time period for a design. In such cases following issues could arise, actual overburden depth is higher than expected overburden depth and some cases overburden depth is thinner than expected overburden depth. Therefore, to overcome these situations sometimes it is needed to blast the rock than expected quantity and sometimes need do design changes, if the rock plain not found in required level. Also while excavating trenches unexpected rock could be found. Those rocks should be removed either by chemical or control blasting. Obtaining chemicals and the explosives. Due to lack of the materials, price of the materials might be extremely high. In such situation cost overrun may be happened.

CONCLUSION

Some of the physical environmental factors were identified through the literature survey. And those factors were validated with the professional experts and concluded that, 9 physical environmental factors impact the construction of foreign funded rural water supply projects. According to the questionnaire survey, respondents had mentioned that, all the selected factors had an impact on cost more or less. Rock conditions and unexpected geological conditions, elevation and slope equally cause highest impact on cost. Most of the rural water supply projects in Sri Lanka had been implemented with the support from foreign funds and counterpart funding by the Government of Sri Lanka. During the life cycle of the project always physical environmental factors impact on the cost of the construction process of the project. When implementing a new foreign funded rural water supply project, it is needed to study about the physical environmental factors that impacts on the cost of the construction works hence physical environmental factors like slope and elevation also much more important for the sustainability and the success of the water supply project.

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THE TRANSFORMATIONAL LEADERSHIP STYLE EXHIBITED BY THE QUANTITY SURVEYORS IN SRI-LANKA

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ABSTRACT

Sri Lanka as a developing country has faced several changes in the sector of construction industry during last few decade and subsequently the profession of Quantity Surveying has transformed. This research assesses the application of Transformational Leadership exhibited by the Quantity Surveyors in Sri Lanka. The scope of this study contains a qualitative data analysis and adopted an approach of survey, using a collection of distributed 80 questionnaires within Quantity Surveyors and 20 interviews from Senior Quantity Surveyors and Project Managers. This study has found that majority of Quantity Surveyors exhibit Transformational Leadership and their leadership role has been impacted by the hierarchy of authority. Therefore, it has recommended Quantity Surveyors to drive beyond the traditional role and the Project Managers to adopt leadership instead of their fixed administrative role.

Key Words: Sri Lanka, Transformational Leadership, Quantity Surveying.

INTRODUCTION

Sri Lanka as a developing country has faced several changes in the sector of construction industry. In reference to the statistical information published by the Central Bank of Sri Lanka in 2018, the construction industry has shown a considerable increase in the growth rate during last few decades. The development of the Sri Lankan construction industry has closely followed the economic changes during the past decade and relatively, the demand tendency stemmed in various variations on the supply side of the industry and the production features enhanced eventually over the era (Weddikkara and Devapriya,2015). There can witness a novel positivity regarding the future Quantity Surveyors (QS') as a profession and QS' are now perceived as significant actors in the construction industry (Smith ,2004). Therefore, it is important to identify the extent to which QS perceive their leadership role in transforming their profession under changes in the construction industry.

In addressing the role of QS' in Sri Lanka under such transforms, leadership skills are required to proceed with the changes in its profession under the new millennium. The Transformational leadership (TL) contains evaluating inspiration to followers, understanding their requirements and wishes and acting them as complete human beings (Chan and Chan, 2005). Therefore, this research emphasizes adaption of TL into the profession of Quantity Surveying in Sri Lanka by considering all the consequences in achieving its

professional goals. By means of the theme, this research attempts to discover the application of TL exhibited by the QS in Sri Lanka and the barriers they may face in being future leaders in the construction industry in Sri Lanka.

LITERATURE REVIEW

TRANSFORMATIONAL LEADERSHIP THEORY

J. M. Burns interpreted the concept of TL in the book "Leadership" in 1978 as a procedure in which "leaders and their followers raise one another to higher levels of morality and motivation". As the well-known researcher Burns understands in 2004, TL can experience when "leaders and followers make each other advance to a higher level of morality and motivation and through the strength of their vision and personality, transformational leaders are able to inspire followers to change expectations, perceptions, and motivations to work towards common goals".

THE MAJOR COMPONENTS OF TRANSFORMATIONAL LEADERSHIP INTRODUCED BY BASS (1985):

Inspirational Motivation	•"The degree to which the leader attains to each followers' needs acting as a mentor".
Individual Consideration	•"The degree to which the leader articulates a vision that is appealing and inspiring to followers".
Intellectual Stimulation	•"The degree to which the leader challenges assumptions, take risks while stimulating the creativity in the followers".
Idealized Influence	•"As a development tool, it provides a role model for high ethical behavior instills pride, gains, respect and trust".

Figure 1 : Components of Transformational Leadership Introduced By Bass (1985)

SIGNIFICANCE OF APPLICATION OF TRANSFORMATIONAL LEADERSHIP INTO THE PROFESSION OF QUANTITY SURVEYING IN THE SRI-LANKAN CONTEXT

Although several researches were focused on the concepts of TL style and/or profession of Quantity Surveying separately, no researcher has examined the application of TL within the role of QS in relation to the Sri Lankan context whereby the gap between previous studies and the present research is brought into light.

The implication of adaption of TL was revealed by the researchers long years back and the findings of (Avolio et al., 2009; Judge and Bono, 2000) stated that although many leadership theories have been developed and studied excessively, the TL style has become the most commonly researched over the last two decades for the improvement of attitudes and the level of performance in the projects. Hence this research study is significant as it attempts to assess the application of TL exhibited by the QS' in Sri Lanka.

RESEARCH GAP

The past few years have seen a renewed interest in TL and consequently a vast number of researches have been done on the subject compensating for the initial scarcity of work. In contrary to the area covered by them, the current thesis undertakes to identify the instances where the QS role is significant as a leader and how far it could be adapted to the present construction field. However, not a single research has attempted to apply it into the career of QS within the context of Sri Lanka. Therefore, the significance of this research in progress lies in the fact that it attempts to apply the theories of TL into the profession of quantity surveying, specifically within Sri Lankan socio- economic setting.

RESEARCH METHODOLOGY

The current research has followed the survey method by the means of collecting primary data through both ways of questionnaire survey and interviews. As this study aims at evaluating the application of TL, among the Quantity Surveyors, the questionnaire survey was carried out among 80 number of QS (both leaders and followers) in Sri Lanka based on simple random sampling method. The interviews are sampled based on purposive method for 10 numbers of expert QS' and 10 numbers of Project Managers in Sri Lankan construction industry whom have experience in the field for more than 10 years. It was aimed at identifying both views of 'follower' and 'leader' towards the application of TL style. The data were then analyzed by the means of statistical analysis and content analysis.

RESEARCH FINDINGS

THE EXTENT OF LEADERSHIP ROLE AS EXHIBITED BY THE QUANTITY SURVEYORS IN SRI LANKA

In assessing the application of TL by the QS' in the Sri Lankan context, it is revealed that 93.18% of leaders and 97.37% of followers have accepted that the QS play leadership role in their career.

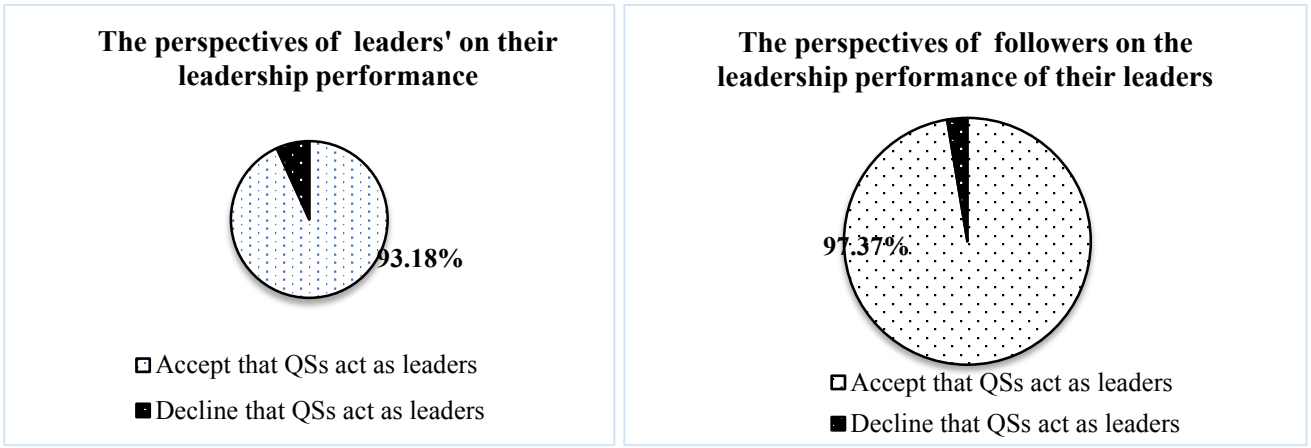

Figure2: Perspectives on Leadership Performance

Similarly, the content analysis of primary data gathered from interviews has also found that majority accept QS as leaders and therefore the profession of Quantity Surveying has been found major as leaders in the construction industry. In discovering where QS act as leaders in the Sri Lankan construction industry, the areas that they exhibit leadership roles are found as the following figures indicates.

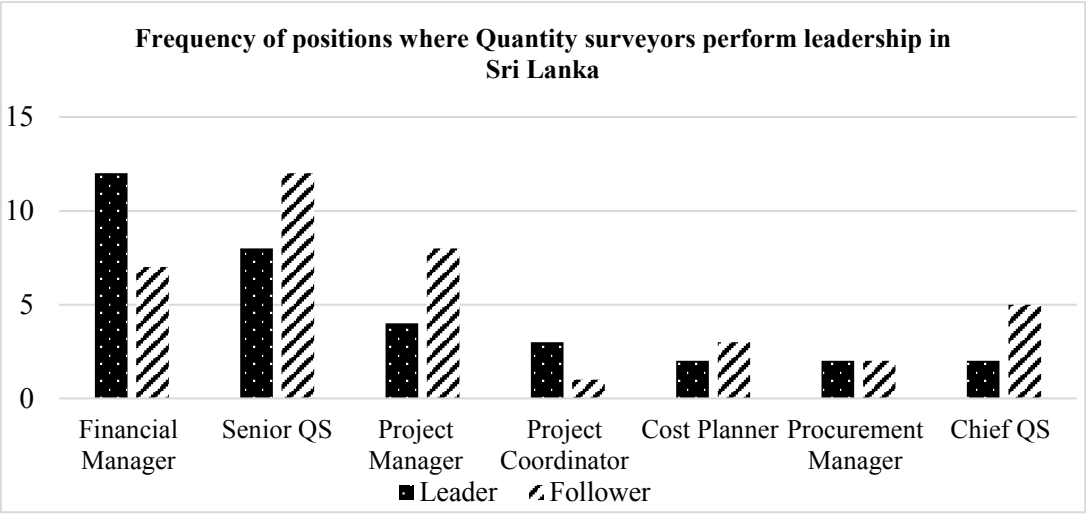

Figure 3: Summary of Frequency Analysis of Quantity Surveying Leadership Positions

In considering the prevailing and future challenges and opportunities, quantity surveying can be seen as a profession at important cross-roads from which it can go beyond its traditional cost engineering and financial management roles and use its core competencies to assume a leadership role in the industry. Ofori and Toor (2012). Therefore, in comparison of global trends in Quantity Surveying, this analysis reveals that the QS' in Sri Lanka are more likely to follow a traditional path.

IMPACTS OF CONSTRUCTION INDUSTRY INTO THE PROFESSION OF QS IN SRI LANKA

Considering that the Project Managers act as leaders while the QS implement under them as followers, it is significant to address the view of the Project Managers towards the QS. According to the extent of their view, 40% of project managers are found to be following TL while the rest have projected other features that cannot be taken into the category of TL traits.

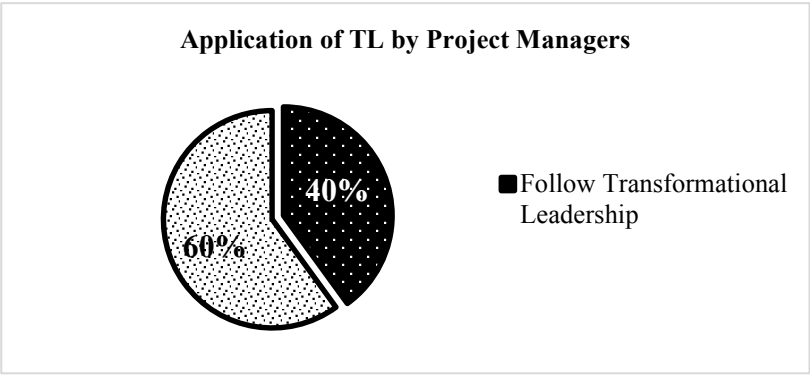

Figure 4: Application of Transformational Leadership by Project Managers

The further analysis based on the responses given by them in the interview has found that the rest of 60% has performed different leadership styles which are more likely to be bureaucratic leadership theoretically. Therefore, the leadership style carried out by these non-transformational leaders sense more likely to show

the characteristics of bureaucratic leadership. These styles are shown in the following chart based on the frequency of the responses.

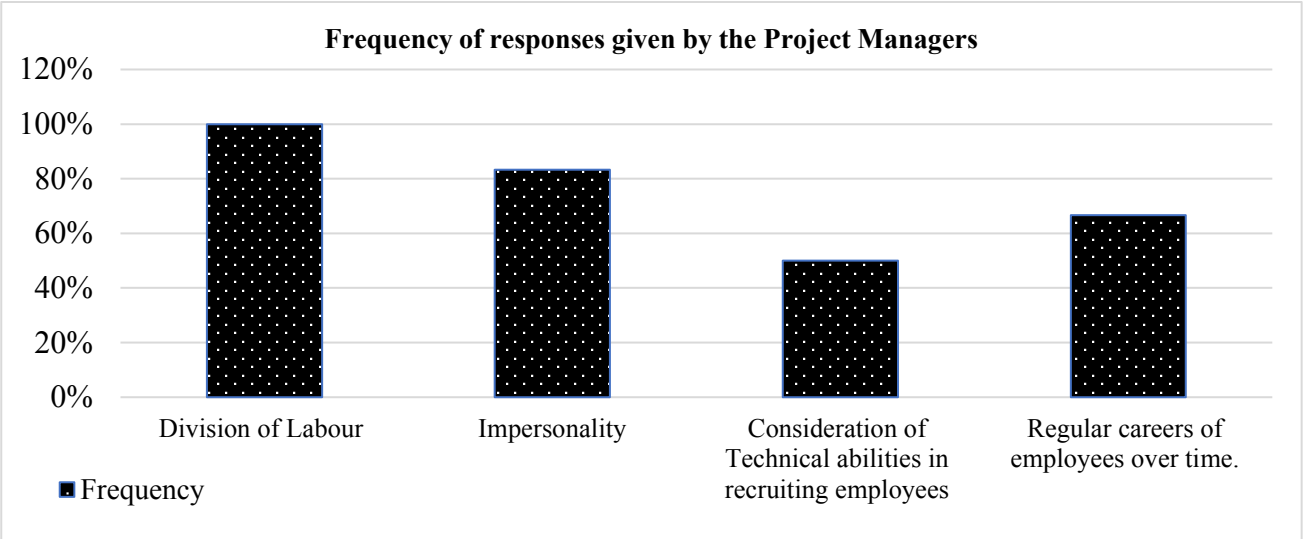

Figure 5: Frequency of Project Managers' Leadership Attributes

As their perspective towards TL are differed from the majority of the QS', this research undergoes a separate study on the organization structure of each construction firm and it revealed that 100% of them are structured within a hierarchy of authority. A sample of an organizational structure is shown in the following figure 6.

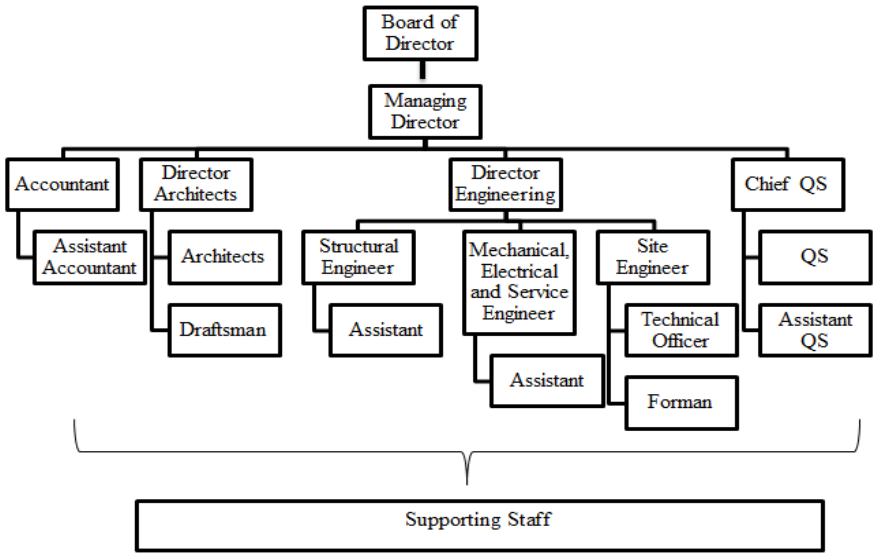

Figure 6: Sample Organization Structure in Construction Industry in Sri Lanka

In referring to the structure virtually in all the contractor and consultant firms in Sri Lanka (Figure 6), the QS are placed under the project manager in the management hierarchy. Under such atmosphere theoretically the quantity surveyor transforms into a follower which makes the project manager a leader.

As the responses received from the project managers made it evident, the latter follows a bureaucratic leadership rather than a TL although this study is directed at addressing the role of the QS, it is important to extend its scope to address the project manager in order that the identified barriers will be overcome.

The discoveries of Bureaucratic leadership by Max Weber (1905) are later defined by Pavia (2014) as "bureaucracy is the phenomenon of affirmation of the rationalization of the world". The analyses illustrated by Figure 4, Figure 5 and Figure 6 are evident that 60% of project managers are Bureaucratic leaders in contrary to the following theoretical base emphasized by Ferreira (2004).

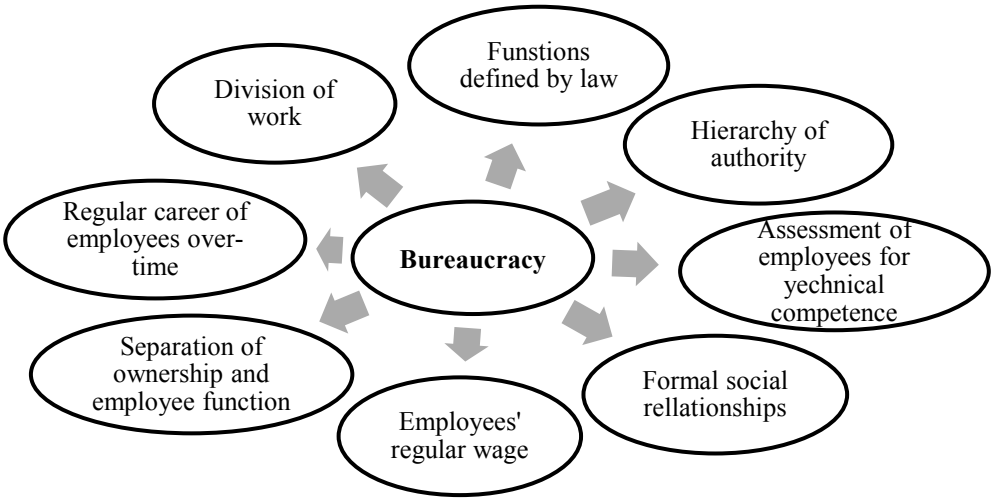

Figure 4: Adapted from Ferreira et al., 2004, pp. 24 and 25

Accordingly, it is obvious that the Quantity Surveyors are obstructed to act out of the traditional box and become future leaders due to the hierarchical authorization and power dominance. Therefore, this study draws the attention on top level managers (Ex: Project Manager), to follow TL style hence this research has justified the significance of application of TL. The following table illustrates the advantages that implies on Quantity Surveyors in adopting TL by the Project Managers.

CONCLUSION

One of the sound areas of the researches carried out on quantity surveying all over the world is that they become leaders in the construction industry. This study has identified the assumption of leadership by Quantity Surveyors in Sri Lanka. In further tracing the specific platforms where Quantity Surveyors play a leadership role, it implied that they up to now hold on to the traditional path in dealing with the aspects encompassing this profession.

In analyzing the impacts of construction industry into the profession of Quantity Surveying**,** it is concluded that the latter is largely affected by the authorization of management hierarchy as,

- Project managers are known for their tendency to follow Bureaucratic Leadership than TL.

- The organizational structure of construction firms in Sri Lanka is largely based on hierarchy of authority.
- The opinions of the Senior QS' demonstrate that the authorization of the Project managers limit them to their confined role.

RECOMMENDATIONS

Explore New Ways of Exerting Quantity Surveyors Beyond the Traditional Frame

- ***SHORT TERM RECOMMENDATIONS:*** To extend beyond the long-established traditional role Knowledge sharing by ways of having symposiums, workshops and seminars while encouraging the researchers for further research as well as motivating the practitioners to implement favorable measures to promote such research are recommended. Equally important is to acquire maximum advantages of globalization process to seek new opportunities for QS to maximize the productivity.
- ***LONG TERM RECOMMENDATIONS:*** Shifting away from the traditional mindset by adopting new trends of the construction industry it will make positive impacts on the profession of Quantity Surveying. According to the findings of the study, becoming innovative by use of new technology and concepts such as sustainability along with modern and critical thinking capacities. Not only that but also forecasting the future threats to the QS profession and inquire the ways of overcoming them in advance.

TRANSFORMATION OF THE LEADERSHIP ROLE UP TO THE PRACTICE BY THE PROJECT MANAGERS

- ***LONG TERM RECOMMENDATIONS:*** As this study revealed that the prevailing leadership role of the project managers is a considerable limitation for the QS' to become leaders, a suitable atmosphere should be created for those who are unable to possess the favorable ground to operate. Therefore, it is recommended to transform the position of the Project Manager into a leader in place of the fixed administrative role.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study has evaluated the barriers that come in the way of a QS in view of the obstacles that confronts the QS in his role as a leader which has left the obstructions that may arise in other forms out of consideration. On such a basis, this study stresses the need for further research on the external factors that prevents QS from becoming an effective leader.

Though this research placed a considerable emphasis on the barriers that exists before QS owing to the Bureaucratic role of the Project Manager, it is deprived of considering the obstacles faced by the project managers in adopting themselves to the TL style. With this understanding, this study concluded that the project managers should function more as leaders rather than administrators. A separate study is required to address the difficulties confronted by Project Managers in transforming themselves into a leader.

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TINY HOUSES AS A SOLUTION TO LIMITED URBAN BUILT SPACE

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ABSTRACT

In the pursuit of minimizing the resource depletion, developed countries have come up with the idea to save the non-renewable resources as much as possible using sustainable concepts which focuses on three main areas; social, economic and environment. Along with this in mind, a research was carried out to promote tiny house concept in Sri Lanka mainly to address the spatial shortage in Colombo metropolitan area, while analyzing the specialized features used in the developed countries. The methodology used in the research is a mixed methodology. The collected data was tabulated and analyzed using RII (Relative Importance Index). Industry experts' reviews were also analyzed. A conclusion is that it is time the government spearheads a public awareness on the Tiny House and promote to increase the number of Tiny houses in future.

***Key words**: Colombo; Spatial; Sustainable; Tiny House*

INTRODUCTION

The construction industry is one of the most significant industries that contributes toward the socio-economic growth specially to developing countries (Ayesha, 2017). As a result, many buildings are coming up at a rapid speed. However, Ayesha (2017) further states that construction industry in developed countries always face problem and challenge. Construction industry at present generates around 5% to 15% of the global GDP. Interesting facts such as half of electricity consumption worldwide, third of overall energy consumption and third of carbon emission globally are all fall under the built environment (IEA, 2013).

The earth is rapidly more and more becoming an urban environment. Over half of entire earth's population live in cities or town since 2008 and it is expected to reach the mark of 10 billion people roughly over the period of next four decades (UN, 2007, 2013). In countries that are developing and cities expanding at rapid phase, the population growth too would rapidly increase and as a result, the demand for infrastructure too would increase (Longman, 1998). At the same time, the rise of different visions such as "sustainable city" is the result of innovative technologies and the drive towards in sustainable development. Unfortunately, however these visions rarely turn in to reality since there are interventions that tend to be adopted poor to the local context or failing to meet the expected enough grasp of the complex interrelations between numerus human attributes (Robertson, 2012).

The "crisis" to afford a house is a continuous problem that's being faced in many countries, especially in developing countries and the ever-growing increase in price seems to resist to any policy that intervenes (Heather and Paul, 2017). Therefore, in order to address the above-mentioned problem, introducing the "Tiny House" concept would be ideal for the community (Ford and Lanier, 2017). A Tiny home tends to high efficiency in cost and it relatively needs very little resources when properly designed. It is the ideal for college students who'd be staying till the studies are done, empty nesters or elderly people who'd prefer a small and cozy home enjoying the retirement. Also, ideal to put up an office behind the home or guesthouse (Foreman, 2005). Typically constructed between 65 and 400 square feet (6 and 37 square meters), and the community if Tiny house is gradually increasing (Chea, 2010).

As per research done by Heather and Paul, in 2017, Apart from the USA, countries like Australia, New Zealand, Germany and Canada, the tiny house culture have moved from fringe to mainstream, and permits given by relevant municipalities is growing rapidly for tiny houses. The number of companies that bespoke tiny house is actively increasing in the market.

As per World Population Review (2018), the urban area of Colombo, meaning its metropolitan population is much larger at 2,234,289, which is roughly more than 10% of the entire population. This means more housing would be needed to house the inhabitants. As a result, the city is very congested, many greenfield lands have been utilized. In Guganeshan's article (2016) he states that "Interestingly, the number of 'empty houses' has been on the rise in Sri Lanka as owners are either residing abroad or own more than one apartment"

Sri Lanka is a developing country and the most populated area is the Western Province. Due to the increase population in this region the inhabitants are in a situation to construct their own dwelling. At the same time majority of Sri Lankan population could be considered as middle class. As a result of population growth, the dwellings too are increasing at a rapid rate which results in shortage of space to build relatively larger house. (Ministry of Housing, Construction & Culture Affairs, 2017).

The tiny houses in developed countries have been widely covered in media including in time to time articles in magazines, narratives, web blogs and even on television shows but research done from academic perspective is limited since its relatively new in developing. (Ford and Lanier, 2017). Therefore, to address the spatial problem and to provide a solution to the middle-class community promoting the Tiny House is the solution and the following research would be a study focused on how the Tiny House could have a better impact and also a sustainable solution and also to address the lack of information on factors that motivate individuals to go towards a different lifestyle change which is Tiny House.

AIM OF THE RESEARCH

Study the impacts of Tiny house concept for space problem in urban areas of Sri Lanka.

OBJECTIVES OF THE RESEARCH

1. To identify the Tiny House concept, its benefits, and implementational barriers along with its relationship to sustainability.
2. To identify the technologies used in Tiny house construction.
3. To identify the Sri Lanka status in Tiny House concept
4. To provide recommendation to improve the usage of Tiny House concept in Sri Lanka.

LITERATURE REVIEW

In the recent period of time, say last few years or so, the tiny house movement has successfully been a solution to the current waste in the housing industry (Ford and Lanier, 2017). The “tiny house movement” is continuously getting positive reviews among the public in recent years. The community has been informed by a common likeness in "de-cluttering, minimizing and also downsizing" which has a long history since its origins in the 19th century (Anson, 2014; Morrison, 2014). Further Ford and Lanier (2017) One of major assumption of the tiny home community is that the occupants could decrease the impacts that's happening to the environment and also increase the ability to affordability by decreasing their spatial footprint.

In fact, tiny house is a design mainly proposed as a solution for people who constantly busy travelling (Shahani, 2015), housing for a temporary period and as a guest house (Hunter, 2015), housing for the homeless, and as a solution in urban areas to address the requirement of housing to include a large number of population with in a small limited space (Priesnitz, 2014). Anson (2014) further states that because of the recent emergence of the Tiny house community/movement, there are only few researches and discussions done in academic level about tiny houses and its feasibility as a sustainable long-term housing solution.

In an academic research paper Kilman, (2016) stresses that Tiny houses are designed in many sizes and shapes, however, it’s a point to note that the tiny house was traditionally constructed on a trailer bed simply due to not having proper zonal codes. Apart from it each tiny house varies from owner to owner, but normally it would have a large room which combines a living room along with a kitchen thus maximizes the space.

Living a sustainable life style means to adopt a long-term practice rather than simply focusing with the needs of the tiny house community. Nevertheless, many tiny home dwellers don't tend to live permanently. Rather, they are adopting the lifestyle as a temporary placement of house (Anson, 2014). According to Lee, Allen, and Kim (2013), when pollutants are compared indoor pollutants are two to five times higher outdoor pollutants, mainly due to harmful emission from building materials used such as flooring options, paints and other coasting options,

adhesives and sealants, wall coverings and wood products (Lee et al., 2013) thus the interior designers have to be aware on what materials are used in relation to sustainability. Therefore, to address the above-mentioned energy concerns Tiny Houses will notably decrease the whole cost(outright) that are lower, and also the cost for heating, cooling and energy consumption. For instance, Mary Murphy states her tiny house only costs $15 to heat during first winter the cost of a space heater (Murphy, 2014).

Thus, in order to promote sustainable solution, tiny house owners and companies took a step forward by started to integrate the use of reclaimed materials and recycled materials in tiny house building. Certain owners make sure to construct in a sustainable way. A company named “Tiny Texas Houses”, arguably builds tiny houses using 99% of recycled materials (Kittel, 2013).

Overall impact to the environment could be reduced when reclaimed materials are utilized where possible, since new materials (or virgin materials) need the extraction of further more resources and the need to be undergo with chemical treatment to make them to usable condition. When it comes to the use of reclaimed materials no harm would be done to the environment. (Mutter, 2013).

Tiny home owners often consume fewer material goods because they have less storage (Williams, 2011). The other key advantage to go towards the lifestyle is most of the tiny home owners are exempted from paying mortgage or additional monthly rent once their home's construction is completed. You can become a homeowner with in a short time by building a Tiny home. Williams (2011) states that a small sum of only $8 a month would be entitled to be paid by a tiny home dweller for utilities which could have a huge impact in overall monthly costs. With the interest with tiny house community grows more investigation needs to be done. While construction of a tiny house has very few concerns to be addressed, the major barrier to the rapid increase is to adhere to the building codes and relevant zoning ordinance (Anson, 2014; Murphy, 2014).

Tiny area falls in between these three types such as a mobile home/trailer/RV (recreational vehicle) with a house. Therefore, it doesn't fit clearly to any of currently available legal category (Ford and Lanier, 2017). Whether one might like it or not, it's not up to a tiny home owner to select the land but rather as per the respective government ordinances and have to comply to these acts (Real Estate News, 2017). A typical gross weight of a tiny house could be summed as 3.5 metric ton, with the inclusion of solar panels and batteries. Throughout the entire construction process there is a need to maintain or focus on sustainability and has incorporated several such features which supports sustainability throughout the home (Borgobello, 2019).

METHODOLOGY

This research is to promote the Tiny house concept in Sri Lanka by evaluating the viability, drawbacks and whether the occupants would like to live in Tiny House. As of now since this is completely a new concept for Sri Lanka but widely used concept in developed countries, therefore mixed methodology should be approached in the research where a quantitative method should be used to collect data from industry experts such as Civil Engineers, Quantity Surveyors, Contractors and Architectures to determine whether the already established and practiced methodologies could be utilized in Sri Lanka. Therefore, suitable questionnaires were prepared to get feedback. The sampling would be done using Judgmental sampling methods and a sample space of thirty would be taken. The data collected would be analyzed using the Relative Importance Index (RII) analysis tool and ranked accordingly.

The technologies that are unable to be practiced or not utilized in Sri Lanka shall further be evaluated by qualitative methodology such as conducting interviews from specialized industry experts

DATA ANALYSIS

As mentioned above professionals who are currently employed at various projects were involved in the data gathering process.

Table 5 Data analyzed as per RII

Material Categories	Material Factors	Mean	Variance	SD	Error	T Value	p	Significance	RII	Rank
HVAC (Off - Grid Heating solutions)	Solar Power	4.300	11.882	3.447	0.629	2.066	0.971	0.02894	0.86	1
	Wood Burning Stove	3.067	10.501	3.240	0.592	0.113	0.544	0.45594	0.61	2
	Natural / Propane gas Stove	1.467	12.492	3.534	0.645	-2.376	0.016	0.98385	0.29	3
HVAC (Grid - Dependent heating solutions)	Radiant in Floor	1.500	12.375	3.518	0.642	-2.335	0.017	0.98254	0.30	3
	Electric fireplaces	2.967	9.200	3.033	0.554	-0.060	0.476	0.52357	0.59	1
	Space Heaters	1.633	11.645	3.412	0.623	-2.194	0.023	0.97718	0.33	2
HVAC (Off - Grid Cooling solutions)	Radiant Barriers	2.667	8.319	2.884	0.527	-0.633	0.268	0.73154	0.53	2
	Light Colour Painting	4.400	10.027	3.166	0.578	2.422	0.985	0.01481	0.88	1
HVAC (Grid - Dependent cooling solutions)	Mini Split systems	4.700	11.682	3.418	0.624	2.724	0.992	0.00823	0.94	2
Heat Recovery Ventilator	Heat Recovery Ventilator	2.967	6.800	2.608	0.476	-0.070	0.473	0.52741	0.59	1
Roofing Systems	Ventilation & No Condensation	4.300	7.882	2.807	0.513	2.536	0.988	0.01187	0.86	2
	Heat Recovery Ventilation (HRV)	2.367	8.667	2.944	0.537	-1.178	0.129	0.87084	0.47	4
	Energy Recovery Ventilation (ERV)	2.800	7.307	2.703	0.494	-0.405	0.346	0.65429	0.56	3
	Balanced Ventilation Systems	4.567	9.609	3.100	0.566	2.768	0.992	0.00755	0.91	1
Solar Energy as main source of power	Solar Energy as main source of power	4.400	8.627	2.937	0.536	2.611	0.990	0.01027	0.88	1
Flooring Systems	Hardwood Floors	4.400	10.027	3.166	0.578	2.422	0.985	0.01481	0.88	2
	Floating Hardwood Floors	4.333	9.330	3.054	0.558	2.391	0.984	0.01570	0.87	3
	Laminate Floors	4.167	13.427	3.664	0.669	1.744	0.948	0.05154	0.83	4
	Tile	5.000	24.167	4.916	0.898	2.228	0.979	0.02138	1.00	1

Civil/Structural Engineers, Material Engineer, Quantity Surveyor, Project Manager and Planning Engineer were involved from about 8 construction projects with experience of over 5 years in their respective area of expertise.

The detailed classification of the sample space for the research is tabulated and represented in a pie chart below

Table 6 Sample space *for quantitative methodology*

Role	Number of professionals
Material Engineer	5
Quantity Surveyor	8
Civil/Structural Engineer	9
Project Manager	4

Planning Engineer	4

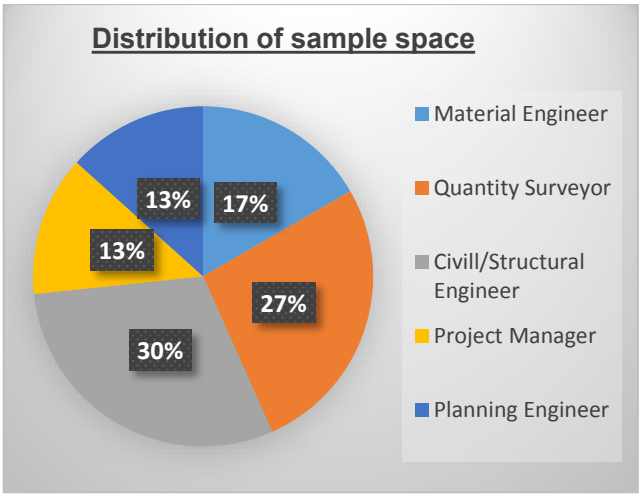

Figure 5 Pie chart representing sample space

To what extent the technologies mentioned below be used in a Tiny House construction in Sri Lanka is tabulated under RII.

Detailed table with RII value and ranking for technologies mentioned above.

Table 7 RII ranking

Material Factors	RII	Rank
Tile	1.00	**1**
Mini Split systems	0.94	**2**
Balanced Ventilation Systems	0.91	**3**
Light Colour Painting	0.88	**4**
Solar Energy as main source of power	0.88	**4**
Hardwood Floors	0.88	**4**
Floating Hardwood Floors	0.87	**5**
Solar Power	0.86	**6**
Ventilation & No Condensation	0.86	**6**
Laminate Floors	0.83	**7**
Wood Burning Stove	0.61	**8**
Electric fireplaces	0.59	**9**
Heat Recovery Ventilator	0.59	**9**
Energy Recovery Ventilation (ERV)	0.56	**10**
Radiant Barriers	0.53	**11**

Heat Recovery Ventilation (HRV)	0.47	**12**
Space Heaters	0.33	**13**
Radiant in Floor	0.30	**14**
Natural / Propane gas Stove	0.29	**15**

FINDINGS AND DISCUSSION

The rows highlighted in yellow are the technologies or construction factors that cannot be used or practiced in western part of Sri Lanka mainly since the above factors are used in cooler areas as its factors concerning heating.

As per above table Tile is the factor which has the highest RII value of 1.0 and was accepted by all the professional since as it's a very common flooring option available in Sri Lanka. The factors such as Wood Burning Stove, Mini Split systems, Balanced Ventilation Systems, Light Colour Painting, Solar Energy as main source of power, Hardwood Floors, Floating Hardwood Floors, Solar Power, Ventilation & No Condensation, Laminate Floors have higher RII value and falls between 0.95-0.80 respectively. These factors are readily available, accepted and widely used by the Sri Lankan community. The factors Energy Recovery Ventilation (ERV), Radiant Barriers have RII value of 0.56 and 0.53 respectively which is partially agreed by the professionals. The reason for lower RII value could mainly be due to implementational barriers and lack of knowledge on the area.

Further expert review was done to learn on further improvements that could be done when constructing a Tiny house. And further to analyze the effect the Tiny House would have on Sri Lankan community which involves Social, economic and environmental aspect of Tiny House. Of the features mentioned or provided to be included in a sustainable Tiny House it was found that Energy Recovery Ventilation (ERV) and Radiant Barriers had mix review and had to go through an expert review to know the factors involved towards the two cooling options.

How an ERV and a radiant barrier could be integrated to a tiny house?

Energy recovery ventilation is a cooling/heating which is similar to an Air conditioning system where air is supplied in and released with cooler air, is a solution relative not heard and used among Sri Lankan since majority prefer fans over mechanical systems such as ERV. Moreover, the build or setting up cost is pretty high. A Radiant barrier is heat recovering and cooling solution where the insulation is done to the inner roof and act as an energy recovery ventilation. And when it comes to radiant barriers it is rarely used in Sri Lanka since insulation is done very rarely mainly due to lack of awareness in the solution and the cost factor in having this as a solution to cool. Either way, the above mentioned two cooling solution are personal preference with the occupant.

The intended community for tiny house is for people who are with relatively low income who would try to build the house for low as possible. However, a Tiny house can be designed with high quality with luxury feature specifically for tourists or upper income community and for luxury designs an ERV or a radiant barrier could be pre-installed. The two features mentioned could be designed as a dual feature say a fan and radiant barrier or a fan and an ERV and the occupant could decide what to use as per their necessity. Radiant barrier could be used without any maintenance needed but Energy Recovery Ventilation has mechanical components and need additional power cost, services to be done regularly.

Of the solutions available (highlighted in yellow in the table above) for heating in cooler part of Sri Lanka, the suitable solution in contrast to affordability, sustainability and durability?

Of solutions mentioned for heating, Electric fireplace and Space heater cold be affordable and in long term could be more benefit. Of the two Space heater is a better solution since it doesn't require wood, and wood being part of sustainable environment. The other benefits of space heaters are it is cost effective, Improved ambiance, more convenience, safety and flexible in installing.

The Natural/Propane gas stove cannot be used since it's against sustainable solution at the same time Heat Recovery Ventilation and Radiant in floor solution are expensive in installing and also incur high maintenance cost.

Thus, the solution for heating in terms of sustainability, durability and affordability in cooler locations in Sri Lanka is Space heater.

Above, there were various discussions on the features a Tiny House in Sri Lanka could have in terms to sustainable. Further discussions on how the Sri Lankan community would adhere to the Tiny House culture, along with its impact towards sustainability is done below.

Cultural impact on introducing a new housing option "Tiny House" in Sri Lanka

Tiny house is suitable for current lifestyle and doesn't require complex construction procedure for instance no strong foundation is needed and also the cost for door and windows are very cheap along with the finishing cost. Ideally its suited for even a middle-class person or couple and to lead a happy and luxury life. Having said that the lifestyle may at first be a little hard to adopt but after the cause of time the occupants would and could easily adopt in Tiny House lifestyle.

Construction of Tiny house in relation to Time, Cost and Quality

A Tiny house could be constructed with in a short time while having better quality and also saves money when compared with conventional construction of house. Apart from that, it could be built with luxury features and a better aesthetic look for much cheaper price. Tiny house in long term as a solution to address the continuously growing spatial problem in Colombo. As we all know Colombo is the most populated city and almost hold 10% of Sri Lanka's population. At present it is very hard to acquire a land and moreover the prices have gone way high than used to be due to lack of space. In such situation, for the people who have certain budget and would be willing to live in an own house, Tiny house is a solution available to satisfy the needs of the people. And recently the local governing bodies are reluctant to give permits for large high-rise residential buildings, due to water shortage in the Colombo Metropolitan area.

Tiny house towards a sustainable living solution in Sri Lanka

Tiny house in Sri Lanka is a good solution for the day to day deforestation and also socially would make most of the people happy since they could build their own house with low income as their budget. Economically speaking this could be marketed by building and renting out to tourists until they leave the island. In brief a human would need a house for a foreseeable future somewhere around 10-15 years, therefore Tiny house could be constructed using environment friendly resources, and even brickwork could be omitted and hard thick ply wood partitions could be used as walls and thus saves more resources and when environment friendly resources are used, it could be more sustainable.

The waste disposal system could be easily designed and constructed without making the process complex as it is done in conventional system. The wiring, plumbing and the maintenance of a Tiny house is very cheap compared to the conventional house. Apart from being small in size, a tiny house could be built as a House on wheel where the occupant could toe to any location where a trailer lorry could go, henceforth the design is very simple and doesn't require much time, could also be a readymade solution for people who're looking to spend few days for lower cost

CONCLUSION AND KEY FINDINGS

Metropolitan area in Sri Lanka is running out of space to construct house, of the remaining virgin land which is rare to find, many are allocated for commercial purposes since Colombo is the capital hub of Sri Lanka. At the same time Sri Lanka's construction procedure towards sustainable construction haven't taken in to high effect. Hence this research is focused on identifying a solution to address the spatial problem faced by the Sri Lankan community and something more favorable towards sustainability is the 'Tiny House' could be used in Sri Lanka.

At present the Tiny house construction and people living a pretty happy life is well witnessed in other developed countries and being used as a housing solution for quite some time. Expert review was done to get a clear understanding of the practicality of certain features and the solution from industry experts, while the review was done few questions needed clarification and the respective solution given by industry experts are below,

- How an ERV and a Radiant barrier could be integrated to a Tiny House – by having luxury models theses could be incorporated
- Of the solutions available (highlighted in yellow in the table above) for heating in cooler part of Sri Lanka, the suitable solution in contrast to affordability, sustainability and durability? – Space heater was suggested as the most affordable, sustainable and durable solution for cooling.
- Cultural impact on introducing a new housing option "Tiny House" in Sri Lanka – Despite it would be hard to adopt at first after a considerable time it would be adopted. With that it's ideal to middle class community.
- Construction of Tiny house in relation to Time, Cost and Quality – Since the design is very simple and easy, a Tiny house takes less time, cheap and batter quality to construct.
- Tiny house in long term as a solution to address the continuously growing spatial problem in Colombo – At present and in foreseeable future and to address the spatial issue tiny house is most suitable due to low cost needed to build with in a smaller space.
- Tiny house towards a sustainable living solution in Sri Lanka – As a solution to the rapid deforestation, to meet a low budget, time and better quality and to meet the criteria for a sustainable living condition, Tiny house is suitable for Sri Lanka.

RECOMMENDATIONS

Government should make awareness of the Tiny House to the local public and promote to increase the number of Tiny houses in future. Mainly ideal for the tourism industry to facilitate more tourists in short time, since the western world is familiar with Tiny house it would be easy to adopt a life in Tiny house. And for dwellers who have low income, and unable to live a life under rent, Tiny house would be an ideal solution for them to have an own house with a very low life cycle cost. Also, to promote heavily, government could give away small chunks of land specifically to construct Tiny house from the large brown lands under government as a charity and also to save preserved land.

Real estate agents could look for existing brown land which is available for constructions rather than using green lands, that way the green lands would be preserved. Tiny house designers could increase when the concept is accepted by the public. And when government actively initiates Tiny House construction projects the contractors involved would have more awareness of the concept and thus more new projects could be done. Finally, if the Tiny house concept is successfully accepted and more demand is generated, the contractors have to be updated and would definitely by a stepping stone towards 'sustainable and healthy living style

LIMITATION

The research is limited to whether the already being used technologies to Tiny house in developed countries could be applied to Sri Lankan context.

FURTHER RESEARCH

1. Further research could be done on creating a Tiny House village (or community) where number of houses confined in a common boundary and live a community.
2. Further research could be done on applying the sustainable and tiny concept to other larger buildings, mainly to conserve space and resources.

3. Research on how the whole life cycle cost affects between a conventional house and a Tiny House towards sustainability

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A STUDY ON DESIGN AND BUILD PROCUREMENT METHODS' BENEFITS TO CLIENTS IN SRI LANKAN BUILDING CONSTRUCTION INDUSTRY

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A Study on Design and Build Procurement Methods' Benefits to Clients in Sri Lankan Building Construction Industry

ABSTRACT

Construction industry is playing a major role in Sri Lankan economy. There are number of procurement methods in the construction industry but Design and Build (D&B) procurement method has become the most innovative method over all the other methods due to special characteristics of it. Single-point responsibility, less project time and certainty of project cost are name to few.

This paper reveals main advantages of D&B method such as fixed time and cost, single-point responsibility and less risk allocation to the client. However, there are some drawbacks such as lack of knowledge of clients about industry, less consultants and incapacity of contractors.

This research is carried out through a literature review and a questionnaire survey. Through this paper successful factors of D&B and advantages in the perspective of clients has discussed which encourage the industry to use integrated procurement methods such as D&B.

Keywords: *Construction Industry; Design and Build; Procurement Method; Traditional Procurement.*

INTRODUCTION

There are number of publications and researches on the topic of procurement. Due to that there are quite a few definitions to the procurement (Love et.al. 1998; McDermott, 1999). Procurement can be mainly divided in to two sections 'Traditional method' and 'Non-Traditional method' (Idiake et al., 2015; Ojo et al., 2006: Rameezdeen and De Silva, 2002: Masterman, 2002).

As this paper mainly focus on D&B integrated procurement system, it can be defined as an arrangement where single contracting company obtains full responsibility (Figure 1) to design, engineering and construct the project as per clients' specific requirements(Joseph and Jayasena, 2008, Ng and Aminah, 2006; Masterman, 2002).

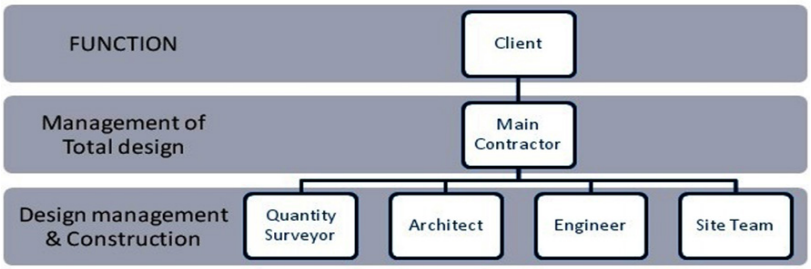


Figure 6: Single Point Responsible Structure of D&B Contract

Source: Ng and Aminah (2006)

Aim

Main focus of this research is to describe successful factors of D&B procurement method and encourage the industry to use integrated procurement methods such as D&B.

Objectives

1. To identify the connection between D&B procurement method and performance of D&B projects with regards to time, cost and quality metrics.
2. To do a comparison between D&B procurement method with traditional procurement methods.
3. To evaluate advantages and drawbacks of D&B procurement method and to propose guidelines.

LITERATURE REVIEW

The Clients do not have much confidence to use integrated procurement methods such as D&B. Therefore, it is important to discuss advantages, drawbacks, strengths and limitations of it in order to give proper idea on the subject to the Clients.

Connection Between D&B Procurement with Regards to Time, Cost and Quality

Time

From all of procurement methods there are some advantages of select D&B method to modern day construction (Joseph and Jayasena, 2008). The main purpose of having an integrated procurement approach is to minimize the project duration (Rameezdeen and De Silva, 2002; Xia and Chan, 2010). In D&B procurement system it is overlapping design phase with the construction stage (Turina et al. 2008).

Cost

In the D&B method client knows firmly project cost in the beginning (Ng and Aminah, 2006; Xia and Chan, 2010). Certainty of ultimate project cost in D&B method is higher than other kind of procurement strategies (Turina et al. 2008).

Quality

From the beginning of the project it is a main concern of each and every client to have a quality structure at the end of the project (Idiake et al., 2015). Ng and Aminah (2006) stated that D&B method has a better-quality control over the project by selecting the proper contractor who meets the expected quality standards of the client.

Comparison Between D&B Procurement Method with Traditional Methods

D&B is an integrated approach to overcome the difficulties of traditional procurement methods (Ng and Aminah, 2006; Joseph and Jayasena, 2008; Turina et al., 2008). This section will discuss some differences among D&B procurement method with traditional methods.

Single point responsibility and Design Responsibility

In D&B procurement method contractor undertakes the whole design and construction process of the project (Beard et al. 2001; Joseph and Jayasena, 2008). In this approach single organization will be responsible for the design, procurement, construction and commissioning (Wardani, 2004; Ng and Aminah, 2006). This can be described as single point responsibility of D&B method (Ng and Aminah, 2006; Turina et al., 2008; Xia and Chan, 2010).

Communication

Hence D&B procurement method having a single point responsibility the communication and co-operation also more efficient (Ng and Aminah, 2006; Turinaet al., 2008). Direct lines of communication between client and contractor allow the contractor to respond and to adapt more quickly to the client's needs. Client and contractor work together from the beginning of the project design stage and it gives opportunity to interact more often and directly than traditional method of procurement (Ng and Aminah, 2006).

Usage

As shown in the Table 1, when considering the usage of procurement methods in Sri Lanka, D&B method only had been second to measure and pay method of traditional approach (Joseph and Jayasena, 2008). Therefore, it can be identified as that D&B method also now getting popular (Kamala, 2000). Konchar and Sanvido (1998) mentioned that Design and Build procurement method has extraordinary growth in recent years.

Table 8: Trend of the use of Construction Procurement Systems in Sri Lanka

Source: Joseph and Jayasena (2008)

Procurement System	% Use (average)					
	1977 - 81	1982 - 86	1987 - 91	1992 - 96	1997 – 00	2001 – 03
Measure and Pay	55	50	58	50	64	72
Lump Sum	12	10	8	7	10	5
Prime Cost	10	8	5	4	3	1
Design and Build	22	31	28	35	21	22
Management Contracting	1	1	1	1	1	0
Joint venture	0	0	0	3	1	0
Total	100	100	100	100	100	100

Advantages and drawbacks

Advantages

According to previous studies, advantages of D&B procurement method can be summaried as follows.

Single point responsibility provides the client to deal with one organization. It reduces resources allocation and time significantly (Molenaar, 1996; Ng and Aminah, 2006; Turina et al., 2008). Because of overlapping of the design and construction process, overall project period can be reduced and will help effective project management (Lahdenpera et al. 1999; Rameezdeen and De Silva, 2002; Ng and Aminah, 2006; Turina et al., 2008). By accurately specifying clients' requirements the final project cost can be determined in the initial stage (Ng and Aminah, 2006; Turina et al., 2008; Joseph and Jayasena, 2008). Early approach of contractors' professionals to the project will provide more integrated and cost saving solutions (Ng and Aminah, 2006; Turina et al. 2008). D&B approach transfer more risk to the contractor by giving design responsibility as well as construction responsibility to contractor (Ng and Aminah, 2006).

Drawbacks

Not only advantages but also draw backs of D&B procurement method can be identified by reviving the previous works of researches.

Lots of clients don't have experience and technical knowledge in the construction. Therefore, the clients will face in difficulties when preparing proper and descriptive client brief (Joseph and Jayasena, 2008; Turina et al. 2008). Furthermore Turina et al. (2008) mentioned that the client has to commit to a concept design in early stage without any final design. As there is no bill of quantities provided by the client it is difficult to evaluate the bids and it will restrict the freedom of client to do future changes on design (Ng and Aminah, 2006; Turina et al. 2008). Moreover, Turina et al. (2008) has stated that relatively fewer firms provide the D&B facility. Therefore, the competition will be less among bidders and it will increase the final bid price. Generally, it is not recommended to use aesthetically important buildings because the client has less control over the design (Rameezdeen and De Silva, 2002; Ng and Aminah, 2006; Turina et al. 2008).

METHODOLOGY

Research Approach

Relevant data for the research collected was through the experience of people, their ideas and opinions. It is decided to use quantitative approach and analyze data using graphical illustrations to generate meaningful symbolic content. Quantitative approach had been used to collect data on this topic by using below mentioned data collection techniques.

Data Collection Techniques

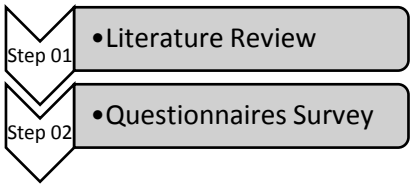


Figure 2: Steps of Data Collection

Survey data collection method can offer many advantages (Wardani, 2004). According to Simon (1969), by a questionnaire survey it can be asked number of questions at the same time and it increases the flexibility of the analysis.

Therefore, to collect data on the findings of the literature review it was planned to do a questionnaire survey (Figure 2). Hence this study had been decided to carry out in quantitative research approach where questionnaires survey was designed to collect qualitative data along with quantitative data which can be support to the findings of this study.

To collect relevant data the questionnaires were distributed among hundred professionals in the industry. Out of that sixty-one had been retrieved. Almost 61% respond rate. Those data have been analyzed and discussed below.

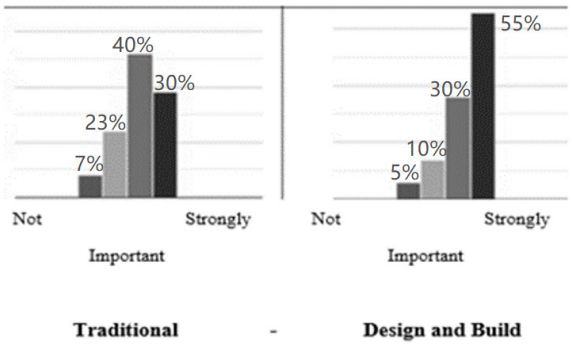
DISCUSSION

The questionnaire findings had been plotted in graphs to have better graphical view on the outcome. Moreover, using those data calculated the weight of each answer as percentage to get a quantum of it. The findings of those had been discussed below.

Criteria for The Selection of Procurement Methods

Time

- Project completion at estimated time & Minimization of construction time



As per the above graph project completion at estimated time and minimization of construction time is important for both procurement methods. But according to the graph D&B method have 55% weight on those while traditional method only scored 30%. Idiake et al., (2015) also had discussed that D&B have more possibility to project completion at estimated time.

Cost

- Project completion at estimated cost

When selecting procurement method, project completion at estimated cost is an important factor. As per analyzed data 90% of responds supported that, D&B method has possibility to complete projects at estimated cost and this has been discussed buy Turina et al. (2008).

Quality

- Quality Assurance

It is important to select a suitable procurement method which can provide the best quality assurance. From the responses 80% are in rage over highly important for D&B method whereas traditional method only having 65%. These have been proved in the findings of Idiake et al. (2015) Ng and Aminah, (2006) and Wardani (2004).

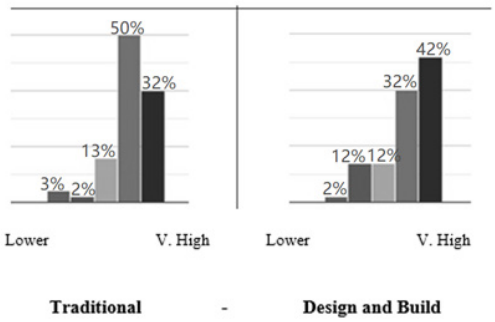
Other

High degree of control of the project, consultancy service offered, communication and co-ordination, complexity of design, nature of client, technical complexity of construction, associated risks, availability of information at project inception, nature of project and stake-holders management also can be considered as criteria for the selection of procurement methods. For all these factors response distributions had a similar nature. While traditional method has responses from not important to strongly important range, most of the D&B responses are in strongly important range. That means those factors are more sensitive in D&B method than traditional procurement method.

From all above it is justified that D&B is more suitable for clients when considering reducing time, cost and risk. Easy communication, single point responsibility and better control over the project gives more benefits to clients.

Factors Affecting the Performance of Procurement Method

- Financial risk



As indicated in the graphs it is clearly shown that traditional method has more effect of financial risk with total of 82% of responds on high to very high range. According to above graph D&B method have more certain project budget and it reduces the financial risk. Ng and Aminah (2006); Xia and Chan (2010) also have mentioned the same.

According to the responses of questionnaire survey, generally more than 50% of responds are in high to very high range for below factors as well. Therefore, it can be identified that contractor's experience, project type, size of contractor's organization, consultant's experience, flexibility of the procurement process to client changes, payment methods, capital cost of project, project size, client's contribution to design, adequacy of contractor resources, project manager's coordination and organizing skills, technology feasibility, degree of innovative technology, government policies, aesthetic appearance of the building also as affective factors for performance of procurement method. Therefore, it can be identified that these factors also have affect to some extend to the performance of procurement method. Waziri (2012) also have similar kind of result in the study on factors affecting project performance.

CONCLUSION AND RECOMMENDATIONS

Key Findings

This paper has highlighted the connection of D&B procurement method and its performance in connection with the time, cost and quality parameters. It has been found that D&B method has more positive features such as single point responsibility, less time consumption, easy management and less risks to the client.

Moreover, some factors were identified from the questionnaire survey as factors affecting to the performance of the procurement method. Financial risk, time management, alterations to design, complexity of project design, contractor's experience and project type are to name a few.

In addition to that, the D&B method has more advantages from client’s perspective when comparing with the traditional procurement method.

Conclusions

Main aim of this research was to identify successful factors of D&B procurement method. According to literature and questionnaires survey it can be concluded that D&B procurement method can provide best performance in time, more benefits in cost and better quality over traditional procurement method. Moreover, comparison between D&B procurement method with traditional procurement methods had been done through past literature as well questioner survey. It is evaluated that advantages of D&B procurement method and there are more advantageous to the clients rather than traditional methods. Thus, the evaluated advantages enhance the importance of application of D&B method in the construction industry.

1.1 Recommendations

According to the findings of the study, following recommendations were made.

1. Need to encourage the clients to select the D&B procurement method and the contractors must be encouraged to expand their capacity to develop their organizations to facilitate D&B projects.
2. Professionals such as project managers, architects, engineers and quantity surveyors need to be educated on integrated procurement methods such as D&B.
3. Moreover, consultancy firms also need to be expanding their services to achieve the requirements for D&B procurement without limiting traditional methods.

Limitations

As per the literature it was identified that, infrastructure development has captured more share of the construction industry. Even if this study was limited to building construction industry in Sri Lanka.

Even though there are collaborative method, management oriented and D&B methods in integrated procurement, this paper focused only on D&B procurement method.

Moreover, this study was discussed only the clients' benefits regarding cost, time and quality matrices. But there are more stakeholders in the construction industry which must be considered for further researches.

Furthermore, as only a very few numbers of professionals have expertise in the integrated project delivery methods such as D&B, it is very difficult to interview and gather the ideas and experience of those experts. Their busy schedule limits the resource parson's availability.

Further research

From the results of the research, it has been identified some other areas that require further research. Current research can be expanded in the following sections.

1. As this study based only on D&B method, it is recommended to carry out similar researches on collaborative procurement method and management-oriented methods.
2. Moreover, further researches can be done from the perspective of benefits to contractor and consultants through D&B procurement method.
3. As it is major concern of clients to select proper procurement method, by concluding qualitative and quantitative research it can be develop a "Decision Support Tool" for the clients.

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EFFECTS OF INTRAGROUP CONFLICTS IN CONSTRUCTION PROJECT TEAMS ON PROJECT DELIVERABLES DURING PRE CONTRACT STAGE

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Sub theme: Construction Management

EFFECTS OF INTRAGROUP CONFLICTS IN CONSTRUCTION PROJECT TEAMS ON THE PROJECT DELIVERABLES DURING THE PRE CONTRACT STAGE

ABSTRACT

Conflicts are inevitable among individuals, teams and organisations and in contractual relationships. The project teams set up in the construction industry to achieve specific goals comprise members from different professions. Project team is the core that holds the project together. The contribution made by each project team member has a significant effect on project deliverables. Conflicts among project stakeholders can significantly change the overall project outcome. Therefore, this study was focused on the intragroup conflicts that arise during the pre-contract stage of the construction projects executed in Sri Lanka and on the effects of those conflicts on project deliverables. The study, using a literature review and case studies, identified three main categories of intragroup conflicts and the constructive and destructive effects of those conflicts on the project deliverables during the pre-contract stages of the construction projects executed in Sri Lanka.

Key words: Intragroup Conflicts, Pre Contract Stage, Project Deliverables

1.0 Introduction

For a project to be successful, the contribution it receives from a multi-disciplinary team of professionals with appropriate levels of expertise will be critical (Khun-anod & Limsawasd, 2019). Thus, it is necessary to select for the team, professionals who are capable of understanding clearly the project objectives (Lines, et al., 2014). Even when the right type of professionals have been selected for the team, conflicts can still occur frequently in a construction project during the goal setting process because of the differences that exist among the objectives and values of the project participants (Afful-Broni & Tah, 2015; Yusuf & Anuar, 2014). The impacts of conflicts can be either destructive or constructive depending on the stages in which the conflicts occur and the type of the conflicts (Tjosvold, 2008). Conflicts can have contradictory impacts on decision making and project outcomes (Kinicki, Kreitner, & Cole, 2002; Omisore & Abiodun, 2014). They can help decision making by getting the parties involved to understand the conflicts and to be committed to implement the decisions made (Yirik, Yõldõrõm, & Çetinkaya, 2015). Conflicts can also affect decision making negatively by distracting the attention of the team members from the critical issues related to the project (Amason, 1996; Omisore & Abiodun, 2014). This contradiction arises because of the nature of these conflicts (Yazid, 2012).

In a construction project, the pre-contract stage is the most important stage as all the designing and developing work of the project is carried out during this stage (Lines, et al., 2014). Intragroup conflicts during the pre-contract stage can have unique effects on project deliverables and will generally be unavoidable (Curşeu, 2011). Thus, to mitigate the destructive effects of these conflicts and enhance their constructive effects on project deliverables, the investigation of the different types of intragroup conflicts and their impacts on each phase of the pre contract stage will be essential (Tjosvold, 2008).

2.0 Problem Statement

In the construction industry in Sri Lanka, many intragroup conflicts are observed among the professionals working in project teams. These conflicts can generate both constructive and destructive effects on project deliverables during the pre-contract stage. The identification of the different types of intragroup conflicts that can arise in the pre-contract stage of a construction project and the consequences of those conflicts can help to mitigate the destructive effects of the conflicts on project deliverables while enhancing their constructive effects. Many studies have been carried out on intragroup conflicts in projects and their effects on project performance. However, the effects of intragroup conflicts that can particularly arise in the pre contract stages of the construction projects executed in Sri Lanka and their consequences on the project deliverables have not been sufficiently investigated.

Thus, the aim of this study was to investigate the intragroup conflicts that can arise among project team members, in the pre contract stages of construction projects executed in Sri Lanka and their effects on project deliverables.

3.0 Literature Review

1. Intragroup Conflicts in a Team

'Intragroup conflicts' is the term used by researchers to describe the conflicts that occur among the members of a team (Thomas, 1992, p. 265). The nature of these conflicts is such that the conflicts and their impacts on a project can have diverse effects and those effects can be both destructive and constructive (Tjosvold, 2008; Yazid, 2012). Three types of intragroup conflicts have been identified in the past studies, namely task conflicts, relationship conflicts and process conflicts. A task conflict can be defined as a disagreement among group members or individuals about their decisions, viewpoints, ideas and opinions (Omisore & Abiodun, 2014). A relationship conflict is an interpersonal incompatibility, and causes annoyance and animosity among the individuals concerned (Jehn, 1995). On the other hand, a process conflict can be defined as a disagreement over the methods and procedures that can be used to accomplish a task. To be more specific, a process conflict will be associated with the allocation of resources; and duties and responsibilities to different people to accomplish a task (Thakore, 2013). Most of the past researchers have considered the three types of conflicts mentioned, as the main categories of intragroup conflicts (Omisore & Abiodun, 2014) that can often create negative effects.

2. Effects of Intragroup Conflicts

Project success can be measured using parameters such as delivery period, cost overruns and quality (Khun-anod & Limsawasd, 2019). The most common opinion about conflicts is that they are mostly unfavourable to project success (Amason, 1996; Omisore & Abiodun, 2014). Because of the dependence of the outcomes of the design phase on the final project planning, resource allocation and construction phase scheduling (Khun-anod & Limsawasd, 2019), conflicts can result in project delays and unproductivity leading to cost overruns, as explained by Amason (1996). These destructive effects of intragroup conflicts significantly impact on the project deliverables of the design phase of a project.

Some past researchers believe that intragroup conflicts generate both negative and positive outcomes (Tjosvold, 2008). Project accomplishment, team satisfaction and team performance can get influenced by some of the impacts of conflicts (Yirik, et al., 2015). Furthermore, some conflicts have positive characteristics, which will enable commercial risk taking, the basis of free enterprise and competition (Omisore & Abiodun, 2014). Therefore, the type (negative or positive) of the impact of the conflict will depend on the method of addressing and managing the conflict (Omisore & Abiodun, 2014; Tjosvold, 2008; Yirik, et al., 2015). The management of intragroup conflicts in a construction project should be considered during the pre-contract stage, which is the initial stage of the project (Yazid, 2012).

3. Pre Contract Stage of a Construction Project

According to Khun-anod and Limsawad (2019), for the successful completion of a construction project, a thorough understanding of all the stages and phases of the project is required, while project success can be enhanced by integrating the design and construction during the pre-construction stage. According to the RIBA plan of work, pre contract stage consists of three main stages, namely initiation and feasibility stage; pre contract scheme design stage; and pre contract tender and contract stage. The initiation and feasibility stage delivers project deliverables such as feasibility designs, budget estimates, feasibility reports and the preliminary project programme, whereas the pre contract scheme design stage delivers project deliverables such as determining the contract type, making proposals for the feasibility options, conducting meetings with the client to determine the preferred design and any alterations required, revising the budget estimate and informing the client about it and holding preliminary discussions with planners. The project deliverables of the pre contract stage relate to inviting tenders with a specific

return date; receiving tenders on the due date and not opening late tenders; and preparing the tender report for the client.

4.0 Research Methodology

Yin (2009) indicated that a research method of a study should be selected according to the research problem and that five different types of research approaches can be adopted in a research: experiment, survey, archival analysis, case study and history. To determine the effects of intragroup conflicts in construction project teams on the project deliverables during the pre-contract stage, the behavioural nature of construction projects had to be studied. The unit of analysis had to be the design team of the project. Therefore, a case study research approach was selected for the study. According to Yin (2009), the number of cases in a case study could vary from one to eight depending on the nature of the study. For the case studies of this study, four leading Sri Lankan building construction projects, which had both in-house design teams and inter-organisational design teams involved in the pre contract stages, were selected and the data required were collected using semi-structured interviews. The key role players in the design team of each project were interviewed and the data collected were analysed through cross analysis and content analysis. Table 1 below presents the details of the four cases and the details of the professionals who were interviewed.

Table 9: Details of the cases and the interviewees

Interviewee Code (IC)	Designation	Professional Designation/ Qualification	Experience in Years
CASE A – Hotel Project with an Inter-organizational Design Team (Client -Private Party) – Rs. 210 Million Project			
IC-A-01	Project Architect	Chartered Architect	12
IC-A-02	Project Manager	B.Sc. in Engineering	15
CASE B – Office Complex Project with an In-house Design Team (Client -Government) - Rs. 700 Million Project			
IC-B-01	Project Architect	Chartered Architect	10
IC-B-02	Project Quantity Surveyor	Chartered Quantity Surveyor	6
CASE C – School Building Project with an Inter-organizational Design team (Client - Private Party) - Rs. 42 Million Project			
IC-C-01	Project Architect	Chartered Architect	19
IC-C-02	Project Quantity Surveyor	Chartered Quantity Surveyor	8
CASE D – Library Building Project with an In-house Design Team (Client -Government) - Rs. 102 Million Project			
IC-D-01	Project Architect	Chartered Architect	13
IC-D-02	Project Quantity Surveyor	Diploma in Quantity Surveying	15

4.0 Research Findings and Discussion

The research findings are discussed under two categories: types of intragroup conflicts in the pre contract stages of the construction projects executed in Sri Lanka and the effects of those conflicts on the project deliverables of the pre contract stage.

1. Types of Intragroup Conflicts in the Pre Contract Stage

From the literature, several intragroup conflicts that could arise in the pre contract stages of construction projects in other countries were identified under three main categories, while their applicability in Sri Lanka was verified through the interviews conducted with the experts. Table 2 presents, under three categories, the different types of conflicts that were identified. Intragroup conflicts that were not mentioned in the literature but presented by the experts who were interviewed, such as disagreements on over time and scheduling; disagreements about arranging meetings; anger that arises in team members while working as a team; negative remarks made about one another by team members and the tension caused by the team members are highlighted.

Table 10: Different types of intergroup conflicts

CAUSE OF CONFLICT	Literature	Case A		Case B		Case C		Case D	
		IC-A-01	IC-A-02	IC-B-01	IC-B-02	IC-C-01	IC-C-02	IC-D-01	IC-D-02
PROJECT PROGRAM AND PROCEEDINGS (PROCESS CONFLICTS)	√	√	√	√	√	√	√	√	√
Disagreement on the distribution of responsibilities and delegation of tasks	√	√	√			√	√	√	
Disagreement about work methods and approaches	√	√	√	√	√	√	√	√	√
Disagreement on over time and scheduling		√	√	√	√	√	√	√	
Disagreement about not completing the assigned tasks on time	√		√	√	√	√	√	√	√
Disagreements about arranging meetings						√	√	√	√
RELATIONSHIPS BETWEEN TEAM MEMBERS (RELATIONSHIP CONFLICTS)	√	√	√	√	√	√	√	√	√
Incompatibilities among interpersonal relationships	√	√	√	√					
Anger that arises in team members while working as a team		√	√	√	√				
Personality clashes among team members	√	√				√	√	√	
Negative remarks made about one another		√	√	√		√	√	√	√
Tension caused by the team members		√	√	√	√				
TASKS, RESOURCES AND INTERPRETATIONS (TASK CONFLICTS)	√	√	√	√	√	√	√	√	√
Disagreement about the decisions	√	√	√	√	√	√	√	√	√
Disagreement on viewpoints, ideas and opinions	√	√	√	√	√				√
Disagreements about the procedures and policies	√	√	√			√	√	√	
Disagreement on the judgments and interpretation of facts				√	√				

2. Effects of the Intragroup Conflicts in the Pre Contract Stage

Both the literature findings and the semi structured interview findings indicate that each intragroup conflict that can occur in the pre contract stage can affect one or more project deliverables of the stage. Most of the effects, namely delay in completing the project brief; difficulties experienced in getting approval for the budget and the delay in completing the design and maintaining the design integrity have a negative impact on the project deliverables, They, however, have certain positive effects as well on the project deliverables, such as improving the buildability of the products. Table 3 presents the different effects of intragroup conflicts in construction project teams on the project deliverables during the pre-contract stages of the projects executed in Sri Lanka. The effects that are highlighted are a result of the intragroup conflicts mentioned by the experts at the semi-structured interviews. These conflicts were not mentioned in the literature.

Table 11: Effects of intergroup conflicts on project deliverables

Project Deliverables of the Pre contract Stage	Process Conflicts	Relationship Conflicts	Task Conflicts	Literature	Case A	Case B	Case C	Case D
Project brief		***Incomplete project brief***	***Poor buildability***		√	√	√	√

Outline proposals	Delay in getting budgetary approvals			√	√	√	√	√
Schematic design		***Difficulties of maintaining design integrity***	***Buildability issues***		√			√
Preliminary budgeting	Delay incurred due to incomplete designs	Inaccurate budgeting	***Buildability of the products***	√	√	√	√	√
		Insufficient information available for budgeting		√	√	√	√	√
		Multiple revisions		√	√		√	√
Detail design		***Erroneous design***	***Buildability of the products***		√		√	
			Cost effectiveness of the design					
Detailed estimating	Delay in getting budgetary approvals	Inaccurate budgeting	Cost effectiveness of the design	√	√	√	√	
	Delay due to incomplete designs	Missing information	Delay in finalizing the documents	√	√	√	√	√
		Multiple revisions	***Time overruns experienced in finalizing the estimate***		√	√	√	√
Specifications		***Incompatible construction methods***	***Buildability of the products***		√	√	√	√
Bills of quantities		Unnecessary provisions	Delay in finalizing the documents	√	√	√	√	√
Tender documentation		Cost increase due to unnecessary provisions		√				√
Tender process		***Tender queries***					√	

Intragroup conflicts have several negative and positive effects on the project deliverables of the pre contract stages of the construction projects executed in Sri Lanka. For example, the task conflicts that occur in the schematic design or detail design phase have positive effects, while the relationship or process conflicts in the same stage have negative effects. The effects of the conflicts can significantly change the outcome of the pre contract stage. Some of the effects on the project deliverables, such as the buildability of the products, inaccurate budget, cost effective design and multiple revisions, can be considered common to all types of intragroup conflicts (Table 3). However, the number of negative effects is higher than the number of positive effects.

6.0 Conclusions

This study focused on the effects of intergroup conflicts in construction project teams on project deliverables during the pre-contract stages of projects. The pre contract stage of project life cycle makes a significant contribution to the final project outcome. The scope, goals, targets of the project and the outcome of the project are defined at this stage. In the projects in the construction industry, professionals from different fields have to get involved as a team to achieve the specific goals of the projects. Project team is the core group that leads the project. The contribution of each member of the project team has a significant effect on project deliverables. According to the literature findings, conflicts can arise even with a good team for various reasons, such as resource scarcity, knowledge gap,

attitudes and ideas. These intragroup conflicts can be constructive or destructive. Constructive conflicts will lead the project to a successful end, while destructive conflicts will delay or even prevent the achievement of project goals. The intragroup conflicts that occur during the design stage of a construction project are generally challenging.

The literature survey revealed, in general, the intragroup conflicts in construction project teams and the effects of those conflicts on the project deliverables during the pre-contract stage, while the semi structured interviews revealed the conflicts and their effects that are specific to construction projects in Sri Lanka. According to the findings, conflicts can cause negative effects as well as positive effects on the project deliverables of the pre contract stage of the projects executed in Sri Lanka. These effects can considerably change the outcome of the pre contract stage. The negative effects, however, outnumbered the positive effects.

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MANAGEMENT OF FINANCIAL DIFFICULTIES FACED BY SUB CONTRACTORS IN BUILDING CONSTRUCTION SITES IN SRI LANKA

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MANAGEMENT OF FINANCIAL DIFFICULTIES FACED BY SUB CONTRACTORS IN BUILDING CONSTRUCTION SITES IN SRI LANKA *ABSTRACT*

The construction industry has a great scope which includes a wide range of activities. Mega and infrastructure projects are not undertaken by sub - contractors alone. According to the nature of the risks, the risks can be categorized. Mainly, this study aims to study the management of financial risks faced by subcontractors. Even though most researchers have done many studies about issues such as financial difficulties, payment delays, etc., specifically they have a concern about mitigation of financial difficulties of sub-contractors. The aim of the study is, therefore, to propose a suitable method to minimize the financial risks faced by sub-contractors. According to the overall responses, some of the major causes of financial risks were identified as unstable financial background of the contractors, poor financial and business management of the clients, fewer chances in getting loans from financiers, and inflation. According to findings, all contractors face a huge problem and challenge in maintaining their cash flows healthily at all phases of their projects. Contractors have to check and identify the gaps or huge discrepancies between the actual and forecasted cash flows, and then the necessary adjustments should be made as early as possible.

Keywords: Cash flow; Contractors, Financial risk, Sub - Contractors.

1.0 INTRODUCTION

A targeting approach of risk management of the reduction of risk and the finance of the risk to different risk layers, including a layer that a possible limit to adaptation is represented and suggested by them. Linnerooth & Stigler identified the procedure that the finance of the risk can complement and stimulate risk reducing by reviewing the traditional post-disaster arrangements of finance (government compensation), and non-traditional pre-disaster instruments.

Antón, Rodríguez, & López (2011) defined construction projects' risks as the probability of an event that impairs the project's viability. Furthermore they identified that the identification, classification and analyzation of the risks which are most sussed inherent in large engineering or construction projects, with particular attention to the economic risks and developing's group finally a conclusion in this regard are aimed .

2.0 LITERATURE REVIEW

2.1 IMPORTANCE OF CASH FLOW

Cash flow means the process of cash moving in and out as income and expenditure within a particular period. If the income of the business is higher than its expenditure, it is called as "positive cash flow," and the opposite of it is called a "negative cash flow" As explored by previous studies it was identified that it is very important for the contractors and sub-contractors to manage and handle the cash flow of construction projects.

2.2 FINANCIAL RISK WITH THE CONTRACTOR

In a previous research which was done by Rahman, et al., (2011) it was concluded that when compared to other risks, financial issues are at a higher level of risk. It can directly impact the progress of the project seriously. This will eventually may badly affect the country's economy. If there is a shortage of finance, there can be failures in project implementation, and also a bankruptcy situation may be resulted (Al-Joburi, et al., 2012).

Al-Joburi, et al., (2012) further stated some contractors and sub-contractor perform well during their project implementation by managing the cash flows using their strategies intelligently. Further, they complete the project on time without being interrupted by negative cash flows). Rahman, et al., (2011) stated , some of the major causes of financial risks were identified as unstable financial background of the contractors, poor financial and business management of the clients, fewer chances in getting loans from financiers, and inflation.

2.3 IDENTIFIED FINANCIAL DIFFICULTIES

FROM THE LITERATURE REVIEW improper planning of cash flow management of s***UBCONTRACTOR*,** frequency of meet an i***N*-**experienced s***UBCONTRACTOR***, the usualness of facing cash flow issues by the main contractors, the usualness of paying on time to the sub contactors, bankruptcies of the partner(s), the geographical area of having most experience and types of projects have mostly involved are identified as the financial difficulties.

2.4 IDENTIFIED FACTORS AFFECTING THE FINANCIAL DIFFICULTIES

From previous studies following factors were identified as factors affecting the financial difficulties.

Complexity and dynamic environments, uncertainty and risk in the projects, Unclearance about allocations of some taxes of payments as responsibilities, tightness of the schedules, Construction techniques, the scope of the work and organization changing, Lack of knowledge in funding utilization, failure to generate income from the bank by the client, Respect & trust of each party, changing fear, agreeing on the communication of groups, Retention percent larger, releasing retention delaying, Interim evaluation, certification, and final payment delaying, Rates of inflation and exchanging, fluctuations of the prices, design changes, the inability of repayment debts of the other parties, New legal framework need, lack of understanding of the contractual language, Scarcity of capital to finance the project, Lacking new, creative ideas and supportively by the structure of the organization, over-focusing on managing the risks, No fixed progress payment duration, Political, sociocultural, economic, natural and other factors, Possible delays on payments and budget constraints, Quality and on time performance of the contractor, Management of information and knowledge systems integration, lack of accurate planning, Not having a process of implementation properly, The productivity of the labour lacking and Site condition, technical and contractual risks.

3.0 RESEARCH METHODOLOGY

Considering the in-depth investigation required in this study, mixed method approach was selected for this study. Data were collected using questionnaire survey and expert interviews. Interviewees were selected using random sampling method. As the 1st stage, a questionnaire survey was prepared by using the knowledge get from background study and the literature survey. Both qualitative and quantitative were collected by using this questionnaire. And also, both open-ended and close-ended questions were included for the expert interview and the general questionnaire survey.

Accordingly, 30 professionals from different levels were selected as the sample through personally made requests. Consequently, 9 Project Managers, 11 Civil Engineers, 7 Quantity Surveyors and 3 Others contribute to this research.

The pilot study was conducted with ten respondents of the research including the subcontractors in Colombo district who were engaged in the building construction.

The collected data were analysed by qualitatively and quantitatively. Accordingly, Microsoft Excel was used for the quantitative analysis, and the content analysis was used to analyse the qualitative data to the qualitative analysis. The method that used to analysis was “Percentage Analyse method” and also, “Mixed method” with “Unilateral analysis”.

4.0 ANALYSIS AND RESEARCH FINDINGS

Analysis of questionnaire data revealed important facts. These are presented under 7 themes.

4.1. OVERVIEW OF THE FACTORS AFFECTING TO THE FINANCIAL DIFFICULTIES

This part reveals an overview on factors affecting to the financial difficulties faced by the subcontractors by analysing data and supportive details provided by the respondents.

Improper planning of Cash Flow Management of Subcontractor - Majority of the respondents accepted that there is improper planning of cash flow management of sub-contractors.

Frequency of meet an In-Experienced Subcontractor - Majority of the respondents have experienced of any improper cash flow management of subcontractors in weekly. Second highest respondents have experienced of improper cash flow management of subcontractors monthly. The least number of respondents have had them “Once in six months”.

The Usualness of facing cash flow Issues by the main contractors - In general scenario, some main contractors are facing cash flow issues when doing the work. Therefore, the respondents has agreed with this.

The Usualness of paying on time to the Sub contactors – Majority of the respondents said that main contractors are paying on time usually.

Any bankruptcies of the Partner(s) – Majority disagreed with this. That reason behind this is sometimes there are some bankruptcies happen with one project partner or some project partners.

The Geographical Area of having Most Experience – Majority of the respondents to this research have worked in Western province. And rest of the respondents have worked in different other areas.

Types of projects have mostly involved – Most of the respondents to this research were involved in Building Constructions (Large Scale) And the rest of the respondents have involved in Irrigation and Water Supply projects.

4.2 OVERVIEW OF RANKING IN ACCORDANCE WITH THE IMPORTANCE OF EACH DIFFICULTY

With relevant to the data gathered form literature review some difficulties have been found and the respondents of the questionnaire had to rank these difficulties according to their opinion and the importance of them.

- Accessibility restrictions and Regulations of site location, Bankruptcy of Project Partner, Compensation Structure, Type of Business Sector – With the responses of the questionnaire survey it is proved that there is less importance for this issue.
- Bank Strict Regulations, Lack of the Capital or Alternatives, Wrong Audit Calculations - Respondents ranked moderately by giving some importance for this issue.
- Delay on the Progress Payment, High Daily Expenses, Inability of repay the debts, Limited Equity of the Owner, Price Fluctuation – According to the respondents it seems to be these issues are more important.
- Low Profit Margin due to Error Production, Restrictions of Regulatory Bodies, Poor Cash Flow Management - According to the respondents it seems to be these issues are important.

4.3 OVERVIEW OF THE SUITABLE STRATEGIES TO MINIMIZE THE FINANCIAL DIFFICULTIES

With reference to the finding of the literature review 13 strategies are given in the questionnaire and they are presented below with the responses.

- **Lack of the capital or alternatives -** Most of the respondents said that the "Influence the Chances of Loans Acquisition" is the suitable strategy for this difficulty.
- **Poor cash flow management** – Majority of the respondents agreed that suitable method for this difficulty is "The Critical Path Method(CPM)". Also respect
- **Delay on the progress payment –** According to the respondents' suitable strategy is the "Financed Based Scheduling" for this issue. And also respectively, the "Program evaluation" and "Cash Flow at Risk(CFaR)" also can be used.
- **Price fluctuation -** For this difficulty according to the respondents the Suitable mitigation method is "Time Series Analysis".
- **Accessibility of the site –** Respondents suggested suitable mitigation method for this difficulty is "Program Evaluation" method.
- **Type of business sector -** Respondents suggested suitable mitigation method for this issue is the "Financial-Based Scheduling" method.
- **Limited equity of the owner -** Respondents suggested that there are two methods that is shown as suitable method to minimize this issue, such as; the "Influence the Chances of Loans Acquisition" and the "Financial-Based Scheduling" method.

- **Inability of repay the debts -** Respondents suggested suitable by the respondents as the "Financial-Based Scheduling" method.
- **High daily expenses -** In order to mitigate this issue, respondents suggested that there are three methods that respondents said such as; "Cash flow at risk (CFaR) model", Review technique (CPM/PERT) and "Financial-based scheduling".
- **Compensation structure -** Respondents suggested for this issue also there are three suitable methods that the respondents said as; "Program evaluation", "Financial-based scheduling" and "The critical path method".
- **Low profit margin due to error production -** Respondents suggested for this issue there is only one method highlighted as the suitable method as "Minimize their profit margins".
- **Wrong audit calculations** – According to respondents there is one method said by the majority as "Cash flow at risk (CFaR) model" for the issue. And also second largest respondents said that as "Financial-based scheduling" method.
- **Bankruptcy of project partner –** As per the respondents there is one method said by the majority as "Program evaluation model" for the issue. And also, second largest respondents said that as "The critical path method" method.
- **Bank strict regulations -** As the previous two issues, here also the majority of the respondents said that "Cash flow at risk (CFaR) model" is suitable. And also, second highest number of respondents said that "The critical path method" also good.
- **Restrictions of regulatory bodies –** Majority of the respondents highlighted one suitable method for this issue as; "Program evaluation". Moreover, second highest respondents said "The critical path method" can be recommended.

5.0 CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

5.1 CONCLUSIONS

With reference to above findings in conclusion, out of fifteen difficulties the most critical financial difficulty, which the majority of the respondents are facing is "Delay on the Progress payment". Secondly, "High Daily expenses" are mentioned.
Furthermore, seven factors are presented mainly as factors that affecting to the financial difficulties. According to the respondents, majority of them have experiences of improper planning of cash flow management of subcontractors.
Thirteen strategies are presented as the strategies to minimize the financial difficulties from the literature findings. Ultimately, based on the all respondents some of the suitable strategies are "Influence the chances of loans acquisition" is to the "Lack of capital and alternatives", "Financial-based scheduling" is to the most critical difficulty "Delay on the progress payment" as per the respondents. Therefore, as the response for the research question, it is possible to propose the subcontractors to use those suitable strategies for their projects for those mentioned financial difficulties when arise.

5.2 RECOMMENDATIONS

It can be recommended to have more experienced subcontractors every timefor the works, due to their maturity, about the cash flow management especially.
And also, giving adequate training about those mitigation strategies from the matured staff members should be done regularly and monitor that.
By using those strategies, they can mitigate that financial difficulties to some extent only. Therefore, further research is required for this area in the future also.

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THE READINESS OF ADOPTING AUTOMATION AND ROBOTICS TO SRI LANKAN CONSTRUCTION INDUSTRY

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The Readiness of Adopting Automation and Robotics to Sri Lankan Construction Industry

ABSTRACT

The applications of automation and robotics have been extended in numerous fields in healthcare, transportation, security, agriculture and manufacturing. Generally, construction industry consists of frequent issues such as higher wastage, low productivity, scarcity of labour and parlous working conditions. This research was aimed to assess the readiness of adopting automation and robotics to Sri Lankan construction industry to overcome above issues. Preliminary interviews were conducted after a comprehensive literature review to refine identified facilitators and barriers towards implementing automation and robotics and thereafter questionnaires were distributed to investigate the readiness of adopting automation and robotics in Sri Lankan context. Research findings of this study emphasized that, Sri Lankan construction industry is still not ready to implement automation and robotics in construction applications. Further the research was recommended to the relevant authority to implement policy direction towards adopting automation and robotics in Sri Lanka.

***Keywords**: Automation; Autonomous Machines; Construction Automation; Robotics*

INTRODUCTION

The evolution of automation had begun from the field of mechanization, which expanded from the industrial revolution, and today its applications are broadly in use on many industries (Groover, 2018). In modern world several fields such as healthcare, transportation, security, agriculture, manufacturing and energy were able to replace majority of its activities with autonomous machines and robots (Goldberg, 2012). Construction industry is still lagging from other industries in terms of productivity, quality assurance, safety and delays. Also, in Sri Lanka, there is a scarcity of labour in construction work sites since most of the construction labour are seasonal workers who are working on a seasonal basis. At a time where the world moves from labour intensive techniques to robots and autonomous machines, it is time to move towards construction automation to overcome the issues in Sri Lankan construction industry as well. Mostly, placement of concrete sidewalks, curbs and gutters, assembling of building interior partitions, closing pavement cracks, bending and assembling of metal pipes, automatic excavation around buried metallic pipes have been done using autonomous machines and robots in developed countries (Skibniewski, 2012). Adopting automation and robotics to construction industry will offer several benefits including enhancing quality and productivity, reduce delays, performing jobs beyond human capabilities, reducing safety hazards, reducing human errors, and shorten the construction process.

Even though Skibniewski (2012) conducted a research on construction automation and robotics to American context, Hasegawa (2006) to the Chinese context and Mahbub (2012) conducted a case study in Malaysian region, in Sri Lanka it has not been investigated yet. Hence this research was aimed to assess the readiness of adopting automation and robotics into Sri Lankan construction industry.

LITERATURE FINDINGS

WHAT IS AUTOMATION AND ROBOTICS

Converting operations from human-based process to an automated or mechanized process can be defined as automation (Arora & Gupta, 2009). Furthermore, Arora & Gupta (2009) had identified that automation can be achieved with or without human interaction which follows a pre-programmed series of actions using specialized equipment, machines and devices that may control the whole process of automation. As defined by Schaefer, Billings, & Hancock (2012) robot is a form of human which can perform same tasks as walking, running and jumping that are done by human beings. The advanced machines which have such competencies like re-programmability, autonomy, flexibility and situational awareness in the present world are also called as robotics systems (Linner, 2013).

ADVANTAGES AND DISADVANTAGES OF AUTOMATION AND ROBOTICS

Previously conducted researchers have identified numerous advantages and disadvantages of adopting automation and robotics over the conventional construction process in the construction industry as shown in the following table 1. Cho, Haas, Liapi, & Sreenivasan (2002) stated remote operations can be easily performed through implementing automation and robotics rather than performing by the labour. Haight & Kecojevic (2005) pointed out adopting automation to the construction industry will reduce the errors and enhance the efficiency of the work while making the work more reliable than being carried out by the labour. Moreover, having robots on construction sites is a one-time investment and it will result in no unions, no healthcare cost and insurance cost for company but just maintenance costs (Ruggiero, Laurent, & Salvo, 2016). Unlike the human being, several automated machines proceed in a pre-programmed sequential manner where it cannot make its own judgments or change according to the situation (Haight & Kecojevic, 2005). Moreover, according to Arora & Gupta (2009), replacing jobs with automated machines will be a threat for the job opportunities in the market. Requirement of huge space for mobility of autonomous machines and negative attitudes and reliability issues of workers will be the other drawbacks of converting traditional construction process into automated environment (Pachon, 2012).

Table 12: Advantages and Disadvantages of Automation and Robotics

Advantages	Disadvantages
Increasing the quality of work	Higher initial investment
Increasing the productivity	Cannot make any judgment
Increasing the safety conditions at site	Loss of job opportunities
Reduce the time for completion	Limited space for mobility
Can address skilled labour scarcity	Negative attitudes to change by workers
Reduce wastage in construction	
Can produce wide variety designs and objects	
More Reliable construction	
Enhance the efficiency of the work	
Reduce errors	
Effective use of resources	
Ensure the continuous work	
Enhance remote operations	
Minimize the harmful effect on environment	

USE OF AUTOMATION AND ROBOTICS

Gambao & Balaguer (2002) stated that, the concept of automation and robotics can be applied to civil engineering constructions such as tunnels, bridges, water supply schemes and road constructions. The idea of inspection robots came into the developer's mind after the Three Mile Island disaster and currently these robots are widely used for tunnel inspections, superstructure and underwater bridge inspections, roadway inspections and storage tank inspections (Lattanzi & Miller, 2017). As described by Montero, Victores, Martínez, & Balaguer (2015), robotic tunnel inspection system was able to replace the manual tunnel inspection due to the downsides in manual process such as discomfort, risk, dusty environment, lack of light and exposure to toxic substances. According to Lattanzi & Miller (2017) UAVs (Unmanned Ariel Vehicles) can be used for aerial inspection whereas UMVs (Unmanned Marine Vehicles) can be used for underwater inspections. Further, with the use of Hume pipe installation robots, pipe laying task can be carried out more efficiently (Linner, 2013).

The concept of automation and robotics can be applied in building constructions such as masonry works, interior finishing works, fixing and installation works and progress monitoring. According to Han (2011), automated robot excavators, brick handling and bricklaying robots, demolishing robots, panel handling robots, curtain wall installation robots, ceiling installation robots, maintenance robots, concrete floor finishing robots, painting robots are several examples for automation and robot applications in building construction. Ground Penetrating Radar System can be used to identify the geological properties and underground profile, including live wires, rocks and pipelines of the site before starting any work (Momin, Nale, & Pati, 2015). According to Chu, Jung, Lim, & Hong (2013) robot-based construction automation has been used in high-rise buildings for steel beam assembling as well. According to Kodithuwakku (2019), SAM 100 is one prominent example for world's first commercially available robot for onsite masonry construction. Hadrian 105 is an industrial robot which can complete the brickwork on its own without any human intervention where its productivity is 225 bricks per hour which is four times more than a mason (Nathan, Paul, Achim, & Justin, 2017). Meanwhile, Carnegie Mellon University has developed a completely autonomous system for bulk excavation and loading the excavated material including a laser range finder to identify the location of the trucks and detect the obstacles (Vaha, Heikkila, Kilpelainen, Jarviluoma, & Gambao, 2013). ODICO formwork robotic can now fix the formwork with a higher degree of accuracy in a short time period using its hot wire cutter unlocking complex designs by addressing time consumption and costly process of formworks (Kodithuwakku, 2019). Furthermore, Japan has developed several concrete floor finishing robots and those are available in the international market as well (Vaha, Heikkila, Kilpelainen, Jarviluoma, & Gambao, 2013). Beyond the confines of construction activities, automation applications have now been prolonged up to site inspection and progress monitoring comparing with the design models and programs (Park, Lim, Kim C, & Kim H, 2013). Today dumping trucks have been replaced by autonomous dumper robots like 'Volvo HX 01' at the sites facilitating efficient work than humans (Kodithuwakku, 2019). According to Ryumin, et al. (2019) 'effibot' can be used as an on-site material and tools travelling trolley which guides the workers to their working location.

CURRENT LEVEL OF APPLICATION OF AUTOMATION AND ROBOTICS IN SRI LANKA

In recent years, automation and robots have been applied at construction industry to coordinate collaborative behavior and providing a powerful basis for applications of complex nature (Karunasena, Amarathunga & Haigh, 2008). Even though construction industry has been able to contribute an amount of more than ten percent of Gross National Product of the country's economy, having conventional construction in the industry may result lagging behind the other industries in terms of productivity (Chen, Soto, & Adey, 2018). Recently, researchers have shown that the productivity has been dropped in construction industry in Sri Lanka during the past decade in compared to other industries (Karunasena, Amarathunga & Haigh, 2008). Even though Bock (2015) argued that construction automation and robots can address the matters regards to skilled-labour shortages, declined productivity, increased costs, unsafe working conditions, and quality control; at present Sri Lankan construction industry is not using single application of automation or robotics due to lack of technology and money. Therefore, this research was assessed the overall readiness of implementing automation and robotics in Sri Lankan construction industry.

RESEARCH METHODOLOGY

Based on the aim and objectives of the research, number of respondents are needed to refine the literature findings in qualitative manner. Meanwhile, construction stakeholder's quantitative response is much needed to identify the overall readiness to implement automation and robotics in Sri Lankan construction industry. Hence, mixed approach is the most appropriate research approach to this research. Preliminary interviews and questionnaire surveys were selected as data collection techniques and four preliminary interviews were carried out with four industry experts who has more than 25-year experience. CS2 contractor organizations were selected as the sample for questionnaire survey through convenience sampling technique. Questionnaire survey was conducted among forty individuals which consists of Civil Engineers, Mechanical Engineers, Project Managers and Quantity Surveyors who are conversant in automation and robotic technology. Out of forty, thirty-one respondents were responded to the

questionnaire survey providing 77.5% of respond rate. Thereafter, content analysis and statistical analysis [relative importance index (RII), mean rating (MR) and criterion suitability score (CSS)] were used to analyze the collected data through above methods.

RESEARCH FINDINGS AND ANALYSIS

OVERALL READINESS OF ADOPTING AUTOMATION AND ROBOTICS TO THE CONSTRUCTION INDUSTRY IN SRI LANKA

Initially, facilitators and barriers were identified through literature review which may impact towards implementation of automation and robotics. In addition to above found list, some more factors were identified and validated to Sri Lankan context through preliminary interviews. Then based on the validated factors, questionnaires were distributed in order to measure the level of importance and availability of each factor within respective organizations. Accordingly, relative importance index (RII), mean rating (MR) and criterion suitability score (CSS) values were calculated for each factor and ranked accordingly based on their importance. Following table 2 represents the facilitators to adopting automation and robotics to the construction industry in Sri Lanka and listed based on the ranking. Facilitators which are labeled with asterisk mark were identified through preliminary interviews.

Table 2: Facilitators to adopting automation and robotics to the Sri Lankan construction industry

Facilitators	RII	MR	CSS	Rank
Employees willingness to work with the new environment	0.78	11.06	8.63	**1**
Top management support	0.89	9.39	8.39	**2**
Include 21st-century skills and knowledge in Company strategies	0.84	9.71	8.14	**3**
***Training and development on automation and robotics**	0.72	10.35	7.48	**4**
Availability of experts within the organization	0.85	8.48	7.22	**5**
Targeted re-training programs for the labour force	0.77	9.06	7.01	**6**
Data protection laws	0.72	9.52	6.88	**7**
***Availability of utilities (hardware and software)**	0.90	7.45	6.68	**8**
Integration of 21st-century skills and knowledge in curricula of employees	0.79	8.35	6.63	**9**
Cyber security strategy	0.75	8.61	6.44	**10**
Availability of high-speed internet	0.67	8.4	5.64	**11**
Total CSS value of facilitators			**79.15**	

Based on the above table, employee's willingness to work with the new environment is the most conductive facilitator towards implementing automation and robotics in construction industry with a CSS value of 8.63. Top management support and including 21st-century skills and knowledge in company strategies were second and third most conductive facilitators with a CSS value of 8.39 and 8.14 respectively. Moreover, the least conductive facilitator is "availability of high-speed internet" with 5.64 CSS value.

Following table 3 represents the barriers to adopting automation and robotics to the construction industry in Sri Lanka and listed based on the ranking. Barriers which are labeled with asterisk mark were identified through preliminary interviews.

Table 3: Barriers to adopting *automation and robotics to the* Sri Lanka*n construction industry*

Barriers	RII	MR	CSS	Rank
***Lack of confidence by the employees**	0.68	14.81	10.03	**1**
Possibility of virus attacks	0.85	11.52	9.73	**2**
Lack of skilled work force within organization	0.77	11.71	8.99	**3**
Employees negative attitudes to change	0.73	12.10	8.82	**4**
Lack of physical resources relevant for automation and robotics	0.81	10.68	8.68	**5**
Possibility of system errors	0.84	10.16	8.52	**6**
Possibility of data loss	0.85	10.03	8.48	**7**
Higher initial investment	0.88	8.23	7.22	**8**
Lack of legal rules and regulations	0.81	8.74	7.05	**9**
***Unreliable internet facility**	0.74	8.10	5.96	**10**
Lack of rules to resolve disputes arising from automation and robotics	0.77	7.32	5.62	**11**
Total CSS value of barriers			**89.10**	

Lack of confidence by the employees was the foremost impeding barrier towards automation and robotics implementation in Sri Lankan context with a CSS value of 10.03. Possibility of virus attacks and lack of skilled work force within organization were the second and third impeding barriers. Moreover, Lack of rules to resolve disputes arising from automation and robotics was the least impeding barrier with 5.62 CSS value.

Overall readiness of implementing automation and robotics in Sri Lankan construction industry can be calculated based on overall suitability score.

OSS = Total CSS value of facilitators – Total CSS value of barriers

= 79.15 – 89.10

= -9.95

Above resulted minus value of OSS emphasized that Sri Lankan construction industry is still not ready to adopt automation and robotics. In current situation, factors that act as barriers are higher than the factors that encourage as facilitators towards implementation of automation and robotics. Hence, for a successful implementation of automation and robotics in the construction industry certain improvements need to be made on the current practice.

CONCLUSIONS AND RECOMMENDATIONS

Over rapid growth of technology, most of the industries have integrated with autonomous machines and robots to make tasks and activities easier and more efficient. However, Sri Lankan construction industry has not widely integrated to autonomous machines and robotic technologies. Based on the research outcomes, Sri Lankan construction industry is still not ready to adopt automation and robotics since major challenge identified is no policy direction from responsible authorities.

Initial step towards implementing automation and robotics need to be taken by responsible regulatory authorities of construction industry. Relevant authorities have to finalize policies on replacing conventional construction process with an automated environment based on the research and

development. Meanwhile, awareness sessions need to be conducted for the contractors emphasizing the benefits of having an automated environment in construction. Key suggestion from all interviewees is to include robotics and automation module into engineer's degree curriculum and creating a technology adopted syllabus from school level to overcome the limited availability of experts in automation and robotics. Moreover, once the authorities are given the policy direction towards implementing automation and robotics, training programs and awareness sessions should be arranged from organization level to the employees. Procure a prudent product and test on Sri Lankan context will be a better solution to overcome the higher initial cost rather than manufacturing the robots or autonomous machines locally.

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ECONOMIC STRENGTHS AND WEAKNESSES OF URBAN RENEWAL PROJECTS IN SRI LANKA

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ECONOMIC STRENGTHS AND WEAKNESSES OF URBAN RENEWAL PROJECTS IN SRI LANKA

ABSTRACT

Even though urbanization can spur economic development, many countries often struggle with the management and governance of the urbanized areas. This study explored the broader economic implications of urban renewal to ensure better performance of urban renewal projects by identifying crucial economic factors that affect planning and delivering of those projects. To explore the implications, a case study was conducted using a qualitative research approach that used semi-structured interviews. The study revealed that urban renewal projects could improve the environmental conditions and living standards while enhancing economic growth. Additionally, it will enhance quality of urban real estate while improving the infrastructure to cater to future demand. Exploring the strengths and weaknesses could also improve the planning and implementation of urban renewal projects, while further research could be conducted to develop the strategies required for better integration and evaluation of urban renewal projects.

***Keywords**: Economic Implication; Sustainable resource utilization; Urban Renewal; Urbanization.*

INTRODUCTION

Demographic studies have found that global urbanization is growing at a rapid phase and that two thirds of the global population could be living in urban settlements by 2030 (UN-Habitat, 2011b). Glaeser and Henderson (2017) claims that urbanization is very important for a developing country that encourages economic growth by concentrating on the economic activities of its cities. According to Zhang et al. (2017), the expansion of urban population has also had a significant impact on the spatial forms of the conventional cities by changing their socio-economic spheres and making their traditional governing structures out-dated. Choe and Laquian (2008) identified that the number of specialized services formed within a city is proportional to the size of that city although the growth of that city will be limited by the negative externalities that emerge with the expansion of the city. Degert et al. (2016) remark that unplanned urban growth has created a highly susceptible urban environment that has poor living conditions, urban infrastructure backlogs and critical environmental problems.

Glaeser and Henderson (2017) and Lee and Chan (2008) believe that the urban renewal strategies that consider physical limitations and the development potential of the locality will be capable of mitigating the adverse impacts of haphazard urban planning. According to Roberts (2015), urban renewal focuses on the improvement of economic, physical, social and environmental aspects of urban settings. On the other hand, Lee and Chan (2008) believe that urban renewal projects enable spatial restructuring by facilitating cities to overcome the physical limitations and the underutilization of their scarce resources. Glaeser and Henderson (2017) criticize the adoption of modern strategies used in developed countries saying that they are irrelevant and misleading. They along with Lee and Chan (2008) suggest to develop and implement spatial and scientific urban renewal strategies that consider the physical limitations and development potential of the locality with a territorial focus, to solve problems of haphazard urbanization.

Sri Lanka is among the 40-odd countries that have the highest population growth rates in South Asia (Emmanuel, 2016). However, Ganegodage and Rambaldi (2011) and Perera, (2016) are critical about most of the regional planning projects because they have been confined to physical development and not to the socio-economic wellbeing of the society, which affects the functionality of the urban community. Perera (2016) explained that urban renewal strategies must be focused on specificities, especially to take advantages of community features and that they must be coherent with broader social and political structures, which guarantee social wellbeing. The focus of this study was, therefore, on improving the planning and implementation of urban renewal projects in order to serve the needs of the community. A literature review was first carried out to explore the economic implications of urban renewal projects, which was followed by a case study to verify the literature review findings. The findings were subsequently analysed to identify the strengths and weaknesses of urban renewal projects.

LITERATURE REVIEW

URBAN RENEWAL

According to Zheng et al. (2014) and Roberts (2015), urban renewal is primarily concerned with the rehabilitation of underutilized urban land for the physical development and improvement in economic, physical, social, and environmental aspects of the people living in those areas. Gao et al. (2017) explained that urbanization accelerates the outward expansion of cities, which deteriorates the inner-city, thereby encouraging urban renewal to serve the needs of the cities. Lee and Chan (2008) highlighted the importance of using urban renewal to produce new land by making use of under-utilized urban land to solve congestion, lack of amenities, deterioration of the urban fabric and unsatisfactory living standards. They also identified 4 subsystems of urban renewal, namely land, housing, infrastructure and heritage.

BENEFITS OF URBAN RENEWAL PROJECTS

Lee and Chan (2008) believe that the proper execution of urban renewal projects could enhance the economic growth of a city while improving the environmental conditions and living standards of the urban community. Adams and Hasting (2001) observed that with urbanization, the value of the land will increase as then the building stock and land resources will be efficiently used. Furthermore, as observed by Choe and Laquian (2008), the provision of quality housing solutions could attract skilled labour and talent, thereby promoting knowledge, skills and management specialization. Choe and Laquian (2008) further claim that economies of scale and spill over effects of knowledge that come with such housing solutions will reduce business costs while increasing the efficiency as the different agents of the economy will be in close proximity to one another. Fields (2015) stated that different transportation modes, economic links, shared resources and social cohesions would result in agglomeration economies, which will help to overcome the weaknesses of the neighbouring cities. Urban renewal creates condensed urban systems having the optimum population and will mitigate most of the issues associated with haphazard urbanization.

ECONOMIC PERSPECTIVE OF URBAN RENEWAL

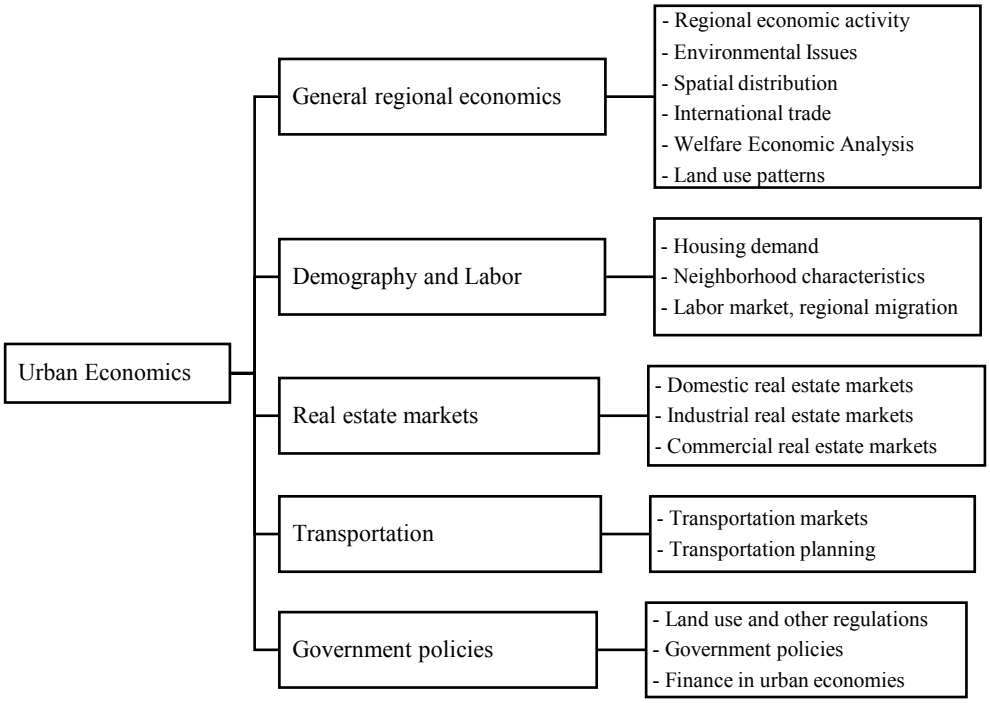
A primary concern of economics is the allocation of scarce resources to a particular task to yield maximum benefit from the available alternatives (Mankiw, 2011). Nesticò and Sica (2017) described cities as an economic mechanism, which facilitates the production, distribution and consumption of goods and services and they believed that the economic objective of urban renewal is to achieve territorial transformation and development through the optimal utilization of the available resources. Therefore, studying the economic implications of urban renewal projects could ensure the effective implementation of projects to provide maximum social benefit through the optimal utilization of the resources.

The classification of urban economic factors depicted in Figure 1 below were derived from the six economic factors that were identified by Lee and Chan (2008a), who found that these factors influence the design features and the theoretical categories of urban renewal developed by the American Economic Association [AEA], (2018) to facilitate a comprehensive study on the different implications of urban renewal.

The general regional economic factors deal with the implementation of efficient regional economic development strategies that would counteract the diseconomies of urbanization. Duranton and Puga (2015) discussed the spatial distribution and the local impact of economic activities. Lambin and Meyfroidt (2011) explained the consumption of local land resources along with the associated environmental issues. Deng et al. (2010) discussed the socio-economic influences that determine the allocation of regional resources.

The employment opportunities created within developing cities will increase the flow of labor as observed by Cohen (2006), and thus will change the demographic characteristics and demand for housing. Baycan-Levent and Nijkamp (2009) discussed the advantages of these increased labor pools, while Hoyman and Faricy (2009) raised concerns about the reduction in the opportunities available for the local workers brought about by urbanization. Zhang et al., (2017) elaborated the implications of urbanization on job creation and consumer and investor behavior changes caused by individual wealth and affordability. Syrett and Sepulveda (2011) explained the implications of urbanization on population diversity, while Alesina and La Ferrara (2005) discussed how personal preferences of the community affect production functions.

Figure 7: Classification of urban economic factors



Quigley and Rosenthal (2005) and Qiu et al. (2015) observed that the demand for spatial improvements has a significant influence on the local real estate markets in relation to residential, commercial and industrial developments. Quigley and Rosenthal (2005) discussed the affordability of housing solutions, while Glaeser and Henderson (2017) explained the regulatory and other factors that determine housing supply. With regard to industrial spatial production, Qiu et al. (2015) explained the agglomeration and spatial morphology factors associated with locating industrial firms. Gao et al. (2017) discussed the integration of residential, commercial and social activities with government policies and patterns of trade. Rode et al. (2017) noted that better quality and high efficiency access is the basis of economic development , which leads to the economic benefits brought about by economies of scale. They further discussed the importance of investments on transport and innovation in infrastructure development.

Bovet et al. (2017) suggest the implementation of policies and regulations to control urban growth and regulate sustainable land-use. Qiu et al. (2015) explored the effects of standard regulations and restrictions on urban development. Additionally, Searle, (2013) explained the impact of affiliations among economies through public private partnership and foreign direct investments.

METHODOLOGY

The aim of this study was to explore the economic implications of the urban renewal projects in Sri Lanka in order to enhance the outcomes of future development projects. The findings of this study will facilitate practitioners to capitalize on the strengths of the past urban renewal projects while mitigating their weaknesses and taking action to overcoming the challenges they faced. As explained by Naoum (2012), an exploratory qualitative research approach can be used to diagnose a situation, screen alternatives and discover new ideas when there is only a limited amount of knowledge available on the topic. Naoum (2012) stated that case studies can be used to support arguments and findings through an in-depth analysis of a person, an organisation or a particular project. Thus, this study used case studies for the in-depth analysis of urban renewal projects.

A pilot survey was carried out before collecting the primary data required to verify the literature review findings and identify the deficiencies, if any, of the research proposal. The data for the pilot study were

collected from four experts who were involved with urban renewal projects. Each of them had more than 14 years of experience. According to the experts, most of the urban development projects focus on the specific needs of the society. Nonetheless, there had been several projects in the past that dealt with each of the subsystems of urban renewal. However, they have not had any cultural or historical value.

The projects for the case study were selected based on judgmental sampling and considering the locations of the projects. Due to geographical limitations, the projects that were located outside the western region were disregarded. The selected projects represent the subsystems of urban renewal as identified by Lee and Chan (2008). The projects within each subsystem were selected were based on their relevance and the availability of the required data. For example, the elevated railway project was selected because of its high impact on the urban environment. Similarly, an urban housing project was selected because a large amount of data could be obtained from it. Similarly, a land and irrigation development project was selected because of its impact on land and irrigation network development. Table 1 presents the details of the selected cases.

Table 13: Details of the selected cases representing the subsystems of urban renewal

Case No.	General Details		Parties Interviewed
CASE 1	**Type of the Project**	Infrastructure Development Project	C1/R1 - Deputy Director
	Employer	Government of Sri Lanka (GOSL) with a Public Private Partnership (PPP)	C1/R2 - Senior Engineer
	Funding	Through Build-Operate-Transfer /PPP	C1/R3 - Senior Engineer
	Scope of the project	To provide an efficient solution to traffic congestion in accordance with the transport development plan	C1/R4 - Civil Engineer C1/R5 - Civil Engineer
CASE 2	**Type of the Project**	Public Housing Project	C2/R1 - Deputy Director
	Employer	Urban Development Authority	C2/R2 - Senior Engineer
	Funding	By the GOSL	C2/R3 - Civil Engineer
	Scope of the project	To meet the housing requirements of lower, middle- and upper-class communities	C2/R4 - Civil Engineer
CASE 3	**Type of the Project**	Land Development Project	C3/R1 - Senior Engineer
	Employer	Sri Lanka Land Reclamation and Development Corporation	C3/R2 - Senior Engineer
	Funding	From overseas	C3/R3 -Civil Engineer
	Scope of the project	To remove the illegal settlements and revitalize the acquired spaces to support other development projects	C3/R4 - Civil Engineer

The semi-structured interviews conducted with professionals who were involved with the planning of the selected cases and reviewing of the documents of the relevant projects enhanced the reliability of the data since they gave the opportunity to verify the findings. The qualitative data collected from the semi-structured interviews were manually analysed using content analysis because of the ease of handling the data obtained from the semi structured interviews and document reviews.

FINDINGS

STRENGTHS

The study findings confirmed the observations made by Glaeser and Henderson (2017), which indicated that these projects provide the background for the growth of economic activities in the region concerned and that they increase the job opportunities within the region, thereby promoting wealth creation within the community. Duranton and Puga (2015) observed that agglomeration and spatial spill over effects will influence the growth of other economic sectors as well, and the study findings too confirmed that observation. As found by Singh, (2010), the involvement of foreign experts in large-scale projects will facilitate the adoption of foreign innovations in Sri Lanka, thereby encouraging technology diffusion. The study revealed that the attraction offered by urban renewal projects to investors and workers to come to new areas will improve the economic potential of the area's leading to changes in their demographic characteristics. Increased investments in various economic sectors will generate more employment opportunities for the people increasing their wealth. The study also revealed that urban renewal projects

improve the standard of living of the people of the area, which confirmed the observations made by Adams and Hastings (2001) and Chan and Yung (2004). It was also found that land development through urban renewal projects will introduce refurbished land of commercial value to cater to the demand for real estate property. This confirms the findings of Zheng et al. (2014), which revealed that compared to demolition and redevelopment, refurbishment is more cost effective, more time saving and less disruptive in meeting the demand for land. Better quality and highly efficient access is the basis for economic development that can influence the economic benefits brought about by economies of scale with advantages related to agglomeration and interconnection. The results of the study indicate that urban renewal projects address the increased demand for transportation and facilitate economic growth, as revealed by Garrison and Levinson (2006) that transportation infrastructure is the key to growth and development. Confirming the findings of Rode et al. (2017), the results of the study also suggest that better infrastructure facilities will improve the physical proximity of the people by increasing their speed of travel. Table 2 presents a summary of the strengths and weaknesses of urban renewal projects.

Table 2: Strengths and weaknesses of urban renewal projects related to different aspects of urban economics

Regional Economy	**Household, Demography and Labour Market**	**Real Estate Market**	**Transportation**
STRENGHTS			
- Growth of regional economic activities - Generation of jobs through increased economic activities - Development of other sectors through the spill over effect - Economic activities and technological fusion due to international trade. - Prevention of land conversion through the introduction of new land - Optimal allocation of developed land to meet social needs	- Increased individual wealth generated through new job opportunities - Creation of wealth within different sectors through the ripple effect - Creation of dense cities with increased population which promote economic development through agglomeration - Increasing of the available labour pool with diverse skills who can contribute differently to the economy.	- Increased housing prices with increased demand - Introduction of new land to cater to the demand for real estate - Improved accessibility to high quality common amenities - Improved integration of residential, economic and social activities - Improved standard of living with modern facilities	- Increased demand for transportation - Agglomeration effects that result from improved transportation - Increased economic activities provided by alternative transportation methods - Agglomeration effects on the neighbouring properties
WEAKNESSES			
- Elimination of small scale economic activities through the relocation of people - Termination of relationships that support economic growth - Increased economic activity have Adverse impact on biodiversity - Conversion of reserved lands due to increased demand for land	- Impact made on the livelihoods of the community through land acquisition and resettlement - Loss of community feeling due to relocation - Impact on living standards due to illegal settlements - Increased labour pool with reduced opportunities for the local labour	- Inadequacy of affordable housing solutions - Adverse impact on real estate due to noise and vibration - Leniency of the regulations established to prevent illegal developments	- Increased demand for transport due to increased population - Impact on bio diversity and wild life - Reluctance to adapt for alternative transportation modes - Interference economic activities related to existing infrastructure by alternatives

WEAKNESSES

Most of the urban development projects expand the urban environment by converting rural and agricultural land. By making available alternative designs and utilizing salvaged land can minimize the need for conversion as suggested by Zheng et al. (2014). The results of the study reveal that the strategic use of multi-storey housing projects will enable efficient land use, which confirms the observations made by Lambin & Meyfroidt (2011). Another issue that was highlighted in the study is the impact on the community relationships that support economic growth. This was emphasised in the findings of the study by Deng et al. (2010) as well. The results of the study also indicate that the relocation process associated with urban

renewal will have an adverse impact on real estate. The experts suggested that the affected parties in such cases should be helped to develop their technical and vocational skills and provided with access to micro-finance and support services to develop their businesses and restore their livelihoods. The results also highlighted the inadequacy of affordable housing solutions, which could be resolved by the adoption of new strategies by the developers, such as the construction of multi-family units. It was also revealed that the adverse impact on real estate caused by on-going construction work can be mitigated by following regulated design standards as also suggested by Ederington and Minier (2003). Strict regulations need to be enforced to prevent illegal developments. In addition to the increase in the demand for transport, it will be a challenge to accommodate the commuters who use other transportation modes although it will be possible to address it by providing more innovative transportation services within the residential areas, thereby encouraging people to use more public transport.

CONCLUSIONS AND RECOMMENDATIONS

The two critical issues that needs to be addressed in urban renewal are the improvement of the environmental conditions and standard of living of the people while enhancing economic growth. The capacity of infrastructure and other urban developments should be improved to cater to future demand. Urban renewal will increase land values and improve the environmental quality of the region. Furthermore, it will promote the efficient use of building stock and land resources through land refurbishment. The findings of the study will provide insights into the critical economic implications of urban renewal projects that need to be considered during project implementation. During the planning of the project, the practitioners could use the findings to ensure the achievement of strategic goals to serve the community while mitigating the challenges. The findings can be further developed as a framework to screen and select potential urban renewal proposals. The selected proposals can also be ranked using the proposed framework by comparing the extent to which the proposals satisfy the proposed criteria. The proposals can also be compared with one another based on their strengths and weaknesses.

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ANALYSIS OF RUNNING COSTS OF COMMERCIAL BUILDINGS IN SRI LANKA

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ANALYSIS OF RUNNING COSTS OF COMMERCIAL BUILDINGS IN SRI LANKA

ABSTRACT

Buildings should be visualized for running costs, which entails a number of key cost components including operation and occupancy costs, and maintenance costs (renewal plus maintain) at the early stage of their life cycle. Hence, the information on different cost elements of running costs and their contributions would be helpful for effective decision making at the design stage. This research analyses the constitution and contribution of running costs of commercial buildings in Sri Lanka. The research was approached quantitatively where the costs data were extracted from financial documents of eight buildings according to standard cost classification systems of Building Maintenance Cost Information Service (BMCIS). The results show that the utility and administrative costs range between 29-38%, taxes and subsidies vary between 6-16%, the cost of cleaning contributes 10%, building services maintenance contributes 6-9%, general maintenance varies between 6-9%, and the insurance and external works range less than 1% of total running costs. So what? You need to write here the implication of this findings

Keywords: *Commercial Buildings; Running Costs; Operational and Maintenance costs, Sri Lanka.*

INTRODUCTION

Often, the building designs are evaluated purely based on the initial costs. This tends to accept the cheapest initial costs by building owners and then hand over to occupiers to maintain the building. However, the reduction of capital cost leads to expensive maintenance, operation, and disposal costs in buildings (Kehily, 2010). Moreover, the occupiers would reject higher rent unless lower operating expenses offset it. Therefore, higher capital cost should be reflected in lower operating and maintenance costs (Korpi & Ala-Risku, 2008). Running costs can be defined as the sum of maintenance and operating costs, which are incurred during the use phase of the building (Al-Hajj & Horner, 1998). A wide range of operations and maintenance activities are possible, which have different costs of the ongoing performance and future replacement cycles of a constructed asset (Arditi & Nawakorawit, 1999).

A study for maintenance projects using the performance approach can provide opportunities to improve cost, risk and quality management of the properties concerned in the long run (Joseph, 2010). Recent research efforts have been put on the study of operation and maintenance in buildings. For example, Building operation and maintenance accounts for over 50% of the total building costs of the building industry (Woodward, 1997). Further, a recent study, Wong et al. (2010) indicated that the 72% to 81% of total life cycle cost (LCC) of commercial building category is committed for operation and maintenance. In another word, over 70% of the total LCC of a building incurs during its in-use phase. The annual electricity consumption of a typical commercial building consists of 43% of energy for air conditioning, 17% is for office equipment, 6% for lifts and escalators, and another 34% for lighting (Yu & Chow, 2001). Lai and Yik (2008) introduced some useful benchmarks of operation and maintenance costs of luxury hotels. Those benchmarks are, the average major operation and maintenance cost expenditures consume 34% for electricity, 23% for capital projects, 19% for repair and maintenance, 13% of operation and maintenance staff, 5% of town gas, 4% for diesel oil and 2% for water. Lai and Yik (2011) discovered that the average operation and maintenance costs in French healthcare facilities cater to 23-34% of the total costs. Moreover, they introduced a benchmark to evaluate and develop operational strategies for health facilities in France.

The forgoing review indicates the importance of accounting the running costs of buildings and the changes in its constituents to different context. Accordingly, this research aims to analyse the constitution and contribution of running costs of commercial buildings in Sri Lanka towards an effective decision making on running costs of commercial buildings at the early stage of building life-cycle.

LITERATURE REVIEW

RUNNING COSTS OF COMMERCIAL BUILDINGS

A commercial building includes office, industrial property, retails, hotel facilities, healthcare, and residential buildings (Aye, Bamford, Charters & Robinson, 2000). When considering the different types of buildings, commercial buildings contribute significantly to resource consumption through building operations and maintenance globally and nationally (Scheuer, Keoleian, & Reppe, 2003). Most of the commercial buildings have similar characteristics such as being a high-rise, air-conditioned by a centralized chiller plant and often used for multiple usages including offices, retailing shops and restaurants (Yu & Chow, 2001). Operation and maintenance costs in commercial buildings similar to any kind of building, compromise with energy and utilities, maintenance, repair, decoration, refurbishment costs, etc. (Yu & Chow, 2001). Several research efforts have put on the study of operation and maintenance costs of buildings. Woodward (1997) indicated that the operation and maintenance costs account for approximately 55% of the total costs over a building's lifespan of 40 years. Later, Lai and Yik (2008) introduced some useful benchmarks of breakdown operation and maintenance costs for luxury hotels, the average major operation and maintenance costs expenditures consume 34% for electricity, 23% for capital projects, 19% for repair and maintenance, 13% of operation and maintenance staff, 5% of town gas, 4% for diesel oil and 2% for water. Subsequently, the same authors (2011) discovered that the average operation and maintenance costs in French healthcare facilities cater to 34% to 23% of the total costs. In the recent past, the Building Owners and Managers Association (BOMA) International and Kingsley Associates (2017) has released a breakdown of operating expenses within the commercial buildings based in the USA as demonstrated in Figure 1.

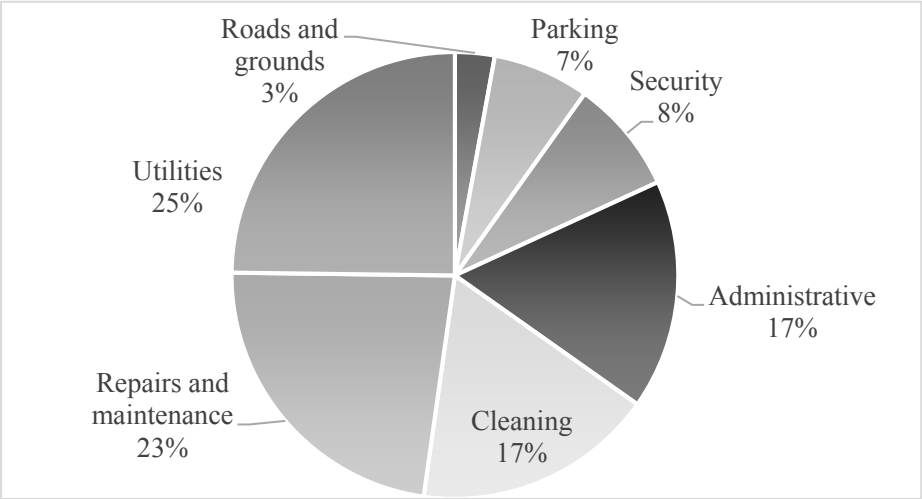

Figure 1: Operations and Maintenance costs breakdown of a typical commercial building. (Source: BOMA, 2017)

As shown in Figure 1, 82% of the operating costs of a typical commercial building is incurred by utilities (25%), repairs and maintenance (23%), cleaning (17%), and administrative work (17%).

The energy consumptions of the commercial buildings in Sri Lanka are high, in terms of electricity (De Silva, 2011). When considered the electricity energy balance of a typical building in Sri Lanka more than 75% may be created by air conditioning systems (Sri Lanka Sustainable Energy Authority [SLSEA], 2014). In Sri Lanka, most commercial and state sector buildings are in Colombo city limits, which have the hottest and a more humid climate. Therefore, air conditioning is one of the main requirements to maintain a comfortable indoor climate. On the other hand, Sri Lanka experiences a considerable rise in electricity tariff rates annually and the national demand for electricity for air conditioning has been increasing over the years (Athukorala et al., 2013).

In the context of Sri Lanka, the operation and maintenance support costs are viewed within a limited range where the energy cost is in primary concern. For example, it has been estimated that the use of energy is 20%-60% of the annual operations and maintenance costs of office buildings (Weddikkara, 2001). Further, the electricity consumption in office buildings accounts for 20% of the total electricity consumption in Sri

Lanka (SLSEA, 2014). The above findings highlight that the electricity cost consumes a greater share of operational costs in commercial buildings in Sri Lanka due to the operation of building services such as heating, ventilation, and air conditioning (HVAC). However, the records of the maintenance costs of commercial buildings are limited. Therefore, there seems a lack of estimations for the total running costs of commercial buildings in Sri Lanka. To this end, as part of the larger study which focuses on developing a running cost model based on building characteristics and running cost indices, this paper presents an analysis of the running cost of commercial buildings towards identifying its constituents and contribution.

RESEARCH METHODS

The research was undertaken using the quantitative approach where the running costs data were extracted from financial documents of eight (08) commercial buildings in Sri Lanka. Running costs data were collected according to a standard structure that is developed based on the Building Maintenance Cost Information Service (BMCIS) framework (Ref). The modified cost categories considered rent, utilities, insurance, administrative cost, and taxes and subsidies as elements of operational costs while decoration, fabric, services, cleaning, external works, and replacements of major components consist of maintenance costs. The running costs data, operating and physical characteristics of buildings were extracted from documents such as organizational annual reports, administrative expenditure budget records, operating expenses reports and as-built drawings of the selected buildings. Physical data collected included: building floor area, height, and the number of floors. Descriptive statistical analysis was used to analyze the running costs data after separating the data into projects with similar characteristics.

DATA ANALYSIS AND FINDINGS

PROFILE OF THE SELECTED BUILDINGS

Selected buildings belonged to different sectors of industries such as property development sector, commercial banking, mixed development, financial sector, customs administration, and commercial office. Table 1 presents the profile of the selected buildings.

Table 1: Profile of Buildings

Building	Type of the Organization	Type of Function	No of Floors	Expected Life Span of the Building (Years)	Years in Operation
B1	Banking industry	Merchant banking, property development, and management, renting of office space	32	50	30
B2	Institution in financial sector	Provide intermediation to distribute financial resources	16	50	15
B3	Customs administration	Controlling and monitoring imports and exports of restricted and prohibited goods	13	50	4
B4	Property development and management	Provide rentable office and business space with modern infrastructure facilities	37	50	20
B5	Banking industry	Commercial banking, project lending, and development banking	23	100	13

B6	Mixed development	Provide apartments, provide space for events and functions	34	50	18
B7	Commercial office	Management and operation of hotels and resorts	13	50	21
B8	Property development and management	Leasing of office space and real estate	17	50	19

THE CONSTITUTION OF THE RUNNING COSTS IN COMMERCIAL BUILDINGS IN SRI LANKA

The running costs of commercial buildings were analysed according to standard cost classification system of BMCIS. The given framework includes the operation costs elements such as rent cost, insurance cost, utility costs, administrative costs and taxes. But, when considering the selected cases, all the selected commercial buildings are owned by the respective organizations that operate and occupy the premises. Most of those buildings own rentable spaces which make rental as an income for the organization. Hence, rent cost is not identified as an element of running costs in commercial buildings in Sri Lanka.

The insurance cost is mainly determined through a certain package of insurance and this may depend on the reinstatement value of the property including plant and machinery. Under the utility costs, costs for electricity, water, fuel, and effluent and drainage are mainly identified. Those costs are separately maintained in the selected cases. The administrative costs of commercial buildings mainly consist of staff costs, waste disposal, security costs, sundries, and porterage. But, an additional cost may incur for property management if the buildings are managed by outsources companies such as property management companies or facilities management firms. Other than that, taxes and subsidies are engaged with any kind of commercial building.

Maintenance costs elements included in the prepared framework are the cost for the decoration, fabric maintenance, building services maintenance, external works, cleaning, and replacement of major systems and components. Basically, decoration includes the cyclical and non-programmed internal and external decorations. And the fabric maintenance and building services are considered as a combination of planned maintenance, corrective maintenance, deferred maintenance (emergency) and repairs and replacement of minor components of those elements.

As identified in the data collection, the cost for the decoration and fabric maintenance has not been maintained separately in commercial buildings in Sri Lanka but, added as a cost for the general building maintenance. Maintenance costs for the building services are separately maintained in commercial buildings in Sri Lanka, according to the types of building services which the commercial buildings are capable of. Moreover, the external works include both the cost of pest controlling and landscaping and separately maintain those costs in commercial buildings. The cost of the cleaning mainly considered as the cost of housekeeping. The replacement of major systems and components comes under the building services maintenance. Basically, those cost elements are categorized as being easy for accounting purposes.

THE CONTRIBUTION OF THE RUNNING COSTS IN COMMERCIAL BUILDINGS IN SRI LANKA

A significant difference was observed between maximum and minimum values of the running cost of selected buildings. Hence, it was not accurate if considered the mean value of the sample to analyze the running costs of commercial buildings in Sri Lanka. Therefore, the median value of the sample is considered. The difference between the median and the actual running cost of each building was calculated and considered to select the best samples to illustrate the composition of running costs.

Table 2: Median running costs to % Deviation in Running Costs of Each Case

Element	**% Deviation of Running Costs compared to Median**							
	B1	B2	B3	B4	B5	B6	B7	B8

Running costs	-120%	7%	-7%	-15%	-91%	69%	75%	68%

As seen in Table 2, there are three different ranges of cost deviations found among selected buildings. The running cost deviation of B2, B3 and B4 ranges around ±10% on average, while the deviation of B6, B7, and B8 ranges between 70 - 75%. The buildings B1 and B5 indicated an extremely high deviation, compared to the running cost of other buildings and ranges around -100% on average. Further, the physical characteristics of the selected buildings are considered, amongst selected buildings, B1 consists of the highest number of floors and the largest gross floor area (refer to Table 1). Therefore, the buildings, B2, B3, and B4 were classified as category 1, while B6, B7, and B8 were classified as category 2 and considered for further analysis. The buildings, B1 and B7 were eliminated from the analysis due to major deviations. Table 3 shows the classified buildings with its description.

Table 3: Scope of Data Used for the Descriptive Analysis

Classification of Buildings	Description	Buildings Selected
Category 1	Commercial high-rise building, having 23 to 34 floors	B2, B3, and B4
Category 2	Commercial high rise building which are having 13 to 17 floors	B6, B7, and B8

Table, 4 indicates the contribution of each element to the total running cost which is derived by the mean value of the cost elements.

Table 4: Contribution of Each Element to the Running costs

Element	Category 1		Category 2	
	Mean Value (LKR)	Contribution to Running costs %	Mean Value (LKR)	Contribution to Running costs %
1) Running costs	397,003,755		110,718,240	
1.1) Operation Cost	296,590,098	74.71	82,623,354	74.62
1.1.1) Insurance cost	4,255,343	1.07	1,661,413	1.50
1.1.2) Utilities	115,007,740	28.97	42,273,008	38.18
1.1.3) Administrative cost	114,587,513	28.86	38,117,559	34.43
1.1.4) Taxes and Subsidies	62,739,502	15.80	6,197,041	5.60
1.2) Maintenance Cost	100,413,657	25.29	28,094,886	25.38
1.2.1) General Building Maintenance	24,383,333	6.14	9,866,265	8.91
1.2.2) Building Services	32,506,575	8.19	6,756,218	6.10
1.2.3) Cleaning	42,671,016	10.75	10,857,509	9.81

1.2.4) Works	**External**	852,733	0.21	614,894	0.56

On closer scrutiny, Figure 2 depicts the composition of running costs of the selected two categories of commercial buildings.

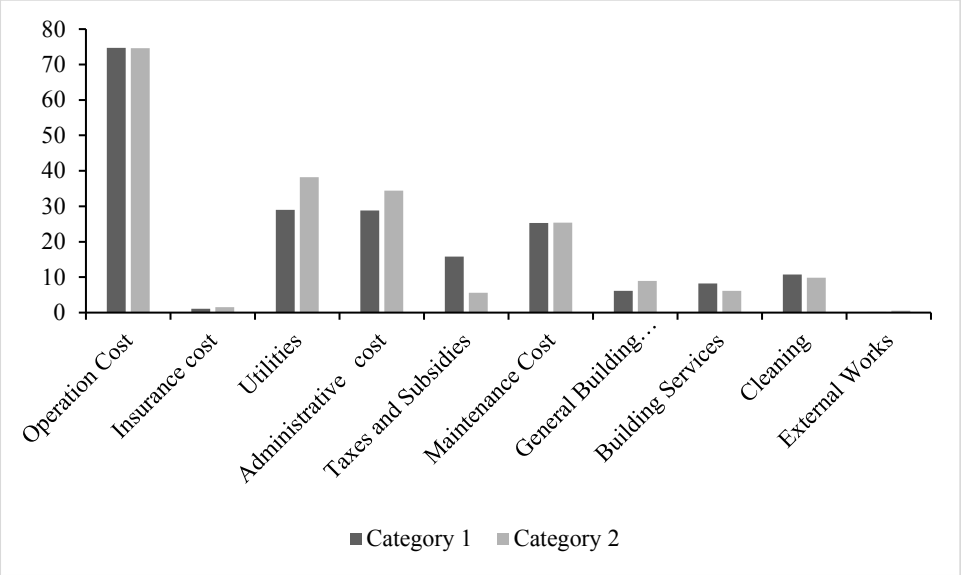

Figure 2: Contribution of Each Element to the Total Running costs

As seen in Figure 2, the running cost consists of operational and maintenance costs. For both categories of buildings, the % contribution of operational and maintenance costs to the running cost is equal, 75% and 25% respectively. As per the results of two categories, the contribution of utility costs varies from 29-38%, administrative costs range from 29-34%, taxes and subsidies range from 6-16%, cost for the cleaning range from 10-11%, cost for the building services maintenance range from 6-8%, general building maintenance vary from 6-9%, and the insurance and external works range below the 1%. In both categories of building, utilities and administrative costs are highly contributing elements to the total running cost with a 30-40% contribution. Amongst the utility cost, the electricity cost consumes a higher proportion than the other energy costs such as fuel, gas, and water, where the electricity cost ranges between 87-94% of utilities. The administrative cost, on the other hand, includes a higher proportion of staff cost than the other administrative costs such as property management, sundries, porterage, and waste disposal costs.

CONCLUSIONS

In the context of Sri Lanka, the commercial building sector has more focused on identifying, collecting, analyzing and reviewing information related to the utility costs and mostly the electricity costs due to the prevailing energy crisis globally. Nevertheless, this does not visualize the attempts towards tracking the running costs of the commercial buildings in Sri Lanka for effective decision making during the early stages of building life-cycle. Therefore, the current study identified the main cost elements of commercial buildings that are insurance, utilities, administrative, taxes and subsidies, general building maintenance, building services maintenance, cleaning, and external works. The study further estimated the contribution of each cost element to the total running cost. Accordingly, the contribution of utility costs varies from 29-38%, administrative costs range from 29- 34%, taxes and subsidies range from 6-16%, cost for the cleaning is between 10-11%, cost for the building services maintenance ranges from 6-8%, general building maintenance varies from 6-9%, and the insurance and external works range below the 1%. Therefore, the current analysis of running costs of commercial buildings provides effective decision making concerned in the long run.

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EXTERNAL STAKEHOLDER INFLUENCES IN MEGA CONSTRUCTION PROJECTS

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EXTERNAL STAKEHOLDER INFLUENCES IN MEGA CONSTRUCTION PROJECTS

ABSTRACT

Conflicts always occur in the development process of mega projects due to the involvement of many stakeholders with diverse expectations and interests. Among them, external stakeholders employ different strategies to influence mega construction projects during the project life cycle. This situation has become a critical issue for project clients, as it results in project suspension, delays, and cost overruns, ultimately leading to technical and internal project-related issues. Thus, this paper aims to discuss about external stakeholders and their influence on mega construction projects. A multiple case design was followed to achieve the research aim with two phases of data collection methods, including a desktop study and semi-structured interviews. As per the findings of this research, a wide range of external stakeholders emerged with the nature of the projects, and thirteen main external stakeholder groups were identified. The local community, national government, social and professional organisations, and political organisations are the usual stakeholders influencing mega construction projects, while some stakeholders are project specific. Once the interests of the external stakeholders get affected, stakeholders tend to influence the project in a legal, social, and an environmental manner. Conducting protests, interrupting the project, issuing suspension orders, criticisms, and making continuous complaints are some of the negative influences created by the stakeholders. The study identified that political agenda, personal agenda, and competitiveness are the main reasons for external stakeholder influences in mega construction projects.

Keywords: *External Stakeholders, Mega Construction Projects, External Stakeholder Influences*

INTRODUCTION

In developing countries, inappropriate identification of various stakeholder groups and their engagement has emerged as one of the challenges of great significance in megaproject development (Othman, 2013). Megaprojects are explained as multibillion-dollar infrastructure projects generally undertaken by governments and delivered by private enterprise. Most importantly, it has characteristics of complexity, uncertainty, politically impact, and engaging a multitude of stakeholders (Marrewijk, Clegg, Pitsis, & Veenswijk, 2008). Nguyen et al. (2018) explored that external stakeholders pressurize decision-makers when the implementation of mega construction projects has influenced their interests. Olander and Landin (2005) discovered that if stakeholders believe in negative attitudes towards a construction project, it can desperately obstruct the project owing to conflicts and controversies regarding both project design and implementation.

In contrast, Mok et al. (2015) stated that effective stakeholder management is a crucial requirement as an approach to mitigate conflicting interests between stakeholders in mega construction projects due to its nature of the complexity and uncertainty. As depicted in literature, the mega-development construction projects have been reported in Sri Lankan construction industry for recent years, and the external stakeholders significantly influence the mega development projects. Thus, there is an urgent requirement to investigate the external stakeholder influences in mega construction projects in Sri Lanka. Hence, this paper aims to investigate the nature of the external stakeholders and their influential strategies in mega construction projects.

LITERATURE FINDINGS

STAKEHOLDER CLASSIFICATION

Boddy and Paton (2004) denoted that stakeholders are any individual, group, or institution with interest in the project outcomes. Different classifications of stakeholders are available in the existing literature. Mitchell et al. (1997) classified stakeholders into three attributes, as power, legitimacy, and urgency. Freeman (1984) identified two types of stakeholders as primary stakeholders and secondary stakeholders. Winch (2010) applied the contractual relationship of the client to construction project stakeholders to classify stakeholders as internal and external. As mentioned by Olander (2007), internal stakeholders are actively engaged in project execution, whereas external stakeholders either influence or are influenced by the project. Moreover, Winch (2010) explained that internal stakeholders are engaged in a legal contract with the client, whereas external stakeholders possess significant direct interests with the project. Roeder (2013) identified external stakeholders as people outside the project organization subjected to be part of, and most importantly, possess the power of decision-making ability in a project. Mei-yung and Olomolaiye (2010) mentioned that not only external stakeholders affect or get affected by the project but also are involved in the relationships with the project where it is not necessary for project survival.

2.2 EXTERNAL STAKEHOLDER INFLUENCES IN MEGA CONSTRUCTION PROJECTS

According to Flyvbjerg (2014), megaprojects, which cost over a billion dollars, are large-scale and complex, taking more time to develop and built with the involvement of public and private stakeholders. It is a significant fact that megaprojects are frequently combined with a sophisticated public interest network owing to the connections of stakeholders and their influences on the project (Greiman, 2013). The media revealed to be actively utilized by external stakeholders to influence during the decision-making process of the mega construction projects and act as a powerful stakeholder who could either be an opponent or a supporter (Olander & Landin, 2008). Owing to the unique project nature, the groups of external stakeholders do not necessarily even exist before the project, and thereafter gradually emerging in consequence of the project. Additionally, considerations of external stakeholders in the feasibility and conceptual design stages have been significant and far more influencing compared to internal project stakeholders (Olander & Landin, 2005). In the project operation phases, external stakeholders use influence strategies as a method of strengthening and maintaining their opposing activities and the critical nature of the claims and the use of influence strategies act as a means of strengthening and maintaining the identity of the group and the severe nature of their claims (Rowley & Moldoveanu, 2003). Previous studies report the conflicts and challenges due to the external stakeholder environment, affecting the project outcomes significantly in mega construction projects (Flyvbjerg, Bruzelius, & Rothengatter, 2003; Bourne & Walker, 2006). Unsuccessful attempts on the management of meeting external stakeholder expectations throughout the project lifecycle have ultimately resulted in project failures, accountable to stakeholder power and resources to stop projects. Thus, stakeholder expectations need to be acknowledged in early stages in construction project development to increase the probability of having stakeholder fulfilment (Chan & Oppong, 2017).

2.3 STAKEHOLDER INFLUENCE STRATEGIES IN MEGA CONSTRUCTION PROJECTS

Stakeholders utilise various tactics or strategies to impact the decision-making process of the projects and firms (Aaltonen et al., 2008). Frooman (1999) explained that influence strategies used by stakeholders are determined by the nature of the resource relationship between the firm and the stakeholder, and identified four stakeholder influencing strategy types as (1) direct withholding, (2) direct usage, (3) indirect withholding, and (4) indirect usage. Hendry (2005) identified nine specific strategies and explained how environmental and non-governmental organisations could

utilise these strategies to influence businesses. Those nine strategies are recognised as a partnership, multi-stakeholder dialogue, blockade, letter-writing campaign, stakeholder resolution, boycott, lobbying, litigation, and communication.

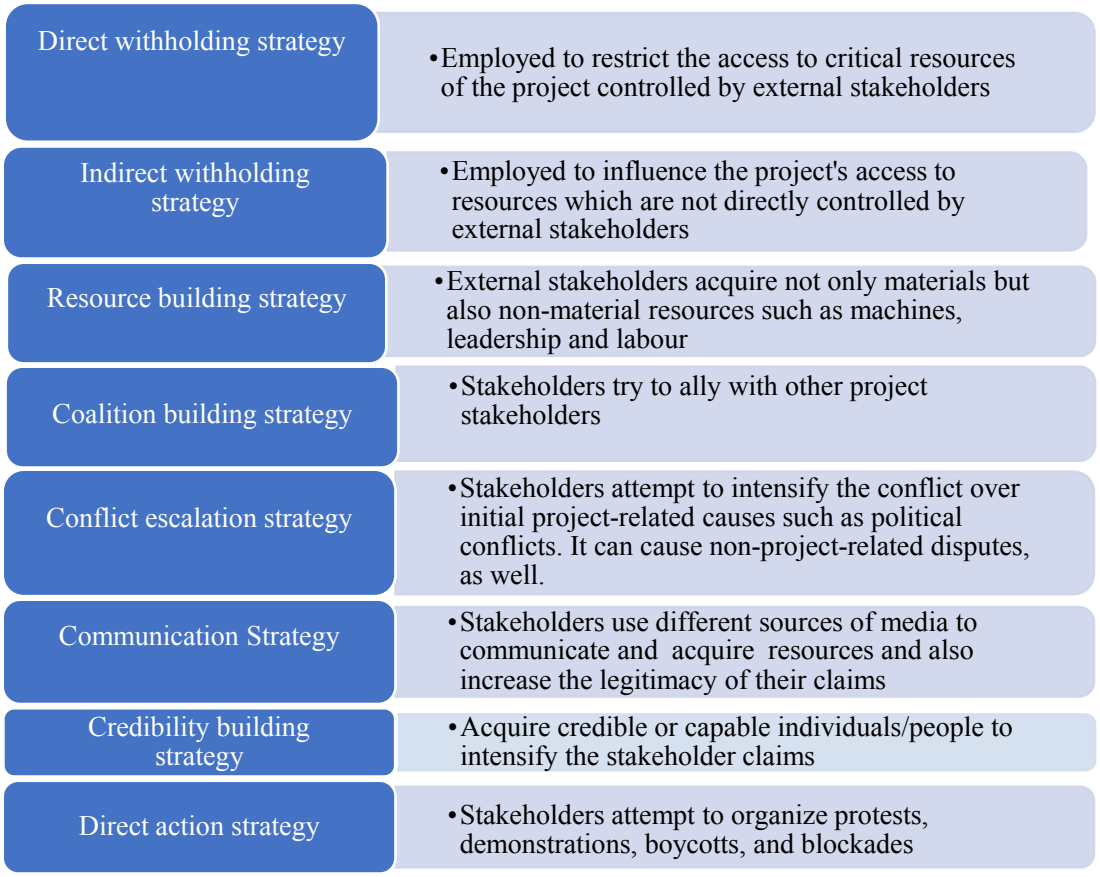

Figure 8: Stakeholder influence strategies in the context of global projects

Source: Adapted from (Aaltonen & Kujala, 2010)

Aaltonen and Kujala (2010) found eight stakeholder influence strategies in global projects after reviewing the previous work of Frooman (1999), Hendry (2005), and Rowley and Moldoveanu (2003), and presented in Figure 1. Frooman (1999) explained that influence strategies could be used as a way of stakeholders attempting to take what they want, and proposed that the nature of the resource relationship between the firm and the stakeholder determines the influence strategy used by each stakeholder. Moreover, stakeholders tend to withhold resources when they act independently from the firm and tend to use firm resources with conditions (Laplume et al., 2008), and the external stakeholders use an appropriate strategy to upsurge the attention of the project team to satisfy stakeholder claims due to their influence on project outcomes (Mok et al., 2015).

RESEARCH METHODOLOGY

First, a comprehensive literature survey was conducted to identify the stakeholder classifications and influential strategies employed by external stakeholders in construction projects. This was followed by a desk study with three adverse cases referring to both government and private sector newspaper articles to identify the respective external stakeholders and their influential sequences during the project life cycle. In this paper review, 164 number of articles, from 2014 January to 2019 May, were reviewed. Out of them, 119 articles stated about Case 1, 26 articles about Case 2, and 19 articles about Case 3.

Additionally, ten (10) semi-structured interviews were held, representing the client, consultant, and contractor parties from each case to validate the desk study findings and collect additional information. Manual content analysis technique was selected due to the convenience of analysing both desktop study and the semi-structured interviews followed by five steps: identifying, grouping, ordering, and within-case and cross-case analysis as discussed by Saldaña (2011). Table 1 provides a detailed explanation of the case profiles.

Table 14: Case profiles

Description	**Case 1**	**Case 2**	**Case 3**
Type	Marine Construction Project	Irrigation development project	Infrastructure Development Project
Client	Private	Public	Public
Type of Contract	Design and Build	Engineering and Procurement	Design and Build
Source of Funding	Public-Private Partnership	Foreign Development Investment	Foreign Development Investment
Contractor	Foreign	Foreign	Foreign
Project Duration	5 years	8 years	4 years
Project Amount	LKR 218 billion	LKR 82 billion	LKR 40 billion
Project Status	10%	94%	Completed

RESEARCH FINDINGS

EXTERNAL STAKEHOLDER INVOLVEMENT IN MEGA CONSTRUCTION PROJECTS

With the combination of desk study and semi-structured interviews, there are respectively 32, 15, and 06 number of external stakeholders who negatively influenced Case 1, Case 2, and Case 3. They were categorised into 13 groups according to the literature terms, which were summarised for all three cases, as shown in Table 2. Local administration authorities, political organisations, local community, social and professional organisations, and national government were identified as common external stakeholders influencing each case. NGOs, environmentalists, and media were the only stakeholders able to influence Cases 1 and 2. Foreign governments, archaeologists, research institutions, regulatory agencies, and local trade and industry were identified as project-specific stakeholders. External stakeholders have different interests due to the nature of the projects where they tend to influence when their interests are affected by project outcomes.

Table 15: Summary of external stakeholder involvement in mega projects

External Stakeholders	Case		
	1	2	3
Local Administration Authorities	●	●	●
Political Organisations	●	●	●
Foreign Governments	●		
Local Community	●	●	●
Social and Professional Organisations	●	●	●
Archaeologists	●		
Non-Governmental Organisations	●	●	
Environmentalists	●	●	
National Government	●	●	●
Regulatory Agencies	●		
Media	●	●	
Research Institutions	●		
Local Trade and Industry		●	

INFLUENCES OF EXTERNAL STAKEHOLDERS DURING THE PROJECT LIFECYCLE

In all three cases, stakeholders have used different influencing strategies to influence mega projects during the project life cycle, as summarised in Table 3. According to the interviewees, local administration authorities made several setbacks by delaying required project approvals and signing agreements, as direct withholding strategies in all three cases. The government followed a similar strategy by making suspension orders as one of the decision-making authority in Cases 1 and 2. Local community and legal agencies employed indirect withholding strategy due to the conflict of legal interests regarding the legal framework of the project by holding court cases in Case 1.

Moreover, social and professional organisations attempted to pressurise the government to stop the project by setting conditions, objections, making entries to project resources, and holding criticisms as conflict escalation strategies in all three cases. The media consistently pressurised the project team by revealing failures to meet compulsory project requirements by means of calling media briefings, article campaigns, spreading false and negative news, and reporting the shortcomings of the project, in Cases 1 and 2. During the construction stage, the media disseminates misleading project information and then intentionally reports environmental hazards, damages to the local community, and other negative impacts to capture the attention of the national government and local administration authorities. In essence, in Case 1, researchers intensified their claims with the publication of research consisting of negative impacts of a particular project input, whose recommendation is to replace the method of construction for the beneficiary of an NGO company as a combination of communication and coalition-building strategies.

Collectively in all three cases, local administration authorities, political organisations, social and professional organisations, NGOs, and environmentalists pressurised the project client by using conflict escalation strategies such as making complaints against the project, giving warnings, and questioning and criticising the project concerning its severe impacts on social and environmental interests of stakeholders. Political organisations communicate their objections due to the bad aspects of the project through press releases and newspapers to convince both the client to scrap the project and opposing groups to intensify their influences in Cases 1 and 2. Furthermore, in Case 3, these stakeholders attempted to change the project scope due to the allegations made by the local community. However, in Cases 1 and 2, with the corporative action with

environmentalists, the local community organised protests and blockades as a direct action to intensify their claims owing to the inadequate attention made to them by the client.

Table 16: Summary of external stakeholder influences in all Cases

External Stakeholder \ Influence Category	Case 1								Case 2								Case 3							
	DW	IW	RB	COB	CE	COM	CRB	DA	DW	IW	RB	COB	CE	COM	CRB	DA	DW	IW	RB	COB	CE	COM	CRB	DA
Local Administration Authorities	✓				✓	✓							✓			✓	✓							
Political Organisations						✓		✓					✓	✓							✓			
Foreign Governments					✓																			
Local Community		✓			✓	✓		✓								✓					✓	✓		
Social and Professional Organisations		✓			✓	✓		✓					✓			✓					✓	✓		
Archaeologists					✓																			
Non-Governmental Organisations				✓		✓	✓						✓											
Environmentalists					✓	✓	✓	✓					✓			✓								
National Government	✓					✓			✓					✓										✓
Regulatory Agencies		✓			✓	✓																		
Media						✓								✓	✓									
Research Institutions					✓	✓																		
Local Trade and Industry														✓										

DW: Direct Withholding; IW: Indirect Withholding; RB: Resource Building, COB: Coalition Building; CE: Conflict Escalation; COM: Communication; CRB: Credibility Building; DA: Direct Action

In Case 3, the local community engaged in the conflicts by initially reclaiming the acquired lands and then complaining about the disturbances made by the client due to project activities. Finally, in the same case, a group of local community collided with the contractor's workmen, leading to violent clashes as a conflict escalation strategy. In Case 3, social and professional organisations held several media campaigns with the participation of their union members to disseminate a direct message to other stakeholders on corruptions made by the contractor. The environmentalists organised a gathering as a credibility building strategy to publicise the environmental hazards of the project to possess a dominant perception against the project to achieve their claims in Case 1. These observations denote that different external stakeholder groups employed different strategies to influence the project. Hence, the project client had to combat many difficulties in proceeding with the project, and at several times the project had to be suspended temporally, thereby affecting the completion time.

CONCLUSIONS

The local community, national government, social and professional organisations, and political organisations were identified as critical external stakeholders influencing mega construction projects. Some stakeholders are project-specific, i.e., foreign governments, legal agencies, local and trade industries, and archaeologists. External stakeholders tend to influence when their legitimate interests and environmental, social, and political interests are conflicted. The communication strategy was commonly used to convince the project governing authority to listen

to their voices. Direct action was employed to intensify the claims of the external stakeholders to convince the project client.

The NGOs, legal agencies, environmentalists and, social and professional organisations interrupt and influence the project indirectly; holding court cases, conducting protests, making continuous complaints and criticisms are some of the negative influences caused by the stakeholders. In the meantime, the media supported the project opposing external stakeholders to raise their voice against the project by press releases and media campaigns. On the other hand, the project location acts as a main determinant for having different types of stakeholders and the nature of the influences.

The stakeholder influence in megaprojects is less considerable in the early design and pre-construction stages, but it has become more significant in the construction stage, after gradually becoming aware of the project. In essence, political agenda, personal agenda, and competitiveness are the essential reasons for external stakeholder influences.

The next step of the study is to identify mitigation measures taken by the client on the negative influences of external stakeholders to make the project a success.

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